



REPUBLIC OF KENYA
MINISTRY OF ROADS AND TRANSPORT

WSCM

Works and Services Contracts Manual

Part 2: Standard Specification for Road and Bridge Construction

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Foreword

This Standard Specification was developed by the Ministry pursuant to The Fourth Schedule of the Constitution which assigns to the National Government the functions and powers of setting standards for the construction and maintenance of all public roads including those under the County Governments.

It is part of a series of manuals that replace the first generation of road manuals developed in the first and second decades after independence. The second-generation road manuals were developed to cover the entire road project cycle covering planning, appraisal, design, contracts, construction, maintenance, operations and monitoring. The series incorporates best practices, climate change considerations, and recent technologies to enable safe, secure, and efficient road infrastructure.

Under the Kenya Vision 2030, infrastructure expansion and modernisation are one of the foundations for the realisation of Kenya's economic, social and political transformation into a rapidly industrialising middle-income country. The plan envisages an integrated, safe and efficient transport and communication infrastructure network consisting of roads, railways, ports, airports, waterways, and telecommunications infrastructure.

The strategies to be pursued under the Vision 2030 plan to improve infrastructure services and to maximise the economic and social impacts of infrastructure development and management include strengthening the institutional framework for infrastructure development and maintenance; raising efficiency and quality of infrastructure projects; Enhancing local content of identified infrastructure projects to minimise import content; Benchmarking infrastructure facilities and services provision with globally acceptable performance standards; and, Implementing infrastructure projects that will stimulate demand in hitherto marginalised areas.

The first three 5-year Medium Term Plan (MTP) under the Vision 2030 from 2008 to 2022 targeted construction of 1,950 km, 5,500 km and 10,000 km of new paved roads totalling 17,450 km. This was a massive infrastructure development program intended to double the paved road network in 10 years compared to the 8,600 km developed from independence in 1963 to 2008.

Implementing MTP I to III resulted in the construction of 14,000 km of paved roads, which was the phenomenal expansion of the paved road network that extended the paved road coverage to the Arid and Semi-Arid regions previously neglected. However, some key milestones of the Vision 2030 goals have not been realised. This has been due to internal and external challenges. External challenges included: climate change - prolonged droughts and floods; the emergence of the COVID-19 pandemic; global supply chain disruptions; exchange rate volatility; and rising interest rates in the leading economies.

The internal challenges included: inadequate road maintenance equipment; pavement overloading by heavy goods vehicles; huge maintenance backlog of the road network; low contracting and supervision capacity particularly in the Counties; poor quality control and assurance of works; congestion in urban areas; encroachment on road reserves; high cost and delays in payments of land acquisition; lack of harmonisation of cross-border transport regulation and operational procedures; rapid urbanisation; increased traffic volume with the exponential growth of motorcycle traffic; high cost/delays in relocation of utilities and services along and across road reserves; inadequate funding of projects and programs; and, delay or default in payments for goods, services and works.

The inability to address some of the above challenges is largely due to intrinsic systemic challenges which include: inadequate funding of research on roads and road construction materials; poor planning; lack of internalisation of policies and processes; lack of respect for professionals and standard practice; ineffective coordination in the implementation of programs and projects; lack of inclusivity in engagement of manpower and procurement of services and works; and, lack of unity of purpose and synergy in development and delivery of projects.

The infrastructure expansion from 2008 – 2022 did not build the local contracting capacity (Micro, Small and Medium Enterprises) rather it destroyed them due to delays or defaults in payments of invoices at both national and county levels.

The implementation of MTP III came to an end on 30th June 2023, ushering in the implementation of the Fourth Medium Term Plan (MTP IV), which has been aligned with the aspirations of the Kenya Vision 2030 and the Bottom-Up Economic Transformation Agenda (BETA) planning approach and its key priorities.

BETA is the Government's transformation agenda geared towards economic turnaround through a value chain approach. BETA has targeted sectors with the highest impact to drive economic recovery and growth. This will be achieved by bringing down the cost of living; eradicating hunger; creating jobs; expanding the tax base; improving foreign exchange balances; and inclusive growth. BETA ensures rational resource allocation by eliminating wastage of resources occasioned by duplication, overlaps, fragmentation and ineffective coordination in the implementation of programmes and projects.

The Fourth Medium Term Plan key priorities are clustered under five key sectors, namely: Finance and Production; Infrastructure; Social; Environment and Natural Resources; and Governance and Public Administration. The infrastructure sector seeks to: enhance transport connectivity by constructing 6,000km of new roads, maintaining rural and urban roads, rail, air and seaport facilities and services; expanding communication and broadcasting systems; and promoting the development of energy generation and distribution by increasing investments in green energy (geothermal, wind, solar and hydro). The infrastructure gap is expected to be bridged by promoting economic participation of the private sector through public-private partnerships in the financing, construction, development, operation and maintenance of infrastructure.

BETA entails a shift of focus to fundamentals in project planning and implementation which include: respect for technical input, regulations and standard practices; adherence to project life cycle i.e., planning, feasibility studies and design before procurement of works; public and stakeholder consultation; procurement within budgetary ceilings; shifting focus during project implementation from the finished product 'black top' to the construction of the foundation; building local capacity particularly MSMEs by ensuring prompt payments; and capacity building at all levels to enable internalisation of policies and processes.

The first generation of the road manuals were used for 35 to 45 years. It is my sincere hope that the second generation of the road standards which have been developed in alignment to the BETA approach will guide in solving most of the above challenges and those expected to emerge in the next 50 years. Implementation of the manuals will enable achievement of the BETA aspirations which include inclusive growth; creation of sustainable employment; building of MSMEs; climate change adaptation and realisation of the UN SDGs; enhanced efficiency in management of infrastructure and transport system; and, laying the foundation for the next national long-term plan at the end of the Vision 2030.

The second generation of the road manuals and specifications was prepared through an extensive consultative process involving review of existing standards and consultation with stakeholders, Ministerial Departments and Agencies, the Technical Task Force, public consultation and stakeholders' workshops at review and drafting phases, and the National Steering Committee.

On behalf of the Government of Kenya, I would like to thank the African Development Bank for its support in the process of preparing this Manual. I would also like to thank the National Steering Committee, the Technical Task Force, the Technical Administrators, and the KeNHA Project Coordination Team for the sterling work done. I also thank the Consultant, TRL Limited for their role in providing technical expertise that was essential for the success of the Road manuals updating exercise.

Hon. Davis K. Chirchir, E.G.H

Cabinet Secretary, Ministry of Roads and Transport

Preface

Designing a new road or upgrading an existing road requires many skills and effective documents to provide advice, instructions, and guidance, not only at the design stage but from conception, planning, through to maintenance, and eventual rehabilitation or upgrading.

A road is designed to provide good service for many years and therefore good planning and good-long term management are required. These activities rely on data and information.

The procedures for the geometric design of roads presented in this manual will assist in achieving the above and are applicable to rural, inter-urban and urban roads.

The manual adopts and encourages context sensitive design, a concept that seeks to produce a design that combines good engineering practice in harmony with the natural and built environment whilst meeting the required constraints and parameters surrounding each and every project.

It further addresses the needs of pedestrians, bicyclists, motor cyclists and non-motorised traffic.

Users of the manual are expected to follow the standards set there-in and seek approval of the Ministry should any departures be warranted.

Eng. Joseph M. Mbugua, CBS

Principal Secretary, State Department for Roads

Document Management

Document Status

This document has the status of a Manual. Users shall apply the contents there-in to fully satisfy the requirements set out. The content of the manual is based on current practice in Kenya and latest practices in the road sector, both regionally and internationally.

Sources of the Document

Copies of the document can be obtained from:

The Principal Secretary, State Department for Roads, Ministry of Roads and Transport, Works Building, Ngong Road, P.O. Box 30260 - 00100, NAIROBI Email: ps@road.go.ke

A secured PDF copy maybe downloaded from: www.roads.go.ke/downloads

Notification of Errors and Requests for Amendments

While all care and consideration has been applied in the compilation of this document, the Ministry accepts no responsibility for failure in any way related to the application of this manual or any reference documents cited in it.

Requests for edits and corrections can be freely sent to the following address:

The Principal Secretary, State Department for Roads, Ministry of Roads and Transport, Works Building, Ngong Road, P.O. Box 30260 - 00100, NAIROBI Email: ps@road.go.ke

Amendments Request Form:

Request No.	Name	Organisation	Chapter	Page	SECTION/ CLAUSE	Ref. to: Figure/ Table/	Type of Request	Request

Type of request: General – G; Editorial – E; Technical - T

Amendments to Date:

Amendment No.	Description	Amendment Effective Date	Amendment Approved by:

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A National Steering Committee was set up and chaired by the Permanent Secretary, Ministry of Roads and Transport, with the following membership: Principal Secretary for Devolution, Office of the Deputy President; Chief Executive Officer, Inter-Governmental Relations Technical Committee; Chief Executive Officer, Council of Governors; Managing Director and Council Secretary, Kenya Bureau of Standards; Director, National Transport and Safety Authority; Director General, Kenya Roads Board; Director General, Kenya Wildlife Services; Chief Executive Officer, Engineers Board of Kenya; Director General, Kenya Rural Roads Authority; Director General, Kenya Urban Roads Authority; President, Institution of Engineers Kenya; Director Policy, Strategy and Compliance; Kenya National Highways Authority; Chief Engineer, Roads Division, State Department for Roads; Chief Engineer, Materials Testing and Research Division, State Department for Roads.

The technical work was undertaken under the guidance of a Technical Task Force, chaired by Eng. David Maganda, with the following gazetted members: Francis Gichaga (Prof.) (Eng.), Andrew Gitonga (Eng.), Timothy Nyomboi (Dr.) (Eng.), Rosemary Kungu (Eng.), Charles Obuon (Eng.), Sylvester Abuodha (Prof.) (Eng.), Samuel Kathindai (Eng.), Nicholas Musuni (Eng.), Charles Muriuki (Eng.), Tom Opiyo (Eng.), John Maina (Eng.), Fidelis Sakwa (Eng.), Daniel Cherono (Eng.), Maurice Ndeda (Eng.), Theo Uwamba (Eng.).

The Consultant for the review and updating of the manuals and specification for road and Bridge Construction was TRL Limited (UK), in partnership with Consulting Engineers Group Ltd, India and Norken International Limited, Kenya. The Consultant's team composed of the Team Leader and Author, Charles T. Bopoto (Eng.), and Project Manager, Warsame Mohamed.

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1101 Kenya Road Manual System

This specification was prepared by the Ministry of Roads and Transport as part of a series of manuals that incorporate best practices, climate change considerations, and recent technologies thereby enabling the provision of road infrastructure that is safe, secure and efficient.

The road manual series is as follows:

Project Cycle Stage	Manual: Volume or Part/Chapter	Code
A. General	Procedures and Standards Manual	PSM
	1. General	
	2. Policies	
	3. Procedures Guidance	
	4. Codes of Practice	
	5. Guidelines	
B. Planning	Network and Project Planning Manual	NPM
	1. Road Classification	
	2. Route/Corridor Planning	
	3. Route/Corridor Planning	
	4. Highway Capacity	
	5. Project Planning	
C. Appraisal	Project Appraisal Manual	PAM
	1. Environmental Impact Assessment & Audit	
	2. Social Impact Assessment	
	3. Traffic Impact Assessment	
	4. Road Safety Audits	
	5. Project Appraisal	
	6. Feasibility Studies	

This table continues onto the next page...

Project Cycle Stage	Manual: Volume or Part/Chapter	Code
D. Design	Road Design Manual	RDM
	1. Geometric Design	
	2. Hydrology & Drainage Design	
	3. Materials & Pavement Design for New Roads	
	4. Bridges and Retaining Structures Design	
	5. Pavement Maintenance, Rehabilitation & Overlay Design	
	6. Traffic Control Facilities & Communication Systems Design	
	7. Road Lighting Design	
E. Contracts	Works and Services Contracts Manual	WSCM
	1. Forms of contracts	
	2. Standard Specification for Road & Bridge Construction	
	3. Bills of Quantities	
	4. Standard/Typical Drawings	
F. Construction	Road Construction Manual	RCM
	1. Construction Management	
	2. Project Management	
	3. Site Supervision	
	4. Quality Assurance	
	5. Quality Control	
G. Maintenance	Road Asset Management Manual	RAAM
	1. Maintenance Management	
	2. General Maintenance	
	3. Pavement Maintenance	
	4. Bridges & Structures Maintenance	
H. Operations	Road Operation Manual	ROM
	1. Traffic Management	
	2. Vehicle Load Control	
	3. Emergency Services	
	4. Tolling	
I. Monitoring & Evaluation	Road Design Manual	MEM
	1. Performance Monitoring Manual	
	2. Technical Audits	
	3. Poverty, Gender Equality & Social Inclusion Monitoring	

1102 Structure Of Standard Specification

This Standard Specification is divided into nine SERIES as follows:

SERIES 1000 General

SERIES 2000 Drainage

SERIES 3000 Earthworks

SERIES 4000 Natural, Crushed Stone and Stabilised Pavement Layers

SERIES 5000 Bituminous Surface Treatments, Seals and Pavement Layers

SERIES 6000 Concrete Pavements and Modular Paving

SERIES 7000 Structures

SERIES 8000 Ancillary Roadworks

SERIES 9000 Environmental, Health, Safety and Social Aspects

Appendices

Each of the nine series is divided into sections comprising a number of clauses, designated by a four digit number, where the first digit is the series number; the second digit is the section number and the last two digits are a sequential number followed by the clause title.

Each clause may have been divided into subclauses designated (a), (b), (c), etc.

These Standard Specifications may contain cross references to other sections and clauses in these Standard Specifications or to the Drawings and other parts of the Contract Documents which shall likewise be construed as Specifications for the Item of Work involved.

In the Bills of Quantity, reference may have been made to certain section(s) or clause(s) in these Standard Specifications corresponding to the main type of Works involved, but this shall not be construed as limiting the specifications for such Item of work only to the section(s) or clause(s) referred to.

All relevant requirements of these Standard Specifications for the particular Item of Work shall be complied with.

The apparent silence of these Standard Specifications, the Drawings or other Contract Documents as to any detail or the apparent omission from them of a detailed description concerning any Works or requirements, shall be regarded as meaning that good engineering practice shall apply and shall be to the approval of the Engineer.

All corporate bodies and third parties are referred to in the male gender throughout this document. In practice the personal pronoun shall apply to both genders.

1103 Scope

This Specification mainly covers matters which relate to the technical aspects of the Contract. Matters covered by the Conditions of Contract are not repeated in this specification, except where necessary for providing more detailed information and/or clarity.

1104 Coverage

The General Specifications are to be read together with modifications, additions or amendments which are written in the Special Specifications which shall take precedence.

Certain information contained in these contract documents or provided separately is being offered as guidance, and in good faith, but, in the circumstances pertaining to the type of information furnished, no guarantee can be given that all the information is necessarily correct or representative of the in-situ condition.

This applies more specifically to materials surveys and soils reports and all soil tests, soil mapping, drilling results, geophysical surveys, geological reports, borrow-pit and similar information, the accuracy of which is necessarily subject to the limitations of testing, sampling, the natural variation of material or formations being investigated and the measure of certainty with which conclusions can be drawn from any investigations made. It also applies to any materials utilisation plan provided, as the diagram may be subject to major alterations during the progress of the work, depending on site conditions.

The Employer will not accept any liability for the correctness or otherwise of the information furnished or for any resulting damage, whether direct or consequential, should it appear, during the course of the Contract, that the information supplied is either incorrect or not representative.

1105 National Specifications

Certain specifications issued by national or other widely recognised bodies are referred to in this Specification and in the Special Specification. Such specifications shall be defined and referred to as National Specifications as hereunder and shall be the latest editions of such National Specifications available twenty eight days prior to the date set for the submission of Tenders.

The Contractor may propose that the materials and workmanship be defined in accordance with the requirements of other equivalent National Specifications and the Contractor may execute the Works

in accordance with such other National Specifications as may be approved by the Engineer. A copy of the National Specification, together with its translation into the English language if the National Specification is in another language, shall be submitted to the Engineer with any request that it be adopted.

In referring to National Specifications the following abbreviations are used:-

KS	Kenya Bureau of Standards
Materials Division of MORT	Materials Division of the Kenya Ministry of Roads and Transport
BS	British Standard
BSCP or CP	British Standard Code of Practice
EN	Eurocode Norm
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society of Testing and Materials

This set shall be made available for use by the Engineer.

The Contractor shall supply and maintain in their office on the Site at least one complete set of all National Specifications referred to in this Specification and all other approved Specifications.

1106 Legal Provisions

In addition to the requirements of the General Conditions of Contract, the Contractor shall be responsible for acquainting themselves with and observing all current Statute Ordinances, By-laws or Regulations including those relating to training levies and similar taxes.

All buildings erected by the Contractor upon the site and camp sites, and the layout of the buildings and the sites, shall comply with laws of Kenya and all local by-laws in so far as they are applicable.

The Contractor shall stay fully conversant with the latest enactment, provisions and regulations of all legislative and statutory bodies and in all respects and at all times shall comply with such enactment, provisions and regulations in regard to executing the Contract.

1107 Units Of Measurement

cm³	Cubic centimetres	mm²	Millimetre squared
g	Gram – kg x 10 ⁻³	MN	Mega newtons
h	Hour	MPa	Mega pascals
ha	Hectare	N	Newton
kg	Kilogram	N/m²	Newton per metre squared
km	Kilometre	no.	Number (units) as in 6 no.
km²	Square kilometre	No.	Number (order) as in no. 6
kN	Kilo newton	°C	Degree Celsius
kPa	Kilo pascals	%	Percent
l	Litre	n mile	Nautical mile
m	Metres	Pen	Penetration
mg	Milligram = kg x 10 ⁻⁶	rad	Radian
m²	Square metre squared	t	Tonne = kg x 10 ³
m³	Cubic metre cubed	µm	Micrometre
mm	Millimetres	w/c	Water cement ratio

1108 Abbreviations

AADT	Annual Average Daily Traffic
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
AC	Asphaltic Concrete
ACV	Aggregate Crushing Value
ADT	Average Daily Traffic
ALD	Average Least Dimension
AmSL	Above mean sea level
BA	Bitumen Affinity
BSM	Bitumen Stabilised Materials
BISAR	Bitumen Stress Analysis in Roads
BS	British Standards
BSI	British Standards Institution
BoQ	Bill of Quantities
CBR	California Bearing Ratio
CESA	Cumulative Equivalent Standard Axles
CIM	Cement/lime Improved Material
CP	Concrete Pavement
CPB	Concrete Paving Block
CR	Crushing Ratio
CSIR	Council for Scientific and Industrial Research
CUSUM	Cumulatively Summed
DCP	Dynamic Cone Penetrometer
DESA	Daily Equivalent Standard Axles
DR	Dump Rock
DSD	Double Surface Dressing
EME-2	Enrobé à Module Élevé (EME2 - High modulus asphalt)
EML	Equilibrium Moisture Levels
EN	Eurocode Norm
ESA	Equivalent Standard Axles
ESM	Emulsion Stabilised Materials
ESP	Exchangeable Sodium Percentage
ETB	Emulsion Treated Base
FACT	Fines Aggregate Crushing Test
FI	Flakiness Index
GCS	Graded Crushed Stone
GDP	Gross Domestic Product
GM	Grading Modulus
GPS	Global Positioning System
H	Heavy Duty
HBM	Hydraulically Bound Material
HBS	Hydraulically Bound Stone

HFS	Hubbard Field Stabilometer
HIG	Hydraulically Improved Granular Material
HMS	Hydraulically Modified Stone
HPS	Hand Packed Stone
HRB	Hydraulic Road Binders
ICL	Initial Consumption of Lime
ICS	Interlocking Cobble Stone
ISO	International Standards Organisation
ITS	Indirect Tensile Strength
ITS_{dry}	Indirect Tensile Strength conducted on a dry sample
ITS_{wet}	Indirect Tensile Strength conducted on a soaked conditioned sample
KS	Kenyan Standard
LAA	Los Angeles Abrasion
LGV	Light Goods Vehicle
LL	Liquid Limit
LV	Low Volume
LVR	Low Volume Roads
LVSR	Low-Volume Sealed Roads
MC	Medium Curing
MDD	Maximum Dry Density
MESA	Million Equivalent Standard Axles
MGV	Medium Goods Vehicle
MLET	Multi-Layer Elastic Theory
MoRT	Ministry of Roads and Transport
MTRD	Materials Testing and Research Division
NMT	Non-Motorised Traffic
NPRA	Norwegian Public Roads Administration
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
PI	Plasticity Index
PL	Plastic Limit
PM	Plasticity Modulus (Product of PI and % passing 0.425 mm sieve).
PP	Plasticity Product
RDM	Road Design Manual
RM	Roads Manual
SE	Sand Equivalent
SI	International Standard Units of Measurements
SF	Seasonal Factors
SG	Specific Gravity
SMA	Stone Mastic Asphalt
SRBC	Specification for Road and Bridge Construction
SSD	Single Surface Dressing
SSS	Sodium Sulphate Soundness
STV	Standard Tar Viscosity

TRL	Transport Research Laboratory
TS	Tensile Strength
UC	Uniformity Coefficient
UCS	Unconfined Compressive Strength
USA	United States of America
VEF	Vehicle Equivalence Factor
VH	Vibrating Hammer
VIN	Voids in Mix
VNA	Voids in Mineral Aggregates
VPD	Vehicles Per Day
WBM	Water Bound Macadam

1109 Definitions And Terms

Accepted	Accepted in writing by the Engineer (or by the Employer where appropriate) as meeting the requirements of the Contract Documents and of any authorised variations thereto. 'Acceptance' means accepted in writing as aforesaid. 'Acceptable' means acceptable to the Engineer as aforesaid.
Aggregate	Natural gravel, sand or crushed stone of specified size and quality to be used in the Works.
Approved	Approved in writing by the Engineer, including subsequent written approval or confirmation of previous verbal approval by the Engineer. 'Approval' means approval in writing as aforesaid.
Asphalt Concrete Surfacing	The layer or layers of a bituminous mix constructed on top of the base course made of a mixture to predetermined proportions of aggregate, filler and bituminous binder material prepared in a mixing plant to meet the requirements for surfacing material and placed by means of a paving machine.
Asphalt Concrete Wearing Course	The uppermost layer of asphalt concrete surfacing.
Asphalt Concrete Binder Course	The lower layer of asphalt concrete surfacing, if more than one layer.
Base Course	A layer or layers of material constructed on top of the sub-base or in the absence thereof, the subgrade.
Bituminous Mix	A mixture of a bituminous binder and aggregate.
Bituminous Seal	A bituminous surfacing made by the application of one or more layers of bituminous binder with layers of aggregate.
Borrow Area	An area within designated boundaries, approved for the purpose of obtaining borrow materials.
Borrow Pit	The excavated pit in a borrow area.
Borrow Material	Any gravel, sand, soil, stones or ash obtained from borrow areas, dumps or sources other than cut within the road prism and which is used in the Works. It shall not include crushed stone, rock or sand obtained from commercial sources or quarries.

Bridge	A structure for carrying motor, railways, pedestrian or other traffic or services over a river, watercourse, or any other gap, with a single span length, or sum of span lengths, of 4.0 metres or more. The length is measured between the abutment faces, or pier head faces respectively, along the centre line of the bridge deck.
Carriageway	The surface normally traversed by vehicles and which consists of one or a number of contiguous traffic lanes, including auxiliary lanes and shoulders.
Catchwater Drain or Bank	A longitudinal drain or bank outside the road prism, for diverting water that would otherwise flow into the road prism.
Certificate Of Guarantee	A signed statement by a person having legal authority to bind a company or supplier to its product, and which confirms that the materials and test results conform to the standards of the Specifications.
Common Excavation	Classification of excavation for payment purposes. Denotes all excavation, except rock excavation, required from the road prism, drains, etc. according to the Drawings and the Specifications.
Conditions of Contract	The appropriate edition of the General Conditions of Contract together with any Conditions of Particular Application forming part of the Contract.
Contract Documentation	To include all the documents which define the content and terms of the Contract entered into by the Employer and the Contractor. The Contract Documentation usually consists of the following documents: <ol style="list-style-type: none"> 1. Contract Agreement 2. Letter or Form of Acceptance 3. The Bid and appendix to Bid 4. Conditions of Contract Special (or Particular) 5. General Conditions of Contract 6. Standard Specification (this document) 7. Drawings 8. Pricing Schedule 9. Bill of Quantities 10. Any other documents forming part of the contract.
Crossfill	Crossfill is earthworks materials taken from cuts in the road reserve and placed in embankments at a distance of 50 m or less from its original position, measured along the centreline of the road.
Culvert	A structure other than a bridge, which provides an opening under the carriageway or median or access road for drainage or other purposes.
Cut	A section of the road where the formation level is below the original ground level requiring excavations for the construction of the pavement layers.
Dayworks	Rates which are used to determine payment for work which cannot be quantified in specific units in the Bill of Quantities, or for additional work ordered by the Engineer during the construction period which was not foreseen at tender stage and for which no applicable rates exist in the Bill of Quantities.
Directed	Instructed in writing by the Engineer including verbal instruction when subsequently confirmed in writing.
Ditch or Drain	Lined or unlined open drain constructed for the collection of surface water from the pavement, shoulders, pedestrian walkways and adjacent land.

Detours, Deviations	Detours or deviations, including barricades and signs, provide for the safe and easy passage of all traffic, including non-motorised vehicles and pedestrians, during the construction and maintenance periods. The usually become redundant after completion of works and require reinstatement.
Drawings	The contractual Drawings of the Works, including any additional and modified drawings issued by (or on behalf of) the Employer in accordance with the Contract.
Earthworks	Activities involving cut or fill material to form the road prism including improved subgrade layers.
Earthworks Materials Classes	Materials used in earthworks, complying with the requirements of the Specifications, are classified:
G14, G8, G3	Natural gravel/soils with nominal CBR values of 14, 8 or 3 respectively.
DR	Dump Rock, un-graded waste rock from quarry or hard material excavations.
Embankment	A section of the road where the vertical alignment requires that formation level is above the original ground level.
Employer	The person, entity or firm named as the Employer in the Contract Documentation for whom the Works are to be carried out and who is responsible for the payment and acceptance of the Works.
Engineer	The person, entity or firm appointed by the Employer, or another person who may be delegated to assist the Engineer in terms of the applicable Conditions of Contract, to manage aspects of the Contract and to supervise the construction of the Works in accordance with the applicable Contract Documentation.
Fill	That portion of the road prism consisting of approved imported material, which lies above the formation level and is bounded by the side slopes, on which improved subgrade layers, pavement and shoulders are to be constructed. Material imported to replace unsuitable material in the formation shall also be classified as fill when placed below the improved subgrade layers.
Fixed Obligations	That part of Contractor's general obligations which is substantially fixed and is not a function of the value of the Works or of the time required for the completion of the Contract.
Footpath	That portion of the road construction works reserved for pedestrians.
Formation Level	The level of the top of the final layer of earthworks upon which the pavement layers are placed.
French Drain	A subsoil drainage system with a graded filter material and/or geotextile surround constructed to intercept and remove subsoil water.
Grade Line	A reference line in the Drawings of the longitudinal sections of the road indicating at regular intervals the elevations according to which the road is to be constructed. The grade line may refer to the level of the completed road, base or any other layer and may indicate the elevations either along the carriageway centre line or along any designated position on the road cross-section.
Grading Coefficient (GC)	$GC = \frac{\% \text{ passing } 28\text{mm} - \% \text{ passing } 0.425\text{mm} - \% \text{ passing } 5\text{mm}}{100}$
Grading Modulus (GM)	$GM = 3 - \frac{\% \text{ passing } 2\text{mm} + \% \text{ passing } 0.425\text{mm} + \% \text{ passing } 0.075\text{mm}}{100}$

Improved Subgrade	The upper layer(s) of the earthworks which are constructed directly beneath the road base or sub-base.
Lane	Part of a roadway intended for a single stream of traffic in one direction, which has normally been demarcated as such by road markings.
Linear Shrinkage	<p>The percentage decrease in length of a soil sample in a mould when dried under standard testing conditions from the liquid limit state.</p> <p>$LS = (L_o - L)100/L_o$. Where LS is the linear shrinkage expressed as a percentage, L_o is the original length of the sample and L is the length of the sample after standard testing.</p>
Lot	A portion of the Works or quantity of material, which is assessed as a unit for the purpose of cost or quality control and selected to represent material or work produced by essentially the same process and materials.
Median	The area within a dual carriageway between lanes of opposing direction, excluding the inner shoulders.
Mitre Bank	A bank placed across a side drain to divert flow into a mitre drain.
Mitre Drain	A drain constructed at an angle to the centreline of the road to divert water from a side drain.
Overburden	Material within or covering a borrow area or quarry, which is not required or is unsuitable for use in construction.
Particle Size Distribution	Particle size distribution is the representation of separation of any soil or aggregate sample into different fractions based on their particles sizes. The separation is based on standardised sieve sizes.
Pavement	The road construction above formation level comprising the sub-base, base, and wearing course, inclusive of shoulders. For rigid pavements the concrete surfacing forms part of the pavement.
Permanent Works	The physical structures within the road reserve resulting from all activities undertaken by the Contractor under the Contract.
Plasticity Index	The numerical difference between the value of the liquid limit and the value of the plastic limit of a soil.
Plasticity Modulus (PM)	$PM = \text{Plasticity Index} \times \text{percentage passing the } 0.425 \text{ mm sieve.}$
Quarry	Area outside the road prism where rock is extracted for production of crushed aggregate and which is used in the construction of the Works.
Road Prism	That portion of the road construction shown in cross-section drawings and included between the original ground level and the outer boundaries of the slopes of cuts, fills and side drains. It shall not include the pavement.
Road Reserve or Right-of-Way	The entire plan area included by the legal boundaries of road area as proclaimed and/or defined on land use maps of the Republic of Kenya.
Rock Excavation	Rock excavation shall be excavation in material which requires drilling and blasting or the use of hydraulic or pneumatic jackhammers to be loosened.
Services	Cables, pipes or other structures, such as conduits for electricity, telephone and telegraph connections, water, sewage, etc.
Shoulder	<p>(a) When referring to this as a surface: The area between the outside edge of the carriageway and the shoulder break point;</p> <p>OR</p> <p>(b) When referring to this as a pavement layer: The pavement layer lying between the outside edge of the pavement base and sub-base courses and the side ditch or embankment toe drain.</p>

Shoulder Breakpoint	The line along which the extended flat plane of the surface of the shoulder terminates as defined by shoulder width.
Shrinkage Product (SP)	The product of Linear Shrinkage (LS) and the percentage passing the 0.425 mm sieve:
Side Drain	An open longitudinal drain situated adjacent to and at the bottom of cut or fill slopes.
Slope	Unless otherwise apparent from the context, slope is the ratio of the vertical difference in elevation and the horizontal distance between two points. This ratio may also be expressed as a percentage.
Spoil (Material)	Material originating from construction operations and which is not utilised for construction purposes.
Stabilisation	The treatment of the materials used in the construction of the earthworks or pavement layers by the addition of a cementitious material such as lime, cement and bituminous products. Asphalt mixes and concrete shall not be considered as materials that have been stabilised.
Structure	Structures shall comprise all objects constructed of materials other than earth, required by the Contract to be built or to be removed, but not including pavement layers.
Sub-base	The layer of material on top of the subgrade layers or fill and below the base course.
Subgrade	Subgrade is all the material below the pavement and may include in-situ material, fill and capping (improved subgrade).
Substructure	All of that part of the structure below the bearings of simple and continuous span bridges, below skewbacks of arches, below deck slab of box and slab culverts, together with return walls and wingwalls.
Subsoil Drainage	Pipes, gravel filters, geotextiles, fin drains and all other materials constructed to intercept and remove subsoil water.
Suitable Material	Materials that comply with the requirements of these Specifications in respect of the relevant layer or position where the material is intended to be used.
Superstructure	All of that part of the structure above and including the bearings of simple and continuous span bridges, skew backs of arches, deck slab of box and slab culverts, including headwalls and parapets but excluding return walls and wingwalls.
Surface Treatment	A bituminous seal made with a bituminous binder and chippings, graded aggregate or sand or a mix of bitumen emulsion and crusher dust.
Temporary Deviation	A temporary deviation can be partial width, single or multi-lane roads that are used to accommodate vehicular and non-motorised traffic while the Works are in progress. They are either a portion (part width) of the road that is under construction or they are newly constructed roads (with a gravel or a bituminous surface) constructed alongside or in close proximity to the Works.
Time-Related Obligations	That part of the Contractor's general obligations which are mainly a function of construction time. Time related costs are paid monthly, or pro rata for parts of a month, from the date of commencement in terms of the Contract until the end of the original Contract Period specified for completion of the Works.
Topsoil	Soils containing organic materials in the upper strata of the natural ground.

Uniformity Coefficient	The ratio of sieve sizes through which 60 % of material passes to that through which 10 % passes. $C_u = (D_{60}/D_{10})$. Where C_u is the coefficient of uniformity, D_{60} is the sieve size through which 60 % by mass of particles pass, and D_{10} is the sieve size through which 10 % by mass of particles pass.
Unsuitable Material	Materials that do not comply with the requirements of these Specifications in respect of the relevant layer or position where the material exists or is intended to be used.
Value-Related Obligations	That part of the Contractor's general obligations which is a function of only the value of the Works, but not of the period of completion of the Works.
Verge	The area between the outer edge of the road prism and the boundary of the road reserve.
Working Drawings	Drawings issued or approved by the Engineer showing enough detail for the Contractor to build the work correctly true to line, level and dimension.
Working Platform	An initial layer constructed over weak ground where selected material is used to provide a stable platform for the construction of the works.
Works	The Permanent Works and the Temporary Works, or either of them as appropriate.

1110 Terminology

The most important terms related to the cross-section and pavement are shown in Figure 1 and Figure 2 for a typical rural setting and Figure 3 and Figure 4 for a typical urban setting.

Figure 1 & 2 A Typical Road Cross-Section in a Rural Setting

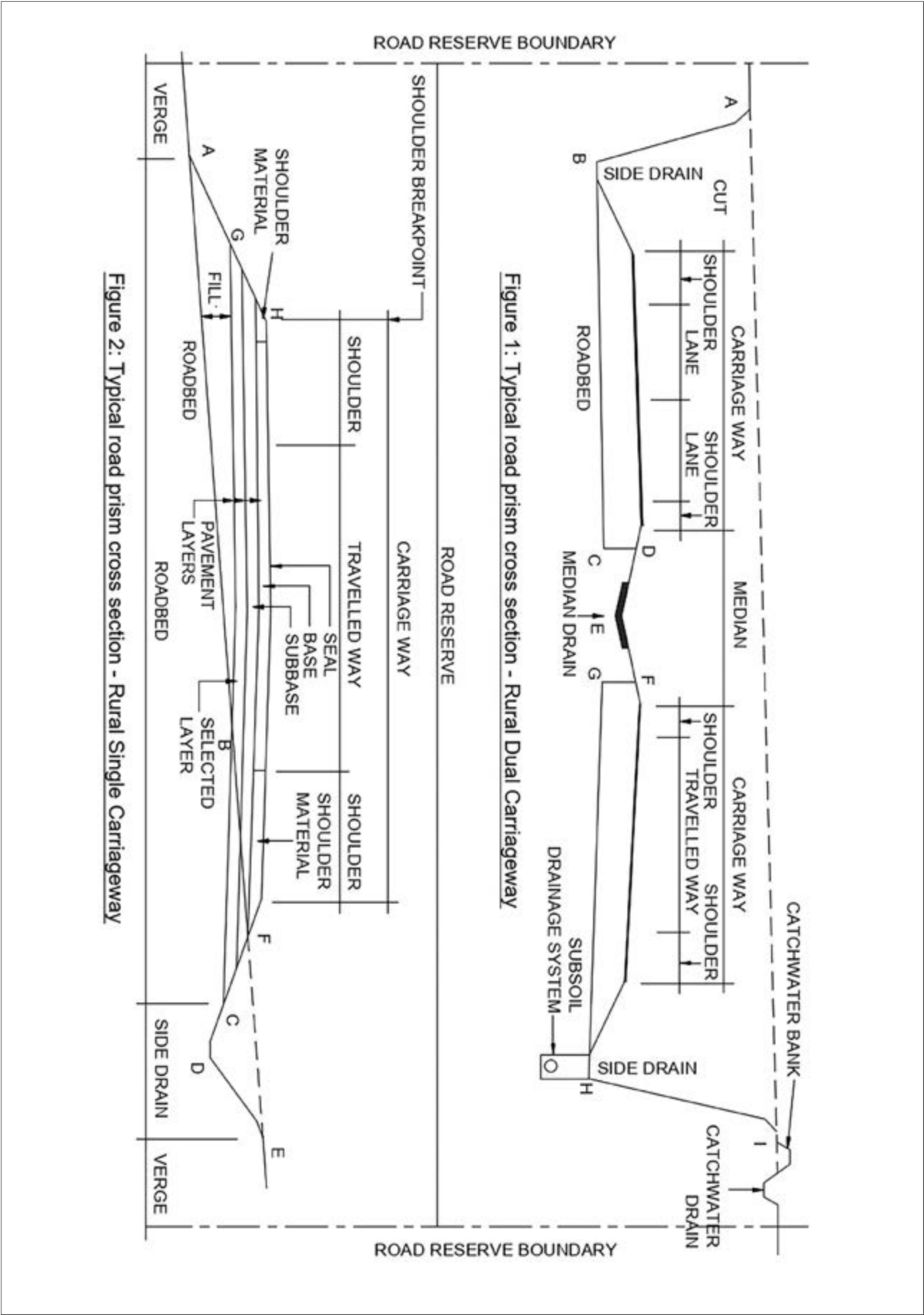
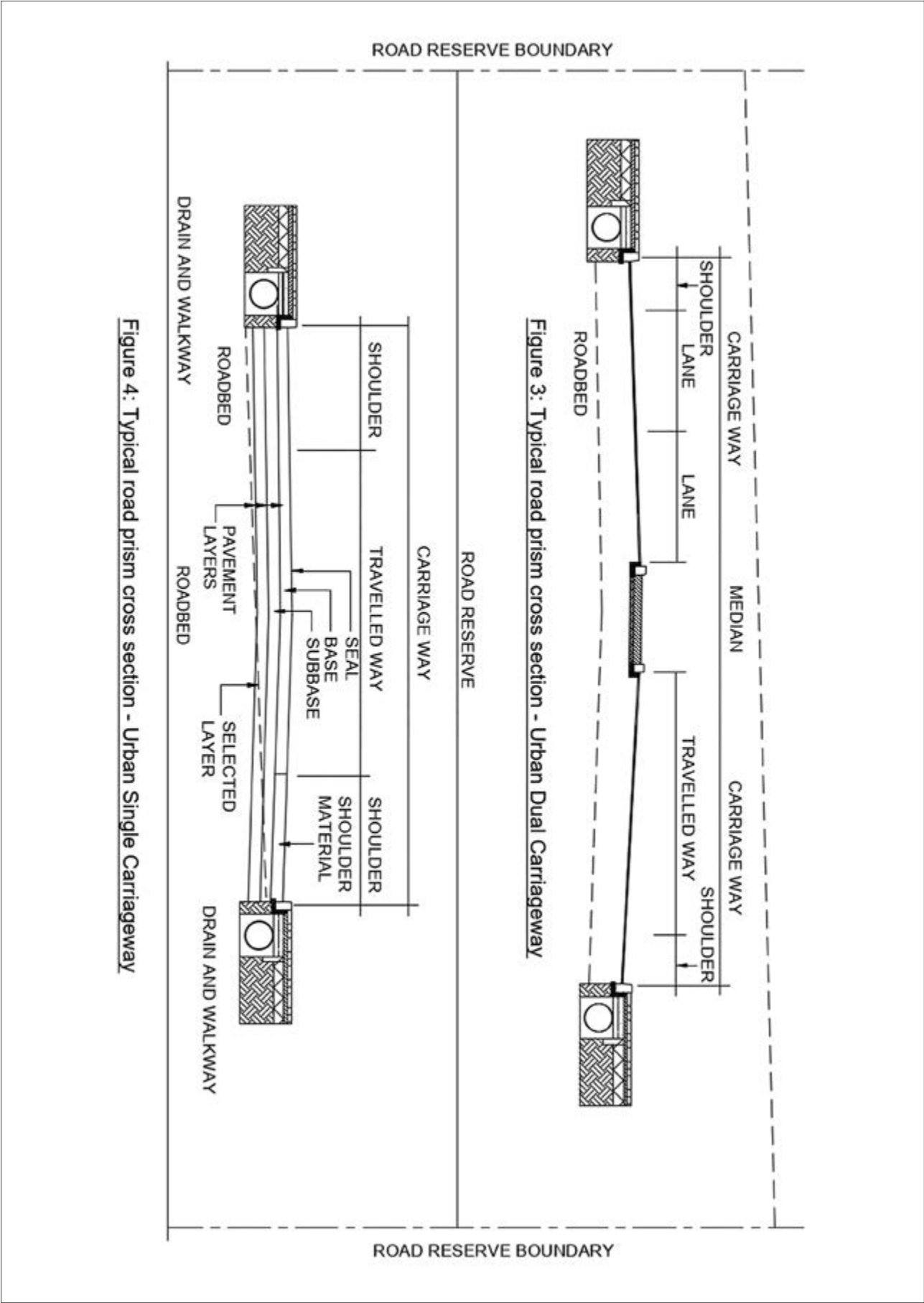


Figure 3 & 4 A Typical Road Cross-Section in a Urban Setting



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1201 Location and Extent of Site

The location of the Site is described in the Special Specification.

The Site of the Works shall be the area within the various road reserves, quarries, borrow pits, spoil areas, access roads and deviations, Contractor's installations, storage areas, camp sites, Engineer's offices, laboratories and accommodation, shown on the Drawings or established specifically for the Contract with the approval of the Engineer.

1202 Extent Of Contract

The extent of the Contract shall be as defined in the Particular Specification.

1203 Drawings

The Drawings referred to in the Conditions of Contract are those listed in the Special Specification and such further drawings as shall be supplied under the Contract.

1204 Possession Of The Site And Access Thereto

The Site will be handed over to the Contractor for construction in accordance with the relevant clause of the Conditions of Contract and subject to such conditions as may be provided in the Special Specifications regarding matters such as the sequence in which the Contractor will be given possession of sections of the site and the time for completion, the maximum total length of bypasses that will be allowed to be in operation at any time and any other matters relating to the Contractor's use and occupation of the Site.

1205 Programme Of Works

In accordance with relevant clauses of the Conditions of Contract, the Contractor shall submit a fully detailed and time related programme, showing the order of procedure and method in which they propose to carry out the Works. The Contractor shall supply, together with a programme, a linked cash flow forecast chart showing their monthly anticipated quantities of work, expenditure and income.

The programme shall be so detailed as to show:

1. Logic links identifying critical activities forming the critical path.
2. The activities in all work packages including those by the Contractor's sub-contractors and suppliers, service owners, any sub-contractors and suppliers directly employed by the Employer and others.
3. The equipment resources required for each activity and which are compatible with the planned rate of production.
4. The labour resources required for each activity and which are compatible with the planned rate of production.
5. The earliest and latest start and finish dates for every activity in each work package. Activities shall include all scope activities and any activities or time durations expected in addition to scope activities.
6. Access dates required or each phase or section of the Works.
7. The earliest and latest start and finish dates for each phase or section of the Works, including dates when the Contractor plans to complete work to allow any other sub-contractors, suppliers or service owners the necessary access to do their work.

8. Programme milestones and other key dates.
9. Allowances for rain delays, holiday periods and the Contractor's pay weekends.
10. Dates by which designs and drawings for the temporary and permanent Works and the mix designs which are to be produced by the Contractor will be submitted to the Engineer for comment and dates by which comments on such design work, drawings and mix designs from the Engineer will be required by the Contractor, allowing time for submittals, re-submittals and reviews.
11. Dates by which samples of manufactured articles or materials to be produced by the Contractor will be submitted for approval by the Engineer and dates by which approval of such samples will be required by the Contractor, allowing time for submittals, re-submittals and reviews.
12. Procurement periods and delivery dates for the major Items of plant and materials to be incorporated into the Works.
13. Occupation dates and re-commissioning dates of utilities and services affected by the Works.
14. Dates by which major work Items will be ready for testing by the Engineer or the Employer.
15. Details and dates of any information required from the Engineer or the Employer.
16. The work contained in all defined provisional sums.
17. Activities representing the likely work content of undefined provisional sums, complete with logic links but with durations set to zero (unless specified otherwise or until the scope of the work is defined).
18. Commissioning periods.
19. Provisions for float, time risk allowances, quality control procedures, health and safety requirements and any other requirements that may be set out in the Contract Documentation.

If at any time it should appear to the Engineer that the actual progress of the Works does not conform to the programme referred to above, the Contractor shall produce, at the request of the Engineer, a revised programme showing the modifications to the approved programme necessary to ensure completion of the Works within the time for completion as defined in the relevant clause of the Conditions of Contract.

The various operations pertaining to the Works shall be carried out in such a progressive sequence as will achieve a continuous and consecutive output of fully completed roadworks inclusive of all bridge works and culverts within the time limits specified in the Contract. Generally, the Contractor shall start at one end of the road and progress continuously towards the other without leaving any isolated section or sections of incomplete road, provided always that the land upon which the Works are to be constructed has been acquired in its entirety and the encumbrances and services thereon removed.

The order of execution of the Works shall be subject to reasonable adjustment as requested by the Engineer.

Failure on the part of Contractor to work according to the programme or revised programmes, shall be sufficient reason for the Employer to take steps as provided for in the Conditions of Contract and shall be construed as not executing the Works in accordance with the Contract.

The approval by the Engineer of any programme shall have no contractual significance other than that the Engineer would be satisfied if the work is carried out in accordance with such programme and that the Contractor undertakes to carry out the work in accordance with the programme.

1206 Extension of Time Arising From Abnormal Rainfall

This clause specifies the conditions under which extensions of time for rainfall delays will be measured.

Any delays caused by rainfall shall be determined in terms of one of the three methods given below. The applicable method for a particular contract shall be specified in the Contract Documentation. The rainfall delay determined by using the specified method shall entitle the Contractor to an equivalent extension of the time for completion without the need for formal claim procedures. (If none of the methods given below are specified in the Contract Documentation then any claims for rainfall related extensions of time will be dealt with according to the applicable Conditions of Contract.)

Any other delays caused by exceptionally adverse weather conditions that have not already been taken into account as specified above shall be dealt with in accordance with the applicable Conditions of Contract.

The Contractor shall take cognisance of all the temperature, wind speed, moisture content and curing related limitations and/or restrictions that are applicable to some Items of the Works as specified in the relevant clauses of this Standard Specification. No extensions of time will be measured or granted for any delays caused by the Contractor's compliance with these limitations and/or restrictions.

a. Method 1 (Rainfall Formula)

If specified in the Contract Documentation the formula below shall be used to calculate separately the delay for each calendar month or part thereof due to rainfall. It shall be calculated each month during the period referred to in the Conditions of Contract as the time for completion of the Works (including any extension thereof that may have been granted), or until the issue date of the Taking-over Certificate, whichever is the shorter period. The delay calculated for a given month shall be used to determine the interim extension of time granted for that month. At the end of the applicable period referred to above, the aggregate of the monthly delays will be taken into account for the final determination of the total extension of time for the Contract. Such determination will not be subject to normal claim procedures.

$$V = (N_w - N_n) + [(R_w - R_n) + X]$$

If V is negative and its absolute value exceeds N_n the V shall be taken as equal to minus N_n .

The symbols shall have the following meanings:

- V = Extension of time in calendar days in respect of the calendar month under consideration.
- N_w = Actual number of days during the calendar month which a rainfall of Y mm or above has been recorded.
- R_w = Actual rainfall in mm for the calendar month under consideration obtained from the Meteorological Department of the Ministry of Water, Lands and Environment, or from a source agreed to in writing by the Engineer.
- N_n = Average number of days, as derived from the existing rainfall records of the Department of Meteorology provided in the Special Specifications, or as agreed to, in writing by the Engineer, on which a rainfall of Y mm or more has been recorded for the calendar month.
- R_n = Average rainfall in mm for the calendar month, as derived from the rainfall records of the Department of Meteorology provided in the Special Specifications, or as agreed to, in writing, by the Engineer.
- X = 20 unless otherwise provided in the Special Specifications.
- Y = 10 unless otherwise provided in the Special Specifications.

The total extension of time shall be the algebraic sum of the monthly totals for the period under consideration. Extensions of time for part of a month shall be calculated using pro rata values of N_n and R_n .

The factor $(N_w - N_n)$ shall be considered to represent a fair allowance for variations from the average number of days during which rainfall exceeds Y mm.

The factor $(R_w - R_n)/X$ shall be considered to represent a fair allowance for variations from the average in the number of days during which rainfall does not exceed Y mm but wet conditions prevented or disrupted work.

This formula does not take into account any flood damage, which could cause further or concurrent delays and which should be treated separately in so far as extension of time is concerned. It also does not deal with other types of weather which may cause delays, for instance snowfalls, abnormally strong wind and extreme temperatures. All such delays shall be dealt with separately in accordance with the terms of the Conditions of Contract.

Rainfall records may be available from Meteorological Department or other recording stations which, if approved as being representative of site conditions by the Engineer, may be used for calculating base case rainfall. Otherwise or additionally rain gauges shall be installed by the Contractor at locations approved by the Engineer. These shall include all sections where the Contractor is working including Borrow Pits where these are outside the road reserve and deemed to have varying climatic conditions. All readings shall be taken by the Contractor and agreed jointly with the Engineer on a daily basis.

As soon as is practicable after the end of each month, the Contractor shall collect daily records for that month and shall calculate V for that month, as specified. The records and calculations shall be submitted to the Engineer without undue delay.

If no suitable rainfall records are available, Method 1 will not apply.

No separate payment shall be made to the Contractor in respect of the requirements of this clause, and the Contractor shall allow for any related costs elsewhere in their rates.

b. Method 2 (Critical Path Method With Consequential Delays)

Where the critical path method with consequential delays is specified in the Contract Documentation for determining the extension of time resulting from rainfall, it shall be applied as follows:

A delay caused by rainfall conditions will be regarded as a delay only if all progress on an Item or Items of work on the critical path of the Contractor's programme has been brought to a halt for part of a day or a full day. Delays on programmed and actually planned working days only will be taken into account for the extension of time. Each day, or portion of a day so agreed will accrue as ' n ' days of delay over the duration of the contract. The summary of accrued agreed ' n ' delays shall be recorded at each site meeting.

The Contractor shall make provision in the programme of work for an expected delay of ' N ' working days caused by predictable normal rainy weather, for which the Contractor will not receive any extension of time. The value of ' N ' shall be given in the Contract Documentation.

Extension of time for rainfall delays which occurred during working days will be granted to the degree to which the agreed cumulative actual delays, in full or part of working days as defined above, exceed the cumulative number of ' N ' working days as mentioned in the Contract Documentation, during the contract period up to the issue of the Taking-over Certificate. Extension of time for rainfall shall apply in addition to any approved contract extension of time due to other causes.

This method does not take into account any flood damage, which could cause further or concurrent delays and which should be treated separately in so far as extension of time is concerned. It also does not deal with other types of weather which may cause delays, for instance snowfalls, abnormally strong wind and extreme temperatures. All such delays shall be dealt with separately in accordance with the terms of the Conditions of Contract.

If a delay due to wet conditions is caused by, or exacerbated by, the lack of adequate temporary drainage measures, such a delay shall not be taken into account in the calculation of any extension of time.

Any delay due to rainfall will only be recognised and granted to the extent that the delay could not be mitigated by changing work sequences. The delay shall be applied to the contract duration after any other caused and approved contract extensions of time have been applied. The total delay caused by rainfall shall not exceed the duration past the issue of the Taking-over Certificate.

c. Method 3 (Critical Path Method Without Consequential Delays)

Where the critical path method without consequential delays is specified in the Contract Documentation for determining the extension of time resulting from rainfall, it shall be applied as follows:

Delays caused by rainfall may be considered as extension to the time for completion only if the Engineer agrees that the event (and not the consequence of the event) occurred during the working day within the contract period and caused all progress on an Item or Items of work on the critical path of the Contractor's programme brought to a halt. Each day, or portion of a day so agreed will accrue as 'n' days of delay over the duration of the contract. The summary of accrued agreed 'n' delays, which exclude any consequential delays as stated below, shall be recorded at each site meeting.

No limitation is placed on the quantity, severity or duration of the rainfall event as being the cause of delay. Expressly excluded from the measurement of 'n' days are consequential delays, which are taken to mean delays to critical path activities attributable to the rainfall event but occurring after (i.e. outside of and distinctly separate from) the duration of the rainfall event itself.

The Contractor shall make provision in the Contractor's programme of work for expected 'N' working days caused by rainfall. This provision shall be shown as a terminal float on the Contractor's programme. The value of 'N' shall be given in the Contract Documentation.

Any extension to the time for completion caused by rainfall delays will only be considered once the agreed cumulative 'n' delays during the contract period up to the issue of the Taking-over Certificate exceed 'N' working days. Extension of time for rainfall shall apply in addition to any approved contract extension of time due to other causes.

This method does not take into account any flood damage, which could cause further or concurrent delays and which should be treated separately in so far as extension of time is concerned. It also does not deal with other types of weather which may cause delays, for instance snowfalls, abnormally strong wind and extreme temperatures. All such delays shall be dealt with separately in accordance with the terms of the Conditions of Contract.

The delay shall be applied to the contract duration after any other approved contract extensions of time have been applied. The total delay caused by rainfall shall not exceed the duration past the issue of the Taking-over Certificate.

1207 Submissions To The Engineer

Wherever the Contractor is required to submit to the Engineer proposals, details, drawings, calculations, information, literature, materials, test reports and certificates, the Engineer will consider each submission and, if appropriate, will reply to the Contractor in accordance with the relevant provisions of the Conditions of Contract. Unless a defined period of time is stated in this Specification or the Special Specification, each submission shall be made by dates to be agreed with the Engineer having regard to the approved programme and the need to give the Engineer adequate time to consider each submission.

Documents submitted, other than drawings and manufacturers' literature, shall be A4 in size. All documents shall be in English and any abbreviations shall be explained. All calculations and technical information shall be in units conforming to the Systems International Unites (SI).

All drawings shall be A1 in size to the ink border. Notes shall be in English. All dimensions shall be in metres or millimetres and all weights in metric units.

All drawings shall include the title of the Contract at the bottom of the drawing followed by the title of the drawing concerned. All drawings shall have the appropriate scales drawn on them and be dated. All amendments to drawings shall be noted and dated.

The approval of the Engineer of any submission shall not relieve the Contractor from their responsibilities under the Contract.

1208 Access To Contractor's Records, Monthly Site Meetings & Progress Photographs

The Engineer shall at all times have full access to all files, drawings, documents, records and whatsoever other information they may require in connection with the execution of the Works.

The Contractor or their authorised representative shall attend monthly meetings on the site with representatives of the Employer and Engineer, at dates and times to be determined by the Employer. Such meetings will be held primarily for evaluating the progress of the Contract and also to discuss any other relevant contractual or technical matter which any of the parties represented may wish to raise.

The Contractor shall arrange with a photographer approved by the Engineer for the taking of progress photographs during the construction of the Works. The Contractor shall submit each month good quality photographs of at least 5 different subjects as agreed with the Engineer. For each subject, the Contractor shall supply at least three colour photographs plus the .jpeg versions as detailed in the Special Specifications or as required by the Engineer. The photographs shall be arranged in plastic photo-pockets with 3 photographs on each side and with a label next to the photograph giving appropriate title and a number with reference to a suitable key plan.

The progress photographs shall be taken by digital camera (min. 4.0 million pixels). In addition to the production of hard copy prints detailed above soft data on a portable storage device and shall be submitted in three (3 no.) copies.

No separate payment will be made for attending site meetings or furnishing progress photographs, the relevant cost being included by the Contractor in their rates in the Bill of Quantities. However, should there be any additional requirement for progress photographs then the Engineer shall instruct the Contractor and agree an appropriate variation and price.

1209 Design By The Contractor

a. Designs and Drawings for the Permanent Works Provided by the Contractor

Where the Contractor is required to prepare any designs and/or drawings for the permanent Works they shall be prepared as specified below and in accordance with any further requirements that may be specified by the Engineer. The drawings shall comply in all respects with the requirements of the Employer. If provided by the Employer, the Contractor shall use the master standard drawing sheets and schedules as masters for all drawings prepared and submitted to the Engineer for consideration.

The Contractor shall submit to the Engineer for comment two A1 paper copies of each drawing and all relevant design calculations prepared by, or on behalf of, the Contractor and signed by a registered competent person. Electronic versions of the drawings and all relevant design calculations should also be provided in the specified format. The standard of detailing and quality of print shall be the same as those of the drawings supplied to the Contractor under the Contract Documentation.

Accepted designs and/or drawings shall form an integral part of the Contract Documentation. Any designs and/or drawings not accepted by the Engineer will not be permitted on the site of the Works for construction purposes and/or used for the manufacture of any Item. Notwithstanding the acceptance and/or signing of the designs and/or drawings by the Engineer or the Employer,

the Contractor shall take full responsibility for all details, discrepancies, omissions, errors, etc. in respect of the said designs and/or drawings as well as for all consequences arising therefrom.

The Contractor shall submit only fully completed and checked designs and/or drawings in accordance with this Standard Specification and shall not be entitled to claim for any delays resulting from the submission of incomplete or incorrect drawings. Unless already specified elsewhere in the Contract Documentation, the Contractor shall agree with the Engineer the amount of time required by the Engineer to consider and comment on the designs and/or drawings. The same time frame requirements will apply to any resubmissions of the designs and/or drawings that may be required. Where the Contractor is required to prepare any drawings for the purpose of this Contract, they shall be prepared as specified below and in accordance with any further requirements.

b. Designs and Drawings for Temporary Works Provided by the Contractor

The Contractor shall be responsible for the design and execution of all temporary work and structures that are required for the construction and completion of the Works. This includes all deviations, temporary drainage and flood diversion or control measures, drilling and blasting, excavations, scaffolding, shuttering, shoring, support structures and all other work that is necessary for the construction of the permanent Works.

The design of all such temporary work must be carried out by experienced persons who are suitably and, where required by legislation, professionally qualified to carry out such designs. The Contractor shall ensure that the design of all temporary works has been carried out in accordance with all relevant legislation and that the construction / erection of the temporary works is carried out by and supervised by competent, experienced persons.

All design calculations and drawings required for the temporary works shall be submitted to the Engineer for comment when the Contractor is requested to do so. Unless already specified elsewhere in the Contract Documentation, the Contractor shall agree with the Engineer the amount of time required by the Engineer to consider and comment on the designs and/or drawings. The same time frame requirements will apply to any resubmissions of the designs and/or drawings that may be required.

1210 Drawings Provided By The Contractor

Where the Contractor is required to prepare any drawings for the purpose of this Contract, they shall be prepared as specified below and in accordance with any further requirements specified by the Engineer.

The Contractor shall submit to the Engineer for their adjudication an electronic 'soft' copy in CAD format on a portable storage device or otherwise transmitted as detailed in the Special Specifications or as required by the Engineer. The standard of detailing and quality of electronic copy or print if required shall be the same as those of the Drawings supplied to the Contractor under the Contract.

The Drawings shall be compiled in the English language and shall comply in all respects with the requirements of the Employer.

Accepted Drawings shall form an integral part of the Contract documents, and any drawing not accepted and signed will not be permitted on the site of the Works for construction purposes and/or used for the manufacture of any Item. Notwithstanding the approval and/or acceptance and signing of the Drawings, the Contractor shall take full responsibility for all details, discrepancies, omissions, errors, etc. in respect of the said Drawings as well as for the consequences thereof.

The Contractor shall submit only fully complete Drawings in accordance with this specification and shall not be entitled to claim for delays resulting from the submission of incomplete drawings. The Engineer will require a period of 28 days for reviewing the complete drawings.

No direct payment for design or preparation and submission of Drawings will be made and all costs shall be included in the rates bid for the relevant pay Items as provided in the Bills of Quantity. The time for review by the Engineer shall be included in the Contractor's programme and no additional compensation for this time period shall be considered.

1211 Access To Site

The Contractor shall make their own arrangements for access to the various parts of the Site where works are to be constructed but all such access-routes shall be subject to the approval of the Engineer.

Where the access route proposed by the Contractor crosses the land of any third party the written consent of the owner and the occupier of the land over which the access lies must be obtained before making use of such access. The written consent shall be submitted to the Engineer.

The Contractor shall also make a record, to be agreed by the Engineer, of the conditions of the surfaces of any land (and of any crops on such land) over which access lies before putting it into use. All surfaces shall be kept in a reasonable state of repair during the execution of the Works. On the termination of the Contractor's use of such access the lands shall be restored to a condition at least equal to that previously existing.

1212 Method Of Working

The Contractor shall submit to the Engineer not later than 28 days from the date of award of the Contract a general description of their proposed arrangements and methods for the execution of the Works, including inter alia temporary offices, buildings, access roads, deviations, Constructional Plant and its intended production output, working shift arrangements, labour strength, skilled and unskilled and supervision arrangements, power arrangements, supply of materials, stone crushing, aggregate production and storage, cement handling, concrete mixing and handling, methods of excavation, dealing with water, testing methods and facilities.

During the execution of the Works, the Contractor shall also submit to the Engineer full and detailed particulars of any proposed amendments to the arrangements and methods submitted in accordance with the foregoing.

The Engineer's normal working hours shall be defined as 8.00 a.m to 5.00 p.m on weekdays with Saturdays and Sundays to be treated as rest days. If the Contractor wishes to execute permanent Works outside these hours, they shall obtain the written permission of the Engineer at least one full working day in advance to enable the Engineer to make provision for supervision of such work, the cost of which shall be borne by the Contractor.

1213 Notice Of Operations

No operation shall be carried out without full and complete notice having been given to the Engineer by the Contractor sufficiently in advance of the time of the operation to enable the Engineer to make such arrangements as they may deem necessary for its inspection and checking.

The Contractor shall give the Engineer not less than ONE full working day's notice in writing of their intention to set out or give levels for any part of the Works in order that arrangements may be made for checking. The Contractor shall also give prompt notice of completion of SECTIONS of work to allow time for the Engineer to undertake all necessary control tests prior to giving the Contractor approval to proceed with subsequent works. Under no circumstances will the execution of such testing be construed as a delay to the Contractor's programme of work.

The method of working to be adopted shall be such as to permit the satisfactory completion of the Works and limit disturbance and damage to a minimum.

The Engineer may at any time withdraw approval and Contractor shall immediately adopt another

method of working. The Contractor shall have no claim against the Employer for costs incurred by changing the method of working or in the provision and use of other equipment.

1214 Land Acquisition

The Government shall make available free of charge to the Contractor land on which the Works are to be executed or carried out, as indicated on the Drawings or as detailed in the Special Specification. Such land shall include the road reserve, areas required for deviations, quarries, stockpile and spoil areas, and borrow pits as defined in this Specification and access roads thereto but shall exclude land for the Resident Engineer's laboratories, offices and houses and land required by the Contractor for their camps, offices, houses, temporary works or any other purpose.

It is entirely the Contractor's own responsibility to obtain all land required for the erection of their offices, stores, workshop, quarters, camps and the like, including land required for the Engineer's accommodation, offices and laboratory as specified in SECTION 1400. Such provision of land shall be considered part of the Contractor's general obligations as defined in SECTION 1300.

The location of land which shall be provided by the Contractor for the Resident Engineer's laboratories, offices and houses and their layout shall be subject to approval by the Engineer.

Where it is necessary for the Employer, in fulfilling their obligations, to acquire any of the above land during the Contract, the Contractor shall determine the ownership of and shall pay, on instruction from the Engineer, the cost of the land or rent, and/or compensation as valued by the National Lands Commission. The Contractor's obligations are set out in detail in SECTION 3400 of this Specification. Although the Contractor may, in the first instance, provide the money for the purchase of the land, all such land shall be the property of the Employer.

Where the Contractor chooses to use an alternative source of material to that specified, the terms of this clause do not apply and the Contractor shall be solely responsible for acquisition of the land and its disposal after completion of the Works.

Should the Contractor request the purchase of land for any purpose and this land is subsequently not used, the Contractor shall be responsible for all costs associated with the compensation, purchase and disposal of such land.

On or before completion of the Contract, the Contractor shall remove all temporary works and shall restore all such land to the condition in which it was immediately prior to the occupation thereof as far as is reasonable and practicable. No separate payment will be made to the Contractor on account of these Items and the Contractor must make due allowance for them in their rates.

The Contractor shall be required to appoint a competent surveyor who will liaise with the Engineer on matters related to the demarcation of the existing road reserve, site measurements, removal and reinstatement of existing services.

The Contractor's attention is drawn to the provisions of CLAUSE 1207 with regard to their activities on private land and to SECTION 3400 with regard to acquisition of land for borrow pits, quarries and temporary works.

The Contractor shall observe all the legal provisions and the provisions of the Special Specifications in respect of their activities at borrow pits, quarries, camp sites etc. and when rehabilitating such areas on completion.

1215 Services

a. Location of Services

The Contractor shall review the positions of all existing services, such as drains, underground and overhead telephone and electricity lines, ducts, poles, water mains, fittings, railway lines, etc. before any excavation or other work likely to affect the existing services is commenced.

The Employer will, in the Contract documents, provide information regarding the location of existing known services but does not accept responsibility for the accuracy of this information.

The Contractor shall, at their own cost, check and determine on the Site the position of any services, whether known or not. This shall be done by consultation with owners of services, visual inspections, use of detecting apparatus and by making excavations as required to expose the position of the services. These positions shall be surveyed carefully, marked on the ground and then drawn accurately on the Drawings. These services will then be defined as known services.

b. Damage to Services

The Contractor shall be held responsible for damage to existing works or services, and shall indemnify the Employer against any claims in this respect (including consequential damages). The Contractor shall be responsible for the reinstatement of the services so affected.

The Contractor shall take all reasonable precautions to protect existing services during construction and during the relocation of such services. Where protective measures involve the construction of permanent work, the Contractor shall execute the work in accordance with the Engineer's instructions, and payment shall be made as provided for in the Special Specifications.

All pipes, cables, conduits or other known services of any nature whatsoever damaged as a result of the Contractor's operations shall be repaired and reinstated forthwith by the Contractor or by the Agency concerned, to the satisfaction of the Engineer, all at the expense of the Contractor.

c. Safety By Overhead Power Lines

Where work is to be carried out in the vicinity of overhead power lines, the Contractor shall ensure that all persons working in such areas are aware of the relatively large distance that high voltage electricity can 'short' to earth when cranes, or other large masses of steel, are in the vicinity of power lines. The Contractor shall be required to work outside the clearances stated in BS 7354 which gives safe clearance for the various voltages.

d. Relocation of Services

All services within the road reserve to be affected by the works shall be relocated by the owners at their own cost unless stated otherwise in the wayleave agreements executed between such owners and Road Agencies.

It shall be clearly understood that, in certain instances, existing services can be relocated only after the Contractor has advanced sufficiently on or has completed certain sections of earthworks or certain structures. Whenever services are encountered which require to be altered in any way or relocated the Contractor shall notify the appropriate Agency and advise the Engineer, whose approval shall be obtained regarding arrangements and execution for such works. The Contractor shall be responsible for these works which shall comply with the specifications of the relevant statutory agency.

When relevant, a Provisional Sum for such relocation work will be included in the Bill of Quantities and the Contractor shall be reimbursed their actual expenditure plus overhead and profit.

e. Negotiations with Owners of Services

The Contractor shall work in close co-operation with private owners or public authorities controlling services, which have to be protected, moved or relocated.

Details regarding the state of negotiations concluded between the Employer and the Owner at the time of bidding in respect of the time when either the Owner is prepared to start moving such services or when the Contractor is required to or will be allowed to start moving the services, and the duration of such operations, will either be stated in the bid documents or be made available within 30 days of the Commencement Date for the Works.

Further such consultations and negotiations with private owners or public authorities shall be carried out as required, by the Contractor. Should the Owners of services refuse to co-operate with the Contractor in a reasonable manner in connection with the protection or moving of services belonging to them, the Contractor shall refer the matter to the Engineer.

f. Programming Relocation of Services

When the Contractor prepares their contract works programme it shall clearly indicate when they propose to start and conclude the moving of each service. They shall have discussed with and received the agreement of the relevant service owner with respect to each activity shown on the programme.

Should it thereafter, through delays on the part the Employer or the owner of the service to be moved, be impossible to adhere to the programme of work, such programme shall be suitably amended by the Contractor in consultation with the Engineer so as to limit, in so far as is possible, the extent of any damages or delays. Should it be impossible to limit entirely the damages or delays resulting from the amendments necessary to the programme of work, the Contractor shall be reimbursed for any additional costs incurred or damages suffered.

g. Payment

Any work required to be undertaken by the Contractor in protecting, altering or relocating public services for which no provision is made in the Contract Documents, will be classified and paid for at Daywork Rates, or if no applicable Daywork Rates exist, the Contractor shall submit a quotation for the Engineer's approval.

1216 Contractor's Activities In Respect Of Property Outside The Road Reserve

1. Statutory provisions

The Contractor shall exercise any rights that may be ceded to them by an Agency in terms of any statutory provisions for purposes of executing the Contract, on condition that:

- a. The Contractor complies strictly with the requirements of such statutory provisions, particularly in regard to the matters relating to serving notice on the Owner or consultation with them.
- b. In each case a written agreement is made with the Engineer regarding the details of the Contractor's proposed actions before the rights of the Contractor in terms of the statutory provisions are exercised.
- c. The provisions shall apply with any necessary alterations to:
 - i. Those areas approved for the purpose of disposing of spoil material; and
 - ii. Those areas occupied by the Contractor for establishment on the Site or for any other purpose and for the Engineer's houses, office and laboratory.

2. Agreements with Owners or Legal Users of Property

The Contractor shall put in writing all agreements with Owners of property outside the road reserve or of services inside or outside the road reserve in respect of the following matters:

- a. The location, extent and use of borrow pits, haul roads, construction roads and bypasses outside the road reserve.
- b. Compensation, if applicable, for land or materials taken or for land temporarily used or occupied.
- c. The reinstatement of property occupied, used, damaged or destroyed, or compensation therefore in lieu of reinstatement.
- d. The procedure for the moving of services and details as to how and when this is to be done.
- e. Any similar matter directly related to the Contractor's activities on or in respect of private property or services.

These agreements shall be signed by all the parties concerned and delivered to the Engineer.

Where the Contractor cannot obtain the Owner's agreement in writing, they shall refer the matter to the Engineer and shall furnish them with details, in writing, of any verbal agreement made.

3. Notice on Owner

Where, in addition to any agreement with the Owner of any property to be entered upon or temporarily occupied or any service to be moved, it is understood or required that the Contractor shall serve notice on the Owner immediately before actually entering upon or occupying the private property or moving a service, and shall give proper notice thereof in writing, and the Engineer shall be supplied with a copy of such notice, together with acknowledgement of receipt.

4. Completion Statement From Owner

On completion of operations, the Contractor shall obtain, from the owner concerned, a written statement to the effect:

- a. That the Contractor has fulfilled their obligations under a written agreement.
- b. In the absence of a written agreement, that the Owner has received all the compensation they are entitled to and is also satisfied that all property occupied, including borrow pits, haul roads and construction roads, has been properly restored and is in a satisfactory condition.

All such statements shall be signed, dated and delivered to the Engineer.

5. Use of Land Outside Provided Area

Should the Contractor wish to use land outside the area provided by the Employer for storing or keeping material or equipment required for the construction of the permanent works, it will be subject to the following:

- a. That the Engineer approves any area selected for this purpose.
- b. That such land be physically separated from any production plant or activities and suitably fenced in.
- c. That the area used for the aforesaid purpose be surveyed, and, where the land does not belong to the Contractor, they shall enter into a contract of lease with the Owner of such land in respect of the full period for which such land shall be used for such purpose,
- d. Which contract shall stipulate that the Owner shall not have any right whatsoever to any material stockpiled on such land during the currency of the contract of lease. That suitable, permanent reference beacons, approved by the Engineer, be placed next to the area, at the cost of the Contractor, for use by the Engineer with a view to, if applicable, taking cross-sections for determining quantities.
- e. That only material to be used for this contract shall be stored on such land.

6. Fences, Gates and Signs (Private)

The Contractor shall be responsible for ensuring that livestock cannot stray as a result of their operations or enter a construction area including borrow areas. When existing fences and gates have to be removed or altered for the proper execution of the Works or are required to exclude livestock, the Contractor shall, at their own expense, erect temporary fencing and gates, and if necessary, provide watchmen to ensure that livestock cannot stray. New tension wires shall be used when re-erecting existing mesh fences. For permanently relocated existing fences and new fences, each horizontal wire shall be tensioned between braced posts using a wire strainer. Each wire shall also be securely fixed to each post using wire ties through drilled holes.

The permanent relocation of existing fences and private signs and the construction of new permanent fences as shown or as directed by the Engineer shall be paid for at the contract price per unit of measurement shown in the Bill of Quantities which price shall include for furnishing and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the work.

1217 Other Contractors

The Contractor is advised that other contractors employed by the Employer and employees of the Employer may be working in connection with the Project on and around the Site.

Pursuant to the provisions of the Conditions of Contract the Contractor shall not interfere in any way with any works, whether the property of the Employer or of a third party and whether the position of such works is indicated to the Contractor by the Engineer or not, except where such interference is specifically described as part of the Works either in the Contract or by the Engineer's instruction. The Contractor shall respect any works executed by others and articles supplied or installed by others and will be held responsible for any loss or damage thereto if caused by themselves, their employees or their sub-contractors.

1218 Transport Of Workmen

The Contractor shall include in their rates and prices for all transport of staff and workmen to and from the various parts of and upon or in connection with the Works and all costs incurred in securing, recruiting and transporting labour to and from the Site.

1219 Temporary Works

Following contract signing and within the period stated in the Particular Specification, the Contractor shall submit to the Engineer drawings showing the general arrangement of the Temporary Works with diagrams and descriptions showing how they proposes to execute such Temporary Works and how they fit into the programme for the Permanent Works, all to be subject to adjustment and approval by the Engineer.

The drawings shall include but not be limited to:

1. Camps, including accommodation for staff and labour
2. Offices
3. Laboratory
4. Workshops
5. Stores
6. Aggregate crushing plants
7. Bitumen storage facilities, etc.
8. Concrete manufacturing plants
9. Precast concrete yards
10. Temporary river crossings
11. Temporary bypass and access roads.

The whole of the Temporary Works and the plant and appliances used, will be the liability of the Contractor in regard to their construction, sufficiency, safety, maintenance and removal on completion of the Contract and approval by the Engineer shall in no way relieve the Contractor of their liability.

No separate payment will be made for Temporary Works, the relevant cost being included in the rates of the Bill of Quantities for other work.

1220 The Setting Out Of Work And Protection Of Beacons

The Engineer will provide sufficient basic survey information to enable the Contractor to set out the Works and the Contractor shall be responsible for setting out all necessary reference points and for the maintenance thereof.

The Contractor shall check the accuracy in line, level and dimension of the basic survey and setting out details provided and should the Contractor discover any error in the information provided by the Engineer, they should at once notify the Engineer. If the information is confirmed to be in error the Engineer will issue amended drawings or instructions regarding the correction of the error.

Prior to commencing construction, the Contractor shall establish the road reserve boundary posts in accordance with **CLAUSE 2001** of this Specification or if no boundary posts are instructed then the Contractor shall establish reference points to define the road reserve at 100 m intervals on both sides.

The Contractor shall establish temporary benchmarks along the road at intervals not exceeding 200 m and shall provide the Engineer with a schedule of their levels and locations.

The Contractor shall not remove, damage, alter or destroy in any way plot beacons or survey beacons of the Survey of Kenya. Should the Contractor consider that any beacon will be interfered with by the Works they shall notify the Engineer who, if they consider it necessary, will make arrangements for the removal and replacement of the beacon.

If the Contractor removes or disturbs a beacon without permission of the Engineer, the Engineer shall be liable for the full cost of its replacement and a fine under the Survey Ordinance, 1951, or any subsequent amendment.

In addition to the requirements of **CLAUSE 1216(a)** the Contractor shall set out the line and level of the Works at intervals of not more than 25 m or such lesser intervals as are required to construct the Works to the tolerances specified in **CLAUSE 1903** of this Specification. Reference pegs and batter rails clearly and indelibly marked with all the relevant information shall be provided clear of the road and at right angles to it from which the centreline, level and batter slope can be directly established at any time. These shall be maintained by the Contractor for as long as they are needed to check the work.

After completion of the setting out and site clearance the Contractor shall take ground cross-sections at intervals of 25 m along the road centreline and along the centreline of all culverts and structures. These shall be plotted to a natural scale off 1:100 on a stable transparent material and a copy of the plot submitted to the Engineer for agreement. If the Contractor fails to take requisite levels, levels determined by the Engineer shall be taken as correct.

The Contractor shall programme for a period of 30 days between submitting the ground cross-sections and being issued with final road, culvert and structure levels. A minimum 5 km section of road shall be submitted but where the Contractor submits cross-sections for more than 10 km of road within the same 30 day period the initial 30 day period shall be extended by 30 days for each additional 10 km or part thereof. Final road, culvert or structure levels will be determined by the Engineer and may be different from the levels shown on the Drawings.

On receipt of the final road levels the Contractor shall mark up the details on the transparencies and the original and one print of the cross-sections shall be provided free of charge by the Contractor for the Engineer.

On completion of the earthworks but before starting formation or pavement layers the Contractor shall establish steel pins at a constant offset to the edges of the carriageway shoulders. The offset may however vary between sections in cut and those in fill. The steel pins will be clearly and indelibly marked with all the relevant information necessary to directly establish the centreline and level at any point across the carriageway by using either boning rods or a string line.

The interval between pins shall not be more than 12.5 m and the pins shall be maintained by the Contractor for as long as they are needed by the Engineer to check the work.

The Contractor's attention is drawn to the requirements of the relevant clause of the Conditions of Contract, and the Contractor shall also comply with all legal provisions in regard to surveying and setting out work.

The Contractor shall be responsible for the proper and accurate setting out of the works as required in the Contract Documents. The Contractor shall provide all survey and measuring equipment and instruments necessary for use in the execution of the scheduled Works.

The Contractor shall allow in their bid rates for being unable to use up to 30 % of the Engineer's control points where such are provided in the Contract, through loss or damage occasioned prior to the commencement date. When the Contractor requires the establishment of a new control point or points due to the above mentioned loss or damage the Contractor shall advise the Engineer who will, if they deem it necessary, arrange for the establishment of a new control point or points.

Control points not affected by the Works shall be protected and preserved by the Contractor. In the case of negligence on the part of the Contractor, or their employees, resulting in the destruction of control points, an amount equal to the cost of replacing the same may be deducted from subsequent payments due the Contractor.

Control points affected by the Works shall be offset by the Contractor to the satisfaction of the Engineer.

The Contractor shall, prior to any setting out, submit to the Engineer for approval, the method of setting out the Contractor proposes to employ. The plan shall include the accuracy, positions of the various types of stakes, method of marking stakes, and methods to be used for protecting stakes, etc. To ensure beyond all doubt that the complex elements of the road, such as traffic interchanges, structures and other important features are located truly and correctly, the Contractor shall check all setting-out by a second method. The Engineer may at any time request the Contractor to submit a proof that the setting-out it has been satisfactorily checked.

No survey work shall proceed prior to the Engineer's approval of the Contractor's plan. At least 24 hours before they intend to survey any portion of the Works, the Contractor shall give written notice to the Engineer. Such notice shall include time, location and type of Works to be set out. The Contractor shall set out the Works and obtain approval of their setting out before proceeding with construction.

In general, the Contractor shall check for the existence of original marks, lines and levels of reference not less than one month prior to commencing works in any section, to allow sufficient time for reinstatement of markings, and checking of lines and levels. Any discrepancies encountered shall be immediately reported to the Engineer, for instruction and co-ordination. The Contractor shall be deemed to have allowed in their bid price for checking and reinstatement of original markings.

Special care shall be exercised during construction not to damage, displace or disturb property and cadastral survey beacons. If such beacons are disturbed or destroyed by the Contractor they shall be replaced without delay by a registered land surveyor at the Contractor's expense.

The Engineer may, if they deem it necessary, revise the line and grade and will require the Contractor to adjust the stakeout accordingly.

The Contractor shall check the condition of all reference and level beacons and shall ensure that they have not been displaced and are true in regard to position and level. If beacons have been destroyed, displaced or damaged before the site is handed over to the Contractor, the Engineer will arrange to have new beacons installed. A beacon, which has been displaced, shall not be used unless its true position and level have been re-established and the new values verified by the Engineer.

Where a beacon is likely to be displaced during construction operations, the Contractor shall establish suitable reference beacons at locations where they will not be displaced during construction. No beacon shall be covered over, displaced or destroyed before accurate reference beacons have been established and details of the positions and levels of such beacons have been submitted to and approved by the Engineer. The Contractor's reference beacons shall be of at least the same quality and durability as the existing beacons.

In cases where the displacement of or damage to property beacons or cadastral survey beacons is unavoidable, the Contractor shall notify the Engineer in good time so that they may arrange to have such beacons suitably referenced and later on reinstated. The cost of such work, if paid for by the Contractor, shall be reimbursable as extra work, as provided for in the Conditions of Contract.

For the purposes of this clause and of the relevant clause of the Conditions of Contract, any beacon made from a metal peg cast in concrete and any boundary beacon, whether or not cast in concrete, shall be regarded as a beacon. Centre-line pegs shall not be classified as beacons.

To protect beacons, the boundary fences of the road reserve shall be splayed at corners so as to avoid the use of corner posts in the same position as property or cadastral survey beacons, all as shown on the Drawings.

Accurate control of line and level shall be provided by the Contractor at all stages of construction as detailed in SECTION 7300 of these Specifications.

Where directed by the Engineer, the Contractor shall provide to the Engineer camber boards to the profile of the normal camber, 3.0 m long straight edges and measuring wedges.

The camber boards shall be constructed of stout timber, angle iron or metal tubes so as to span 6.5 m without deflection, and preferably supported on trollies and fitted with a device for raising and lowering the board. The bottom of a timber board shall be shoed with steel plate, the width of the timber, and at least 5 mm thick. The construction of the boards shall be to the satisfaction of the Engineer.

The 3.0 m long straight edges and measuring wedges shall be made of durable strong materials such that they are inflexible and will not warp and do not suffer from abrasion.

The setting-out of work will not be measured and paid for separately, and compensation for the work involved will be deemed to be covered by the rates bid and paid for in the various Items of work included in this Contract. No separate payment will be made to the Contractor for the provision of camber boards, straight edges and measuring wedges, their cost being included by the Contractor in their rates in the Bill of Quantities.

No separate payment will be made for stakeout, adjustments to the stakeout, or to establish and compute new points/benchmarks the relevant costs being deemed to be included in the bid rates for other Items in the Bill of Quantities.

1221 Construction Generally

The following general requirements shall apply:-

- a. The Contractor shall provide adequate lighting where work is being executed at night and shall provide and install any additional lighting which the Engineer may require in order to gain access to, watch and supervise the Works and carry out any testing and examination of materials.
- b. Materials available on the Site or materials made available or supplied by the Employer shall be used solely for the execution of the Works.
- c. The Contractor shall minimise the pollution of and disturbance to lands, roads and other places on and around the Site. No trees or other vegetation shall be removed except to the extent necessary for the Works.

- d. The Contractor shall ensure that access is provided to all properties adjacent to the Site for the duration of the Contract.
- e. The Contractor shall comply with the current Government regulations with regard to the transport, storage and use of explosives and radioactive materials.
- f. The Contractor shall take all reasonable precautions:-
 - i. In connection with any rivers, streams, waterways, drains, watercourses, lakes and the like to prevent silting, flooding, erosion of beds and banks and pollution of the water so as to affect adversely the quality or appearance thereof or cause injury or death to human, animal or plant life;
 - ii. In connection with underground water resources (including percolating water) to prevent any interference with the supply to or abstraction from such sources and to prevent pollution of water so as to affect adversely the quality thereof.
- g. The Contractor shall provide, maintain and remove on completion of the Works, settling lagoons and other facilities to minimise pollution due to the Contractor's operations including but not limited to quarrying, aggregate washing, concrete mixing and grouting.
- h. If the Contractor provides a radio communications network around the Site, the Contractor shall allow the Engineer reasonable use of the facilities. Any requirements for the provision of radio communications for the sole use of the Engineer are stated in the Special Specification.
- i. The Contractor shall provide, maintain and remove on completion of the Works, fencing around the Site and appropriate security measures on access roads, but without prejudice to their obligations including maintenance of free access for the Employer, the Engineer, other contractors and any other persons entitled to such access.
- j. In addition to the requirements of clause 26 of the Conditions of Contract, the Contractor shall be responsible for observing all current Statute Ordinances, Bye-laws or Regulations including those relating to training levies and similar taxes.

All buildings erected by the Contractor upon the Site and camp sites, and the layout of the buildings and the sites, shall comply with Laws of Kenya and all local Bye-laws in so far as they are applicable.

- k. The Contractor shall be absolutely and solely responsible for the adequacy, safety and security of Temporary Works including (but not limited to) all workyards, pilings, staging, dams, cofferdams, trenches, fencing or other works and for the plant in connection therewith which may be erected or provided for the carrying out of the Contract and for the execution of the Works. This provision shall be applicable to all Temporary Works and Constructional Plant whenever provided and erected by the Contractor and/or their sub-contractors for the purpose of or in connection with the Works.

Examination by the Engineer of the Contractor's and/or their sub-contractors' Temporary Works or of the drawings connected therewith shall not absolve the Contractor from any liability imposed by the provisions of the Contract.

1222 Protection From Water

Except as otherwise specified, the Contractor shall be responsible for dealing with water, whether from existing drainage systems, water courses, underground springs, precipitation or any other source or cause. In discharging and diverting water the Contractor shall avoid flooding or damaging other works or services, causing erosion and/or polluting water courses.

The Contractor shall keep the whole of the Works free from water and shall provide all dams, cofferdams, pumping, piling, shoring, temporary drains, sumps, etc., necessary for this purpose.

Well in advance of commencing the permanent Works the Contractor shall at their own expense cut drains and ditches and carry out any other measures necessary to effectively drain the original ground and/or shall programme their Works that the necessity of temporarily draining the original ground is partially or totally obviated by working in the dry season.

The Contractor shall at their own expense take all necessary precautions to prevent damage due to erosion and siltation during construction. Precautions will include temporary drainage berms, scour checks, riprap and the like. Spoil material or stockpile material shall be dumped so as not to interfere with streams, watercourses or any of the drainage works detailed by the Engineer.

On cessation of the works each day the surface of each completed layer shall be trimmed so that ponding and concentration of surface run-off does not occur. Should any water accumulate on any part of the Works either during construction or after construction until the end of the Defects Notification Period, giving rise to soaking or eroding conditions, the Engineer may order the Contractor to remove and replace at the Contractor's expense any material or Works that has been so affected.

Any damage to the Works or to adjacent properties resulting from the Contractor's failure to take the necessary precautions shall be made good at the Contractor's expense.

1223 Health, Safety And Accidents

The Contractor shall ensure, so far as is reasonably practicable and to the satisfaction of the Engineer, the health, safety and welfare at work of employees including those of sub-contractors and of all other persons on the Site. Responsibilities shall include:-

- a. The provision and maintenance of Constructional Plant and systems of work that are lighted, safe and without risks to health;
- b. The execution of suitable arrangements for ensuring safety and absence of risks to health in connection with the use, handling, storage, transport and disposal of articles and substances;
- c. The provision of protective clothing and equipment, first aid stations with such personnel and equipment as are necessary and such information, instruction, training and supervision as are necessary to ensure the health and safety at work of all persons employed on the Works all in accordance with the Laws of Kenya;
- d. Designation as Safety Officer of one of senior staff who shall have specific knowledge of safety regulations, and experience of safety precautions on similar works and who shall advise on all matters affecting the safety of workmen and on measures to be taken to promote such safety;
- e. The provision and maintenance of access to all places on the Site in a condition that is safe and without risk of injury;
- f. The provision of adequate waterborne sanitation, refuse collection and disposal, complying with the Laws of Kenya and all local Bye-laws and to the satisfaction of the Engineer, for all houses, offices, workshops, and laboratories erected on the camp site or sites;
- g. The provision of -an adequate number of suitable latrines and other sanitary arrangements at sites where work is in progress to the satisfaction of the Medical Officer in the area and of the Engineer;
- h. The execution of appropriate measures in consultation with the appropriate Public Health Authority to control within the Site, including the camp sites, mosquitoes, flies and pests including the application of suitable chemicals to breeding areas;
 - i. Reporting details of any accident to the Engineer and the Kenya Police if appropriate as soon as possible after its occurrence.
 - ii. Compliance with The Factories Act (Cap 514) and in particular the Factories (Building Operations and Works of Engineering Construction) Rules 1984.

1224 Water Supply

It is the Contractor's responsibilities to provide a clean and sufficient supply of fresh water for both construction purposes and also for all the houses, camps, offices, workshops, laboratories, etc.

In this respect the Contractor's attention is drawn to current relevant Kenyan Legislation, with which the Contractor must comply.

The construction water shall be clean, free from suspended solids and undesirable concentrations of salts and from any matter in quantities considered by the Engineer to be deleterious to the proposed work. The water shall be provided at the locations, in the amounts, and during the hours, including nights, as directed by the Engineer.

The distributors used for watering shall be equipped with spray bars and shall be of ample capacity and of such design as to ensure uniform application of water in the amounts directed by the Engineer.

Water supplied to the Resident Engineer's offices, laboratories and all houses and camps shall be drinkable to the satisfaction of the Medical Officer of the Area and the Engineer. The water for drinking and cooking purposes shall be filtered, boiled or treated as necessary for human consumption. All water sources used shall be approved by the Engineer.

The Contractor's attention is drawn to the fact that no separate payment will be made for the provision of water and the Contractor shall include in their rates and lump sum Items for the provision of all water required in and for the Works.

1225 Preservation And Maintenance Of Fences And Gates

The Contractor shall be responsible for ensuring the safety of all persons and property on the Site and for ensuring that livestock cannot stray as a result of their work. When existing fences and gates have to be removed or altered for the proper execution of the Works, the Contractor shall erect, temporary fencing and gates and, if required, provide watchmen to ensure that livestock cannot stray, provided always that the fences or gates referred to have not been the subject of a negotiated agreement for compensation whereby the owner or tenant has been made responsible for such removal or alteration.

The Contractor shall discipline employees to ensure that no fence or gate, except where these are required to be removed or altered for the proper execution of the Works, is damaged and that no gates are left open which may allow livestock to stray.

1226 Use Of Explosives

The Contractor shall only use explosives for blasting in rock at such times and places and in such manner as the Engineer may approve. Such approval shall not relieve the Contractor from their responsibility for damage to the Works and adjoining or adjacent structures, roads, places and things, injury, loss, inconvenience and accident to persons, animals and property consequent on the use of such explosives. The Contractor shall be entirely liable for any accident which shall occur and shall save the Employer harmless and indemnified from all claims arising therefrom.

For handling of explosives and blasting, the Contractor shall employ only persons experienced in blasting and these persons must be in possession of an approved current blasting certificate and be able to demonstrate their experience to the satisfaction of the Engineer. The purchase, transport, storage and use of explosives shall be carried out in accordance with the most recent Explosive Ordinance and Rules issued by the Government of Kenya.

The Contractor shall use explosives for blasting in connection with the Works only at such times and places and in such a manner as the Engineer may approve but such approval shall not relieve the Contractor from their responsibilities for injury, loss, inconvenience and annoyance to persons, damage to the work and adjoining structures, roads, places and things, and injury or damage to

animals and property consequent to the use of such explosives. The Contractor shall be entirely liable for any accident which may occur and shall save the Employer and the Engineer harmless and indemnified from all claims arising therefrom. Where loss, inconvenience, injury or accident is likely to be caused to persons, animals, works, property, places and things, the Engineer shall have the power to regulate or prohibit blasting and in the event of such regulations or prohibition the Contractor shall have no claims against the Employer.

Contractor will be permitted to use explosives for breaking up rock and hard materials during excavation, for demolishing existing structures, and for such other purposes for which it may normally be required, upon approval by the Engineer and subject to the following conditions:

1. The Engineer will have the right to prohibit the use of explosives in cases where, in their opinion, the risk of injury to persons or damage to property or adjoining structures is too high. Such action by the Engineer shall not entitle the Contractor to any additional payment for having to resort to other less economical methods of demolition unless otherwise provided in the Special Specifications or the Bill of Quantities.
2. The Contractor shall prepare a risk assessment for all blasting activities which shall be submitted to the Engineer for approval. All unacceptable risks identified shall be limited by appropriate mitigation measures which are to be implemented by the Contractor prior to approval being given for blasting. Such risk assessment and approval procedures shall not relieve the Contractor of responsibilities under the Contract nor shall additional payments be made for compliance with the agreed mitigation measures.
3. The provisions of SECTION 3400 shall be complied with.
4. Legal provisions in regard to the use of explosives and the requirements of the Inspector of Explosives or equivalent shall be strictly complied with.
5. The Contractor shall, at their own cost, make arrangements for supplying, transporting, storing and using explosives.
6. Before any blasting is undertaken, the Contractor together with the Engineer, shall examine and measure up any buildings, houses or structures in the vicinity of the proposed blasting and establish and record, together with the Owner thereof, the extent of any cracks or damage that may exist before blasting operations are commenced. It shall be the responsibility of the Contractor to make good, at their own expense, any further damage to such houses, buildings or structure which may result from the blasting operations.
7. Where there is danger of damage to power or telephone lines or underground or other services or any other property, the Contractor shall suitably adapt their method of blasting and the size of the charges, and shall take adequate protective measures, such as cover blasting, in order that any perceived risk of damage is within acceptable limits. If the risk cannot be so minimised then the Contractor must adopt alternative methods.
8. The Engineer shall, twenty-four hours before each blasting operations is carried out, be advised thereof, in writing, unless otherwise agreed upon by the Engineer.
9. No explosives of any kind shall be used by the Contractor without the prior written consent of the Engineer. The Contractor shall purchase and import their own explosives for use in connection with the Works and shall comply with all relevant ordinances, instructions and regulations which the Employer, or other person or persons having due authority, may issue from time to time regarding the handling, transportation, storage and use of explosives.
10. The Contractor shall comply with the Statutory Regulations in force in Kenya regarding the use and storage of explosives.
11. Before commencing demolition work on any unit the Contractor shall ensure that all affected public utilities have been disconnected as directed by the Engineer and any necessary temporary arrangements made. Any material or equipment required by the Employer shall be transferred to their store and the remaining debris shall become the property of the Contractor who shall dispose of it from the Site.

12. The Contractor shall at all times when engaged in blasting operations post sufficient warning flags and other measures to the full satisfaction of the Engineer.
13. The people likely to be affected by the blasting shall be informed in advance and no such blasting should be carried out at night.
14. Special care is to be taken near pipelines especially those conveying oil and sewage because of risk of contamination in the event of damage.

1227 Protection Of Existing Works And Services

The Contractor shall review the position of all existing services such as sewers, surface water drains, cables for electricity and telephone, telephone and lighting poles, water mains, and the like before commencing any excavation or other work likely to affect the existing services.

Where work is to be carried out in the vicinity of overhead power lines, the Contractor shall ensure that all persons working in such areas are aware of the relatively large distance that high voltage electricity can 'short' to earth when cranes, or other large masses of steel, are in the vicinity of power lines. The Contractor's attention is drawn to BS 162 which gives safe clearances for the various voltages.

The Contractor shall be held responsible for injury to existing works or services, and shall indemnify the Employer against any claims in this respect (including consequential damages). The Contractor shall be responsible for the reinstatement of the services so affected.

In all cases where such works or services are exposed, they shall be properly shored, hung up or otherwise protected. Special care must be exercised in filling and compacting the ground under mains, cables, etc., and to leave uncovered exposed water meters, stopcock boxes and similar items.

Installations adjacent to the Works, shall be kept securely in place until the work is completed and shall then be made as safe and permanent as before.

Notwithstanding the foregoing requirements, and without reducing the Contractor's responsibility, the Contractor shall inform the Engineer immediately if any existing works or services are exposed, located or damaged.

All costs which may be incurred by the Contractor /as a result of programming and coordinating work to enable any alterations to the services to be carried out and the cost of any safety precautions which shall be deemed necessary due to the proximity of the Works to the power lines belonging to the Kenya Power and Lighting Co. Ltd. shall be at the Contractor's expense.

1228 Diversion Of Services

The Contractor shall be responsible for arranging in liaison with the appropriate Authority as soon as the requirement is known for the moving of or alterations to services such as power and telephone lines, water mains, sewers and surface water drains which are affected by the Works. The arrangements for such moving or alteration shall be subject to the agreement of the Engineer and the appropriate Authority.

1229 Closure Of Roads

When a road used by the Contractor for transporting labour or Constructional Plant or for delivery of any material for the Works is closed under Section 71 of the Traffic Ordinance 1962, or amendments thereto, the Contractor shall obey such closure order and shall suspend operations or use alternative roads. The fact that the Contractor is performing work for the Ministry of Roads and Transport will give no special privileges in this respect.

1230 Protection Of The Works And Requirements To Be Met Before Construction Work

a. Nature of Ground and Condition of Work

The Contractor must satisfy themselves as to the general circumstances at the site of the Works and the construction thereon, the form of river beds, and banks, the flows in the rivers, the surface of the ground and nature of the materials to be excavated, the possibility of subsidence from soft ground and bad and broken materials, and falls of rock in or arising out of the Works, and the possibility of floods and landslides, and the rates and prices in the Bill of Quantities will be held to cover all such contingencies.

In order to minimise the possible adverse effects of flooding the drainage of the natural ground in the vicinity of the earthworks and the drainage works generally shall be carried out in advance of the rest of the Works.

b. Landslides

The removal of materials in slips, slides or subsidences and overbreaks of rock extending beyond the lines and slopes or below the levels shown on the Drawings or required by the Engineer will not be paid for unless such occurrences were, in the opinion of the Engineer, beyond the control of the Contractor and could not have been prevented by the exercise of due care and diligence.

Where payment is made for the removal of such materials, it will be paid as a variation at the appropriate rate inserted in the Bill of Quantities having regard to the condition and situation of the material at the time of removal and regardless of its condition and situation prior to the slip.

c. Drainage

The provision of temporary drainage work such as drains, open channels, banks, etc.; the provision and operation of temporary pumps and such other equipment as may be necessary for adequately protecting, draining and de-watering the Works and temporary works. This will be in addition to any permanent drainage works specified and installed, and in addition to any temporary drainage works specifically paid for separately as in the case of deviations.

d. Wet Material

Material in borrow pits shall not be allowed to become excessively wet. All completed layers shall be properly drained and dumps of material on completed layer work shall not inhibit surface drainage or form wet spots under and around dumps. All parts of the Works shall be protected against erosion by floods and rain.

Material shall not be spread on a layer that is so wet as to result in damage being caused to the layer during compaction of a subsequent layer, or when opened to traffic.

When material is spread out on the road the Contractor shall ensure that during wet periods it will have a good cross-fall and be lightly compacted on the surface to facilitate rain water run-off.

Materials or works that are damaged during wet weather due to the Contractor's work method shall be repaired or replaced as necessary at the Contractor's expense.

e. Fill and Cut Slopes

Fill and cut slopes shall be repaired immediately whenever damaged by surface water. The Contractor's methodology shall be subject to the approval of the Engineer. Particular attention is required in relation to erosion on high fills where the slopes may require cutting back and the formation of benches. All repair work will involve compacting backfill mechanically to the specified densities, using suitable light equipment.

f. Excavations

Excavations for pipe drains, culverts, service ducts and similar structures shall be adequately protected against the possible ingress of water during rainstorms.

g. Completed Layer Work

All completed layer work shall be protected and maintained until the following layer is constructed. Maintenance shall include immediate repairs to any damage or defects which may occur and shall be repeated as often as may be necessary to keep the layer continuously intact and in good condition.

h. Preparation of Layer Work

Before any completed layer is primed or a succeeding layer is constructed thereon, any damage to the existing layer shall be repaired, so that, after repair or reconstruction if necessary, it will conform in all respects to the requirements specified for that layer. All repair work other than minor surface damage repairs shall be notified to the Engineer for inspection before it is covered up.

The previously constructed layer shall be thoroughly cleaned by the removal of all foreign material before construction of a succeeding layer or application of a prime coat, surfacing or surface treatment. In the case of all bituminous work in particular, the existing layer shall be thoroughly broomed and all dung, clay, mud and other deleterious material completely removed. Where necessary, the surface shall be sprayed with water before, during and after brooming to remove all foreign material.

Work performed as part of the above obligations a) – h), shall not be measured and paid for separately, and the cost thereof shall be included in the rates bid for the various Items of work requiring protection and the Items for the Contractor's establishment on the site, as specified in SECTION 1300.

1231 Variation From Specified Nominal Rates Of Application Or Nominal Mix Proportions

The various sections of these specifications specify nominal rates of application or nominal mix proportions for materials such as bituminous materials, aggregates, fillers, stabilising agents, paint and the like. Bidders shall base their bids on these nominal rates of application and mix proportions. Allowance is made in the various sections of these Specifications, where such rates of application and mix proportions are given, for variations arising from different rates of application or mix proportions ordered by the Engineer to suit the materials and conditions on the Site in every particular case.

Where the actual rates of application or mix proportions used in the works vary from the nominal specified rates or mix proportions, adjustment or compensation will be made:

- As a payment to the Contractor in respect of any authorised increase in quantities from those specified, where such increase has been ordered in writing by the Engineer.

OR

- As a refund to the Employer in respect of any authorised decrease in quantities from those specified which has been ordered in writing by the Engineer.

Payment for a varied rate of application or mix proportion shall be based on the actual rate of application or mix proportion used or ordered by the Engineer, provided that the actual rate of application or mix proportion is within the specified tolerance.

If the actual rate of application or mix proportion is below the prescribed rate of application or mix proportion ordered, payment shall be based on the actual rate of application or mix proportion regardless of any tolerance allowed. Notwithstanding the above, the Engineer shall be fully entitled to reject work which has not been constructed in accordance with the specifications or the rate of application or mix proportions prescribed.

The Employer shall be refunded for any decrease in the specified rates of application or mix proportions at the same rate per unit of measurement as that tendered by the Contractor for additional materials required by an increase in the rates of application or mix proportions.

1232 Faulty Work, Remedial Work

a. General

Any work which fails to comply with the Specifications shall be rejected and the Contractor shall, at their expense, make good any defects as directed by and to the satisfaction of the Engineer.

When any part of the Works or any equipment or material is found, upon examination by the Engineer, not to conform to the requirements, or at any stage before final acceptance is damaged so that it no longer conforms to the requirements, of the Specifications, the Engineer may order its complete removal and replacement with satisfactory work, equipment or material. The Engineer may permit the Contractor to apply remedial measures in order to make good any such defects or damage. The actual work done shall at all times be entirely at the Contractor's own initiative, risk and costs, but subject to the Engineer's approval regarding the details thereof.

In particular, remedial measures shall ensure full compliance of the final product with the requirements of the Specifications, shall not endanger or damage any other part of the Works and shall be carefully controlled and submitted to the Engineer for examination when completed or at any intermediate stage as may be required.

For the guidance of the Contractor, an indication is given below of what would normally be required in the more common cases of defects or damage but the Engineer will in no way be bound to accept or approve the measures given below, as the actual remedial measures will be dictated by the circumstances of each particular case.

b. Earthworks

- i. Where a cut slope has been over excavated or undercut or where the floor of a cutting has been taken too deep, back filling and re-compaction shall be carried out as set out in SECTION 3700. All necessary measures shall be taken to drain away groundwater that may accumulate in back filled sections.
- ii. Excess width of fills shall to be trimmed down if required by the Engineer.
- iii. Where erosion has damaged the surface of cuts or fills, the damage shall be made good by back filling with suitable material and re-trimming. In more serious cases in the opinion of the Engineer, the slopes shall be cut back by benching, back filled and compacted to the required standard of compaction with suitable light equipment and then re-trimmed, all in accordance with SECTION 3700.

c. Stabilising

Any sections failing to meet the requirements specified or damaged to the extent that they require breaking-up and re-compaction will have to be re stabilised with the type and quantity of stabilising agent ordered by the Engineer. The Engineer may also order that the layer be removed entirely and replaced with fresh material to be stabilised.

d. Local defects in pavement layers

Where remedial measures are taken to make good local defects, the width of the area to be repaired by machines shall be such as will be necessary to accommodate the full width of the machines used, and it shall be of a reasonable length to ensure effective operation by the machinery. The depth to which material will have to be removed will depend on the type of material. Gravel will require breaking up to a depth of at least 75 mm and crushed stone will usually require breaking up over its full depth. Asphalt material will normally require removal over its full depth.

e. Concrete

Concrete work will normally require the cutting-back and complete removal of any weak or honey combed sections and making good by using special suitable compounds to bind fresh concrete to old concrete. Cracks, when permitted to remain, shall be injected with suitable compounds, and test cores shall then be drilled for testing the efficacy of the injection process.

1233 Authorised Measurements and Tolerances

The work specified in the various sections of these Specifications shall comply with the various dimensional and other tolerances specified in each case. Where no tolerances are specified, the standard of workmanship shall be in accordance with good industry practice. No representation is made that the full specified tolerances will be available independently of each other, and the Contractor is cautioned that the liberal or full use of any one or more tolerances relating to other aspects of the Work may lead to its rejection. The latter would apply particularly in respect of level tolerances on layer work and the related requirements regarding layer thicknesses provided under **CLAUSE 1800** of these Specifications.

In the description of certain pay Items, where it is stated that quantities will be determined from the authorised dimensions, this shall be taken to mean the dimensions as specified or shown on the Drawings, or, if changed, as finally instructed by the Engineer, without any allowance for tolerances being specified. If the work is therefore constructed in compliance with the authorised dimensions, plus or minus any tolerances allowed, quantities will be based on the authorised dimensions regardless of the actual dimensions to which the work is constructed.

Where the work is not constructed in accordance with the authorised dimensions, plus or minus any tolerances allowed, the Engineer may nevertheless, at their sole discretion, accept the work for payment. In such cases no payment will be made in respect of quantities of work or material in excess of those calculated from the authorised dimensions and where the actual dimensions are less than the authorised dimensions, minus any tolerance allowed. Quantities for payment shall be based on the actual dimensions as constructed.

1234 Work On, Over, Under or Adjacent to Railway Lines

All work carried out on, over, under or adjacent to railway lines shall be carried out strictly in accordance with the latest edition of the Specifications of the relevant Rail Authority, a copy of which will normally be included in the Special Specifications or where the copy included in the Special Specifications is amended or superseded by another, the Contractor shall obtain the latest edition, which shall be kept on the site before any work of this nature is commenced.

Attention is drawn particularly to the requirements contained in the Specifications regarding the approval that must be obtained from the Rail Authority for a work permit or occupation of its property and the approval of falsework and formwork plans.

1235 Haul Roads

The Contractor shall submit to the Engineer for approval full details of any construction haul roads they proposes to build. Such details shall be submitted well in advance in order to afford the Engineer sufficient time to investigate their implications. The timing shall be agreed with the Engineer. Haul roads may not be built without the Engineer's prior approval, and shall be kept to a minimum quantity, width and length, whilst taking due cognisance of adverse environmental impact mitigation measures.

1236 Measurement of Depth of Trenches and Foundation Excavations

Where trenches or foundation excavations are required below the level of mass excavations for the road prism, the depth of excavation of the trenches or foundation shall be measured from ground level after completion of the mass excavation, unless the Engineer is satisfied that the excavation of the trenches or foundation from the original ground level or any lower lever was unavoidable. The Contractor shall ensure that they obtain such instructions in good time and, where required, shall submit proposals to the Engineer for approval.

1237 Electricity Supply

The Contractor shall provide and maintain at their expense an adequate electricity supply for the works site which shall be available 24 hours per day, 7 days per week. When generators are required, a standby generator shall be provided to maintain the supply during routine maintenance periods and as a reserve supply source in case of breakdown. The supply shall be 240 volt, 50 cycle AC and must be adequate to supply the area set aside for the housing of staff and for the Contractors and the Engineer's office and site laboratory as well as for the housing of the Engineer's staff.

The Contractor shall provide and maintain all necessary temporary power and lighting and all associated apparatus for the duration of the Contract at their own expense. The Contractor must make allowances for the use of the said supplies and equipment by all sub-contractors.

The Contractor shall provide adequate lighting where work is being executed at night and shall provide and install any additional lighting which the Engineer may require in order to gain access to, watch and supervise the Works and carry out any testing and examination of materials.

Once equipment becomes redundant and having received the approval from the Engineer, the Contractor shall disconnect and remove said equipment and make good any works disturbed at their own expense.

1238 Co-Operation at Site

The Contractor is advised that other contractors employed by the Employer and employees of the Employer may be working in connection with the Project on and around the Site.

Pursuant to the requirements of the General Conditions of Contract the Contractor shall not interfere in any way with any works, whether the property of the Employer or of a third party and whether the position of such works is indicated to the Contractor by the Engineer or not, except where such interference is specifically described as part of the Works either in the Contract or by the Engineer's instruction. The Contractor shall respect any works executed by others and articles supplied or installed by others and will be held responsible for any loss or damage thereto if caused by the Contractor, their employees or sub-contractors.

All work shall be carried out in such a way as to allow access and afford all reasonable facilities for any other Contractor and workforce and for all the workforce of the Employer and any other person who may be employed in the execution and/or operation at or near the Site of any work in connection with the Contract or otherwise.

The Contractor shall use best endeavours to co-operate with such persons without interfering with them and shall observe all the instructions and orders of the Engineer in that connection.

In the preparation of the programme of work the Contractor shall at all times take full account of and co-ordinate with the programming of work of other contractors.

1239 Roads and Site To Be Kept Tidy

The Contractor shall take all necessary care and precautions to ensure that roads and thoroughfares used by him either for the construction of the Works or for the transport of equipment, labour and materials are kept in good repair and condition and not damaged or made untidy as a result of such construction or transport. In the event of their becoming damaged or made untidy, in the opinion of the Engineer, the Contractor shall immediately take all necessary steps to repair or clean as required by the Engineer.

1240 Security of the Works

Security of the Works shall be provided by the Contractor at their own expense. If the Engineer considers it necessary, they will order in writing that additional watchmen be provided, all at the Contractor's expense.

1241 Health and Safety

The Contractor shall comply with all Health and Safety Regulations and the particular requirements of SECTION 9200 of these Specifications.

The Engineer shall be notified by the Contractor immediately any accident occurs whether on Site or off Site in which the Contractor is directly involved which results in any injury to any person whether directly concerned with the Site or whether a third party. Such initial notification may be verbal and shall be followed by a written comprehensive report within 24 hours of the accident.

1242 Notices, Signs and Advertisements

The Contractor and subcontractors shall not erect any signs, notices or advertisements on or along the Works or the site of the works without the approval of the Engineer or according to format given by the Engineer.

No sign boards other than those approved will be permitted on or adjacent to the Works, except that the Contractor may permit each of their sub-contractors to display one, (1 no. only), signboard of less than 2 m² at the works office.

At each end of the Works the Contractor shall provide and erect, as part of their obligations under SECTION 1300, and on approved locations, at the starting and ending points of the Works, sign boards of sound, weather proof construction, painted by an approved firm of sign writers in accordance with the details shown on the Drawings or the description in SUBCLAUSE 1302(c) of these Specifications.

These signs are to be erected not later than one month after the Contractor has been given access to the Site.

The Engineer shall have the right to have any sign, notice or advertisement moved to a better position or to have it removed from the site of the Works if it should in any way prove unsatisfactory, inconvenient or dangerous to the general public.

All advertisements, notices and signs shall be removed by the Contractor at the end of the Defects Notification Period.

1243 Traffic Over Completed Pavement Layers

The Contractor's traffic including that for hauling materials over structures or pavement layers of an uncompleted road shall, in so far as is possible, and in addition to other restrictions specified elsewhere, be limited to a minimum by planning of the sequence of operation and the use of construction roads and deviations.

The Contractor's traffic over structures or the completed road will be restricted to the maximum axle load permitted in terms of statutory provisions. Exceptional loads may be allowed with the approval of the Engineer. Any damage to structures or completed layers caused by the Contractor's traffic shall be repaired at their own cost.

1244 Completion of the Works

The use of any completed roadway or portions of the work, whether for unhindered use by the public or for accommodation of traffic while other portions are being constructed, shall not constitute use or occupation by the Employer.

Completion of the Works (Substantial Completion/Taking Over) in terms of the relevant clause of the Conditions of Contract will be certified by the Engineer only if the following Sections of the Works as may be applicable have, inter alia, been duly completed according to the Specifications, or the extent of the outstanding works is of value less than 2 % of the tendered value plus the value of any variations or extra works orders:

1. The gravel wearing course, seals, asphalt or concrete pavement
2. All above-ground and subsoil drainage structures
3. All fencing
4. The final surfacing of medians and slopes of cuts and fills
5. All the necessary road signs and road-surface markings
6. All guardrails
7. All structures
8. Reinstatement of all areas employed by the Contractor as required in **CLAUSE 1703**.

1245 Final Clearance

Upon completion of each section of the Works the Contractor shall remove all temporary buildings, plant and debris, remove or level off and fine grade all excavated material which is surplus to requirements and ensure that the whole of the site is in a clean and workmanlike condition to the satisfaction of the Engineer.

No separate payment shall be made for any such work, the costs for which shall be deemed to be included in the rates of the relevant Items entered in the Bill of Quantities.

The provisions of **SECTIONS 9100, 8600 and 8700** of these Specifications shall be observed where applicable.

1246 Workmanship and Quality Control

a. General

The Contractor shall, not later than 28 days after the notice to commence the Works, submit details of a Quality Management System, including the Work Method Statements and Quality Audit procedures for major Items of work, showing how the Contractor will ensure that all the works shall conform to the requirements of the Contract. The responsibility rests with the Contractor to produce work which conforms in quality and accuracy of detail to all the requirements of the Specifications and Drawings and the Contractor shall, at their own expense, institute a quality control system and provide experienced engineers, foremen, surveyors, materials technicians, other technicians and other technical staff, together with all transport, instruments and equipment, to ensure adequate supervision and positive control of the Works at all times. The Contractor shall provide chainmen and labourers as necessary for the Engineer to carry out checks on the Works.

The Contractor shall conduct tests or have them conducted continually on a regular basis, to check the properties of natural materials and processed natural materials and of products manufactured on the site, such as concrete and asphalt. The Contractor shall ensure that regular tests are undertaken on any commercially produced products such as cement, bitumen, steel and pipes, and submit test certificates for every batch of material or product purchased for incorporation into the works. The Contractor shall remain fully responsible for any defective material or equipment provided.

The intensity of control and of tests to be conducted by the Contractor shall be adequate to ensure that proper control is being exercised.

Where any natural materials or products made from natural materials are supplied, and upon completion of each element of the construction work, the Contractor shall test and check such

materials, products and/or elements for compliance with the specified requirements and shall submit the results to the Engineer for approval. Such submission shall include all the Contractor's measurements and test results and shall furnish adequate proof of compliance with the specified requirements.

No specific pay Items are provided as compensation for the above obligations, including the provision of all samples delivered to the Engineer, the repair of places from which samples were taken, and the provision of the necessary personnel and testing apparatus and facilities, for which compensation shall be included in the bid rates of the Contractor for the various Items of work to which these obligations apply.

The Contractor's attention is also drawn to the provisions of the various sections of the Specifications regarding the minimum frequency of testing that will be required to provide adequate quality control. The Contractor shall at their own discretion increase this frequency where necessary to ensure adequate control.

The Contractor shall submit to the Engineer for examination, the results of all relevant tests, measurements and levels indicating compliance with the Specifications on completion of every part of the Work.

b. National Specifications

Certain specifications issued by national or other widely recognised bodies are referred to in this Specification and in the Special Specifications. Such specifications shall be defined and referred to as National Specifications as hereunder and shall be the latest editions of such National Specifications available twenty eight (28) days prior to the date set for the submission of Tenders.

The Contractor may propose that the materials and workmanship be defined in accordance with the requirements of other equivalent National Specifications and the Contractor may execute the Works in accordance with such other National Specifications as may be approved by the Engineer. A copy of the National Specification, together with its translation into the English language if the National Specification is in another language, shall be submitted to the Engineer with any request that it be adopted.

c. Source of Supply and Quality Requirements

The Contractor shall before placing any order for materials and manufactured articles for incorporation in the Works submit to the Engineer the names of the firms from whom the Contractor proposes to obtain such materials and manufactured articles giving for each firm a description of the materials and manufactured articles to be supplied, their origin, the manufacturer's specification, quality, weight, strength and any other relevant details. The Contractor shall deposit with the Engineer samples of such materials and manufactured articles when requested and where appropriate, manufacturer's certificates of recent tests carried out on similar materials and manufactured articles.

At the option of the Engineer, materials may be approved at the source of supply before delivery is started. If it is found after trial that sources of supply for previously approved material do not produce uniform and satisfactory products, or if the product from any source proves unacceptable at any time, the Contractor shall furnish acceptable materials from other sources.

The Contractor shall provide the Engineer with copies of all orders for the supply of materials and manufactured articles required in connection with the Works as the Engineer may require.

When instructed by the Engineer, the Contractor shall submit Certificates of Test from the suppliers of materials and manufactured articles to be used for the Contract. Such Certificates shall certify that the materials and manufactured articles concerned have been tested in accordance with the requirements of this Specification and shall give the results of all the tests carried out. The Contractor shall provide adequate means of identifying the materials and manufactured articles delivered to the Site with the corresponding Certificates.

All materials to be permanently incorporated in the work shall be new unless otherwise specifically prescribed in the Contract Documents.

All iron and steel products, which are to be incorporated in the work shall be manufactured, produced or fabricated at recognised factories meeting specified standards. Where domestically manufactured materials meet the Specifications, the Contractor should take them as the first choice of material supply before consideration of another source.

d. Unacceptable Materials

All materials not conforming to the requirements of the Contract at the time they are used shall be considered as unacceptable and all such materials will be rejected and shall be removed immediately from the site of the work unless otherwise instructed by the Engineer. If in place, they shall be removed by the Contractor at their expense and replaced with acceptable materials. No rejected material, the defects of which have been corrected, shall be used until approval has been given by the Engineer. Upon failure of the Contractor to comply forthwith with any other instruction of the Engineer pursuant to the provisions in the Conditions of Contract, the Engineer shall have authority to remove and replace defective materials and to deduct the cost of removal and replacement from any monies due or becoming due to the Contractor.

e. Samples and Tests

All materials should be inspected, tested, and approved by the Engineer before incorporation in the work. The Contractor shall give sufficient advance notice of placing orders to permit tests to be completed before the materials are incorporated in the work, and the Contractor shall afford such facilities as the Engineer may require for collecting and forwarding samples and making inspections. All samples shall be furnished without charge to the Employer.

f. Stored Materials

All materials and manufactured articles shall be stored on Site in a manner acceptable to the Engineer and the Contractor shall carefully protect from the weather and vermin all work, materials and manufactured articles which could be affected.

All stored materials shall be inspected at the time of use in the work, even though they may have been inspected and approved before being placed in the storage. The Contractor may use the road reserve for storage of materials, but any stockpiled shall be confined to such cleared areas as may be approved by the Engineer. If the stockpiling is done outside the road reserve, the additional space required shall be provided by the Contractor at their own expense.

g. Handling Materials

All materials shall be handled in such manner as to preserve their quality and fitness for the work. Aggregates shall be transported from the storage sites to the work in tight vehicles as to prevent loss or segregation of materials after loading.

1247 Road Intersections And Junctions

Except where otherwise specified, no additional payment over and above payment for the various Items of work included in this Contract will be made for the construction, in a confined space, of curves, tapers, bell mouths, traffic islands, farm accesses and other appurtenant Works in connection with the construction and maintenance of road intersections and junctions.

The Contractor shall be required to provide safe and unrestricted flow of public traffic at all times during the construction and maintenance of such intersections and junctions.

1248 Methods Of Measurements

a. Units of Measurements

All work shall be measured in accordance with the SI system of metric units.

b. Bills of Quantity

The quantities set out in the Bills of Quantity are estimated and used for the comparison of bids and for awarding the Contract. It must be clearly understood that only the actual quantities of work done or materials supplied will be measured for payment, and that the scheduled quantities may be increased or decreased as provided for in the Conditions of Contract.

c. Measurement of Completed Work

All distances along the centre line of the road as shown on the Drawings are horizontal distances, which will be used in calculating the quantities of fill and pavement layers for purposes of payment. All cross-sections shall be taken in a vertical plane.

The quantity of bituminous and similar materials to be paid by volume shall be measured at the temperature of application and paid for in accordance with approved application rates.

The quantity of bitumen in mixes and stabilisers in cemented materials shall be paid by mass in accordance with approved mix design proportions.

Structures shall be measured to the neat lines shown on the Drawings and shall include any changes ordered in writing by the engineer and, for purposes of payment, the calculated volume of concrete structures shall include the volume of reinforcing steel, and minor ducts up to 150 mm in diameter.

1249 Methods Of Payment

a. Contract Rates

In computing the final Contract amount, payment shall be based on the actual quantity of authorised work done in accordance with the specifications and drawings. The bid rates shall apply, subject to the provisions of the Conditions of Contract, irrespective of whether the actual quantities are more or less than the estimated billed quantities.

Where no rate or price has been entered against a pay Item in the Bill of Quantities by a bidder it shall be understood that the bidder does not require any compensation for such work. Where, however, a pay Item described in these Specifications or in the Special Specifications does not appear in the Bill of Quantities, the Contractor will receive reasonable compensation for such work if required, unless anything to the contrary has been determined elsewhere.

b. Rates to be Inclusive

The Contractor shall accept the payment provided for in the Contract and represented by the rates bid in the tendered Bill of Quantities, as payment in full for executing and completing the work as specified; for procuring, furnishing, placing and installing all materials, for procuring and providing labour, supervision, constructional plant, tools and equipment, for wastage, transport, loading and off-loading, handling, maintenance, temporary work, testing, quality control, overheads, profit, risk and other obligations and for all other incidentals necessary for the completion of the work and maintenance during the Defects Notification Period.

The Contractor shall note that the cost of all works and materials for minor construction details at bridges, for example small quantities of caulking compound and joint filler (other than expansion joints), anchor-bar covers, etc, not shown in the Bill of Quantities, shall be included in the bid rates for concrete.

c. The Meaning Of Certain Phrases In Payment Clauses

i. Procuring and furnishing (material)

Where any of the words “supply”, “procure”, “provide”, “provision of”, “furnish (material)”, are used in the description of a pay Item, it shall mean the supply and delivery to the point of use of all materials of any kind required for the work covered by the particular pay Item, including all applicable tax, purchase costs, claims, damages, insurance, royalties and transport costs involved, but excluding overhaul.

In the case of borrow materials, stone and sand, it shall also include all negotiations with the Owners concerned, excavating, producing, preparing, processing, testing, hauling and delivering the material to the point of use; the construction, repair, maintenance and making good after completion of all access roads, and all work required in opening, using and rehabilitating off borrow pits unless covered by other pay Items in the Bill of Quantities.

ii. Placing material

The phrase “placing material” shall mean the off-loading, spreading, blending, processing, watering, mixing, shaping and compacting (where specified) of the material in the pavement layer, fills and bypasses, as well as the procuring, furnishing, applying and admixing of water, the breaking-down of oversize material, the removing of oversize material which cannot be broken down, correcting irregular or uneven surfaces or layers, the thickness of which is not to specification, finishing-off to within the specified tolerances, the refilling of test holes and protecting the completed work. In the case of asphalt courses and bituminous seals, it shall also mean the heating and spraying of binder, the spreading of aggregate or asphalt mixtures, rolling, compacting, finishing-off to within the specified tolerances, and maintaining the completed work.

The phrase, “procuring, furnishing and placing” shall mean procuring and furnishing in addition to placing, all as defined herein.

d. Pay Items

The description under the pay Items in the various Sections of the Specifications, indicating the work for which allowance shall be made in the bid rates for such pay Items, are for the guidance of the Contractor and do not necessarily repeat all the details of work and materials required by and described in the Specifications.

These descriptions shall be read in conjunction with the relevant Specifications and Drawings, and the Contractor shall, when bidding, bear in mind that rates shall be inclusive as specified in SUBCLAUSE 1239(b) above.

e. Materials on Site

Payment in respect of Materials on Site for subsequent incorporation into the Permanent Works will be in accordance with the relevant clause of the Conditions of Contract, subject to such payment being allowable in said clause and the appropriate % written into the Particular Conditions of Contract.

f. Rate-only Items

Against an Item in the Bill of Quantities where no quantity is given but a rate only is required, the Contractor shall fill in a rate or amount which will constitute payment for work which may be done in terms of this Item. Such rate only Items will be used where the Item is to be considered as an alternative for another Item where a quantity is given, for work unquantified at the time of tender or for variations in rates of application or mix proportions in relation to CLAUSE 1218.

Work under rate-only Items will be paid for only if it has been executed against a written instruction by the Engineer.

g. Lump Sum

Lump Sum shall refer to a fixed sum tendered by the Contractor which covers all costs, incidentals, overheads and profit for providing materials and supervising and carrying out the work and/or services that are specified under the relevant pay Item.

h. Prime Cost Sum

Prime Cost Sum shall cover the actual cost of the supply of materials and/or work that will be provided by a supplier and/or subcontractor that will be nominated by the Employer or a sum to cover the costs of Items and/or services provided by an outside provider where the cost is not known in advance.

i. Provisional Sums

The Bill of Quantities may contain Provisional Sums, so designated, which are entered as a preliminary allowance to cover the cost of work, materials, goods or services to be provided by the Contractor and which have not been fully specified or measured or to cover the cost of unforeseen Items of work or contingent expenditure, for which no rates are applicable but for which the Contractor is to be paid according to the applicable provisions of the Contract.

Work done under such Provisional Sums shall only be executed upon a written order by the Engineer which order shall also specify the method of payment. The expenditure in respect of a Provisional Sum for work ordered by the Engineer shall be entirely within their discretion and any final expenditure in respect of a Provisional Sum may be more, less or equal to the amount provided in the Bill of Quantities.

Payment as specified in the order given by the Engineer shall be either at Contract rates, where such are applicable, or where none is applicable, the Contractor shall submit a separate quotation to the Engineer.

j. Dayworks

In accordance with the General Conditions of Contract the Engineer may instruct that additional or substituted work be executed on a daywork basis.

Provisional Items shall be included in the daywork section of the Bills of Quantities to cover the payment of plant, labour and materials for work executed in accordance with the Engineer's instructions on a daywork basis by the Contractor or by their sub-contractors.

Measurement for purposes of dayworks shall be as follows:

A. Plant

Payment shall only be made for the time each Item of plant is actually working on Daywork instructed by the Engineer. Idle time, where due solely to the nature of the Daywork or authorised method of procedure, shall be paid for at one half of the tendered rate. Idle time due to breakdowns, inefficiency or incompleteness of the plant shall not be paid.

The rates for plant shall include for the costs of the following:-

- i. Supervision and transport of supervisory staff.
- ii. Transporting or travelling of each Item of plant to and from the place of Daywork.
- iii. Operators, drivers and turn boys including overtime.
- iv. Electric power, water, fuel, oil, grease and other consumables and equipment.
- v. Power cables, delivery or suction pipes and fittings, steam or air hoses and tackle, and all other appurtenances of whatever nature required for the safe and efficient operation of the plant.
- vi. Maintenance, spare parts, drill bits and chisel points and all costs of repairs.
- vii. Depreciation, insurance, overheads, profits, and any other costs or allowances.

B. Labour

Payment shall only be made for the time each class of labour is actually working on Daywork Instructed by the Engineer.

The rates for labour shall include for the cost of the following:-

- i. Supervision and transport of supervisory staff.
- ii. Any special allowance to such labour in respect of subsistence, overtime, bonuses, feeding, housing, holidays, transport to and from the place of Daywork, overhead charges in respect of recruitment, camp administration and welfare and insurances.
- iii. Supply, transport about the Site, use, maintenance and renewal of small tools used on Daywork, such as picks, shovels, barrows, trowels, hand saws, buckets, trestles, hammers, chisels and all Items of a like nature and not specifically referred to in the Items for Constructional Plant, and protective clothing.
- iv. All other costs which the Contractor may incur in the employment of labour including overheads, profit and any other costs or allowances.

C. Materials

Payment shall only be made for materials instructed by the Engineer for use on Dayworks. The net weights, volumes and areas as appropriate verified by the Engineer in accordance with their instructions shall be measured.

The rates for materials shall include for the cost of purchase or provision of the material, transport to Site and place of Daywork, storage, insurance, handling, placing, supervision, overheads, profit and any other costs or allowances.

1250 Measurement And Payment

Item		Unit
12.01	Land acquisition	
(a)	Arrange and pay compensation for acquisition of land for the permanent works.	Provisional sum
(b)	Allow for contractor's overheads and profits as a percentage of SUBITEM 12.01(a)	Percent (%)

The Provisional Sum shall be for reimbursement of the net cost for compensation and purchase of land subject to the agreement of the Engineer, and upon production of receipts.

The percentage inserted by the Contractor shall be for overheads and costs.

Item		Unit
12.02	Relocation of Services	
(a)	Arrange and pay for removal and/or alteration to services provided by agencies for electricity supply, water supply or telecommunication services.	Provisional sum
(b)	Allow for contractor's overheads and profits as a percentage of SUBITEM 12.02(a) percent (%)	Percent (%)

The Provisional Sum shall be for reimbursement of the net cost for arranging the removal or alteration of all existing services, such as drains, underground and overhead telephone and electricity lines,

ducts, poles, water mains, fittings, railway lines, etc. before any excavation or other work likely to affect the existing services is commenced. Payment is subject to the agreement of the Engineer, and upon production of receipts

The percentage inserted by the Contractor shall be for the Contractor's overheads and costs in making the arrangement, for co-ordinating the work and effecting payment.

Item		Unit
12.03	Provision Of Facilities For Other Contractors	
(a)	Use and maintenance of access roads, temporary works or equipment and other services, all at the instructions of the engineer.	Provisional sum
(b)	Allow for contractor's overheads and profits as a percentage of SUBITEM 12.03(a)	Percent (%)

SECTION 1300 Contractor's Establishment On Site & General Obligations

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1301 Scope

This Section covers the establishment of the Contractor's organisation, camp and constructional plant on the Site and their removal on completion of the Contract. It also covers payment for certain general obligations, risk and liabilities and general Items of cost not covered elsewhere.

1302 General Requirements

a. Camps, Construction Plant and Testing Facilities

The Contractor shall establish construction camps, offices, stores, workshops and testing facilities on the Site. The exact location of these facilities shall be approved beforehand by the Engineer. Accommodation, ablution and other facilities for site staff shall also be provided as required and the standard of accommodation and the location of all facilities shall comply with the requirements of the authorities concerned and those of the Engineer.

The requirements specified in CLAUSES 9104 to 9106 concerning preservation of landscape and trees shall be complied with when selecting sites for construction camps, offices, stores, workshops etc. This implies that it is undesirable to locate such facilities in woodland and forest areas requiring the felling of trees with a diameter of more than 0.25 metre in a height of 1.0 metre above ground level.

Before choosing the sites for work camps it shall be assured that waste and sewage cannot pollute the local water resources for instance by placing the work camps away from human habitation. Preferably work camps should be located more than 200 metres from larger water courses. However riparian land may be government owned and the Contractor must determine the actual distance by reference to the local relevant Authority in charge of water resources and other relevant Government Officers responsible for the project area. The Environmental Management Plan must take full account of the impact of temporary and permanent works upon the drainage systems affected by the works.

The Contractor shall only be regarded as fully mobilised after establishment of all camps, offices, stores, workshops etc., and bringing all necessary constructional plant and personnel to the Site. On completion of the work and after receiving approval in writing from the Engineer, all construction plant, buildings, fencing and other temporary structures shall be removed and the camp site shall be restored to its original condition and left in a neat and tidy condition.

b. Building Regulations

All buildings erected by the Contractor on the site and camp site or sites and the layout thereof shall comply with the Laws of Kenya and all By-Laws in so far as they are applicable.

c. Sign Boards

The Contractor shall provide, erect and maintain signboards to the layout, colours and dimensions shown on the Drawings. The signboards shall be erected at locations to be selected by the Engineer.

The signboards shall be erected within one month of the date of commencement of the Contract. The Contractor shall remove the signs at the end the Defects Notification Period.

d. Maintenance During Construction

During construction, the Contractor's camps, staff living quarters and other facilities shall be maintained in a neat and tidy condition.

e. Legal And Contractual Requirements and Responsibility to the Public

The Contractor shall take all necessary steps to comply with the Conditions of Contract, particularly in respect of the insurances and sureties required and general obligations to the public and the Employer. The Contractor shall comply with all the regulations of statutory bodies.

f. Liaison with Government and Police Officials

The Contractor shall consult and keep in close contact with the Police and other Government officials of the area regarding their requirements in the control of traffic and other matters and shall provide all assistance or facilities which may be required by such officials in the execution of their duties.

1303 Contractor's Offices, Stores, Workshops, Camps, Etc.**a. General**

It is entirely the Contractor's responsibility to obtain land or make whatever arrangements with Land Owners or Legal Occupiers regarding use of land for the purpose of erecting offices, stores, workshops, garages, stockpiling of materials, camps and quarters for housing of labour and staff, welfare facilities, etc, including land required for the Engineer's accommodation, offices and laboratory as specified in SECTION 1400. All costs incurred in connection with obtaining, leasing or renting such land shall be at the Contractor's expense.

Offices for the Contractor's supervisory staff and administration, stores, workshop, camps etc. shall be erected by the Contractor at their own expense at a location to be agreed upon with the Engineer.

Before giving such approval, the Engineer will give particular attention to the temporary and permanent effects of the proposed activities on the drainage of the area and the Contractor's proposals for reinstatement.

b. Contractor's Offices, Stores and Workshops

The Contractor shall provide and maintain at an approved location a suitable main office together with such site offices as may be necessary for the efficient control of the Works. The Contractor shall also provide and maintain on approved sites sufficient suitable stores, tanks and workshops for the proper storage of materials, fuel, plant and equipment and the efficient maintenance of all such plant and equipment.

The stores shall be of such size and construction as to provide adequate storage and protection for stocks of materials, fuel, spares and the like in quantities ensuring uninterrupted progress of the work. The workshops shall be suitably equipped for carrying out routine maintenance, major repairs, overhaul or modification of all plant and equipment as necessary for execution of the Works and other work connected with the permanent work.

c. Contractor's Quarters and Camps

The Contractor shall provide, erect, maintain and clear away on completion all quarters and camps for staff and labour necessary for the efficient control and execution of the Works. Suitable, sufficient and properly equipped messing, cooking and sanitary accommodation, an adequate supply of clean water, proper disposal of refuse and sewerage and sufficient labour in attendance shall be provided. The Contractor shall be responsible for meeting the requirements of the local authorities, labour officers and other officers regarding the camp accommodation, sanitation and messing facilities for the entire workforce and provide the staff necessary for proper control and supervision.

All sites selected by the Contractor for the erection of offices, stores, workshops, quarters, camps and the like are subject to the prior approval of the Engineer. The Contractor shall, by notice in writing, indicate their requirements for sites well in advance in order that the Engineer may assess the impact on local communities and businesses and engage relevant stakeholders.

d. First aid

The Contractor shall provide, equip and maintain adequate first-aid stations throughout the Works, and erect conspicuous notice boards indicating where these are situated and provide all requisite transport for employees requiring medical attention. The Contractor shall comply with the government medical or labour requirements at all times and provide, equip and maintain first aid stations where directed and at all times have experienced first-aid personnel available throughout the Works for attending minor injuries.

1304 Measurement and Payment

Compliance with the requirements, performance of all work, furnishing of all equipment, materials, including water, labour, tools and incidentals necessary to complete the work prescribed in this CLAUSE shall not be measured for direct payment but shall be considered as an obligation of the Contractor covered under the prices quoted for other Bill Items.

Item	Unit
13.01 Contractor's General Obligations	
(a) Fixed Obligations	Lump sum
(b) Value-related Obligations	Lump sum
(c) Time-related Obligations	Month

Payment of the lump sums tendered under SUBITEMS (a), (b) and (c) shall, for the three SUBITEMS together, include full compensation for all the Contractor's charges in respect of the following Items, collectively termed the "Contractor's General Obligations":

- i. Setting up and maintaining their organisation, camps, accommodation and construction plant on the site and their removal on completion of the Contract.
- ii. Complying with the requirements of the General Conditions of Contract and SECTION 1200, including all necessary insurances and providing the sureties required.
- iii. All general site and office overheads, profit, financing costs, risks, legal and contractual responsibilities and other costs and obligations of a preliminary or general nature which are not specifically measured for payment under any other Items of payment.

The lump sum tendered under SUBITEM 13.01(a) above shall represent full compensation for the fixed part of the Contractor's general obligations, i.e. that part which is substantially fixed and is not a function of the time required for the completion of the Contract or of the value of the work. This lump sum shall not be subject to variation.

Payment of the lump sum tendered under SUBITEM 13.01(a) will be made in three instalments, as follows:

1. The first instalment, 50 % of the lump sum, will be paid in the first payment certificate after the Contractor has met all obligations under this section and has made a substantial start with construction in accordance with the approved programme.
2. The second instalment, 35 % of the lump sum, will be paid when the value of the work done reaches one half of the tendered amount, excluding contingencies and price adjustments in terms of the General Conditions of Contract.
3. The third and final instalment, 15 % of the lump sum, will be paid when the Works have been completed and the Contractor has fulfilled all the requirements of this section.

Before any payment is made under this item, the Contractor shall satisfy the Engineer that the Contractor has provided camps and constructional plant of good quality on the site, the value of which exceeds that of the first instalment.

The Contractor may also be required to furnish documentary proof that they owns the camps and constructional plant on the site, the value of which shall exceed that of the first instalment.

In the event of the Contractor not being able to satisfy the Engineer as to the ownership of the camps and constructional plant, the Engineer shall have the right to withhold parts of any payments to be made under this item, until the Works have been completed.

The lump sum tendered in SUBITEM 13.01(b) shall include full compensation for that part of the Contractor's general obligations which is a function of only the value of the Works, but not of the period of completion of the Works. Should the final value of the Works (excluding any contract price and special material adjustment payments made in terms of the Contract Documentation) increase or decrease in relation to the tendered contract price (less any allowances, if any, in the tendered contract price for contract price adjustment and special material adjustment payments), the lump sum for ITEM 13.01(b) will be increased or decreased accordingly pro rata. The adjusted lump sum will be the full settlement of any difference in value-related general obligations resulting from an increased or decreased value of the work.

Payment of this lump sum will be made in instalments in each payment certificate (usually issued monthly). The value of each instalment will be in proportion to the value of Work done up to the date that the payment certificate is prepared (excluding the value of any price adjustments made in terms of the Contract Documentation).

The tendered rate per month for SUBITEM 13.01(c) represents full compensation for that part of the Contractor's general obligations, which are mainly a function of construction time. The tendered sum will be paid monthly, pro rata for parts of a month, from the date on which the Contractor has received a written instruction, in terms of the General Conditions of Contract, to start the work until the end of the period for completion of the Works, plus any extension thereof as provided for in the General Conditions of Contract, provided that:

- a. Should the works be certified as having been completed before the contractual date for completion of the Works, the Contractor will then be entitled to payments in regard to the unexpired period for completion;
- b. Should the progress of the Contractor in terms of the value of work done be in arrears in regard to their approved original programme, payments in respect of this Item may be limited to payments for that period, which, in this original programme (after suitable adjustments in respect of the extension of time granted) agree with the actual value of work done.

Adjustments to SUBITEMS 13.01 (b) and (c) will be made only if the value of the work or the period for completion vary by the % provided in the Conditions of Contract and it is agreed that such adjustments will be in full settlement of the changed compensation for amended general obligations.

SECTION 1400 Engineer's Site Establishment

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1401 Scope

The section covers the provision of accommodation and facilities for the Engineer, their supervisory staff and for the Employer.

1402 Facilities for the Engineer

a. General

The Contractor shall provide and maintain offices, houses, site cabins, vehicles, survey equipment etc. for the Engineer, their staff and for the Employer. Materials and workmanship shall be to generally recognised standards for permanent buildings of this type. Detailed drawings showing the design, the construction details, the type of materials proposed and their characteristics, shall be submitted by the Contractor for the Engineer's approval, which shall be obtained before starting the construction of the office or houses or ordering the relevant materials.

All buildings for accommodation, offices and laboratories shall be constructed using approved materials. Materials containing asbestos, radioactive materials and other materials that are harmful to the environment shall not be used.

The Contractor may provide rented accommodation subject to the approval of the Engineer if available properties exist at suitable locations.

The Contractor shall provide the buildings with potable water, electricity, sanitary installations, sewage disposal arrangements, air-conditioning, furniture and equipment, and shall maintain them, all to the satisfaction of the Engineer 24 hours of the day during the Contract Period.

All facilities shall conform to the best standards for the required types. The facilities described herein shall be understood to represent the minimum requirements. The Contractor shall provide all additional incidentals necessary, so that the facilities will be completely adequate and satisfactory in every respect for the intended use. All equipment and furniture shall be new and unused when initially put in place.

The Contractor shall maintain, replace and/or restore as directed any facilities or parts thereof that become damaged, worn out, lost or stolen, except through causes due to negligence of the occupying Engineer's staff. The Contractor shall also provide an adequate stock of all expendable items, such as light bulbs, light tubes, kitchenware, soap, towels, toilet paper, paper towels, drinking cups, materials and accessories and at all times ensure proper and continuing functioning of all components and parts of the Engineer's houses and office.

The houses, offices and installations, etc. including all required equipment to be provided under this Contract shall be handed over to the Engineer in finished and fully habitable condition not later than 90 days after the Engineer's order to commence Work (according to the relevant clause of the Conditions of Contract) and such buildings shall be to the entire satisfaction of the Engineer. Suitable temporary office and residential accommodation for the Engineer and their staff shall be provided from the date of the order to commence the Works until such time as the permanent office and residential accommodation are available for use.

b. Siteworks for “Engineers Compound”

The houses and buildings shall be sited within the “Engineer's Compound” to the satisfaction of the Engineer. The Type I, II and III houses shall be placed on separate plots of approximately 0.1 hectares each. The location of the houses shall be separate from that of the Contractor's staff housing.

Access roads of 3 m width shall be provided for each house and shall be surfaced with at least 150 mm consolidated thickness of gravel properly graded, cambered, drained and provided with culverts where required.

The Contractor shall be responsible for raising the ground (if necessary), grading and drainage in the vicinity of each facility, with suitable access walkways, gravelling, seeding and sodding of the ground, all as directed and approved by the Engineer. Also, the Contractor shall construct a roofed parking area for the Engineer near the buildings, large enough for 8 vehicles, and a satisfactory access road to the parking area. The ground around the buildings, the parking area and the access road shall be raised high enough for them not to be inundated during the rainy season.

Outside lighting around the buildings and on the parking area shall be installed to the satisfaction of the Engineer and appropriate signs shall be erected to inform the public of the purpose of the facilities.

The whole of the “Engineer's Compound” shall be fenced with chain link fencing (or equivalent) 2.0 m high with necessary gates complete with padlock and chain as directed by the Engineer. The Contractor shall be responsible for the security of the compound and shall provide such gatemen and watchmen, etc., as required to ensure this security.

c. Construction

The housing shall consist of concrete block masonry or prefabricated units on concrete floors raised not less than 150 mm above natural ground level.

The roofs shall be constructed from aluminium or corrugated iron roof sheeting and the roof space between the sheeting and the ceilings shall be adequately ventilated and the openings shall be screened with mesh screening to prevent the entry of vermin, etc. into the roof space.

The ceilings shall not be less than 2.8 m inside height and shall be of 10 mm hard boarding or similar approved materials.

Air conditioners shall be wall mounted - not window mounted.

Internal wall partitions shall be of timber framed construction lined both sides. All doors shall be of flush timber type, plywood faced and a minimum size of 2.0 m x 0.80 m. All timber construction shall be termite proofed.

The windows shall be dust proof, of aluminium framing with glass tightly fitted or similar approved and shall be located in the design to provide the maximum amount of cross ventilation.

The kitchens shall be equipped with adequate benches, wall cupboards and shelves and with a stainless steel double sink with hot and cold running water built into a special sink cabinet.

The bedrooms shall be provided with built in wardrobes and wall mirrors.

Bathrooms shall be provided with western flush type WC with hinged cover, shower with hot and cold running water and soap dish on wall, wash basin with hot and cold running water, and wall mirror with light above.

Toilets shall be provided with western flush type WC with hinged cover, wash basin with hot and cold running water and wall mirror with light above.

d. Finishing

All external walls and doors shall be provided with one prime coat, one undercoat and two finishing coats of gloss paint. Internal walls, doors and ceilings shall be painted with one prime coat, one undercoat and two finishing coats of emulsion paint. All paint shall be from an approved manufacturer. The concrete floor shall be covered with an approved type of floor tiles or sheeting.

All windows and doors shall be burglar-proofed and insect-screened to the satisfaction of the Engineer.

e. Services

The Contractor shall provide, maintain and install the following services to the Engineer's approval:

- i. Adequate piped supply of clean potable water connected to toilets, bathrooms and kitchens in each house.
- ii. An automatic 270 litre electric immersion water heater or an equivalent instant water heating system in each house Types I-III (see below) connected to the piped water supply.
- iii. 240 Volt, 50 cycle A.C. electricity supply with sufficient wiring, light fittings and socket outlets in each house. The power shall be adequate to operate the electrical equipment specified. Socket outlets shall be provided in each room to the Engineer's approval.
- iv. Suitable soil and wastewater drainage
- v. Water borne sewage disposal
- vi. Rubbish disposal by providing outside bins and a daily collection service to a central disposal area.

1403 Houses For The Engineer

a. General

Upon completion of the Contract, the houses, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay Items in CLAUSE 1411 are invoked in the Special Specifications.

b. Furniture and Equipment

The general description of the type of houses to be supplied is as follows:

i. Type I House

As illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 150 m² complete with furnishings and equipment as listed in TABLE 1403/1. The cost of providing the houses, furnishings, equipment, water, electrical supply, drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/1: TYPE I HOUSE FURNITURE AND EQUIPMENT	
New Furniture and Equipment, to the Approval of the Engineer	Units
Furniture	
Kitchen table	1 No.
Kitchen chair	2 No.
Dining table	1 No.
Dining chairs	6 No.
Dining chairs with arms	2 No.
Writing desk (3 drawers)	1 No.
Bookshelf	1 No.
Settee (3 cushions)	1 No.
Easy chairs	4 No.
Coffee tables	2 No.
Sideboard	2 No.
Beds, single with inner-spring mattress	3 No.
Beds, double with inner-spring mattress	2 No.
Pillows	10 No.
Side tables	5 No.
Dressing tables with mirrors	2 No.
Dressing table stools	2 No.
Chest of drawers	3 No.
Bedside chairs	5 No.
Bathroom cabinet with mirror	1 No.
Bathroom stool	1 No.
Floor rugs	5 No.
Equipment, bed linen and towelling	
Air Conditioner 12,000 BTU/hr	4 No.
75 inches Smart Television with internet connection capabilities	1 No.
Refrigerator min. 0.40 m ³ (Electric frost-free)	1 No.
Electric or gas cooker with 4 burners, separate grill and oven	1 No.
Fume hood	1 No.
Water filter	2 No.
Dust bin metal with lid (outdoor type)	3 No.
Door mats	2 No.
Vacuum Cleaner (electric)	1 No.
Ceiling Fans	3 No.
Set of 8 pieces crockery, cutlery, glassware	1 Set.
Set of kitchen utensils	1 Set.
Set of pots, pans, etc.	1 Set.
Deep-freeze cabinet 0.40 m ³	1 No.
Water cooler / dispenser	1 No.
Fire extinguisher	2 No.
Standard lamps	2 No.
Table Lamps	2 No.

TABLE 1403/1: TYPE I HOUSE FURNITURE AND EQUIPMENT	
New Furniture and Equipment, to the Approval of the Engineer	Units
Toilet Tissue Holders	2 No.
Waste Baskets	5 No.
Mixer (Electric Portable)	1 No.
Bedside lights	5 No.
Wall lights	6 No.
Curtain rods	all windows
Curtains	all windows
Bed sheets	20 No.
Pillow cases	10 No.
Duvet sets (cover and inner)	10 No.
Towel rails	2 No.

ii. Type II House

As illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 130 m² complete with furnishings and equipment as listed in TABLE 1403/2. The cost of providing the house, furnishings, equipment, water, electrical supply drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/2: TYPE II HOUSE FURNITURE AND EQUIPMENT	
New Furniture and Equipment, to the Approval of the Engineer	Units
Furniture	
Kitchen table	1 No.
Kitchen chair	2 No.
Dining table	1 No.
Dining chairs	4 No.
Dining chairs with arms	2 No.
Writing desk (3 drawers)	1 No.
Bookshelf	1 No.
Settee (3 cushions)	1 No.
Easy chairs	2 No.
Coffee tables	2 No.
Sideboard	1 No.
Beds, single with inner-spring mattress	3 No.
Beds, double with inner-spring mattress	1 No.
Pillows	8 No.
Side tables	4 No.
Dressing tables with mirrors	1 No.
Dressing table stools	1 No.
Chest of drawers	2 No.
Bedside chairs	4 No.
Bathroom cabinet with mirror	1 No.
Bathroom stool	1 No.
Floor rugs	4 No.

TABLE 1403/2: TYPE II HOUSE FURNITURE AND EQUIPMENT	
New Furniture and Equipment, to the Approval of the Engineer	Units
Equipment, bed linen and towelling	
Air Conditioner 12,000 BTU/hr	2 No.
65 inches smart television with internet connection capabilities	1 No.
Refrigerator min. 0.40 m ³ (Electric frost-free)	1 No.
Electric or gas cooker with 4 burners, separate grill and oven	1 No.
Fire extinguisher	2 No.
Fire axe	1 No.
Fume hood	1 No.
Vacuum cleaner (electric)	1 No.
Mixer (electric portable)	1 No.
Water Filter	1 No.
Dust bin metal with lid (outdoor type)	1 No.
Door mats	2 No.
Ceiling fans	2 No.
Set of 6 pieces crockery, cutlery, glassware	1 Set.
Set of kitchen utensils	1 Set.
Set of pots, pans, etc.	1 Set.
Deep-Freeze cabinet 0.40 m ²	1 No.
Water cooler / dispenser	1 No.
Standard lamps	2 No.
Bedside lights	4 No.
Wall lights	5 No.
Curtain rods	all windows
Curtains	all windows
Bed sheets	16 No.
Pillow cases	8 No.
Duvet sets (cover and inner)	8 No.
Towel rails	2 No.
Table lamps	1 No.
Toilet tissue holders	1 No.
Waste baskets	4 No.

iii. Type III House

As illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 70 sq. m. complete with furnishings and equipment as listed in TABLE 1403/3. The cost of providing the house, furnishings, equipment, water, electrical supply, drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/3: TYPE III HOUSE FURNITURE AND EQUIPMENT	
New Furniture and Equipment, to the Approval of the Engineer	Units
Furniture	
Kitchen table	1 No.
Kitchen chair	2 No.

TABLE 1403/3: TYPE III HOUSE FURNITURE AND EQUIPMENT	
New Furniture and Equipment, to the Approval of the Engineer	Units
Dining table	1 No
Dining chairs	4 No.
Writing desk (2 drawers)	1 No.
Book shelf	1 No.
Settee (3 cushion)	1 No.
Easy chairs	2 No.
Coffee table	1 No.
Sideboard	1 No.
Beds, single with inner-spring mattresses	2 No.
Pillows	2 No.
Side table	1 No.
Dressing table	1 No.
Dressing table stool	1No.
Chest of drawers	1 No.
Bathroom cabinet with mirror	1 No.
Bathroom stool	1 No.
Floor rugs	4 No.
Bathroom cabinet with mirror	1 No.
Bathroom stool	1 No.
Floor rugs	4 No.
Equipment, bed linen and towelling	
Air Conditioner 12,000 BTU/hr	2 No.
50 inches Smart Television with internet connection capabilities	1 No.
Refrigerator min. 0.40 m ³ (Electric frost-free)	1 No.
Electric or gas cooker with 2 burners, separate grill and oven	1 No.
Fire extinguisher	1 No.
Fire axe	1 No.
Fume hood	1 No.
Vacuum cleaner (electric)	1 No.
Water filter	1 No.
Dust bin metal with lid (outdoor type)	1 No.
Door mats	2 No.
Ceiling fans	2 No.
Set of 4 pieces crockery, cutlery, glassware	1 Set.
Set of kitchen utensils	1 Set.
Set of pots, pans, etc.	1 Set.
Water cooler / dispenser	1 No.
Standard lamps	1 No.
Bedside lights	2 No.
Wall lights	3 No.
Curtain rods	all windows
Curtains	all windows
Bed sheets	8 No.
Pillow cases	4 No.

TABLE 1403/3: TYPE III HOUSE FURNITURE AND EQUIPMENT	
New Furniture and Equipment, to the Approval of the Engineer	Units
Duvet sets (cover and inner)	4 No.
Towel rails	1 No.
Toilet tissue holders	1 No.
Waste baskets	2 No.

iv. Multiple Living Accommodation Type IV

Each unit as illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 17 sq. m. complete with furnishings and equipment as listed in TABLE 1403/4. The cost of providing the house, furnishings, equipment, water, electrical supply, drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/4: TYPE IV MULTIPLE LIVING ACCOMMODATION	
New Furniture and Equipment, to the Approval of the Engineer	Units
Furniture	
Kitchen table	1 No.
Kitchen chair	4 No.
Sideboard	2 No.
Beds, single with inner-spring mattresses	2 No.
Pillows	4 No.
Side table	1 No.
Bathroom cabinet with mirror	1 No.
Bathroom stool	1 No.
Equipment, bed linen and towelling	
Air Conditioner 12,000 BTU/hr	2 No.
32 inches Smart Television with internet connection capabilities	2 No.
Refrigerator min. 0.40 m ³ (Electric frost-free)	2 No.
Electric or gas cooker with 2 burners, separate grill and oven	1 No.
Fire extinguisher	1 No.
Water filter	1 No.
Dust bin metal with lid (outdoor type)	1 No.
Door mats	2 No.
Ceiling fans	1 No.
Set of 8 pieces crockery, cutlery, glassware	1 Set.
Set of kitchen utensils	1 Set.
Set of pots, pans, etc.	1 Set.
Water cooler / dispenser	1 No.
Curtain rods	all windows
Curtains	all windows
Bed sheets	4 No.
Pillow cases	4 No.
Duvet sets (cover and inner)	2 No.
Towel rails	1 No.
Toilet tissue holders	1 No.
Curtains	all windows

TABLE 1403/4: TYPE IV MULTIPLE LIVING ACCOMMODATION	
New Furniture and Equipment, to the Approval of the Engineer	Units
Bed sheets	8 No.
Pillow cases	4 No.
Duvet sets (cover and inner)	4 No.
Towel rails	1 No.
Toilet tissue holders	1 No.

v. Multiple Living Accommodation Type V

Each block of 3 units as illustrated in the Drawings or described in the Special Specifications having an internal floor area of approximately 17 sq. m. complete with furnishings and equipment as listed in TABLE 1403/5. The cost of providing the house, furnishings, equipment, water, electrical supply, drainage and maintenance during the whole period of the Contract shall be deemed to be included in the Bill of Quantities.

TABLE 1403/5: TYPE IV MULTIPLE LIVING ACCOMMODATION	
New Furniture and Equipment, to the Approval of the Engineer	Units
Furniture	
Beds, single with mattresses	1 No.
Pillows	2 No.
Coffee table	1 No.
Chair	1 No.
Wall mirror	1 No.
Equipment, bed linen and towelling	
Air Conditioner 12,000 BTU/hr	1 No.
24 inches Smart Television	1 No.
Fire extinguisher	1 No.
Electric or gas Cooker with 1 burner	1 No.
Water filter	1 No.
Water cooler / dispenser	1 No.
Dust bin metal with lid (outdoor type)	3 No.
Door mats	2 No.
Ceiling fans	1 No.
Set of 8 pieces crockery, cutlery, glassware	1 Set
Set of kitchen utensils	1 Set
Set of pots, pans, etc.	1 Set
Curtain rods	all windows
Curtains	all windows
Bed sheets	2 No.
Pillow cases	2 No.
Duvet sets (cover and inner)	2 No.
Towel rails	1 No.
Toilet tissue holder	1 No.

c. Rented Accommodation

Where rented accommodation is provided it shall be at least equivalent to that detailed in Section (b) above in size, number of rooms etc. All the furniture and equipment detailed in (b) shall also be provided.

1404 Office For The Engineer

a. General

Upon completion of the Contract, the Engineer's office buildings, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay Items in **CLAUSE 1411** are invoked in the Special Specifications.

The Contractor shall provide, furnish and maintain office accommodation for the Engineer as detailed hereunder.

The Site office shall be erected at a location to be agreed with the Engineer. The plot shall not be less than 0.3 hectares in area and shall be fenced with a 2.0 m high chain link fence and a lockable gate.

The office shall be provided with a constant supply of electricity sufficient for all electrical equipment installed including lighting, all to the satisfaction of the Engineer.

A broadband internet communication system shall be provided with a dedicated bandwidth as described in the Special Specification for the sole use of the Engineer. The system may be shared with the Contractor provided there is sufficient capacity at all times for the Engineer's requirements. At least two (2 no.) satellite telephones and ten (10 no.) mobile telephones shall be provided. If no cell system is available at the site the Contractor will establish a radio communication network around the site. The Contractor's network shall be made available to the Engineer. The Contractor shall pay all charges associated with the Engineer's electricity supply, broadband internet and telephone/fax including toll calls lawfully demanded by the electricity authority and the telecommunication service throughout the Contract Period.

The Contractor shall provide an access road at least 3.0 m wide to the Engineer's office and parking area for 10 cars. The road and car park shall be surfaced with a minimum of 150 mm compacted thickness of gravel.

The office shall be erected and handed over to the Engineer fully furnished and equipped, within three months from the date of the Engineers order to commence work.

b. Construction

The office shall be dimensioned as shown in the Drawings with a minimum of 2.8 m headroom internally, complete with ceiling, smooth concrete, ceramic tiles or wooden floor and a 2.7 m wide covered veranda extending along the full length of the front. The rooms shall be adequately ventilated and well lit.

The roofs shall be constructed from aluminium or corrugated iron roof sheeting and the roof space between the sheeting and the ceilings shall be adequately ventilated and insulated and the openings shall be screened with mesh screening to prevent the entry of vermin, etc. into the roof space.

Internal wall partitions shall be timber framed and lined both sides. All doors shall be of flush timber type, plywood faced and a minimum size of 2.0 m x 0.80 m. All external doors shall be provided with cylinder locks with three keys, or equivalent as approved by the Engineer. All external walls and doors shall be provided with one prime coat, one undercoat and two finishing coats of gloss paint. Internal walls, doors and ceilings shall be painted with one prime coat, one undercoat and two finishing coats of emulsion paint. All paint shall be from an approved manufacturer.

c. Furniture and Equipment

The Site office for the Engineer shall be complete with furnishings and equipment as listed in **TABLE 1404/1**.

TABLE 1404/1: OFFICE FOR ENGINEER

New Furniture and Equipment, to the Approval of the Engineer	Units
Furniture	
Conference table 3.0 m x 2.4 m with 8 chairs	1 No.
Table 1.5 m x 0.75 m with minimum 2 drawers	8 No.
Chairs with arms	8 No.
Visitor's chairs	16 No.
Computer work station	3 No.
Ceiling fans	6 No.
Air conditioners 12,000 BTU/hr.	4 No.
Refrigerator min. 0.40 m ³ (Electric frost-free)	1 No.
Water cooler / dispenser	1. No.
Dust bin metal with lid (indoor type)	8 No.
Dust bin metal with lid (outdoor type)	3 No.
Door mats	2 No.
Vacuum cleaner (electric)	1 No.
Ceiling fans	3 No.
Set of 8 pieces crockery, cutlery, glassware	1 Set
Set of kitchen utensils	1 Set
Personal computers in number and equipped as specified in Special Specification	
Laptop computers in number and equipped as specified in Special Specifications.	
A3 laser printer or equivalent, compatible with the above personal computer with supply of A4 and A3 paper and consumables, as specified and number as in Special Specifications.	
Colour printer inkjet or equivalent compatible with above laptop computer with supply of A4 paper and consumables, in number and as specified in Special Specifications.	
UPS (Uninterruptable Power Supply) with surge protector, capable to support and back-up all computer equipment as specified in Special Specifications.	
Computer software complete with manuals as specified in Special Specifications.	
Smart television set minimum size 75 inches with internet connectivity capabilities as specified in the Special Specifications.	
Safe for cash and valuables, min. size 0.8 m x 0.5 m x 0.4 m, to be concreted in place (either wall or floor mounted) complete with lock and keys	1 No.
Two drawer steel lockable filing cabinet	1 No.
Electronic calculators, in number and type as specified in Special Specifications	
Fire extinguisher, type as specified in Special Specifications	3 No.
First aid kits	2 No.
Snake bite kit	1 No.
Stapling machines	8 No.
Paper punches	8 No.

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TABLE 1404/1: OFFICE FOR ENGINEER	
New Furniture and Equipment, to the Approval of the Engineer	Units
Binding machine	1 No.
A3 size photocopy machine with accessories and supplies as specified in Special Specifications	1 No.
Single side band multi-channel radio communication equipment of minimum 2,500 km range together with free standing antenna of appropriate heights and one set of matching crystals with that of the Employer's communication system, base and mobile sets in number and as specified in the Special Specifications.	
Water filters	4 No.
Thermos jug 4.5 litres capacity	8 No.
Tea cups	12 No.
Water glasses	12 No.
Coffee cups	12 No.
All other office equipment necessary including stationery, as specified in the Special Specifications.	

The Site office shall be connected to a water and an electricity supply. The Contractor shall be responsible for cleaning and maintaining the office and toilets and shall provide soap, towels and all necessary fittings and cleaning materials.

1405 Wash House

The Contractor shall provide a Washhouse comprising two rooms of 20 m² each with electricity, water, wastewater outlet and water borne sewage disposal and equipped with two automatic washing machines, two stainless steel tubs with hot and cold running water and automatic electric water heater, all to the approval of the Engineer.

The cost of providing the house, furnishing, equipment, water, electrical supply and maintenance during the whole period of the Contract shall be deemed to be included in the rates the Bill of Quantities.

Upon completion of the Contract, the Engineer's wash house, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay Items in **CLAUSE 1411** are invoked in the Special Specifications.

1406 Site Cabin / Office

The Contractor shall, if instructed by the Engineer, provide and maintain during the duration of the Contract portable site cabins. Each site cabin shall have a floor area of at least 10 m² and shall be equipped with one bedstead including mattress, blankets, pillows, bed sheets, one wardrobe, one desk with drawers, one metal cabinet, shelves, two chairs and a small gas refrigerator. These units shall be positioned always close to the Work and moved from one location to another by the Contractor as may be directed by the Engineer. The Contractor shall supply the units with light, potable water if possible and sanitary facilities.

The cost of providing the Site Cabins furnishing, equipment, water, electrical supply (where available), moving the site cabins to different locations and maintenance during the whole period of the Contract shall be deemed to be included in the price inserted in **ITEM 14.04** of the Bill of Quantities.

Upon completion of the Contract, the Engineer's site cabin/office, furniture, equipment and services specified herein shall revert to either the Contractor or the Employer depending on which of the pay Items in **CLAUSE 1411** are invoked in the Special Specifications.

1407 Vehicles For The Engineer And Employer

The Contractor shall provide new diesel propelled vehicles or equivalent as listed below licensed and comprehensively insured for replacement value and shall maintain and provide fuel, oil and replacement parts during the whole of the Contract period. The vehicles shall be for the exclusive use of the Engineer, their staff and the Employer during the Contract period. The quantities of vehicles to be supplied shall be as defined in the Special Specifications. The Contractor shall insure the vehicles and passengers fully comprehensively for any driver at all times throughout the Contract Period.

- a. 4 Wheel Drive Station Wagon with a minimum engine cubic capacity of 3.2 litres
- b. 4 Wheel Drive Pickup, with double cabin with a minimum engine cubic capacity of 2.8 litres
- c. 4 Wheel Drive Pickup, with single cabin with a minimum engine cubic capacity of 2.8 litres
- d. 2 wheel drive saloon vehicle with a minimum engine capacity of 1.8 litres
- e. 2 wheel drive 11-seater van with a minimum engine capacity of 1.8 litres.

The vehicles shall have factory installed air-conditioning units and power steering. The vehicles shall have diesel-engines and be provided with the following optional equipment, factory installed seat belts, rear pintle hook, front hook, door mirrors, two spare wheels, toolbox with necessary tools, jack etc. Makes of vehicles shall be approved by the Engineer prior to ordering.

The Contractor shall service and maintain in good working order the vehicles at all times. In the event of any vehicle being unavailable for the use due to accident, damage or its being maintained or repaired, the Contractor shall immediately provide a substitute acceptable to the Engineer.

In the event of the Contractor defaulting on this obligation, the Engineer shall be authorised to hire a substitute similar vehicle for the period of non-availability of the Contractor's vehicles, and the cost incurred will be recovered from the Contractor.

Upon completion of the Contract, the Engineer's vehicles specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in **CLAUSE 1411** are invoked in the Special Specifications.

1408 Attendance Upon The Engineer

a. Staff

The Contractor shall provide night and day watchmen, gardeners, labourers, cleaners and sanitary staff as well as all necessary cleaning materials as may be required by the Engineer to keep the offices, the laboratory and houses in first class condition.

b. Stationery

The Contractor shall provide any stationery required for the office and laboratory of the Engineer.

c. Assistance to the Engineer

The Contractor shall provide all assistance such as labourers, all tools and protective clothing, wooden pegs, iron pins and pickets, water, cement and aggregate for concreting, transport for labour and materials, as may be required by the Engineer and their staff for checking, setting out, surveying and measuring and testing the work.

d. Payment

No separate payment will be made for attendance upon the Engineer the relevant cost being included by the Contractor in rates in the Bill of Quantities or elsewhere. If the Contractor fails in any obligations under this Specification, the Engineer is authorised to employ any staff and/or labourer and to buy any material, as mentioned above, and the costs incurred will be recovered from the Contractor.

1409 Provision Of Survey Equipment

The Contractor shall provide at all times during the period of the Contract all such workforce and instruments for the exclusive use of the Engineer as they may deem to be necessary for carrying out their duties in connection with the Contract. The workforce shall be selected for their survey skills and must be able to communicate at an adequate level in both written and spoken English. As far as possible the same employees shall be provided throughout the period of the Contract.

The instruments to be provided include those given in TABLE 1409/1 or equivalent as specified in Special Specifications:

TABLE 1409/1: NEW SURVEY EQUIPMENT	
For the Approval of the Engineer	Units
GNSS Equipment (Base and Rover) plus data collector, chargers, roving pole and all other related accessories. (Recent model-not more than 5 years) Dual frequency, Internal and external radio, Static and RTK Modes	1 Set.
Tripod	2 No.
Tribrach	2 No.
Total Station Instrument with 1" accuracy, dual axis tilt sensor and collimation compensation plus	3 No
2.6 m tracking poles	1 No.
5.0 m tracking pole with all accompanying prisms. (recent model-not more than 5 years)	1 No.
1 sec accuracy, double face, downloading cable and software/USB port	1 No.
Spare batteries	2 No.
Rapid charger	1 No.
Digital Level Instrument plus accessories including	2 No.
5 m barcoded levelling staff and	1 No.
Aluminium fibre telescopic tripod (recent model-not more than 5 years)	2 No.
Downloading cable and software/USB port	2 No.
Spare batteries	4 No.
Rapid charger	2 No.
Handheld GNSS Data Collector 1.0 GHz processor, 256 mb RAM, 4GB storage (recent model-not more than 5 years)	2 No.
Scientific calculators	4 No.
Two-way Communication Radio (Walkie Talkie) with 16 memory channels, 50CTCSS/105 CDCSS	2 sets.
Heavy duty Tripods	4 No.
Digital levelling staves 5 m (foldable)	4 No.
GPS/motion sensor	4 No. watch
Steel white face tape 50 m	4 No.
Steel tape 25 m	4 No.
200 m range laser distance measuring machine	1 No.
100 m steel band tape	5 No.
Fibre-glass tapes 50 m	4 No.
30 m linen tape	2 No.
Ranging rods 3 m (metal, joinable)	6 No.
Reflectors with mounts	3 No.
Triple prism mount with reflectors	2 No.
Steel hammers (2kg)	4 No.

TABLE 1409/1: NEW SURVEY EQUIPMENT	
For the Approval of the Engineer	Units
Mattock	2 No.
Spirit levels for staves	4 No.
Surveying umbrella	2 No.
Reflective road safety vests	12 No.
Scale rules	2 No.
Drawing pen 0.25 mm	2 No.
Graph paper A3 size 1 mm	1 Roll

The Contractor shall be solely responsible for the maintenance of all such instruments and shall ensure that they are at all times in good condition and adjustment. Repairs shall only be carried out by persons or organisations approved by the Engineer.

Supply of miscellaneous survey items (e.g. spray paint, beacon materials, spades, axes, safety/fieldboots, assistants, drawing equipment, approved surveying forms A4 size and field-surveying books).

Upon completion of the Contract, the Engineer's survey equipment specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in **CLAUSE 1411** are invoked in the Special Specifications.

1410 Laboratory For The Engineer

a. General

The Contractor shall provide, erect and maintain for the duration of the Contract a laboratory adjacent to the Engineers Representative's office or where directed by the Engineer.

The laboratory shall be for the sole use of the Engineer and shall be dimensioned as shown in the Drawings or described in the Special Specifications with a minimum of 2.8 m headroom internally complete with ceiling, smooth concrete floor and a 5 m wide covered veranda extending along the length of the front with a concrete floor for drying of material and sufficient covered outdoor space for location of soaking basins for CBR testing where required.

The rooms shall be adequately ventilated and well lit. Walls shall be constructed of prefabricated timber sections or sand cement blocks, or equivalent as approved by the Engineer. All external doors shall be provided with cylinder locks with three keys, or equivalent as approved by the Engineer.

The working area floor shall have a strengthened section incorporated consisting of 3.0 m x 3.0 m x 450 mm mass concrete plinth.

A separate sample store of at least 12 m² floor area shall be provided.

The laboratory shall be provided with electric lighting and power points to the satisfaction of the Engineer (to be 240 Volts, 50 cycles).

The permanent fixtures in the laboratory shall include:

- i. 2 no. double draining board stainless sinks, piped drinkable water supply to each and waste water outlets.
- ii. Work benches, comprising a working surface and one full length and width shelf under, of seasoned timber, or concrete, 1.0 m wide and 0.9 m high or its equivalent.

- iii. Soaking tanks for CBR and concrete specimens shall be provided at floor level indoors, in the laboratory. The soaking tanks shall have built-in drainage pipes.

A samples drying area of 20 m² floor area, covered from the elements, shall be provided externally adjacent to the laboratory main building.

The laboratory for the sole use of the Engineer shall be complete with furnishings and equipment as listed in TABLE 1410/1.

TABLE 1410/1: LABORATORY EQUIPMENT FOR THE ENGINEER	
For the Approval of the Engineer	Units
Desks 1.5 m x 0.75 m with 2 chests of drawers	2 No.
Arm chairs	2 No.
Chairs	6 No.
Air conditioners 12,000 BTU/hr.	5 No.
Work benches in numbers as given in the Special Specifications	2 No.
Curing tanks 2.5 m long, 1 m wide and 0.75 m high	3 No.
Stationery cupboard 2 m ³ .	2 No.
Book-cases, purpose made to accept box files	2 No.
Shelves 2.0 m long	2 No.
Stools	4 No.
Metal filing cabinet with 2 drawers	2 No.

b. Testing Equipment, Materials And Testing Standards

The Contractor shall provide and install in the laboratory 2 stainless steel fan-circulated drying ovens, minimum 70 litre capacity, and all the necessary apparatus and materials for the performance of all tests required for the testing and control of the works and materials.

The Contractor shall supply one new copy of the latest edition of the Specifications for all referred material standards and testing standards used for the Contract.

All the laboratory equipment, including air conditioners, shall be new and of a make approved by the Engineer.

The Contractor shall immediately after the award of the Contract prepare and submit for the approval of the Engineer a list showing all instruments and apparatus to be purchased.

Upon completion of the Contract, the Engineer's laboratory building, laboratory equipment, air conditioners and furniture specified herein shall revert to either the Contractor or the Employer depending on which of the pay items in CLAUSE 1411 are invoked in the Special Specifications.

1411 Measurement And Payment

Item		Unit
14.01	Houses for the Engineer	
(a)	Provide Type I House Fully Furnished And Equipped For The Engineer	Lump Sum
(b)	Provide Type II House Fully Furnished And Equipped For The Engineer	Lump Sum

(c)	Provide Type Iii House Fully Furnished And Equipped For The Engineer	Lump Sum
(d)	Provide Type Iv House Fully Furnished And Equipped For The Engineer	Lump Sum
(e)	Provide Type V House Fully Furnished And Equipped For The Engineer	Lump Sum
(f)	Provide Multiple Accommodation Units Fully Furnished And Equipped For The Engineer	Lump Sum
(g)	Provide Fully Furnished And Equipped Temporary Accommodation And Offices For The Engineer	Lump Sum
(h)	Maintain And Pay All Rents And Municipal Services For Type I House Fully Furnished And Equipped For The Engineer	House Unit X Month
(I)	Maintain And Pay All Rents And Municipal Services For Type II House Fully Furnished And Equipped For The Engineer	House Unit X Month
(j)	Maintain And Pay All Rents And Municipal Services For Type III House Fully Furnished And Equipped For The Engineer	House Unit X Month
(k)	Maintain And Pay All Rents And Municipal Services For Type IV House Fully Furnished And Equipped For The Engineer	House Unit X Month
(l)	Maintain And Pay All Rents And Municipal Services For Type V House Fully Furnished And Equipped For The Engineer	House Unit X Month
(m)	Maintain And Pay All Rents And Municipal Services For Multiple Accommodation Units Fully Furnished And Equipped For The Engineer	House Unit X Month
(n)	Maintain And Pay All Rents And Municipal Services For Fully Furnished And Equipped Temporary Accommodation And Offices For The Engineer	House Unit X Month

All SUBITEMS 14.01(a) to (g) shall be applied in the case where the houses, furniture and equipment revert to the Employer Government upon completion of the Contract.

Only SUBITEMS 14.01(h) to (n) shall be applied in the case where the houses, furniture and equipment revert to the Contractor upon completion of the Contract OR where the houses are privately owned rented accommodation where the tenancy period shall remain in force for the period of the contract and for any additional period during the Defects Notification Period as may be required by the Engineer.

Municipal services shall include provision of potable water, water-borne sewerage reticulation, garbage and waste collection and disposal.

Item	Unit
14.02	Offices for the Engineer
(a)	Provide Fully Furnished And Equipped Offices For The Engineer
(b)	Maintain and Pay all Rents and Municipal Services for Fully Furnished And Equipped Offices For The Engineer

Both SUBITEMS 14.02(a) and (b) shall be applied in the case where the houses, furniture and equipment revert to the Government upon completion of the Contract.

Only SUBITEMS 14.02(b) shall be applied in the case where the houses, furniture and equipment revert to the Contractor upon completion of the Contract.

Item		Unit
14.03	Wash house for the Engineer	
(a)	Provide And Maintain Fully Furnished and Equipped Wash House For The Engineer	Lump Sum
(b)	Maintain and Pay all Rents and Municipal Services for Fully Furnished And Equipped Wash House For The Engineer	Wash House Unit x Month

Both SUBITEMS 14.03(a) and (b) shall be applied in the case where the houses, furniture and equipment revert to the Government upon completion of the Contract.

Only SUBITEM 14.03(b) shall be applied in the case where the houses, furniture and equipment revert to the Contractor upon completion of the Contract.

Item		Unit
14.04	Site Cabin/Office for the Engineer	
(a)	Provide Fully Furnished and Equipped Site Cabin/Office For The Engineer	Lump Sum
(b)	Maintain and Pay all Rents and Municipal Services for Fully Furnished And Equipped Site For The Engineer	Site Cabin / Office Unit x Month

Both SUBITEMS 14.04(a) and (b) shall be applied in the case where the houses, furniture and equipment revert to the Government upon completion of the Contract.

Only SUBITEM 14.04(b) shall be applied in the case where the houses, furniture and equipment revert to the Contractor upon completion of the Contract.

Item		Unit
14.05	Four Wheel Drive Station for the Engineer	
(a)	Provide Vehicles For The Engineer (Specify Type and Number)	Lump Sum
(b)	Operate and Maintain Vehicles (Specify Type and Number) for an Average of 3,000 km Per Month	Vehicle x Month
(c)	Operate Vehicles Specified for Travel Distance in Excess of Average 3,000 km Per Month	Kilometres (km)

All SUBITEMS 14.05(a) to (c) shall be applied in the case where the vehicles revert to the Government upon completion of the Contract.

Only SUBITEMS 14.05(b) and (c) shall be applied in the case where the vehicles revert to the Contractor upon completion of the Contract.

Item		Unit
14.06	Four Wheel Drive Double Cab Pick-up for the Engineer	
(a)	Provide Vehicles For The Engineer and Employer (Specify Type and Number)	Lump Sum
(b)	Operate and Maintain Vehicles (Specify Type and Number) for an Average of 4,000 km Per Month	Vehicle x Month
(c)	Operate Vehicles Specified for Travel Distance in Excess of Average 4,000 km Per Month	Kilometres (km)

All SUBITEMS 14.06(a) to (c) shall be applied in the case where the vehicles revert to the Government upon completion of the Contract.

Only SUBITEMS 14.06(b) and (c) shall be applied in the case where the vehicles revert to the Contractor upon completion of the Contract.

Item		Unit
14.07	Survey Equipment for the Engineer	
(a)	Provide Specified Survey Equipment for the Engineer	Lump Sum
(b)	Maintain Specified Survey Equipment for the Engineer	Month

Both SUBITEMS 14.07(a) and (b) shall be applied in the case where the survey equipment reverts to the Government upon completion of the Contract.

Only SUBITEM 14.07(b) shall be applied in the case where the survey equipment reverts to the Contractor upon completion of the Contract.

Item		Unit
14.08	Laboratory for the Engineer	
(a)	Provide Laboratory Fully Furnished For The Engineer	Lump Sum
(b)	Maintain Laboratory Fully Furnished For The Engineer	Month
(c)	Payment for Tests Carried Out at the Regional Laboratory for the Government Agency Responsible for Testing and Advise on Materials Usage.	Lump Sum

Both SUBITEMS 14.08(a) and (b) shall be applied in the case where the laboratory and furniture reverts to the Government Agency responsible for testing and advice on materials usage upon completion of the Contract.

Only SUBITEM 14.08(b) shall be applied in the case where the laboratory and furniture reverts to the Contractor upon completion of the Contract.

Item		Unit
14.09	Laboratory Equipment for the Engineer	
(a)	Provide Specified Laboratory Equipment For The Engineer	Lump Sum
(b)	Maintain Specified Laboratory Equipment For The Engineer	Month

Both SUBITEMS 14.09(a) and (b) shall be applied in the case where the laboratory equipment reverts to the Government Agency responsible for testing and advice on materials upon completion of the Contract.

Only SUBITEM 14.09(b) shall be applied in the case where the laboratory equipment reverts to the Contractor upon completion of the Contract.

Payment for providing vehicles, for providing and maintaining houses, offices, laboratory, survey equipment, wash house and site cabin for the Engineer's Representative will be made at the Lump Sum entered in the Bill of Quantities, for each single Item of each type, on the following basis:

- i. 80 % of the Lump Sum when the respective facilities are completed, and accepted by the Engineer, fully furnished and equipped.
- ii. 20 % of the Lump Sum will be paid at the end of the Contract period.

Payment for operating and maintaining vehicles under ITEMS 14.05 and 14.06, SUBITEMS (b) and (c) above, for the Engineer, their staff and the Employer, will be made as follows:

- i. By rates per vehicle month, SUBITEM (b). Such rates shall include for the first 4,000 km per vehicle travelled in any calendar month. Should a vehicle be used for less than 4,000 km in a particular month, then the unused distance shall be offset against months when the distance travelled exceeds 3,000 km.
- ii. By a rate per km, SUBITEM (c), over and above the first 4,000 km per vehicle travelled in any one calendar month, subject to the condition mentioned in above.

The rates bid by the Contractor shall include for provision of the vehicle all licensing, insurance, fuel, lubricants, maintenance and repairs, drivers' salaries and allowances and replacement of the vehicles should this be considered necessary by the Engineer.

SECTION 1500 Accommodation of Traffic

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1501 Scope

This Section covers the construction and maintenance of the necessary temporary deviations, barricades and signs, and everything necessary for the safe and easy passage of all traffic, including non-motorised vehicles and pedestrians, during the construction and maintenance periods, as well as the reinstatement of deviations as they become redundant.

1502 General Requirements

a. Handing Over the Site

The Site will be handed over to the Contractor in the lengths and sequence specified in the Special Specifications. Where no other provision is made in the Special Specification, the Contractor will be given possession of the Site in Sections in accordance with the approved programme as specified in SECTION 1208 and sufficiently ahead of road construction works to enable deviations to be constructed in good time and to the Engineer's satisfaction.

b. Providing Deviations

Except where the existing road is to remain in use for through traffic, the Contractor shall provide, construct or put in order such deviations as may be necessary for deviating traffic from such sections of the road as are handed over.

c. Passage of Public Traffic

The Contractor shall be responsible for the safe and easy passage of public traffic past or over sections of roads of which the Contractor has occupied. The Contractor shall at all times and in all operations and in using construction equipment take the necessary care to protect the public and to facilitate the flow of traffic.

Further, the passage of public traffic on sections of a road may be allowed prior to the 'Taking-Over Certificate' where this is clearly in the interest of the public and the traffic can be accommodated on the road surface in a safe manner without damage to structures or pavement layers and without undue disruption of the Contractor's work. The Contractor shall be responsible for the control of public traffic over such sections, including temporary traffic control facilities, as provided in CLAUSE 1503.

d. Minimum Vertical Clearance

The minimum vertical clearance over any section of a diversion shall be 5.5 m.

e. Property and Survey Beacons

Where possible, deviations shall be constructed so as not to damage or displace property or trigonometric survey beacons. In exceptional cases where this is not possible, the Contractor shall notify the Engineer in good time so that they may arrange to have them suitably referenced before they are displaced.

f. Access to Properties

The Contractor shall also provide and grant access to persons whose properties fall within or adjoin the area over which they are working, and in this respect the Contractor's attention is drawn to the requirements as detailed in the Special Specifications.

g. Approval of Temporary Deviations

The need for, and details concerning, all temporary deviations shall be approved by the Engineer before the construction of such temporary deviations commences. The Contractor shall ensure before bidding that they can make arrangements in respect of any temporary deviations as may be necessary for the safe and convenient passage of traffic.

h. Temporary Works

The temporary deviations provided by the Contractor shall include the construction of temporary gates, barriers, fences, drainage works and other incidentals considered by the Engineer to be necessary.

i. Public Services

The Contractor, in co-operation with the Engineer, shall make arrangements for all public services such as power lines, telephone lines, water mains, etc, to be moved where required for the construction works and shall be solely responsible for the safety of such services. No payment will be made for any additional expenses caused by delays in moving such services. Where the moving of services is not required, the Contractor shall mark on the ground or provide signs indicating where such services cross the diversion so that these points will be clearly visible to the operating staff.

1503 Improvements To Existing Roads

Where shown on the Drawings or instructed by the Engineer the Contractor shall carry out improvements to any existing roads adjacent to or affected by the Works including:

1. Site clearance and removal of topsoil from the shoulders and verges.
2. Scarifying, re-shaping, widening and watering and compacting the top 150 mm of the existing road to 95 % MDD of AASHTO T99 compaction.
3. Laying of gravel wearing course.
4. Cutting, re-shaping and deepening where necessary, side drains and mitre drains, including clearing and maintaining existing protection works.
5. Clearing and maintaining culverts and cutting or deepening outfall drains.
6. Clearing and maintaining existing watercourses and protection works.
7. Repair of potholes in bitumen roads.
8. Re-sealing of bitumen roads.
9. Providing, erecting and maintaining temporary traffic signs, barriers, lights etc.

The extent of improvements required will be detailed in the Special Specifications.

1504 Maintenance Of Existing Roads

The Contractor shall maintain the existing roads scheduled in the Special Specification from the commencement of the Contract until the adjacent section of new road or deviation where applicable is opened to public traffic.

The road shall be maintained to the same standard as existed at the commencement of the Contract or to the standard following improvement under SECTION 1503 of this Specification. Maintenance shall include watering, full width grading and dragging as necessary, keeping clear watercourses and culverts, cutting grass, minor repairs to culverts and bridges and assistance to traffic. In the case of bitumen roads, potholes and edge failures shall be repaired with cold asphalt mixed and laid in accordance with SECTION 5800 of this Specification.

Major repairs to culverts and bridges, flood damage, resealing and re-gravelling may be instructed in which case separate payment will be made.

1505 Temporary Traffic Control Facilities

a. Programme for Control of Traffic

Following the receipt of the order to commence, the Contractor shall submit to the Engineer a detailed Traffic Control Plan. Such Plan shall be approved by the Engineer before the Contractor commences work, and shall show amongst other things the method of protection of the public and give details of the hours of operation, location, types and numbers of traffic safety devices, barricades, warning signs, flagmen etc. The Traffic Control Plan shall be in accordance with and complementary to the Programme of Works submitted under SECTION 1208 above.

In the preparation of this Traffic Control Plan, the Contractor should take into consideration the following:

- i. The Contractor shall conduct operations in such a manner that no greater length or amount of work is undertaken than he can carry out efficiently having due regard to the rights and convenience of the public.
- ii. If the Contractor proposes a road closure he shall provide an alternative routing for the traffic, which must be approved by the Engineer.
- iii. No revisions shall be made to the approved Traffic Control Plan without the prior written permission of the Engineer, and the Contractor shall allow 14 days for the Engineer to review any request for a revision of the Traffic Control Plan.

The Traffic Control Plan shall conform in all respects with the requirements of this Specification.

b. Traffic Control Devices

Traffic control devices involve, but are not restricted to, the use of flagmen, traffic lights, portable STOP and GO signs or STOP and SLOW signs, and all temporary traffic management signs, whichever may be the most suitable methods under prevailing circumstances. The STOP and GO or STOP and SLOW signs, plus all temporary traffic control signs should conform to **Volume 6, Traffic Control Facilities and Communications Systems, Part 2 Traffic Signs Manual**, of the Kenya Road Design Manual (RDM), or if this manual is silent on particular requirements then conformity with standard international signage complying with BS 12899, BS EN 12368 or equivalent will be required.

The type of construction, spacing and placement of traffic control facilities shall be in accordance with the prescriptions and recommendation of the latest editions of **Volume 6, Traffic Control Facilities and Communications Systems, Part 2 Traffic Signals Manual**, of the Kenya Road Design Manual (RDM). The Contractor shall present suitable proposals for the approval of the Engineer. The various traffic control facilities which may be required are the following, or as directed by the Engineer:

i. Road signs and barricades

Road signs shall comply with the requirements of **SECTION 8400** and the latest edition of **Volume 6, Traffic Control Facilities and Communications Systems, Part 2 Traffic Signals Manual**, of the Kenya Road Design Manual (RDM).

ii. Channelisation devices and barricades

Channelisation devices shall include cones, delineators and drums. Barricades include barrier lattices, movable barricades or other types approved by the Engineer.

Steel drums shall be cut, painted in black and white stripes and provided with reflective tape strips. Drums shall be kept in position with ballast of sand or soil. Stones shall not be used for this purpose. Drums shall be maintained in a clean and serviceable condition.

iii. Barriers

Barriers for preventing vehicles from leaving the permitted lanes may consist of guardrails on both sides of steel drums for separating two opposite traffic streams, movable concrete barriers (New Jersey type), or ordinary guardrails which comply with the provision of **SECTION 8200**.

iv. Warning devices and traffic lights

Warning devices consist of amber flicker lights. Traffic lights shall be operated automatically, by radio, or manually in a proper manner by adequately trained staff. The provisions of **Volume 6, Traffic Control Facilities and Communications Systems, Part 2 Traffic Signals Manual**, of the Kenya Road Design Manual (RDM), shall be followed.

v. Road markings

Road markings, as specified in **SECTION 8500**, may be required on sealed surfaces and will include road studs wherever necessary. The road markings shall be made in accordance with the provisions of **SECTION 8500** and the provisions of **Volume 6, Traffic Control Facilities and Communications Systems, Part 2 Traffic Signs Manual** of the Kenya Road Design Manual (RDM).

Any painted road markings which no longer apply shall be removed or may be over painted with black road paint, subject to the approval of the Engineer.

Road studs shall be removed completely and the surface reinstated to the satisfaction of the Engineer.

c. Passage and Control of Traffic

It is an intention of the Contract that public traffic should be able to pass along the road to be reconstructed or rehabilitated including bridges at all times during construction and in all weather. For this purpose the Contractor will be required to order their work etc. in such a way as to assure that a single lane at least 3.5 m wide is available for public traffic at all times and he shall furnish sufficient warning signs, competent flagmen equipped with two way radios, and the like to control and regulate the flow of traffic under one-way traffic operations.

The frequency and duration of delays to traffic while passing through, over or across the Works, shall be kept to a minimum. They shall, in no case exceed half an hour and should normally be less than 10 minutes. Any method of working which requires road closures in excess of 30 minutes shall be the subject of 48 hours prior notice to, and agreement of, the Engineer, who may refuse to allow such closure in default of due notice or may require rescheduling of the closure.

The Contractor shall ensure, when passing traffic through the Works, that all excavations and other hazards are properly protected with barriers and are illuminated at night.

1506 Construction Of Temporary Deviations

a. General

Where in the opinion of the Contractor it is preferable not to pass traffic through the Works, the Contractor will, upon previous approval of the Engineer, be allowed to construct and maintain temporary deviations provided that such temporary deviations are passable to traffic at all times, subject to the provisions of SECTION 1507 below.

The length of the temporary deviations shall be of the shortest practical length having regard to gradient and obstructions and shall be sited as agreed between the Engineer and the Contractor. The maximum length of diverted road shall be restricted to 5 kms at any given time unless otherwise instructed. The Contractor shall construct and complete temporary deviations to the satisfaction of the Engineer before commencing any permanent work on the existing road. Also during these works the contractor shall provide a detour of adequate pipe culverts for pedestrian and traffic crossing where there is bridge works.

The Contractor will be allowed to open a further 5 km of the diversion road only when 80 % of the permanent work has been completed on the preceding section. The sequencing of diversion road opening may be shown on the Drawings and further described in the Special Specifications and shall be subject to approval by the Engineer.

Where required in the Special Specifications or by the Engineer, temporary deviations shall be provided with bituminous surfacing in accordance with the requirements of the Special Specifications or of SECTION 5000, or as may be instructed by the Engineer.

b. Widths, Gradient, Camber

For the diversion of an existing trunk road, the carriageway width of the temporary road shall be the width of the existing carriageway or 6.0 m whichever is less. If wider temporary deviations are required, such widths shall be specified in the Special Specifications or shown on the Drawings.

For the diversion of a minor public road or a private road, the width of the temporary carriageway shall be the same as the existing carriageway, or such other width as agreed by the Engineer.

Where in the opinion of the Engineer, it is impracticable to provide a two-lane diversion, a single lane carriageway not less than 4.0 m wide with traffic control and passing places shall be provided.

The verges of the diversion shall be cleared and maintained clear for a width of at least 1.5 m beyond the edge of the carriageway or such lesser width as the Engineer may agree.

The temporary traffic deviations shall have a minimum horizontal radius of 30 metres and a maximum gradient of seven (7) percent unless otherwise agreed to by the Engineer in exceptional cases. Any acute intersection of gradient shall be properly graded to a smooth vertical curve, to the satisfaction of the Engineer.

1507 Temporary Drainage Works

a. General

Temporary ditches and culverts of adequate size and strength shall be provided alongside and under the temporary road to the satisfaction of the Engineer.

The Contractor shall construct the necessary temporary drainage works such as side drains, catch water drains, mitre drains, culverts, etc., to deal adequately with surface run-off. The temporary culverts of adequate type and size shall be installed on existing drainage channels wherever required by the Engineer. Any suitable prefabricated culverts salvaged from an existing road or an abandoned diversion may be re-used if in a good condition and approved by the Engineer.

b. Temporary bridges

Where it is necessary to construct a diversion to permit construction of a new bridge the Contractor shall provide and maintain a temporary bridge over the waterway. The minimum clear width of a temporary bridge shall be 3.5 m and it shall be designed in accordance with the requirements of the latest edition of the **Road Design Manual Volume 4, Part 2 - Bridge and Culvert Design**, to accommodate loads from HGVs and appropriate wind and other live loads. The bridge design and specification shall be approved by the Engineer before construction is commenced. Approach roads shall comply with **CLAUSE 1504** above.

c. Drifts

Where the Drawings require the construction of a drift, or the Contractor proposes a drift crossing, it shall be constructed in accordance with the Drawings or to a minimum design standard with a firm bottom consisting of cobbles or small boulders within a matrix of suitably graded gravel to the approval of the Engineer. This base layer shall be designed to resist erosion by the normal flow of the water course and shall be carried up the banks of the watercourse above the flood level of the stream. Where water flow is found to be too fast for such a crossing to retain integrity under the combined effects of passage of traffic and water flow the Engineer may instruct the Contractor to provide suitable erosion protection measures and/or a concrete surfacing to the drift. The dimension of the drift shall be such that there is less than 0.15 m of water over the road at all times, except in flood. The edge of the drift shall be defined with posts or other markers and a gauge installed to indicate the maximum depth of water over the road. The minimum width of the drift shall be 4.0 m.

The Contractor shall render to the public all possible assistance, particularly in times of flood, and if necessary shall provide a vehicle, labour and tow rope to extract vehicles immobilised in the drift.

1508 Earthworks For Deviations Or Existing Roads Used As Deviations

The Contractor shall shape and grade the temporary deviations and shall make full use of all material that can be obtained from alongside the diversion, from side cuts or from the immediate vicinity. If an adequate quantity of material cannot be obtained in this manner, he shall import material from other approved sources. Earthworks shall include all necessary cut and fill activities to achieve satisfactory vertical alignments and shall generally comply with the requirements of **SECTION 3600**. The Contractor shall initially undertake the necessary clearing and grubbing, including the removal of all trees and stumps. The subgrade shall be compacted to the satisfaction of the Engineer as specified in **SECTION 3600** prior to the construction of the earthworks.

The Contractor shall take all necessary measures to protect the environment and shall construct temporary deviations along alignments and in such a manner as to avoid unnecessary destruction of trees and natural habitats for both flora and fauna. The recommendations of an environmental specialist shall be obtained wherever this is deemed necessary by the Employer or the Engineer before construction work commences.

All material shall be watered, mixed and compacted with suitable compaction equipment to achieve dry density of 95 % MDD AASHTO T180.

The Contractor shall take all necessary measures to prevent pollution and siltation of water courses and the creation of dust pollution of adjacent vegetation and property. He shall give attention to erosion protection from water and wind, as well as man-made, traffic etc., sources.

1509 Gravelling Of Temporary Deviations Or Existing Roads Used As Deviations

The temporary deviations shall be provided with a wearing course of suitable gravel approved by the Engineer and in accordance with the requirements of **SECTION 4100**.

All material shall be watered, mixed and compacted with suitable compaction equipment to achieve dry density of 95 % MDD AASHTO T180.

1510 Assistance To The Public

The Contractor shall be responsible for safely maintaining and directing traffic through or around any part of the Works included in the Contract for twenty four hours every day. He shall maintain close liaison with the relevant authorities to clear any broken down vehicles or such vehicles or debris including oil spillage resulting from accidents, from the temporary deviations and the main road, in order to maintain smooth and safe flow of the traffic.

The Contractor shall render to the public all possible assistance when they are passing over roads maintained by the Contractor and over minor, private or temporary roads or bridges when used as temporary deviations or when passing through the Works.

The Contractor shall ensure that their operations do not create a condition hazardous to traffic or to the public, and in this regard he shall furnish, erect and maintain such fences, barricades, lights, signs and other services, as are necessary to prevent accidents or damage or injury to the public. The Contractor shall undertake risk assessments for every activity which may expose the public to the works and agree appropriate mitigation measures with the Engineer.

As part of the agreed mitigation measures the Contractor shall train and furnish such guards and flagmen as are necessary to give adequate warning to traffic or to the public in order to keep them away from risk of exposure to any dangerous conditions that might arise from their activities.

He shall provide prompt assistance to any vehicle experiencing difficulty in passing over the Works under construction, or through any temporary deviations or roads maintained by the Contractor, if necessary by providing a towing vehicle, labour and tow rope to assist such vehicles.

Should the Contractor appear to be neglectful or negligent in furnishing warning and protective measures, as above provided, the Engineer may direct attention to the existence of hazard, and the necessary warning and protective measures shall be furnished and installed at the Contractor's expense. Should the Engineer point out the inadequacy of warning and protective measures, such action on the part of the Engineer shall not relieve the Contractor from responsibility for public safety or relieve the Contractor of the obligation to furnish and pay for these devices.

1511 Use of Minor Private Roads as Diversion

Where agreed by the Engineer that the Contractor may use a minor or private road as a diversion, the Contractor shall be entirely responsible for negotiation with and obtaining the prior consent of the authorities and owners, and shall pay for any additional maintenance costs or shall, if necessary, maintain the minor road for the period it is used as a diversion, shall reinstate the road afterwards to the satisfaction of the authority or owner, and shall compensate the authority or owner for any damage arising out of the use of the road as a diversion.

The standard of such minor or private road when used as a diversion shall at least comply with [CLAUSE 1506](#) above for temporary roads and if necessary the Contractor shall, at their own expense improve the road to bring it to this standard before it is used as a diversion, and shall maintain it to that standard while it is used as diversion.

The length of the diversion shall not be excessive and shall be kept as short as practicable. As a guide, any part of the diversion shall generally not exceed twice the length of the corresponding part of the original road, while the total route distance via all temporary deviations shall generally not exceed that via the original road by more than 25 %.

1512 Riding Quality and Maintenance of Deviation and Existing Roads Used as Deviations

The surface of all temporary deviations shall be maintained smooth, free from ruts and potholes and loose material, and shall be graded and watered as required.

Where existing roads are to be used as temporary deviations, the Contractor shall, after consultation with the Owner or Authority having control of such road, carry out any improvements, repairs, alterations or additions to such roads as may be required to bring them to a condition suitable for traffic and to the satisfaction of the Engineer.

All temporary deviations and existing roads used as temporary deviations shall be maintained by the Contractor in a safe trafficable condition. The roads and temporary deviations shall be graded and watered to provide a smooth riding surface free from corrugations and to keep dust down. All potholes shall be repaired within 24 hours of such damage developing to a size greater than 200 mm in width or 25 mm depth. All drainage works shall be maintained in a good working order. Gravel surface wearing courses shall not be allowed to be worn through and shall be scarified and reshaped, with the addition of gravel as necessary, whenever such maintenance is necessary. The Engineer may instruct the Contractor but the responsibility for all maintenance work rests with the Contractor.

Temporary deviations shall be maintained to a standard that generally allows a travelling speed of at least 30 km/h for all vehicular groups.

The Contractor shall also water the temporary deviations to keep down dust or, if considered by the Engineer to be more effective, apply an alternative dust suppressant as may be required instead of water.

1513 Signs, Barriers And Temporary Fencing, Gates And Grid Gates

The Contractor shall be responsible for the provision, erection, maintenance and removal of all temporary signs, barriers, lights, traffic control devices, etc., necessary for safety and convenience, to pass traffic not only upon the existing road to be constructed or realigned and such temporary roads or bridges as he may construct, but also on all minor and private roads off the site of the Works which are used as temporary deviations.

Temporary "Diversion Ahead Signs" shall be erected before any road junction and a "Diversion Sign" shall be erected at the junction of the diversion route and other minor roads where there is any possibility of the diverted traffic mistaking the route of the diversion, and there shall be mounted on the same posts, a sign bearing the inscription "Diversion Ahead" or "Diversion".

In addition, any hazard such as a narrow bridge, drift, level crossing, steep hill, sharp bend, etc. occurring on the diversion shall be marked by the Contractor with the appropriate sign if the existing sign is inadequate or non-existent. All sharp bends and all places where the shoulder is higher than 2.0 m above the natural ground shall be marked with painted posts.

Where ordered by the Engineer or specified on the Drawings or in the Special Specifications, the Contractor shall make arrangements for providing either new fencing and gates or moving and subsequently reinstating existing fencing and gates in accordance with the provisions of SECTION 8300.

1514 Accommodation of Traffic Where the Road is Constructed in Half Widths

Where, for reasons of difficult terrain or for any other reason, the construction of temporary deviations is not feasible, the Contractor shall upon the written instruction of the Engineer construct the road in half widths to allow traffic to use that half of the road not under construction. The length of the half width construction shall be kept to a minimum, with provision for traffic travelling in opposite directions to pass at frequent intervals.

The length of half-width construction, where the other roadway lane is open to one-way traffic only, shall be restricted to 1 km in length. Traffic control for short sections of maximum 100 m in length of one-way traffic may be controlled by qualified flagmen and portable STOP and GO signs. Traffic lights shall be used for longer sections unless otherwise agreed to by the Engineer.

The Contractor shall arrange work so as to allow traffic to have free one-way access to at least half the width of the roadway at all times during the Construction period. He shall maintain that half of the road, which is being used for traffic for the time being, free from corrugations or other defects to the satisfaction of the Engineer

Should the road not be in a safe trafficable condition for two-way traffic over the entire width at the end of each day's work the Contractor shall provide adequate flagmen, signs, traffic lights, barricades, light and the necessary staff at their own cost to ensure a free flow of traffic alternatively in each direction, through the entire period when the roadway is open to one-way traffic only.

1515 The Use of Temporary Deviations by the Contractor

Where the Contractor constructs haul or construction roads for accommodating construction traffic, the Contractor shall construct and maintain them at their own cost and in accordance with details previously agreed in writing with the Engineer. Such roads shall be closed and the entire area of the road and its drainage and cut/fill profiles and surfaces properly reinstated to the original condition or better when no longer required, all at the Contractor's own cost.

The Contractor shall have the right to use public roads, including temporary deviations open to public traffic, but where their traffic causes excessive damage or wear to such roads or creates an increased risk or condition hazardous to public traffic, the Engineer shall have the right to regulate the Contractor's traffic over such temporary deviations and require the Contractor to provide at their own cost, such maintenance and/or mitigation measures as in the Engineer's opinion will be necessary.

1516 Reinstatement Of Temporary Deviations

When traffic is routed permanently onto the new road following the completion of construction, the temporary deviations which are no longer required and, unless otherwise instructed by the Engineer, such sections of obsolete roads and road marking as instructed by the Engineer, shall be reinstated in accordance with SECTION 8700.

1517 Penalty For Failure To Comply With These Specifications

The failure or refusal of the Contractor to construct and/or to maintain temporary deviations, existing roads etc. at the proper time, or to take the necessary precautions for the safety and convenience of public traffic as required by statutory authorities or as instructed by the Engineer, shall be sufficient cause for the closing down of all work under this contract until all provisions prescribed have been complied with to the satisfaction of the Engineer.

The Employer shall deduct from any payments due to the Contractor all reasonable expenses necessitated by the failure of the Contractor to comply with the provisions of these Specifications.

1518 Measurement & Payment

Item	Unit
15.01	Accommodating Traffic and Maintaining Temporary Deviations
(a)	Accommodating traffic and maintaining temporary deviations Kilometre (km)

The unit of measurement shall be the kilometre, measured along the centre lines of temporary deviations, existing roads used as temporary deviations, and roads constructed in half-widths. It shall not include sections along which the traffic is diverted onto existing roads where the contractor is not responsible for the maintenance of such existing roads.

The tendered rate shall include full compensation for accommodating traffic and maintaining temporary deviations, including roads constructed in half-widths and existing roads used as temporary deviations

during construction and maintenance periods, but excluding maintenance and repair work for which payment is specifically made under the other pay Items provided in SECTION 1500. The tendered rate shall also include full compensation for the provision of a full-time traffic safety officer and for all the duties they perform. The tendered rate shall also include full compensation for the provision of communications equipment required for regulating the traffic, arranging for the moving of services, solving traffic problems, complying with the legal requirements of all authorities concerned, for providing temporary access to private property, and for the provision and maintenance of temporary drainage, but excluding the work specifically paid for under ITEM 15.12. The tendered rate shall also include full compensation for the specified general requirements and all incidental Items of cost which are required under the provisions of SECTION 1500 and which are not specifically paid for under the other pay Items provided in SECTION 1500.

Payment will be made in two equal instalments in respect of each section. The first instalment will be made when suitable temporary deviations have been approved for use or when traffic is taken over half-width construction. The second instalment will become due when the traffic can be accommodated on the new road, all temporary deviations have been obliterated and all general obligations of the contractor have been complied with, all to the satisfaction of the Engineer.

Item	Unit
15.02	Earthworks for Temporary Deviations
(a)	Shaping of temporary deviations
(b)	Cut and borrow to fill
(c)	Cut to spoil
	Kilometre (km)
	Cubic meter (m ³)
	Cubic meter (m ³)

a. Shaping of Temporary Deviations

The unit of measurement shall be the kilometre of temporary deviations shaped, compacted and constructed in accordance with the provisions of CLAUSE 1506 of this section. Where the contractor has to provide access roads to private property, the length of such access roads outside the road reserve shall also be included in the quantity measured for payment.

The tendered rate shall include full compensation for clearing and grubbing where necessary, the removal of small trees and stumps, the shaping and grading, watering, mixing and compacting of the material and all cuts and fills constructed from material obtained from alongside the temporary deviations or side cut, but including only such portions of the fills which are less than 0.5 m in height.

b. Cut and Borrow to Fill

The unit of measurement shall be the cubic metre of fill measured in situ from levelled cross-SECTIONS taken before and after construction where such material is either imported from a locality more than 100 m from the point of use or is utilised in a portion of a fill which is in excess of 0.5 m above the original ground level.

Where measurement by cross-sections is impractical, the volume can be assumed to be equal to 70 % of the loose volume measured in trucks in the case of soil and gravel material, and equal to 60 % of the loose volume in trucks in the case of hard material consisting predominantly of particles of which the maximum dimension exceeds 100 mm.

The tendered rate shall include full compensation for procuring, furnishing and the placing all the classes of material, including transporting over a free-haul distance of 0.5 km.

c. Cut to Spoil

The unit of measurement shall be the cubic metre of authorised excavation taken from cut in temporary deviations or removed from fill in temporary deviations which are no longer required and carted to spoil on the instructions of the engineer, all measured in situ before excavation by means of levelled cross-sections.

The tendered rate shall include full compensation for excavating in all classes of material, loading, transporting, off-loading, including the shaping and levelling of spoil material and transporting over a free-haul distance of 0.5 km.

Item	Unit
15.03	Temporary Traffic-control Facilities
(a)	Flagmen
(b)	Portable STOP and GO-RY signs
(c)	Temporary traffic-control signals as specified or as shown on the drawings
(d)	Amber flicker lights
(e)	Road signs, R- and TR-SERIES, (size indicated)
(f)	Road signs, TW-SERIES, (size indicated)
(g)	Road signs, STW-, DTG-, TGS- AND TG-SERIES (excluding delineators and barricades)
(h)	Delineators (DTG50J) (size indicated):
(i)	Movable barricade/road sign combination (size indicated)
(j)	Traffic cones (size indicated)
(k)	Single guardrails attached to posts
(l)	Movable barriers (type indicated)
(m)	Two-way communication devices

a. Flagmen

The unit of measurement shall be a day worked by a flagman.

The tendered rate shall include full compensation for a flagman who is required to control traffic by way of flags or portable STOP and GO-RY signs and shall include the provision of flags and safety jackets.

b. (b), (c), (d), (e), (f) and (h)

The unit of measurement shall be the number of each sign provided, and, as may be applicable, completely erected.

The tendered rates shall include full compensation for providing, and where applicable, erecting each sign complete. In the case of SUBITEM (b) it shall also include moving the sign as may be necessary.

(g) The unit of measurement shall be the square metre of sign face, measured on the face of each item provided. The tendered rate shall include full compensation for providing and erecting each sign, complete with posts.

(i) The unit of measurement shall be the number of movable barricades, complete with road signs provided. The tendered rate shall also include full compensation for moving the barricades to fresh positions as and when necessary.

(j) The unit of measurement shall be the number of cones provided and the measured quantity shall be the maximum number in use at any one time in accordance with the layout shown on the drawings or as directed by the engineer. The tendered rate shall also include for all moves to new positions for the duration of the contract.

(k) The unit of measurement shall be the metre of straight or curved temporary guardrails erected, complete with end units, posts, reflective plates, etc.

(l) The unit of measurement shall be the metre of each type of movable barriers provided and shall include the initial erection.

(m) The unit of measurement shall be the number of two-way communication devices ordered by the engineer for the duration of the contract.

The tendered rate shall include full compensation for the supply of two-way communication devices suitable for the control of one-way traffic when half the width of the roadway is closed for construction purposes. The tendered rate shall also include full compensation for the maintenance of the devices and for the provision of operating staff for the duration of the contract.

General:

The tendered rates for the respective traffic control facilities shall include full compensation for the supply and initial erection complete with posts, stakes, portable stands and sandbags as may be required, for cleaning and maintenance, for covering with non-transparent material when temporarily not required and removal off the site when no longer required. 75 % of the tariff will be payable when the Items have been provided and erected in position for their first use on site and 25 % when finally removed from the site. Facilities which become unserviceable or are damaged by vehicles or stolen, in particular delineators, shall be replaced promptly at no additional cost.

Item	Unit
15.04 Relocation of Traffic-Control Facilities	
(a) Relocation of traffic-control facilities	Lump Sum

The tendered lump sum shall include full compensation for dismantling, storing if necessary, transporting, re-erecting and inspecting the traffic-control facilities, and for all labour, equipment, constructional plant and incidentals necessary to execute the work complete as specified or shown on the drawings.

Item	Unit
15.05 Gravelling and repair of temporary deviations and existing gravel shoulders used as temporary deviations	
(a) Temporary deviations	Cubic metre m ³
(b) Existing gravel shoulders	Cubic metre m ³

The unit of measurement shall be the cubic metre of gravel provided as wearing course for the surfacing of temporary deviations and existing gravel shoulders, computed from the dimensions of the layer as actually constructed in place, in accordance with the engineer's instructions.

Where measurement by the above method is considered to be impracticable by the engineer, the volume may be computed by taking 70 % of the loose volume of the gravel as measured in the hauling vehicles.

The tendered rate shall include full compensation for procuring, furnishing, placing and compacting the gravel wearing course, including a free-haul distance of 1.0 km, and the repair of local sections of the temporary deviations and gravel shoulders.

Item	Unit
15.06 Watering of Temporary Deviations	
(a) Watering of temporary deviations	Kilolitre (kl)

The unit of measurement shall be the kilolitre of water applied to the temporary deviations on the written instruction of the engineer. Water required for the construction of temporary deviations will not be measured for payment.

The tendered rate shall include full compensation for the supply, transport and application of the water. Overhaul shall not apply to transporting the water used for the watering of temporary deviations.

Item		Unit
15.07	Blading by Road Grader	
(a)	Temporary deviations	Kilometre-pass (km-pass)
(b)	Existing roads used as temporary deviations	Kilometre-pass (km-pass)
(c)	Existing gravel shoulders used as temporary deviations	Kilometre-pass (km-pass)

The unit of measurement for using a road grader to blade the surfaces of temporary deviations, existing roads and existing gravel shoulders used as temporary deviations shall be the kilometre-pass, that is, each kilometre of the full width of the temporary deviation, the entire surface of which has been bladed by one pass of the road grader. In the case of temporary deviations constructed as two separate one-way roads, they shall be considered as one full width of the temporary deviation for purposes of measurement.

Only the number of kilometre-passes actually authorised by the Engineer, in writing, will be measured.

Where the blading of temporary deviations has not been carried out satisfactorily and the surface has not been improved as much as can reasonably be expected from such an operation, the contractor shall carry out further grading work at their own expense until a satisfactory result is obtained.

The tendered rate shall include full compensation for providing the road graders and operators, flagmen, guards, barricades, signs and all other costs incidental thereto and for blading the temporary deviations to a smooth surface free from corrugations.

Item		Unit
15.08	Repairs, alterations and/or additions to existing roads used as temporary deviations	Provisional Sum

The provisional sum provided to cover the cost of work ordered by the engineer in terms of **CLAUSE 1510** of the specifications shall be expended in accordance with the provisions of **CLAUSE 48** of the general conditions of contract. Where the exact nature of the work can be determined in advance, provision may be made in the project specifications for suitable rates to be tendered in lieu of providing a provisional sum.

Item		Unit
15.09	Maintenance Of The Bituminous Surfacing and Pavement of Temporary Deviations With Bituminous Surfacing and Existing Roads With Bituminous Surfacing Used as Temporary Deviations	Provisional Sum

The provisional sum provided to cover the cost of work ordered by the engineer in terms of **CLAUSE 1512** for repairing and maintaining the bituminous surfacing and pavement of existing and temporary roads with bituminous surfacing used as temporary deviations, shall be expended in accordance with the provisions of **CLAUSE 48** of the general conditions of contract.

Item		Unit
15.10	Accommodation Of Traffic Where The Road Is Constructed In Half-Widths	Kilometre (km)

The unit of measurement for accommodating traffic where the road is constructed in half-widths shall be the kilometre measured along the centre line of the road which road is constructed in half-widths on the written instructions of the engineer.

The tendered rate shall include full compensation for providing all plant, equipment, tools, transport, labour, supervision, flagmen, guards, road signs, lights, barricades and all other incidentals necessary for the proper and safe handling of traffic as specified and shall also include full compensation for all additional costs and work resulting from constructing the road in half widths.

Item		Unit
15.11	Traffic Signals	Provisional Sum

The provisional sum provided to cover the cost of providing traffic signals shall be expended in accordance with the provisions of CLAUSE 48 of the general conditions of contract.

Item		Unit
15.12	Temporary Culverts	
(a)	Provision and laying of temporary prefabricated culverts complete (state size, type and bedding)	Metre (m)
(b)	Re-use of prefabricated culverts complete (state type, size and type of bedding)	Metre (m)
(c)	Eventual removal of prefabricated culverts	Metre (m)
(d)	Overhaul on excavated material carted to spoil, backfill material (but excluding portland cement), prefabricated culverts removed and reinstalled, and prefabricated culverts removed and stacked, for haul in excess of a free-haul distance of 1.0 km.	Cubic Kilometre (km ³)

15.12(a)

The unit of measurement shall be the metre of culvert provided and installed by the contractor.

The tendered rate shall include full compensation for procuring and furnishing new culverts, all excavations, bedding, laying the culverts and backfilling.

15.12(b)

The unit of measurement shall be the metre of culvert installed.

The tendered rate shall include full compensation for taking up the culverts from their previous positions and installing the culverts in fresh positions, including all excavations, backfilling and bedding, the loading and transporting and off-loading of the culverts.

15.12(c)

The unit of measurement shall be the metre of culvert removed.

The tendered rate shall include full compensation for the eventual removal of prefabricated culverts that are not to be re-used, including excavation, taking up the culverts, loading, transporting, off-loading and stacking the culverts at an approved location, including a free-haul of 1,0 km, and the reinstatement of surfaces. The culverts remain the property of the employer.

15.12(d)

Measurement and payment for overhaul shall be made in accordance with the provisions of SECTION 1600.

In the case of culverts, the outer volume of each culvert shall be measured.

Item		Unit
15.13	In Situ Preparation And Compaction Of Existing Gravel Shoulders to 95 % MDD (AASHTO) density	Cubic metre (m ³)

The unit of measurement shall be the cubic metre of shoulder material prepared and compacted as specified.

The tendered rate shall include full compensation for ripping, shaping, mixing, watering, compacting to a depth of 150 mm below the final road surface, and for all labour, equipment, constructional plant and incidentals necessary to execute the work as specified or shown on the drawings.

General notes:

The following pay Items described in other sections will be listed under this section in the schedule of quantities where they relate to work executed under this section.

1. Overhaul as specified in SECTION 1600.
2. The clearing and grubbing of large trees as specified in SECTION 3100.
3. The removal of overburden as specified in SECTION 3100.
4. The construction of mass earthworks as specified in SECTION 3600.
5. The construction of pavement layers as specified in SERIES 4000.
6. Bituminous seals as specified in SERIES 5000 or in the project specifications.
7. Temporary fencing as specified in SECTION 8300.
8. Road markings as specified in SECTION 8500.

1000

General

SECTION 1600 Overhaul

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1601 Scope

This Section covers the hauling of overhaul materials as defined herein from the place of excavation to the position of placement, where such haul distance is in excess of free haul distance as defined herein. Overhaul shall be calculated on the basis of a Mass Haul Diagram approved by the Engineer. Any change in the earthworks material utilisation shall be subject to the Engineer's approval. Overhaul will be paid for as specified in the Special Specification.

1602 Overhaul Computation

a. Layers to which Overhaul Applies

The Contractor's attention is drawn to the fact that overhaul will only be paid for in the cases where it is so specified in the Special Specifications. Overhaul material shall be transported material to which overhaul applies when hauled in excess of the free haul distance and shall include only the gravel materials, soil or rock materials used in the construction of fills, pavement layers, banks and dykes.

Overhaul shall not be paid for materials made from crushed stone, nor for materials used in side fill, bituminous layers and bituminous seals, concrete and rip-rap.

b. Volume

Unless specified otherwise, the method of computation of volumes will be that of average end areas and centreline distances between cross-sections taken at 25 m intervals. In irregular ground or tight curvature the Engineer may direct that ground cross-sections are taken at closer intervals.

c. Fill

Earthwork fill shall be measured by the cubic metre of compacted material measured in the completed embankment. No separate measurement or payment shall be made for excavating material to form embankments other than as described below.

d. Mass Haul Diagram

The mass haul diagram which is included in the Drawings is a guide only and must be considered as such by the Contractor. The final measurement and quantities will be determined from the actual ground cross-sections and final road levels and the mass haul diagram adjusted accordingly.

The mass haul diagram will be drawn 'in fill' on the basis that 1.0 m³ of material obtained from cuttings will on being compacted into the embankments produce 0.8 m³ of fill unless otherwise specified in the Special Specification. No allowance will be made for variations in materials, wastage, or consolidation etc. as referred to in SECTION 3600 of this Specification.

In the event of any realignment being instructed a revised mass haul diagram will be prepared for that realignment and agreed between the Contractor and the Engineer.

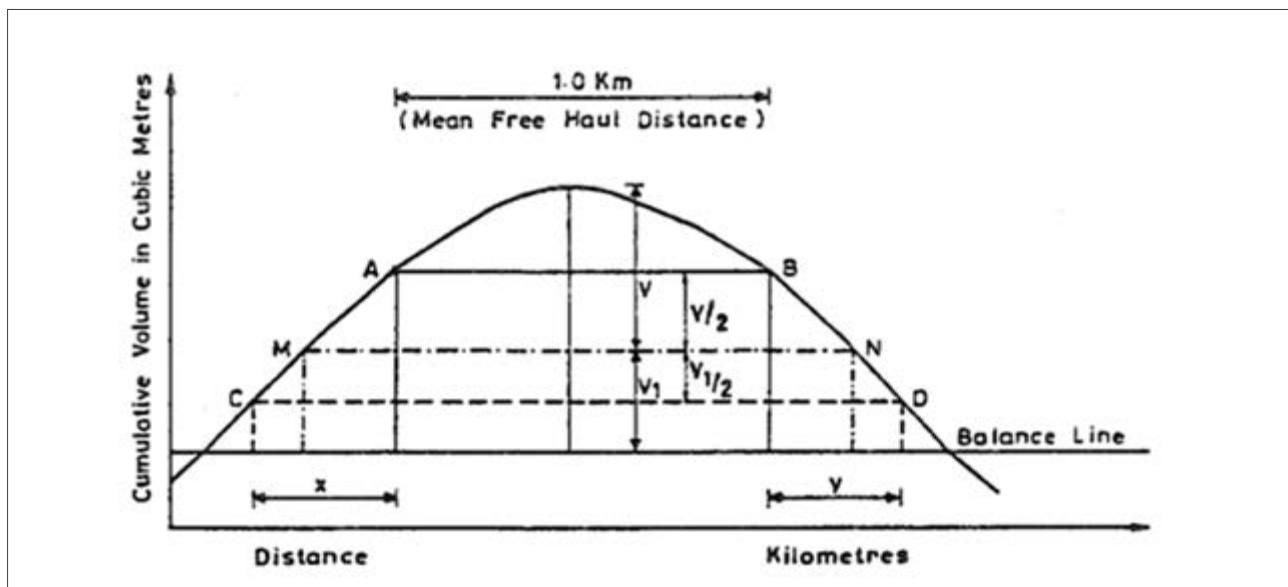
In the event that the Contractor elects to spoil suitable fill material from cuttings and substitute material from borrow pits, the mass haul diagram will not be amended and the quantities and distances determined from the adjusted mass haul diagram as referred to in the first paragraph of this clause shall apply.

Where unsuitable material is encountered in cuttings it shall be replaced if required by suitable material from borrow pits or widened cuttings. The mass haul diagram will be adjusted to take account of the change.

Where the mass haul diagram indicates that fill material is required in addition to that provided by the excavation, including widening of cuttings, and the Engineer instructs the opening of a borrow pit, separate measurement and payment shall be made for:-

- i. Site clearance of the borrow area and access road per hectare in accordance with SECTION 3100 of this Specification.
- ii. Removal of topsoil (if instructed by the Engineer to be stockpiled separately) from the borrow area per cubic metre in accordance with SECTION 3100 of this Specification.
- iii. The construction of access road, per km, in accordance with SECTION 1500 of this Specification.
- iv. Removal of topsoil and/or overburden, as "Spoil", from the borrow area per cubic metre in accordance with SECTION 3100 of this Specification.

Figure 5 Diagram Showing Method of Computation of Free Haul and Overhaul on Typical Mass Haul Section



NOTES:

1. A & B are centres of volume of Free Haul Earthworks
2. C & D are centres of volume of Overhaul Earthworks
3. M N is limit of Free Haul
4. Free Haul Earthworks = V
5. Overhaul Earthworks = VI
6. Overhaul Distance = CD - 1.0
7. Overhaul = VI (CD - 1.0) m³km

Cut and fill volume for ramps, slip roads, junctions, road approaches, and connections on either side of the road shall be considered as concentrated at the centreline of the road.

The distance between the centres of volume of borrow pits and fills and for cut to spoil material shall be measured along the shortest route determined by the Engineer as feasible and satisfactory. If the Contractor chooses to haul earthworks material over some other longer route, computations for measurement shall nevertheless be based on the distance measured along the shortest route designated by the Engineer.

The mean "Free Haul Distance" for all materials to which "Overhaul" shall apply shall be one kilometre.

"Overhaul" shall be calculated on the basis of a Mass Haul Diagram approved by the Engineer. Any change in the earthworks material Utilisation shall be subject to the Engineer's approval.

The rate shall include for the cost of haulage in excess of the free haul and the maintenance of the haul road.

e. Cut and Spoil

Excavation to spoil of unsuitable material (as defined in **CLAUSE 3102** of this Specification) shall be measured as the volume of the excavation formed. Measurement of spoil of surplus material shall be measured by the volume of 'cut' taken from the mass haul diagram or otherwise in accordance the Drawings and Special Specifications.

f. Haul Distance

The haul distance shall be the distance between the centres of volume of the overhaul material in the cut or borrow pit before excavation and the centre of volume of the portion of the fill constructed with the overhaul material.

The distance between the centres of volume shall be measured along the centre line of the road, and any additional distance of haul ascribed to the following of a different haul route will not be considered. Cut and fill volumes for ramps, road approaches and connections on either side of the road shall be considered as concentrated at the centre line of the main roadway under construction for computing overhaul quantities for payment, unless otherwise specified in the Special Specifications.

The haul distance for material from borrow pit shall be measured along the shortest route determined by the Engineer as being feasible and satisfactory. Should the Contractor choose to haul material over some other longer route, computations for payment shall nevertheless be based on the haul distance measured along the shortest route approved by the Engineer. The haul distance for borrow materials shall be measured to the nearest 0.1 km.

Any handling of materials such as stabilisation, crushing and/or screening oversize materials, etc. shall not have any effect on the haul distance.

If the Contractor chooses not to utilise all the identified suitable borrow areas and quarry sites, but haul material over some longer distance, the overhaul computations will be based on the identified suitable sources and not the actually utilised sources.

g. Free- haul Distance

The free haul distance shall be the distance which material as described in **SUBCLAUSE 1602(a)** must be transported on any trip before overhaul becomes payable. This distance shall be as given in **TABLE 1602/1**, or as otherwise given in the Special Specifications, for material in the respective layers.

Overhaul shall apply to all overhaul in excess of the distance given for materials where the following material types are prescribed as a minimum quality in the Specifications or on the Drawings:

TABLE 1602/1: FREE-HAUL DISTANCES

Material for Layer	Free Haul Distance (km)
Fill and improved subgrade layers	1.0
Sub-base and base course	1.0
Gravel wearing course	1.0

h. Overhaul Distance

The overhaul distance shall be the total haul distance, minus the free haul distance measured to the nearest 0.1 km.

i. Quantity of Material

The quantity of material overhauled shall in all cases be measured after placing and compaction in its final position calculated in the same manner as the Item for the layer to which the overhaul applies.

1603 Measurement And Payment

Overhaul will only be paid for in the cases where it is so specified in the Special Specification. In the cases where overhaul is paid for, the measurement and payment shall be as follows:

Item		Unit
16.01	Over Haul Material Hauled in Excess of its Respective Free Haul Distance	
(a)	Material For Fill Or Improved Subgrade Layers	Cubic Metre x Kilometre (m ³ km)
(b)	Material For Pavement Layers As Specified	Cubic Metre x Kilometre (m ³ km)
(c)	Material For Gravel Wearing Course	Cubic Metre x Kilometre (m ³ km)

The unit of measurement shall be the cubic metre of overhaul material for layers described in SUBCLAUSE 1602(a), measured in accordance with SUBCLAUSE 1602(i), hauled in excess of free haul distance prescribed in SUBCLAUSE 1602(g), multiplied by the overhaul distance measured for payment purposes in as described SUBCLAUSE 1602(h).

The bid rates for overhaul shall include full compensation for hauling material in excess of the free haul distances.

SECTION 1700 Testing of Materials and Workmanship

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1701 Scope

This section covers the tests and methods of testing which are required for the selection and control of the materials and for control of workmanship, trials and construction control testing. During the progress of the Work tests shall be conducted on materials and to check quality of workmanship to ensure compliance with the requirements of the Specifications.

The Contractor's attention is drawn to the provisions of **CLAUSE 1706** with regard to their obligations to conduct tests on a regular basis to check compliance with specification requirements. The Contractor shall submit a Quality Control management system for approval but the intensity of control and of sampling and testing to be conducted by the Contractor may be varied by the Engineer. Any such variations shall be at the Contractor's cost.

1702 Materials Generally

All materials shall conform to the requirements of the Contract, the Drawings and the Specifications and shall be approved by the Engineer prior to incorporation in the Works. Test Certificates shall be submitted by the Contractor for all materials and products supplied which must carry relevant identification marks. Any materials condemned as unsuitable for use in the Works shall be removed immediately from the Site by and without recompense to the Contractor.

1703 General Specifications

Where in the Specifications tests on materials, tests on completed Works and construction control tests are called for or implied, they shall be carried out according to the test methods listed in this SECTION 1700. If a particular test is not covered by the referred standard, then the method shall be to an equivalent standard called for in the contract documents or as directed by the Engineer.

Materials shall comply with the requirements of the current edition of Specifications issued by the Kenya Bureau of Standards or other specifications relevant which may be applicable. These shall be British Standards (BS or BS EN) or American Association of State Highway and Transportation Officials (AASHTO) or American Society for Testing Materials (ASTM). Exceptionally an equivalent Specification may be called for in the contract documents or as directed by the Engineer.

1704 Materials Testing And Acceptance

The Contractor shall provide a preliminary list of all the suppliers from whom he proposes to purchase materials within 30 days of commencement of the site works. Prior to delivery of materials to the job site, the Contractor shall submit certified test reports and samples to the Engineer of all materials proposed for use in the Works, whether from an outside supplier or whether supplied from the Contractor's own resources. The certificate(s) shall show the appropriate test(s) for each material, the test results, and a statement that the material meets the specification requirement. The Engineer's approval shall be received prior to any materials being delivered in bulk to the works.

The Engineer may request further samples for testing, prior to and during construction to verify the quality of the materials and to ensure conformance with the applicable specifications. The Contractor shall provide all samples for confirmatory tests free of charge.

All equipment to be used in testing shall be calibrated at the start of the project or valid calibration test certificates submitted. Recalibration shall be undertaken at regular intervals throughout the project period as approved by the Engineer.

The Contractor shall test samples as specified from each quarry location and borrow pit proposed for use in the Works. The particular tests to be carried out will be determined by the function for which the Contractor proposes to use the material in the Works, as necessary to show compliance with these Specifications. The results of these tests shall be submitted to the Engineer for approval at least 14 days before the quarry or borrow pit material is required for use. Should any quarry or borrow pit material prove to be unsuitable, the Contractor shall investigate further sites or establish more appropriate quality control procedures in existing sites, until suitable materials are found and approved.

The Contractor's programme shall allow sufficient time for materials testing and no claim for delays or extra costs arising out of this will be accepted.

All materials supplied for use in the Works shall conform with specified tolerances and be comparable with the quality of the approved samples which will be retained at the Engineer's office until the completion of the Contract.

Where a material has been specified by a manufacturer's trade name the product of another manufacturer will be accepted provided that, in the opinion of the Engineer, it is in all respects of an equivalent or higher quality.

1705 Independent Testing By The Engineer

The Contractor shall facilitate independent testing by the Engineer as the Engineer may deem necessary in accordance with SECTION 1410.

1706 Testing By The Contractor

The Contractor shall provide, use and maintain on the site throughout the period of execution of the works a suitable laboratory and adequate equipment operated by competent staff for carrying out tests required for the selection and control of the quality of materials and for the control of workmanship in accordance with this Specification, in accordance with SECTION 1410. The Contractor shall assume that tests will be required on all materials used in the works and on all finished work.

The Contractor shall carry out all necessary tests and shall report to the Engineer the results of such tests before submitting materials and finished work to the Engineer for approval. The engineer may confirm from time to time as well as carry out confirmatory tests. In appropriate circumstances, tests may be carried out at the place of manufacture.

1707 The Cost Of Testing

a. Process Control

The cost of testing undertaken by the Contractor in terms of their obligations under CLAUSE 1706 for purposes of process control, including the taking of samples, reinstating where samples have been taken, and provision of all testing equipment, labour, materials, etc, shall be included in the rates for the various Items of work supplied and will not be paid for separately.

b. Producing Certificates

Where the properties of materials or manufactured products are required in these specifications to comply with specifications published by a Standards Authority approved by the Engineer, the Contractor shall produce, when called upon to do so, certificates from the manufacturer confirming that the materials or products supplied comply with the relevant specifications. All costs of providing such certificates shall be borne by the Contractor.

c. Testing Materials and Products Covered by Certificates

The Engineer shall be entitled to take samples of, and order tests to be made on, products and materials for which certificates of compliance may be required. The Contractor shall only be paid at the appropriate rates if the costs of such tests are Itemised in the Bill of Quantities.

1708 Taking And Submitting Samples

a. General

Where the Contractor is required in these Specifications to submit samples of materials or mixtures thereof to the Engineer for approval prior to their being used in the Works, he shall submit such samples in sufficient quantities in addition to sufficient time for proper testing and shall not proceed with the works until the materials are approved.

The Engineer's approval of tests on any materials or mixtures shall in no way relieve the Contractor of their obligation to provide materials, mixtures and workmanship which comply with the Specifications.

All earthworks and pavement samples for testing shall be taken after completion of sections of work on the particular layer to be tested unless otherwise specified or instructed. Where specified or required by the Engineer stratified random sampling methods, as defined in SUBCLAUSES 1803(b) and 1804(b), shall be followed. For the testing of layer work stratified random sampling methods shall be used for obtaining all the sample portions and for determining the locations of in situ test sites.

The method of taking samples shall be as specified in the appropriate sampling and testing methods listed in SECTION 1710 to SECTION 1732, or similar, as approved by the Engineer.

The Engineer shall have full access to the Works for the purpose of taking samples. The Contractor shall render any assistance necessary for taking the samples and shall be responsible for the reinstatement of pavement layers or other structures at the positions where the samples have been taken. Full compensation for rendering assistance with sampling and for reinstatement where samples have been taken shall be included in the rates tendered for the various Items of work tested, and no additional payment will be made in this respect.

b. Sampling Frequency

The minimum sampling frequencies shall be as given in TABLE 1708/1. Samples for tests that are not mentioned in TABLE 1708/1, but for which there are material requirements in these Specifications, shall be taken as required by the Engineer.

Samples shall be taken for laboratory testing for each new material encountered, or when there is a significant change in material properties in the opinion of the Engineer.

TABLE 1708/1: SAMPLING FREQUENCIES

Layer and nominal class of material	Tests to be carried out ¹	Sampling frequency, minimum			
Formation	CBR	1	sample per	10000	m ²
	MDD, PI, grading	1	sample per	5000	m ²
Earthworks fill using soils	CBR, PI, grading	1	sample per	2000	m ³
	MDD	1	sample per	1000	m ³
Backfill to culverts and structures	CBR, PI, grading	1	sample per	500	m ³
	MDD	1	sample per	200	m ³
Substrates of lined drains and channels	MDD	1	sample for every 500 linear metres		
Substrates of drainage chutes	MDD	1	sample for every 20 linear metres		
Improved subgrade or gravel wearing course	CBR, PI, grading	1	sample per	10000	m ²
	MDD	1	sample per	5000	m ²
Sub-base	CBR, incl. swell, grading	1	sample per	5000	m ²
	MDD, PI, LS	1	sample per	5000	m ²
Sub-base, stabilised	UCS or CBR, PI	1	sample per	5000	m ²
	MDD, grading	1	sample per	5000	m ²
Base course	CBR, PI, grading	1	sample per	5000	m ²
	MDD	1	sample per	2500	m ²
Base course, stabilised	UCS, PI	1	sample per	5000	m ²
	MDD, grading	1	sample per	2500	m ²
	MDD	1	sample per	2500	m ²

TABLE 1708/1: SAMPLING FREQUENCIES

Layer and nominal class of material	Tests to be carried out ¹	Sampling frequency, minimum			
Base or Sub-base course using crushed aggregate	PI, SG, Vib. Hammer, grading, flakiness	1	sample per	5000	m ²
	MDD, ACV	1	sample per	10000	m ²
Base course of a bituminous mix or asphalt concrete surfacing	Extraction, grading	1	sample per	10000	m ²
	Marshall test / Gyratory Compaction Test	1	sample per	5000	m ²
Surface treatments	TFV	1	sample per	20000	m ²
	Grading, flakiness	1	sample per	5000	m ²
	Tray Test ²	1	sample per	500	m ²

Notes: 1. The referred tests shall be carried out in accordance with standards test methods indicated in the special specifications or other standards approved by the Engineer.

2. Tray test shall be performed for both bitumen spraying rate and chipping spreading rate.

1709 Testing Methods

All tests shall be conducted in accordance with the Standards specified. Other equivalent national standard specification tests may only be adopted if approved by the Engineer.

Where in the Specifications tests on materials, tests on completed works and construction control tests are called for or implied, they shall be carried out according to test methods listed in hereunder, unless the test in question is not covered within this section. When a particular test is not listed in this section, then the method shall be an equivalent standard called for in the contract documents or as directed by the Engineer.

In all cases the latest amendment or current revision at 28 days prior to the closing date of the tender is implied when reference is made to one of the above standards in the Specification.

The Contractor shall have on the Site all the relevant standards required for the work he is to undertake under the Contract and shall provide one copy of each for the Engineer.

It is emphasised that the Atterberg limits of soil fines shall be measured according to the Kenyan (KS) and British Standard (BS) procedures and utilise BS equipment. Other laboratory test procedures and equipment do not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

All CBR testing shall be carried out using the three-point method as described or other approved method at the discretion of the Engineer. All CBR tests relate to material compacted to the dry density obtained using the compaction test as specified in the respective clauses for material requirements. The CBR testing shall be carried out at moisture content as specified in the respective clauses for material requirements.

1710 Testing Of Soils and Gravels

a. Samples and Sampling

Sampling of soils and gravels shall be carried out as specified or as directed by the Engineer.

Samples shall be prepared for testing as indicated in **CLAUSE 1.5** of BS 1377-1, except that:

- The mass (in g) of a sample required for sieve analysis is about 400D, D being the maximum particle size (mm).

- ii. Samples containing particles larger than 20 mm shall be prepared for compaction and CBR tests as follows:

Sieve an adequate quantity of representative material over the 50 mm and 20 mm sieve. Weigh the material passing the 50 mm sieve and retained on the 20 mm sieve and replace it with an equal mass of material passing the 20 mm sieve and retained on the 5 mm sieve. Take the material for replacement from the remaining portion of the main sample.

Note: Preparation of gravel samples

The aggregations of particles shall be broken with a wooden or rubber hammer or pestle.

Care shall be taken that no individual particles are crushed in the operation.

b. Standard Methods of Testing

Tests on soils and gravels shall be performed in accordance with the standard methods given in TABLE 1709/1.

It is further specified that:

- i. Sieve analysis (BS 1377 - Test 7 (A) - wet sieving) shall be carried out using ISO sieves.
- ii. Compaction test using a 2.5 kg rammer is denoted AASHTO T99. Compaction test using a 4.5 kg rammer is denoted AASHTO T180.

Wherever in the text of this Specification and the Special Specification the term "x % of the MDD (AASHTO T99 or T180)" is used it shall mean that a standard of compaction shall be achieved such that the dry density of the compacted material is x % of the maximum dry density determined from the AASHTO T99 or T180 compaction test.

Samples for the AASHTO T99 or T180 compaction tests shall be taken before compaction of the layer begins unless in the opinion of the Engineer the compactive effort proposed or applied by the Contractor is such that the material characteristics have changed in which case the samples for the tests shall be taken after all compaction is complete.

- iii. Compaction tests: when the material is susceptible to crushing during compaction, a separate and new sample shall be used in the determination of each point on the moisture/density curve.
- iv. In Method A of AASHTO T99 and T180, moulds having a diameter of 102 mm shall normally be used. However, existing moulds to BS 1377 (diameter 105 mm - volume 1 litre) may also be used. The number of blows shall then be increased from 25 to 27, so as to obtain the same compactive energy per unit volume.
- v. The dry density of material placed in the Works shall be determined by the Sand Replacement Method unless the Engineer elects to use a nuclear method as detailed in TABLE 1709/1.

c. Samples and Sampling of Water, Soils, and Rocks for Geotechnical Tests

Sampling of soils and gravels shall be carried out at intervals as specified or as directed by the Engineer. Sampling shall be in accordance with ISO 22475-1.

d. Standard Methods of Testing of Water, Soils, and Rocks for Geotechnical Tests

Tests of water, soils, and rocks for geotechnical tests shall be performed in accordance with the standard methods given in TABLE 1709/2.

Field ground tests during the construction road alignments shall be performed in accordance with the standard methods given in TABLE 1709/3 and as instructed by the Engineer.

TABLE 1709/1: TEST PROCEDURES APPLICABLE TO DISTURBED SAMPLES OF SOILS AND GRAVELS

S/No.	Test Description	Source Standard
1	Sampling and preparation	BS 1377-1
2	Moisture content	BS 1377-2:2022, CI 4.1
3	Liquid limit	BS 1377-2:2022, CI 5
4	Plastic limit	BS 1377-2:2022, CI 6
5	Linear shrinkage	BS 1377-2:2022, CI 7
6	Grading	BS EN ISO 17892-4
7	Sedimentation test	BS EN ISO 17892-4
8	Organic matter content	BS 1377-3:2018, CI 4 &
9	Total sulphate content	BS 1377-3:2018, CI 7
10	pH value	BS 1377-3:2018, CI 12
11	Density-moisture content relationship (2.5 kg rammer)	AASHTO T99
12	Density-moisture content relationship (4.5 kg rammer)	AASHTO T180
13	Density-moisture content relationship Vibrating hammer	BS 1377-2:2022, CI 11.7
14	California Bearing Ratio	AASHTO T193 (ASTM D1883)
15	Density of soil In Place by the Sand Cone Method	AASHTO T191 (ASTM D1556)
16	Density of soil and moisture content In-Place using Nuclear Method	AASHTO T310 (ASTM D6938)

TABLE 1709/2: GEOTECHNICAL TEST PROCEDURES FOR WATER, SOILS AND ROCKS

S/No.	Test Description	Test Standard
Field Tests		
1	Sampling of soil, rock and groundwater	ISO 22475-1
2	Electric Cone Penetration Test	ISO 22476-1
3	Mechanical Cone Penetration Test	ISO 22476-12
4	Dynamic Probing	ISO 22476-2
5	Standard Penetration Test, SPT	ISO 22476-3
6	Plate Bearing Test	ISO 22476-13
7	Geohydraulic Tests	ISO 22282-1
8	Field Density	BS 1377-9
9	Flat Dilatometer Test	ISO 22476-11
10	Field Vane Shear Test	ISO 22476-9
11	Menard Pressuremeter Test	ISO 22476-4
12	In-situ Stress Measurement Tests	BS 5930
13	Redox potential	ISO 11271
14	Measuring while drilling	ISO 22476-15
Laboratory Tests		
15	Water content	ISO 17892-1
16	Bulk density	ISO 17892-2
17	Particle density	ISO 17892-3
18	Particle size distribution	ISO 17892-4
19	Atterberg Limits	ISO 17892-12
20	Organic content	BS 1377-3, CI 4

TABLE 1709/2: GEOTECHNICAL TEST PROCEDURES FOR WATER, SOILS AND ROCKS

S/No.	Test Description	Test Standard
21	Carbonate content	BS 1377-3, Cl 8
22	Sulphate content	BS 1377-3, Cl 7
23	pH value	BS 1377-3, Cl 12
24	Chloride content	BS 1377-3, Cl 9
25	Unconfined compression test	ISO 17892-7
26	Unconsolidated undrained triaxial compression test	ISO 17892-8
27	Consolidated triaxial compression test	ISO 17892-9
28	Compressibility and deformation	ISO 17892-5
29	Direct Shear Test	ISO 17892-10
30	Strength index tests	ISO 17892-6
31	Permeability and erodibility	ISO 17892-11
32	Compaction	BS 1377-4
33	Uniaxial compression	ASTM D7012
34	Indirect tensile test	ASTM D3967
35	Point load test	ASTM D5731

TABLE 1709/3: FIELD GROUND TESTS DURING THE CONSTRUCTION OF ROAD ALIGNMENTS

S/No.	Test Description	Test Standard
1	Field Density – Sand Replacement method (Small pouring cylinder)	BS 1377-9:1990, Cl. 2.1
2	Field Density – Sand Replacement method (Large pouring cylinder)	BS 1377-9:1990, Cl. 2.2
3	Field Density – Nuclear method	BS 1377-9:1990, Cl. 2.5
4	In-situ California Bearing Ratio (CBR) Test	BS 1377-9: 1990, Cl. 4.3
5	Plate Loading Test	BS 1377-9: 1990, Cl. 4.1
6	Field Density – Water Replacement Test method	BS 1377-9:1990, Cl. 2.3
7	Field Density – Core Cutter Test method	BS 1377-9:1990, Cl. 2.4
8	Field Density – Electrical method	Manufacturer's guidance
9	In-situ Penetration Test (Static Cone Penetration Test, SCPT)	ISO 22476-1 for electrical CPT BS EN 22476-12 for mechanical CPT
11	In-situ Penetration Test (Dynamic Probing, DP)	ISO 22476-2
12	In-situ Penetration Test (Standard Penetration Test, SPT)	ISO 22476-3
13	In-situ Corrosivity Test (Apparent Resistivity of Soil)	BS 1377-9: 1990, Cl. 5.1
14	In-situ Corrosivity Test (Redox Potential of Soil)	BS 1377-9: 1990, Cl. 5.2

1711 Testing Of Stone, Aggregate, Sand and Filler

a. Testing Stone, Aggregates, Sand and Filler

Stone, aggregates, sand and fillers shall be regularly tested by the Contractor at a frequency to the satisfaction of the Engineer as part of the Contractor's quality control procedures as they are being manufactured or brought onto the site and used or taken to stockpile.

b. Sampling and Preparation of Samples

Sampling shall be carried out and the samples prepared in accordance with the standard methods given in TABLES 1711/1 to 1711/4.

c. Standard Methods of Testing

Tests on stone, aggregate, sand and filler shall be performed in accordance with the standard methods given in TABLES 1711/1 to 1711/4.

i. The Average Least Dimension of an aggregate shall be determined as follows:

By means of a riffler divide out a representative sample of such a size as to give at least 200 aggregate particles of each fraction to be tested. Sieve the sample through a sieve with an aperture size half the nominal size of the aggregate to be tested and discard the particles passing the sieve (the nominal size is the smallest sieve through which at least 85 % of the aggregate will pass).

By means of callipers with platens of at least 5 mm diameter (or square) measure the smallest dimension of each particle retained on that sieve accurate to 0.1 mm and record the measurement and the number of particles tested. The average least dimension is then calculated as the sum of the smallest dimension of the particles divided by the number of particles measured.

ii. Test for presence of organic impurities in aggregates.

This test is designed to indicate the presence of organic impurities in aggregates used for making concrete.

A 350 cc graduated bottle shall be filled to the 120 cc mark with a sample of the aggregate to be tested and a 3 % solution of sodium hydroxide in water added until the volume of aggregate and liquid after shaking gives a total volume of 200 cc. The bottle shall be stoppered, shaken thoroughly and allowed to stand for 24 hours. If, after 24 hours, the colour of the solution is no darker than a pale brown, the aggregate under test may be deemed satisfactory.

iii. Rapid field test for chlorides in aggregates (Quantab Test).

The purpose of this test is to provide a quick method of testing for chlorides at the point of delivery so that immediate action can be taken to remove any contaminated load.

1. Apparatus required:

- Plastic buckets.
- Spring balance capable of reading to 5 kg with an accuracy of ± 10 g. Plastic drinking cups or similar containers.
- Whatman No. 90 filter papers 125 mm diameter.

Quantab chloride titrators Type 1175 Method

Weigh out 2 kg of the aggregate under test into a bucket. Add 2 kg of clean chloride free water.

Stir once every minute for 15 minutes.

Take a container of the solution from the bucket and place into it, point downwards a filter paper folded into a cone.

Insert into the clear liquid within the filter paper a Quantab titrator strip and leave until the yellow bar at the top of the strip has turned completely blue.

Read off from the scale on the strip the level reached at which the strip has turned white (to first decimal point)

Consult the calibration chart supplied with the test strips and read the percentage NaCl corresponding to the test strip reading.

2. Calculation:

If the % NaCl is X, the amount of Cl ion by weight of aggregate is given by:

$$\text{Cl ion} = 0.61X \%$$

Note: It is important to ensure that the control number on the chart corresponds with the control number on the bottle of test strips in use.

TABLE 1711/1: TEST PROCEDURES APPLICABLE TO AGGREGATE FOR CONCRETE

S/No.	Test Name / Property	Reference Standard
1	Sampling and sample preparation	BS EN 932-1
2	Water content	BS EN 1097-5
3	Particle density and water absorption	BS EN 1097-6
4	Water soluble chloride content	BS EN 1744-1:1998, cl 7
5	Water soluble sulphate content	BS EN 1744-1
Coarse Aggregates		
6	Particle size distribution (PSD)	BS EN 933-1
7	Flakiness index for coarse aggregates	BS EN 933-3
8	Aggregate impact value (AIV)	BS EN 1097-2:2020, Cl 6
9	Loose bulk density and voids	BS EN 1097-3
10	Shape index for coarse aggregates	BS EN 933-4
11	Los Angeles Abrasion For coarse aggregates < 37.5 mm For coarse aggregates > 20 mm	AASHTO T96/ASTM C131 ASTM C535
12	Aggregate Soundness	AASHTO T104/ASTM C88
13	Aggregate abrasion value	BS EN 1097-8:1999, annex A
14	Shell content for coarse aggregates	BS EN 933-7
15	Drying shrinkage	BS EN 1367-4
16	Polished stone value (PSV)	BS EN 1097-8
Fine Aggregates		
17	Fines quality (Sand Equivalent)	BS EN 933-8
18	Organic impurities in sand	AASHTO T21 (ASTM C40)
19	Fines content (sieving method)	BS EN 933-1
20	PSD for filler aggregates (air jet sieving)	BS EN 933-10

TABLE 1711/2: TEST PROCEDURES APPLICABLE TO AGGREGATES FOR UNBOUND AND BOUND MATERIALS

S/No.	Test Name / Property	Reference Standard
1	Sampling and sample preparation	BS EN 932-1
2	Particle density and water absorption	BS EN 1097-6
3	Particle size distribution	BS EN 933-1
4	Fines content	BS EN 933-1
5	Flakiness index	BS EN 933-3
6	Aggregate crushing value	BS EN 1097-2
7	Ten percent fines value (TFV) or 10 % Fine Aggregate Crushing Test (10 % FACT).	BS EN 1097-2

TABLE 1711/2: TEST PROCEDURES APPLICABLE TO AGGREGATES FOR UNBOUND AND BOUND MATERIALS

S/No.	Test Name / Property	Reference Standard
8	Los Angeles Abrasion For coarse aggregates < 37.5 mm For coarse aggregates > 20 mm	AASHTO T96/ASTM C131 ASTM C535
9	Aggregate Soundness	AASHTO T104/ASTM C88
10	Fines quality using Sand Equivalent test	BS EN 933-8
11	Shell content	BS EN 933-7
12	Water soluble chloride content	BS EN 1744-1:1998, cl 7
13	Water soluble sulphate content	BS EN 1744-1
14	Atterberg Limits	BS 1924-2:2018, CLAUSE 4.2

TABLE 1711/3: TEST PROCEDURES APPLICABLE TO AGGREGATES AND FILLERS FOR BITUMINOUS MIXES

S/No.	Property	Test Standard
1	Sampling and sample preparation	BS EN 932-1
Coarse Aggregates		
2	Bulk specific gravity	ASTM C127/AASHTO T85
3	Apparent Specific gravity	ASTM C127/AASHTO T85
4	Water absorption	ASTM C127/AASHTO T85
5	Grading	ASTM C136/AASHTO T27
6	Flakiness Index	BS EN 933-3
7	Flat and Elongated Particles	ASTM D4791
8	Aggregate Crushing Value	BS EN 1097-2
9	Los Angeles Abrasion test	ASTM C131/AASHTO T96
10	Aggregate Soundness	ASTM C88/AASHTO T104
11	Loose Unit Weight	AASHTO T19
12	Rodded Unit Weight	AASHTO T19
13	Bitumen affinity (Static immersion test)	AASHTO T182
Fine Aggregates		
14	Bulk specific gravity	ASTM C128/AASHTO T84
15	Apparent Specific gravity	ASTM C128/AASHTO T84
16	Water absorption	ASTM C128/AASHTO T84
17	Grading	ASTM C136/AASHTO T27
18	Loose Unit Weight	AASHTO T19
19	Rodded Unit Weight	AASHTO T19
20	Sand Equivalent	AASHTO T176
21	Fine Aggregate Angularity	AASHTO T304
Mineral Filler		
22	Specific gravity	AASHTO T100
23	Plasticity Index	AASHTO T90

TABLE 1711/4: TEST PROCEDURES APPLICABLE TO AGGREGATES, SANDS AND FILLERS FOR SURFACE DRESSING

S/No	Property	Test Standard
1	Sampling and sample preparation	BS EN 932-1
Coarse Aggregates		
2	Bulk specific gravity	ASTM C127/AASHTO T85
3	Apparent Specific gravity	ASTM C127/AASHTO T85
4	Water absorption	ASTM C127/AASHTO T85
5	Grading	ASTM C136/AASHTO T27
6	Flakiness Index	BS EN 933-3
7	Aggregate Crushing Value	BS EN 1097-2
8	Los Angeles Abrasion test	ASTM C131/AASHTO T96
9	Sodium Sulphate Soundness	ASTM C88/AASHTO T104
10	Loose Unit Weight	AASHTO T19
11	Rodded Unit Weight	AASHTO T19
12	Bitumen affinity (Static immersion test)	AASHTO T182
13	Average Least Dimension test	AS 1141.20 Part 1, 2 or 3
Fine Aggregates		
14	Bulk specific gravity	ASTM C128/AASHTO T84
15	Apparent Specific gravity	ASTM C128/AASHTO T84
16	Water absorption	ASTM C128/AASHTO T84
17	Grading	ASTM C136/AASHTO T27
18	Loose Unit Weight	AASHTO T19
19	Rodded Unit Weight	AASHTO T19
20	Sand Equivalent	AASHTO T176
Mineral Filler		
21	Specific gravity	AASHTO T100
22	Grading	ASTM C117/AASHTO T11
23	Plasticity Index	AASHTO T90

1712 Testing Of Cement

Ordinary and Rapid Hardening Portland Cement shall be sampled and tested in accordance with and shall comply with all the requirements of Kenya Standard KS EAS 18-1.

Portland blast-furnace cement or Portland pozzolan cement may be used if specified in the Special Specifications, and shall comply with the requirements of the national specification or AASHTO M240-97 or equivalent standard on approval of the Engineer.

Other types of cement shall comply with the specification named.

Tests on cement shall be performed in accordance with the standard methods given in TABLE 1712/1.

TABLE 1712/1: TEST PROCEDURES APPLICABLE TO CEMENT

S/No	Property	Kenyan Standard
1	Sample preparation	KS EAS 148-7
2	Fineness	KS EAS 148-6
3	Cement strength	KS EAS 148-1
4	Setting times and soundness	KS EAS 148-3
5	Chemical analysis	KS EAS 148-2
6	Quantitative determination of constituents	KS EAS 148-4
7	Pozzolanicity test for pozzolanic cements	KS EAS 148-5
8	Heat of hydration – solution method	KS EAS 148-8

1713 Testing Of Lime

Lime shall meet the specifications and conformity criteria set out in KS 1780-1. Samples for quicklime, hydrated lime, lime slurry and lime putty shall be obtained and prepared according to KS 1755-1.1 prior to testing.

Initial consumption of lime

The minimum amount of lime required for stabilisation shall be determined according to BS 1924-2, CLAUSE 10.3. The test is applicable to soils treated with lime only.

In addition to the standard reporting requirements, the test report shall include the type of lime used whether quick lime or hydrated lime, and the available lime content.

The provided information shall be compared to the properties of the lime used during construction. Necessary adjustments shall be made if the properties differ from those considered during design.

Lime for treatment of road materials shall be Hydrated Calcium Lime or Quicklime and, unless otherwise specified, shall comply with the requirements set out in TABLE 1713/1.

TABLE 1713/1: TEST PROCEDURES APPLICABLE TO CEMENT

S/No	Property	Ref. to Standard Test Method
1	Lime specifications	KS 1780-1
2	Sample preparation for lime	KS 1755-1.1
3	Fineness (wet sieving)	KS 1755-2.1
4	Slaking (Dewar Flask)	KS 1755-3.1
5	Soundness (Le Chatelier)	KS 1755-4.2
6	Soundness (Autoclave)	KS 1755-4.3
7	Chemical composition	KS 1755-5.1
8	Lime index – Available lime	KS 1755-6.1
9	Loss on ignition	KS 1755-7.1
10	Free moisture	KS 1755-8.1

1714 Testing of Cement or Lime Treated Materials

Prior to stabilisation, material properties such as particle size distribution/grading, Atterberg's limits, ten percent fines value, sulphate content, chloride content and total organic content shall be determined. Following thereof, an assessment shall be made as to the need for stabilisation. The test results shall also guide the choice of binder to use.

Sampling for stabilisation shall be done according to BS 1924-1:2018, CLAUSE 5. The samples for testing materials mixed with treating agents prepared according to BS 1924-1:2018, CLAUSE 6. Except that samples containing particles larger than 20 mm shall be prepared for compaction and CBR tests as follows:

1. Sieve an adequate quantity of the representative material over the 50 mm and 20 mm sieve.
Note: The mass (in g) of sample required for sieve analysis is around $400D$, D being the maximum particle size (in mm)
2. Weigh the material passing the 50 mm sieve and retained on the 20 mm sieve and replace it with an equal mass of material passing the 20 mm sieve and retained on the 5 mm sieve.
3. Take the material for replacement from the remaining portion of the main sample.

Following the mix design of HBM, the selected binder content shall allow for the method of mixing, type of mixer, expected site conditions (such as material variability and moisture content).

The assumptions made in selecting the binder content should be included in the test report. Testing of cement or lime-treated materials shall be in accordance with methods given in TABLE 1714/1.

TABLE 1714/1: TEST PROCEDURES APPLICABLE TO CEMENT TREATED MATERIALS

S/No	Property	Ref. to Standard Test Method
1	Initial consumption of lime	BS 1924-2
2	Sample preparation	BS 1924-2
3	Moisture content	BS 1924-2
4	Plasticity index of modified/improved materials	BS 1924-2
5	Compaction relationships	AASHTO T180
6	California bearing ratio	BS EN 13286-47
7	Unconfined compressive strength	BS 1924-2
8	Effect of immersion in water on compressive strength	BS 1924-2
9	Indirect tensile strength	BS EN 13286-42
10	Modulus of elasticity in compression	BS EN 13286-43

1715 Testing Of Concrete

a. General

Test standards for concrete constituents, fresh concrete and hardened concrete for use in concrete works, and rigid pavements are included in this section.

Sampling fresh concrete shall be done according to BS EN 12350-1. Care shall be taken to ensure segregation is avoided.

b. Tests on Fresh Concrete

Properties of fresh concrete such as slump, compacting factor, compaction test, air content shall be determined according to the standards provided in TABLE 1715/1.

TABLE 1715/1: TEST STANDARDS FOR FRESH CONCRETE

S/No	Property	Test Standard
1	Sampling	BS EN 12350-1
2	Slump test	BS EN 12350-2
3	Degree of compactability	BS EN 12350-4
4	Vebe Test	BS EN 12350-3
5	Flow table test	BS EN 12350-5
6	Density	BS EN 12350-6
7	Air content Pressure methods	BS EN 12350-7
8	Self-compacting concrete - Slump-flow test	BS EN 12350-8
9	Self-compacting concrete V funnel test	BS EN 12350-9

The air content test shall be conducted for air entrained concrete using two methods as follows:

1. Method A with a graduated cylinder and Method B with a pressure meter, for measuring air content. For method A, the personnel should check that the equipment is calibrated before conducting the test.
2. Method B, on the other hand, is easier and faster to use but is prone to leakage from the valves. As such caution should be taken during testing to ensure leakages are fixed and variations in dial gauge readings are corrected.

The concrete on which the tests have been conducted should be discarded and not used for any other test.

Properties for fresh concrete should always be conducted before concrete cubes for compressive strength tests are made. Only fresh concrete meeting the design requirements shall be used for preparing the cubes.

c. Tests For Cured Concrete Samples

Tests on hardened concrete shall be according to the standards provided in TABLE 1715/2. Where mechanical compaction is used for preparing the samples, over compaction should be avoided as it may lead to segregation. Vibration shall be done until no more bubbles are visible on the surface of the layer.

The shape, dimensions and other requirements for specimens and moulds are specified in BS EN 12390-1.

A log of the daily curing tank temperature should be kept at the laboratory to ensure that the required environmental conditions are maintained.

Concrete cubes shall be tested on a face perpendicular to the casting face. A comment on if the failure shape in the compressive strength test was satisfactory or unsatisfactory shall be included in the report.

TABLE 1715/2: TEST STANDARDS FOR CURED CONCRETE SAMPLES

S/No	Property	Test Standard
1	Sample preparation	BS EN 12390-1
2	Compressive strength of test specimens	BS EN 12390-3
3	Tensile splitting strength of test specimens	BS EN 12390-6
4	Flexural strength of test specimens	BS EN 12390-5
5	Density of hardened concrete	BS EN 12390-7
6	Making and curing specimens for strength tests	BS EN 12390-2
7	Depth of penetration of water under pressure	BS EN 12390-8

TABLE 1715/2: TEST STANDARDS FOR CURED CONCRETE SAMPLES

S/No	Property	Test Standard
8	Determination of the carbonation resistance of concrete at atmospheric levels of carbon dioxide	BS EN 12390-10
9	Determination of the carbonation resistance of concrete Accelerated carbonation method	BS EN 12390-12
10	Determination of the chloride resistance of concrete, unidirectional diffusion	BS EN 12390-11
11	Determination of secant modulus of elasticity in compression	BS EN 12390-13
12	Semi-adiabatic method for the determination of heat released by concrete during its hardening process	BS EN 12390-14
13	Adiabatic method for the determination of heat released by concrete during its hardening process	BS EN 12390-15
14	Determination of the shrinkage of concrete	BS EN 12390-16
15	Determination of creep of concrete in compression	BS EN 12390-17
16	Determination of the chloride migration coefficient	BS EN 12390-18
17	Determination of electrical resistivity	BS EN 12390-19

d. Tests for Concrete Pavements

Strength tests on concrete pavements shall be conducted on cores that have been drilled from the full depth of the slab. The reference test standards for tests on concrete pavements are provided in TABLE 1715/3.

TABLE 1715/3: TEST STANDARDS FOR CONCRETE PAVEMENTS

S/No	Property	Ref. to Standard Test Method
1	Splitting tensile strength of concrete on cylindrical discs	BS EN 13863-6
2	Thickness of a concrete pavement by survey method	BS EN 13863-1
3	Bond between two concrete layers	BS EN 13863-2
4	Thickness of a concrete pavement from cores	BS EN 13863-3
5	Bond stress of dowels to be used in concrete pavements	BS EN 13863-5

e. Coring

Concrete cores shall be taken to determine the in-situ compressive strength of hardened concrete works. The sampling, preparation and testing of concrete cores shall be done according to BS EN 12504-1.

Cores should be taken when the concrete cube strength does not meet the specified design strength. The number of cores required shall be at the Resident Engineer's discretion.

Remedial work and the method statement must be approved prior to any coring works.

The diameter of the cores shall be specified before coring but it should be more than 3 times the maximum aggregate size. 100 mm diameter cores should be drilled for 20 mm aggregate concrete and 150 mm diameter cores for 40 mm concrete. Smaller diameter cores less than 100 mm however should be avoided as these produce variable results.

Immediately after drilling, the location and orientation of each core shall be clearly labelled. Drilling through steel reinforcement shall be avoided and the drilled core shall contain no reinforcement.

f. Non-destructive Tests

Non-destructive tests (NDT) for concrete shall be conducted according to BS EN 12504-2. The rebound number determined by this method can be used to assess the uniformity of concrete in-situ, to delineate zones or areas of poor quality or deteriorated concrete in structures. NDT should be calibrated against test cores or cubes whose compressive strength is known.

Non-destructive tests (NDT) for concrete by determination of Ultrasonic Pulse Velocity (UPV) shall be conducted according to BS EN 12504-4. A correlation of pulse velocity and strength of concrete should be established using moulded specimens or by tests on cores to determine the in-situ compressive strength of concrete.

g. Tests for Paving Blocks and Kerbs

Concrete paving blocks and kerbs shall be tested for total water absorption, breaking strength and breaking load, abrasion resistance (Wide wheel) and Slip resistance according to the test standards in TABLE 1715/4.

TABLE 1715/4: TEST STANDARDS FOR CONCRETE PAVING BLOCKS AND KERBS

S/No	Property	Ref. to Standard Test Method
1	Concrete paving blocks	BS EN 1338
2	Kerbs	BS EN 1340

1716 Testing Of Bituminous Binders**a. Samples and Sampling**

Sampling of straight-run and cut-back bitumen shall be carried out in accordance with AASHTO Method T40 (ASTM D 140).

Sampling of bitumen emulsion shall be carried out in accordance with BS 434, except where a delivery is made in drums or barrels, the number of samples shall be as indicated in AASHTO Sampling Method T40 paragraph 11.1.

b. Standard Methods of Testing**1. Straight-run bitumen**

Tests on straight-run bitumen shall be carried out in accordance with the test procedures in TABLE 1716/1.

TABLE 1716/1: TEST PROCEDURES APPLICABLE TO STRAIGHT RUN BITUMEN

S/No	Test Name	Test Standard
1	Sampling and sample preparation	ASTM D140
2	Specific Gravity at 25°C	AASHTO T228 (ASTM D70)
3	Penetration at 25°C, 100g, 5 Sec(0.1 mm)	AASHTO T49/ASTM D5
4	Softening point (0°C) – Ring and Ball test	AASHTO T53
5	Retained penetration after TFOT, %, Minc	AASHTO T49/ASTM D5
6	Kinematic Viscosity at 135°C	ASTM D2170
7	Ductility at 25°C (Min)	ASTM D113
8	Loss on heating, Max	ASTM D6
9	Solubility in Trichloroethylene, %	ASTM D2042
10	Flash Point (C.O.C), Min	AASHTO T48/ASTM D92
11	Ductility after TFOT (cm), Min	ASTM D113
12	Water	AASHTO T55/ASTM D95
13	Thin film oven test	AASHTO T179/ASTM D1754

2. Cut-back bitumen

Tests on cut-back bitumen shall be carried out in accordance with the test procedures in TABLE 1716/2.

TABLE 1716/2: TEST PROCEDURES APPLICABLE TO CUT-BACK BITUMEN

S/ No	Test Name	Test Standard
1	Sampling and sample preparation	ASTM D140
2	Flash point (T.O.C) °C, Min	ASTM D3143
3	Kinematic Viscosity at 60°C	ASTM D2170
Distillate Test:		
4	Distillate, volume % of total distillate to 360°C	To 225°C (Max)
		To 260°C
		To 316°C
5	Residue from distillation to 360°C, % Vol by difference, Min	ASTM D402
Tests on residue from distillation:		
6	Specific Gravity at 15°C	AASHTO T228 (ASTM D70)
7	Penetration at 25°C, 100g, 5 Sec	ASTM D5
8	Ductility at 25°C, Min	ASTM D113
9	Solubility in Trichloroethylene, %, Min	ASTM D2042
10	Water, %, Max	ASTM D95

3. Bitumen emulsion

Tests on bitumen emulsion shall be carried out in accordance with the test procedures in TABLE 1716/3.

TABLE 1716/3: TEST PROCEDURES APPLICABLE TO BITUMEN EMULSION

S/ No	Test Name	Test Standard
Anionic Emulsions:		
1	Sampling and sample preparation	ASTM D140
2	Flash point (T.O.C) °C, Min	ASTM D3143
3	Viscosity, Saybolt Furol at 500C, SFS	ASTM D7496
4	Storage stability test, 24h, %, Max	ASTM D6930
5	Demulsibility, 35 mL, 0.8 % diocetyl sodium sulfosuccinate, %, Min	ASTM D6936
Coating Ability and Water Resistance:		
6	Coating dry aggregate	ASTM D244
7	Coating after spraying	ASTM D244
8	Coating, wet aggregate	ASTM D244
9	Coating after spraying	ASTM D244
10	Particle charge test	ASTM D7402
11	Sieve test, %	ASTM D6933
12	Cement Mixing Test, %	ASTM D6935
Distillation:		
13	Oil Distillate, by volume of emulsion, %	ASTM D6997
14	Residue, %	ASTM D6997

TABLE 1716/3: TEST PROCEDURES APPLICABLE TO BITUMEN EMULSION

S/ No	Test Name	Test Standard
Tests on Residue from Distillation Test:		
15	Penetration at 25°C,100g,5Sec	ASTM D5
16	Ductility at 25°C, Min	ASTM D113
17	Solubility in Trichloroethylene, %, Min	ASTM D2042
Anionic Emulsions:		
19	Sampling	BS 434-1 Annex A
20	Sample preparation	BS 434-1 Annex B
21	Storage stability (short period test) (inversions to clear sediment, Max)	BS EN 1429
22	Storage stability (long period test) (% water content difference, Max)	BS EN 1429
23	Particle charge	BS EN 1430
24	Residue on 500µm BS sieve (% (m/m, max)	BS EN 1429
25	Residue on 160µm BS sieve per 100 mL, max)	BS EN 1429
26	Stability to mixing with Cement (% coagulation)	BS EN 12848
27	Stability to mixing with coarse aggregate (% coagulation)	BS 434-1 Annex C
28	Binder content (% m/m), min	BS EN 1428
29	Viscosity (degrees Engler °E at 20°C)	BS 434-1 Annex D
30	Coagulation of emulsion at low temperature	BS 434-1: Annex E

c. Requirements**1. General**

Before any bituminous binder is delivered to the Site, the Contractor shall provide the Engineer with a certificate from the manufacturer that the material to be supplied complies in all respects with the relevant specification.

Any bituminous binder delivered in leaking or deteriorated containers may be rejected.

2. Straight-run bitumen

Straight-run bitumens shall comply with all the requirements given in TABLE 1716/4.

TABLE 1716/4: SPECIFICATION FOR STRAIGHT RUN BITUMEN

Penetration Grade	20/30	40/50	60/70	80/100	180/200
Penetration at 25° (100g-5 s) - 0.1 mm	20 - 30	40 - 50	60 - 70	80 - 100	180 - 200
Softening point (Ring and Ball) °C	59 - 69	52 - 60	48 - 56	45 - 52	37 - 43
Flash point (Cleveland open cup) °C (min)	250	250	250	225	200
Ductility at 25°C cm (min)	30	100	100	100	100
Loss on heating (5 h at 163°C) % (max)	0.2	0.2	0.2	0.5	0.5
Penetration of residue from loss on heating % (100g-5s) of Initial pen (min)	80	80	80	80	80
Specific gravity at 25°C	1.02-1.07	1.01-1.06	1.01-1.06	1.00-1.05	1.00 - 1.05
Solubility In Carbon tetrachloride % (min)	99	99	99	99	99

3. Cut-back bitumen

Rapid-curing cut-backs shall comply with all the requirements of AASHTO Standard Specification M81 (ASTM D 2028).

Medium-curing cut-backs shall comply with all the requirements of AASHTO Standard Specification M 82 (ASTM D 2027), except the cut- back 800/1400 which shall comply with the requirements in TABLE 1716/5.

TABLE 1716/5: SPECIFICATION FOR CUT-BACK BITUMEN

STV Viscosity at 40°C (10 mm orifice)	80 - 180 seconds
Distillation (% of total volume)	
Distillate to 225°C	0 - 2 %
Distillate to 315°C	3 - 11 %
Distillate to 360°C	13 % maximum
Penetration on residue from distillation at 360°C (25° - 100g - 5s)	80 - 200 mm
Specific gravity at 15°C	0.92 – 1.04
Solubility In Carbon tetrachloride % (min)	99

Slow curing cut-backs shall comply with all the requirements of AASHTO Standard Specification M 141 (ASTM D 2026).

4. Bitumen emulsion

Bitumen emulsions shall comply with all the requirements of BS 434.

1717 Testing Of Bituminous Mixes

a. Samples and Sampling

Sampling of bituminous mixtures shall be carried out in accordance with AASHTO Method T168 (ASTM D 979).

b. Standard Methods of Testing

Tests on bituminous mixtures shall be carried out in accordance with the test procedures in TABLE 1717/1.

TABLE 1717/1: TEST PROCEDURES APPLICABLE TO BITUMINOUS MIXES

S/ No	Test Name/ Property	Test Standard
1	Sampling	ASTM D979
2	Moisture and volatile distillates	AASHTO T110/ASTM D1461
3	Quantitative extraction and recovery of asphalt binder from asphalt mixtures	AASHTO T319 AASHTO T164
4	Specific gravity of compacted mixture	AASHTO T166 (ASTM D1188 and ASTM D2726)
5	Recovery of bitumen from solution	AASHTO R59 (ASTM D1856)
6	Degree of particle coating	AASHTO T195 (ASTM D2489)
7	Coating and stripping	AASHTO T182 (ASTM D1664)
8	Coating and stripping with adhesion agent	ASTM D2727
9	Maximum specific gravity	AASHTO T209 (ASTM D2041)
10	Degree of pavement compaction	AASHTO T230
11	Marshall stability	AASHTO T245 (ASTM D1559)
12	Hubbard-Field stability	ASTM D1138
13	Modified Lottman (Indirect Tensile Test)	AASHTO T283 (ASTM D4867M)
14	Resilient modulus of asphalt mixtures	ASTM D4123

TABLE 1717/1: TEST PROCEDURES APPLICABLE TO BITUMINOUS MIXES

S/ No	Test Name/ Property	Test Standard
15	Gyratory compaction procedure	AASHTO T312
16	Refusal density by vibrating hammer	BS EN 12697-32
17	Compaction using a slab compactor	BS EN 12697-33
18	Wheel tracking test (Hamburg Wheel)	AASHTO T324
19	Particle size distribution	AASHTO T30
20	Field density - Nuclear Method	ASTM D2950

1718 Testing Of Reinforcing Steel

Structural steel shall comply with the following requirements: KS EAS 412 PART 1-3, KS EAS 134, KS ISO 6934 PART 1-3. Reinforcing steel for use in structures such as bridges shall be tested according to the test standards in TABLE 1718/1.

TABLE 1718/1: TEST STANDARDS FOR REINFORCEMENT STEEL

S/ No	Test Name/ Property	Test Standard
1	Sampling	ISO 15630-1
2	Tensile Test	ISO 15630-1 (KS EAS 193) ISO 6892-1 (KS ISO 6892-1)
3	Bend Test	ISO 15630-1, ISO 7438
4	Rebend Test	ISO 15630-1
5	Chemical Analysis	ISO 15630-1
6	Measurement of geometrical characteristics	ISO 15630-1
7	Determination of the relative rib or indentation area	ISO 15630-1
8	Determination of deviation from nominal mass per meter	ISO 15630-1
9	Welding	ISO 17660
10	Arc stud welding of metallic materials	ISO 14555
11	Studs and ceramic ferrules for arc stud welding	ISO 13918

1719 Testing Of Prestressing Steel

Prestressing steel shall be tested according to the test standards in TABLE 1719/1.

TABLE 1719/1: TEST STANDARDS FOR PRESTRESSING STEEL

S/ No	Test Name/ Property	Test Standard
1	Sampling	ISO 15630-3
2	Tensile Test	ISO 15630-3, ISO 6892-1
3	Bend Test	ISO 15630-3, ISO 7438
4	Reverse Bend Test	ISO 15630-3
5	Isothermal stress relaxation test	ISO 15630-3
6	Stress corrosion test in a solution of thiocyanate	ISO 15630-3
7	Deflected tensile test	ISO 15630-3
8	Chemical analysis	ISO 15630-3
9	Measurement of the geometrical characteristics	ISO 15630-3
10	Determination of the relative rib area	ISO 15630-3
11	Determination of deviation from nominal mass per metre	ISO 15630-3
12	Prestressing steel bars	EN 10138 Part 1 and 4

1720 Testing Of Concrete Pipes And Fittings

Concrete pipes shall comply with the requirements of BS 5911-1 and BS 5911-3.

Concrete for concrete pipes shall be Class 25/30 as specified in SECTION 7400 of this Specification.

The pipes shall have flexible joints in accordance with BS 5911-1 or ogee joints in accordance with BS 5911-3.

Reinforcement may be inserted in the pipes to strengthen them for handling, but the size, spacing and placing of reinforcement shall be to the approval of the Engineer.

All concrete shall be compacted either by spinning or vibrating.

All concrete pipes shall be cured by keeping them saturated with water for at least seven days after casting and protected from the sun and drying winds for at least fourteen days after casting. No pipe shall be used in the work until it is twenty-one days old. The date of casting shall be painted on the barrel.

A minimum of 10 % (ten per cent) of the pipes shall be tested from initial batches prepared by the Contractor and thereafter the frequency of testing shall be decided by the Engineer.

All pipes shall be capable of supporting the works proof loads set out in table 2 of BS 5911-1 for Class M pipes when tested in accordance with Paragraph 25.4 of BS 5911-1.

A set of six concrete cubes shall be made for each day's manufacturing of concrete pipes. Where the crushing strength does not reach the Class 30 requirement, or if pipes appear sub-standard the Engineer may order the above load tests on a set of three pipes from the suspect batch.

Concrete pipes for use in subsoil drains shall be one of the following:

1. Porous concrete pipes to BS 1194;
2. Concrete pipes to BS 5911-1 and BS 5911-3 with a maximum length of 1.5 m laid with open joints.

1721 Testing Of Metal Pipes And Arches

Corrugated metal pipe culverts shall be in accordance with ASTM A760AASHTO Specification M 36 - 82.

Structural plate for pipe, pipe-arches and arches shall be in accordance with ASTM A761AASHTO Specification M 167.

1722 Testing Of Paints For Structures

a. Paint for Structural Steelwork

Paints for steel shall be tested according to the test standards in TABLE 1722/1.

TABLE 1722/1: TEST STANDARDS FOR PAINTS FOR STEELWORK

S/ No	Test Description	Ref. to Standard Test Method
1	Determination of dry-film thickness	EN ISO 12944-6, EN ISO 2808
2	Determination of scratch resistance	EN ISO 1518-1, EN ISO 1518-2

Galvanised Coatings on Iron and Steel

Galvanised coatings on iron and steel shall be tested according to the requirements of EN ISO 1461, EN ISO 2178 and EN ISO 1460.

Red lead priming paint

Lead based priming paints shall comply with BS2523. The composition of lead based priming paint shall be one of the following:

- **Type A:** Red lead (Type C) complying with BS 217-78 % to 82 %. Remainder as specified in BS 2523. This type of paint should only be selected when it is intended to use it within four weeks of manufacture.
- **Type B:** Red lead (Type C) complying with BS 217 - 60 % min. Remainder as specified in BS 2523
- **Type C:** Red lead (Type C) complying with BS 217 - 2 parts; White lead complying with BS 239 - 2 parts; Asbestine complying with BS 1795 - 1 part. These three ingredients shall make 77 - 82 %. The remainder as specified in BS 2523.

Type B and C are suitable for storage for a reasonable period and shall be selected when the paint is not due to be used within four weeks of manufacture.

Bituminous aluminium paint

Bituminous aluminium paint shall be of a type approved by the Engineer.

Other paints

All other paints used in the Works shall be subject to approval by the Engineer.

b. Testing of paints for road signs

Road signs, posts and fittings shall be prepared, treated and painted in accordance with the requirements of ASTM D823.

1723 Testing Of Paint For Road Marking

a. General requirements

The paint to be used for road surface marking shall be specifically manufactured for such purposes. It shall be suitable for applying by brush, low pressure spraying equipment and high pressure spraying equipment. The paint shall be reflectorised unless otherwise specified.

The paint shall be of a type approved by the Engineer.

b. Colour

White

The colour of white markings shall be BS Colour No. 00E55 of BS-4800. The pigment used for white materials shall be titanium dioxide Type A (Anatase) or Type R (Rutile) complying with BS 1851.

Yellow

The colour of yellow markings shall be to BS Colour No. 08E51 of BS 4800.

Red

The colour of red markings shall be to BS Colour No. 04E55 of BS 4800.

Blue

The colour of blue markings shall be to BS Colour No. 28E56 of BS 4800.

Green

The colour of green markings shall be to BS Colour No. 14E53 of BS 4800.

c. Drying Time

The drying time allowed shall be as specified by the manufacturer, subject to the touch dry condition being reached in a maximum of 15 minutes.

d. Reflectorisation

Retro-reflective road-marking paint shall comply with the requirements of KS EAS 927. The retro-reflective glass beads shall conform to the requirements of BS EN 1423 or equivalent, subject to a maximum nominal size of 0.8 mm.

1724 Testing Of Hot-Applied Thermoplastic Material For Road Marking**a. General requirements**

The material for hot-applied thermoplastic "paint" for road marking shall be in accordance with KS EAS 928: Part 2. The material shall be of & type approved by the Engineer.

b. Colour

White

The colour of white markings shall be BS Colour No 00E55 of BS 4800.

Yellow

The colour of yellow markings shall be to BS Colour No. 08E51 of BS 4800.

c. Composition

The hot-melt thermoplastic road-marking material shall be of tropical grade with a softening point of the binder of 45° - 50°C. The binder shall be plasticised synthetic resin and the material shall be reflectorised by mixing in 20 % by mass Class A glass beads. The thermo-plastic road marking material shall consist of light-coloured aggregate, pigment and extender bound together with resin, elasticised with oil as necessary, in approximately the following proportions:

- Aggregate, including Ballotini beads: 60 %
- Pigment and extender: 20 %
- Binder: 20 %

The maximum size of aggregate shall be 2 mm.

The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in TABLE 8502/2 and TABLE 8502/3.

1725 Testing Of Reflective Materials On Road Signs**a. General Requirements**

The reflective material, when applied to the sign plate, shall give the appearance of a continuous reflecting surface under any angle of observation. It shall consist of a smooth exterior film with spherical lenses embedded beneath the surface, and shall have a protected, precoated adhesive backing which shall be tack-free, heat-activated for mechanical vacuum-heat application. The combination"- of various elements shall result in a non-exposed lens type optical reflecting system. The reflective material shall be applied as per the instructions from the manufacturer of the retro-reflective material used.

Specific requirements

The reflective material shall comply with the following specifications:

i. Reflective brightness

The minimum coefficient of luminous intensity CIL (Coefficient d'Intensite Lumineuse) of the

reflective sign surface, when illuminated by CIE Standard Illuminant A (colour temperature of 3127°C), shall be as specified in TABLE 1725/1. The response of the photoelectric receiver shall be corrected to the colour sensitivity of the average photopic human eye.

The brightness of the reflective material totally wet by rain shall be not less than 90 % of the above values.

ii. Weather resistance

The reflective surface of the sign shall be weather resistant and shall show no appreciable cracking, blistering, crazing or dimensional changes after 2 years unprotected outdoor exposure at 45° upwards inclination to the vertical facing West in Nairobi or Mombasa in accordance with approved testing procedures conducted by Ministry responsible for Roads, Materials Branch. After cleaning, the CIL values of the reflective surface shall then be not less than 80 % of the values given in TABLE 1724/1, and the colours shall still conform to the specified requirements.

iii. Bonding strength

When reflective surfaces are laminated to the base materials, the adhesion shall be such that the reflective material shall resist peeling, scuffing and marring during the normal handling or shocking off when jabbed with a spatula at - 20°C. It shall withstand 8 hours of soaking in water at 25°C without any noticeable edge lifting or curling. The adhesive shall have no staining effect on the reflective material. The adhesive shall permit the reflective material to adhere securely 48 hours after application at temperatures between - 20°C and + 93°C

iv. Flexibility

When bent around a 20 mm diameter mandrel at a temperature of 20°C, the reflective material applied to an aluminium panel of 0.5 mm ' thickness shall show no evidence of cracking around the outside of the bend. After flattening out, the CIL values shall be not less than those given in TABLE 1725/1.

v. Impact resistance

When a 25 mm diameter steel ball is dropped from 2 metres height onto the reflective face of the sign specimen at an ambient temperature of 20°C, the reflective material around the impact point shall show no evidence of cracking or peeling off. The CIL values of the impact area shall be not less than those given in TABLE 1725/1.

vi. Solvent resistance and cleaning

After immersion of a specimen of reflective sign material for 10 minutes in methyl alcohol, kerosene or turpentine, or for 1 minute in toluol or xylol, the reflective material shall show no evidence of dissolving, puckering or blistering. The reflective material shall be capable of withstanding washing with a mixture of water and mild detergent, turpentine and methanol. The reflective surface shall be such as to be readily refurbished by cleaning and clear over-coating in accordance with the manufacturer's recommendations.

TABLE 1725/1: COEFFICIENT OF LUMINOUS INTENSITY

Angle of		Minimum CIL Value Candelas per hex m ²				
Divergence +	Incidence ++	White	Yellow	Red	Green	Blue
0.2°	5°	70	50	14.5	9	4
	30°	30	22	6	3.5	1.7
	40°	12	10	2.7	1.5	0.7
0.33°	5°	50	35	10	7	3
	30°	24	10	4	3	1
	40°	9	6	1.8	1.2	0.4
0.5°	5°	30	25	7.5	4.5	2
	30°	15	13	3	2.2	0.8
	40°	7	5	1.4	1.1	0.3
2°	5°	4	5	1	1	0.5
	30°	2	2.5	0.5	0.4	0.1
	40°	1.5	1.3	0.3	0.2	0.06

+ *Divergence Angle* - The angle between the line formed by a light beam striking the surface and the line formed by its reflected light.

++ *Incidence Angle* - The angle between a light beam striking a surface at a point and the line perpendicular to the surface at the same point.

1726 Testing Of Colours For Road Signs

Standard colours to be used for signs, posts and fittings shall be as described in the relevant BS standards listed in TABLE 1726/1:

TABLE 1726/1: TESTING STANDARDS FOR ROAD SIGN COLOURS

S/ No	Test Description	Ref. to Standard Test Method
1	Red	BS 381C No. 537
2	Blue	BS 4800 No 18 E 53
3	Yellow	BS 381C No. 355
4	Green for Primary Route signs	BS 4800 No. 14 C 39
5	Grey for posts, fittings and back of signs	BS 4800 No. 10 A 11
6	Cream	BS 381C No. 352
7	White	BS 873 Part 1 - CLAUSE 1-3.2
8	Black	BS 873 Part 1 - CLAUSE 1-3.3

1727 Testing Of Waterproof Paper

Waterproof paper to be used under concrete slabs and foundations shall comply with BS 1521 for Waterproof Building Paper, Class B, and shall have fibrous reinforcement.

1728 Testing Of Galvanised Coatings

Galvanised coatings on iron and steel shall comply with the standards in TABLE 1728/1.

TABLE 1728/1: TESTING STANDARDS FOR ROAD SIGN COLOURS

S/ No	Test Description	Ref. to Standard Test Method
1	Determination of thickness of hot dip galvanised coatings	ISO 1461, ISO 2178, ISO 1460
2	Galvanised coatings on corrugated sheets:	BS 3083
3	Galvanised coatings on iron and steel:	BS EN 1461
4	Galvanised coatings on steel sheet and strip:	BS EN 10143
5	Galvanised coatings on wire:	BS EN 10244-2

1729 Testing Cementitious Binders and Concrete

a. General

Tests to determine the properties of hydraulically modified and hydraulically bound materials shall be conducted according to the standards in TABLE 1729/1 and to requirements outlined below.

b. Test for Cementitious Binder Content

Where the cementitious binder content is determined, due allowance shall be made for the presence in the un-stabilised material of naturally occurring MgO or CaO which affects the result of such tests. If the standard deviation of the natural CaO plus MgO content of the untreated material exceeds 0.35 % any determination of the cementitious-binder content shall be ignored.

Sample holes shall be randomly (as defined in SUBCLAUSES 1803(b) and 1804(b)) spaced transversely as well as longitudinally over the area to be tested, or as directed by the Engineer, and if the material is road-mixed, samples shall be taken from the top and bottom of each hole. The minimum number of samples per test shall be 10.

c. Canvas Patch Test for the Spreading Rate of Cementitious Binder

The following method shall be used for determining the spreading rate of a chemical stabilising agent where bulk distributors are used: At least 10 clean canvas patches, each measuring 1.0 m x 1.0 m shall be placed flat on the road in selected positions in relation to the bulk distributor's track. After the stabilising agent has been spread by the bulk distributor, the canvas patches shall be carefully lifted and all the material on the patches transferred to a container and weighed. The total mass of stabilising agent on each patch is then recorded and the average rate of application determined. Instead of canvas patches, flat metal trays may be used for collecting the stabilising agent.

d. Test for Mix Uniformity in Chemically Stabilised Layers

Where required by the Engineer, the Contractor shall determine the mix uniformity in chemically stabilised layers by means of unconfined compressive strength tests, using an approved method.

The Contractor shall without delay make the necessary arrangements to take samples in accordance with the requirements in the method used.

e. Test for Initial Consumption of Lime

The objective of the gravel ICL test is the control of the pH in lime and cement stabilised soil in order to allow the possible formation of cement minerals, calcium silica hydrate in particular, and for proper modification to take place. The stabiliser to be used during construction (or the nearest equivalent) should be used to carry out this test.

f. Determining the Compressive Strength

The procedure for sampling and manufacturing, storing, curing and testing test cubes shall be in accordance with appropriate tests in SECTION 1804 (b).

Where specified in the Special Specifications, the compaction of concrete specimens in the moulds by means of a vibrating table shall be obligatory. In such case the method of compaction shall be as follows:

i. Plastic Concrete

Fill the mould halfway and vibrate it and spade it on all four sides with a suitable trowel to remove air bubbles. Stop the vibration as soon as a wet sheen appears on the surface. Fill the mould and repeat the procedure, but stop when again a wet sheet appears on the surface.

ii. Stiff Concrete

The same procedure is followed, except that the mould is filled in three to four steps instead of in two. The vibration is stopped for each layer when a wet sheen appears.

g. Consistency

The test method described in shall apply in regard to the slump test.

h. Air Content

The air content of the freshly mixed concrete shall be tested by the method given in BS 1924, or equivalent. Air content tests shall be conducted on the same samples of concrete from which cubes were made for the 28 – day compressive strength tests.

i. Drilling and Testing the Cores

Where sections of concrete which have failed to comply with the Specifications are required to be further investigated by extracting and testing concrete cores, 100 mm or 150 mm cores shall be drilled and tested. The sampling and testing procedure to be followed shall be in accordance with the publication Concrete Core Testing for Strength – Concrete Society Technical Report No.11, published by the Concrete Society of Great Britain.

The instructions of this report shall be followed for determining the “estimated potential strength”, which shall be compared with the 28 days cube strength specified for each type of concrete. Corrections to the actual core strength to allow for excess voids, included steel and the length: diameter ratio of cores shall be as stated in this publication, and the correction for curing shall be determined by the Engineer in accordance with this publication and such other information as he may deem to be appropriate.

The Engineer’s decision regarding the degree to which the concrete, which is represented by the cores tested as described above, complies with the requirements and also regarding the properties and suitability of the concrete, shall be final and binding.

TABLE 1729/1: TEST STANDARDS FOR HYDRAULICALLY MODIFIED AND HYDRAULICALLY BOUND MATERIALS

S/ No	Test Name / Property	Test Standard
1	Sampling and sample preparation	BS 1924-2
2	Plasticity index of modified/improved materials	BS 1924-2
3	California bearing ratio	BS EN 13286-47
4	Water content	BS 1924-2
5	Initial consumption of lime	BS 1924-2
6	Compaction relationships	AASHTO T180
7	Unconfined compressive strength	BS 1924-2
8	Indirect tensile strength	BS EN 13286-42
9	Effect of immersion in water on compressive strength	BS 1924-2
10	Modulus of elasticity in compression	BS EN 13286-43

1730 Field Density Testing

a. General

All earthwork and pavement layers and backfill to drainage works and structures will be subject to construction control testing by the Engineer, and the Contractor must allow for any disturbance or delays to the sequence of their operations occasioned by such control testing.

The Contractor shall request, in writing, the Engineer's approval for each layer of each section of earthworks and pavement construction and backfill to drainage works and structures. Such requests shall be made only when the Contractor is fully satisfied that the section of the work concerned is in the condition required by this Specification. Such requests shall be accompanied by the test results required in accordance with this Specification.

The Engineer shall thereupon without undue delay inspect the section for any visible wet spots, laminations, heaving material (visible during compaction or on proof rolling), segregation, and for the uniformity of the mixing and compaction. Providing the visual aspects are satisfactory, the Engineer shall test the section of the works submitted and inform the Contractor in writing of the results of the tests at the same time accepting or rejecting the section or layer concerned.

Work on layers shall in no circumstances commence until the preceding layer has been approved and accepted by the Engineer in writing. The Contractor is wholly responsible for protecting and maintaining the condition of the work which has been submitted for approval.

Should any layer be left unprotected for more than 24 hours subsequent to approval the Contractor shall request re-approval of the layer and the layer will again be subject to proof rolling, construction control testing, and tolerance checks in accordance with this Specification.

Notwithstanding the Engineer's approval of a layer, the Contractor shall be responsible for making good any subsequent damage due to traffic, ingress of water or any other reason and should any damage occur the layer will again be subject to proof rolling, construction control testing and tolerance checks in accordance with this Specification.

b. Testing Frequency

The minimum testing frequencies shall be as given in TABLE 1730/1.

c. Testing Methods

If a nuclear method is used for determining density and moisture content, tests will be done at least at the same frequency required when using the sand replacement method but at each nuclear densometer test location, the average of two readings taken at positions rotated by 180° shall be used. A check/comparison test using the sand replacement method shall be carried out as required by the Engineer.

Initial calibration of the nuclear testing equipment shall be done by carrying out at least fifty tests in parallel with the sand replacement method for each different material encountered.

When starting to use a new material source, or whenever there is a change of material type, a calibration shall be carried out in accordance with the manufacturer's guidelines or as required by the Engineer to establish a moisture correction and any correction of density required. Check tests will be used to update the initial calibration of the nuclear density testing equipment.

d. Field Density Requirements

The required field densities for each material type shall be as shown in TABLE 1730/2. The values shown are nominal values to which an assessment of the results shall be applied in accordance with SECTION 1800.

TABLE 1730/1: TESTING FREQUENCIES FOR FIELD DENSITY TESTING

Layer and nominal class of material	Frequency, minimum	Absolute minimum
Formation	1 test per 1000 m ²	3 tests per section and 1 test per 50 m
Earthworks fill using soils	1 test per 200 m ³	3 per section per layer
Backfill to culverts and structures	2 tests per 10 m ³	2 per section
Substrates of lined drains and channels	1 test for every 200 linear metres	1 test for every 200 linear metres
Substrates of drainage chutes	1 test for every 10 linear metres	1 test for every 200 linear metres
Fill or improved subgrade layers using dump rock (DR)	Method Specification	
Improved subgrade layers using gravel/soils	1 test per 1000 m ²	4 per section per layer
Gravel wearing course used on gravel roads: (GW)	1 test per 1000 m ²	4 per section
Sub-base: (granular, bitumen stabilised, and hydraulically improved or bound)	1 test per 750 m ²	5 per section
Base course: (granular, bitumen stabilised, and hydraulically improved or bound)	1 test per 500 m ²	6 per section
Base course of bituminous mix: (DBM, EME, SBM)	1 test per 500 m ²	6 per section
Asphalt surfacing (AC, SMA, DBM, Gap Graded Asphalt, Sand Asphalt, Cold Mix)	1 test per 400 m ²	6 per section

TABLE 1730/2: MINIMUM FIELD DENSITY, NOMINAL VALUES

Layer and Nominal Class of Material	Field Density, Lower Specification Limit
Formation (after removal of topsoil etc.)	Depends on the depth below formation, reference is made to TABLE 3606/1
Backfill to culverts and structures	To be the same as adjacent layers at the same level, not less than 95 % AASHTO T180
Substrates of lined drains and channels	93 % of MDD (AASHTO T180)
Substrates of drainage chutes	93 % of MDD (AASHTO T180)
Fill or improved subgrade layers using dump rock: (DR)	Method specification
Earthworks fill using soils: (more than 300 mm below formation level)	100 % of MDD (AASHTO T99)
Lower improved subgrade layers using gravel/soils	100 % of MDD (AASHTO T99)
Upper improved subgrade layers using gravel/soils	95 % of MDD (AASHTO T180)

TABLE 1730/2: MINIMUM FIELD DENSITY, NOMINAL VALUES

Layer and Nominal Class of Material	Field Density, Lower Specification Limit
Gravel wearing course used on gravel roads: (GW)	95 % of MDD (AASHTO T180)
Sub-base of natural gravel	95 % of MDD (AASHTO T180)
Sub-base of hydraulically modified material	95 % of MDD (AASHTO T180)
Sub-base of crushed aggregate	96 % of vib. Hammer
Base course of natural gravel	95 % of MDD (AASHTO T180)
Base course of cemented material: (HBS3, HBS6, HBS9)	95 % of MDD (AASHTO T180)
Base course of crushed aggregate	98 % of vib. Hammer
Base course of cold bituminous mix	96 % of Marshall density, or method specifications in notes below.
Base course of hot bituminous mix: (DBM, EME, SBM)	> 93.5 % of Max. Theoretical Density Gmm
Asphalt concrete: (AC20, AC14, AC10)	96 % of Marshall bulk density
Asphalt concrete: (19.0, 12.5, 9.5 Nominal mixes)	> 93.5 % of Max. Theoretical Density Gmm

Notes: Marshall density cannot be used on coarse bituminous material types, i.e. with nominal aggregate size 30 mm or larger. Whether or not Marshall compaction can be applied for a specific type of cold bituminous mix shall be decided by the Engineer.

1731 Tests Of Surface Regularity, Levels And Layer Thickness

a. General

i. Straight edge measurements, normal conditions

Measurements of surface regularity shall be carried out with a 3 m straight edge having sharp right angled corners at the bottom, and shall be placed on the road at any angle to the centreline as directed by the Engineer. Measurements shall be carried out by measuring the largest deviation from true surface along the straightedge.

Using the rolling straight edge for measuring surface irregularities, the apparatus and testing method for this shall be in accordance with testing Method BS EN 933-1ST3 of TMH6 of South Africa.

ii. Straight edge measurements, severe conditions

Where surface irregularities are measured on a surface with a coarse surface texture in the opinion of the Engineer, such as grooved concrete pavements, crushed aggregate pavement layers, natural gravel base course, asphalt with rolled in such chipping, seals and other like surface, the following procedure shall be followed.

A metal wedge of 100 mm in length and 50 mm in width shall be constructed with a taper of 7.5 horizontal to 1.0 vertical and tapering to a feather edge (50 mm wide). Parallel lines spaced at 7.5 mm intervals shall be engraved on the sloping face and numbered to indicate the positions where the wedge is 1.0 mm, 2.0 mm, etc, thick.

iii. Horizontal tolerances

At no point shall the distance between the centreline and the edge of the top of a layer be less than that detailed or more than 150 mm in excess of that detailed.

iv. Shoulders

Shoulders shall be constructed to the same thickness, level, crossfall and surface regularity requirements as for the adjacent pavement layers, except otherwise as stated in the special specifications

b. Surface Regularity, Straight Edge Measurements

The required surface regularity, measured with a 3 m straight edge at any angle in relation to the centreline, shall be within the limits shown in TABLE 1731/1.

TABLE 1731/1: SURFACE REGULARITY, MEASUREMENTS WITH 3 M STRAIGHT EDGE

Layer	Maximum Straight Edge Deviation (mm)
Bituminous wearing course	6
Bituminous binder course	6
Base course (not pre-mixed materials)	6
Gravel wearing course	15
Sub-base	20

c. Surface Levels

The maximum deviation in levels shall be as shown in TABLE 1731/2.

TABLE 1731/2: SURFACE LEVELS

Layer and Material Class	Maximum Deviation Levels (mm)			
	High (+)		Low (-)	
	H_{90} value ¹	Absolute max H_{max} value	H_{90} value ¹	Absolute max H_{max} value
Base course, when followed by a seal only	10	15	10	15
Base course, when followed by AC surfacing	NIL	5	10	20
Sub-base	NIL	5	20	25
Formation	NIL	NIL	50	60
Gravel wearing course	15	20	15	20

¹) H_{90} is the limit within which 90 % of the measurements shall fall when assessing 50 or more measurements against the specified level at the respective locations the measurements were taken.

d. Surface Crossfall

The maximum deviation in longitudinal slope or crossfall shall be as shown in TABLE 1731/3. The values shown are nominal values to which an assessment of the results shall be applied in accordance with SECTION 1800.

TABLE 1731/3: SURFACE CROSSFALL

Layer	Maximum Crossfall Deviation \pm (%)
Bituminous wearing course	0.25
Base course (not pre-mixed materials)	0.25
Sub-base	0.50
Formation	0.50
Gravel wearing course	0.50

e. Layer Thickness

The final compacted layer thickness measured by excavating trial pits or core drilling shall not deviate more from the specified thickness than the maximum deviations shown in TABLE 1731/4. The measurements shall be taken at locations as directed by the Engineer at intervals not less frequent than 25 metres and a lot size shall be at least 20 measurements.

TABLE 1731/4: LAYER THICKNESS

Layer	Maximum Deviation in Layer Thickness (mm)	
	T_{90} value ¹	Absolute max T_{max} value
Bituminous wearing course	5	10
Bituminous base course (not pre-mixed materials)	10	15
Base course, aggregate or natural gravel	10	20
Sub-base	15	25
Improved subgrade layers	20	35
Gravel wearing course	15	25

¹) T_{90} is the limit within which 90 % of the measurements shall comply when assessing 20 or more measurements against the specified layer thickness.

1732 Laboratory Trials And Site Trials

a. Laboratory Trials

Laboratory trials shall be carried out by the Contractor and the Engineer on earthwork and pavement materials which are to be used in the works in their natural state to establish a relationship between their specified end product requirements and properties which can be readily determined in the field for construction control purposes.

Laboratory trial mixes and site trials for bituminous mixes shall be carried out in accordance with the requirements of **SERIES 5000** of this Specification.

Mixed materials, the composition of which meets the specified requirements and is accepted by the Engineer, shall then be used in the site trials to establish that all specified requirements of the completed pavement course can be achieved.

The Laboratory trial mix results and the Contractor's proposals based thereon shall be submitted to the Engineer at least two weeks before the Contractor proposes to use the mixed material in the site trials.

b. Site Trials

The Contractor shall prepare a Trial Section Programme for the approval of the Engineer detailing all sequences of the proposed trial section. In addition to the Items listed further below, at least the following, where appropriate, shall be included:

1. Date and time, location, sketch of location and type of layer to be placed;
2. Preparation of surface;
3. Rate of application;
4. Frequency of testing (test trays, cores, density measurements, gradation, etc);
5. Type and number of equipment to be used;
6. Roller pattern;
7. Joint construction methods.

The detailed plan for the proposed trial section shall be forwarded to the Engineer for approval not less than two working days before the planned trial. Attention shall be given to joint construction methods, limitation of longitudinal and transversal joints and handling of materials.

Full scale laying and compaction site trials shall be carried out by the Contractor on all earthwork and pavement materials proposed for the works using the constructional plant and methods

proposed by the Contractor for constructing the works. The trials shall be carried out with the agreement, and in the presence of, the Engineer.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of their mixing and compaction equipment to provide and compact the material to the specified density and to confirm that the other specified requirements of the completed earthwork or pavement layer can be achieved.

Each trial area shall be at least 100 metres long and to the full construction width and shall be laid to the specified depth for the material. It may form part of the works provided it complies with the Specification. Any areas which do not comply with the Specification shall be removed and a new trial section shall be laid.

The Contractor shall allow in their programme for conducting site trials and for carrying out the appropriate tests. The trial on each pavement layer shall be undertaken at least 21 days ahead of the Contractor proposing to commence full scale work on that layer.

The Contractor shall compact each section of trial over the range of compactive effort the Contractor is proposing and if appropriate, the following data shall be recorded for each level of compactive effort at each site trial:

- i. The composition and grading of the material before the site trial.
- ii. The composition and grading of the material including the cement, lime or bitumen content.
- iii. The moisture content at the time of compaction and the optimum moisture content for the specified compaction.
- iv. The type, size, tyre pressure, frequency of vibration and the number of passes of the compaction equipment.
- v. The maximum dry density or target density as appropriate measured on a sample before and at intervals through the site trials.
- vi. The density achieved.
- vii. The compacted thickness of the layer.
- viii. Any other relevant information as directed by the Engineer.

At least eight sets of tests shall be made by the Contractor and the Engineer on each 100 metres of trial for each level of compactive effort and provided all eight sets of results over the range of compactive effort proposed by the Contractor meet the specified requirements for the material the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements.

The Contractor shall not proceed with the placing of the layer tried in the trial section until the methods, materials and procedures established in the trials have been approved. Such approval shall be based on a detailed trial section report prepared by the Contractor including all observations and test results. Should the trial fail, the Contractor shall perform additional trials at their own cost until a trial and the trial section report has been approved by the Engineer.

If during the execution of the works, the construction control tests indicate that the requirements for a material are not being consistently achieved, then work on that layer shall stop until the cause is investigated by the Contractor. Such investigation may include further laboratory and site trials on the material to determine a revised set of data as above which, when agreed, shall be the basis on which all subsequent material will be provided and processed to achieve the specified requirements.

Agreement by the Engineer to a set of data recorded in a site trial shall not relieve the Contractor of any responsibility to comply with the requirements of this Specification and the Special Specification.

1733 Tests On Structures

a. Test on Elastomeric Bearings

Tests on elastomeric bearings shall be conducted in accordance with BS EN 1337-2, BS EN 1337-3, BS EN 1337-5 and the bearings shall comply with the test requirements specified.

b. Prestressed Concrete

i. General

Where so directed by the Engineer the Contractor shall make arrangements for samples of the materials he intends to use in the Works to be tested by an independent testing authority. The cost of testing prestressing steel, anchorage assemblies and couplings shall be included in the rates.

Material represented by samples which do not comply with the specified requirements shall be removed and replaced with suitable material.

ii. Anchorage's and Couplers

Anchorage's and couplers shall be tested in accordance with the requirements of **CLAUSE 7503**. The anchorages and couplers shall be assembled in accordance with their practical application on the site where all components necessary for anchoring shall be used excluding the ducts.

iii. Prestressing Steel

Prestressing steel shall be tested in accordance with the requirements of **CLAUSE 7503**.

iv. Grout

The fluidity of grout shall be measured with a flow cone, immersion apparatus or viscometer. The instrument shall be accurately calibrated in an approved laboratory before use.

The results obtained from grout testing shall be compared with the times determined in the laboratory for grouts of the specified viscosities.

The Contractor shall submit a detailed method statement for grout testing to the Engineer for approval at least 30 days prior to any work being undertaken.

c. Test on Foundation Piles

Testing will be required on piles for the purpose of establishing the settlement to be expected at working load, or some multiple thereof; determining the ultimate bearing capacity and checking the structural soundness of the piles.

Load tests will be carried out as described in BS 8004 Section 7, and either be Maintained Load or Constant Rate of Penetration tests. The selection of test type will be made by the Engineer unless otherwise prescribed in the Special Specifications. The type of pile, its function in the works design and the ground conditions at the site will be considered by the Engineer in determining the most appropriate test or numbers of tests to be executed. When the ultimate bearing capacity is critical to the design then CRP tests will be required.

The structural soundness of all cast-in-place piles will be determined by integrity testing. Various methods are available for checking the integrity of concrete piles after installation and the Contractor may propose their preferred method. The Engineer will decide whether the results of these tests point to the likelihood of a defect being present such as to materially affect the long term load carrying capacity of the pile. He will then decide whether to carry out further examination of the pile or to take remedial action.

The Contractor shall submit a detailed method statement for pile testing to the Engineer for approval at least 30 days prior to any work being undertaken.

All pile testing shall be included in the Contractor's rates for piling work and shall not generally be the subject of a separate Item in the Bills of Quantity. Where the site location is remote and the number of piles required is relatively small then separate Bill Items will be included in the rates. Under all conditions any remedial work required will be at the Contractor's cost.

1734 Measurement And Payment

Payment for the Engineer's laboratory shall be in accordance with SECTION 1400.

Item		Unit
17.01	Special Tests Requested by the Engineer	
(a)	Tests	Provisional Sum
(b)	Contractor's Overhead and Profit	%

The actual costs of special tests requested by the Engineer shall be reimbursed from the provisional sum entered in the Bill of Quantities for such tests. The Contractor's overhead and profit associated with arranging and paying for the tests shall be covered by a percentage on the actual costs.

SECTION 1800 Quality Control

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1801 Scope

This section describes the scheme used for determining, by means of tests and measurements and by applying statistical quality and process controls, whether certain specified requirements related to the properties of materials and workmanship are being complied with.

It also covers the requirements for the control to be exercised by the Contractor when monitoring the quality of their work and materials and the routine tests and inspections to be carried out by the Engineer.

1802 General

Certain standards of quality and performance are defined in the Specifications with regard to the properties of materials and workmanship to be supplied. Tests shall be conducted and measurements taken to check the relevant properties of the materials and workmanship and the results of such tests and measurements shall be assessed on the basis of the prescribed criteria for compliance with the specified requirements.

Wherever possible, acceptance criteria shall be determined by way of statistical principles described in this section or in BS 5702 – 2, Guide to Statistical Process Control. Wherever statistical acceptance criteria are deemed inappropriate the minimum specified requirement shall be fully complied with.

Despite acceptance of those properties judged by these statistical methods, the materials or work submitted will be rejected when other properties (which are not controlled by statistical methods) fail to comply with the requirements of the Specifications, or where there are other causes for rejection such as obviously defective workmanship or excessively variable properties, visible signs of poor workmanship, and similar considerations which constitute sufficient grounds for rejecting the work without any further testing.

The Engineer shall be entitled to assess separately any specified portion of a lot if it exhibits significant deviations compared with the remainder of the lot.

1803 Definitions

Values and limits thereon will depend on the sample sizes and may be defined by lower or upper limit or double limits. For the purposes of this section the following words and symbols shall have the following meanings:

a. Lot

A lot is a sizeable portion of work or quantity of material which is assessed as a unit for the purpose of quality control and selected to represent material or work produced by essentially the same process and from essentially the same materials.

b. Random Sample

Random samples are test measurements at separate test positions or on separate sample portions obtained from the lot in an unbiased manner.

c. Stratified Random Sample

Stratified random sampling ensures that specific characteristics are proportionally represented in the sample. Samples are split into strata/subgroups (same characteristics) and then separate samples randomly selected from each of these strata/subgroups.

d. Nominal value or specification limit

This is the limit value of the property of any material outside which not more than a specified percentage of the population of values representing an acceptable material is allowed to lie. The nominal value may be a single lower limit or a single upper limit or a double limit consisting of a lower limit and an upper limit.

e. Acceptance limit for sample mean

This is the limit value of a product property within which the sample mean shall lie for a product to be acceptable.

f. Acceptance limits for individual test values

These are the limit values of a product property within which the sample values representing a product shall lie for the product to be acceptable.

g. Outliers

Where, in a sample, one or more test results differ significantly from the other values obtained, this difference could be ascribed to an assignable cause, subject to approval by the Engineer. In this case any such test result(s) shall be regarded as an outlier and disregarded when assessing the lot.

1804 General Requirements**a. Determining the Lot Size****i. Road-construction layers**

The lot size shall be a section compacted in one process where essentially the same materials and construction equipment have been used.

Where production is on a continuous basis, a lot shall normally mean the product of one day's work and shall not exceed the product of two full days' work. However, a lot of any smaller size may be ordered by the Engineer where:

1. The properties under investigation exhibit abnormal local variation within the normal lot size.
2. An area is obviously of a different quality than the rest;
3. The rate of production is very high.

ii. Concrete

The lot size shall be determined by the Engineer, with due regard being given to the size and the type of structure in which the concrete is placed, the specific portion of the structure, and the total quantity of concrete placed in a day. The lot sizes in concrete structures could therefore vary considerably and, particularly in the case of small structures, it could be necessary to combine samples of the same grade of concrete from different structures at the discretion of the Engineer, provided that the concrete has been obtained from the same concrete plant and has been cast in the same period.

iii. Other

In certain cases, as for example in material stockpiles, where in the opinion of the Engineer the definition of a lot in accordance with this section does not apply directly, the Engineer will determine lot sizes in accordance with circumstances pertaining to each case.

b. Random sampling

When any lot is tested, whether a normally sized lot or an isolated section that clearly exhibits an abnormal variation of the properties under consideration, all samples shall be taken in a random pattern.

For this purpose use shall be made of tables of random numbers according to standard instructions approved by the Engineer.

c. Sample Sizes

For purposes of acceptance control, the Engineer will determine sample size, i.e. the number of values to be assessed in a lot.

d. Outliers

Test results shall be scanned for possible outliers. Where there is reason to believe that a test result may be erroneous it shall, if possible, be re-examined by further testing and if there is reasonable evidence to suggest that the test result is erroneous it shall be regarded as an outlier, rejected and replaced with a fresh result.

Where reinvestigation of a test result is not possible, the procedure described below shall be used for identifying outliers:

Calculate the value of T_o from:

$$T_o = \frac{abs(X_o - X_n)}{S_n}$$

Where X_n and S_n are the arithmetic mean and the sample standard deviation respectively, and X_o is the value of the test differing most from the mean.

Compare the value of T_o with the value of T for the applicable value of n from TABLE 1804/1.

If T_o is greater than T , then X_o is an outlier.

Every outlier shall be disregarded and replaced by another random test value. The sample mean and the sample standard deviation shall then be recalculated. If an outlier cannot be replaced, the sample mean and the standard deviation shall be calculated using the remaining test results. The final number of test results used in the assessment, after the elimination of outliers, shall never be less than three.

TABLE 1804/1: VALUES OF T FOR DIFFERENT SAMPLE SIZES

Number of Observations n	Critical Value T
1	
2	
3	
4	1.46
5	1.67
6	1.82
7	1.94
8	2.03
9	2.11
10	2.18
11	2.23
12	2.29
13	2.33
14	2.37
15	2.41
16	2.44
17	2.47
18	2.50
19	2.53
20	2.56

e. Resubmission

Where a lot has been accepted conditionally, or has been rejected, the Engineer may agree to its resubmission for approval if it has been rectified to the satisfaction of the Engineer. In such case a fresh sample shall be taken, and a fresh (second) set of test values determined.

The first and second sets of test values shall then be compared with each other to determine whether their properties differ significantly.

Where in the opinion of the Engineer a significant difference does occur, the submission of the lot shall be regarded as a first submission and assessed as such, and only the second set of test values shall then be used for this purpose.

1805 Procedures**a. General**

The statistical judgement procedures described below shall apply to the corresponding product properties for the purpose of acceptance control. Outliers shall be identified, disregarded, and, if possible, replaced at the discretion of the Engineer.

b. Straight-edge Measurements

Six straight-edge measurements shall be taken in the longitudinal direction and six measurements shall be taken in the transversal direction every 20 m along the road or as otherwise directed by the Engineer. The measurements shall be taken at offsets as agreed with the Engineer. All measurements taken shall fall within the limits given in TABLE 1731/1 including the requirement for surface dressing.

c. Surface Levels

At least 5 points across road shall be taken every 20 m. The levels shall be taken at the centreline, at the edge of the carriageway and at the edge of the shoulders or as directed by the Engineer. The levels may be taken at shorter intervals than 20 m, see **CLAUSE 1731**.

At least 50, but preferably more, levels shall be determined for each lot of completed work. The lot will be considered to comply with the requirements in respect of surface levels if, before any repair work is undertaken, at least 90 % of the level measurements show a deviation from the specified levels which is smaller than the tolerance specified in **TABLE 1731/2** and no measurements fall outside the maximum allowed deviation H_{max} .

Isolated spots, where the surface levels deviate by more than the appropriate tolerance of the specified levels shall be repaired to bring the deviation to within the tolerance.

d. Crossfall and Longitudinal Slope

All measurements of crossfall and longitudinal slope as directed by the Engineer shall fall within the limits given in **TABLE 1731/3**.

Isolated spots, where the crossfall and longitudinal slope deviate by more than the appropriate tolerance of the specified crossfall shall be repaired to bring the deviation to within the tolerance.

e. Layer Thickness

At least 20, but preferably more, layer thickness measurements shall be determined in accordance with a stratified random pattern (as defined in **SUBCLAUSES 1803(b)** and **1804(b)**) for each lot of completed layer work. Layer thickness may not be determined by means of level measurements, but shall be measured by core drilling or excavation of sample pits at locations approved by the Engineer.

The lot will be considered to comply with the requirements for layer thickness if both the following conditions are fulfilled:

- At least 90 % of all the thickness measurements taken before any thickness repairs are made are equal to or greater than the specified nominal thickness, minus the T90 tolerance specified in **TABLE 1731/4**.
- The mean layer thickness of the lot is not less than the specified nominal thickness

f. Relative Compaction of Earthworks and Pavement Layers

At least the following number of relative density determinations shall be taken in a random pattern (as defined in **SUBCLAUSES 1803(b)** and **1804(b)**) on each section or as directed by the Engineer and assessed as a lot:

- Formation, fill: 3 tests.
- Improved subgrade layers, Gravel wearing course: 4 tests.
- Sub-base: 5 tests.
- Base course, surfacing: 6 tests.

After outliers have been examined and replaced as directed by the Engineer, compliance with the specified density requirements shall be determined by the statistical method specified below unless a fixed minimum average value and/or absolute minimum value has been specified for the compaction elsewhere in these Specifications.

The lot will be considered to comply with the requirements for field density if the following conditions are fulfilled:

1. For a lower limit specification, LL_s

$$X_n > LL_s + S_n K$$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

2. For an upper limit specification, UL_s

$$X_n < UL_s - S_n K$$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

3. For a double limit specification, LL_s and UL_s

$$LL_s + S_n K < X_n < UL_s - S_n K$$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

Where,

X_n = The arithmetic mean of a set of n test results constituting the sample.

S_n = The sample standard deviation defined by:

$$S_n = \left(\frac{\sum (X - \bar{X}_n)^2}{n - 1} \right)^{0.5}$$

Where,

X = The value of an individual sample portion, i.e. an individual test result or measurement.

n = The number of sample portions, i.e. the number of individual test results or measurements.

K = A statistical constant defined by:

$$K = \frac{t}{\sqrt{n}}$$

Where,

t is the Student's t .

The value of K is dependent on the number of sample portions in the sample and the acceptance criteria. The acceptance criteria normally used where statistical control of materials and workmanship are applied is that the specification limit, L_s , is satisfied for more than 90 % of the lot and that the risk of accepting a lot that does not satisfy the specified requirement is less than 10 %.

The value of K determined according to the above criteria is given in TABLE 1805/1.

TABLE 1805/1: VALUES OF STUDENT'S-*T* AND *K* FOR DIFFERENT SAMPLE SIZES

<i>n</i>	Student's- <i>t</i>	$K = t/\sqrt{n}$
1	1.89	1.09
2	1.64	0.82
3	1.53	0.68
4	1.48	0.60
5	1.44	0.54
6	1.42	0.50
7	1.40	0.47
8	1.38	0.44
9	1.37	0.41
10	1.36	0.39
11	1.36	0.38
12	1.35	0.36
13	1.34	0.35
14	1.34	0.34
15	1.34	0.32
16	1.33	0.31
17	1.33	0.31
18	1.33	0.31
19	1.33	0.31

g. Cementitious Binder Content Of Cemented Layers**i. Method**

1. Take 50 samples according to a random pattern (as defined in SUBCLAUSES 1803(b) and 1804(b) and determine their cementitious binder content.
2. Examine the results for outliers and replace them if any in the opinion of the Engineer.

ii. Analysis

The lot will be considered to comply with the requirements for cementitious binder content if the following conditions are both fulfilled:

1. The mean cementitious-binder content shall be not less than 91 % of the specified binder content.
2. The cementitious binder content in not more than 12 of the 50 samples may be lower than 70 % of the specified binder content.

h. Binder Content of Bituminous Mixes**i. Method**

1. Take at least four specimens of bituminous mix in a random pattern (as defined in SUBCLAUSES 1803(b) and 1804(b) and determine the binder content.
2. Examine the results and replace any outliers as directed by the Engineer. Determine the sample mean and assess the lot by using the following criteria.

ii. Analysis

The binder content of bituminous mixes shall not deviate from the specified binder content by more than the values given in TABLE 1805/2 or according to the Special Specifications.

TABLE 1805/2: ACCEPTANCE LIMITS FOR BITUMINOUS BINDER CONTENT IN MIXES

Number of Tests in Lot	Maximum Deviation from the Specified Binder Content (%)	
	Sample Mean	Single Values
2	0.37	0.54
3	0.33	0.58
4	0.30	0.60
5	0.28	0.62
6	0.27	0.64
7	0.26	0.65
8 or more	0.25	0.66

i. Concrete Cube Compressive Strength, 28-day**i. Method**

Take at least the minimum number of samples as given in TABLE 1805/3 according to a random pattern (as defined in SUBCLAUSES 1803(b) and 1804(b)) and make test cubes. Test for cube compressive strength after 28 days.

TABLE 1805/3: MINIMUM NUMBER OF TESTS OF STRUCTURAL CONCRETE FOR COMPRESSION STRENGTH

Volume of Lot (m ³)	Minimum Number of Tests in Lot ¹
2	0.37
3	0.33
4	0.30
5	0.28
6	0.27
7	0.26
8 or more	0.25

Notes: (1) Each test consists of the average value of a set of three cubes.

ii. Analysis

Examine the results for outliers and disregard as required in the opinion of the Engineer. The results are then assessed according to the criteria set out below. A lot will comply with the requirements for the characteristic strength denoted **X**, if it meets the following requirements by using the acceptance factors **A** and **B** given in TABLE 1805/4:

- Mean value: minimum (**X** + **A**)
- Single test value: minimum (**X** - **B**)

TABLE 1805/4: ACCEPTANCE FACTORS FOR STRENGTH OF STRUCTURAL CONCRETE

Number of Tests in Lot	Acceptance Factors for Strength of Structural Concrete	
	A (MPa)	B (MPa)
3	2.7	3.9
4	2.7	4.2
5	2.6	4.5
6	2.5	4.7
7	2.4	4.9
8	2.3	5.0
9	2.2	5.2
10	2.1	5.3
11	1.9	5.4
12	1.7	5.5
13	1.4	5.6
14	1.1	5.7
15	0.5	5.8

j. Relative Compaction of Superpave™ Layers

The relative density of asphalt is given by the following equation:

$$\text{Percentage Relative Density} = \frac{\text{Average Core Specific Gravity}}{\text{Average Theoretical Specific Gravity}} \times 100$$

The relative compaction (U) of Superpave™ layers shall be determined by employing the following equation:

$$U = \frac{G_{mb} x h_m}{G_{mm} x h_n} \times 100$$

Where,

G_{mb} = Bulk Specific Gravity.

G_{mm} = The theoretical maximum specific gravity.

h_m = The height of the sample (the core).

h_n = The height of the sample after gyratory compaction.

1. For a lower limit specification, LL_s

$$X_n > LL_s + S_n * K$$

S_n is the sample standard deviation defined by:

$$S_n = \left(\frac{\sum (X - \bar{X}_n)^2}{n - 1} \right)^{0.5}$$

Where,

X = The value of an individual sample portion, i.e. an individual test result or measurement (U).

n = The number of sample portions, i.e. the number of individual test results or measurements.

K = A statistical constant defined by:

$$K = \frac{t}{\sqrt{n}}$$

Where,

\bar{X} = The sample mean.

t = The Student's t (refer to TABLE 1805/1).

S_n = The standard deviation.

n = The number of samples.

1806 Routine Tests And Inspection By The Engineer

The Engineer will at regular intervals inspect and test materials and completed work for compliance with the specified requirements and where applicable the various specified statistical analyses will be applied.

All sections of completed work shall be submitted to the Engineer for routine inspection and testing and the Contractor shall not cover up or construct any work on top of sections of completed work before being advised by the Engineer of the outcome of their tests and inspection. The Contractor shall arrange the submission of work for testing in a manner as will afford the Engineer reasonable opportunity for inspecting and testing.

1807 Quality Control By The Contractor

The requirements of [CLAUSE 1706](#) shall apply in respect of the Contractor's obligation to institute and implement Quality Control systems for the specific processes detailed in [TABLE 1806/1](#). The process control systems shall provide for monitoring the quality of the work and materials supplied.

The Contractor shall take immediate steps to rectify any deviation from the specified requirements indicated by their quality control system, and the Engineer shall have the right to inspect and be given all details of tests and testing procedures in order to satisfy themselves that the Contractor is implementing the procedures of the approved control system in all respects.

1808 Measurement And Payment

No separate measurement or payment shall apply to this section.

SECTION 1900 Setting Out and Tolerances

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1901 Scope

This section covers the procedures for setting out and gives the limits for geometric tolerances for earthworks and layer works, and structures.

1902 General

The Engineer will provide sufficient basic survey information to enable the contractor to set out the works and the Contractor shall be responsible for setting out all necessary reference points and for the maintenance thereof.

The Contractor shall ensure the accuracy in line, level, and dimension of the basic survey and setting out details provided. Should the Contractor discover any error in the information provided by the Engineer, they should notify the Engineer immediately. If the information is confirmed to be in error the Engineer will issue amended drawings or instructions regarding the correction of the error.

Prior to commencing construction, the Contractor shall establish the road reserve boundary posts, or if no boundary posts are instructed, then the Contractor shall establish reference points to define the road reserve at 100 m intervals on both sides.

If the traverse points to be used for the setting out are close to the existing carriageway and interfere with construction works then the Contractor will have to relocate them to a position where they will not be disturbed. The co-ordinates and heights of all traverse points so located shall be listed and provided to the Engineer for checking and/or approval. The Contractor shall also monument the new centreline every 200 m along straights and all salient points along curves by a pin in the concrete beacon before commencement of any works.

The road reserve boundary posts shall have 12 mm diameter steel pins embedded in concrete, 200 mm long with 25 mm exposed to the air, sticking out from its top surface. This pin shall be referenced and levelled and details provided to the Engineer for approval.

The Contractor shall establish temporary benchmarks along the road at intervals not exceeding 200 m and shall provide the Engineer with a schedule of their levels and locations.

The Contractor shall not remove, damage, alter or destroy in any way plot beacons or survey beacons. Should the Contractor consider that any beacon will be interfered with by the works he shall notify the Engineer who, if he considers necessary, will make arrangements for the removal and replacement of the beacon.

If the Contractor removes or disturbs a beacon without permission from the Engineer, he shall be liable for the full cost of its replacement and any legal consequences thereof including payment of fines.

1903 Detailed Setting Out

The Contractor shall set out the line and level of the works at intervals of not more than 25 m or such lesser intervals as are required to construct the Works to the tolerances specified in SECTION 1904. Reference pegs and batter rails clearly and indelibly marked with all the relevant information shall be provided clear of the road and at right angles to it from which the centreline, level and batter slope can be directly established at any time.

Reference pegs shall be 50 mm by 50 mm in section, 600 mm long and driven 400 mm firmly into the ground and painted white above ground level or as approved by the Engineer. The offset from centreline shall be indicated by a small nail 20 mm to 25 mm long with its head driven flush with the top of the peg. Chainages, offset and reference elevation shall be clearly indicated on the sides of the peg to the satisfaction of the Engineer. These pegs shall be maintained by the Contractor for as long as they are needed to check the work.

After cutting of benches and prior to commencement of earthworks or subgrade works, the Contractor shall take cross-sections again and submit these for the agreement of the Engineer. These cross-sections shall then be used as the basis of measurement for all subsequent layers, unless otherwise stated.

After completion of the setting out and site clearance the Contractor shall take ground cross-sections at intervals of 20 m along the road centreline and along the centreline of all culverts and structures. These shall be digitally recorded and/or plotted or printed to a natural scale of 1:100 on a stable transparent material or other approved material and a copy of the plot and/or a portable storage device submitted to the Engineer for agreement. If the Contractor fails to take requisite levels, levels determined by the Engineer shall be taken as correct.

The Contractor shall allow in their programme for a period of 30 days between submitting the ground cross-sections and being issued with final road, culvert and structure levels. A minimum 5 km section of road shall be submitted, but where the Contractor submits cross-sections for more than 10 km of road within the same 30 day period the initial 30 days shall be extended by 30 days for each additional 10 km or part thereof. Final road, culvert or structure levels will be determined by the Engineer and may be different from the levels shown on the Drawings.

On receipt of the final road levels the Contractor shall digitally record and mark up the details on the CAD drawings and/or transparencies and the original CAD drawing and one PDF print of the cross-sections stored on a portable device shall be provided free of charge by the Contractor for the Engineer.

On completion of the earthworks but before starting formation or pavement layers the Contractor shall establish steel pins at a constant offset to the edges of the carriageway shoulders. The offset may however vary between sections in cut and those in fill. The steel pins will be clearly and indelibly marked with all the relevant information necessary to directly establish the centreline and level at any point across the carriageway by using either boning rods or a string line.

The interval between pins shall not be more than 10 m and the pins shall be maintained by the Contractor for as long as they are needed by the Engineer to check the work.

1904 Tolerances: Pavements

a. General

In addition to the requirements set out in this clause attention is drawn to the requirements of SECTION 1800 which shall all be fulfilled.

b. Horizontal Alignments

Horizontal alignments shall be determined from the centreline of the pavement surface as constructed, and all other parallel alignments shall be corrected within a tolerance of ± 13 mm therefrom.

c. Thickness of Pavement Layers

The thickness of any pavement layer as specified or ordered by the Engineer, measured at five points in any length of 100 m, shall meet the requirements given in TABLE 1731/4.

d. Surface Levels of Pavement Layers and Formation

The level measured at any point on the surface of a pavement layer or the formation level shall not deviate from the corresponding level calculated from the Drawings by more than the tolerances shown in TABLE 1731/2.

For checking compliance with TABLE 1731/2 measurements of surface levels will be taken at points to be selected by the Engineer at 10.0 m centres longitudinally and at 2 m centres transversely. At junctions, the grid point spacing shall be determined by the Engineer.

e. Surface Regularity

The surface regularity of pavement layers and the formation shall be tested at points decided by the Engineer with a rigid steel straightedge 3 m long placed at any angle to the centreline of the road. The maximum allowable deviation of the surface below the straightedge shall be as given in TABLE 1731/1.

In addition the longitudinal slope or transverse crossfall shall not deviate from that shown on the Drawings by more than the tolerances given in TABLE 1731/3.

f. Shoulders

Shoulders shall be constructed to the same thickness, level and surface regularity requirements as for the adjacent pavement layers.

g. Cutting and Embankment Slopes

In the final trimmed slope of cuttings a tolerance of +0.25 will be permitted, i.e. if a slope of 1 in 2 is specified, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25

In the final trimmed slopes of embankments, a tolerance of +0.25 will be permitted, i.e. if the specified slope is 1 in 2, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25.

h. Width Of Cuttings And Embankments

The tolerance permitted in the width of the bottom of cuttings shall be 200 mm between the centreline of the road and the toe of the cutting slope.

The width of embankments measured as the horizontal distance from the centreline of the road to the top of the embankment shall not be less than that shown on the Drawing or more than that shown on the Drawings plus 0.25 m.

i. Depth Of Side Drains

The depth of side drains measured as the vertical height difference from the centreline of the finished pavement and the invert of the side drain shall not be less than that shown on the Drawings nor more than that shown on the Drawings plus 0.15 m.

j. Construction Control Testing

Unless otherwise directed values given in this Specification are minimum values. Workmanship will only be considered as satisfactory if all tests, taken at the frequency specified in SECTION 1800 of this Specification, are at least equal to those specified in the relevant section.

k. Pavement Widths

For pavement widths for sub-base, base and wearing course, the allowable tolerances shall be -0 to +50 mm.

l. Pipe culverts

The maximum deviation from the specified line of a drainage pipe shall be:

Horizontal	-	20 mm in 3.0 m
Vertical	-	30 mm in 10.0 m

m. Concrete Kerbing and Channelling

Reference should be made to SECTION 2300, CLAUSE 2306 for relevant Tolerances.

1905 Tolerances: Structures

Except where otherwise specified, the following aspects of construction to which tolerances apply shall have the meanings attributed to them below:

a. Position

The position of a structure or structural member shall be the horizontal position of its centre line(s) and/or centre point(s) in relation to the overall layout of the Works as shown on the Drawings.

b. Alignment

The alignment of a structure or structural member shall be the alignment of its centre line(s) in relation to the overall layout of the Works as shown on the Drawings. Deviation from true alignment shall be measured in degrees of an arc.

c. Leading and Cross-sectional Dimensions

The leading and cross-sectional dimensions of a structure or structural member shall be the dimensions relating to width, length, height, thickness, etc, which collectively determine its shape, and are shown on the Drawings. Dimensional tolerances not relating to leading or cross-sectional dimensions shall be shown on the Drawings.

d. Levels

The level of any structure or structural member shall be the level of the upper or lower surface, as may be relevant, with reference to an established datum-level on the site.

e. Surface Regularity

Surface regularity is the shape of a surface with reference to a 3 m straight-edge (or template in the case of curved surfaces) placed on the surface.

The tolerance for surface regularity is expressed as a distance by which the surface tested may deviate from a straight-edge (or template in the case of curved surfaces) held against the surface.

f. Tolerances

The tolerances given below shall be the maximum permissible deviations from the specified dimensions, levels, alignment, positions, etc, shown on the Drawings of the structures or structural members.

1. Foundations, footings, pile capping slabs, columns, walls, piers, abutments, bridge and culvert superstructures

The tolerances are given in TABLES 1905/1, 1905/2, 1905/3, 1905/4 and 1905/5.

TABLE 1905/1: TOLERANCES OF PILE FOUNDATIONS

Position	
0.177 times the diameter of the pile, or 100 mm, whichever shall be the greater	
External Dimensions	
Prefabricated piles	+ 25 mm -5 mm
Cast in situ piles	plus-tolerance not specified, minus-tolerance 0 mm
Pile-head level	Average level of trimmed cut pile head ± 25 mm
Verticality or rake	1.5°
Straightness	
For precast piles the permissible maximum deviation from straight is 5 mm for piles up to 3 m in length and 1.0 mm more for each additional metre of pile length.	

TABLE 1905/2: TOLERANCES OF CAISSONS

Position of top of caisson	
10 % of the smallest outer dimension of the caisson, measured in plan	
Vertically	
1.5°	
Dimensions	
Wall thickness	+ 25 mm -5 mm
Outer dimension of circular, rectangular or square cross-section	± 25 mm
Level: Upper level of trimmed/cut caisson head	
Maximum deviation of average level	± 25 mm
Maximum deviation of any individual level	± 50 mm
Foundation fill	
Average level of top of fill	± 25 mm

TABLE 1905/3: TOLERANCES OF FOOTINGS, PILE CAPPINGS, CAISSON COVER SLABS etc.

Position	
15 mm	
Alignment	
Individual members	5°
Members as they collectively determine the alignment of the structure as a whole	1 minute
Dimensions	
Leading dimensions in plan	± 25 mm
Thickness	+ 25 mm - 15 mm
Levels	
Average level of slabs, footings, etc	± 25 mm

TABLE 1905/4: TOLERANCES OF COLUMNS, WALLS, PIERS, ABUTMENTS, etc.

Position	
10 mm	
Alignment	
Walls, piers, abutments and column groups	2 minutes
Dimensions	
Leading dimensions of walls, piers and abutments	± 25 mm
Thickness of walls, piers and abutments and cross-sectional dimensions of columns:	
Plus-tolerance	25 mm
Minus-tolerance	3 % of the specified dimensions within the range of 5 mm to 25 mm
Levels	
Levels: Average level of finished or trimmed/cut columns, piers, walls, abutments, etc	± 10 mm
Vertically	
Using ordinary formwork	1 in 400. Maximum 25 mm
Using sliding formwork	1 in 200. Maximum 50 mm
Surface Regularity	
Using ordinary formwork	3 mm
Using sliding formwork 1 in 200.	6 mm

TABLE 1905/5: TOLERANCES OF BRIDGE AND CULVERT SUPERSTRUCTURES

Position	
10 mm	
Alignment	
Superstructure as a whole	1 minute
Dimensions	
Leading dimensions in plan	± 25 mm
Thickness of slabs, width and depth of beams:	
Plus-tolerance	15 mm
Minus-tolerance	3 % of the specified dimensions within the range of 5 mm to 15 mm
Surface Regularity	
All surfaces other than upper surface of deck	3 mm
Bridge and culvert decks, surface tolerances:	
The tolerances specified in CLAUSE 1731 for the base in respect of level, grade, cross-section and surface regularity shall apply. Surface regularity shall be tested by straight-edge.	

2. Precast Beams

The following tolerances shall apply to precast beams in addition to the requirements stated in **SUBCLAUSE 1904(d)** for the superstructure.

The width of the gap between contiguous beams shall not exceed twice the width of the specified nominal gap shown on the Drawings or the width of the nominal gap plus 40 mm, whichever is the less, and the overall width between the outermost beams of the bridge deck shall be within 40 mm of the specified width.

STRAIGHTNESS OR BOW: The deviation from the prescribed line measured on the overall length of the beam shall not exceed the following:

- i. In the horizontal plane:
0.5 mm per metre length of the beam within the tolerance range of 6 mm to 15 mm.
- ii. In the vertical plane:
 - a. I-beams: 2 mm per metre length of the beam within the tolerance range of 6 mm to 20 mm.
 - b. Other beams: 1.0 mm per metre length of the beam within the tolerance range of 3 mm to 20 mm.

CAMBER: The soffits of adjacent beams when placed side by side on the bridge deck shall not at any place differ by more than 2 mm per metre length of the beam within the tolerance range of 6 mm to 20 mm.

THE LENGTHS OF PRECAST BEAMS: Before stressing, the length shall be ± 0.1 % of the total length within the tolerance range of ± 5 mm to 20 mm.

SURFACE REGULARITY: 6 mm

3. Reinforcing Steel

Except for the requirements given below, no tolerances are given for the placing and fixing of reinforcing steel. The steel, however, shall be neatly and accurately fixed in a manner which is consistent with proper workmanship and the structural integrity of the structural member. Specifically the following requirements shall apply:

- i. Tension steel
The actual position of tension steel shall not deviate from the true position by a distance which would reduce the effective lever arm by more than 2 % of the overall depth of the member, or 10 mm, whichever is the greater.
- ii. Concrete cover
The concrete cover on reinforcing steel shall nowhere be less than the specified cover.
- iii. Spacing between bars
The spacing between closely spaced parallel bars, especially in beams and columns, shall, unless otherwise specified, be not less than the maximum size of the aggregate used in the concrete.
- iv. Bending of reinforcement
The requirements of BS 8666 or equivalent regarding dimensional tolerances for cutting and bending of the reinforcing steel shall apply, with the proviso that the other requirements set out in this clause shall be complied with even if the tolerances in BS 8666 or equivalent are not exceeded.

4. Prestressing

Sheaths for prestressing tendons shall be placed and maintained in position within the following tolerances:

- i. In the direction of the width of the member:
For members of up to 200 mm in depth: ± 20 mm
For members exceeding 200 mm in depth: ± 10 mm
- ii. In the direction of the depth of the member:
For members of up to 200 mm in depth: $\pm 0.025 \times \text{depth}$
For members exceeding 200 mm in depth: $\pm 0.01 \times \text{depth}$ within the tolerance range of ± 5 mm to ± 25 mm.

5. Bearings

Bearings for structures shall be installed to within 5 mm of the position shown on the Drawings and to within 2 mm of the required level.

Dimensional tolerances for elastomeric bearings shall comply with the requirements of BS EN 1337-3.

6. Miscellaneous

- i. Chamfers
Fillets used for forming chamfers shall be within a tolerance of 1.0 mm in cross-sectional dimensions, and the actual chamfer on the concrete shall not vary by more than 3 mm from the specified dimensions.
- ii. Kerbs, copings, sidewalks, bridge railings, parapets, etc
The members shall be constructed within a tolerance of ± 5 mm for all dimensions. The alignment shall not deviate from the true alignment by more than 10 mm in any place, nor shall the alignment deviate by more than 5 mm from the true alignment over any length of 5 m.

7. Fabrication and Assembly tolerances for Structural Steel

- i. General
The fabrication and assembly tolerances on all dimensions for structural steel shall be ± 2 mm. Holes for connections shall be drilled/punched and aligned as specified in SUBCLAUSES 7705(d) and (g) respectively.
- ii. Cross-section
The tolerances on cross-sectional dimensions of rolled sections shall be as specified in the Design tables according to Eurocode 3 or equivalent.
- iii. Straightness
A structural member before erection shall not deviate from straightness (or the specified shape) by more than the following:

For compression members and beams, one-thousandth of the length between points which are laterally restrained. For other members, one five hundredth of the overall length, but not exceeding 25 mm.
- iv. Length
The length of a member shall not deviate from its prescribed length by more than the following:

For compression members faced at both ends for bearing, ± 1.0 mm
For other members: + 0 mm and - 4 mm

For such members as trusses and lattice girders, the above tolerances shall apply to the members as a whole. The lengths of component parts shall be such that the structural member can be properly assembled with the required accuracy.

v. Bearing surfaces

Where two steel surfaces are required to be in contact for transferring compressive forces, the maximum clearance between the bearing surfaces shall not exceed 1.0 mm when the members in contact are aligned.

vi. Accuracy of erection

Steelwork shall not be out of plumb over any vertical distance by more than 5 mm or one thousandth of the distance, whichever is the greater.

8. Fabricating and Construction Tolerances for Reinforced-earth Structures

i. Individual concrete panels:

Surface regularity:

- When tested with a 1.5 m straight-edge, the deviation shall not exceed 5 mm.
- Leading dimensions ± 5 mm

ii. Completed walls:

Surface regularity:

- When tested with a 3 m straight-edge, the deviation shall not exceed 20 mm.
- No point of the structure shall be out of position vertically by more than 10 mm per metre height of the structure, with a maximum of 50 mm.

1906 Measurement and Payment

No separate payment shall be made for work described in this section.

1000

General | 1900 | *Setting Out and Tolerances*

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2101 Scope

This Section covers all work in connection with the excavation, construction and testing of open drains, subsoil drainage, French drains and banks and dykes at the locations and to the sizes, shapes, grades and dimensions as shown on the Drawings or as directed by the Engineer.

The execution of cleaning work for open drains and the repairing of subsoil drainage, clearing of existing culvert barrels and their inlet and outlet structures is also specified. In special circumstances this work may be executed outside the road reserve.

2102 Open Drains

Open-drain excavation shall involve the excavating of open drains and channels, including channels to direct the course of streams, all as shown on the Drawings or as directed by the Engineer.

Any excavation required for constructing a channel or open drain within the road prism, such as median drains, side drains and open drains on excavation-slope benches, shall be classed as Excavation in soft material or Excavation in hard material as defined in **CLAUSE 3503** and shall be measured and paid for under **SECTION 3500**.

Open drains shall be constructed true to line, grade and cross-section and shall be so maintained for the duration of the Contract.

Care shall be taken to avoid excavation below the required grades for the open drains and any excavation carried beyond the required grade shall be backfilled with suitable, approved, material and compacted to at least 90 % MDD of AASHTO T180 density by the Contractor at their own expense.

Material resulting from the excavations for open drains shall be used in the construction of fills, banks and dykes, or for other purposes, or shall be disposed of to spoil, all as directed by the Engineer.

If ordered by the Engineer all existing open drains, but excluding open drains constructed by the Contractor, shall be cleared and where necessary, shaped by removing the sediment and trimming the floors and sides.

Any pitching of open drains ordered by the Engineer shall be done in accordance with the requirements of SECTION 2500. The concrete lining of open drains shall be done as specified in SECTION 2300.

All culverts indicated by the Engineer shall be cleared. The Contractor shall remove all undesirable materials, all silt, sediment, driftwood, debris and rubble that has accumulated in and around the culvert inlet and outlet structures and in the culvert barrels. All materials resulting from the clearing operations shall be disposed of at locations approved by the Engineer. The clearing shall be done by means of hand tools or mechanical equipment operated in such a manner that it will not cause damage to existing drainage and other structures. The Contractor shall repair all structures damaged by their employees and subcontractors at his own cost and to the satisfaction of the Engineer.

2103 Banks And Dykes

Mitre banks, catchwater banks and dykes shall be constructed of approved soil or gravel obtained from open-drain excavation or, if no suitable material can be obtained from that source, from suitable alternative sources and be placed in such a way that the water will flow on the natural ground and against the bank. The Contractor may also propose construction of mitre banks with hand-packed stone, provided that the interstices are filled with an approved cohesive soil.

The banks and dykes shall be properly compacted to 93 % MDD of AASHTO T180 density in layers not exceeding 150 mm in thickness or as approved by the Engineer.

2104 Subsoil Drainage

A subsoil drain includes any type of drain designed to collect groundwater whether this is rising from below or percolating from the surface and may or may not include a pipe. It may also include impermeable membranes above or below the pipe or permeable filter membranes all as detailed on the Drawings, or instructed by the Engineer during the course of the Works. Instructions for subsoil drains in cuttings will not generally be given until the bulk earthworks are complete within that particular cutting and subsoil drains that are instructed shall be completed before the work on the adjacent 300 mm layer below formation commences.

a. Materials

i. Pipes

Pipes for subsoil drainage shall have the specified internal diameter, which shall be not less than 100 mm, and shall be one of the following types:

1. Perforated or slotted unplasticised PVC pipes complying with BS EN 13598 - 1 and BS EN 1401-1 or equivalent.
2. Perforated high-density polyethylene pressure pipes complying with the requirements of BS EN 253 or equivalent.

The size of pipe perforations shall in all cases be 8 mm in diameter ± 1.5 mm and the number of perforations per metre shall be not less than 26 for 100 mm pipes and 52 for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and four rows for 150 mm pipes. All rows shall be in the lower half of the pipe but no row shall be closer than 36 degrees to the invert. Perforations in each row shall be a maximum of 100 mm centre to centre.

Slotted pipes shall have a slot width of 3 mm ± 1.0 mm and slot length of 8 mm ± 1.5 mm and the inlet area per metre shall not be less than 2250 mm²/m of pipe. The arrangement of slots shall be to the Engineer's approval.

Pipes without slots or perforations required for conveying ground water from the subsoil drainage proper to the point of discharge, shall be unperforated pitch fibre, PVC or polyethylene pipes of the types specified above, or concrete pipes complying with the requirements of BS 5911-1 and BS EN 1916 or BS EN 1917, or equivalent.

ii. Permeable filter material

Permeable filter materials for bedding and surrounding of drain pipes shall consist of crushed stone of suitable particle size distribution. Crushed stone shall be of hard, clean rock. If for environmental reasons or scarcity of natural resources in the project vicinity, permeable filter material conforming to the criteria given below is not easily obtainable then the Contractor may propose the use of an appropriate geotextile for the approval of the Engineer.

Permeable filter material shall be free of organic material, silt or clay lumps and shall conform to the following requirements:

1. d_{85} for the permeable filter material shall be minimum 1.25 times the width of the slots in the drainage pipe,
2. d_{15} for the permeable filter material shall be maximum 5 times d_{85} for the adjacent soils,
3. d_{50} for the permeable filter material shall be maximum 25 times d_{50} for the adjacent soils,
4. d_{15} for the permeable filter material shall be minimum 5 times d_{15} for the adjacent soils,
5. The permeable filter material shall have maximum 50 % passing the 2 mm sieve,
6. The permeable filter material shall have maximum 3 % passing the 0.075 mm sieve.

Where,

d_{15} , d_{50} and d_{85} are the corresponding sieve sizes which 15 %, 50 % and 85 % of material respectively pass in the sieve analysis.

The filter criteria shall be complied with for both the surrounding soil (subgrade) and for possible pavement layers above the drain pipe.

Tests for permeable filter material shall be performed in accordance with the standard methods given in TABLE 1711/1.

Sieve analysis of the surrounding subgrade and or sub-base shall be performed at minimum 100 m intervals of trench and the filter material shall be adjusted according to the above specified filter criteria. If necessary, the Engineer can at any position demand further sieve analysis and will do so should the materials encountered in excavation appear to vary in consistency.

The sieve analysis for the subgrade, sub-base and filter materials must be approved by the Engineer before commencement of the drain pipe works. All costs to perform sieve analysis are to be included in the rates for subsoil drains.

iii. Geotextile fabric

Should the use of geotextile fabric in subsoil drainage, or as filter blankets, or for any other purposes, be proposed, it shall comply with the requirements as specified in SECTION 2700. The fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

iv. Composite in-plane draining fabric

The make and class of fabric shown on the Drawings or approved by the Engineer shall be used.

b. Construction Of Subsoil Drainage Systems

i. With permeable filter material

Trenches for subsoil drainage systems shall be excavated to the dimensions and gradients shown on the Drawings or as directed by the Engineer.

A layer of permeable filter material of the grade and thickness as shown on the Drawings shall be placed on the bottom of the trench and be lightly tamped and finished to the required gradient.

Pipes of the type and size required shall then be firmly bedded on the permeable filter material, true to level and grade, and be coupled in accordance with the manufacturer's specifications. Thereafter the trench shall be backfilled with permeable filter material in layers not exceeding 250 mm thickness and lightly compacted to such height above the pipes as shown on the Drawings or as directed by the Engineer. Further layers of finer permeable filter material shall then be placed, lightly compacted and finished to an even surface, as directed by the Engineer. The remainder of the trench, if any, shall be backfilled with approved impermeable material and as required by the Engineer, in layers not exceeding 150 mm, and compacted to at least the same density as the surrounding material. The trench shall be specially protected against the ingress of water until the impermeable layer has been completed. The width of the backfill that will be measured for payment shall not exceed the specified width of the trench.

The total thickness of each type of natural permeable filter material shall be carefully controlled, and when thinner layers of differing particle size distribution are placed they shall be kept separate by temporary metal or plywood baffles which shall be removed when the filling is complete. When successive layers are placed, the lower layer shall not be walked on and, as far as possible, shall not be disturbed. Care shall be taken to prevent the contamination of natural permeable filter material during construction of the subsoil drainage system and all permeable filter material contaminated by soil or silt shall be removed and replaced by the Contractor at their own expense.

Perforated and slotted pipes shall be jointed by means of couplings. Perforated pipes shall be laid with perforations as may be prescribed or as detailed in [SUBCLAUSE 2104 \(a\)](#).

Unless the higher end of the pipe is connected to a manhole or inspection chamber, it shall be bent to a 750 mm radius to end 200 mm below ground level. A 500 mm x 500 mm x 100 mm Class C16/20 concrete frame shall be cast around the pipe end which shall be sealed off with a loose concrete cap of Class C16/20 concrete as shown on the drawings. The lower end of the drain pipe shall be built into a Class C20/25 reinforced concrete headwall as shown on the drawings providing a positive outlet, or connected to a culvert wingwall, drop inlet, inspection chamber or manhole. The complete system, together with concrete outlet structure, shall be constructed in one process starting from the outlet.

Any section of a subsoil drainage system constructed of pipes without perforations or slots shall be backfilled with impermeable backfill material as described herein. Where suitable, the excavated material may be used for backfilling.

ii. With polyethylene lining to trenches for subsoil drainage systems

Where shown on the Drawings or directed by the Engineer trenches for subsoil drainage systems shall be lined with approved polyethylene sheeting 0.15 mm thick. The polyethylene sheet shall cover the bottom of the trench and shall extend upwards on both sides for as far as may be directed by the Engineer in each particular case, in order to form a waterproof channel. At joints the polyethylene sheeting shall be heat-welded together or lapped by a minimum of 200 mm.

When backfilling the trench with natural permeable filter material, care shall be taken not to displace or damage the polyethylene lining in any way. The use of plastic other than polyethylene will be considered provided that the material is of equal quality and is approved by the Engineer.

iii. With geotextile fabric

Where specified that geotextile fabric shall be used for lining in subsoil drainage systems it shall be procured, furnished and installed as specified and shown on the Drawings. The fabric shall not be displaced or damaged in any way when the trench is being filled with natural permeable filter material. The filter fabric shall be lapped both longitudinally and transversely

by at least 300 mm or as prescribed by the manufacturers. The transverse lap shall be positioned on top of the box forming the drain and shall be stitched together with plastic or galvanised wire or strong synthetic thread at 1.0 m intervals. The longitudinal lap shall be in the direction of flow.

Geotextile fabric shall meet the requirements in SECTION 2700 and shall be stored under suitable cover. The fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

iv. With composite in-plane drainage fabric

Wherever specified, composite in-plane drainage systems shall be constructed in accordance with the details shown on the Drawings. The elements of the system shall be assembled above ground in manageable lengths, and all exposed surfaces shall be sealed with an approved geofibre seal. The trench sides shall be vertical and the composite in-plane system shall be installed against the side through which the subsoil flow is expected. The trench shall then be backfilled with sand, which shall be saturated with water after placement up to the prescribed level. The sand shall comply with the requirements of AASHTO M6-08 or equivalent. The upper part of the trench shall be backfilled with impermeable material which shall be compacted to the density of the surrounding material, in layers not exceeding 100 mm in thickness.

Tests for composite in-plane drainage fabric shall be performed in accordance with the standard methods given in TABLE 2703/1 and 2703/2.

c. Test flushing

Final acceptance of longitudinal subsoil drains will be subject to satisfactory test flushing after completion and installation of the rodding eye inlets. Flushing tests shall be carried out in the presence of the Engineer's representative by flushing the drain and metering the outflow to ensure the drain is clear of any blockage. Should blockages be apparent the Contractor shall locate and clear the obstruction and repeat the test.

d. Transport and storing of drain pipes

The full length of the pipe shaft shall rest on the loading area of the lorry used for transporting the pipes. Overhanging of pipes which may cause sagging and deformation shall be avoided. Rough handling and dragging of pipes and fittings shall be avoided. All pipes and fittings shall be protected from sunlight during transportation by use of tarpaulins, or any other material approved by the Engineer. Grass cover will not be accepted.

The Contractor shall transport and store the pipes on site in accordance with the manufacturers specifications for the prevailing climatic conditions. These specifications shall also be submitted to the engineer for prior approval before transportation

PVC pipes shall not be stored on top of each other to a height exceeding 1.5 m. Pipes shall be stacked in such a manner to prevent the sockets resting on the shaft of the pipes. The first tier shall be placed on a well-drained layer of sand.

e. Drain Markers

Subsoil drains shall be marked on the ground as follows:

- i. Wherever practicable, concrete markers in accordance with SECTION 8100 shall be placed at the start of the subsoil drain. The concrete markers shall be painted and provided with identification numbers as directed by the Engineer.
- ii. In rock cuttings or where concrete kerbs or linings are provided, paint marks approximately 150 mm x 150 mm in size, shall be used in lieu of the above concrete markers. No separate payment for provision of such paint mark will be made.

2105 French Drains

French drains shall be constructed at the locations and to the dimensions shown on the Drawings or as directed by the Engineer.

The trench shall be excavated to the required width and depth and levelled and smoothened to the satisfaction of the Engineer prior to filling with aggregates. The specified gradation of fine or coarse aggregate shall then be placed to the required depth and covered with the next specified layer of material.

When the use of geotextile is specified for lining the trench, the geotextile shall be delivered to the Site in such a manner to facilitate handling and incorporation into the work without damage. In no case shall the geotextile be stored and exposed to direct sunlight that might significantly diminish its strength or toughness. Torn or punched geotextile shall not be used.

After the trench has been approved by the Engineer, the geotextile shall be loosely rolled out so that the centre of the geotextile is at the centreline of the excavated trench. The geotextile will be laid into the trench in such a manner that it will not tear when the aggregate is placed. At joints the geotextile shall overlap a minimum of 600 mm or to the manufacturer's specification (whichever is more). Enough geotextile shall remain uncovered after the trench is filled to provide for geotextile overlap at the top.

Measurement and payment shall be made under ITEMS 21.01, 21.03, 21.04, 21.06, 21.07 and 21.10.

2106 Classification Of Excavated Materials

All excavations for open drains and subsoil drainage systems shall be classified as hard or soft excavation in accordance with [CLAUSE 3503](#) of these Specifications.

2107 Manholes, Outlet Structures And Cleaning Eyes

Manholes, outlet structures and cleaning eyes for subsoil drainage systems shall be constructed in accordance with the details shown on the Drawings or in positions as instructed by the Engineer.

2108 Measurement And Payment

Item	Unit
21.01 Excavation for Open Drains	
(a) Excavating soft material situated within the following depth ranges below the surface level:	
i 0.0 m up to 1.5 m	Cubic Metre (m ³)
ii Exceeding 1.5 m and up to 3.0 m	Cubic Metre (m ³)
iii Exceeding 3.0 m per increment of 1.5 m	Cubic Metre (m ³)
(b) Extra over SUBITEM 21.01(a) for excavation in hard material as defined in CLAUSE 3503 , irrespective of depth.	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

Irrespective of the total depth of the excavation, the quantity of material in each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for the excavation of the material to the required lines, levels and grades and the disposal of the material as directed, including all haulage.

Item	Unit
21.02 Clearing and Shaping Existing Drains	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

The bid rates shall include full compensation for excavating the material to the required lines, levels and grades, protecting the existing drainage structure, trimming the sides and floors of the open drains and the disposal of the material as directed, including all haulage.

The clearing of existing concrete side drains will be measured and paid for under ITEM 21.17.

Item	Unit
21.03 Excavation for Subsoil Drainage Systems	
(a) Excavating soft material situated within the following depth ranges below the surface level:	Cubic Metre (m ³)
i 0.0 m up to 1.5 m	Cubic Metre (m ³)
ii Exceeding 1.5 m and up to 3.0 m	Cubic Metre (m ³)
iii Exceeding 3.0 m per increment of 1.5 m	Cubic Metre (m ³)
(b) Extra over SUBITEM 21.03(a) for excavation in hard material as defined in CLAUSE 3503, irrespective of depth.	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

Irrespective of the total depth of the excavation, the quantity of material in each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for the excavation of the material to the required lines, levels and grades and the disposal of the material as directed, including a free haul determined according to SUBCLAUSE 1602(c).

Where subsoil drainage systems are adjacent to structures such as culverts, that part of the excavation for subsoil drainage systems which can be made by widening the excavation for the structure shall be measured and paid for under excavation for such structure, and not under excavation for the subsoil drainage systems.

Item	Unit
21.04 Impermeable Backfilling to Subsoil Drainage Systems	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of completed backfill, measured in place in the subsoil drainage systems and calculated in accordance with the authorised dimensions.

The bid rate shall include full compensation for procuring, furnishing, placing and compacting the backfilling including all haulage.

Item	Unit
21.05 Banks and Dykes	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material, measured in place in the banks or dykes, and calculated in accordance with the authorised dimensions.

The bid rate shall include full compensation for procuring, furnishing, placing, watering, compacting, shaping and trimming the material in the banks and dykes including all haulage.

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Drainage | 2100 | Drains

Item	Unit
21.06	Permeable Material in Subsoil Drainage Systems
(a)	Crushed stone obtained from approved sources (indicate grade) Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of approved crushed stone in place in the drains, calculated in accordance with the authorised dimensions. The volume occupied by the pipe shall be deducted when calculating the volume of the permeable material.

The bid rate shall include full compensation for procuring and furnishing and transporting the materials from the borrow areas and commercial suppliers to the site and placing the material as specified.

For payment purposes a distinction shall be made between the different grades of crushed stone.

Item	Unit
21.07	Natural Permeable Material in subsoil Drainage Systems (Sand)
(a)	Sand obtained from approved sources on the site (state grade) Cubic Metre (m ³)
(b)	Sand obtained from approved sources outside the site (state grade) Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of approved sand in place in the drains, calculated in accordance with the authorised dimensions. The volume occupied by the pipes shall be deducted when calculating the volume of the permeable material.

The bid rate shall include full compensation for procuring, furnishing, transporting from the borrow areas and placing the sand as specified.

For payment purposes a distinction shall be made between the different grades of sand.

Item	Unit
21.08	Pipes in Subsoil Drainage Systems
(a)	Pitch-fibre pipes and fittings complete with coupling (state size and whether or not perforated) Metre (m)
(b)	Unplasticised PVC pipes and fittings, normal duty, complete with couplings (state size and whether or not perforated slotted) Metre (m)
(c)	High-density type poly-ethylene pressure pipes and fittings, complete with couplings (state size, type and class and whether or not perforated) Metre (m)
(d)	Concrete pipes (state type and diameter) Metre (m)

The unit of measurement for pipes shall be the metre of pipe, measured in place along its centre line, including the length of fittings.

The bid rate shall include full compensation for procuring, furnishing, laying and jointing the pipes and fittings as specified.

Item	Unit
21.09	Polyethylene Sheeting, 0.15 mm thick, or similar approved material, for lining subsoil drainage system Square Metre (m ²)

The unit of measurement shall be the square metre of polyethylene sheeting installed, measured net from the specified dimensions.

The bid rate shall include full compensation for procuring, supplying, cutting, overlapping, jointing, placing and protecting the sheeting as specified, as well as for wastage.

Item	Unit
21.10 Synthetic-fibre Filter Fabric (Describe Type and Grade)	Square Metre (m ²)

The unit of measurement shall be the square metre of filter fabric supplied and installed as specified.

The bid rate shall include full compensation for furnishing procuring, cutting, overlapping, jointing, placing and protecting the filter fabric as specified as well as for wastage.

Item	Unit
21.11 Composite In-plane Drainage System (Describe Type and Grade)	Square Metre (m ²)

The unit of measurement shall be the metre of composite in-plane drainage system measured in place along the centreline of the system.

The bid rate shall include full compensation for procuring, furnishing, assembling, installing and jointing the composite in-plane drainage system, including perforated or other types of pipes, complete as specified.

Item	Unit
21.12 Concrete Outlet Structure, Manhole Boxes, Junction Boxes and Cleaning Eyes for Subsoil Drainage	
(a) Outlet Structures	Number (No.)
(b) Manhole Boxes	Number (No.)
(c) Junction Boxes	Number (No.)
(d) Cleaning Eyes	Number (No.)

The unit of measurement shall be the number of outlet structures, manhole boxes, junction boxes and cleaning eyes for subsoil drainage systems constructed in accordance with the details on the Drawings and the Engineer's instructions.

The bid rates shall include full compensation for all excavation, backfilling, compacting to 93 % MDD of Modified AASHTO T180 density, disposing of surplus excavated material, keeping the excavations safe, dealing with any surface or subsurface water, procuring and furnishing all materials, providing, erecting and removing formwork, mixing, transporting, placing and curing the concrete, and all labour and constructional plant required for constructing the concrete outlet structures, manhole boxes, junction boxes and clearing eyes, complete as specified.

Item	Unit
21.13 Concrete Caps for Subsoil Drain Pipes	Number (No)

The unit of measurement shall be the number of caps supplied and the bid rate shall include full compensation for supplying and installing the caps.

Item	Unit
21.14 Repairing or Replacing Existing Drainage Systems	Provisional Sum

The provisional sum given for repairing existing drainage systems shall be expanded in terms of the Conditions of Contract.

Item	Unit
21.15 Backfill Existing Eroded Side Drains	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of approved granular material placed and compacted to 93 % MDD of Modified AASHTO T180 density, measured in place after compaction, where instructed by the Engineer.

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The bid rate shall include full compensation for trimming the side drains disposing of the resulting material and procuring, furnishing, transporting, placing and compacting the granular material and all haulage.

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This Item shall also apply to the backfilling of side drains and other open drains and channels such as inlet and outlet channels to culverts.

Item		Unit
21.16	Test Flushing of Pipe Subsoil Drains	Number (No)

The unit of measurement shall be the number of tests satisfactorily completed on unblocked sections of drain. No payment will be made for tests which have to be repeated due to blocked pipes or faulty workmanship.

The bid rate shall include full compensation for the provision of a water tanker, water, equipment and labour necessary to carry out the tests, complete as specified.

Item		Unit
21.17	Excavation for the Clearing of Existing Drainage Systems	
(a)	Manholes and Inlet and Outlet Structures	Cubic Metre (m ³)
(b)	Culvert Barrels	Cubic Metre (m ³)
(c)	Concrete Side Drains	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated and removed, measured in place before excavation.

The bid rate include full compensation for excavating the material, protecting the existing drainage structures, dealing with any surface or subsurface water and disposing of the excavated material, including shaping and levelling - off piles of soil material. The bid rate shall also include full compensation for all haulage of the material.

Item		Unit
21.18	Selected Backfill Material Under Concrete-Lined Side Drains Compacted to 90 % MDD AASHTO T180 Density	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of compacted material and the quantity shall be calculated from the authorised dimensions given on the Drawings.

The bid rate shall include full compensation for procuring as if from soft excavation or borrow pits, breaking down, placing and compacting the material in 150 mm layers, transporting the material and shaping the top surface in accordance with the Drawings.

SECTION 2200 Prefabricated Culverts

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2201 Scope

This section covers work in connection with the construction from prefabricated units of culvert and other closed conduits such as storm water and service ducts, together with inlet and outlet structures, manholes and other ancillary structures.

2202 Open Drains

For the purpose of this specification, the term “prefabricated culvert” means a culvert constructed from:

1. Prefabricated concrete pipes with circular sections, hereafter referred to as “concrete pipe culverts”.
2. Prefabricated concrete culverts other than pipe culverts hereafter referred to as “portal culvert” or “rectangular culvert”.
3. Prefabricated corrugated metal pipes and pipe arches, hereafter referred to as “metal culvert”.

Other types of prefabricated culvert not mentioned above such as wooden culverts or others, will be specified in the Special Specifications or Bills of Quantity or on the Drawings as required.

2203 Materials

The prefabricated culvert units shall be factory produced by a reputable manufacturer of these articles and shall comply with the following requirements:

a. Prefabricated concrete pipe culvert units

Prefabricated concrete pipe culvert units shall comply with the requirements of BS 5911-1 and BS EN 1916 or equivalent. Pipes with ogee joints shall be provided, unless otherwise specified.

b. Portal And Rectangular Prefabricated Concrete Culvert Units

Portal and rectangular prefabricated concrete culvert units shall comply with the requirements of BS 6073-2 or equivalent.

c. Corrugated Metal Culvert Units

Corrugated metal culvert units shall comply with the requirements of BS EN 10025, ASTM A760M, A761M or equivalent for pipes and pipe arches, and for multi-plate pipes and pipe arches.

Metal culverts shall be supplied with inlet and outlet ends finished by one of the following two methods whichever is shown on the Drawings or has been prescribed by the Engineer:

- i. Where concrete inlet and outlet structures are not required but bevelled pipe ends are required, inlet and outlet units shall be bevelled to suit the skew angle of the culverts and the side slope of the fill and pavement.
- ii. Where concrete inlet and outlet structures are required, the ends of the culvert units shall be cut to the required plan skew (if any) and provided with anchor bolts projecting radially around the edge as shown on the Drawings for bonding the metal culvert into the concrete inlet and outlet structures.

The Contractor shall store any nestable culvert units on the site in such a manner that moisture cannot accumulate between the contact faces of the nested units, as this may adversely affect the spelter coating and render the units liable to rejection. Any units damaged by corrosion shall, if not rejected, be repaired by cleaning all affected areas and applying at least two coats of an approved zinc-rich epoxy primer which complies with the requirements of BS 4652 or equivalent, in accordance with the manufacturer's instructions, or as directed by Engineer.

d. Fine Granular Material

Fine granular material shall comply with the following. Maximum fines passing through 0.075 mm sieve shall be $\leq 3\%$ for natural sand and $\leq 10\%$ for crusher sand. The fine aggregate size in bedding shall be of size 0/2 or 0/6.3 mm.

e. Coarse Granular Material

The coarse granular material shall consist of natural and /or aggregate and shall comply with the following. Maximum fines passing through 0.063 mm sieve shall be $\leq 1.5\%$ for natural aggregate and $\leq 4\%$ for crushed aggregate. The granular materials include graded granular material or single size granular material. The aggregate size for pipes ≤ 400 nominal diameters shall be 2/14 or 4/20 mm for graded aggregates and 10/20 mm for single graded aggregates. For pipes exceeding 400 mm nominal diameter, the size of aggregate shall be 2/14, 4/20 or 4/40 mm for graded and 10/20 or 20/40 mm for single sized aggregate. Los Angeles abrasion value shall be ≤ 50 . Water soluble sulphate content of less than 0.2 % when tested in accordance with BS EN 1744-1. Granular material shall be provided for class B, F and S beddings as specified in SUBCLAUSE 2210(a).

f. All-in Granular Material

All-in granular material shall comply with the following. Maximum fines passing through 0.063 mm sieve shall be $\leq 3\%$ for natural aggregate and $\leq 12\%$ for crushed aggregate. The all-in aggregate size shall be 0/10 or 0/20 mm for nominal pipe diameters ≤ 400 mm and 0/10, 0/20 or 0/40 mm for nominal pipe diameters exceeding 400 mm. Los Angeles abrasion value shall be ≤ 50 . Water soluble sulphate content of less than 0.2 % when tested in accordance with BS EN 1744-1.

g. Protective Coating For Metal Culverts

Where soil or water conditions are likely to cause excessive corrosion of metal culverts, the Engineer may order that prefabricated units be protected by the application of a mastic asphalt protective coating. The coating shall be applied to the inside, the outside or both sides of the metal culvert units as may be directed by the Engineer.

The mastic asphalt shall conform to AASHTO M190.

The surfaces to be protected shall be cleaned to remove all moisture, dirt, oil, paint, grease, alkalis, rust, mill scale or other deleterious matter.

The material shall be mixed until all filler is uniformly distributed.

Spray-grade mastic shall be applied by means of an airless gun and shall be of a suitable consistency without the addition of harmful amount of thinners.

Brush-grade mastic shall be applied with an ordinary roofing brush, with the second coat being applied at right angles to the first coat.

The final film thickness measured on the crest of corrugations shall be a minimum of 1.3 mm or such other thickness as may be specified.

Care shall be taken not to damage the protective coating, and all damage to the coating shall be repaired before the culvert is put to use.

h. Skewed Ends

Where culverts are to be constructed at a skew angle, the culvert shall be supplied with skew ends by the manufacturer, if required. The cutting of skewed ends on site shall not be allowed.

Portal and rectangular units shall be provided with square ends and any portions that would otherwise be cut off, shall project beyond the culvert head walls.

Where instructed by the Engineer, portal and rectangular culverts shall be provided with skewed ends constructed from cast in situ reinforced concrete in accordance with the details shown on the Drawings.

i. Defects

All broken, bent, chipped, cracked, dented, corroded or otherwise damaged units shall be rejected.

Culvert units, which are thinner than the specified thickness, or the spelter coating of which has been bruised or broken, or which may exhibit signs of faulty work, will be rejected.

The following defects will be rejected as poor work, and the presence of any of or all such defects or any other defects in any individual unit or in general shall constitute adequate reason for rejection: uneven joints, distorted shapes, deviations from a straight centre line, irregular or diagonally ruptured sides, loose rivets, rivets not in line or irregularly spaced, poorly finished rivet heads, illegible trade marks, or a lack of rigidity.

j. Material at Joints

Joint filler and joint sealing material shall comply with the requirements of [CLAUSE 7603](#).

k. In situ Concrete

All concrete work shall be carried out in accordance with the requirements of [SECTIONS 7200, 7300 and 7400](#).

2204 Construction Methods

Prefabricated culverts shall be installed by either:

1. The “trench method”, where the units are laid in a trench excavated below the existing ground level or in a trench excavated in previously constructed subgrade and if necessary, sub-base layers; or
2. The “embankment method”, where the units are laid approximately on the existing ground surface and the subgrade is then constructed on either side and over the culvert.

Culverts shall be constructed by the method shown on the Drawings or given in the Special Specifications.

The large sizes of metal culvert and the large portal or rectangular culverts shall normally be constructed by the embankment method.

Surface drainage shall be controlled by the construction of temporary earth berms and drainage channels.

The Contractor shall comply strictly with all the appropriate statutory provisions in regard to trench excavations.

2205 Excavation For Construction By The Trench Method

a. Depth of Excavation

In the case of culverts to be constructed by the trench method, the Contractor shall first construct the fill, subgrade and if necessary, the sub-base to such level of the top of the culvert, as described herein after for the various types of culvert. The Contractor may then commence excavating the trench for the culvert.

i. Concrete pipe culverts

The minimum height of embankment construction over the top of the proposed pipe culvert before excavation may be commenced, shall be the minimum cover specified on the Drawings for the type of pipe and bedding onto which it shall be laid.

The minimum amount by which the excavation is to exceed the proposed level of the bottom side of the pipe shall be 75 mm or such other as may be required for accommodating the type of bedding required for the pipe in each case.

ii. Portal and rectangular culverts

The minimum height of embankment construction over the top of the proposed culvert before excavation may be commenced, shall be 100 mm or such greater height as may be shown on the Drawings, whichever is the greater.

The minimum amount by which the excavation is to exceed the proposed level of the bottom of the culvert invert slab shall be 75 mm in the case of culvert with pre cast invert slabs. In the case of culverts with cast in situ invert slabs, the excavation shall exactly accommodate the invert slab.

iii. Metal culverts

The minimum height of embankment construction over the top of the proposed metal culvert before excavation may be commenced, shall be the minimum cover specified on the Drawings for the type of metal culvert, or 0.25 times the diameter of pipes, or 0.25 times the span of pipe arches, whichever is the greatest.

The minimum amount by which the excavation is to exceed the proposed level of the bottom of the pipe shall be 75 mm or such other amount required for accommodating the type of bedding required for the culvert in each case.

b. Width of Excavation

The width of excavations shall be sufficient to allow the proper formwork laying, bedding and backfilling of culverts. The widths of the excavation for each type and size of culvert shall be as shown on the Drawings or as may be prescribed by the Engineer in writing. Where the widths are not shown, the width of excavation, W , shall be determined from the following formula:

$$W = nD + (n - 1)C + A$$

Where,

n = the number of culverts

D = the external diameter of the pipe in metres which, in the case of corrugated metal pipes, shall be measured to the outside edge of the corrugations.

C = 0.15 m for concrete pipes surrounded in concrete

C = 0.30 m for concrete pipes not surrounded in Concrete

C = 0.5 D for corrugated metal pipes

A = 0.3m for concrete pipes surrounded in concrete

A = 0.6m for concrete pipes of 600 mm nominal diameter or less not surrounded Concrete

A = 0.9m for concrete pipes of 750 mm nominal diameter or greater not surrounded in concrete.

A = 0.9m for corrugated metal pipes.

2206 Preparation For Construction By The Embankment Method

Where culverts are to be constructed by the embankment method as defined in [CLAUSE 2204](#), the Contractor shall level existing ground by excavating, filling and compacting as may be necessary so as to provide exactly the required slope and a uniform density over the entire length of the culvert.

The finished level of the ground for the bedding of the culvert shall be the same depth below the proposed bottom level of the culvert as specified in [CLAUSE 2210](#) for the various types of culverts.

2207 Unsuitable Founding Conditions

Where the bottom of the trench does not provide a suitably firm foundation for the culvert unsuitable material shall be excavated to a depth as may be indicated by the Engineer and replaced with gravel or other properly compacted approved material.

The width of the excavation shall be as required by the Contractor to allow compaction of backfill, safe working within close or open boarded trench supports, or to allow safe batters to be constructed. The Engineer may instruct the Contractor to widen the excavation or take any other steps to ensure safe working conditions or to ensure the best quality of construction can be executed.

Other special construction methods may be shown on the Drawings or detailed in the Special Specifications as required.

2208 Classification Of Excavation

All excavations for prefabricated culverts shall be classified as provided in [CLAUSE 3503](#) for payment purposes.

2209 Disposal Of Excavated Material

Where excavated material does not comply with the specifications as backfill or is surplus to requirements, such excavated material shall be removed from the site and used for rehabilitation of borrow pits or at other places as directed by the Engineer.

Excavated material meeting the specified requirements for fill shall be incorporated elsewhere in the Works with the approval of the Engineer.

Payment for such material will be made as for excavation under [ITEM 22.01](#), and also under the appropriate Item for such part of the Works as may be constructed from such material.

No haulage will be paid for excavated material.

2210 Laying And Bedding Of Prefabricated Culverts

a. Concrete Pipe Culverts

Concrete pipe culverts shall be laid on Class A, B, D, F, N or S bedding as shown on the Drawings or as directed by the Engineer. The pipe ends shall be laid hard up against each other so as to obtain tight joints. Ogee pipes shall be laid with their spigot ends downstream. The joints shall be sealed on the outside with two layers of bitumen impregnated burlap as specified in SUBCLAUSE 2210(b).

The insides of the culvert shall be smooth and without any displaced joints. All pipes shall be laid true to line and level.

i. Class A bedding

The pipe shall be laid with its bottom part on concrete bedding of specified thickness below the lower part of the pipe and shall extend upwards on both sides of the pipe to the specified portion of its height encompassing 120° of the bottom of the pipe. The concrete for bedding shall be of minimum strength class C20/25. The minimum thickness of concrete bedding below bottom of pipe shall be 1/4th of the nominal diameter of pipe or 150 mm whichever is more. Concrete bedding can be unreinforced or reinforced as shown on the drawings depending upon the required bedding factor to sustain the design loads.

The bed formation below concreting bedding shall be levelled and provide a firm foundation by using a layer of blinding concrete. The concrete cradle shall be monolithic and concrete shall be poured such as to avoid formation of voids underneath the pipe.

Before concreting the pipes shall be supported on suitably shaped cradles at the correct level. No longitudinal construction joints on the horizontal plane will be permitted.

ii. Class B bedding

The pipe shall be laid on a bedding cradle of compacted selected coarse granular material as specified. The bedding shall extend upwards on both sides of the pipe to the height covering half diameter i.e. encompassing 180° of the bottom of pipe as shown on the Drawings. Joint holes shall be formed in the bedding cradle leaving a clearance of at least 50 mm for pipe sockets and couplings, to ensure that each pipe is fully supported throughout the length of its barrel on the bedding cradle. Side fills shall be densely compacted particularly beneath the haunches of pipe with care taken not to displace the pipe during compaction.

iii. Class D bedding

The pipes shall be laid directly on the in situ material in the excavation bottom after the bottom has been hand trimmed to support the pipe along the entire length of its barrel in accordance with the details shown on the Drawings. Wherever necessary the in situ material shall first be stabilised in accordance with the details shown on the Drawings or as prescribed by the Engineer. Socket holes shall be formed providing at least 50 mm clearance under the pipe socket where required to ensure pipe barrel support throughout its length.

iv. Class F bedding

The pipe shall be laid on a bedding cradle of compacted selected coarse granular material as specified. The bedding shall extend upwards on both sides of the pipe to specified portion of its height encompassing 45° of the bottom of pipe as shown on the Drawings. Socket holes shall be formed providing at least 50 mm clearance under the pipe socket where required.

v. Class N bedding

The pipe shall be laid on a flat layer of all-in granular/ fine granular material as specified and shown on the drawings. Socket holes shall be formed providing at least 50 mm clearance under the pipe where required to ensure pipe barrel support throughout its length.

vi. Class S bedding

Under this bedding class S, the pipe shall be laid in a complete surround with selected coarse granular bedding material as specified. The bedding shall extend upwards on both sides of the pipe and over the crown of pipe to a specified height as shown on the Drawings. Socket holes shall be formed providing at least 50 mm clearance under the pipe where required.

vii. Rock foundation

Where rock, shale or other hard material is encountered on the bottom of excavations, the installation of pipes on Class B bedding shall proceed as follows:

1. The material below the pipe shall be excavated and replaced with a bed of sand or approved gravel or soil to a depth as shown on the Drawings or prescribed by the Engineer. The depth of replaced bed shall not be less than 150 mm. Such material shall be classed as backfill for purposes of payment.
2. The backfill material shall be watered and compacted as specified and if not specified, shall be at least 93 % of Modified AASHTO density. Class B bedding shall then be prepared as described in SUBCLAUSE 2210(a).

viii. Concrete casing

Pipes shall be fully encased in concrete according to a minimum strength class of C20/25 and dimensions as shown on the Drawings or ordered by the Engineer. Minimum thickness of concrete surround i.e. below bottom of pipe, above pipe crown or sides $\frac{1}{4}$ th of outside diameter of pipe or 150 mm whichever is more. Supports shall be provided close to the pipe ends during the placing of concrete. Poker vibrators shall be used to ensure the proper filling of all spaces below and around the pipes with concrete. Concrete casing shall be cast in one continuous operation until completed. Concrete casing/surround can be unreinforced or reinforced as shown on the drawings depending upon the required bedding factor to sustain the design loads.

ix. General

The bedding below pipes and any improvement required below bedding, e.g. sand layer in rock foundation, shall be well compacted. The completion of the remaining part of bedding, haunching and surrounding of the pipes is to be carried out after jointing. The bedding beneath and at sides of pipes shall be well compacted. Bedding/ backfill directly above the pipe for a height 300 mm above pipe crown to be compacted by hand. Backfill above this height shall be compacted and constructed in accordance with the specifications for embankment construction for road works.

The bedding materials with compaction fraction ≤ 0.15 are suitable for bedding Class F, B and S. The lower the fraction, the greater is the self compacting properties.

b. Portal and Rectangular Culverts**i. Cast in situ floor slabs**

Cast in situ floor slabs shall be constructed to the dimensions and at the locations as shown on the Drawings or as may be instructed by the Engineer. Reinforcement, joints and other details of construction for the floor slabs and the inlet and outlet structures shall be as shown on the Drawings. The cast-in-situ concrete shall be laid over a prepared levelled surface with blinding concrete.

ii. Prefabricated floor slabs

A layer of fine granular material or blinding concrete at least 75 mm thick shall be placed on the bottom of the excavation, levelled, compacted and trimmed to line and grade to form a bed to receive the precast slabs.

The slabs shall be carefully placed on the prepared bed, true to line and grade and so bedded that they will be uniformly supported over their whole area on the bedding.

iii. Placing the portal portions of culverts

The portal portions of portal and rectangular culverts shall be placed accurately and symmetrically on the floor slabs with a thin layer of mortar of one part of cement and six parts of sand between the contact surface to ensure a firm and uniform support.

The units shall be butted end to end with butt joints, which joints shall be covered with two layers of burlap of 340 g/m², pre-impregnated with a bituminous emulsion, or a similar approved material. The strip of burlap shall be at least 150 mm wide and placed symmetrically over the joint. The units shall first be treated with a primer of 60 % bitumen emulsion over the width of the strip of burlap.

Where two or more culverts are placed side by side to form a multi-barrel culvert, the space between the culvert shall be filled with concrete up to the level of the top of the culvert. Where prescribed, filter fabrics shall be applied to the vertical outer faces in accordance with the details shown on the Drawings.

c. Metal Culverts

The excavation shall be trimmed to the shape of the invert of the culvert and a bed of fine granular material not less than 75 mm thick shall be placed, watered, compacted and shaped to enable the culvert to be bedded as shown on the Drawings.

Where rock is encountered, the depth of excavation shall extend to a depth of at least 200 mm below the invert of the culvert, and shall be filled with granular material as before.

The culverts shall be installed in accordance with the manufacturer's recommendations as approved by the Engineer. Where these Contract Specifications are inconsistent with the manufacturer's recommendations, these Specifications shall have preference unless the Engineer instructs otherwise. Anchor bolts shall be installed at the ends of metal pipe culverts in accordance with the manufacturer's instructions to bond them into inlet and outlet head walls which shall be constructed as soon as possible after installation of the culverts.

No concrete bedding or casing shall be used in the installation of metal culverts unless shown on the Drawings. The invert of metal culverts with diameters or spans exceeding 1500 mm which are laid on steep grades, or in other circumstances where high erosion potential exists, may require protection with a layer of concrete with dimensions and class as specified by the Engineer.

d. Extension of Existing Culverts

Where an existing culvert requires extension or partial replacement, the new section shall be placed at the same grade and level where it joins the existing structure.

Any sections of existing wing walls, approach slabs and head walls which may obstruct any work shall be demolished and removed. If damage occurs to existing culvert ends the repair work shall be done before the placement of any fresh concrete or new culverts. Loose material shall be removed and joint faces thoroughly cleaned to the satisfaction of the Engineer.

Jointing shall be done in accordance with [CLAUSE 2214](#).

After completion of the extension or partial replacement of a culvert, new approach slabs, head walls, wing walls, catchpits etc, shall be constructed in accordance with the Drawings and [CLAUSE 2212](#).

e. Construction Of Culverts In Half Widths In Existing Roads

If necessary for accommodating traffic or for any other reasons, or if instructed by the Engineer, culverts shall be constructed in half widths.

Unless otherwise prescribed, the downstream section shall be constructed first. The end of the excavation adjoining the traffic lane shall be properly supported to prevent instability. The necessary warning signs shall be erected in accordance with requirements of SECTION 1500.

Where the culvert is constructed in an existing road the pavement layers at least shall be benched and compacted to 93 % MDD of AASTHO T180 during backfilling. The depth of benching shall be equal to or less than the respective layer thickness, and the width shall be at least 150 mm.

f. General

The construction of culverts shall be commenced at one end of the culvert, the position of which shall be fixed as shown on the Drawings or as instructed by the Engineer.

Units which have been deformed or cracked, or which are not constructed to the required lines, levels and grades or which become displaced in the process of the work or during the Defects Notification Period shall be removed and replaced by the Contractor at their own expense.

Prefabricated units shall be lifted and handled by means of approved lifting devices only. Lifting eyes shall be caulked with a suitable mortar after the units have been installed.

The Contractor shall exercise due care not to damage, overstress or displace any prefabricated culverts with the Contractor's traffic or compaction equipment. Where loads exceeding those prescribed in the appropriate statutory provisions are likely to pass over completed culverts, the Contractor shall provide additional cover over the culverts to ensure that design stresses on the culverts will not be exceeded.

All concrete work shall be carried out in accordance with provisions of SERIES 7000.

When the Contractor is required to supply and install culverts at slope exceeding 1:4, the work shall be carried out as specified in CLAUSE 2216.

Culvert inlet levels, outlet levels and all other levels shall adhere to what is shown on the drawings.

2211 Backfilling Of Prefabricated Culverts

After the culverts have been firmly laid on the required bedding as described in CLAUSE 2210, backfilling shall be carried out as follows:

a. Material for Backfilling

The material used for the backfilling of those portions of culverts subject to traffic loads shall be selected material of at least sub-base quality or such other lower quality as may be permitted by the Engineer. Where the excavated material is not of adequate quality, selected material shall be imported for this purpose. The Contractor shall, in advance, ascertain from the Engineer which portions will require selected quality material for backfilling.

In the case of concrete pipe culverts on Class B bedding and metal culverts, the backfilling material shall be thoroughly compacted in under the flanks of the culverts to provide a uniform bedding which shall be approved by Engineer. Metal culverts shall be temporarily ballasted during backfilling to prevent them from lifting.

b. Backfilling

The placement of initial and main backfill shall only be commenced when the pipe joints, bedding and sidefills are in a condition to permit loading. The initial backfill directly above the pipe should be compacted by hand where required. Mechanical compaction of the main backfill directly above the pipe should not be commenced until there is a total depth of cover of at least 300 mm above top of the pipe. The depth of cover directly above the pipe before mechanical compaction is commenced, depends on the type of compaction device.

Backfilling alongside and over all culverts shall be placed at or near the optimum moisture content and compacted in layers not exceeding 150 mm after compaction, or less if required, to a density

1000

2000

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of at least the density required for the material in adjoining layers of fill, subgrade and sub-base. The density of backfilling in excavations made in natural ground shall be at least 93 % MDD of Modified AASHTO T180 density.

Backfilling shall be carried out simultaneously and equally on both sides of a culvert to prevent unequal lateral forces arising.

Where the Engineer so directs, metal culverts with large diameters or spans or multi – barrel culverts shall be constructed by the embankment method as defined in SUBCLAUSE 2204. In such cases, the backfilling shall be carried out to the same standard as described above, simultaneously and equally on both sides of the culvert and placed over the culvert until the minimum specified cover is obtained which shall be no less than 300 mm or 1/6th of the pipe diameter, whichever is greater. The width of backfill on each side of the culvert, after completion, shall be at least equal to the diameter (or span) of one of the openings of the culvert.

Metal culverts shall be backfilled symmetrically to prevent distortion of the units, and the Contractor shall also ensure that the required cover as specified is in place to allow construction equipment to pass over it without causing damage.

c. Backfilling with Concrete

Whenever specified or as may be instructed by the Engineer, the backfilling shall consist of concrete placed between the side of the culvert and the excavation up to the top of the culvert. The class of concrete shall be C12/15 or as otherwise shown on the drawings. This concrete in backfilling is different from the concrete used in concrete bedding Class A or concrete surround where minimum grade of C20/25 is used. Curing shall be done for at least fourteen days before backfilling after completion.

d. Backfilling with Soil-cement

When specified or ordered by the Engineer, the backfilling of culverts shall be done using a wet or a stiff mixture of soil/cement in lieu of compacted gravel or lean concrete. A wet mixture of soil cement shall consist of an approved soil or gravel mixed with 5 % of a common cement complying with the requirements of KS EAS 18-1, BS EN 197-1 or equivalent standard on approval of the Engineer and only sufficient water to give a consistency that will permit the soil cement to be placed with vibrators, so that all voids between the pipes and the sides of excavations and between culverts in the case of multi barrel culverts will be properly filled. A stiff mixture of soil/cement shall contain 3 % of a common cement complying with the requirements of KS EAS 18-1, BS EN 197-1 or equivalent standard on approval of the Engineer and just sufficient water for it to be placed and compacted like ordinary backfill material. The height to which the soil/cement backfill shall be taken shall be as prescribed by the Engineer or as shown on the Drawings, and any remaining backfill shall be carried out as described above with a granular material.

The aggregate used for soil/cement shall preferably be a sandy material but may contain large particles up to 40 mm. It shall not have a Plasticity Index exceeding 10 %. Detrimental percentages of silt or clay shall be avoided and the aggregate shall be obtained from an approved source.

The soil/cement shall be mixed on the Site with suitable concrete mixers, and the water and cement contents shall be carefully controlled. The material shall be placed and then thoroughly compacted so that all voids are filled as described above. At culvert ends, stones shall be packed to prevent the soil/cement from flowing beyond the required limits.

Soil/cement shall not be used for backfilling corrugated metal culverts.

e. Haulage

When haulage is paid for in accordance with the Special Specifications a free haul distance determined according to SUBCLAUSE 1602(c) shall apply in respect of all imported materials used for backfilling the culverts. No overhaul shall be paid on any cement, water or concrete aggregates used.

2212 Inlet And Outlet Structures, Catchpits And Manholes

Inlet and outlet structures for prefabricated culverts as well as catchpits and manholes shall be constructed in accordance with the details shown on the Drawings.

a. Excavation And Backfilling

The specifications given elsewhere in this section for excavating and backfilling the culverts shall apply with changes as required to inlet and outlet structures, catchpits and manholes.

No backfilling of a concrete structure may be done for a period of at least fourteen days after the structure has been completed, unless otherwise specified or directed by the Engineer.

b. Concrete Work

Concrete work shall be carried out in accordance with the provision of **SERIES 7000** and the Drawings. If not specified on drawings, the minimum strength class of concrete shall be C20/25.

c. Masonry

Masonry shall be constructed in accordance with **CLAUSE 2505**.

Where pipes enter masonry they shall be thoroughly caulked into the wall and rendered with mortar.

d. Plaster

Where the plastering of masonry is required, all joints shall be well raked out and the stone face thoroughly wetted before plaster is applied. Plaster shall not be less than 12 mm or more than 20 mm thick. Plaster finish shall be smooth and even and shall not show any trowel marks. Unless otherwise specified all plaster shall be finished with a steel trowel. Plaster shall consist of one part of cement to four parts of approved fine sand.

e. Manhole Covers, Grid Inlets Etc

Manhole covers and frames, grid inlets and other metal accessories shall be fabricated and/or manufactured in accordance with the details shown on the Drawings. Road and pavement manhole covers and frames shall comply with the requirements of BS 7903 and BS EN 124 or equivalent and shall be of the size and type indicated.

Before fixing manholes covers and frames they shall be dipped in an approved preservative and gratings and frames painted with two coats of bituminous paint. Manhole frame shall be set firmly in a cement mortar to leave the covers flush with the final surface.

f. Prefabricated Concrete Chambers and Shafts

Prefabricated chambers and shafts shall be constructed from non-pressure concrete pipes which comply with the requirements of BS 5911-4, BS EN 1917, or equivalent. Pipes with ogee joints shall be provided unless otherwise specified. The pipes shall be to the diameters specified. All chambers and shafts shall be installed with the spigot ends pointing upwards and shall be bedded in mortar thoroughly caulked to ensure watertight joints.

g. Benching

All benching shall be rendered in 25 mm granolithic screed and finished smooth and true with a steel trowel. Corners shall be rounded to dimensions shown on the Drawings.

h. Prefabricated Inlet And Outlet Structures

Where specified for use, prefabricated inlet and outlet structures shall be manufactured in accordance with the dimensions shown on the Drawings. The units shall be laid and jointed generally as specified for prefabricated concrete pipe culverts.

i. Prefabricated Energy Dissipaters In Outlet Structures

Where shown on the Drawings, the Contractor shall supply and install in the outlet structures, prefabricated reinforced concrete energy dissipaters of Class C20/25 concrete with dimensions as shown on the Drawings. All concrete work shall comply with the requirements of SERIES 7000.

2213 Removal Of Existing Work

Where shown on the Drawings or directed by the Engineer existing inlets and outlets to pipe culverts shall be demolished and debris or rubbish disposed of in an approved waste site as directed by the Engineer. Existing pipes shall be removed where necessary and saved for later use. All such work shall be carried out to prevent damage being done to former work which is to remain.

The Contractor's attention is directed to the provisions of SECTION 3100 which specifies any structures which have to be removed as part of the clearing and grubbing operations, the removal of which will therefore not be measured and paid for under this section.

Pipes shall be carefully removed from existing culverts and thoroughly checked. Undamaged pipes shall be re-used in the Works where indicated by the Engineer. Pipes which cannot be re-used shall remain the property of the Employer and shall be stacked within the road reserve or where directed by the Engineer.

2214 Joining New Work To Old

Where partial demolition is required for extension work to existing structures, the contact face shall be cut to predetermined lines and levels, any loose and fragmented material shall be removed and projecting steel cleaned and bent as directed by the Engineer. Where partial demolition is not required, but extension work only, the contact surface shall be roughened and cleaned of all dirt and loose particles.

If dowels are required, they shall be installed in holes drilled into the existing structures, in accordance with the details shown on the Drawings and secured by means of an approved type of epoxy resin grout.

Fresh concrete shall be bonded to the old concrete by using epoxy resins specially designed for bonding old and new concrete. The preparation of the surface and the application of epoxy resin shall be in accordance with the requirements of the manufacturer and the Engineer's instructions. specified in SECTION 6100.

Reinforced or plain concrete removed in the process of partial demolition shall be measured and paid for under ITEM 22.12 and the installation of dowels and those surfaces treated with an epoxy bonding compound will be paid for separately but no separate payment will be made for any other work described above, the cost of which shall be deemed to be included in the rates bid for the concrete supplied for extensions to the existing structures.

2215 Service Ducts

Where required the Contractor shall construct service ducts for the easy installation and maintenance of existing, new and future cables and other services. Where the service provider is to install such ducts, the Engineer shall instruct that the contractor employed to undertake this work shall comply with the requirements of this clause.

Service ducts shall be constructed from one or more of the following materials:

1. Heavy duty PVC pipes in accordance with BS EN 13598-1 and BS EN 1401-1 or equivalent.
2. Fibre-cement pressure pipes in accordance with BS EN 512 or equivalent. Class C pipes shall be used unless other types are specified.
3. Reinforced-concrete pipes in accordance with BS 5911-4, BS EN 1917:2002, or equivalent.

Where required, the pipes shall be cut length-wise and accurately in two halves. The actual type of pipe required shall be in accordance with the Specifications. The pipes shall be installed in the required positions, and accurate record shall be kept regarding the depth, position and number of pipes installed in each duct. Pipes shall be laid at the grades shown on the Drawings to facilitate flushing with water and shall, where required, be encased in concrete or soil cement.

The width of excavation for service duct trenches shall be equal to the nominal inside diameter of the pipe, plus 150 mm on each side of the duct. Where ducts consist of two or more units, the minimum spacing between the units shall be 75 mm, and the 150 mm side clearance specified above shall apply to the outside units of the group.

Below the carriageway the depth of excavation shall accommodate a minimum cover of 1.0 m above the upper side of the installed services duct.

All pipes shall be joined with watertight couplings made from the same materials as the pipe. Fibre-cement couplings shall be of rubber – ring type.

Split pipes shall normally be used only for providing ducting for existing services which cannot be severed and threaded through the ducts. The pipes shall be accurately cut longitudinally in two halves and opposite halves shall be matched as sawn. Split pipes shall be placed around the service as required, firmly bound by steel straps and finally encased in concrete if required.

Excavating, laying and bedding the pipes shall be in accordance with the Specifications for prefabricated culverts with any modifications as may be necessary or specified here.

Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt from entering the ducts and the service provider shall make provisions to ensure that the ducts remain clean and are maintained to an appropriate standard for purpose.

The end of each duct shall be marked with a marker block constructed to the details shown on the Drawings. Each duct marker block shall be at least 50 mm proud of the finished surface level.

2216 Culverts On Steep Gradients

Where culverts are constructed on gradients exceeding 1:4, they shall be referred to as inclined culverts. Inclined culverts shall be constructed of the unit type specified, normally either circular concrete pipe units or metal culvert units as described in [CLAUSE 2203](#).

Particular care shall be taken to protect excavations against stormwater damage. The trenches shall be excavated down to firm ground, and backfilled with selected gravel or concrete if it is necessary to over excavate to achieve a firm floor.

After the outlet structure has first been completed, the culvert units shall be laid in the normal manner by starting from the lower end and placing successive units firmly against each other to prevent subsequent movement. The lower unit shall be securely cast into the outlet structure, and metal culverts shall be provided with the necessary anchor bolts at both inlet and outlet structures and also at all thrust and anchor blocks.

Thrust and anchor blocks shall be constructed from concrete as required in accordance with Drawings and details furnished by the Engineer. Anchor bolts, straps and other anchoring devices required at anchor and thrust blocks shall be provided.

The backfilling of trenches shall be done in horizontal layers starting at the lower end.

2217 Stormwater Ducts, Tremies and Other Closed Conduits

The specifications given in this section for culverts, including the method of measurement and payment, shall apply with changes as required to the construction of stormwater ducts or any other closed conduits constructed from the prefabricated units described in **CLAUSE 2203**, whether intended for drainage or for any other purpose.

No distinction will be made in the Bill of Quantities between the construction of culverts as defined in **SECTION 1100** and that of the other closed conduits described above, all being classed as culverts.

Closed conduits constructed from prefabricated units shall be classed as inclined culverts where laid to a grade steeper than 1:4.

2218 Measurement And Payment

Item	Unit
22.01 Excavation	
(a) Excavating Soft Material Situated Within The Following Depth Ranges Below The Surface Level	Cubic Metre (m ³)
i 0.5 m up to 1.5 m	Cubic Metre (m ³)
ii Exceeding 1.5 m and up to 3.0 m	Cubic Metre (m ³)
iii Exceeding 3.0 m per increment of 1.5 m	Cubic Metre (m ³)
(b) Extra Over SUBITEM 22.01(a) For Excavation In Hard Material As Defined In CLAUSE 3503 , Irrespective Of Depth	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated within the specified widths over the lengths and depths authorised by the Engineer in each case. Excavation in excess of the widths specified or authorised by the Engineer shall not be measured for payment.

Irrespective of the total depth of the excavation, the quantity of material in each depth range shall be measured and paid for separately.

When measuring excavation for the removal of existing culverts, the volume occupied by the culvert shall not be subtracted from the calculated volume of excavation.

In the case of manholes, catch pits and inlet and outlet structures, the dimensions for determining the volume of excavation shall be the neat outside dimensions of the structure.

The bid rates shall include full compensation for all excavation, temporary timbering, shoring and strutting, for preparing the bottom of the excavation for the culvert beds, the disposal of excavated material unsuitable for backfilling, keeping excavations safe, dealing with any surface or subsurface water, and for any other operations necessary for completing the work as specified.

No haulage will be paid.

Item	Unit
22.02 Backfilling	
(a) Using Excavated Material	Cubic Metre (m ³)
(b) Using Imported Selected Material	Cubic Metre (m ³)
(c) Extra Over SUBITEMS 22.02(a) and (b) for soil Cement Backfilling (Percentage of Cement Indicated)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material in place after compaction. The quantity shall be calculated from the neat outside dimensions of the structure as specified or as authorised by the Engineer.

If excavation were carried out in excess of the dimensions authorised by the Engineer, the quantity of backfilling will nevertheless be based on the authorised dimensions. The volume occupied by the culvert shall be subtracted when calculating the volume of backfilling.

The bid rates shall include full compensation for backfilling under, alongside and over conduits, for watering and for compacting the backfill material to the specified density. The bid rate for SUBITEM 22.02(b) shall, in addition, include full compensation for supplying selected material of sub-base quality from approved sources, including a free haul determined according to SUBCLAUSE 1602(c) in the cases where haulage is paid for in accordance with the Special Specifications.

The bid rate for SUBITEM 22.02(c) shall be additional to the rates bid for SUBITEMS 22.02(a) and (b) and shall include full compensation for all incidentals required for the complete backfilling with soil cement as specified.

Item	Unit
22.03 Concrete Pipe Culverts	
(a) On Class A Bedding (Type And Diameter Indicated)	Metre (m)
(b) On Class B Bedding (Type And Diameter Indicated)	Metre (m)
(c) On Class D Bedding (Type And Diameter Indicated)	Metre (m)
(d) On Class F Bedding (Type And Diameter Indicated)	Metre (m)
(e) On Class N Bedding (Type And Diameter Indicated)	Metre (m)
(f) On Class S Bedding (Type And Diameter Indicated)	Metre (m)

The unit of measurement for concrete pipe culverts shall be the metre of culvert laid as shown on the Drawings or ordered by the Engineer. The length shall be measured along the soffit of the culvert.

The bid rates shall include full compensation for providing, testing, loading, transporting and unloading the culverts, for providing and placing the fine-grained material, where required, and for the installation, laying and jointing of the culverts, as specified. The bid rate shall also include for jointing with existing pipes where culverts have to be extended. Any concrete required for the jointing or for bedding, haunching and surround will be paid for separately under ITEM 22.07.

Should it be inevitable for a section to be cut off from a concrete pipe unit of standard length, the full standard length of the unit shall be measured for payment. No additional compensation for cutting and disposing of such section will be paid.

Before payment, differentiation shall be made between the various types and sizes of culverts and between the culverts placed on A, B, C and D classes of bedding.

Item	Unit
22.04 Metal Culverts	
(a) Size, Wall Thickness And Type Indicated	Metre (m)
(b) Cutting Off Bevelled And/ Or Skew Ends (Size And Type Indicated)	Number (No.)
(c) Anchor Bolts	Number (No.)

The unit of measurement shall be the metre of culvert laid, the number of cuts made and the number of anchor bolts installed as shown on the Drawings or ordered by the Engineer.

In the case of a metal pipe, the culvert length shall be measured along the pipe centre line. In the case of a metal pipe arch, the culvert length shall be measured along the bottom of the pipe arch. In both cases, the length of bevelled and/or skew ends shall be included.

The bid rates shall include full compensation for providing, testing, loading, transporting and off-loading the culverts, for providing and placing fine-grained material where required for the installation of culverts, and for installing, laying and jointing the culverts as specified. For payment purposes,

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Drainage | 2200 | Prefabricated Culverts

a differentiation shall be made between the various types and sizes of culverts and also between culverts with differing wall thicknesses. The bid rate shall also include for jointing with existing pipes where culverts have to be extended. Any concrete required for the jointing will be paid for separately under ITEM 22.07.

Payment shall be made separately for the cutting of bevelled and/or skew ends, and the bid rate shall include full compensation for all work in connection with the cutting of ends.

The bid rate per anchor bolt shall include full compensation for procuring, providing and installing the bolts.

Item	Unit
22.05 Portal and Rectangular Culverts	
(a) Complete with Prefabricated Floor Slabs (Size and Type Indicated)	Metre (m)
(b) Without Prefabricated Floor Slabs (Size And Type Indicated)	Metre (m)

The unit of measurement for prefabricated portal or rectangular culverts shall be the metre of culvert laid as shown on the Drawings or as directed by the Engineer.

The length shall be measured along the soffit of the culvert.

The bid rates shall include full compensation for supplying, testing, loading, transporting and off-loading all culverts, providing and placing the fine-grained material where required for installing the culverts, and installing, laying and jointing the culverts as specified, including cutting them on the site, and any wastage.

Payment will be made separately for floor slabs of cast in situ concrete.

Payment shall distinguish between the different sizes and types of culverts and between culverts installed with or without prefabricated floor slabs.

Item	Unit
22.06 Extra Over ITEMS 22.03, 22.04 and 22.05 for Constructing Inclined Culverts Steeper Than 1:4	Metre (m)

The unit of measurement shall be the metre of culvert installed at a grade steeper than 1:4 as specified in CLAUSE 2216.

The bid rate shall include full compensation for additional or more difficult work of any nature in regard to laying, excavating and backfilling as may be required for installing the culverts at a grade steeper than 1:4.

Item	Unit
22.07 Casting In Situ Concrete and Form Work	
(a) In Class A Bedding, Screeds And The Encasing For Pipes, Including Formwork, (Class Of Concrete Indicated)	Cubic Metre (m ³)
(b) In Floor Slabs For Portal Or Rectangular Culverts, Including Formwork And Class U2 Surface Finish (Class Of Concrete Indicated)	Cubic Metre (m ³)
(c) In Inlet And Outlet Structures, Catchpits, Manholes, Thrust And Anchor Blocks, Excluding Formwork But Including Class U2 Surface Finish (Class Of Concrete Indicated)	Cubic Metre (m ³)
(d) Concrete Formwork Under SUBITEM 22.07 (a) Above (Type Of Finish Indicated)	Cubic Metre (m ³)
(e) In Concrete Linings For The Inverts Of Metal Culverts, Including Formwork And Class U2 Surface Finish (Class Of Concrete Indicated)	Cubic Metre (m ³)

Measurement of formwork and cast in situ concrete shall be as specified in SECTIONS 7200 and 7400.

Payment for formwork and cast in situ concrete shall be made as provided in SECTIONS 7200 and 7400, except that payment for the formwork for concreting in SUBITEMS 22.07(a), (b) and (e) shall not be made separately, and the Contractor's rates for concrete shall include full compensation thereof.

No separate payment shall be made for the construction of joints in culvert floor slabs or at inlet and outlet structures, and the bid rates for concrete shall include full compensation for forming the joints complete in accordance with the details shown on the Drawings.

Item	Unit
22.08 Concrete Backfill Culvert (Class Indicated)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of concrete backfill. The quantity shall be calculated from the dimensions of the excavation as specified or as may be authorised by the Engineer, minus the volume taken up by the culverts, irrespective of whether the actual excavation to be backfilled exceeds the specified or authorised dimensions.

Payment shall be made as for concrete in ITEM 22.07 above.

Item	Unit
22.09 Prefabricated Concrete Inlets and Outlets to Culverts (Size and Type Indicated)	Number (No.)

Prefabricated concrete inlets and outlets for concrete pipe culverts shall be measured per inlet or outlet, complete in position.

The bid rate shall include full compensation for procuring, providing, loading, transporting, off-loading and installing the inlets or outlets as specified.

Item	Unit
22.10 Steel Reinforcement	
(a) Mild Steel Bars	Tonne (t)
(b) High-Tensile Steel Bars	Tonne (t)
(c) Welded Steel Fabric	Tonne (t)

Measurement and payment for steel reinforcement shall be made as specified in SECTION 7300.

Item	Unit
22.11 Dowels for Joining Old and New Concrete	Kilogramme (kg)

The unit of measurement shall be the kilogram of steel dowels installed.

The bid rate shall include full compensation for supplying all materials, all cutting, drilling and grouting, and any other operation or Item necessary for the proper execution of the work.

Item	Unit
22.12 Removing Existing Concrete	
(a) Plain Concrete	Cubic Metre (m ³)
(b) Reinforced Concrete	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of existing concrete removed.

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The bid rates shall include full compensation for all demolition and for loading, transporting and disposing of the products of demolition, including a free haul determined according to SUBCLAUSE 1602(c).

Payment shall distinguish between plain and reinforced concrete. For the purpose of this Item, reinforced concrete shall be defined as concrete containing at least 0.2 % of steel reinforcement measured by volume. Plain concrete shall, for the purpose of this Item, be deemed to include stone masonry and brickwork.

The bid rates shall also include full compensation for cutting straight grooves of the specified depth at joint positions where shown on the Drawings.

Item		Unit
22.13	Removing and Relaying Existing Pipes (Size and Type of Bedding Indicated)	Metre (m)

The unit of measurement shall be the metre of existing pipe removed and re-laid.

The bid rate shall include full compensation for lifting, loading, transporting, off-loading, and laying pipes according to the Specifications. No haulage will be paid.

Payment for any excavation and backfilling required for the removal and relaying of existing pipes shall be made separately under ITEMS 22.01 and 22.02.

Where existing pipes are loaded, transported and used in temporary deviations, they shall not be measured for payment under this Item, but payment therefore shall be made under SECTION 1500.

Item		Unit
22.14	Removing and Stacking Existing Prefabricated Pipes (All Sizes)	Metre (m)

The unit of measurement shall be the metre of existing prefabricated culverts removed and stacked.

The bid rate shall include full compensation for lifting, loading, transporting to stack, off-loading, and stacking the prefabricated culverts.

Payment for any excavation and backfilling required for removing, transporting and stacking the existing prefabricated culverts shall be made separately under ITEMS 22.01 and 22.02. No haulage will be paid.

Payment for all other work in demolishing existing culverts shall be as described under pay ITEM 32.01.

Item		Unit
22.15	Treating Surfaces with Epoxy Resin for Joining New to Old Concrete (Type of Epoxy Resin Specified)	Litre (l)

The unit of measurement shall be the litre of epoxy- resin compound used at the specified rate of application.

The bid rate shall include full compensation for providing and applying the epoxy-resin compound.

Item		Unit
22.16	Protective Mastic Asphalt Coating For Corrugated Metal Culvert Units (State Whether To Be Applied By Brush Or By Spray Gun)	Square Metre (m ²)

The unit of measurement shall be the square metre of protective coating applied as specified and as directed by the Engineer. When both inside and outside surfaces are treated, both surfaces shall be measured.

The bid rate shall include full compensation for procuring and furnishing the mastic asphalt, applying the material, and for all other additional work and incidentals required for providing the protective coating as specified.

Item		Unit
22.17	Manholes, Catchpits, Precast inlet and outlet structures complete	
(a)	Manholes (Type Indicated)	Number (No.)
(b)	Catchpits (Type Indicated)	Number (No.)
(c)	Precaste Inlet and Outlet Structures (Type Indicated)	Number (No.)
(d)	Extra Over or Less Than SUBITEM 22.17 (a) For Variations in the Depths of Man Holes From the Standard Depth Designated For Bidding Purposes (Standard Depth and Type of Catchpit Indicated)	Metre (m)
(e)	Extra Over or Less Than SUBITEM 22.17 (b) For Variations in the Depths of Catchpits From the Standard Depth Designated For Bidding Purposes (Standard Depth and Type of Catchpit Indicated)	Metre (m)

The unit of measurement, in the case of SUBITEMS 22.17 (a), (b) and (c) above, shall be the complete unit as shown on the Drawings, including all concrete, brickwork, covers, frames, grids and other accessories.

The bid rates shall include full compensation for procuring, furnishing and installing, and laying where applicable, the complete units except for excavation and backfilling, which shall be measured separately. The bid rate shall also include full compensation for connecting up to and building any conduits into the walls of the various structures.

The unit of measurement in the case of SUBITEMS 22.17 (d) and (e) above shall be the metre of increased or decreased depth of the manhole or catchpit measured in relation to the standard depth furnished for bidding purposes.

The bid rates per metre shall be an adjustment to the compensation for the standard Item, payable either as increased compensation to the Contractor in the case of an increased depth, or as a decrease in compensation in the case of a decreased depth in relation to the standard depth.

Where the above Items of work cannot be conveniently standardised for payment according to complete units, the various types of work and Items of material provided shall be measured separately in accordance with ITEMS 22.18 to 22.21 and such other Items as may be necessary.

Concrete and formwork shall be measured and paid for under SUBITEMS 22.07 (c) and (d) respectively, excavation under ITEMS 22.01 and backfilling under ITEM 22.02.

Item		Unit
22.18	Brickwork	
(a)	115 mm Thick	Square Metre (m ²)
(b)	230 mm Thick	Square Metre (m ²)
(c)	345 mm Thick	Square Metre (m ²)

The unit of measurement shall be the square metre of brickwork built, calculated from the leading dimensions of the brickwork. Areas in walls occupied by conduits, shall not be included in the areas measured, and corners and intersections common to more than one brick wall shall be measured only once.

The bid rates per square metre shall include full compensation for the brickwork complete as specified, including pointing and the building in of conduits.

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Item	Unit
22.19 Plaster	Square Metre (m ²)

The unit of measurement shall be the square metre of plaster work provided.

The bid rate shall include full compensation for raking out joints in the brick work and applying a 1:4 plaster, as specified, to all surfaces where required.

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Item	Unit
22.20 Benching	Square Metre (m ²)

The unit of measurement shall be the square metre of benching, measured in plan, constructed in Class C16/20 concrete with granolithic rendering.

The bid rate shall include full compensation for procuring and furnishing all materials, placing the concrete benching and rendering with the specified granolithic rendering.

Item	Unit
22.21 Accessories	
(a) Manhole Covers Including Frames (Description)	Number (No.)
(b) Inlet Grid Including Frames (Description)	Number (No.)
(c) Step Irons (Description)	Number (No.)
(d) Other Accessories	Number (No.)

The unit of measurement shall be the number of each type of accessory delivered and installed.

The bid rates shall include full compensation for procuring, furnishing and installing the accessories.

Item	Unit
22.22 Anchors for Pipes (Description)	Number (No.)

The unit of measurement shall be the number of complete anchors installed, including straps, bolts, etc, but excluding any concrete work, which shall be measured under SUBITEMS 22.07(c) and (d).

The bid rate shall include full compensation for procuring, providing and installing the anchors.

Item	Unit
22.23 Service Ducts	
(a) Ordinary Pipes (Type and Diameter Indicated)	Metre (m)
(b) Split Pipes (Type and Diameter Indicated)	Metre (m)

The unit of measurement shall be a metre of service duct laid.

The bid rates shall include full compensation for procuring, providing, and laying the pipes, including end stoppers, draw wires and complete installation, but shall exclude excavation, backfilling, and encasing with concrete, which shall be measured for payment under the appropriate Items of payment of this section.

Item	Unit
22.24 Duct Marker Blocks (Type Indicated)	Number (No.)

The unit of measurement shall be the number of marker blocks installed, and the bid rate shall include full compensation for manufacturing, delivering and installing the marker blocks, complete as shown on the Drawings.

Item	Unit
22.25 Hand Excavated to Determine the Positions of Existing Services	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated within the lengths and widths authorised by the Engineer and the depth required to expose the service. Excavation in excess of the authorised dimensions shall not be measured for payment.

The bid rate shall include full compensation for all excavation, backfilling, compacting to 93 % MDD of AASHTO T180 density, disposing of any surplus excavated material, keeping the excavations safe, dealing with any surface or subsurface water, taking special care to ensure that services are not damaged in any way and any other operation necessary for completing the work. The bid rate shall also include all haulage of material. Any damage to a service caused by the Contractor shall be repaired at their own cost, to the satisfaction of the Owner of the service and the Engineer.

No distinction will be made between rock and soft material, neither will distinction be made between the various types of services to be exposed or the depths to which excavations are taken.

Item	Unit
22.26 Reinstating Trenches Crossing Roads	
(a) Improved Subgrade Layers	Square Metre (m ²)
(b) Subbase Layers	Square Metre (m ²)
(c) Base Course Layers	Square Metre (m ²)
(d) Bituminous Surfacing (Including Tack Coat)	Square Metre (m ²)
(e) Kerbing	Metre (m)

The unit of measurement for SUBITEMS 22.26(a) to (d) shall be the square metre of the layer reinstated where instructed by the Engineer.

The unit of measurement for SUBITEM 22.26(e) shall be the metre of kerbing replaced due to trench excavations where instructed by the Engineer.

Any reinstatement required beyond the agreed or instructed dimensions owing to damage caused by the Contractor will not be measured for payment.

The appropriate sections of the Specifications shall also be applicable to the reinstatement of the trenches.

The bid rates shall include full compensation for procuring, furnishing, placing, compacting and finishing all materials, providing all labour and construction plant, cutting and preparing the edges of the existing surfacing, and protecting and maintaining the completed reinstatement as specified.

Item	Unit
22.27 Prefabricated Reinforced Concrete Skew End Units For Concrete Culverts Constructed At A Skew Angle (Type And Dimensions Of Unit And Class Of Bedding Indicated)	Number (No.)

The unit of measurement shall be the number of each type and size of prefabricated reinforced-concrete skew end unit provided and installed, irrespective of the angle of skew.

The bid rates shall include full compensation for providing, testing, loading and unloading the units, constructing the prescribed class of bedding, and for installing, laying and joining the units, complete as specified and in accordance with the details shown on the Drawings.

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Drainage | 2200 | Prefabricated Culverts

SECTION 2300 Concrete Kerbing, Concrete Channelling, Open Concrete Chutes And Concrete Linings For Open Drains

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2301 Scope

This SECTION covers the construction of concrete kerbing and channelling, open concrete chutes and concrete linings for open drains at the locations and to the details as shown on the Drawings or as directed by the Engineer.

2302 Materials

a. Concrete

All concrete work shall be carried out in accordance with the requirements of SECTIONS 7200, 7300 and 7400.

b. Kerbing and Channelling

Prefabricated kerbing and channelling shall comply with the requirements of BS EN 1339 and BS EN 1340 or equivalent. Cast in situ kerbing and channelling shall be of the Class C20/25 or of the class indicated on the drawings.

c. Joint Sealant

- i. Cold-applied joint sealant shall be conforming to the requirements of BS EN 14188.
- ii. Hot applied joint sealants shall comply with the requirements of BS EN 14188-1 or equivalent.
- iii. Silicone-based joint sealants shall comply with the requirements of the Special Specifications.

d. Bedding Material

The material on which concrete kerbs and channels are to be bedded shall consist of crushed rock, natural gravel, sand or other approved well graded porous material with a maximum particle size of 14 mm.

Concrete may also be prescribed as bedding material, in which case it shall comply with the requirements of SECTION 7400.

2303 Types Of Structures

Kerbing shall include barrier kerbs, mountable and semi-mountable types. All these elements may be prefabricated units or constructed in a continuous operation using slipforms.

Channelling may be cast in situ, prefabricated units or of slip-form construction.

Chutes may be either prefabricated units or cast in situ, and the concrete lining of open channels shall be cast in situ only, except that side slabs may be precast.

Downpipes shall be prefabricated units.

2304 Construction

a. Excavation, and Preparation of Bedding

i. Kerbs and channels

Trenches for kerbs and channels shall be excavated to the required depth and all unsuitable material shall be removed and replaced with a layer of approved bedding material at least 75 mm thick. The bedding shall be compacted and accurately shaped to the required grade. No concrete or precast concrete unit shall be placed on uncompacted or disturbed material. All compaction to a density of not less than 93 % MDD of AASHTO T180 density.

ii. Concrete linings

The excavation work for open drains shall be executed and paid for in accordance with the provisions of SECTION 2100.

The excavations shall then be neatly trimmed to the lines and levels specified so as to permit the accurate construction of the concrete linings. All loose material shall be compacted to a density of not less than 93 % MDD of AASHTO T180 density.

Where the in-situ material is unsuitable, the Engineer may order that it be removed to the required depth and replaced with selected material compacted to a density of 93 % MDD of AASHTO T180 density.

Where excavations for open drains are in rock, over break shall be backfilled as ordered, either with mass concrete or with selected natural gravel or soil compacted to 93 % MDD of AASHTO T180 density.

iii. Chutes

Excavations for chutes shall be neatly trimmed. All loose material shall be thoroughly compacted, and where overbreak occurs in rock material, the excavations shall be backfilled with mass concrete. If required by the Engineer, the excavations shall be taken deeper to accommodate a concrete screed cast to act as a working platform for the construction of the chutes.

b. Prefabricated Concrete Kerbing and Channelling

Prefabricated concrete kerbing and channelling shall be laid on the approved bedding with close joints filled with 1:3 cement: sand mortar not exceeding 10 mm in thickness and neatly pointed with a pointing trowel. The exposed faces of kerbs and edging shall be constructed true to line and elevation. Kerbing around curves shall first be laid along the full curve length before the joints are filled, unless otherwise allowed by the Engineer.

Kerbs shall be temporarily propped during construction.

Unless otherwise instructed by the Engineer, prefabricated concrete kerb units shall be 1.0 m in length, except at curves at road junctions, where they shall be 0.3 m in length.

Prefabricated concrete kerbs shall be laid with a Class C20/25 cast in situ concrete support behind the kerbs in accordance with the details shown on the Drawings.

c. Prefabricated Concrete Chutes on Side Slopes of Fills and Cuts

Prefabricated concrete chutes shall be manufactured in accordance with the dimensions shown on the Drawings, and the units shall fit neatly into each other as shown. The bottom unit shall rest against the outlet structure or footing as shown on the Drawings. The units shall be laid true to line and grade from the bottom up so that each unit fits neatly into the previous one.

A transition section shall be constructed at the inlet to lead the water into the chute as shown on the Drawings.

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Drainage

| 2300 | Concrete Kerbing, Concrete Channelling, Open Concrete Chutes And Concrete Linings For Open Drains

d. Slip – Form Kerbing

Slip-form kerbs and channels shall be placed on approved bedding by a continuous process with an approved machine. Contraction joints shall be sawn at intervals shown on the Drawings or prescribed by the Engineer in a manner so as not to cause the concrete to spall at the joint. The concrete shall be cured in accordance with the requirements of **CLAUSE 7409**.

The kerbs and channels shall be constructed true to line and elevation and shall have a neat appearance. Where transverse cracks occur, the Contractor shall replace the entire section between the contraction joints at their own cost.

e. Cast In Situ Kerbs and Channels

Forms for kerbs and channels shall be accurately set to line and elevation and shall be firmly held in position during the placing of the concrete. Stops and jointing material at the ends of sections shall be accurately placed so as to ensure that joints between adjacent sections are truly perpendicular to the surface of the concrete and at right angles to the edge of the road.

After concrete has been placed in the forms it shall be tamped and worked until mortar entirely covers any exposed faces. Exposed faces shall then be finished to smooth and even surfaces and edges shall be rounded to the radii shown on the Drawings.

Forms shall be removed from any concrete surface that will be exposed within a period of 24 hours of the concrete having been placed. Minor defects shall be repaired with a 1:2 cement: sand mortar. Plastering shall not be permitted on exposed faces and all rejected portions shall be removed and replaced at the Contractor's expense. When completed the sections shall be cured in accordance with the requirements specified in **CLAUSE 7409**.

The completed kerbs and channels shall be true to line and elevation and shall have an even and neat appearance.

f. Cast In Situ Chutes On Cut Slopes

Cast in situ concrete chutes on cut slopes, together with the inlet and outlet structures, shall be constructed in accordance with the Drawings. The class of concrete shall be C20/25 or as indicated on the Drawings. The concrete class shall comply with **TABLE 7404/1**.

Where required by the Engineer, a concrete screed shall first be cast on excavations that cannot be trimmed accurately. The screed shall be accurately finished to the level of the underside of the chute floor slab and allowed to set before the floor slab is cast. Where the material being excavated cannot be accurately trimmed or where the chute sides have to extend above the surface of cut slopes the outer faces of the sides shall be cast against formwork.

g. Concrete-lined Open Drains

The exposed surfaces of the concrete linings of open drains shall be given a Class U2 surface finish as defined in **CLAUSE 7209**. Concrete shall be cured in accordance with the requirements of **CLAUSE 7409**.

Sealed joints in concrete shall be in accordance with the details indicated on the Drawings and the provisions of **SECTION 7600**. Cold joints shall be painted with a coat of approved bituminous emulsion containing 60 % of pure bitumen by mass, or with an approved anti-adhesive before any adjoining slabs are cast.

Expansion joints shall be made in accordance with the Drawings.

Where required, the surfaces on which concrete lining is to be cast shall, after having been trimmed, be covered with polyethylene sheeting 0.15 mm thick and all joints in the sheeting shall be overlapped by at least 150 mm.

h. Backfilling

After completing the concrete work, the spaces at the backs of kerbs shall be backfilled with approved material to pavement or road shoulder level. Spaces adjoining chutes shall be backfilled level with the side slope. Such backfill shall be placed in layers not exceeding 150 mm, or less as required, and each layer shall be compacted to 93 % MDD of AASHTO T180 density at or around optimum moisture content before the succeeding layer is placed thereon.

Where kerbs and channels are laid after construction of the base the spaces between the concrete and adjoining base shall be backfilled with premixed bituminous material.

i. Construction Sequence

- i. Where kerbs and channelling are constructed before the base course:

In this case, slip-form units or cast in situ units may be constructed. During working and constructing the base precautionary measures shall be taken to prevent the concrete work from being damaged or shifted.

- ii. Where kerbs and channelling are constructed after the base course:

The base shall be constructed wider than the specified width, after which a neat trench shall be dug for the kerbing or channelling. Any over-excavation shall be filled with concrete cast simultaneously with the kerbs and channelling.

- iii. Where kerbs and channelling are constructed after the asphalt surfacing

The asphalt surfacing shall be constructed wider than the specified width and shall be cut back accurately with a mechanical saw to a marked line to give a neat joint line between the kerbs or channelling and the asphalt layer. The base shall then be removed to the required depth.

Any concrete spilt onto the asphalt surface shall be removed. Where so required by the Engineer, the Contractor shall, without any additional compensation, paint emulsion over the stained surface.

j. Protection

During transporting and laying care shall be taken to protect all precast units against chipping or breakage.

Concrete kerbing and channelling as well as any other structures adjacent to the road shall be protected against staining by bitumen being sprayed or premix being placed. Where bitumen is to be sprayed, all such work shall be completely covered with polyethylene sheeting at least 0.25 mm thick, specially reinforced paper or other approved material, properly secured to prevent the sheeting from lifting during windy conditions. Any work stained by bitumen shall be broken down and replaced, unless all such bitumen is completely removed so as not to show any stains. Painting over stained concrete is not permitted.

k. Cutting existing bituminous surfacing and pavement layers

Where the Engineer instructs kerbing, channelling or concrete lined drains to be constructed against existing bituminous surfacing the full depth of the bituminous surfacing, and the base and sub-base if necessary, shall be accurately cut with a mechanical saw to the required line before the kerbing, channelling or concrete lined drain is constructed. The edge shall be vertical for kerbing and channelling. The concrete shall then be placed directly against the cut edge without formwork. All material outside the cut edge shall be removed to the required depth before the concrete is placed. The debris shall be disposed of at a dumping site to be provided by the Contractor subject to the approval of the Engineer. The bituminous surfacing shall be protected and kept clean to the Engineer's satisfaction.

2305 Inlet And Outlet Structures And Transition SECTIONS

Transition sections on kerbing, kerbing-channelling combinations and concrete lined open drains shall be constructed to the same standards and by the same methods as described for the uniform sections but with the required modifications. Sections may be either precast or cast in situ units.

Inlet and outlet structures may be either precast or partially precast concrete units or of cast in situ concrete.

Where shown on the Drawings or instructed by the Engineer the Contractor shall supply and install in the outlet structures energy dissipaters consisting of prefabricated reinforced concrete blocks of Class C20/25 concrete of the dimensions shown on the Drawings or listed in the Bill of Quantities. All concrete work shall comply with the requirements of **SERIES 7000**.

Components such as grids, covers and frames shall be in accordance with the details shown on the Drawings and the requirements of **SUBCLAUSE 2212(e)**.

2306 Construction Tolerances And Surface Finish

a. Concrete kerbing and channelling

Concrete kerbing and channelling shall be constructed to the following dimensional and alignment tolerances:

i. Horizontal alignment

The maximum deviation of edges, centre line, or vertical surfaces from the specified position shall be 25 mm.

The maximum deviation of edges, centre line or vertical surfaces from the specified alignment, shall be 1:500 when taken over any section exceeding 10 m in length.

ii. Vertical alignment and level

The inside edge tolerance of channelling shall be + 0/-10 mm in relation to the finished road surface. The invert level of channels and open drains and the top of kerbing shall nowhere deviate by more than 10 mm from the required level and nowhere shall channels or drains have adverse grade.

iii. Trueness of exposed surfaces

When tested with a 3 m straight – edge, no surface irregularities shall exceed +/- 6 mm.

iv. Cross-sectional dimensions

All cross-sectional dimensions shall be within 6 mm of the specified dimensions except that the underside of channelling may extend up to 25 mm below the level at which it would have the required thickness.

b. Concrete Lined Opens Drains And Concrete Chutes

Concrete lined open drains and concrete chutes shall be constructed to within the following tolerances:

i. Horizontal alignment

The maximum deviation from the true position of the edges or centre line shall be 25 mm.

ii. Vertical alignment

The invert level of concrete lined open channels shall nowhere deviate by more than +10/-25 mm from the required level and nowhere shall the open drain inverts have an adverse grade.

iii. Trueness of exposed surface

When tested with a 3 m straight edge, no exposed surface shall show surface irregularities exceeding +/-10 mm.

iv. Cross-SECTIONal dimensions

When considering any complete slab or slab sections with a surface area of 10 m² or more, and disregarding a thickness exceeding 10 mm of the specified thickness, all cross-sectional dimensions shall be within 10 mm of the specified dimensions and the average thickness of a floor or side slab shall not be less than the specified thickness.

c. Surface Finish

All unformed exposed concrete surfaces shall have a Class U2 surface finish and all formed exposed concrete surfaces shall have a Class F2 surface finish as defined in **CLAUSE 7209**.

2307 Measurement And Payment

Item	Unit
23.01 Concrete Kerbing (Class of Concrete Indicated for Cast In Situ Concrete)	
(a) Description of Type with Reference of Drawing	Metres (m)
(b) For Other Types	Metres (m)

Item	Unit
23.02 Concrete Kerbing - Channelling Combination (Class of Concrete Indicated for Cast In Situ Concrete)	
(a) Description of Type with Reference of Drawing	Metres (m)
(b) For Other Types	Metres (m)

The unit of measurement shall be the metre of concrete kerbing, or a combination kerbing and channelling, complete as constructed, measured along the front face of the kerb.

The bid for each metre of concrete kerbing and/or kerbing channelling combination shall include full compensation for the necessary excavation and preparation of bedding, backfilling, formwork, finishing and for procuring, furnishing and installing all materials, kerbing and channelling and protecting it against staining, supporting the kerbs with in situ cast concrete and filling and painting all joints, all complete as specified.

Item	Unit
23.03 Concrete Chutes (Typical Designs)	
(a) Descriptions of Type with Reference to Drawing. State Whether Prefabricated or Cast in Situ and Class of Concrete	Metres (m)
(b) For Other Types	Metres (m)

The unit of measurement shall be the metre of completed chute as constructed, including any overlap measured along the slope as laid but excluding transition sections and inlet and outlet structures measured separately.

The bid rate per metre shall include full compensation for procuring, furnishing and installing the completed chutes as specified and all excavation and the preparation of bedding, backfilling, formwork and finishing required.

Item	Unit
23.04 Cast In Situ Concrete Chutes (Measured by Components)	
(a) Concrete (Class Indicated)	Cubic Metre (m ³)
(b) Formwork (Surface Finish Indicated)	Square Metre (m ²)

Measurement and payment for formwork and concrete shall be as specified in SECTIONS 7200 and 7400 except that payment for excavation and gravel or soil backfilling shall be deemed to be included in the rates bid for concrete and shall not be measured and paid for separately.

Item	Unit
23.05 Inlet, Outlet, Transition and Similar Structures (Typical Designs)	
(a) Description Of Structure, Type, Etc., With Reference To Drawing And Class Of Concrete	Cubic Metre (m ³)
(b) For Other Types	Number (No.)

The unit of measurement and payment shall be the number of completed units of each type of structure constructed and payment shall include full compensation for all formwork, concrete, excavation, trimming and backfilling, including such accessories as grids, etc. as may be specified on the Drawings.

Item	Unit
23.06 Inlet, Outlet, Transition and Similar Structures (Measured by Components)	
(a) Concrete (Class Indicated)	Cubic Metre (m ³)
(b) Formwork (Surface Finish Indicated)	Square Metre (m ²)
(c) Other Components	Number (No.)

The measurement and payment for formwork and concrete shall be as specified in SECTIONS 7200 and 7400, except that excavation, trimming and backfilling shall not be measured and paid for separately, the cost of which shall be deemed to be included in the rates bid for concrete.

The unit of measurement for other components such as grids shall be number of each type of component installed. The bid rates shall include full compensation for procuring, furnishing and installing the components, including any painting or protective coating required in the Special Specifications or as shown on the Drawings.

Item	Unit
23.07 Trimming of Excavations for Concrete - Lined Open Drains	
(a) In Soft Material as Defined in CLAUSE 3503	Square Metre (m ²)
(b) In Rock as Defined in CLAUSE 3503	Square Metre (m ²)

The unit of measurement shall be the square metre of excavation trimmed to receive concrete lining.

The bid rates shall include full compensation for all labour, constructional plant, material and other additional work and incidentals necessary for trimming the excavations for open drains to the standard of finish required for the construction of concrete linings. All excavation, including the removal of unsuitable ground and backfilling with suitable material shall be measured and paid for

under SECTION 2100. Payment shall distinguish between trimming in soft material and trimming in hard material as defined in CLAUSE 35603. No extra payment shall be made in respect of any soil or gravel backfilling, additional concrete or mass concrete backfilling required due to over-break or unavoidable unevenness of the excavations in difficult ground, the cost of which shall be deemed to be included in the bid rates for trimming in rock material.

Item	Unit
23.08 Concrete Lining for Open Drains	
(a) Cast in Situ Concrete lining (Class of Concrete and Type of Open Drain Indicated)	Cubic Metre (m ³)
(b) Class U2 Surface Finish to Cast In Situ Concrete (Type of Open Drain Indicated)	Square Metre (m ²)

Measurement of and payment for concrete shall be as specified in SECTION 7400, but the bid rate shall include full compensation for painting open joint surface as specified.

The unit of measurement for surface shall be the square metre of finished surface.

The bid rate for surface finish shall include full compensation for all labour, constructional plant, formwork, material and other additional work and incidentals required for trimming the concrete lining specified.

Item	Unit
23.09 Formwork to Cast In Situ Concrete Lining for Open Drains (Class F2 Surface Finish)	
(a) To Sides with Formwork On The Internal Face Only	Square Metre (m ²)
(b) To Sides With Formwork on Both Internal and External Faces (Each Face Measured)	Square Metre (m ²)
(c) To End of Slabs	Square Metre (m ²)

Measurement of and payment for formwork shall be as specified in SECTION 7200. Formwork under SUBITEM 23.09(a) shall be measured and paid for only when the side slope of the slabs exceeds 1:2 and the slabs cannot be constructed without formwork even when a stiff concrete mix is used. When the Contractor elects to use precast side slabs payment will be made for formwork as if cast in situ concrete had been used.

Item	Unit
23.10 Formwork to Cast In Situ Concrete Lining for Open Drains (Class F2 Surface Finish)	
(a) Sealed Joints In Concrete Linings Of Open Drains (Description Of Type With References To Drawing)	Metre (m)

The unit of measurement shall be the metre of completed joint of each size and type.

The bid rate shall include full compensation for the supply of all materials and for all labour, formwork and incidentals necessary for sealing the joint as shown on the Drawings or set out in the Special Specifications.

Item	Unit
23.11 Concrete Screed or Backfill Below Chutes (Class of Concrete Indicated)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of concrete screed or backfill as may be instructed by the Engineer to be placed below chutes.

The bid rate shall include full compensation for furnishing, procuring and placing the concrete in screed or backfill.

Item	Unit
23.12 Steel Reinforcement	
(a) Mild Steel Bars	Tonne (t)
(b) High Tensile Steel Bars	Tonne (t)
(c) Welded Steel Fabric	Tonne (t)

Measurement and payment shall be in accordance with the provisions of SECTION 7300.

Item	Unit
23.13 Polyethylene Sheeting (0.15 mm Thick) For Concrete-Lined Open Drains	Square Metre (m ²)

The unit of measurement shall be the square metre of area covered with polyethylene sheeting.

The bid rate shall include full compensation for procuring, furnishing and installing the polyethylene sheeting, including wastage and overlap.

Item	Unit
23.14 Cutting Bituminous Pavement Layers for Concrete Kerbing, Channelling or Concrete-Lined Drains	Metre (m)

The unit of measurement shall be the metre of bituminous surfacing and pavement layers cut where instructed by the Engineer, irrespective of the depth cut. The various layers shall not be measured separately for payment.

The bid rate shall include full compensation for all labour, constructional plant and materials required for cutting the surfacing and pavement layers to the required depth, removing and disposing of the debris and protecting and keeping the surfacing clean, all as specified.

Item	Unit
23.15 Precast Concrete Blocks in Outlet Structures (Size to be Specified)	Number (No.)

The unit of measurement shall be the number of precast concrete blocks provided and installed as shown on the Drawings or directed by the Engineer.

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Drainage | 2300 | Concrete Kerbing, Concrete Channelling, Open Concrete Chutes And Concrete Linings For Open Drains

Item		Unit
23.16	Side Drain Pedestrian Crossing	Number (No.)

The unit of measurement shall be the number of pedestrian crossings constructed in accordance with the Drawings.

The bid rate shall include full compensation for furnishing all materials and labour including excavation, trimming, backfilling, and removing any surplus excavated material.

SECTION 2400 In Situ Concrete Culverts

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2401 Scope

This section covers the construction of in-situ concrete culverts using pneumatic tubular forms.

2402 Materials

a. Concrete

All concrete work shall be carried out in accordance with the requirements of SECTIONS 7200, 7300 and 7400 of these Standard Specifications.

b. Falsework and Formwork

Except where otherwise provided for in this section the provisions of SECTION 7200 shall apply.

c. Pneumatic Forms

Forms shall be manufactured of synthetic fabric coated on both sides with elastomeric compounds. The materials used shall not be adversely affected by heat, chemical substances and biological elements which may be present at the work site. The tubular form shall be factory produced and be fitted with an automatic safety valve and pressure gauge. Adequate provision for inflating to the required pressure and subsequent deflating shall be provided.

2403 Construction Methods

The relevant requirements of SECTION 2200 shall apply and the Contractor's detailed method statement shall be submitted to the Engineer for approval at least 14 days prior to commencement of any activities related to culvert construction.

- i. Following the Engineer's approval of the excavation works and bedding materials the Contractor shall place a concrete saddle (inverted arch) for the full length of the culvert to provide support to the pneumatic form over 120 degrees or 1/3 of the culvert internal circumference. The surface finish of the invert arch shall be true to the line and level of the finished culvert and have a Class U2 surface. Alternatively the support to the form shall be provided by spacer blocks placed at 1.0 m intervals or other spacing as may be required for the particular pneumatic form to be used. These spacer blocks shall be levelled in to the required line and level and secured in position in such a manner that the form may be placed and inflated without disturbance to the supports.
- ii. Formwork and spacer blocks shall be positioned to ensure that the minimum thickness of concrete surround shall be 150 mm or 1/4th of diameter of culvert whichever is more unless otherwise shown on the drawings. The concrete shall be a minimum strength class of C20/25.
- iii. Tie wires shall be cast into the invert arch or alternative methods of fixing tie wires shall be provided. These wires shall be spaced to provide adequate anchorage of the inflated form during the first phase of concreting and to resist buoyancy effects.
- iv. The deflated form shall be placed along the supports provided and inflated using a compressed air or manual pump source to the required pressure for the particular size of culvert, height of concrete, and in accordance with the manufacturer's specifications.
- v. The concrete to be placed shall be designed to suit the method of placement, pipe wall width and density and strength requirements. It shall achieve adequate strength to allow deflation of the

form 12 to 24 (max.) hours after placement to ensure that the form may be deflated and recovered without damage by adherence to the cast concrete. The concrete shall be a pumpable or free flowing C20/25 grade concrete unless otherwise specified on the drawings or in the special specifications where particular details will be provided. Appropriate additives should be used to achieve the required properties.

- vi. The tie wires shall be secured ensuring that wooden spacers separate the form from the wires.
- vii. Side shutters shall be of steel or wooden construction. Beams to counteract buoyancy may be provided at 1.0 m spacing to engage with a longitudinal spreader beam positioned along the top of the form as an alternative to the use of tie wires secured to the invert saddle.
- viii. Concrete shall be placed equally to each side of the form to a level sufficient to provide constraint to any movement of the form prior to the removal of the tie wires and wooden spacers. Concreting shall then continue to complete the in-situ cast of the culvert to the required height.
- ix. Vibration of concrete shall be undertaken only to ensure sufficient compaction and distribution of the concrete within the form and removal of entrapped air. Excessive vibration may damage the form or lead to unsatisfactory final shape and must therefore be kept to a minimum and closely monitored.

2404 Trial Construction

The Contractor shall undertake the construction of a culvert of a specified diameter at a location indicated by the Engineer. This culvert shall be constructed as though it were to be incorporated in the Works and all procedures shall be in accordance with the Contractor's method statement. The work will be observed by the Engineer and subject to his approval before any other culverts are permitted to be constructed using pneumatic forms. The Contractor shall demonstrate their competence in producing works in accordance with the requirements of the Specifications and to the satisfaction of the Engineer. No additional payment shall be made for this trial construction unless it is agreed with the Engineer that the trial culvert may be subsequently incorporated in the Works.

2405 Handling and Storing the Pneumatic Forms

The pneumatic form should be placed and removed after casting by hand. The use of mechanical pulling devices can cause damage which may lead to rejection of the form for subsequent use.

The form must always be washed with water after use. Any build-up of concrete or adhering hardened laitance may be reason for rejection of the form.

Forms should be kept out of direct exposure to sunlight for prolonged periods.

2406 Pressure Monitoring

The internal air pressure of the pneumatic form shall be monitored by use of an automatic safety valve and pressure valve calibrated to ensure that the correct inflation pressure is maintained at all times. A valid calibration certificate for the valves shall be supplied by the Contractor or a Calibration Declaration obtained from the manufacturer which shall be valid for the period of the contract works.

The automatic safety valve should be designed to allow bleed off or automatic opening to maintain the required pressure in the form to counteract atmospheric pressure or temperature variations after placement of concrete or to compensate for any small leakages that may occur.

2407 Measurement And Payment

Measurement and payment will be as detailed under [CLAUSE 2218](#) other than as amended below.

The bid rates shall include full compensation for providing all formwork including establishment on site and moving the forms from one location to another.

SECTION 2500 Pitching, Stonework and Protection Against Erosion

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Drainage | 2500 | Pitching, Stonework and Protection Against Erosion

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2501 Scope

This section covers the furnishing of materials and the construction of a protective covering in stone pitching, cast in situ concrete pitching, masonry or prefabricated concrete blocks on exposed surfaces such as earth slopes, drains and stream banks and beds, as well as heavier protective layers in the form of riprap and the construction of stone masonry for walls, all as shown on the Drawings or ordered by the Engineer.

2502 Materials

a. Stone

i. Pitching

Stone for pitching shall be sound, tough and durable, of size less than 200 mm in minimum dimension. The shapes of the materials used shall be such as to form a stable protective layer of the required thickness. Rounded boulders or cobbles shall not be used on slopes steeper than 2:1 unless grouted.

All material intended for use on a particular pitching job shall be subjected to the prior approval of the Engineer.

ii. Riprap

Riprap shall be unweathered rock originating from a rock mass type not susceptible to disintegration or excessive weathering on exposure to the atmosphere or water. It shall be free from inclusions of soft material such as sand, clay or organic material and particle shape shall generally be angular to sub-angular. Individual cobbles or boulders shall be of dimensions approved by the Engineer.

The required size of the riprap will depend on the "critical mass" specified. At least 50 % by mass of the material comprising the riprap shall consist of boulders with a mass heavier than the critical mass, and not more than 10 % by mass of the material shall consist of boulders with a mass of less than 10 % of the critical mass or more than 5 times the critical mass.

b. Cement

Cement shall be common cements which comply with the requirements of KS EAS 18-1 or equivalent standard on approval of the Engineer.

c. Sand

i. Sand for concrete

Sand for concrete, cement grout and cement mortar shall comply with the requirements of AASHTO M6-08 or equivalent. Tests for quality shall be performed in accordance with the standard methods given in TABLE 1711/1.

ii. Sand bedding

Sand for bedding used for paving blocks shall not contain any deleterious impurities and shall comply with the grading requirements in TABLE 2502/1.

After completion and approval by the Engineer the laying course shall be spread in a loose uncompacted layer to approximately the final depth below surface profile. The compacted laying course thickness shall be 40 mm for heavy vehicle parking and 30 mm for footpaths.

The moisture content of the laying course shall be between 80 – 105 % of OMC for that material.

iii. Sand for joints

Sand used for brushing into the joints between pavement blocks shall all pass through a 1.18 mm sieve, and between 10 and 15 % of it shall pass through a 0.075 mm sieve.

d. Paving Blocks

Paving blocks shall comply with the requirements of KS 830 or equivalent for Class C20/25 paving blocks where paving blocks are made from concrete, and bricks used as paving blocks shall be facebrick units which shall comply with the requirements of BS EN 772-3, BS EN 772-7. Engineering units may also be used instead of facebrick units.

The surface texture and colour of all units shall be uniform.

Paving blocks for footpaths shall be square precast concrete blocks, 450 mm x 450 mm x 50 mm in size or of other dimensions shown on the drawings and manufactured from Class C25/30 concrete. The appearance of the blocks shall comply with the requirements of BS EN 1338 or equivalent. The upper surface shall have an approved finish to provide adequate frictional resistance.

Concrete grass blocks shall consist of concrete slabs of the dimensions shown on the Drawings, with openings through the slab totalling at least 20 % of the surface area.

Plastic paving blocks shall comply with the requirements of CLAUSE 6203(d).

e. Concrete

Concrete work shall be carried out in accordance with provision of SECTION 7200, 7300 and 7400.

f. Wire

Tie wire for securing pitching in position shall consist of 4 mm diameter galvanised wire, which complies with the requirements of BS EN 10244 or equivalent.

g. Permeable Material For Filter Layers

Permeable material for filter layers shall comply with the requirements specified for permeable material for subsoil drains in CLAUSE 2104.

h. Geotextile Fabric

Synthetic- fibre filter fabric shall be of the grade and type specified in the Bill of Quantities or Special Specifications and shall comply with the requirements of SECTION 2700.

2503 Stone Pitching**a. Plain Stone Pitching**

The area to be pitched shall be excavated, shaped and trimmed as necessary and thoroughly compacted by mechanical compactor or hand ramming to prevent subsequent settlement. A trench shall be excavated as directed by the Engineer along the toe of any slopes to be pitched or along the unprotected edge of the pitching in the beds of streams. Two pitching methods follow, and the method to be adopted shall be decided on by the Engineer.

i. Method 1

Commencing at the bottom of the trench the “stones” shall be laid and firmly bedded into the slope and against adjoining pitching and laid with their longitudinal axes at right angles to the slope and with staggered joints. All pitching material shall be well rammed into the bank or surface to be protected and the spaces between the cobbles shall be filled with gravel or spalls of approved material securely rammed into place.

Placing of material by dumping shall not be allowed.

ii. Method 2

The technique and requirements laid down in Method 1 shall also apply to Method 2, except in the following aspects:

1. No small cobbles, gravel or spalls shall be used to fill in spaces between larger material.
2. Simultaneously with the placing of the pitching, topsoil shall be introduced between individual cobbles, and sufficiently rammed so as to provide a firm bonded structure. The topsoil shall be provided to the full depth of the pitching at any point.
3. Rooted grass or tufts of grass shall then be planted in the soil between stones and watered immediately and copiously and thereafter at regular intervals until the grass has been established.

Whichever of the above two methods is adopted, the finished surface of the pitching shall present an even, tight and neat appearance with a surface tolerance of ± 25 mm from that specified or shown on the drawings. The thickness of the pitching, measured at right angles to the surface, shall not be less than 200 mm.

b. Grouted Stone Pitching

The work shall be done in accordance with all the requirements specified for plain pitching in SUBCLAUSE 2503(a) above, except that the pitching material shall be thoroughly cleaned of adhering dirt or clay, moistened and embedded in freshly laid cement mortar composed of one part of cement to six parts of sand. Any spaces between the cobbles used shall be filled with cement grout of the same composition as the mortar. The mortar and the grout shall be placed in a continuous operation for any days run at any one location. The grout shall be worked into the pitching to ensure that all spaces or voids will be completely filled with grout to the full depth of the pitching. Grout spilt onto exposed surface of the pitching shall be removed while still soft, and the joints between stones shall be neatly finished.

The grouted pitching shall be cured with wet sacking or other approved wet cover for a period of not less than four days after grouting, and shall not be subjected to loading until adequate strength has been developed. Mortar not used within 45 minutes after mixing shall be discarded. Where required, weep holes shall be formed in the pitching.

c. Wired and Grouted Stone Pitching

The area to be pitched shall be prepared as described in SUBCLAUSES 2503(a) and 2503(b) and a concrete bed (Class 15 concrete) with a thickness of at least 75 mm shall then be placed. The pitching material shall be of cobbles with a minimum dimension of 200 mm, which shall be laid while the concrete is still fresh. The matrix of the pitching shall be filled with cement grout as described in SUBCLAUSE 2503(b), and care shall be taken not to spill the grout onto the finally exposed surface. Any such surface grout shall be removed while still soft and the exposed grout surface shall be neatly finished.

Curing shall be done as described for grouted stone pitching in SUBCLAUSE 2503(b).

The completed pitching shall have an even compacted appearance with a surface finish tolerance of ± 25 mm from the specified lines and grades.

2504 Riprap

a. General

Riprap shall consist of large boulders placed on bank slopes and toes in stream and river beds and at other localities where protection of this type may be required.

Two types of riprap are specified here, viz. one type where the boulders are individually packed, which is designated as packed riprap, and the other type where the boulders are dumped and then spread by machines, which is designated as dumped riprap.

The surface of areas to receive riprap shall be neatly trimmed to line and level and all loose material compacted. The perimeters of riprap areas shall be protected by the construction of either cobble or boulder filled trenches, walls or other structures as may be required. Perimeter trenches shall normally be backfilled with material of the same size and quality as that used in the construction of the adjoining riprap, but any voids shall be filled with cobbles or coarse gravel of similar rock type and the entire backfill shall be well compacted.

b. Filter Bed

The filter bed shall consist of a layer or layers of permeable material placed on the prepared surface to the required thickness and each layer shall be finished to an even surface and thickness. Compaction of pervious material will not be required. Care shall be taken so that various grades of filter material are not intermixed nor that material already placed is disturbed when subsequent layers or riprap are being placed.

When the use of synthetic fibre filter fabric is required, the material shall be placed on the prepared surface on the filter bed in accordance with the drawings or special specifications or as otherwise instructed by the Engineer. The overlap between adjacent sheets shall be 150 mm unless otherwise specified. Care shall be taken not to damage the filter fabric when subsequent layers are being placed, nor to expose the filter fabric to the sun for periods exceeding three days before it is covered.

c. Packed Riprap

Packed riprap shall be constructed from boulders placed individually to stagger the joints and so as to be firmly bedded in the prepared surface. The spaces between boulders shall be filled with cobbles, gravel or 'spalls' securely rammed into place. On inclined surfaces the riprap shall be laid in long horizontal strips starting from the bottom, and not in strips up the slope.

The completed riprap shall present a tight and even surface. Local surface irregularities of the riprap shall not exceed +/- 150 mm from the required surface profiles shown on the drawings or otherwise specified.

d. Dumped Riprap

Dumped riprap shall be constructed by dumping the cobbles and/or boulders on the prepared surface, spreading it by bulldozer or other suitable earth-moving equipment, and trimming it to the required lines and levels. The material shall be placed in a manner that will prevent segregation and the top layer shall be tight with a minimum of voids.

2505 Stone Masonry Walls

a. General

Stone masonry walls may be dry packed stone walls with dry joints or otherwise mortared stone walls with stones bedded in cement mortar as indicated on the Drawings, as specified or as may be ordered.

The minimum mass of each stone used shall be 10 kg and its minimum dimension 75 mm.

b. Dry Packed Stone Walls

A foundation trench shall be excavated down to rock or to material with an adequate bearing capacity at a minimum depth of 300 mm below ground level. Larger selected cobbles or small boulders shall be used for the foundation layer. Cobbles shall be angular to sub-angular and selected to fit together with a maximum degree of surface contact. Elongated material shall be laid with the largest dimension in the horizontal plane. Cobbles shall be packed individually to stagger the joints and to provide a minimum of voids and shall be firmly bedded and strongly interlocked. Voids shall be filled with gravel or "spalls" securely rammed into place. The larger cobbles shall not bear on the material used for filling the voids. The top and ends of the wall shall be neatly finished with selected coping stones.

The appearance of the completed wall shall present an even and tight surface.

c. Cement – Mortared Stone Walls

The walling shall be constructed as specified in (b) above, with the exception that the cobbles shall be wetted and set in a 6:1 sand:cement mortar. The exposed parts of the stones on the wall faces shall be cleaned of all mortar by washing or wire brushing. The mortar shall be flush pointed to the satisfaction of the Engineer, who may require a capping and end treatment of the same mortar.

Weep holes shall be provided as prescribed and shall be cleaned of mortar or any other clogging material that may have entered during construction.

The walling shall be protected from the elements and kept moist for a minimum period of four days after completion.

2506 Precast Concrete Block Paving**a. General**

The underlying layers for surfaces to be pitched shall be constructed as specified or as indicated on the Drawings. Where no specified requirements have been set in respect of the underlying layers, the top layer shall be mechanically compacted to at least 90 % MDD of AASHTO T180 density down to at least 150 mm from the top. During this process the top layer shall be trimmed to the required grades and levels.

Where specified or required by the Engineer the prepared surface shall be treated with approved environmentally compatible herbicide and termite poison before the layer of sand for bedding is placed.

b. Sand for Bedding

A layer of well graded sand or stone dust for bedding shall be placed on top of the prepared surface, and when still loose, accurately floated to an uncompacted thickness of 30 mm (± 5 mm) so as to afford the correct level to the pavement after compaction. Sand for bedding shall be placed immediately before the paving blocks are laid and shall not be compacted before the blocks have been laid.

c. Laying the Paving Blocks

The pattern for laying the paving blocks shall be that as shown on the Drawings or approved or prescribed by the Engineer. Unbroken blocks shall first be laid and filler pieces afterwards. Filler pieces shall be neatly sawn or hewn to fit exactly into the space to be filled. Spaces of less than 25 % of a full-sized block may be filled with 25 MPa concrete. The joints between blocks shall be sized between 2 and 6 mm and the top faces of blocks shall be flush. After the paving blocks have been laid, the pavement shall be compacted by two passes of a suitable vibrating-plate compactor operating at a frequency of 65 to 100 Hz and at low amplitude. Its plate surface shall be 0.2 to 0.4 m² and shall develop a centrifugal force of 7 to 16 kN.

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After compaction of the pavement as described above, joint sand shall be spread and brushed into the joints until the joints have been properly filled. Any surplus sand shall then be broomed off and pavement shall then be subjected to two further passes by the plate vibrator.

d. Edge Beams

Concrete edge beams conforming to KS 829, or any such other edge supports as approved by the Engineer, shall be constructed onto the supporting layer in accordance with the details shown on the Drawings, and shall be constructed and left to cure before any paving blocks are laid.

e. Paving Blocks for Footpaths

Paving blocks for footpaths shall be laid in the same way as that described above for paving blocks, also on a bed of sand but on the proviso that where so specified, joints shall be filled with a 6:1 sand:cement mortar instead of with sand only. In this case the width of the joints between the stones shall be strictly in accordance with the dimensions shown on the Drawings and the pavement shall be fully compacted before the joints are filled.

f. Concrete Grass Blocks

Concrete grass blocks of the size specified or shown on the Drawings shall be placed on areas prepared for grassing as specified in **SECTION 8600**. The holes in the blocks shall be filled with topsoil and grassed with grass cuttings or hydro-seeding as specified in **SECTION 8600**.

g. Finishing Requirements

i. Precast concrete block paving

The completed paving shall be even and neat, flush with the kerb or edge beam and may not lie below the side of the kerbing. The final surface levels shall nowhere deviate by more than 15 mm from the specified levels and planes, and no irregularities exceeding +/-10 mm may occur during testing with a 3 m straight-edge.

ii. Grass block pavement

The completed grass-block pavement shall have a neat and even appearance. The final surface of the pavement may nowhere deviate by more than 15 mm from the specified levels and planes.

2507 Cast In-Situ Concrete Pitching

The areas where cast-in situ concrete pitching is to be constructed shall be trimmed and prepared as described in **CLAUSE 2506** for block paving. The areas shall also be treated with an environmentally compatible herbicide and termite poison if required. The concrete shall comply with the requirements of **SERIES 7000**.

Prior to placing the concrete, the surface shall be watered and kept damp until the concrete has been placed. The type of concrete used shall, unless otherwise specified, be Class 20 and the concrete shall be accurately laid in alternate panels to the lines and levels indicated after which the remaining panels shall be similarly placed. Accurately set-up guides shall be used to achieve the required line and slope. The concrete shall be thoroughly compacted and finished to a Class U2 surface finish as defined in **CLAUSE 7209**.

Where indicated the concrete pitching shall be contained by concrete edge beams constructed as described in **CLAUSE 2506(d)**.

The concrete pitching shall be cured for at least seven days and no traffic shall be allowed to move across the pitching before the specified 28-day strength has been reached.

The final surface may nowhere deviate by more than 25 mm from the specified levels and planes and no irregularities exceeding +/- 10 mm occur during testing with a 3 m straight edge.

2508 Measurement And Payment

Item	Unit
25.01 Stone Pitching	
(a) Plain Pitching	Square Metre (m ²)
i Method 1	Square Metre (m ²)
ii Method 2	Square Metre (m ²)
(b) Ground Stone Pitching	Square Metre (m ²)
(c) Wired and Grouted Stone Pitching (Total Thickness Indicated)	Square Metre (m ²)

The unit of measurement for pitching shall be the square metre of each type of pitching in place.

The bid rate for each type of stone pitching shall include full compensation for furnishing all materials, making all excavations excluding trench and bulk excavations, compacting and trimming the excavated surfaces, forming and cleaning the weep holes, placing stones and grouting or wiring and grouting where applicable, grassing and watering (applicable to Method 2) and for all other work necessary for completing the pitching as specified. The bid rate for grouted stone pitching on a concrete bed shall also include full compensation for the concrete bed.

Excavations for foundation trenches and concrete edge beams and the construction of the concrete edge beams will be paid for separately.

Item	Unit
25.02 Riprap	
(a) Packed Riprap (Critical Mass Of Stones Indicated)	Cubic Metre (m ³)
(b) Dumped Riprap (Critical Mass Of Stone Indicated)	Cubic Metre (m ³)
(c) Filter Backing (SUBCLAUSE 2104(a)(li) And 2504(b)) Consisting of:	Cubic Metre (m ³)
i Crushed Stone	Cubic Metre (m ³)
ii Filter Sand Obtained From Borrow Pits	Cubic Metre (m ³)
(d) Synthetic Fibre Filter Fabric (Type, Class And Grade Stated)	Square Metre (m ²)

The unit of measurement for riprap and filter layer SUBITEMS 25.02(a), (b) and (c) above) shall be the cubic metre of riprap or filter layer in place and shall include rock used in trench backfill. The unit of measurement for SUBITEM 2502 (d) shall be the square metre of filter fabric laid as specified, including overlaps.

The rates bid for SUBITEMS 25.02(a), (b) and (c) shall include full compensation for preparing the surfaces, including excavation (but excluding excavation for trenches and bulk excavations) and for the furnishing, transporting, handling and placing of riprap or filter layers. The rate bid for SUBITEM 25.02 (d) shall include full compensation for procuring and furnishing the filter fabric and for laying it as specified, including wastage. Collectively the rates shall also include full compensation for all other incidentals necessary for completing the work as specified.

Item	Unit
25.03 Stone Masonry Walls	
(a) Plain Packed Stone Walls	Cubic Metre (m ³)
(b) Cement-Mortared Stone Walls	Cubic Metre (m ³)

The unit of measurement for stone masonry walls shall be the cubic metre of actual walling constructed and accepted.

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The bid rate for each type of stone wall shall include full compensation for furnishing all materials, trimming the areas, placing the stones and cement-mortared masonry where required, and all other work necessary for completing the walls in accordance with the Specifications. Excavation of foundation trenches will be paid for separately.

Item	Unit
25.04 Concrete Pitching and Block Paving	
(a) Cast In Situ Concrete Pitching (Class of Concrete and Thickness of Pitching Indicated)	Square Metre (m ²)
(b) Precast Concrete Block Paving (Type and Thickness Indicated)	Square Metre (m ²)
(c) Prefabricated Concrete Grass Blocks	Square Metre (m ²)
(d) Prefabricated Concrete Paving Blocks For Footpaths (Thickness Indicated)	Square Metre (m ²)

The unit of measurement shall be the square metre of each type constructed.

The bid rates shall include full compensation for furnishing all material, all excavation (but excluding bulk excavation and excavation for foundation trenches and edge beams), compacting and trimming all the excavated areas, providing a sand bedding (SUBITEMS 25.04 (b) and (d)), laying and compacting the paving blocks (SUBITEMS 25.04 (b) and (d)), laying concrete grass blocks (SUBITEM 25.04 (c)), topsoiling and grassing, (SUBITEM 25.04 (c)), constructing concrete pitching, including normal formwork and the shaping of surfaces (SUBITEM 25.04 (a)), making and cleaning weepholes (SUBITEM (a)) and for all other work necessary for completing the work as specified.

Item	Unit
25.05 Concrete Edge Beams (Class of Concrete Indicated)	Cubic Metre (m ³)

The unit measured shall be the cubic metre of concrete in edge beams constructed as instructed.

The bid rate shall include full compensation for furnishing all materials and labour, including formwork as necessary, placing concrete and shaping all surfaces and all excavations required (in all classes of material).

Item	Unit
25.06 Provision of Herbicide and Pesticide	Cubic Metre (m ³)
A Provision of Materials	Prime Cost Sum
B Contractor's Charges And Profit Added To The Prime Cost Sum	Per Cent (%)

Payment under the prime cost sum for providing environmentally compatible termite poison and herbicide and the Contractor's cost and profit in this respect shall be made in accordance with the provisions of the General Conditions of Contract but in addition the Contractor's bid rate for costs and profit shall include full compensation for applying the chemicals as specified.

Item	Unit
25.07 Foundation Trenches	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated for foundation trenches irrespective of the class or depth of material. The quantity shall be calculated according to the dimensions shown on the Drawings or instructed by the Engineer.

The bid rate shall include full compensation for the excavation of the foundation trenches irrespective of the class or depth of material complete as specified, or as shown on the Drawings or as instructed by the Engineer.

SECTION 2600 Gabions

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2601 Scope

This section covers the construction of gabion walls, aprons, retaining walls, lining channels, revetments, bridge and culvert protection, protection of road embankments and other anti-erosion structures including river training.

Gabions shall be flexible galvanised steel wire and wire-mesh cages packed with boulder or cobble sized rock fragments.

2602 Materials

a. Rock

Rock used as filling for cages shall be clean, hard, un-weathered boulders or cobble size rock fragments. No material shall exceed the maximum size given in TABLE 2602/1, and at least 85 % of the boulders shall be of a size equal to or above the average least dimension size in TABLE 2602/1.

The minimum density of rock shall normally be 2,300 kg/m³, though the Engineer may approve the use of material of lower density in exceptional circumstances which will depend upon availability and environmental considerations.

TABLE 2602/1: ROCK FILL SIZES

Depth of Cage (m)	Rock Fill Material Dimensions	
	Average Least Dimension (mm)	Maximum (mm)
0.3	125	200
0.5	125	250
1.0	125	250

b. Wire

All wire for making the gabions and for tying during the construction of the gabions shall comply with the following requirements:

i. Tensile strength:

350-500 N/mm² as per BS EN 10223.

ii. Coating:

All the wire shall be heavily zinc coated with a minimum mass of coating in accordance with the provisions of BS EN 10244, see TABLE 2602/2 below:

TABLE 2602/2: WIRE COATING

	Mesh Wire Diameter (mm)			
	<2.2	2.2 – 2.9	3.0 - 3.6	3.7 – 4.0
Coating (gr/m ²)	245	260	275	290

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The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six turns round a mandrel of four times the diameter of the wire, it shall not flake or crack to such an extent that any zinc can be removed by rubbing with bare fingers.

iii. Elongation:

Elongation shall be not less than 10 % as per BS EN 10223-3.

c. **PVC- coated Galvanised Wire**

The gabions of PVC-coated mesh shall be of an acknowledged make which shall be subject to approval by the Engineer. PVC-coating is applied after zinc coat galvanising. The specifications for wire and zinc coating are same as specified in 2602(b). The PVC coating nominal thickness is 0.50 mm and nowhere less than 0.4 mm. The PVC coating material shall meet the following initial properties:

Specific gravity: 1.30-1.35 gm/cm³ in accordance with ASTM D792;

Durometer Hardness: between 50 and 60 Shore D, according to ASTM D 2240;

Tensile strength: not less than 20.6 MPa, according to ASTM D 412;

Modulus of elasticity: not less than 18.6 MPa, in accordance with ASTM D 412;

Abrasion resistance: the percentage of the weight loss shall be less than 12 %, according to ASTM D1242.

Creeping corrosion: max. penetration of corrosion of the wire from a square cut end shall be 25 mm when the specimen has been immersed for 2,000 hours in a 5 % solution HCl (hydrochloric acid 12 Be).

The PVC coating shall not show any sign of cracking, stripping or air bubbles, and no appreciable variation in colour when exposed for a period not less than 3000 hours to Salt spray when tested according to ASTM B117 and UV rays when tested according to ASTM D1499 and ASTM G23- 93 apparatus Type E.

d. **Galvanising**

All wire used in the making of gabions shall be galvanised in accordance with the provisions of BS EN 10244 or equivalent for Class A heavy galvanised mild- steel wire.

e. **Wire Mesh**

Wire mesh shall comply with the requirements of BS EN 10223-3 or equivalent. The wire mesh shall be hexagonal woven mesh wherein the joints are formed by twisting each pair of wires through three half turns. The tightness of the twisted joints shall be such that a force of not less than 1.7kN is required when pulling on one wire in order to separate it from the other wire provided each wire is prevented from turning due to the applied forces and the wires are kept in the same plane. The mesh size i.e. mesh openings shall be hexagonal and of nominal dimension of 50 mm, 60 mm, 80 mm or 100 mm and shall conform to BS EN 10223-3.

f. **Geotextile Filter Fabric**

Geotextile filter fabric shall comply with the requirements of SECTION 2700.

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2603 Constructing Gabion Cages

a. General

Gabion cages shall be made from wire mesh of the size and type and selvedge as specified below. The cages shall be subdivided into cells by wire mesh diaphragms and will be of two types.

i. Boxes which are generally used for the construction of gabion walls.

These boxes are subdivided into cells by diaphragms spaced at 1.0 m intervals. No diaphragms are required for a box of length less than 1.5 m. The standard sizes of gabions are as shown in TABLE 2603/1 below:

TABLE 2603/1: GABION SIZES

Mesh Type (mm)	Wire Diameter (mm)	Sizes
80 x 100	2.7 mm	Length: 1.5 – 2 – 3 – 4 m
		Width: 1 m
		Height: 0.5 – 1 m

ii. Mattresses which are generally used as single-layer aprons only in revetments, channel linings, etc. and in which the maximum width shall be subdivided by diaphragms into cells with a width of 1.0 m as specified in the Bill of Quantities.

The standard sizes of mattresses are as shown in TABLE 2603/2 below:

TABLE 2603/2: MATTRESS SIZES

Mesh Type (mm)	Wire Diameter (mm)	Sizes
60 x 80	2.2 mm	Length: 3 – 4 – 5 – 6 m
		Width: 2 m
		Height: 0.30 m
50 x 70	2.0 mm	Length: 3 – 4 – 5 – 6 m
		Width: 2 m
		Height: 0.30 m

Other sizes of gabion boxes and mattresses may be supplied subject to the approval of the Engineer.

The cut edges of all mesh used in the construction of gabions, except the bottom edge of diaphragms and end panels, shall be selvedged with wire as specified in TABLE 2603/03.

b. Selvedges

The cut edges of all mesh used in the construction of gabions, except the bottom edges of diaphragms and end panels, shall be selvedged with wire having a diameter as specified in TABLE 2603/3. The selvedge wire and the wire used for lacing operation must have the same technical specification of the mesh wire. The combination of the diameters of mesh wire, selvedge wire and lacing wire shall be as specified in TABLE 2603/3.

TABLE 2603/3: DIAMETER OF MESH WIRE, SELVEDGE WIRE AND LACING WIRE

Mesh Type (mm)	Combination				
	1	2	3	4	5
Mesh wire diameter (mm)	2.0	2.2	2.4	2.7	3.0
Selvedge wire diameter (mm)	2.4	2.7	3.0	3.4	3.9
Lacing wire diameter (mm)	2.0	2.2	2.2	2.2	2.2

Where the selvedge is not woven integrally with the mesh but has to be tied to the cut ends of the mesh it shall be attached by tying the cut ends of the mesh to the selvedge so that a force of not less than 8.5 kN applied in the same plane as the mesh at a point on the selvedge of a mesh sample of 1.0 m in length will be required to separate it from the mesh.

c. Diaphragms and End Panels

The diaphragms and end panels shall be selvedged on the top and vertical sides only. The end panels shall be attached by the cut ends of the mesh wires at the bottom of the panel being twisted around the selvedge on the base of the gabion. Similarly, the diaphragms shall be attached by the cut ends of the mesh being twisted to the twisted joints of the mesh in the base of the gabion. In each case the force required to separate the panels from the base shall be not less than 6 kN/m.

d. Binding and connecting wire

Sufficient binding and connecting wire for all the tying to be done during construction of the gabions as specified in **CLAUSE 2604** shall be supplied with the gabion cages. The diameter of the wire shall be 2.2 mm.

e. Tolerances

The tolerance on the specified diameter of all wire shall be +2.5 %. The length of the cages shall be subject to a tolerance of ± 10 % and the width of the cages shall be subject to a tolerance of +5 % and the depth of the cages shall be subject to a tolerance of +5 %.

2604 Constructing Gabions

a. Preparing the Foundation and Surface

The surface on which the gabion cages are to be laid prior to being filled with rock shall be levelled and compacted to 93% MDD of AASHTO T180 density and at the depth shown on the Drawings or as directed by the Engineer so as to present an even surface. Cavities between rock protrusions shall be filled with material similar to that specified in **SUBCLAUSE 2602(a)**. Where required, a foundation trench along the toe of the revetment or wall shall be excavated to the dimensions shown on the Drawings or indicated by the Engineer.

b. Filter Fabric

One layer of Grade 3 filter fabric shall be placed where indicated on the Drawings or ordered by the Engineer. The material shall be placed in accordance with the specifications in strips with a minimum overlap of 300 mm at the joints and shall be properly fastened to prevent any movement or slipping while the gabions are being placed.

c. Assembly

The methods of constructing, stretching, placing in position, wiring and filling the gabions with rock shall generally be in accordance with the manufacturer's instructions which must be approved by the Engineer. Notwithstanding, sufficient connecting wires shall be tensioned between the vertical sides of all the outer visible cells to prevent the deformation of boxes as they are being filled.

It is essential that the corners of gabion cages be securely wired together to provide a uniform surface and ensure that the surface does not resemble a series of block or panels.

The layout and the tolerances for the layout of the boxes shall be as shown on the Drawings or as instructed by the Engineer.

d. Rock Filling

i. Boxes

Particular care shall be taken in packing the visible faces of gabion boxes where only selected stone of the specified size shall be used so as to obtain an even-faced finish. The boxes shall be filled in layers to prevent deformation and bulging. Boxes shall be filled to just below the

level of the wire braces, after which the braces shall be twisted to provide tension. Care must be taken to ensure that consecutive layers of cages are filled evenly to a level surface ready to receive the next course.

ii. Mattresses used in revetments and aprons

The gabion mattresses forming aprons and revetments shall be filled by random stones being packed in the first layer and selected stones being used for the top layer so as to resemble normal stone pitching.

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2605 Measurement And Payment

Item		Unit
26.01	Foundation Trench Excavation	Cubic Metre (m ³)
(a)	Excavating Soft Material Situated Within The Following Depth Ranges Below The Surface Level:	Cubic Metre (m ³)
i	0.0 m up to 1.5 m	Cubic Metre (m ³)
ii	Exceeding 1.5 m and up To 3.0 m	Cubic Metre (m ³)
iii	Exceeding 3.0 m per increment of 1.5 m	Cubic Metre (m ³)
(b)	Extra Over SUBITEM 26.01 (a) For Excavation in Hard Material as Defined in CLAUSE 3503, Irrespective of Depth	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of each class of excavation made in accordance with the authorised dimensions.

The bid rates shall include full compensation for excavating in each class of material, including unavoidable overbreak, the trimming of trenches and compacting the trench inverts, and the disposing of surplus excavated material unsuitable for backfilling.

No haulage will be paid.

Item		Unit
26.02	Foundation Trench Backfilling with:	
(a)	Material from the Excavations	Cubic Metre (m ³)
(b)	Imported Selected Material	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material in place after compaction. The quantity shall be calculated in accordance with the authorised dimensions.

The bid rates shall include full compensation for backfilling and compacting the backfill material to the specified density. The bid rate for SUBITEM 26.02(b) shall, in addition, include full compensation for supplying selected material from approved sources.

Item		Unit
26.03	Surface Preparation for Bedding the Gabions	Square Metre (m ²)

The unit of measurement for levelling and preparing surfaces for receiving the gabions shall be in square metre to the neat dimensions of revetments, aprons or wall foundations.

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The bid rate shall include full compensation for excavating, filling any cavities with rock and levelling the ground surface so as to be ready for receiving the gabion cages for retaining walls, aprons and revetments.

Item		Unit
26.04	Gabions and Mesh Cages	
(a)	Galvanised Gabion Boxes (Dimensions Of Box And Mesh Size Indicated)	Square Metre (m ²)
(b)	PVC - Coated Gabion Boxes (Dimensions Of Box And Mesh Size Indicated)	Square Metre (m ²)
(c)	Galvanised Gabion Mattresses (Dimensions Of Mattress, Mesh Size And Diaphragm Indicated)	Square Metre (m ²)
(d)	PVC - Coated Gabion Mattresses, Mesh Size And Diaphragm Spacing Indicated)	Square Metre (m ²)

The unit of measurement for Gabion mesh shall be square metre calculated as the net area of the material required to construct the gabions including diaphragms.

The rate for Gabion mesh shall include full compensation for supplying the wire-mesh cages, tying and connecting wires, loading, transporting, off-loading, assembling and any other work necessary for constructing the gabion cages.

Item		Unit
26.05	Rockfill to Gabions	Square Metre (m ²)

The unit of measurement shall be the cubic metre of the rock filled in gabion cages and the quantity shall be calculated from the dimensions of the gabions indicated on the Drawings or prescribed by the Engineer, irrespective of any deformation or bulging of the completed gabions or mats.

The bid rates shall include full compensation for supplying all the rockfill materials, including hauling and filling of the cages, and any other work necessary for constructing the gabions.

Item		Unit
26.06	Filter Fabric (Type and Grade Indicated)	Square Metre (m ²)

The unit of measurement shall be the square metre of area covered with filter fabric placed in position.

The bid rate shall include full compensation for supplying the filter fabric, cutting, waste, placing, joining, overlapping and securing the material in position.

SECTION 2700 Filter Fabric and Drainage Composite

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2701 Scope

This section covers the geotextile filter fabrics and drainage composites to be used in drainage systems such as surface drainage, drainage trenches, perforated pipes wrap, retaining wall backfill and vertical drainage where the function of the geotextile filter fabric is to allow the water to go through preventing the fine soil particles to enter the drainage system (filtration) that can be obtained by the use of filling gravel material or synthetic core (drainage composite).

2702 Materials

a. Geotextile for Drainage Applications

The geotextile used as filter (as filter itself or as filter of the drainage composite) shall meet the mechanical and hydraulic properties listed in TABLE 2703/3 and the following general requirements:

- i. The geotextile shall be a “non-woven” type manufactured with a heat-bonding process with continuous spun bonded filaments
- ii. The raw material of the filament yarns shall be produced with a mixture of polypropylene and polyethylene where the polyethylene content will not exceed the 30 % of the overall mass and will be used as external revetment of each filament
- iii. The geotextile will be manufactured and supplied according to a certified quality control process
- iv. The geotextiles shall be rolled in an UV resistant package and it will be itself resistant to wearing out, rotting, solvents, acids, alkalis, bacteria and other microorganism and to any chemical reaction occurring in standard natural soils
- v. Geotextiles can be easily transported and installed. During transportation and storage, the geotextile rolls shall be kept wrapped to avoid damage. Each geotextile roll shall be labelled and marked for identification during quality control of product.

b. Drainage Geocomposites For Drainage Applications

In drainage applications, drainage composites can be used to replace the drainage system composed of granular material and filter. The drainage composite shall meet the mechanical and hydraulic properties listed in TABLE 2703/2 and the following general requirements:

- i. Drainage composite shall be a laminated filter drain composed of two layers of the above described geotextile which is used as a filter separated by a high density polyethylene net.
- ii. The three components (nonwoven-net-nonwoven) shall be bonded together over the entire surface by thermal lamination.
- iii. The filters will be larger than the core width to guarantee (at least at one side) an overlapping to prevent the intrusion of fine soil into the drainage core.
- iv. The geocomposite will be manufactured and supplied according to a certified quality control process.

2703 Standard Testing Procedures

a. Test Standards

TABLE 2703/1 lists test standards for geotextiles. Any other standard meeting the basic requirements stated here can be accepted at the discretion of the Engineer provided that the Contractor has submitted to the Engineer the manufacturer's test certificate.

TABLE 2703/1: TESTS FOR NON-WOVEN GEOTEXTILE FILTERS FOR DRAINAGE APPLICATIONS AND DRAINAGE COMPOSITES

Test	Test Standard
Wide width strip tensile (kN/m)	BS EN ISO 10319
Elongation (%)	BS EN ISO 10319
CBR Puncture resistance (N)	BS EN ISO 12236
Trapezoidal tear resistance (N)	ASTM D4533-04(2009)
Permeability -10 cm head (l/sqmxsec)	BS EN ISO 12958
Pore Size (mm)	BS EN ISO 12956

TABLE 2703/2: TESTS FOR NON-WOVEN FILTERS OF DRAINAGE COMPOSITES

Test	Test Standard
Tensile breaking load (kN/m)	BS EN ISO 10319
CBR Puncture resistance (N)	BS EN ISO 12236
Compressive strength at 10 % compression (kN/sqm)	ASTM D1621-00
Water flow –hydraulic gradient = 1.0 hard/hard (l/sec/m)	BS EN ISO 12958

The Engineer reserves the right to reject any geotextile material they consider unsuitable for the Works.

In addition to that, the Engineer reserves the right to take samples of the geotextile during the course of the work and subject them to the tests they he/she deems necessary in a suitably equipped laboratory

b. Characteristics Of Non-Woven Geotextiles

The locations of the geotextiles employed for drainage function shall be shown in the Drawings or as directed by the Engineer. The required mechanical and hydraulic properties of the geotextile conform to the minimum property requirements as specified in the TABLE 2703/3.

In addition to the properties given in TABLE 2703/3 the filter geotextile shall be unaffected by chemical materials and will be resistant to all natural occurring soil alkalis and acids (pH range 2-13).

The geotextile shall remain wrapped in a black polyethylene wrapper to protect it from the harmful effects of UV-rays. During the placement the temporary exposure to the light shall not exceed 10 hours.

TABLE 2703/3: GEOTEXTILE PROPERTIES

Test	Minimum Requirement
Wide width strip tensile (kN/m)	8.0
Elongation (%)	Max. 30
CBR Puncture resistance (N)	1500
Trapezoidal tear resistance (N)	300
Permeability -10 cm head (L/sqmxsec)	90
Pore Size (µm)	100

c. Characteristics Of Drainage Composites

The purpose of usage and application locations of the geocomposites employed for drainage function shall be stated in designs and shall be used if the Engineer approves. The required mechanical and hydraulic properties of the geocomposite selected at the end of the design phase shall be stated and the geocomposite shall meet the minimum property requirements as specified in the TABLE 2703/4.

TABLE 2703/4: PROPERTIES OF GEO-COMPOSITE

Test		Minimum Requirements	
		Type A	Type B
Tensile breaking load (kN/m)		16	20
CBR Puncture resistance (N)		2700	3400
Compressive strength at 10 % compression (N)		150	193
Water flow (m/sec)	20 kPa		0.52
	200 kPa		0.41
	300 kPa		0.31
	400 kPa		0.27

Type A drainage composite shall be used for vertical applications as retaining walls or in flat applications where the vertical loading is limited to 60 kPa. Type B shall be used in flat applications exceeding the 60 kPa.

In addition to the properties given in TABLE 2703/4 the drainage composite elements shall be unaffected by chemical materials and will be resistant to all natural occurring soil alkalis and acids (pH range 2-13).

The geocomposite shall remain wrapped in a black polyethylene wrapper to protect it from the harmful effects of UV-rays. During the placement the temporary exposure to the light shall not exceed 10 hours.

The performance of the filter geotextiles of the drainage composite will comply with the specification limits indicated in CLAUSE 2702.

d. Care During Transportation and Construction

When the use of geosynthetics is required with purpose of drainage applications at specified locations in projects, the geosynthetics should not be damaged during transportation, placement and compaction of the granular fill material (if required by the application) in/on which the geosynthetics will be placed. In case of damage, the damaged sections will be repaired in a way approved by the Engineers either by patching as defined in CLAUSE 5905 or by replacement of the damaged section by new material.

e. Quality Control

For the purpose of quality control of the geosynthetics to be used, the number of rolls to be tested out of the total number of rolls supplied shall be in accordance with ASTM D4354-99 (2009) and 5 test samples shall be taken from each test roll and tested in the main direction. If the average value of the results of five tests satisfies the specifications limits, the geosynthetic material shall be accepted otherwise rejected. If one or more rolls fall below the specification limits, the procedure defined above shall be repeated by resampling. If the average test results of the resampled roll exceed the specification limits, the geosynthetics of the batch shall be accepted.

2704 Measurement And Payment

Measurement and payment for geotextile filter fabric will be according to the relevant pay ITEMS included in SECTIONS 2500 and 2600.

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Drainage | 2700 | *Filter Fabric and Drainage Composite*

SERIES 3000 Earthworks

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SECTION 3100 Clearing, Grubbing and Removal of Topsoil

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3101 Site Clearance

a. General

Site clearance is defined as the clearing, grubbing, removal and disposal of all vegetation, grass, debris, bushes, scrub, dense bush, trees, hedges, undergrowth, stumps, roots, shrubs plants and the backfilling of holes left by the removal of stumps and roots.

The width and length over which site clearance is to be carried out shall be as shown on the Drawings or instructed by the Engineer.

Site clearance over the area of quarries, borrow pits, stockpiles, spoil tips, road junctions, ditches and drains and other areas shall be carried out where shown on the Drawings or instructed by the Engineer.

The Engineer may give instructions that specific trees, stumps or objects shall not be removed during the site clearance operation.

b. Clearing, Except Trees

Where the Engineer instructs that site clearance is required, the entire area shall be cleared and all materials thus cleared shall become the property of the Employer. Unless otherwise instructed, vegetation and perishable materials shall be disposed of by burning. Where material or debris cannot be burnt, it shall be carted to spoil areas, which spoil areas shall be provided in accordance with requirement of SECTION 3400 of this Specification.

If the Contractor clears the Site in advance of the main Works such that grass and other vegetation re-grows prior to the main Works commencing at any particular location then any additional, or repeating of, site clearance required shall be at the Contractor's expense.

c. Removal of Trees

Trees outside the construction width but within the road reserve having a trunk girth of more than 450 mm at a point 600 mm above the ground shall not be cut down without the prior approval of the Engineer.

Where the Engineer instructs that site clearance is required, trees not designated to remain shall be uprooted or cut down as near to ground level as possible, and shall be either burnt, or, where the Engineer instructs that they shall be saved, the trunk and branches shall be cut into convenient lengths and stacked neatly off the line of the road and shall become the property

of the Employer and shall be preserved and protected by the Contractor until removed by the Employer or until the expiry of the Defect Notification Period. The remainder of the trees shall be disposed of by burning.

Stumps and tree roots shall be grubbed up and burnt. All holes left by removal of stumps and roots shall be backfilled with approved material compacted to 100 % MDD (AASHTO T99) up to the existing ground level or up to the formation level if the area is in cut.

3102 Removal Of Topsoil

Where shown on the Drawings or directed by the Engineer the Contractor shall remove topsoil. The depth of the topsoil shall be as directed by the Engineer but shall not exceed 200 mm. At any cross-section the depth instructed may vary and such variation may occur both along the road and across the cross-section.

Where directed by the Engineer the Contractor shall, prior to removal of topsoil, excavate trial holes of a depth sufficient to enable the Engineer to measure the depth of topsoil. Where topsoil is found to depths greater than 200 mm that portion below 200 mm shall, if required by the Engineer, be treated as fill or spoil in accordance with the requirements of SECTION 3500 of this Specification.

Topsoil shall be stripped, loaded, transported and deposited in stockpile areas, which stockpiles areas shall be provided in accordance with the requirements of SECTION 3400 of this Specification.

Should the Contractor strip to depths greater than those instructed by the Engineer, then the Contractor shall replace the material with fill material at the Contractor's expense.

3103 Removal Of Structures, Fences And Obstructions

When instructed by the Engineer, the Contractor shall demolish wholly or in part, remove and dispose of all buildings, foundations, structures, fences and any other obstructions -which have not been designated to remain.

The Contractor shall carefully take down such buildings, structures, fences etc. and the components shall be dismantled, cleaned and stacked in separate heaps. All materials which, in the opinion of the Engineer, are not fit for re-use shall be removed from the Site to spoil areas provided in accordance with the requirements of SECTION 3400 of this Specification. All materials which are re-usable shall remain the property of the Employer and shall be preserved and protected by the Contractor until removed by the Employer or until the expiry of the Defect Notification Period.

3104 Protection Of Fences, Trees, Hedges Etc.

All existing paths, fences, walls, hedges, trees, shrubs, lawns and other features which the Engineer instructs shall not be removed or otherwise dealt with, shall be protected from damage, and any damage which occurs due to the Contractor's failure to 'take adequate precautions' shall be repaired at the Contractor's expense.

3105 Measurement And Payment

No payment will be made for the moving of soil or gravel material which may be inherent in or unavoidable during the process of clearing.

Clearing, grubbing and removal of topsoil required for quarries, borrow areas and any other natural material sources, for haul roads and all temporary construction will not be measured for payment.

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Earthworks | 3100 | Clearing, Grubbing and Removal of Topsoil

Item	Unit
31.01 Clearing, Grubbing and Removal of Topsoil	
(a) Clearing And Grubbing	Hectare (ha)
(b) Removal Of Topsoil	Cubic Metre (m ³)

The unit of measurement for SUBITEM 31.01(a), clearing and grubbing, shall be the hectare (to the nearest 0.1 ha) designated by the Engineer and cleared of the vegetation cover and grubbed and in accordance with these Specifications, all to the satisfaction of the Engineer. The unit of measurement for SUBITEM 31.01(b), removal of topsoil as specified or instructed by the Engineer, shall be the cubic metre measured in place at the depth and width specified.

The bid rate shall include full compensation for all work necessary for the clearing of the surface, any necessary de-watering, removal of topsoil to the depth as specified or as instructed by the Engineer after removal of the vegetation cover, the removal and grubbing of trees and tree stumps (except large trees and stumps as defined below), cutting of branches, backfilling of cavities, demolishing and disposal of buildings and structures (except for removal of drainage structures as provided for in SECTION 2200), and the removal, transporting and disposal or conservation of material all as specified in this SECTION 3100. The Contractor's attention is drawn to SUBCLAUSE 3102(d) for further explanation of the work included under this pay Item.

Item	Unit
31.02 Removal and Grubbing of Large Trees and Tree Stumps	
(a) Girth Exceeding 1.0 m up to and Including 2.0 m	Number (No.)
(b) Girth Exceeding 2.0 m up to and Including 3.0 m	Number (No.)
(c) Girth Exceeding 3.0 m	Number (No.)

The girth of trees or stumps shall be measured at the narrowest point of the tree or stumps in the first metre of its height above ground level. Trees and stumps with a girth exceeding 1.0 m shall be measured individually and classified according to the size in increments of 1.0 m as indicated above.

The bid rates shall include full compensation for all work necessary for the clearing and grubbing of trees and stumps with girth exceeding 1.0 metre, the backfilling of holes and the removal and disposal of material, all as described in this SECTION 3100.

Where construction is carried out through plantations or where the number of trees with a girth exceeding 1.0 m renders individual measurement impractical, the Special Specifications may provide that the clearing and grubbing of trees in such areas be measured in hectares. If this method of measurement is used, the areas where it applies will be shown on the Drawings or stated in the Special Specifications. Where the Special Specifications provide for the cleaning and grubbing of large trees per hectare in such specific cases, the bid price shall include full compensation for all work as described in connection with individual trees above.

Item	Unit
31.03 Applying Approved Pesticides to Ant and Termite Nests	Litres (l)

The unit of measurement for applying approved pesticides to ant and termite nests shall be the litres as instructed by the Engineer applied in accordance with these Specifications.

The bid rate shall included full compensation for all work necessary for applying approved pesticides to ant and termite nests.

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Earthworks | 3100 | *Clearing, Grubbing and Removal of Topsoil*

SECTION 3200 Removal of Existing Structures

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3201 Scope

This section covers the requirements for removing the existing bridges, culverts, kerb and gutter, grouted stone side ditch, buildings, concrete entrance slabs and other obstructions that are not designated to remain.

3202 General

The Contractor shall remove and dispose of all buildings, foundations, bridges, drainage structures and other obstructions within the limits of the Works, except Items designated to remain and utilities and obstructions to be removed as stipulated in SECTION 3100 or under other provisions of this Contract.

Existing utilities through, at or near existing structures shall be protected and/or relocated as directed by the Engineer.

All existing structures designated as salvage material shall be removed, without damage, in sections or pieces that may be readily transported, and shall be stored by the Contractor at locations specified in the Special Specifications. Unusable perishable material shall be destroyed. Non-perishable material, waste concrete and masonry shall as far as practicable be placed in slopes of embankments. Any broken concrete or masonry which cannot be used in construction, and all other materials not considered suitable for use elsewhere, shall be disposed of by the Contractor. In no case shall any discarded materials be left in windrows or piles adjacent to or within the Site. The manner and location of disposal of materials shall be subject to the approval of the Engineer and shall not create an unpleasant or objectionable view. When the Contractor is required to locate a disposal area outside the Site at their own expense, the Contractor shall obtain and file with the Engineer, permission in writing from the property owner for the use of their property for this purpose.

Basements or cavities left by structure removal shall be filled to the level of the surrounding ground and, if they are within the formation, the backfill shall be compacted in accordance with the relevant requirements in this Specification.

3203 Removal Of Grouted Stone Side Ditches

Existing grouted stone side ditches shall be preserved as far as feasible, in accordance with the instructions of the Engineer. However, where necessary, they shall be totally or partially removed, as directed by the Engineer, and if required the salvaged stones shall be stockpiled where directed by the Engineer.

3204 Removal Of Bridges, Culverts And Other Drainage Structure

Bridges, culverts, and other drainage structures shall not be removed until satisfactory arrangements have been made to accommodate traffic and the flow of water.

Unless otherwise indicated, the existing substructures shall be removed down to the natural stream bottom and those parts outside the stream shall be removed 300 mm below natural ground surface. Portions of existing structures within the limits of a new structure shall be removed to accommodate the construction of the proposed structure.

Bridges designated as salvage material shall be dismantled without damage and match marked, and transported to designated locations as directed by the Engineer. Structures designated to become the property of the Contractor shall be removed from the Site.

Blasting or other operations necessary to remove existing structures or obstruction, which may damage new construction, shall be completed prior to placing the new work.

Sections of pipe culverts lost from storage or damaged by negligence shall be replaced at the Contractor's expense. Pipes shown on the Drawings or directed by the Engineer to be plugged shall be left in place and the ends plugged.

3205 Removal Of Concrete Entrances, Gabions, Kerbs, Etc

All concrete pavement, gabions, kerbs, channels, buildings, foundations, slabs, etc designated for removal shall be disposed of by the Contractor at approved dump sites

Concrete designated for use as riprap shall be broken into pieces not less than 10 kg but not exceeding 80 kg and stockpiled at designated locations for use on the project.

3206 Removal Of Utilities

The removal of existing utilities required to permit orderly progress of work will be accomplished by local agencies, unless otherwise provided for in the Special Specifications or shown on the Drawings. Whenever a telephone, pipeline, conduit, sewer, or other utility is encountered and must be removed or relocated, the Contractor shall advise the proper local authority or owner to arrange for its removal/relocation.

3207 Measurement And Payment

Item	Unit
32.01 Removal of Existing Structures:	
(a) Removal Of Existing Pipe Culverts Of Any Size	Linear Metre (m)
(b) Removal Of Reinforced Concrete In Bridges, Box Culverts And Slabs Including Headwalls, Wingwalls, Retaining Walls, Aprons Etc.	Cubic Metre (m ³)
(c) Removal Of Plain Concrete And Masonry In Bridges And Culverts Including Abutment, Headwalls, Retaining Walls, Wingwalls, Apron Etc.	Cubic Metre (m ³)
(d) Removal Of Kerb And Channel	Linear Metre (m)
(e) Removal Of Existing Grouted Stone Pitching	Square Metre (m ²)
(f) Removal Of Existing Gabions	Cubic Metre (m ³)

The unit of measurement for removal of existing pipe culverts shall be the linear metre of pipe acceptably removed, as directed by the Engineer.

The unit of measurement for removal of reinforced or plain concrete in bridges and culverts shall be the cubic metre of concrete acceptably removed, as directed by the Engineer.

The unit of measurement for removal of kerb and channel shall be the number of linear metres of kerb and channel acceptably removed, as directed by the Engineer.

The unit of measurement for removal of grouted stone pitching shall be the square metres of surface of grouted stone side ditch acceptably removed, as directed by the Engineer.

The unit of measurement for removal of gabions shall be the cubic metre of gabion as acceptably removed, as directed by the Engineer.

The tendered rate for removal of pipe culverts shall include full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work for demolishing of pipes of any size and type including any concrete bedding and surround, removing and disposing of all materials including supply and compaction of material for backfilling. Removal of concrete and masonry in headwalls, wingwalls and apron will be paid for separately under SUBITEMS 32.01(b) and 32.01(c) as applicable.

The tendered rate for removal of reinforced or plain concrete and masonry in bridges and culverts shall include full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work for demolishing of the bridge and culverts, removing and disposing of all materials including supply and compaction of material for backfilling.

The quantities, determined as provided above for kerb, channel, grouted stone pitching and gabions shall be paid at the rate per unit of measurement, respectively, for each of the particular pay Items, included in the Bill of Quantities which price and payment shall be full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work of demolishing, removing, disposing or stockpiling, as applicable, including supply and compaction of material for backfilling.

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Earthworks | 3200 | Removal of Existing Structures

SECTION 3300 Breaking Up Existing Pavement Layers

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3301 Scope

This Section covers the breaking up and excavation of existing pavement layers by conventional means or by milling, selecting the material, and the removal thereof to spoil dumps or to stockpiles for later reprocessing or recycling.

3302 Selecting the Material

Where directed by the Engineer, the Contractor shall remove the layers of the existing pavement, taking care not to damage the existing kerbs and/or gutters, if any. In case of damage to the existing kerbs or gutters, they shall be replaced to the satisfaction of the Engineer at the Contractor's expense.

Material from existing pavements may only be used for purposes approved by the Engineer. The material shall be excavated so that material from the various pavement layers, or materials of different types, will not be mixed unless so permitted by the Engineer.

3303 Classifying the Material

Existing grouted stone side ditches shall be preserved as far as feasible, in accordance with the instructions of the Engineer. However, where necessary, they shall be totally or partially removed, as directed by the Engineer, and if required the salvaged stones shall be stockpiled where directed by the Engineer.

Material from existing pavements shall be classified as follows for excavation and processing purposes:

a. Existing Bituminous Material

Existing bituminous material shall be asphalt or other bituminous seal or base course material removed separately from the pavement as instructed by the Engineer. Where underlying material is broken down or excavated together with bituminous materials, the mixture will not be classified as bituminous material.

b. Non-cemented Material

Non-cemented material shall be existing pavement material which in the opinion of the Engineer can be ripped with the teeth of a bulldozer, of flywheel power of not less than 93 kW, or equivalent, and which can be made usable for pavement material by breaking with the tracks of the bulldozer by reasonable efforts in the opinion of the Engineer.

c. Cemented Material

Cemented material is classified as existing pavement materials made from gravel or crushed stone, which, in the opinion of the Engineer, cannot be ripped and made usable for pavement material by the method described in SUBCLAUSE 3303(b). Unless specified as such in the Special Specifications, cemented material will not be classified as concrete.

d. Concrete

Concrete is classified reinforced or un-reinforced Portland cement concrete when specified as such in the Special Specifications or as decided by the Engineer.

e. Milled Material

Milled material shall be bituminous material or cemented material excavated with an approved milling machine. Milled material will be classified as such only when milling is specified or ordered by the Engineer. Payment will distinguish between milling of asphalt, concrete and of cemented material where so specified in the Bill of Quantities.

3304 Plant and Equipment**a. General**

The equipment to be used for the conventional breaking-up and excavation of existing pavement layers will be determined by the size and depth of the pavement section to be processed or excavated, taking into consideration of the fact that work may have to be carried out in restricted areas. Only approved cutting or sawing equipment may be used for cutting or sawing the pavement layers. The equipment shall be capable of cutting the pavement layers to the specified depth in one operation without fragmenting the material, and in straight lines within the required tolerances.

b. Milling Equipment

Only approved milling equipment may be used. The equipment shall be capable of milling asphalt and/or cemented material to the prescribed depth in one operation over the width specified in the Special Specifications. The milling depth shall be controlled electronically.

The direction and speed of the milling machine and the speed of rotation of the milling drum shall be adjustable so as to obtain the required grading of the milled material. The machine shall be capable of making a neat vertical cut at the outer edges when milling the layer and to leave the floor of the cut level and with a uniform texture.

Unless otherwise specified in the Special Specifications, the milling machine shall be equipped with a self-loading conveyor belt, which can be easily removed and installed and adjusted for slope and direction.

3305 Construction**a. General**

Where all or a part of the existing surfacing material is to be reprocessed together with the underlying layer, the surfacing shall be properly broken down and mixed through the full depth of the existing base material to the satisfaction of the Engineer. Fragments of bituminous material shall be broken down to sizes not exceeding 40 mm.

Where specified in the Special Specifications or ordered by the Engineer, the existing bituminous material shall first be removed before the underlying layers are broken up.

Bituminous material may be milled out or otherwise broken up and removed to stockpile sites approved for recycling or to spoil sites, whichever is required. The exposed surface shall be cleaned to the satisfaction of the Engineer after removal of the bituminous material.

The existing pavement material shall be broken down to the specified depth and removed, or reprocessed in place, whichever may be required. The underlying layers may not be damaged, and material from one layer may not be mixed with that of another layer. Where such mixing occurs or where the material is contaminated in any other way by the actions of the Contractor, The Contractor shall remove such material and replace it with other approved material, all at their own cost.

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Earthworks | 3300 | Breaking Up Existing Pavement Layers

Where a layer or layers require to be broken down over part of the pavement width only, the limit of the work shall be clearly demarcated, which limit shall not be exceeded by the Contractor by more than 100 mm. Pavement layers broken down outside the specified limits shall be repaired by the Contractor at their own cost, to the satisfaction of the Engineer.

Where ordered by the Engineer, asphalt and cemented layers shall be cut or sawn through to the specified depth along the measured limit with approved equipment. Payment will be made for sawing only where specified on the Drawings or ordered, in writing, by the Engineer.

Payment will not be made for sawing or cutting work where the existing layer requires removal by milling.

Where existing roads have to be widened, the existing pavement layers shall be cut back to a firm, well compacted or cemented material. Material so broken up, if acceptable, may be used together with imported material in the widening process provided the mixture consistently meets all requirements for the material type specified for the layer in question.

Where pavement layers are broken down over a section of the road width or where pavement layers are widened, the Engineer may order that the various pavement layers be excavated in benches in accordance with their instructions. No additional payment will be made for excavating benches.

Where underlying layers are still structurally sound and are included as structural layers in the new design drawings, care must be taken not to break them up during removal of the surfacing or underlying layers.

b. Milling

i. General

The floor of the milled excavation shall have an even texture and any loose patches or patches of unsuitable material shall be remedied in accordance with the instructions of the Engineer. Payment for removing and replacing unsuitable material and remedying loose patches shall be as specified elsewhere.

The floor of an excavation shall comply with the requirements of the surface level, grade and regularity for the layer which it will form in the new pavement.

Payment for milling will not distinguish between various types of milled material and between various milling depths unless such distinction is given in the Bill of Quantities.

ii. Preparing the pavement surface

Before milling may be commenced, the pavement surface shall be clean and free from soil or other deleterious material. Where only part of the pavement is to be milled out, the milling area shall be properly demarcated. Milling may not exceed the required width by more than 50 mm. Payment will not be made for milling beyond the required width, and such additional milling shall be backfilled with approved material in accordance with the provisions for the specified pavement material at the cost of the Contractor.

iii. Trial milling

Where ordered by the Engineer, the Contractor shall execute trial milling on the various materials to be milled. During the trial work, the Contractor will be expected to vary the direction and speed of the milling machine, the speed of rotation of the milling drum, and also the milling depth, in order to obtain milled material of the required grade. No payment will be made for trial milling.

iv. Asphalt

Where the asphalt and/or the cemented base must be reused, the asphalt shall be removed separately. Where the asphalt consists of layers of various mixes or grades, the Engineer may instruct the separate removal of the layers to different stockpiles. Where the milled material

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is not conveyed directly by conveyor belt and then loaded, and the Engineer so approves, the material shall first be cut to windrow and then loaded. During loading, the floor of the excavation or the underlying material shall not be damaged.

The milled material shall be inspected and classified in accordance with the various types of asphalt and its suitability for recycling. Different stockpiles shall be used for the different types of material as ordered by the Engineer. Contamination of the asphalt with underlying material will not be permitted, and the Contractor shall adjust the depths of milling in accordance with the thickness of the layer.

v. Cemented material

Unless otherwise specified milled cemented material to be reprocessed on the road shall first be windrowed with a view to inspecting the underlying surface for any patches of poor or unsuitable material. Where unsuitable material is encountered in the floor of the excavation, such material shall first be removed by further milling (where the underlying layer also consists of the cemented material), or by other approved methods, all to the satisfaction of the Engineer. The unsuitable material shall be replaced with approved material of the required type, which shall be placed in accordance with the specifications for the relevant underlying layer.

Where in the opinion of the Engineer, it may be necessary, they may instruct the Contractor to taper the ends or edges of a milled excavation. No additional payment will be made for tapering the ends or edges of a milled excavation.

vi. Coring of cemented material

Where existing cemented layers are to remain as a structural layer in the new pavement the Engineer may instruct the Contractor to drill cores from the layer and have them tested for compressive strength in accordance with the provisions of BS 1924-2 or equivalent. The number of cores to be drilled out and the drilling locations will be determined on site by the Engineer.

c. Sawing or Cutting

Where required in the opinion of the Engineer, diamond blade sawing or cutting shall be employed if necessary to achieve the required edge finish of milled layers. No additional payment will be made for sawing or cutting unless deemed necessary and approved by the Engineer.

d. Treatment of Pavement Excavation Floor

The floor of any pavement excavation, whether or not excavated by milling, shall be treated and paid for as specified in the relevant sections of the Specifications.

e. Scarification of Existing Pavement

Wherever shown on the Drawings or directed by the Engineer, the existing pavement surfacing and base course material or part of the existing base layer shall be scarified, watered and recompact. The depth of scarification and density of compaction shall be according to the Drawings and the Specifications.

Unless specified otherwise existing bituminous surfacing shall, if located within 1.0 m of proposed new pavement surface, be scarified by such method and to such depth that will ensure that any lumps of surfacing is not more than two-thirds of the specified scarification depth and ensuring that a homogeneous mix is obtained.

3306 Storing Recovered Pavement Material

Excavated pavement material intended for reprocessing but which cannot be reprocessed in place or, in the opinion of the Engineer, cannot be windrowed next to the excavation, nor placed in position directly at any other place, and material intended for recycling or reprocessing in a plant, shall be transported to approved stockpiles with the written permission of the Engineer.

Stockpile sites for material intended for recycling or reprocessing in a plant shall be set out at the corresponding mixing or crushing plant or at such other locations as approved by the Engineer.

The stockpile site shall be cleaned, and all loose stones, vegetation and other materials which may cause contamination shall be removed. The site shall be graded smooth with an adequate slope to ensure proper drainage. Where so instructed by the Engineer, the surface shall be watered and compacted to a depth of at least 150 mm to a density of 90 % of AASHTO (T180) density.

The compacted surface shall be firm without any loose patches. Where asphalt is recovered for recycling, the Engineer may order the surface to be chemically stabilised to a depth of 150 mm. Upon completion, this surface shall be swept clean.

Stockpile sites shall be sufficiently large to allow the placing of stockpiles of different types of material or types of recovered asphalt without the stockpiles overlapping or the limits of the prepared site being exceeded. The enlargement of the stockpile site after the stockpiles have already been placed will not be permitted without the approval of the Engineer.

Stockpiles of milled material shall be made in a manner which prevents segregation and undesirable consolidation or changes in moisture content. Adequate approved covers shall be provided as required in the opinion of the Engineer to prevent them from undesirable wetting or drying, or being contaminated by dust.

Upon completion of the work, the stockpile sites shall be broken up in accordance with the instructions of the Engineer.

The stockpiling of excavated material will not be paid for directly, but full compensation therefore shall be included in the rates for the various Items of work in which the stockpiled material will be used. Separate payment will not be made for the preparation of storage sites.

3307 Measurement And Payment

a. General

i. Material to be reprocessed

Payment will be made for breaking up and excavating or milling of existing pavement material that is to be reprocessed and reused, when:

1. The material is excavated or milled out in accordance with the provisions of the Special Specifications or upon the written instruction of the Engineer.
2. Bituminous surfacing or other bituminous pavement layers are removed separately from the underlying material in accordance with the Special Specifications or the written instructions of the Engineer.

ii. Material from an existing pavement which is not reprocessed

Existing gravel pavement material, or existing bituminous material not intended for reprocessing, may be spoiled or be used in other layers or Items of work where approved by the Engineer. Payment for the excavation of pavement material to be spoiled will be made directly under ITEM 36.01(a). Dumping shall only occur on approval of the Engineer in an approved waste site.

Where used for other purposes full compensation for excavating shall be included in the rates bid for the various pavement layers and Items or work in which the material is used.

iii. Measurement for excavating existing pavement material and underlying fill

Where payment is made separately for the excavation of existing pavement material and underlying fill, the quantity will be calculated in accordance with the authorised horizontal dimensions of the excavated layer and the average depth of excavation. The average depth of excavation will be determined in accordance with the test holes made or cores drilled at intervals not exceeding 10 m, and which are so distributed over the surface that a realistic estimate of the depth can be obtained.

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Earthworks | 3300 | Breaking Up Existing Pavement Layers

Item	Unit
33.01 Excavating Or Milling Of Material From An Existing Pavement:	
(a) Granular Material	Cubic Metre (m ³)
(b) Bituminous Material	Cubic Metre (m ³)
(c) Cemented Material	Cubic Metre (m ³)
(d) Concrete (Indicate Whether Reinforced Or Un-Reinforced)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of material excavated or milled from the existing pavement using approved equipment and methodology.

The bid rate shall include full compensation for excavating or milling the material from the existing pavement irrespective of layer thickness, for loading, transporting, off-loading, and placing the material in approved spoil dumps or stockpiles as directed by the Engineer.

Item	Unit
33.02 Sawing or Cutting Concrete, Asphalt or Cemented Pavement Layers:	
(a) Bituminous Material	Linear Metre (m)
(b) Cemented Material	Linear Metre (m)
(c) Concrete (Indicate Whether Reinforced Or Un-Reinforced)	Linear Metre (m)

The unit of measurement shall be the linear metre of sawcut calculated in accordance with the authorised length of sawcut.

The bid rate shall include full compensation for all material and sawing or cutting costs and for all incidentals for cutting or sawing the pavement in accordance with the instructions of the Engineer.

Item	Unit
33.03 Drilling and Testing Cores from Concrete, Asphalt or Cemented Pavement Layers:	
(a) Bituminous Material	Number (No.)
(b) Cemented Material	Number (No.)
(c) Concrete (Indicate Whether Reinforced Or Un-Reinforced)	Number (No.)

The unit of measurement shall be the number of cores drilled on the instructions of the Engineer.

The bid rate shall include full compensation for setting out the core locations, for drilling the cores and testing their strength in the laboratory as specified.

Item	Unit
33.04 Scarification and Recompaction of Existing Pavement Layers (State Scarification Depth and Density of Compaction):	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of existing pavement materials scarified to the specified depth using approved equipment and methodology.

The bid rate shall include full compensation for scarification of the existing pavement materials to specified depth irrespective of individual pavement layer thicknesses, mixing with imported materials if required, shaping, and compacting the material as specified.

SECTION 3400 Borrow Pit, Quarry Acquisition and Exploitation

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3401 Scope

Unless stated otherwise in the Special Specification, it is the responsibility of the Contractor to select the sources of aggregate for concrete and lean concrete, stone for bases and sub-bases, bituminous mix bases, binder courses and wearing "courses, chippings for surface dressings and rockfill for swamps. Such sources shall be designated as quarries and are defined in **CLAUSE 34602 (a)**. Such potential quarry sites as may have been identified prior to commencement of the Contract and were available for inspection at the time- of tender will also be the responsibility of the Contractor should the elect to use them.

The sources of natural materials such as fill material for the construction of embankments, and gravel for sub-base, base, surfacing and shoulders shall be designated as borrow pits and are defined in **CLAUSE 3402**. Certain borrow pits have been identified prior to commencement of the Contract and the Engineer will instruct the Contractor as to which of these are to be utilised for the extraction of natural material, to be used in the Works.

Provisions are included in subsequent **CLAUSES** of this section of the Specification for additional borrow pits to be identified and located by the Contractor during the Contract. Stockpile and spoil areas shall be located by the Contractor subject to the approval of the Engineer.

3402 Definitions

a. Quarry

A quarry is an open surface working from which stone is removed by drilling and blasting for use in the Works.

b. Borrow Pit

A borrow pit is a site from which material, other than stone, is removed for use in the Works.

A borrow pit may have been selected by the Engineer and be available for inspection at the time of Tender or alternatively it may be one proposed by the Contractor and approved by the Engineer during the Contract.

c. Stockpile Area

A stockpile area is an area where material such as topsoil, fill material, gravel or aggregate is stockpiled prior to use in the Works.

d. Spoil Area

A spoil area is a site upon which surplus or unsuitable materials arising out of the Works are dumped. Surplus or unsuitable material shall not be dumped within the road reserve without the approval of Engineer.

3403 Acquisition Of Land (Provision Of Land)

The Contractor shall make available free of charge to the Contractor and be responsible for acquisition of all land required for quarries, borrow pits, spoil and stockpile areas and for access thereto in accordance with **CLAUSE 1214** of this Specification.

The location and size of quarries, borrow pits, spoil and stockpile areas proposed by the Contractor shall be subject to the approval of the Engineer. The Engineer's approval may be withheld for any of the following reasons:

If the quarry, borrow pit, spoil or stockpile area, or access into then, in the opinion of the Engineer:

1. Is less than 3 km from the next quarry, borrow pit, spoil or stockpile area;
2. Will have a detrimental effect on the environment;
3. Will incur relatively high land acquisition costs or would be very difficult to acquire;
4. Is in or near an urban centre
5. Will require an access road which is excessively long;
6. Has excessively thick layers of overburden;
7. Covers too large an area;
8. Would constitute a danger to the public;
9. Is an excessive distance from the location the material is to be used removed from; or
10. A source of suitable material is closer at hand.

The Contractor shall inform the Engineer in writing not later than 90 days after the Contract Commencement Date of all quarries, borrow pits, spoil and stockpile areas that the Contractor will require for the whole of the Works and the Contractor shall programme for a period of 90 days from the date of the Contractor's written notice to the date when the Engineer makes the quarries, borrow pits, spoil and stockpile areas available to the Contractor. Prior to the submission of a written notice, the Contractor shall set out each quarry, borrow pit, spoil and stockpile area with concrete beacons clearly identifying the areas required for working areas, stockpile areas, blasting safety zones and access routes. The Contractor's written notice shall include the following for each quarry, borrow pit, stockpile and spoil area:-

1. A plan at 1:500 scale in ink on a stable transparent material giving details of:
 - i. Plot boundaries;
 - ii. Owners' names and addresses, and if appropriate id numbers;
 - iii. The district, location, registration section and number for each plot;
 - iv. Local details such as buildings, fences, graves, types and areas of cultivation and services, all agreed with the land owners; and (v) areas to be used for working areas, stockpile areas, blasting safety zones etc.
2. Cadastral maps covering the areas to be acquired.
3. Details of the proposed access road route.

Where Contractor uses a quarry or borrow pit identified or instructed by the Engineer he shall obtain the Engineer's approval of the areas required for the quarry or borrow pit and of the siting of the access roads into the quarry or borrow pit. The Engineer may require the Contractor to modify requirements for any of the reasons outlined in (b), (c), (d), (e), or (g).

Where borrow pits, available for inspection at the time of Tender, are instructed by the Engineer the Contractor shall satisfy themselves as to the quality and quantity of material available before providing the information required in this CLAUSE. Should such investigations reveal that there is insufficient suitable material for the use for which the borrow pit was intended, the Contractor shall immediately inform the Engineer in writing and the Engineer shall either direct that the borrow pit is extended or that a new borrow pit shall be used.

The Contractor shall be responsible for any delays in the land acquisition which occur due to any of the above information being incorrect and the 90- day period for land acquisition shall be extended by the period of any such delay.

When a quarry, borrow pit, spoil or stockpile area has insufficient suitable material or area for the use for which it was intended the Contractor shall propose in writing that either an existing quarry, borrow pit, spoil or stockpile area be extended or that a new quarry, borrow pit*- spoil or stockpile area shall be used. The approval and acquisition of such new or extended quarries, borrow pits, spoil or stockpile areas shall be in accordance with all the above provisions of this CLAUSE 3403 for the acquisition of the original quarries, borrow pits, spoil or stockpile areas.

The Contractor's obligations with regard to quarries etc. as set out above shall also apply to land required in accordance with CLAUSE 1214 of this Specification

3404 Entry Upon Land

The Contractor shall, before entering upon any land provided by the Employer, satisfy themselves that legal rights of entry have been obtained.

Where it is necessary to agree levels for the calculation of quantities, the Contractor shall not enter the area until such levels have been agreed and the Engineer's approval obtained.

3405 Safety And Public Health Requirements

The Contractor shall comply with the Bye-laws of the Local Authority regarding public health and safety in respect of the operation of quarries, borrow pits, stockpile or spoil areas, and in the absence of, or in addition to such Bye-laws, shall comply with the following conditions:-

- a. All areas being worked shall be drained and kept drained. Where a quarry or borrow pit has been excavated so that it will not drain naturally, it shall be kept pumped dry while being used.
- b. The Contractor shall confine operations solely to the areas provided and shall demarcate the boundary of the area and erect temporary or permanent fencing as instructed by the Engineer.
- c. Where the height of any face exceeds 1 metre, the Contractor shall provide, erect and maintain at their own expense stockproof to prevent unauthorised access to the top of the working face.
- d. On completion of work all faces shall be neatly trimmed to a slope flatter than 1 in 4. Where this is impracticable or where the working face is to be left exposed, the edge shall be permanently fenced, as instructed by the Engineer, and measurement and payment for such fencing shall be in accordance with the requirements of SECTION 8300 of this Specification.
- e. On completion of work temporary fences and all temporary structures shall be demolished and removed, all latrine pits filled in and drained and the site topsoiled and left neat and tidy.

3406 Access Road And Traffic Control

The Contractor shall comply with the provisions of SECTION 1500 of this Specification with regard to the construction and maintenance of access roads to quarries, borrow pits, spoil and stockpile areas and with regard to traffic operations thereon.

3407 Site Clearance And Removal Of Top Soil

Unless otherwise instructed by the Engineer, the Contractor shall clear the sites of all quarries, borrow pits, stockpile and spoil areas in accordance with SECTION 3100 of this Specification, but measurement and payment will be in accordance with this section of this Specification.

All existing fences, trees, hedges and other features which the Engineer instructs shall not be removed or otherwise dealt with shall be protected in accordance with the requirements of SECTION 3100 of this Specification.

Unless otherwise directed by the Engineer the Contractor shall remove topsoil and/or overburden from quarries, borrow pits, spoil and stockpile areas. The Engineer shall direct whether topsoil shall be stripped and stockpiled separately or shall be excavated and spoiled together with the overburden. If suitable the Engineer may direct that overburden be used in the Works.

On completion of work in any quarry, borrow pit, spoil or stockpile area the overburden and/or topsoil which has not been used in the Works shall be pushed back, spread and landscaped over the area of the quarry, borrow pit, spoil or stockpile area. Where topsoil has been stockpiled separately it shall be pushed back and spread over the quarry, borrow pit, spoil or stockpile area after landscaping unless the Engineer has instructed that it be used for topsoiling in accordance with SECTION 3100 of this Specification.

3408 Opening And Working Borrow Pits And Quarries

a. Excavating Borrow Material

The Contractor's attention is drawn to the provisions of SECTION 9100 regarding provision of an Environmental Management Plan.

All opening and working of borrow pits shall be undertaken in a manner which prevents contamination or undesirable mixing of materials.

Where any borrow pit contains different types of materials which require mixing to produce a suitable product, the materials shall be excavated and handled by use of methods approved by the Engineer.

The Contractor shall take all precautionary measures so as to avoid contamination of the suitable material by the inclusion of clayey or otherwise unsuitable material from the floor of the borrow pit, the overburden, any unsuitable layers, or areas beyond the approved limits of the borrow area. During loading, any hard oversize material which will not break down during processing on the road shall be excluded as far as is practicable.

During borrow operations, and especially when excavating material near the floor and outer boundaries of the borrow areas, the Contractor shall plan their operations so as to reduce, in so far as is possible, the amount of earth moving work that will be necessary for finishing-off the borrow pits. Indiscriminate excavation without due regard being made to the desired final shape of the borrow pit will not be permitted.

The material in borrow pits shall be blasted or ripped and excavated in a manner that will ensure the effective breaking-down of the material in the borrow pit before it is loaded. Rippable material which tends to break into large blocks shall be cross-ripped.

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b. Control at Borrow Pit

The Contractor shall be responsible for controlling their operations at every borrow pit where material is being excavated to ensure compliance with all the requirements of the Specifications.

The Contractor shall carry out sufficient tests on the material being excavated from the borrow pit to ensure that the quality of the material will comply with the specific requirements for the particular layers for which it will be used. If required for the proper control of quality, in the opinion of the Engineer, the materials shall be stockpiled prior to loading and tests of the stockpiles carried out as required.

If there is any doubt concerning the quality of the borrow material being excavated at any time, the Contractor shall notify the Engineer immediately, and in any case before such material is brought onto the road. The results of all tests carried out by the Contractor shall be submitted without delay to the Engineer. The Engineer may, after further testing or inspection if necessary, approve the use of the material in the borrow area, or they may order the borrow pit to be finished off and abandoned. Any such approval by the Engineer does not indemnify the Contractor with regards to their obligations to fulfil all requirements of the Specifications in respect of the quality of materials for earthworks or pavement layers.

c. Protecting Borrow Pits and Quarries

Borrow pits and quarries shall be continuously protected against the ingress of surface water, and the Contractor shall construct such temporary banks as may be required for diverting surface water, and, in so far as is possible, their operations shall be planned in such a way that the borrow pit and quarry will be self draining. Where this is not possible, borrow pits and quarries shall be dewatered by pumping. The Contractor shall be solely responsible for keeping borrow areas and quarry sites dry and ensuring that borrow material is sufficiently dry when required for use.

d. Access Roads

The Contractor shall obtain the Engineer's prior approval to the siting of junctions of access roads with existing roads and shall comply with the Engineer's conditions of access particularly regarding clearance of obstructions to provide adequate sight lines, temporary drainage or culverts and the provision of signs and traffic control.

The provision of access roads shall not be measured for payment.

e. Private Access Roads

Where private roads are to be used as access roads, the Contractor shall after consultation with the Owner or Authority having control of such road, carry out any repairs, alterations or additions to such roads as may be required to bring them to an acceptable condition suitable for traffic. Where materials from a borrow pit or quarry are hauled on private access roads, such roads shall be maintained properly to the satisfaction of the Engineer during borrow and quarry operations. No additional payment will be made for this work, and full compensation for maintaining private access roads used as haul roads will be regarded as being included in the bid rates and paid for in the various Items of work where the materials are used.

3409 Selection, Breaking Down Materials, Mixing And Stockpiling Of Materials

Before a borrow pit is opened, the Engineer will instruct the Contractor as to the type of material to be excavated and the areas and depths to be worked.

The Contractor may be required to mix the selected materials by bulldozing into stockpiles and/or by face loading by shovel. The stockpiles shall be formed at least six weeks before intended use for materials which are to be treated and at least three weeks before intended use for materials which are not to be treated.

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The Contractor shall ensure that oversize material, clay, humus or other inferior material encountered in the workings is separated from the materials proposed for use in the Works and such inferior material shall be removed to spoil.

A separate stockpile shall be used for each type and grading of material.

When removing material from stockpiles, none of the underlying material shall be mixed with it, and generally at least the bottom 100 mm layer shall be left behind.

Should any stockpiles prove surplus to requirements the Contractor shall spread the material over the area of the quarry or borrow pit unless directed otherwise by the Engineer.

3410 Material Utilisation

Where the Contractor uses a borrow pit, instructed by the Engineer for use in earthworks or under 'Method A' of SECTION 4100 of this Specification, for the construction of access roads, deviations, detours, haul roads, camps, temporary works or for any other works not part of the permanent works then the cost of site clearance, topsoil and overburden removal and access roads to such borrow pits shall be borne by the Contractor in the proportion that the volume of material removed for the Contractor's purposes and not part of the permanent Works bears to the total volume of material removed from the borrow pit.

Where a borrow pit instructed by the Engineer for use in earthworks or under 'Method B' of SECTION 4100 of this Specification is used to construct works for which there are different methods of measurement and payment then the quantity of site clearance, topsoil and overburden removal and access roads to such borrow pits shall be divided between each method of measurement in the proportion that the volume of material removed for each purpose bears to the total volume of material removed from the borrow pit.

Where a borrow pit instructed by the Engineer under 'Method A' of SECTION 4100 of this Specification is used to construct several works for which there are different methods of measurement and payment then the site clearance, topsoil and overburden removal and access roads shall all be measured and paid for in accordance with 'Method A' of SECTION 4100 of this Specification.

All materials from borrow pits instructed by the Engineer shall only be used for permanent Works shown on the Drawings or instructed by the Engineer and any other use shall be subject to the Engineer's approval.

3411 Reinstating Borrow and Quarry Areas And Haul Roads

a. Borrow and Quarry Areas

On completion of their operations in borrow and quarry areas, the Contractor shall reinstate the entire area so as to blend it with the surrounding area and to permit the re-establishment of vegetation. For this purpose the borrow area shall be shaped to even contours without any slopes being steeper than 1:3, except where the Engineer so permits in specified cases. In such cases the Contractor shall, if so instructed by the Engineer, construct berms and contour banks to prevent erosion.

All material in and around the borrow areas, where spoil from clearing and grubbing operations or excess overburden, shall be used or disposed of as directed by the Engineer. Solid waste and rubbish may not be dumped into the borrow area. Material incapable of supporting vegetation shall be buried and used for shaping the borrow area and shall subsequently be covered with soft material. All available soft material shall be spread evenly to the prescribed thickness, and where sufficient material is not available for so covering the entire area, the remaining portions shall be scarified along contours so as to avoid undue erosion.

The shaping and reinstatement of the borrow pit shall be done in such a manner that the borrow pit will be properly drained wherever practicable, and, where required, the Contractor shall place earth banks to divert surface water from the borrow area. If so directed, the borrow and quarry area shall be fenced off and provided with gates as specified in SECTION 8300, and top-soiled and/or hydro-seeded as specified in SECTION 8600.

The reinstatement of the borrow and quarry areas shall be to the entire satisfaction of the Engineer and the Contractor shall submit to the Engineer a signed certificate from the Landowner, or Legal Occupants of land or relevant Government Agency stating that the finishing-off complies with all necessary legal provisions. The Contractor's attention is drawn to the provisions of CLAUSE 1216 in this respect.

b. Haul Roads

Unless otherwise specified or instructed by the Engineer all haul roads shall be obliterated and their surfaces scarified, earth banks shall be constructed to prevent erosion, and all damaged fences and other structures shall be reinstated.

Where materials from a borrow pit or quarry are hauled on private access roads, such roads shall be restored to their original condition to the satisfaction of the Engineer when operations at the borrow pit and quarry are completed, unless otherwise specified.

No additional payment will be made for obliteration, or restoration respectively, of haul roads or access roads to borrow pits or quarries. Full compensation for this work is regarded as being included in the bid rates and paid for elsewhere.

3412 Disposal Of Borrow Or Quarry Material

The Contractor shall not have the right to use material obtained from borrow pits or quarries for any purpose other than for the execution of this Contract. The Contractor shall not dispose off any such material whether processed or not either by sale or donation to any person without the authorisation of the Employer.

3413 Measurement and Payment

No separate measurement and payment will be made for procuring and providing borrow or quarry material, but it will be regarded as an obligation on the part of the Contractor to be covered by the contract prices paid for the various Items of work for which the material is used as prescribed in these Specifications.

Such bid rates related to procuring and providing borrow or quarry material shall also include full compensation for all obligations, costs, activities and work as prescribed in SECTION 1200, including all necessary de-watering as well as for all supervision, labour, plant, tools and incidentals required, including all costs as may be necessary for conducting control tests on all materials, draining and protecting all borrow or quarry areas, and concluding all negotiations with Owners or Legal Occupants of land (except negotiations that are conducted by the Employer as specified, also for finally shaping and finishing the borrow pits and quarries.

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SECTION 3500 Earthworks, Ground Improvement, Fill and Subgrade Treatment

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3501 Scope

This section covers all excavation of cuttings, which for the purposes of this section includes side drains and benches, the placing and compaction of hard and soft material for fill in embankments, ground compaction, the formation of the subgrade, excavation and rock fill to swamps and top soiling and grassing.

3502 General

All earthworks shall be constructed as shown on the Drawings or as directed by the Engineer to the specified slopes, levels, depths, widths, tolerances and heights. Should any earthworks not be constructed to the slope, level, depth, width, tolerance or height shown on the Drawings or as directed by the Engineer the Contractor shall make good the area affected at the Contractor's expense.

The Contractor shall excavate cuttings and place fill in embankments in accordance with the Drawings or as directed by the Engineer. Suitable excavated materials will be used to form embankments, excess or unsuitable materials being disposed of to spoil areas. Where the mass haul diagram in accordance with SECTION 1600 of this Specification indicates that the quantity of material required for embankments exceeds that available from cuttings, the Contractor will be instructed by the Engineer to widen cuttings and/or to open borrow pits.

At all times the Contractor shall ensure that earthworks are not damaged by weather or traffic. In the event of such damage occurring the Engineer may withdraw approval from the affected Works until the Contractor has carried out repairs to restore the Works to their original condition. The expenses of all such repairs and any additional testing will be borne by the Contractor.

The Contractor shall provide adequate supervision to ensure that only suitable materials are incorporated in embankments. If any unsuitable material is included it shall be removed and replaced with suitable material at the Contractor's expense.

All trimming of cuttings, embankments, side drains, and shoulders to the specified slopes and shapes shall be carried out concurrently with the earthworks that are being carried out at that particular site and level.

3503 Classification Of Material

There shall be two classifications of material, that is "hard material" and "soft material" which shall be defined as follows:-

a. Hard material

Hard material shall be defined as material whose average unconfined compressive strength determined from a sample of six cores, exceeds 10 MPa.

Where it is impractical to prove hard material by the above method then the quantity of hard material, if any, shall be determined by the Engineer.

Where excavation contains individual boulders of hard material greater than 0.3 m³ each in volume then such boulders shall be classified as hard material.

Hard material shall not be placed within 600 mm of the formation level in embankments and shall be removed to a depth of 300 mm or as otherwise instructed by the Engineer below formation level in cuttings.

b. Soft Material

Soft material shall be all materials other than hard material. Soft material shall include waterlogged and swampy material except within swamps covered by [CLAUSE 3506](#) of this Specification.

3504 Preparation Prior To Forming Embankments

The Contractor shall excavate benches in natural ground having a side slope greater than 1 in 5 or as instructed by the Engineer. The existing slopes, after the removal of topsoil shall be benched in accordance with the Drawings prior to the construction of embankments. The material which is excavated to form benches shall either be taken to spoil or if suitable used as fill. The actual bench widths will be shown on the Drawings or Instructed by the Engineer.

The existing ground under embankments, and bench surfaces where appropriate, shall be compacted over the full width of construction to 95 % MDD (AASHTO T99) to a depth of 150 mm. The existing ground moisture content shall be adjusted prior to compaction by either uniformly mixing in water or drying out the material such that at the time of compaction the moisture content shall be within the range 75 - 105 % of the Optimum Moisture Content (AASHTO T99).

Whenever the existing ground is unsuitable in quality for receiving fill, the Contractor shall excavate to the depth instructed by the Engineer, remove the material to a spoil area and replace it with suitable material.

3505 Construction Of Lower Embankments

Material obtained from cuttings shall be used to construct embankments. Material from borrow pits shall be used only where the Contractor has demonstrated and the Engineer agreed that there is an inadequate quantity of suitable material obtainable from cuttings.

The Contractor may, to suit their method of working, take suitable fill material obtained from cuttings to spoil provided they substitute an equivalent quantity of suitable fill material from a borrow pit or other source. The Contractor shall be solely responsible for the acquisition of land for the spoil and borrow areas required in these circumstances and any additional costs due to the substitution over and above the cost of taking the material from cuttings or benches to fill shall be at the Contractor's expense.

All fill materials shall comply to with the specifications set out in [TABLE 3505/1](#) and detailed in [TABLES 3505/2](#) to [3505/7](#).

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Soft material in the upper 300 mm below formation level in both embankments and cuttings shall not contain particles larger than 25 mm. In addition the material shall have a CBR of not less than 10 % measured after a 4-day soak on a laboratory mix compacted to a dry density of 100 % MDD (AASHTO T99), a swell of less than 1 % and a Plasticity Index of less than 50 %. In situ material in the 300 mm below formation level in cutting that does not meet these requirements shall either be spoiled or if suitable placed in the embankment and replaced with material from cuttings or borrow pits that does meet the requirements for soft material for use in the 300 mm below formation level.

The in situ compaction requirements shall be as follows:

- i. All fill material in embankments, except the 300 mm below formation: 100 % MDD (AASHTO T99)
- ii. The 300 mm below formation in embankments: 95 % MDD (AASHTO T180)
- iii. The 300 mm below formation in cuttings under the carriageway and shoulders: 95 % MDD (AASHTO T180).

Where materials of differing quality are available for placing in embankments the Engineer may instruct that certain materials should be excluded from the upper 300 mm of fill and he may instruct that certain materials should be set apart, or obtained from borrow pits, for use in these upper layers. He may also instruct that part or all of these upper layers be stabilised using either cement or lime in accordance with SECTION 4400 of this Specification. The extent of stabilisation will be detailed in the Special Specification or shown on the Drawings.

The Contractor shall ensure that earthworks proceeds towards completion in an orderly and continuous manner. The Contractor shall submit a written request for approval of any layer at least 18 working hours before he intends to cover a completed layer. Fill material for subsequent layers shall be placed immediately approval of the previous layer has been given to ensure retention of moisture.

Should any layer be left unprotected for more than 24 hours subsequent to approval, the Contractor shall request re-approval of such layer.

Soft material as fill shall be deposited in layers not exceeding 150 mm compacted depth unless, as a result of site compaction trials, the Contractor has satisfied the Engineer that their compaction plant is capable of consistently achieving the specified densities at a greater depth; in no case shall this depth exceed 250 mm. Each layer shall extend over the full width of the embankment and shall be compacted in accordance with CLAUSE 3511.

Hard material used for fill shall be of maximum dimension 250 mm, and be deposited in horizontal layers not exceeding 400 mm loose depth and shall extend over the full width of the embankment except for any specified external cover to slopes. The material shall be spread and levelled by a crawler tractor weighing not less than 15 tonnes. Each layer shall consist of reasonably well graded rock and shall be blinded with smaller rock fragments and gravel so as to fill as many of the voids as possible before the next layer is placed. The top 600 mm of the subgrade shall be formed using soft material.

In forming embankments, the Contractor shall make due allowance in height and width for consolidation, settlement and shrinkage. Any consolidation, settlement, bulking, punching of material into the underlying layer, or shrinkage during the construction of embankments shall be rectified by the Contractor by providing, placing and compacting approved fill material to reinstate each layer to the instructed level and width and shall be at the Contractor's expense.

During the construction of embankments the Contractor shall control and direct constructional traffic uniformly over the full width. Fill material shall not be stockpiled on embankments without the express permission of the Engineer.

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When constructing embankments up to bridges and up- to and over culverts, the Contractor shall raise the embankment equally on each side of such structures and shall unless otherwise instructed by the Engineer carryout this work concurrently with the filling to the structure. The embankment compaction plant shall be used as close to the structure as is feasible without damaging the structure. Any damage to the structure will be made good at the Contractor's expense.

TABLE 3505/1: REQUIREMENTS FOR FILL MATERIAL

Determined Native/ In-situ Subgrade Class	Requirements for Fill in Soft Material		
	Lower subgrade (Fill below the Pavement Foundation ¹)	Upper subgrade (Pavement Foundation)	
		Top 300 mm of the subgrade below the formation	Top 300 mm of fill below improved subgrade ²
Below Class S1: CBR < 2 %	CBR ≥ 3 %	N/A	G3
	Swell: < 3 %		
	LL: ≤ 70 %		
	PI: ≤ 50 %		
S1: CBR 2-5 %	CBR ≥ 3 %	N/A	G3
	Swell: < 3 %		
	LL: ≤ 70 %		
	PI: ≤ 50 %		
S2: CBR 5-10 %	CBR ≥ 5 %	N/A	G8
	Swell: < 3 %		
	LL: ≤ 70 %		
	PI: ≤ 50 %		
S3: CBR 7-13 %	CBR ≥ 7 %	G10 for foundation Class F1	G10
	Swell: < 2.5 %		
	LL: ≤ 50 %		
	PI: ≤ 35 %		
S4: CBR 10-18 %	CBR ≥ 10 %	G14 for foundation Class F2	G14
	Swell: < 2.5 %		
	LL: ≤ 50 %		
	PI: ≤ 30 %		
S5: CBR 15-30 %	CBR ≥ 15 %	G23 for foundation Class F3	G23
	Swell: < 2 %		
	LL: ≤ 35 %		
	PI: ≤ 25 %		
S6: CBR 30-60 %	CBR > 30 %	G45 for foundation Class F4	G45
	Swell: < 0.5 %		
	PI: ≤ 12 %		
	PM: ≤ 250		

Notes:

1 The foundation is the upper subgrade below the formation. Where no capping (improved subgrade) is provided, it is the upper 300 mm of the subgrade below the formation. Where a capping layer is provided, the foundation shall be defined as the combination of the top 300 mm of fill or cutting and all the capping layers provided. The sub-base is not part of the foundation, it is considered a pavement layer.

2. Material specifications for G3, G8, G10, G14, G23, G30 and G45 are provided in TABLES 3505/2 to 3505/7.

TABLE 3505/2: SPECIFICATIONS FOR G3 FILL MATERIAL

Property	Specification
Natural silty/sandy/gravelly clays, silty/clayey sands conforming to the following requirement:	
CBR at 100 % MDD (AASHTO T99) and 4 days soak (%)	Min. 3.0
Swell (%)	Max. 3.0
Max. size	1/2-layer thickness or 50 mm whichever is lesser
Liquid Limit	Max. 70
Plasticity Index (%)	Max. 50

TABLE 3505/3: SPECIFICATIONS FOR G8 FILL MATERIAL

Property	Specification
Natural silty/sandy/gravelly clays, silty/clayey sands conforming to the following requirement:	
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min. 8
Swell (%)	Max. 3.0
Max. size	1/2-layer thickness or 50 mm whichever is lesser
Liquid Limit	Max. 70
Plasticity Index (%)	Max. 50

TABLE 3505/4: SPECIFICATIONS FOR G10 FILL MATERIAL

Property	Specification
Natural or blended silty/sandy/gravelly clays, silty/clayey sands, sands, or gravels conforming to the following requirement:	
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min. 10
Swell (%)	Max. 2.5
Max. size	2/3-layer thickness or 80 mm whichever is lesser
Liquid Limit	Max. 50
Plasticity Index (%)	Max. 30
Coefficient of Uniformity	Min 6

TABLE 3505/5: SPECIFICATIONS FOR G14 FILL MATERIAL

Property		Specification
Natural or blended silty and clayey sands, sands, gravels, volcanic gravel (scoria), conforming to the following requirement:		
Gravels	Max. size	10 – 50
	Passing 0.075 mm sieve (%)	Max 50
Sands, silty and clayey sands	Max. size	0.5 – 10
	Passing 0.075 mm sieve (%)	Max 50
All materials	CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min 14
	Swell (%)	Max. 1.0
	Plasticity Index (%)	Max. 30
	Plasticity Modulus	Max. 2500
	Organic matter (%)	Max 2
	Coefficient of Uniformity	Min 6

TABLE 3505/6: SPECIFICATIONS FOR G23 FILL MATERIAL

Property		Specification
Natural or blended silty and clayey sands, sands, or gravels conforming to the following requirement:		
Gravels	Max. size	10 – 50
	Passing 0.075 mm sieve (%)	Max 40
Sands, silty and clayey sands	Max. size	0.5 – 10
	Passing 0.075 mm sieve (%)	Max 50
All materials	CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min 23
	Swell (%)	Max. 1.0
	Plasticity Index (%)	Max. 25
	Plasticity Modulus	Max. 2500
	Organic matter (%)	Max 2
	Coefficient of Uniformity	Min 6

TABLE 3505/7: SPECIFICATIONS FOR G45 FILL MATERIAL

Property	Specification	Property	Specification
Grading After Compaction		CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min 45
Sieve (mm)	% by weight passing		
50	100	Los Angeles Abrasion (%)	Max 70
37.5	90 – 100	Aggregate Crushing Value (%)	Max 40
28	75 – 95	Plasticity Index (%)	Max 10
20	60 – 90	Plasticity Modulus	Max 250
10	40 – 75	MECHANICAL STABILISATION These requirements and limitations also apply to mixtures of natural gravel and sand and of natural gravel and up to 30 % of stone (crushed or not)	
5	29 – 65		
2	20 – 45		
1.18	17 – 40		
0.425	12 – 31		
0.075	5 – 25		

Treatment of Expansive Soils

If so specified in the Special Specification or directed by the Engineer particular remedial measures shall be taken to reduce the risk of future damage to the road caused by swelling or shrinkage of expansive roadbed material. If cost considerations prohibit full replacement of the expansive soils, the remedial measures should aim at providing nearest possible constant moisture content over the full width of the carriageway below the embankment. The remedial measures may include one or more of the following:

1. Replace the upper layer of the expansive soil to a depth of at least 600 mm with no expansive material, i.e. The zone where the largest proportion of the volumetric changes takes place,
2. Provide wider paved shoulders to move the zone of seasonal changes in moisture content further away from the roadway,
3. Provide embankment with minimum height of about 1 m and with side slopes of 1:4 or flatter,
4. Provide an impermeable membrane in the full embankment width under the pavement and sandy drainage layer on top of the membrane,

5. Lime stabilisation of the expansive clay to a depth of 300 mm to achieve a plasticity index less or equal to 15, normally by use of lime, to counteract volumetric changes in the expansive soils, but although this is technically possible it requires careful appraisal of the associated construction costs as well as the potential practical problems in admixing stabilisers into deep layers of clayey soils.
6. Any combination of the above measures as specified in the Special Specification or directed by the Engineer.

Embankment Protection

Where required, the toes of fills shall be protected against erosion by special rock protection, which shall be installed as shown on the Drawings and as further directed by the Engineer, by the outer part of the toes of fills being constructed from assorted boulders and/or blasted rock, as described below.

The rock protection shall be constructed simultaneously with the rest of the fill and shall consist of selected durable rock material varying in size between 150 mm and 750 mm. If required, a layer of approved geotextile filter shall be installed at the interface between the normal fills and the rock protection.

The outer part of the rock protection shall consist of larger boulders properly bedded by means of smaller fragments so as to form a stable interlocking rip-rap surface. The rock protection shall otherwise be constructed and compacted as rock fill as described in the Specifications.

Finishing the Slopes

a. General

Except in solid rock, the tops and bottoms of all slopes including the slopes of drainage ditches shall be rounded as indicated on the Drawings or as ordered by the Engineer. Slopes at the junctions of cuts and fills shall be adjusted and warped to flow into one another or into the natural ground surfaces without any noticeable break.

When so directed by the Engineer, adjustment to the slopes shall be made in order to avoid damage being done to standing trees and to harmonise with existing landscape features. The transition to such adjusted slopes shall be gradual.

Cut and fill slopes shall be finished to a uniform appearance without any noticeable break which can be readily discerned from the road. The degree of finish required for all fill slopes and for cut slopes flatter than 1:4 shall be that normally obtainable by motor grader or hand-shovel operations.

The slopes of cuts and fills which are designated for grassing shall, after finishing, be prepared for grass planting and/or for topsoil for grass planting as specified in **CLAUSE 3516** and **SECTION 8600**.

All trimming of cut slopes shall be completed before any work on the sub-base is commenced inside such cuttings.

b. Cut Slopes

i. Cuts in Soils

The slopes of cuttings shall be trimmed to neat lines and to a standard that is generally attainable with proper care and workmanship in the type of material concerned. All loose rocks, stones and nests of loose material shall be removed, especially in solid-rock cuts, which must be completely free from such material. The final surface of batters must be absolutely smooth to prevent initiation of slope erosion unless alternative methods for grassing or the establishment of natural vegetation is instructed by the Engineer.

ii. Cuts in Rock

Cuts in rock shall be cleared of all loose stones to the satisfaction of the Engineer.

c. Fill Slopes

Fill slopes shall be finished to neat lines with all loose rocks and un-compacted material removed. The degree of finish required shall depend on the nature of the material used for the fill slope but shall be as smooth as is consistent with the material involved and good workmanship to the satisfaction of the Engineer.

3506 Swamps

Areas that are to be classified as swamps or soft material will be identified and the treatment thereof shall be as follows.

Two different techniques may be employed when constructing the embankments across swamps and wetlands as directed by the Engineer:

1. In shallow swamps where tracked earthmoving plants can operate without getting stuck, the soft material shall be removed by tracked earthmoving plant and immediately be replaced with G8 material.

Where filling takes place under the water table, the fill materials shall be selected, well-draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 15 % and a maximum Plasticity Index of 25 %. This layer is to be constructed by dumping and spreading successive loads of material in a uniform layer thickness just sufficient to provide a stable working platform for the construction of further fill layers above the water table which are to be compacted according to the Specifications. The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material.

Light hauling equipment shall be used when driving on top of this stable platform as instructed by the Engineer.

The fill placed under the water table cannot be compacted to the normally required density for fill and will be allowed to settle under the dead weight of the embankment, until the movements in the surface of the embankment have diminished.

2. In swamps where the above technique cannot be used due to the thickness of the soft and unsuitable material, the embankment shall be constructed using the displacement method. In this method the excavation of soft and unsuitable materials shall be done by a tracked excavator, followed by end-tipping G8 material up to a height above the water table which can provide a stable working platform for the construction of further fill layers up to the top of the embankment. The end-tipping of the G8 material shall be done before soft or unsuitable material flows into the excavation for the embankment. The inflow could possibly be reduced by excavating outside the boundary of the material to be backfilled.

The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this stable platform as instructed by the Engineer.

The fill material under the water table shall be selected, well-draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 5 % and a maximum Plasticity Index of 6 %. It is not expected that it will be possible for the excavator to excavate all soft materials as similar ground will be flowing into the excavation. However, as the soft material has a very low strength, which has been further reduced by the excavation operation, the soil is expected to be displaced by the dead weight of the embankment.

Preloading, including vertical drains, shall be as specified in the Special Specifications. The operation shall move along the existing embankment and displace the soft and unsuitable material in an outgoing direction. Displacement without excavation by excavator will not be permitted due to the risk of leaving highly compressible material below the embankment soil.

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The fill above the water table shall be compacted according to the Specifications, whereas the fill placed under the water table cannot be compacted to the normally required density for fill and will be allowed to settle under the dead weight of the embankment.

The slope of the embankment sides in swamps where this technique is employed shall be increased to 1 in 4.

After construction of the embankment, the Contractor shall carry out auger drillings through the constructed embankment and into the in situ subsoil below the fill at intervals not exceeding 40 square metres. The Engineer may at their discretion instruct further auger drillings at no additional cost. The findings shall satisfy the Engineer that all soft materials such as peat and soft clay have been excavated/displaced by the embankment soil. Any sections not constructed to the satisfaction of the Engineer shall be reworked.

In order to minimise differential settlements in the finished road surface, the widening of embankments shall be carried out well in advance of placing the pavement layers on that particular section. This is expressly important where the new road will be placed partly on a new constructed embankment and partly on the existing road embankment. In such cases, where the height of the new embankment exceeds 2.0 m, the existing embankment shall be cut to the level of the stable working platform of the embankment widening but in no case lower than 0.5 m above the water level/adjacent ground level. Embankment fill material shall be placed full width according to normal and approved construction methods over both the existing and widened embankment foundation. The existing embankment material shall where possible be used for this filling operation and be compacted according to the Specifications.

Widening of the embankments through the swampy areas shall be performed as early as possible and be completed within 12 months of Notice to Commence. The time lap between finished embankment up to formation level and placement of the pavement layers will depend on the rate of settlement in the surface. To monitor this rate of settlement, the Contractor shall, unless otherwise instructed by the Engineer, erect secure concrete beacons on the finished embankment, and perform accurate levelling at times determined by the Engineer. No compensation will be paid to the Contractor for a delay in time of up to four months between finishing the embankment and commencement of the pavement layers on that particular section

The rates for construction of the embankment fill is deemed to include all extra cost relating to the special techniques used in constructing the embankment across swampy areas, use of material from the existing fill in the construction of the widened part of the new fill and any other measures directed by the Engineer.

All areas other than those so specified shall be considered as normal earthworks and the Contractor's rates shall include for all the requirements of **CLAUSE 3505** of this Specification.

3507 Rockfill To Swamps

Where specified in the Special Specification or instructed by the Engineer the Contractor shall place rockfill to swamps. The rockfill shall be obtained from a rock quarry and shall be loaded, transported from a rock quarry, placed in uniform layers rolled and trafficked until it is fully embedded over the whole area instructed. The rockfill shall be of maximum dimension 250 mm, reasonably well graded and with not more than 5 % finer than 10 mm. The layer thickness and number of layers shall be as instructed by the Engineer who may vary the requirement during the rockfill operation. Each layer shall be blinded with smaller rock fragments so as to fill as many of the voids as possible before the next layer is placed. Before additional layers are placed or before normal earthworks resume the Contractor shall proof roll each layer in accordance with **CLAUSE 3514** of this Specification.

Where instructed by the Engineer the Contractor shall place a filter fabric under or around the rockfill. When placing the rockfill onto or in the filter fabric the Contractor shall ensure that the filter fabric is not punctured or damaged in any way. Where the filter fabric is placed around the rockfill the final

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layer of rockfill shall be blinded with gravel so as to present a smooth surface to receive the filter fabric. The filter fabric shall be installed in accordance with the manufacturer's instructions.

Where instructed by the Engineer, the Contractor shall first excavate unsuitable material and then place and embed rockfill on and into the underlying material, or on a filter fabric if specified by the Engineer.

Dump Rock

Dump rock (minimum core UCS 7.5 MPa) meeting the requirements in TABLE 5.5 may be used for swamp treatment. Dump rock may be placed in layers not thicker than 1 metre in one operation. Each boulder shall not be larger than two-thirds (usually not larger than 600 mm diameter) of the compacted thickness. It is dumped in soft uncompactable soils as initial step in embankment construction in swampy soils. Where impermeable layers of fill are required, dump rock shall not be used. Construction of improved subgrade made of dump rock shall be finished off by filling the voids with non-plastic rock dust. Where applicable a geosynthetic may be used for separation, followed by the placement of fill material and/or improved subgrade layers.

3508 Construction Of Pavement Foundation

The pavement foundation shall comprise natural improved subgrade materials, lime and cement treated materials, and bitumen stabilised materials. These shall be constructed in accordance with CLAUSE 3511. The maximum compacted thickness processed and compacted at one time shall be 150 mm.

Performance-designed foundations shall be constructed as special specifications and under the supervision and to the satisfaction of the Engineer.

3509 Natural Improved Subgrade Materials

The moisture content of all capping materials shall be adjusted immediately prior to compaction by either uniformly mixing in water or drying out the material such that the moisture content during compaction is between 75 % and 105 % of the Optimum Moisture Content (AASHTO T180). The moisture content shall be kept within these limits until compaction is complete except where otherwise instructed by the Engineer.

Each layer of material shall be compacted at a moisture content within the above limits to a dry density equal to at least 95 % of the Maximum Dry Density (MDD) determined in accordance with AASHTO T180.

The maximum compacted thickness processed and compacted at one time shall be 150 mm.

3510 Hydraulically Improved Subgrades

Improvement with a hydraulic binder if required by the Special Specification or Drawings shall be carried out on subgrade materials that comply with the requirements of SECTION 3500 and shall be treated in accordance with SECTION 4400 of this Specification.

3511 Compaction Of Lower And Upper Subgrade

The lower subgrade is defined as cut or fill embankments below the foundation/upper subgrade. The upper subgrade is defined as the top 300 mm of the subgrade below formation level in cuttings and fills where there is no improved subgrade, or the upper 300 mm of the subgrade in cuttings and fills including any improved subgrade layer.

The moisture content of fill material, except the 300 mm below formation, shall be adjusted immediately prior to compaction by either uniformly mixing in water or drying out the material such

that the moisture content during compaction is between 75 % and 105 % of the Optimum Moisture Content (AASHTO T99). The 300 mm below formation in both embankments and cuttings shall be adjusted by either uniformly mixing in water or drying out the material such that the moisture content during compaction is between 75 % and 100 % of the Optimum Moisture Content (AASHTO T180). The moisture content shall be kept within these limits until compaction is complete except where otherwise instructed by the Engineer.

Each layer of material shall be compacted at a moisture content within the above limits to a dry density equal to at least the percentage of the Maximum Dry Density (MDD) specified below:-

- i. All fill material in embankments, except the 300 mm below formation: 100 % MDD (AASHTO T99)
- ii. The 300 mm below formation in embankments: 95 % MDD (AASHTO T180)
- iii. The 300 mm below formation in cuttings under the carriageway and shoulders: 95 % MDD (AASHTO T180).

Compaction under and in embankments, and on the 300 mm below formation in cuttings, shall be completed to the procedures proposed by the Contractor in accordance with **CLAUSE 1732** of this Specification.

The maximum compacted layer at any one time shall be 150 mm on fills and cuttings and 200 mm on improved subgrade layers.

The maximum compacted layer thickness shall be 150 mm, unless as a result of trials it is demonstrated that compaction can be consistently achieved at greater depth which should not exceed 200 mm.

Each layer of hard material used as fill in embankments shall be systematically compacted by at least 8 passes of a towed vibrating roller weighing not less than 5 tonnes dead weight or a grid roller weighing not less than 13 tonnes dead weight or other approved plant. During compaction the surface of the layer shall be watered as necessary to facilitate the filling of the voids with the blinding material.

In accordance with **SECTION 1700** of this Specification the Contractor shall submit their proposals to the Engineer for the compaction of each main type of material to be used in the embankments, including those in relation to the types of plant, the range of passes and the loose depth of layer. The Contractor shall carry out site compaction trials, supplemented by any necessary laboratory investigations using the procedure proposed by the Contractor for earthworks and shall satisfy the Engineer that all the specified requirements regarding compaction will be achieved. Site compaction trials with the main types of material likely to be encountered shall be completed before the permanent Works with corresponding materials commences.

The Contractor shall provide all water necessary for compaction. The water to be used shall be clean and fresh, free from all Impurities and shall be obtained from a source approved by the Engineer. The Contractor shall if required by the Engineer arrange for the analysis of water to demonstrate compliance with this Specification.

The Contractor shall provide all plant necessary for conveying and distributing water. Water shall be evenly sprinkled on the surface of the fill material by machines of a type approved by the Engineer, and capable of distributing water at a known, predetermined and constant rate.

3512 Spoil Material

Spoil material shall be material which, being obtained from cuttings, is surplus to that required for fill and/or unsuitable material from cuttings which the Engineer has instructed to be excluded from use as fill in embankments, and/or unsuitable material from beneath embankments or below formation level in cuttings which the Engineer has instructed to be spoiled.

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Spoil material shall be deposited in spoil areas located by the Contractor subject to the approval of the Engineer and the Contractor shall give the Engineer at least 24 hour notice of intention to commence spoiling operations at a particular location.

3513 Borrow Pits

Fill material which is required in addition to that provided by the excavation, or widening of cuttings shall be obtained from borrow pits which shall be located by the Engineer.

Should the Contractor locate alternative borrow pits then he shall obtain the Engineer's approval to such borrow pits. In such instances no additional payments will be made for such borrow pits over and above such payment as would have been made for borrow pits located by the Engineer.

The Engineer may direct that materials be selected in borrow pits which may include double handling, stockpiling and excavation in particular areas of a borrow pit.

The Contractor shall construct all accesses, clear and remove all ant hills, ants, nests, vegetation, boulders and unsuitable or oversize material. The Contractor shall provide adequate supervision in every borrow pit to ensure that suitable material is not contaminated with unsuitable material. Unsuitable material shall be spoiled in accordance with **CLAUSE 3512** of this Specification.

Borrow pits shall be excavated to regular widths and shapes and shall be cleaned up on completion so that the sides are neatly trimmed and the bottoms levelled and drained away from the Works all in accordance with the provisions of **SECTION 3400** of this Specification. All topsoil removed prior to borrow pit utilisation shall be reinstated uniformly over the entire cleaned and shaped area.

3514 Proofrolling

All subgrade and, embankment layers, cuttings, benches and original ground shall be proof rolled with a loaded scraper or truck with a minimum axle load of 8 tonnes. Proof rolling shall be satisfactorily completed before the layer is submitted to the Engineer for approval and shall be carried out in the presence of the Engineer. All such proof rolling shall be at the Contractor's expense.

3515 Trimming Of Slopes

The slopes of cuttings and embankments shall be trimmed by hand or by approved mechanical means to uniform batters as shown on the Drawings or as instructed by the Engineer. Such trimming shall be completed before the commencement of sub-base construction.

Any rock or boulder appearing in the face of a cutting or embankment shall be trimmed back to within the tolerance specified and in addition any such rock or boulder which is unstable shall be completely removed and the resulting void filled with suitable material compacted to the approval of the Engineer.

3516 Topsoiling And Grassing

Where specified or instructed by the Engineer, the Contractor shall provide protection to embankment slopes, cut faces, side drains, shoulders, guiding dams and spoil or borrow areas by one of the following means:-

1. Grassing
2. Topsoiling and grassing

Where grassing is required the Contractor shall plant sprigs of approved indigenous 'runner' type grass at 150 mm centres. The Contractor shall care for and water the grass until it is firmly established.

Where topsoiling is required prior to grassing the minimum compacted thickness of topsoil shall be 50 mm and the quality of the topsoil shall be to the approval of the Engineer. Light compaction shall be carried out to the approval of the Engineer.

The Contractor shall ensure that neither their watering nor rainfall or rainfall runoff from adjacent areas washes out the topsoil or grass, and any damage before the grass is firmly established shall be rectified at the Contractor's expense.

3517 Side Drains

Side drains are considered as cuttings in accordance with **CLAUSE 3501** of this section of this Specification and the excavation thereof is classified as earthworks. The Engineer may during the course of the Works instruct amendments to the dimensions, slopes and depths of side drains and providing such amendments are instructed before the completion of earthworks in the section side drains will continue to be considered as cuttings and the excavation thereof classified as earthworks. Where the side drain detail is amended after completion of earthworks in the section, then such additional excavation shall be classified as excavation of catchwater drains in accordance with **SERIES 2000** of this Specification.

3518 Measurement And Payment

Unless specified otherwise, the method of computation of volumes will be that of average end areas and centreline distances between cross-sections taken at 25 m intervals. In irregular ground or tight curvature the Engineer may direct that ground cross-sections are taken at closer intervals.

Earthwork fill shall be measured by the cubic metre of compacted material measured in the completed embankment. No separate measurement or payment shall be made for excavating material to form embankments.

Where the mass haul diagram indicates that fill material is required in addition to that provided by the excavation, including widening of cuttings, and the Engineer instructs the opening of a borrow pit, separate measurement and payment shall be made for:-

- i. Site clearance of the borrow area and access road per hectare in accordance with **SECTION 3100** of this Specification.
- ii. Removal of topsoil (if instructed by the Engineer to be stockpiled separately) from the borrow area per cubic metre in accordance with **SECTION 3100** of this Specification.
- iii. The construction of access road, per km, in accordance with **SECTION 1500** of this Specification.
- iv. Removal to topsoil and/or overburden, as "Spoil", from the borrow area per cubic metre in accordance with **SECTION 3500** of this Specification.

Excavation to spoil of unsuitable material (as defined in **CLAUSE 3512** of this Specification) shall be measured as the volume of the excavation formed. Measurement of spoil of surplus material shall be measured by the volume of "cut" taken from the mass haul diagram prepared in accordance with **SECTION 1600** of this Specification.

Material shall be classified as either hard or soft in accordance with **CLAUSE 3503** of this Specification.

Item	Unit
35.01 Fill in Soft Material	Cubic Metre (m ³)

The rate for fill in soft material shall include for the cost of excavating the material either from cutting, bench or borrow pit, loading, transporting a free haul of 1.0 km and depositing the material in an embankment or other area requiring fill, trimming, shaping and compacting, and complying with the requirements of **SECTION 3500** of this Specification.

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Item	Unit
35.02 Fill In Hard Material	Cubic Metre (m ³)

The rate for fill in hard material shall include for the cost of excavating the material from cutting, loading, transporting a free haul of 1.0 km and depositing the material in an embankment or other area requiring fill, breaking down the material, production of rock fragments, trimming, shaping and compacting, blinding, and complying with the requirements of SECTION 3500 of this Specification.

Item	Unit
35.03 Spoil in Soft Material	Cubic Metre (m ³)

The rate for spoil in soft material shall include for the cost of excavating the material, loading, transporting a free haul of 1.0 km and depositing the material in a spoil area, providing trimming, shaping and top-soiling spoil areas in accordance with SECTION 3400 of this Specification, and complying with the requirements of SECTION 3500 of this Specification.

Item	Unit
35.04 Spoil in Hard Material	Cubic Metre (m ³)

The rate for spoil in hard material shall include for the cost of excavating the material, loading, transporting a free haul of 1.0 km and depositing material in spoil areas, providing trimming, shaping and topsoiling spoil areas in accordance with SECTION 3400 of this Specification, and complying with the requirements of CLAUSES 3502, 3504, 3509, 3513, 3516 of this Specification.

Item	Unit
35.05 Compaction of Existing Ground	Cubic Metre (m ³)

The volume of existing ground compacted shall be calculated as the product of the plan area and the vertical compacted thickness specified.

The rates for compaction of existing ground shall include for scarifying, supplying and mixing in water or drying the material, levelling and compacting and complying with the requirements of SECTION 3500 of this Specification.

Item	Unit
35.06 Compaction Of The 300 mm Below Formation Level in Cutting to 95 % MDD (AASHTO T180)	Cubic Metre (m ³)

The rate for compaction of the 300 mm below formation level in cutting shall include for compacting underlying material as necessary to achieve the specified compaction in the 300 mm below formation level, compacting that 300 mm of subgrade in two 150 mm layers including the removal of the upper 150 mm to allow the compaction of the lower 150 mm, scarifying, supplying and mixing in water or drying the material, levelling and compacting and complying with SECTION 3500 of this Specification.

Item	Unit
35.07 Extra Over 35.01 For Compaction of Top 300 mm to 95 % MDD (AASHTO T180)	Cubic Metre (m ³)

The rate for extra over CLAUSE 3500 shall include ITEM 35.01 "Fill in soft material" for compaction of the 300 mm below embankments to 100 % MDD (AASHTO T99), shall include for compacting underlying material as necessary to achieve the specified compaction in the 300 mm below formation level, compacting that 300 mm of subgrade in two 150 mm layers, scarifying, supplying and mixing In water or drying out the material, levelling and compacting and complying with SECTION 3500 of this Specification.

Item	Unit
35.08 Excavation in Swamps	Cubic Metre (m ³)

The rate for excavation in swamps shall include for the cost of excavating the material, loading, transporting and depositing the material on a spoil areas, trimming shaping and topsoiling of spoilt areas in accordance with SECTION 3400 of this specification, all additional excavation required to achieve the instructed area and depth, excavating underwater, a free haul of 1.0 km and complying with the requirements of CLAUSE 3506 and 3507 of this Specification. Overhaul will be measured in accordance with CLAUSE 1602 (e) of this Specification

Item	Unit
35.09 Rockfill in Swamps	Cubic Metre (m ³)

Rockfill shall be measured by the number of tonnes instructed to be placed.

The rate for rockfill shall include for the cost of providing the material, all hauls as necessary and complying with the requirements of CLAUSE 3507 of this Specification.

Item	Unit
35.10 Filter Fabric Under, Over Or Around Rockfill	Square Metre (m ²)

The filter fabric placed under, over or around rockfill shall be measured as the net area of filter fabric instructed.

The rate for filter fabric shall include for the cost of the preparation of the surface to receive the filter fabric, the provision, transport, storing and laying the fabric in accordance with the manufacturer's instructions, all laps and/or stitching and for complying with CLAUSES 3506 and 3507 of this Specification.

Item	Unit
35.11 Topsoiling	Square Metre (m ²)

Topsoiling shall be measured by the square metre calculated as the net area, measured on the slope, instructed by the Engineer for each different situation i.e. side drain, embankment, etc.

The rate for topsoiling shall include for the cost of providing the topsoil, all hauls as necessary and complying with the requirements of CLAUSE 3516 of this Specification.

Item	Unit
35.12 Grassing	Square Metre (m ²)

Grassing shall be measured by the square metre calculated as the net area, measured on the slope, instructed by the Engineer for each different situation i.e. side drains, embankments, etc.

The rate for grassing shall include for the cost of providing and establishing the grass sprigs and complying with the requirements of CLAUSE 3516 of this Specification.

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SECTION 3600 Rectification of Earthworks

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3601 Scope

This section sets out the methods for rectification of earthworks constructed outside permitted geometric tolerances. Where any tolerances in SECTION 1900 are exceeded, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement course, earthworks or formation in the manner described below.

3602 Rectification Measures

a. Earthworks Excluding Improved Subgrade Layers

Where a cutting slope is steeper, and an embankment slope is slacker, than the specified slope then the slope shall be trimmed to the specified slope. Where a cutting slope is slacker, and an embankment slope is steeper, than the specified slope then the slope shall be benched and fill material placed and compacted and the slope shall be trimmed all in accordance with requirements of SERIES 3000 and any other relevant part of this Specification.

Where the width of a cutting is less and the width of an embankment more than the specified width then the cutting or embankment shall be trimmed to the specified width. Where the width of a cutting is more and the width of an embankment is less than the specified width then the embankment or cutting shall be benched and fill material placed and compacted and the slopes shall be trimmed all in accordance with the requirements of this Specification.

Where the depth of a side drain is less than that specified the side drain shall be trimmed to the specified depth. Where the depth of a side drain is more than specified the side drain shall be backfilled with fill material compacted to a dry density of at least 95 % MDD of AASHTO T180 up to the specified depth.

Where the results of the construction control tests are less than that specified the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50 m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with this Specification.

b. Improved Subgrade Layers

Where the levels or widths are out of tolerance then the full depth of the layer shall be reworked to specification. The area treated shall be at least 10 m long and 3 m wide or such area to be determined by the Engineer as necessary to obtain compliance with this Specification.

Where the results of the construction control tests are less than that specified the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or following a retest a length of at least 50 m both sides of each test and retest, failure.

3603 Measurement And Payment

The Contractor shall be deemed to have allowed in their general rates and prices for the cost of complying with the requirements in this section and no additional payment will be made.

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Earthworks | 3600 | Rectification of Earthworks

SERIES 4000 Natural, Crushed Stone and Stabilised Pavement Layers

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SECTION 4100 Gravel Wearing Course

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4101 General

a. Definitions

The term "gravel" used throughout this section means any material used as a wearing course, and shall - include lateritic gravel, quartzitic gravel, calcareous gravel, decomposed rock, soft stone, coral rag, clayey sands and crushed rock.

A "gravel wearing course" means a top surfacing course constructed from one or a combination of these materials and may be a course placed on the formation of a new road where no pavement and final bituminous surface is included in the Contract, or placed on the formation of a service road, deviation or access road.

b. Improved Subgrade Layers

Material for gravel wearing course may be obtained from any of the following sources:-

- i. Borrow pits
- ii. Spoil areas
- iii. Excavation in cuttings, widened if necessary.

In all cases the Engineer will instruct the Contractor as to the source of material to be used and the location in which it is to be placed.

c. Inspection of Site

Where a source of material is available for inspection during the Tender Period the Contractor shall ensure they are satisfied with the nature and amount of work involved particularly in respect of the volume of overburden, the quality and hardness of material, the degree of selection necessary, the method of extraction, and access to the source.

d. Borrow Pits and Spoil Areas

The Contractor shall comply with all the requirements of SECTION 3400 of this Specification in respect of borrow pits and spoil areas.

4102 Classification of Material

Gravel wearing course material shall be material which can be extracted from a borrow area or a road cutting by ripping to a depth of 300 mm with a single tine hydraulic ripper acceptable to the Engineer drawn by a track type crawler tractor in good order complete with all equipment and accessories as supplied and rated at 300 BHP flywheel power or over with an operating weight of not less than 37.2 tonne and being operated in accordance with the manufacturer recommendations.

The material may require the use of either a grid or sheepsfoot roller with more than 8000 kg mass per metre width of roll to break it down and/or screening to achieve the specified grading.

4103 Material Requirements

Materials for unpaved shoulders and gravel wearing course layers of GW materials as specified on the Drawings shall meet the requirements given in TABLE 4102/1.

TABLE 4103/1: REQUIREMENTS FOR LAYERS OF GRAVEL WEARING COURSE G20 MATERIAL

Property			Specification		
Natural gravel or mixtures of natural gravels, volcanic gravel (scoria), and sand or up to 30 % of natural stone, crushed stone, scarified pavement material or milled bituminous pavement material conforming to the following requirement:					
Bearing Strength & Plasticity Properties			Grading After Compaction for Gravel Wearing Course		
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min 20		Sieve (mm)	% by weight passing	
				Class 1	Class 2
Swell (%)	Max. 1.0		37.5	-	100
Plasticity Index (%)	Wet areas	5 – 20	28	100	95 – 100
	Dry areas	5 – 25	20	95 – 100	85 – 100
Plasticity modulus	200 – 1,200		14	80 – 100	65 – 100
Plasticity Product	280 – 480		10	65 – 100	55 – 100
Grading modulus	1.0 – 1.9		5	45 – 85	35 – 92
			2	30 – 68	23 – 77
			1	25 – 56	18 – 62
			0.425	18 – 44	14 – 50
			0.075	12 – 32	10 – 40

4104 Order of Work

Unless otherwise instructed by the Engineer, the Contractor shall commence laying wearing course starting as close as possible to the source and shall work away from it so that the maximum amount of compaction is given to the wearing course by the Contractor's vehicles. The Contractor shall route their vehicles to give even wear and compaction over the whole width of the wearing course.

Where black cotton, or other high-swelling material, is used in the upper subgrade layers, the Contractor shall place wearing course material upon this section immediately after compaction of formation level.

4105 Preparation of Formation

The formation shall be cleaned of all foreign matter, and any potholes, loose material, ruts, corrugations, depressions and other defects which have appeared due to improper drainage, traffic or any other cause shall be corrected, and, if considered necessary by the Engineer, the Contractor shall scarify, water, grade and recompact the subgrade to line and level. The specified compaction level shall be adhered to.

4106 Setting Out

The gravel wearing course shall be set out in accordance with SECTION 1800 of this Specification.

4107 Laying and Compacting Gravel Wearing Course

The gravel wearing course material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown upon the Drawings or instructed by the Engineer. Every reasonable effort shall be made to prevent segregation during the loading, hauling, dumping, spreading, mixing, trimming and compacting operations.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 225 mm and where a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum layer thickness shall be 100 mm.

The material shall be broken down in the pavement to the grading specified in CLAUSE 4103 of this Specification. Any oversize material which cannot be broken down to the required size shall be removed and disposed of by the Contractor.

The material shall be scarified and the moisture content adjusted by either uniformly mixing in water or drying out the material such that the moisture content during compaction is between 80 % and 105 % of the Optimum Moisture Content (AASHTO T180). It shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out but once 25 % of the compactive effort has been applied no further trimming or correction of surface irregularities will be allowed.

The final trim shall be in cut and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works.

Following the final trim the material shall be compacted to a dry density of at least 95 % MDD of AASHTO T180. During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out by applying fog sprays of water or other approved means sufficient to maintain the surface and/or material within the specified limits of moisture content.

4108 Proofrolling

The Contractor shall proofroll the completed layers in accordance with CLAUSE 4205 of this Specification

4109 Tolerances

The gravel wearing course shall be constructed to the tolerances specified in SECTION 1800 of this Specification.

4110 Maintenance

The wearing surface shall be maintained by the Contractor in its finished condition and shall be watered, graded, dragged, reshaped, or recompact as necessary, until the Certificate of Completion is issued, or until the Engineer instructs that the road shall be opened to public traffic, whichever is the sooner.

4111 Measurement and Payment

Item	Unit
41.01 Gravel Wearing Course:	
(a) Natural Gravel Class G20 Used For Gravel Wearing Course (Method A)	Cubic Metre (m ³)
(b) Natural Gravel Class G25 Used For Gravel Wearing Course (Method B)	Cubic Metre (m ³)

Gravel wearing course shall be measured by the cubic metre placed and compacted upon the road calculated as the product of the compacted sectional area specified to be laid and the length instructed.

Separate Items are included in the Bills of Quantities to cover the following circumstances:-

- i. The source of material is available for inspection by the Contractor at the time of tendering - Method A.
- ii. The source of material is not available for inspection by the Contractor at the time of tendering - Method B.

The rates for gravel wearing course provided in accordance with Method A shall include for the cost of the following:-

- i. Opening up the borrow area, site clearance, removal of topsoil and overburden, fencing, drainage, and landscaping and topsoiling on completion and leaving neat and tidy.
- ii. Constructing and maintaining access roads, complying with conditions of access, traffic control, safety and public health requirements, fencing, drainage and making good on completion and leaving neat and tidy.
- iii. Excavation and selection of material, removing and spoiling of oversize material, screening, stockpiling, providing and mixing water, or drying out the material, mixing, processing, spreading, and compaction.
- iv. Spreading, providing and admixing of fines if necessary, rolling, brooming, making good defective areas and maintenance of the surface.
- v. Loading, hauling a free haul of 1.5 km measured from the centre of volume of the source of material and dumping the material.
- vi. Complying with the requirements this SECTION 1600, 3400 and 3100 of this Specification

The rates for gravel wearing course provided in accordance with Method B shall include for the cost of complying with all the provisions for Method A described above except the following which shall be measured and paid for separately:-

- i. Site clearance of the borrow area per hectare in accordance with SECTION 3100 of this Specification.
- ii. Removal of topsoil (if instructed by the Engineer stockpiled separately) from the borrow area per accordance with SECTION 3100 of this Specification.
- iii. Length of access road, per km, in accordance with SECTION 1500 of this Specification.
- iv. Removal of top soil and/or overburden, as "Spoil", from the borrow area per cubic metre in accordance with SECTION 3500 of this Specification.

SECTION 4200 Natural Granular Material Pavement

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4201 General

a. Definitions

The term "natural material" includes lateritic gravel, quartzitic gravel, calcareous gravel, soft stone, coral rag, conglomerate, sand or clayey sand or a combination of any of these materials. A natural material is also referred to as "gravel".

b. Sources of Materials

Natural material for sub-base and base may be obtained from any of the following sources:-

- i. Borrow pits
- ii. Spoil areas
- iii. Excavation in cuttings, widened if necessary.

In all cases the Engineer will instruct the Contractor as to the source of material to be used and the location in which it is to be placed.

c. Inspection of Site

Where a source of material is available for inspection during the Tender Period the Contractor shall ensure they are satisfied with the nature and amount of work involved particularly in respect of the volume of overburden, the quality and hardness of material, the degree of selection necessary, the method of extraction, and access to the source.

d. Borrow Pits

The Contractor shall comply with all the requirements of SECTION 3400 of this Specification in respect of borrow pits.

e. Soluble Salts

Soluble salts are salts that dissolve easily in water and are sufficiently soluble to cause deleterious physical or chemical effects. Salts that generally occur in such quantities to affect the road materials are sodium chloride and sulphates.

Soluble salts can be encountered in the roadbed, the earthworks and in any of the road pavement layer materials. The dissolved salt migrates upwards through the earthworks and road pavement layers, and is precipitated at the contact between the base layer and the surfacing. The salt then causes the disruption of the bond between the base layer and the surfacing, and blisters develop. This generally results in the failure of the surfacing.

The electric conductivity tests shall be carried out on the soil paste. The total soluble salt content of the natural or untreated material in the road pavement layers (crushed stone or gravel) shall have electric conductivity (EC) less than or equal to 0.15 Siemens/m and 0.40 Siemens/m for base and sub-base layers, and selected fills, respectively. For selected fills, where the EC > 0.20 Siemens/m is encountered, the selected layer shall be covered by the next layer within 14 days.

The Contractor shall discard the material or fulfil all requirements for appropriate construction techniques and timing of operations to the satisfaction of the Engineer if assessments of soluble salt contents in base course or sub-base materials show deleterious values in terms of the criteria indicated above. Such assessments are only required where the pavement is going to receive a bituminous seal as the only surfacing. No additional payment will be made for any measures taken, or for any alterations of the material utilisation, due to presence of soluble salts in materials or construction water.

4202 Classification Of Material

Natural material shall be material which can be extracted from a borrow area or a road cutting by ripping to a depth of 300 mm with a single tine hydraulic ripper acceptable to the Engineer drawn by a track type crawler tractor in good order complete with all equipment and accessories as supplied and rated at 300 BHP flywheel power and over with an operating weight of not less than 37.2 tonne and being operated in accordance with the manufacturer's recommendations.

The material may require the use of either a grid or sheepsfoot roller with more than 8000 kg mass per metre width of roll to break it down and/or screening to achieve the specified grading.

4203 Material Requirements

Materials for natural base and sub-base as specified on the Drawings shall meet the requirements given in TABLE 4203/1 to TABLE 4203/4.

TABLE 4203/1: REQUIREMENTS FOR G25 MATERIAL

Property		
Natural gravel or mixtures of natural gravel and sand or up to 30 % of natural stone, crushed stone, scarified pavement material or milled bituminous pavement material conforming to the following requirement:		
Natural Gravels		
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min. 25	
Swell (%)	Max. 1.0	
Maximum size	2/3 of layer thickness or 80 mm whichever is lesser	
Uniformity Coefficient	Min. 6	
Plasticity Index (%)	Wet areas	Max 15
	Dry areas	Max 20
Plasticity modulus	Max 250	
Clayey and Silty Sands		
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min. 25	
Swell (%)	Max. 1.0	
Passing 2 mm sieve (%)	Max. 95	
Passing 0.075 mm sieve (%)	Min. 10 – Max 30	
Uniformity Coefficient	Min. 6	
Plasticity Index (%)	Wet areas	Min. 5 – Max 15
	Dry areas	Min. 5 – Max 20
Plasticity modulus	Max 250	

TABLE 4203/2: REQUIREMENTS FOR L G30 MATERIAL

Characteristic	Value	Grading After Compaction	
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min 30	Sieve (mm)	% by weight passing
Plasticity Index (%)	Max 12	50	100
		37.5	80 – 100
Plasticity modulus	Max. 250	28	
Swell (%)	Max. 0.5	20	60 – 100
MECHANICAL STABILISATION These requirements and limitations also apply to mixtures of natural gravel and sand and of natural gravel and up to 30 % of stone (crushed or not)		10	
		5	30 – 100
		2	20 – 95
		1.18	17 – 75
		0.300	9 – 50
		0.425	7 – 33
		0.075	5 – 25

TABLE 4203/3: REQUIREMENTS FOR G45 MATERIAL

Characteristic	Value	Grading After Compaction	
		Sieve (mm)	% by weight passing
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min 45		
Swell (%)	Max. 70	50	100
Plasticity Index (%)	Max. 40	37.5	90 – 100
		28	75 – 95
Plasticity modulus	Max. 10	20	60 – 90
Plasticity Product	Max. 250	10	40 – 75
MECHANICAL STABILISATION These requirements and limitations also apply to mixtures of natural gravel and sand and of natural gravel and up to 30 % of stone (crushed or not)		5	29 – 65
		2	20 – 45
		1.18	17 – 40
		0.425	12 – 31
		0.075	5 – 25
		0.075	5 – 25

TABLE 4203/4: REQUIREMENTS FOR G80 MATERIAL

Characteristic	Value	Grading After Compaction	
		Sieve (mm)	% by weight passing
CBR at 95 % MDD (AASHTO T180) and 4 days soak (%)	Min 80		
Los Angeles Abrasion (%)	Max. 50	50	100
Aggregate Crushing Value (%)	Max. 35	37.5	95 – 100
		28	80 – 100
Plasticity Index (%)	Max. 10	20	60 – 100
Plasticity Modulus	Max. 250	10	35 – 100
MECHANICAL STABILISATION		5	20 – 95
		2	12 – 80
		1.18	10 – 65
		0.425	7 – 50
		0.075	4 – 20

4204 Laying And Compacting

The material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown on the Drawings or instructed by the Engineer. Every reasonable effort shall be made to prevent segregation after mixing and during the dumping spreading, trimming and compacting operations.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 225 mm and where "a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum layer thickness shall be 100 mm.

The material shall be broken down to the grading specified in **CLAUSE 4203**. Any oversize material which cannot be broken down to the required size shall be removed and disposed of.

The material shall be scarified and the moisture content adjusted by either uniformly mixing in water or drying out the material such that the moisture content during compaction is between 80 % and 105 % of the Optimum Moisture Content (AASHTO T180). It shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out but once 25 % of the compactive effort has been applied no further trimming or correction of surface irregularities will be allowed.

The final trim shall be in cut and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works. Following the final trim the material shall be compacted to a dry density of at least 95 % MDD of AASHTO T180. During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out by applying fog sprays of water or other approved means sufficient to maintain the surface and/or material within the specified limits of moisture content.

On completion of compaction, the surface shall be well closed, free from movement under compaction plant and free from compaction planes, ridges, cracks, loose or segregated material. If the surface fails to meet the requirements of this Specification the Contractor shall take the action set out in the appropriate part of **SECTION 1800** of this Specification or such other action as the Engineer may instruct or agree.

4205 Proofrolling

Unless otherwise directed by the Engineer, the Contractor shall proofroll the completed layer with a steel three wheeled roller applying a load of not less than 5 tonnes per metre width of roll and the layer shall be free from visible movement under the proofroller. Approval of the layer will only be given after the satisfactory completion of the proofrolling and any remedial measures will be at the Contractor's expense.

4206 Setting Out And Tolerances

The layer shall be set out and constructed to the appropriate tolerances specified in **SERIES 1800** of this Specification.

4207 Drainage Of Subgrade, Sub-Base And Base Layers

The subgrade, sub-base and base shall be kept continuously drained and any damage caused by water accumulating on or running off the surface shall be made good at the Contractor's expense. In particular, the drainage requirements of **SERIES 2000** of this Specification shall apply.

Should water accumulate on any part of the subgrade, sub-base or base, the Contractor shall remove and dispose of any material which becomes saturated, or cannot then be compacted to the required density, and shall replace it to specification, all at his own expense.

4208 Treated Materials

Lime or cement treatment, if required by the Special Specification or Drawings, shall be carried out in accordance with **SECTION 4400** of this Specification

4209 Measurement And Payment

Item	Unit
42.01 Natural gravel for Base Course:	
(a) Natural Gravel Class G80	Cubic Metre (m ³)

Item	Unit
43.01 Natural Gravel for Subbase:	
(a) Natural Gravel Class G30	Cubic Metre (m ³)
(b) Natural Gravel Class G30	Cubic Metre (m ³)
(c) Natural Gravel Class G45	Cubic Metre (m ³)

The quantity of natural gravel shall be the number of cubic metres completed in place compacted to the depths and widths shown on the Drawings or as directed. The quantity shall be measured by the cross-section area shown on the construction drawings times the section length. Where gravel wearing course material, GW, is placed on an existing gravel road the measurement of levels before the start of the operation shall form the basis for calculating the cubic metre quantities. In the cases where gravel wearing course material is not to be compacted on the approval of the Engineer, the quantity shall be measured as cubic metres in un-compacted state.

The bid rates shall include full compensation for procuring, breaking down, placing, compacting, testing and proof rolling the material including the protection and maintenance of the layer, all as specified.

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When payment for overhaul is allowed for in accordance with the Special Specifications, the rates shall include the free haulage distance as defined in SECTION 1600. When GW materials are used as unpaved shoulders for paved roads the corresponding free haul distance shall as for natural gravel sub-base material.

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When payment for overhaul is not allowed for in the Special Specifications, the rates shall include for all transportation of the material.

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Natural Crushed Stone & Stabilised Pavement Layers | 4200 | Natural Granular Material Pavement

SECTION 4300 Graded Crushed Stone Pavement

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4301 Definitions

"Graded crushed stone" shall mean crushed stone with a smooth grading curve which is within a specified envelope. The stone class shall be specified in the Special Specification.

The nominal size of graded crushed stone shall be referred to by the denomination O/D as defined by the grading in SUBCLAUSE 4303 (c) below. Where O is the minimum particle size and D is the nominal particle size.

The class and nominal size of the graded crushed stone to be provided will be specified in the Special Specification.

4302 Sources Of Material

The Contractor shall be responsible for locating and developing suitable sources of material for graded crushed stone. Such sources shall be termed quarries and the opening up of quarries and the construction and maintenance of access roads shall be carried out in accordance with SECTION 3400 of this Specification.

4303 Material Requirements

a. General Requirements For Graded Crushed Stone

The aggregate used for graded crushed stone base shall comply with the requirements specified in TABLE 4302/1 and in SUBCLAUSE 4303(b). It shall not contain any deleterious material such as weathered rock, clay, shale or mica. Argillaceous rocks may only be used if specified in the Special Specification, or with the Engineer's written approval.

b. Soluble Salts

- i. The percentage of soluble salts in the material shall be subject to the following provisions:

Untreated material (< 6.7 mm fraction)

Where the pH < 6.0, it shall be treated with lime until pH \geq 10, and then used. (The aggregate is normally treated at the crusher, and if the pH exceeds 10 at that stage, the decrease which will occur later on, shall be ignored should it remain \geq 8.0.)

Where the pH \geq 6.0, the material is used as it is.

Other materials such as natural gravel and other crushed stone

Where the electrical conductivity (EC) 0.15 Sm^{-1} , the material may be used.

Where the EC > 0.15 Sm^{-1} , the pH shall be determined.

Where the pH < 6.0, the material shall be treated with lime until the pH > 10. The material may then be used. (Any later decrease of the pH shall be ignored should it remain > 8.0.)

Where the pH > 6.0, it may be used, but special attention should be given to design and construction measures.

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Natural Crushed Stone & Stabilised Pavement Layers | 4300 | Natural Granular Material Pavement

c. Materials Particle Size Grading

After compaction, the individual fractions making up the grading of the material in place in the road shall conform to the proportions in TABLE 4302/1, subject to the following requirements.

The target grading after compaction shall be as near as possible to the mean of the specified particle grading envelope shown in TABLE 4302/1.

The approved target grading shall be based on test results obtained from a trial section constructed in accordance with SUBCLAUSE 4303 and subject to complying with the following requirements unless otherwise approved, where such approval shall be based on substantive evidence relating to the crushing characteristics of the parent rock and its impact on the shear characteristics and compatibility of the structural layer.

The selected target values shall produce a gradual change from the coarse to the finer fractions without any marked gaps or excessive quantities at a particular size.

In order to satisfy the specification requirements in TABLE 4302/1, the mean grading of the approved trial section may not necessarily represent the target grading finally approved for quality assessment (e.g. the variability actually obtained for particular fractions will dictate the setting of the target grading).

For Class A, Class B and Class C base material the mean grading of each lot (minimum of 4 but preferably 6 test points per lot) determined from samples obtained in a stratified random sampling procedure shall conform to the approved target grading within the tolerances specified in TABLE 4302/1.

TABLE 4302/1: REQUIREMENTS FOR GRADED CRUSHED STONE (GCS)

GCS Class		Class A	Class B	Class C		Class D	Class E
Nominal Size (mm)		0/30	0/30	0/40	0/60	0/50	0/50
Grading Envelope	BS Sieve (mm)	Percentage by Weight Passing					
	75	-	-	-	100	-	-
	63	-	-	-	95 - 100	-	-
	50	-	-	100	85 - 100	100	100
	37.5	100	100	90 - 100	75 - 95	90 - 100	90 - 100
	28	90 - 100	90 - 100	75 - 95	60 - 87	80 - 100	75 - 95
	20	65 - 95	65 - 95	60 - 90	50 - 80	60 - 100	60 - 90
	10	40 - 70	40 - 70	40 - 75	30 - 67	35 - 90	40 - 75
	6.3	30 - 55	30 - 55	30 - 63	23 - 58		
	5					20 - 75	29 - 65
	2	20 - 40	20 - 40	20 - 45	13 - 40	12 - 50	20 - 45
	1	15 - 32	15 - 32	15 - 35	7 - 32	10 - 40	17 - 40
	0.425	10 - 24	10 - 24	10 - 26	4 - 20	7 - 33	12 - 31
	0.075	4 - 10	4 - 10	4 - 12	0 - 10	4 - 20	5 - 12

TABLE 4302/1: REQUIREMENTS FOR GRADED CRUSHED STONE (GCS)

Stone Physical Requirements	Parameter	Percentage					
	LAA Max.	30	35	40	40	50	50
	ACV Max.	25	28	30	30	35	35
	SSS Max.	12	12	12	12	20	-
	FI Max.	20	25	30	30	-	-
	CR Min.	100	100	80	80	-	-
	PI Max.	NP	NP	NP	NP	6	10
	Sand E Min.	40	40				
Elastic Modulus (MPa)	Min	500	500	400	400	350	300

Material From Existing Pavements

Where existing crushed-stone material is to be reprocessed, the Engineer will inspect the material and instruct the Contractor to reprocess it as gravel sub-base or base, or as crushed-stone base or sub-base.

The compaction requirements specified in TABLE 4302/1 shall apply to crushed-stone layers constructed from recovered material.

Payment for crushed-stone layers constructed from recovered material, will differentiate between the various types of material and their preparation.

4304 Crushing Screening And Mixing

Unless otherwise instructed, crushing shall be carried out in at least two stages.

The crushing, screening and proportioning of materials, and their subsequent mixing shall be carried out using such methods and machines as shall be acceptable to the Engineer.

To avoid segregation, graded crushed stone shall be moistened when being handled and shall not be stockpiled in heaps higher than 5 m.

Should the Contractor wish to add material from another source in order to achieve the specified grading, the following conditions shall apply:-

- The Contractor shall be responsible for all costs associated with the provision and mixing in of the material, including land acquisition.
- The material shall be non-plastic and consist of 90-100 % quartz or other approved hard, sharp durable particles and shall be free from organic materials, clays and other, deleterious substances.

4305 Transporting Graded Crushed Stone

Graded crushed stone shall be transported damp and in such a way that no segregation occurs.

4306 Laying And Compacting Graded Crushed Stone Sub-Base And Base

The Contractor shall take appropriate measures to prevent segregation during dumping and spreading operations.

The graded crushed stone shall be laid by plant capable of distributing the graded crushed stone in a layer of uniform thickness and without segregation.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 200 mm and where a greater thickness is required, the graded crushed stone shall be laid in two or more layers.

The compacted thickness of any base layer shall not be less than 3 times the maximum size of the graded crushed stone and the compacted thickness of any sub-base layer shall not be less than 2 times the maximum size of the graded crushed stone.

As soon as possible after laying, compaction shall be carried out. The moisture content shall be adjusted as necessary and, during compaction, care shall be taken to maintain the moisture content evenly at the required value. Unless otherwise instructed by the Engineer, the moisture content at the time of compaction shall be between 80 and 100 % of the Optimum Moisture Content as determined by the vibrating hammer method in BS 1377 - Test 14. The appropriate sub-CLAUSES of CLAUSE 4204 of this Specification shall apply.

All rolling shall be longitudinal and shall commence at the outer edges of the pavement and progress towards the center, except that on super elevated curves, rolling shall progress from the lower to the higher edge. Where laying is carried out in lanes care must be taken to prevent water entrapment.

The dry densities to be achieved as a percentage of the Maximum Dry Density (MDD) determined by the vibrating hammer method in BS 1377 Test 14 shall be:

Base: Average dry density not less than 98 % MDD with no result less than 96 % MDD with no results less than 96 % MDD.

4307 Measurement and Payment

Item	Unit
43.01 Crushed Aggregate for Road Subbase:	
(a) Constructed From Class A Material Obtained From Commercial Sources And Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(b) Constructed From Class B Material Obtained From Approved Borrow Pits, Crushed By The Contractor, And Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(c) Constructed From Class C Material Obtained From Commercial Sources And Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)

Item	Unit
43.02 Crushed Aggregate for Road Base:	
(a) Constructed From Class A Material Obtained From Commercial Sources And Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(b) Constructed From Class B Material Obtained From Approved Borrow Pits, Crushed By The Contractor, And Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(c) Constructed From Class C Material Obtained From Commercial Sources And Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(d) Constructed From Class D Material Obtained From Approved Borrow Pits, Crushed By The Contractor, And Compacted To 96 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(e) Constructed From Class E Natural Material Obtained From Commercial Sources (Nominal Maximum Size Of Stone Indicated) And Compacted To 96 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of completed crushed-stone base in place as the case may be, and compacted to the specified density. The quantity shall be calculated from the authorised dimensions of the layer as shown on the drawings or prescribed by the Engineer.

The tendered rates shall include full compensation for procuring, furnishing and placing all materials, including the crusher fines or sand (if approved) necessary for correcting the grading of the crushed stone, for crushing and screening, for hauling the material over an unlimited free-haul distance where material is obtained from commercial sources, and over a 1.0 km free-haul distance where material is obtained from approved borrow pits, for rolling, slushing and correcting the layers, and for testing, protecting and maintaining the work as specified.

Item	Unit
43.03 Crushed-Stone Base Trial section (Thickness Indicated) Constructed in Accordance With the Provisions of CLAUSE 3603	Square Metre (m ²)

The unit of measurement shall be the square metre of completed trial section approved by the Engineer.

The tendered rate shall include full compensation for constructing the trial section complete as specified.

Only trial sections in which the base material and the completed layer comply with all the requirements of the specifications shall be paid for.

Item	Unit
43.04 Crushed-Stone Base Constructed With Class A Material From Existing Pavement Layers (Indicate Thickness Of Crushed-Stone Base In Each Case):	
(a) Material From Existing Uncemented Crushed-Stone Layers Screened and Recombined In A Plant, Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(b) Material From Existing Cemented Crushed-Stone Layers, Not Milled Out But Crushed, Screened and Recombined In A Plant, Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(c) Material Milled-Out Material Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)

Item	Unit
43.05 Crushed-Stone Base Constructed With Class B Material From Existing Pavement Layers (Indicate Thickness Of Crushed-Stone Base In Each Case):	
(a) Material From Existing Uncemented Crushed-Stone Layers Screened and Recombined in a Plant, Compacted To 98 % of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(b) Material From Existing Cemented Crushed-Stone Layers, Not Milled Out But Crushed, Screened and Recombined in a Plant, Compacted To 98 % of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(c) Material Milled-Out Material Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)

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Item	Unit
43.06 Crushed-Stone Base Constructed With Class C Material From Existing Pavement Layers (Indicate Thickness Of Crushed-Stone Base In Each Case):	
(a) Material From Existing Uncemented Crushed-Stone Layers Screened and Recombined in a Plant, Compacted To 98 % of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(b) Material From Existing Cemented Crushed-Stone Layers, Not Milled Out But Crushed, Screened and Recombined in a Plant, Compacted To 98 % of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(c) Material Milled-Out Material Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)

The unit of measurement shall be a cubic metre of completed crushed-stone base. The quantity shall be calculated in accordance with the authorised dimensions of the layer. If the underlying layer has not been reconstructed or reworked, but only rolled, or where no work has been done on it, the quantity shall be calculated from the measured cross-sections before and after placing the layer, but subject to the provisions of SUBCLAUSE 1220.

The tendered rate shall include full compensation for breaking up the existing pavement layer, excavating the material from the existing pavement, loading the material, mixing in the crusher fines or sand required for rectifying the grading of the material, transporting the material for a free-haul distance of 1.0 km, and placing and compacting the material, slurring, and watering and rolling the underlying layers.

The tendered rate under SUBITEM 43.06(a) shall also include full compensation for screening and recombining the material to comply with the specified requirements.

The tendered rate under SUBITEM 43.06(b) shall also include full compensation for crushing, screening and recombining in an approved plant.

The tendered rates for milled-out material shall also include full compensation for loading the material at the stockpile and for hauling it to a screening plant where applicable or to the point of use for a free-haul distance of 1.0 km, and for any additional processing required to bring the material up to the required standards, but shall not include compensation for milling.

The tendered rates for material mixed with existing surfacing material shall also include full compensation for breaking down fragments of bituminous material to the specified maximum size and for removing over-sized fragments by hand.

Item	Unit
43.07 In Situ Reconstructed Uncemented Crushed-Stone Base (Indicate Thickness Of Crushed-Stone Base In Each Case):	
(a) Class A Material Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(b) Class B Material Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)
(c) Class C Material Compacted To 98 % Of MDD (AASHTO T180) (Layer Thickness Indicated)	Cubic Metre (m ³)

The unit of measurement shall be a cubic metre of completed crushed-stone base. The quantity shall be calculated in accordance with the authorised depth and area of the existing broken up layer.

The tendered rate shall include full compensation for breaking up the existing crushed-stone layer to the specified depth, breaking down and preparing the material, spreading and mixing the crusher dust or sand necessary for correcting the grading of the material, placing and compacting the crushed-stone layer, and watering and rolling the underlying layers.

The tendered rate shall also include full compensation for spreading and mixing in the additional approved crushed stone where the existing layer thickness is inadequate, and the increase of the layer thickness is specified or ordered by the Engineer.

Payment for breaking down, placing and compacting the material temporarily removed to windrow to expose or remove underlying material, shall be made under this Item. The operation to cut material to windrow and later to cut back such material will be paid for under ITEM 43.07.

The tendered rate for material mixed with existing surfacing material shall also include full compensation for breaking down fragments of surfacing material by hand, and for removing oversized fragments by hand.

Item	Unit
43.08 Extra Over ITEM 43.07 for Temporarily Blading the Material to Windrow:	Cubic Metre (m ³)

The provisions under ITEM 43.06 shall apply.

Item	Unit
43.09 Crusher Fines or Sand For Improving the Grading of Recovered Crushed Stone:	
(a) Material from Approved Borrow Pits	Cubic Metre (m ³)
(b) Material from Commercial Sources	Cubic Metre (m ³)

The unit of measurement shall be a cubic metre of approved material added on the instruction of the Engineer, and the quantity shall be the loose volume measured in trucks.

The tendered rate for SUBITEM 43.09 (a) shall include full compensation for procuring and providing the material and hauling it over a free-haul distance of 1.0 km.

The tendered rate for SUBITEM 43.09 (b) shall include full compensation for procuring and providing the material from commercial sources and hauling it from the source to the point on the site where required.

Item	Unit
43.10 Extra Over ITEM 43.07 for Using Added Crushed-stone:	
(a) Material from Approved Borrow Pits	Cubic Metre (m ³)
i Class A Material	Cubic Metre (m ³)
ii Class B Material	Cubic Metre (m ³)
ii Class C Material	Cubic Metre (m ³)
(b) Material from Commercial Sources	Cubic Metre (m ³)
i Class A Material	Cubic Metre (m ³)
ii Class B Material	Cubic Metre (m ³)
ii Class C Material	Cubic Metre (m ³)

The unit of measurement shall be a cubic metre of approved material added on the instruction of the Engineer. The quantity shall be taken as being 70 % of the loose volume measured in the trucks. Only approved freshly broken stone from a commercial source, crusher plant or stockpile shall be paid for.

The tendered rate for SUBITEM 43.10 (a) shall include full compensation for the additional cost of providing the material and hauling it over a free-haul distance of 1.0 km.

The tendered rate for SUBITEM 43.10 (b) shall include full compensation for the additional cost of providing the material and transporting to it from the source where it was obtained to the point on the site where it is required.

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Compensation for processing and compacting the material shall be included in the rate for ITEM 46.06.

Item	Unit
43.11 Extra Over Item 43.06 for Excavating Crushed Stone from Existing Pavements in Restricted Areas:	
(a) Non-cemented Crushed Stone	Cubic Metre (m ³)
(b) Cemented Crushed Stone	Cubic Metre (m ³)

The unit of measurement shall be a cubic metre of material excavated in a restricted area, the quantity of which shall be calculated in accordance with the area and the average thickness of the layer excavated.

The tendered rate shall include full compensation for all additional costs for executing the work in restricted areas.

Item	Unit
43.12 Extra Over Payment for Placing and Compacting or for In Situ Reconstruction of Crushed-Stone Base in Restricted Areas:	
(a) Extra Over ITEM 43.05 For Placing And Compacting Material From Existing Pavement Layers	Cubic Metre (m ³)
(b) Extra Over ITEM 43.06 For In Situ Reconstructing Uncemented Crushed-Stone Base	Cubic Metre (m ³)

The unit of measurement shall be a cubic metre of crushed-stone base constructed in restricted areas, the quantities of which shall be calculated as determined for the Item concerned.

The tendered rates shall include full compensation for all additional costs for executing the work in restricted areas, irrespective of the density required.

Notes:

1. Payment Items from other sections

Where material has been obtained from approved borrow pits on the site, whether indicated on the plans or approved after work has started and the Engineer has instructed that the borrow pits be used, the following payment Items from other sections shall apply to crushed stone, but shall be listed under this section in the schedule of quantities.

ITEM 16.02 Overhaul for material hauled in excess of 1.0 km.

ITEM 31.02 Excess overburden in borrow pits for obtaining crushed stone for pavement layers.

ITEM 31.03 Finishing-off borrow pits.

ITEM 32.06 Stockpiling of material.

ITEM 38.09 Removing the remaining asphalt from the underlying surface.

2. Overhaul

Overhaul shall apply to material obtained from existing pavements, and the distance is measured along the centre line of the road from the point of excavation to the point of use on the road if used directly, or from the stockpile or processing plant if stored with the approval of the Engineer or processed in a plant (see also [CLAUSE 4406](#)). Overhaul shall also apply to fines and additional crushed stone used on the instruction of the Engineer. Where the fines or additional material is obtained from a commercial source, no overhaul will be payable (see [ITEMS 36.07 and 36.08](#)).

SECTION 4400 Hydraulically Improved & Bound Treated Materials

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4401 Scope of Section

This section deals with the addition and mixing in of hydraulic binders, hereinafter described as the "stabiliser", to the upper layers of earthworks as described in SECTION 3500, natural materials as described in SECTION 4200, and crushed materials as described in SECTION 4300, of this Specification.

Following the addition and mixing in of the stabiliser the material is referred to as "improved, modified, or bound" depending on the behaviour of the material after mixing and compacting. The nomenclature of the materials in CLAUSE 4501 reflects this.

This section also deals with the compaction and curing of the treated material.

Treated materials may be used in the upper earthworks layers, shoulder layers, sub-base layer or base layer.

4402 Sources Of Material

In accordance with SECTIONS 3300, 4200 and 4300 of this Specification.

4403 Material Requirements

a. Natural Materials

In accordance with SECTIONS 3600, 4200 and 4300 of this Specification.

b. Cement and Lime

i. Cement

Unless otherwise specified cement shall be ordinary Portland cement complying with the requirements of KS EAS 18-1, or equivalent standard as approved by the Engineer.

ii. Lime

Lime shall be hydrated calcium lime or quicklime and shall comply with the requirements of KS 1755, or equivalent standard as approved by the Engineer.

iii. Storage and handling

The requirements of CLAUSE 7403 of this Specification shall apply to cement.

All lime shall be kept under cover and protected from moisture. Consignments shall be used in the same sequence as they are delivered. Stocks which become damaged or which are stored on the Site for more than 3 months shall not be used, and shall be replaced at the Contractor's expense. Operators and labour shall be provided with protective clothing, masks and goggles.

4404 Amount Of Stabiliser To Be Added

The amount of cement or lime to be added shall be determined by the Engineer following laboratory trials, and site trials carried out by the Contractor in accordance with **CLAUSE 1732** of this Specification.

4405 Mix-In-Place Method Of Construction

The mix-in-place method may be used for the addition and mixing in of stabiliser.

a. Mixing Equipment

The equipment for pulverising the material and mixing in the stabiliser shall be purpose - built equipment, capable of pulverising the materials and mixing in the stabiliser to the full depth of the loose layer necessary to give the specified thickness of compacted material mixed and compacted in accordance with this section of this Specification.

The equipment may be either single or multi-pass machines and shall only be acceptable if, during the site trials carried out in accordance with **CLAUSE 1732** of this Specification, it can produce material to the specified requirements.

If single-pass equipment is used for plastic soils, the degree of pulverisation as determined in accordance with Test 17 of BS 1924 shall be not less than 80 percent.

The mixers shall be equipped with a device for controlling the depth of processing and mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

Mixing by grader will not be permitted.

b. Preparation of the Layer

Before the stabiliser is applied, the material to be treated shall be spread and broken down and oversize material removed so that the maximum size of the particles is not more than specified. If multi-pass processing is employed, the material shall first be pulverised to the required tilth by successive passes. The material shall then be shaped true to line, grade and cross-section and, if required, lightly compacted. The loose thickness shall be such as to give the specified thickness after full compaction has been carried out.

The moisture content of the layer before the addition of the stabiliser shall be adjusted to within the range of 70 % to 85 % of the "Optimum Moisture Content (AASHTO T180).

c. Spreading the Stabiliser

After the layer to be treated has been* prepared to the satisfaction to the Engineer, the stabiliser shall be uniformly spread over the width to be worked at the specified rate. If a spreader is used to spread the stabiliser ahead of the mixer, it shall be fitted with a device to ensure a uniform and controllable rate of spread both transversely and longitudinally.

Only sufficient stabiliser for immediate use shall be spread ahead of the mixing operation and any which, in the opinion of the Engineer, becomes defective, shall be replaced at the Contractor's expense.

Only equipment actually used in the spreading or mixing operation shall be allowed to pass over the stabiliser, when so spread, before it has been mixed into the material to be treated.

d. Mixing and Watering

Immediately after the stabiliser has been spread, it shall be thoroughly and intimately mixed into the material for the full depth, of the layer. Mixing shall continue until the resulting mixture forms a fine and homogeneous tilth. The mixing machine shall be set so that it cuts at least 100 mm into the edge of any adjoining lane processed previously so as to ensure that all the material forming the layer has been properly processed.

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Care shall be taken both during this and during subsequent watering operations that the underlying layer is not disturbed and that no material from the underlying layer or shoulders is mixed with that being processed. If watering is necessary to bring the mixture to the required moisture content, then this shall be done after spreading and mixing in the stabiliser. Water shall be added in a uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed in as a separate mixing operation. Care shall be taken to avoid a concentration of water at any point or a flow of water over the surface.

Any part of the mixture which becomes too wet after the stabiliser has been added and before the mixture is compacted will be rejected and any such part shall be allowed to dry out until its moisture content is satisfactory and shall be retreated with fresh stabiliser and finished off in accordance with this **CLAUSE 4407**.

Throughout the process of mixing in the stabiliser and water, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct uncompacted thickness and shape. Any part of the mixture that becomes segregated shall be removed and replaced.

4406 Stationary Plant Method Of Construction

a. Mixing Equipment

Stationary mixing plant shall be of the power driven paddle or pan type and may be of the batch or continuous type.

If batch mixers are used, the appropriate measured amounts of material and stabiliser shall first be placed in the mixer, water being then added as necessary to bring the moisture content of the resulting mixture within the range determined in the laboratory and site trials. Special care shall be taken with batch type paddle mixers to ensure that the stabiliser is spread uniformly in the loading skip so that it is fed evenly along the mixing trough and that with both paddle and pan mixers the stabiliser is proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilised. Mixing shall be continued until the mixture has the required uniformity and for not less than 1 minute unless a shorter minimum period is permitted by the Engineer after satisfactory trials.

If continuous mixing is used, the paddles, baffles and rate of feed of materials shall be adjusted to give uniformly mixed material.

If a spray is used for distributing water into the mixer, it shall be adjusted to give uniformity in moisture content throughout the mix.

b. Transporting

Mixed material shall be transported to the road in suitable vehicles. Material that becomes segregated or is affected by weather shall be removed and replaced at the Contractor's expense.

c. Laying

The mixed material shall be spread by means of a mechanical paver to the required width and such thickness that the tolerance requirements as specified in **SECTION 1800** of this Specification are obtained after final compaction. Segregation shall be avoided and the layer shall be free from pockets of coarse or fine material.

4407 Compaction and Finishing

For cement treated materials final compaction and finishing shall be completed within 2 hours after the cement comes into contact with the material to be treated. For lime treated materials, final compaction and finishing shall be completed within 4 hours after the lime comes into contact with the material to be treated.

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a. Thickness Limitations

The compacted thickness of any treated layer laid, processed and compacted at one time shall not exceed 180 mm where a greater thickness is required, the material shall be laid in two or more layers.

The compacted thickness of any base layer shall not be less than 3 times the maximum particle size of the material and the compacted thickness of any sub-base layer shall not be less than twice the maximum particle size of the material.

b. Compaction Requirements

The minimum density for all lime and cement treated materials shall be 95 % MDD of AASHTO T180. The moisture content at the time of compaction shall be between 95 % and 105 % of Optimum Moisture Content (AASHTO T180).

c. Finishing

The surface finish after compaction of any treated layer shall be free from ridges, compaction planes, laminations, loose and segregated material and other surface irregularities and shall be to line and level and within the tolerances specified in SECTION 1800 of this Specification. If the surface fails to meet the requirements of this Specification the Contractor shall take the action set out in the appropriate part of SECTION 1800 of this Specification or such other action as the Engineer may instruct, or agree.

4408 Joints Between New And Existing Work

The forming of construction joints and the protection of previously treated or other work shall be carried out so as to produce a uniformly compacted and homogeneous layer free from ridges or other irregularities.

Full width working, without longitudinal joints, will generally be required. Half-width working may be instructed by the Engineer to pass traffic. When forming longitudinal joints, with the mix-in-place, method, at least 100 mm of the first laid half-width layer shall be retreated and mixed in with the second laid half-width layer.

When forming transverse joints, with the mix-in-place method, at least 1.0 m length of the previously laid treated work shall be incorporated into the new treated layer and the Engineer may instruct that the percentage of stabiliser be increased at these places.

When forming longitudinal or transverse joints with the stationary plant method of construction, previous work shall be cut back to expose fully treated and compacted material.

4409 Protection And Curing

Treated layers shall be kept continuously damp by lightly spraying with water, from completion of compaction until one of the curing systems specified below is placed.

Treated layers shall be protected, within 4 hours of completion of compaction in the case of cement treated material and 8 hours in the case of lime treated material, by one of the following methods:-

- i. Completely covering the layer with clear or light coloured approved polythene sheeting of minimum thickness 0.1 mm. The sheeting shall be laid to cover the whole of the surface of the layer. At joints the sheeting shall be lapped by at least 500 mm and any damaged sheeting shall be replaced at the Contractor's expense.

The sheeting shall be securely held in contact with the layer by an approved method.

- i. Completely covering the treated material with a layer of damp uncompacted gravel or soil material of minimum thickness 100 mm. This material, which may be that forming the next layer, shall be kept continuously damp.

- ii. Spraying the layer with A3 anionic emulsion at a rate of 1.5 l/m² to be applied in accordance with **CLAUSE 5203** and **5204** of this Specification. This method shall not be permitted where the following layer is to be a bituminous mix in accordance with **SECTION 5700** of this Specification.
- iii. Unless otherwise instructed by the Engineer, no prime will be required where method (iii) is adopted and the contractor shall comply with the requirements of **CLAUSE 5203** and **5204** of this Specification.

Plant used for dumping and spreading material, and the application of water or emulsion shall be approved by the Engineer and shall have individual axle loads not exceeding 6 tonnes.

Immediately prior to placing protection methods (i) or (iii) the surface of the treated layer shall be made thoroughly damp by lightly spraying with water.

The curing system shall be kept in place and intact for a minimum of 7 days after completion of compaction although small areas may be temporarily removed for the purposes of carrying out control testing but only for the minimum amount of time required for the testing.

4410 Traffic

Traffic or equipment, other than that actually engaged in the various treatment or protection processes, shall not run over the layer being processed or compacted.

On completion of curing no traffic or equipment shall be allowed on the treated layer with the exception of that required for proofrolling, priming or construction of the subsequent layer.

4411 Tolerances

a. Geometric Tolerances

The treated upper earthworks, sub-base and base shall be constructed within the tolerances specified in **SECTION 1800** of this Specification.

b. Amount of Stabiliser

i. Mix-in-place method of construction.

The average amount of stabiliser, measured before mixing, over a length of 100 m, shall not be less than the amount ordered.

The average amount of stabiliser in the treated material, measured at five points over a length of 100 m, shall not be less than the amount ordered.

The amount of stabiliser, measured after mixing, shall at no point be less than 70 % or more than 130 % of the amount ordered.

ii. Stationary plant method of construction

The average amount of stabiliser in the treated material measured at five points over a length of 100 m, shall not be less than the amount ordered.

The amount of stabiliser measured after mixing shall at no point be less than 90 % or more than 110 % of the amount ordered.

iii. Determination of stabiliser content

The cement content in mixed materials shall be determined according to Test 14 of BS 1924 or to AASHTO T211-65 (1982).

The lime content in mixed materials shall be determined according to Test 15 of BS 1924.

4412 Measurement And Payment

For the purpose of measurement and payment no distinction shall be made between the mix-in-place and stationary plant methods of construction.

The work of providing, placing, spreading mixing, watering shaping and hauling the materials to be stabilised will be measured and paid for in **SECTIONS 3600, 4200 and 4300**, as appropriate, of this Specification.

For the additional work of providing and mixing-in the stabiliser and curing the treated materials the Contractor will be paid as follows:-

Item	Unit
44.01 Stabiliser	Tonne (t)

The provision of the stabiliser shall be measured by the tonne calculated as the specified weight of stabiliser added to the material.

The rate for stabiliser shall include for the cost of provision, storage, handling, transport and spreading of the stabiliser at any point on the Works and complying with the requirements of **CLAUSES 1401, 1403, 1404, 1405, 1406, 1408 and 1411** of this Specification.

Item	Unit
44.02 Stabiliser	Cubic Metre (m ³)

Mixing stabiliser into the material shall be measured by the cubic metre of treated material calculated as the product of the compacted Sectional area specified to be treated and the length instructed.

The rate of mixing shall include for the cost of complying with the requirements of **CLAUSES 4405, 4406, and 4407** of this Specification.

Item	Unit
44.03 Curing Treated Material	Square Metre (m ²)

Curing treated material shall be measured by the square metre of the layer cured calculated as the product of the specified width of treated layer and the length cured.

The rate for curing shall include for the cost of watering, provision placing and maintenance of the curing system, and for complying with the requirements of **CLAUSE 1409 and SECTION 5200** of this Specification.

SECTION 4500 Bound and Stabilised Materials

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4501 Scope of Section

This section covers the stabilisation of materials used in the construction of the formation, fill or pavement layers by mechanical modification of the material by mixing various materials or by treating the material with a bituminous stabilising agent. It includes the furnishing, spreading and mixing-in of the stabilising agent or soil binder.

This section covers the requirements for the following types of material classified according to their minimum CBR strength, unconfined compression strength (UCS) and indirect tensile strength (ITS):

1. **HIG50** Hydraulically improved granular material of minimum soaked CBR 50 %.
2. **HIG60** Hydraulically improved granular material of minimum soaked CBR 60 %.
3. **HIG100** Hydraulically improved granular material of minimum soaked CBR 100 %.
4. **HIG160** Hydraulically improved granular material of minimum soaked CBR 160 %.
5. **HMS1** Hydraulically modified stone of minimum UCS 1 MPa and maximum 2.5 MPa.
6. **HBS3** Hydraulically bound stone of minimum UCS 3 MPa.
7. **HBS6** Hydraulically bound stone of minimum UCS 6 MPa.
8. **HBS9** Hydraulically bound stone of minimum UCS 9 MPa.
9. **BSM50** Bitumen stabilised material of minimum ITS 50 kPa.
10. **BSM100** Bitumen stabilised material of minimum ITS 100 kPa.
11. **BSM175** Bitumen stabilised material of minimum ITS 175 kPa.

These materials shall comply with the specifications given in TABLE 4502, TABLE 4503, TABLE 4504.

4502 Materials

a. Chemical Stabilising Agents

The stabilising agent shall be either one or more of the following agents specified on the Drawings, in the Bill of Quantities or in the Special Specifications or as ordered by the Engineer.

i. Lime

Lime shall comply with the requirements of KS 1755.

ii. Portland Cement

Portland cement shall comply with the requirements of KS EAS 18-1 or equivalent standard on approval of the Engineer.

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b. Soil Binder

Soil binder for mechanical modification shall be taken from an approved source and shall be subject to such requirements regarding grading, plasticity index or other properties as may be indicated on the borrow-pit plans, or prescribed by the Engineer.

c. Materials for Bituminous Stabilisation**i. Bituminous stabilising agents**

For the purposes of this specification the bituminous stabilising agent shall be one or more of the following agents specified on the drawings, in the schedule of quantities or in the project specifications, or as may be instructed by the engineer, and shall comply with the appropriate specification given below:

Slow-set bituminous emulsion (60 % net bitumen) complying with BS 434.

ii. Filler

Fillers such as lime and cement and added for improving adhesion and/or stability shall comply with the requirements of **CLAUSE 5202**.

iii. Aggregate

Material for bituminous stabilisation shall be subject to the requirements prescribed for chemically stabilised gravel or crushed-stone base, with the provision that the plasticity index shall not exceed 6 after the addition of chemical stabilising agent (if required) and before stabilisation.

In the case of gravel material, the percentage of material smaller than 0.075 mm shall not exceed 12 %. No gravel from weathered igneous rock may be used, unless it is prescribed in the project specifications.

Where gravel material or crushed stone has been recovered from existing pavements, the engineer may allow up to 15 % material smaller than 0.075 mm to be present in material intended for bituminous stabilisation.

Where specified in the project specifications, material from existing pavements mixed with existing bituminous surfacing material may be used in bitumen stabilised base where so approved by the engineer, in writing. The end materials specification still apply.

d. Water

Water used for diluting emulsions shall be clean and free from excessive salts as will break the emulsions during dilution and shall be tested for compatibility with the prescribed stabilising agent.

e. Selection of Stabiliser

The most suitable type of stabiliser to use for a particular type of soil shall be as given in the Special Specifications, or as directed by the Engineer whereby **TABLE 4502/1** may be used as guidance.

TABLE 4502/1: GUIDE TO SELECTION OF STABILISER

Lime or Cement	Soils with more than 25 % particles passing the 0.075 mm sieve			Soils with less than 25 % particles passing the 0.075 mm sieve		
	PI ≤ 10	10 < PI < 20	PI ≥ 20	PI ≤ 6 PP ≤ 60	PI ≤ 10	PI ≥ 10
Lime	Marginal effectiveness	Yes	Yes	Not suitable	Marginal effectiveness	Yes
Cement	Yes	Yes	Marginal effectiveness	Yes	Yes	Yes

f. Purchase and Storage of Stabilisers

From the time of purchase to the time of use, all stabilising agents shall be kept under proper cover and be protected from moisture.

Consignments of these materials shall be used in the same sequence as that in which they are delivered at the Works. Stock which have been stored on the Site for periods longer than three months shall not be used in the Works, unless authorised by the Engineer.

g. Material Properties

i. Durability

In order to ensure that an irreversible stabilisation reaction occurs, the amount of stabiliser added shall not be less than the Initial Consumption of Lime (ICL) as determined according to BS 1924: Part 2 plus 1 %.

ii. Material requirements

The requirements for materials before and after treatment are given in TABLE 4502/2 to TABLE 4502/12.

Wherever grading modulus (GM) is referred to the value shall be calculated as follows:

$$GM = 3 - \frac{\% \text{ pass } 2\text{mm} + \% \text{ pass } 0.425\text{mm} + \% \text{ pass } 0.075\text{mm}}{100}$$

TABLE 4502/2: REQUIREMENTS FOR HIG50 MATERIAL

Material Before Treatment			Cement / HRB	
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.			Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.	
Material Classification		Min G14	Amounts required	Plastic gravels 2 - 4 %
Grading for natural gravels	Maximum Size	10-15 mm		Sands and clayey sands 2 - 3 %
	Passing 0.075 mm Sieve	Max. 40 %	Lime	
Grading for sands, silty sands and clayey sands	Maximum size	0.5 – 10 mm	Hydrated calcium lime (See standard specification)	
	Passing 0.075 mm Sieve	Max. 50 %		
Plasticity Index		Max. 30 %	Amounts usually required:	1 – 4 %
Plasticity Modulus		Max. 2,500		
Organic Matter		Max. 2 %	Treated Material	
Extra Requirements for Lime Treatment	Passing 0.425mm sieve	Min. 15 %	HIG50: CBR of Laboratory mix at 95 % MDD of AASHTO T180 and 7 days cure + 7 days soak: 50 %, PI min 5 % - max 12 %. PM max 250.	
	Plasticity Index	Min. 10		

TABLE 4502/3: REQUIREMENTS FOR HIG60 MATERIAL

Material Before Treatment			Cement / HRB		
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.			Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.		
Material Classification		G20	Amounts required	Plastic gravels	2 - 4 %
Grading for natural gravels	Maximum Size	10 - 15 mm		Sands and clayey sands	2 - 4 %
	Passing 0.075 mm Sieve	Max. 40 %	Lime		
Grading for sands, silty sands and clayey sands	Maximum size	0.5 – 10 mm	Hydrated calcium lime (See standard specification)		
	Passing 0.075 mm Sieve	Max. 50 %			
Plasticity Index		Max. 25 %	Amounts usually required:		2 – 4 %
Plasticity Modulus		Max. 1,200			
Organic Matter		Max. 2 %	Treated Material		
Extra Requirements for Lime Treatment	Passing 0.425mm sieve	Min. 15 %	HIG60: CBR of Laboratory mix at 95 % MDD of AASHTO T180 and 7 days cure + 7 days soak: 60 %, PI min 5 % - max 12 %. PM max 250		
	Plasticity Index	Min. 10			

TABLE 4502/4: REQUIREMENTS FOR HIG100 MATERIAL

Material Before Treatment			Cement / HRB		
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.			Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.		
Material Classification		G25	Amounts required	Plastic gravels	2 - 4 %
Grading for natural gravels	Maximum Size	10 - 50 mm		Sands and clayey sands	2 - 3 %
	Passing 0.075 mm Sieve	5 - 35 %	Lime		
Grading for sands, silty sands and clayey sands	Maximum size	1 – 10 mm	Hydrated calcium lime (See standard specification)		
	Passing 0.075 mm Sieve	Max. 40 %			
Plasticity Index		Max. 20 %	Amounts usually required:		2 – 4 %
Plasticity Modulus		Max. 250			
Organic Matter		Max. 1 %	Treated Material		
Extra Requirements for Lime Treatment	Passing 0.425mm sieve	Min. 15 %	HIG100: CBR of Laboratory mix at 95 % MDD (AASHTO T180) and 7 days cure + 7 days soak 100 %. PI max 8. PM max 250.		
	Plasticity Index	Min. 10			

TABLE 4502/5: REQUIREMENTS FOR HIG160 MATERIAL

Material Before Treatment			Cement / HRB	
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.			Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.	
Material Classification		G30	Amounts required	Plastic gravels 2 - 4 %
Grading for natural gravels	Maximum Size	10 - 50 mm		Sands and clayey sands 2 - 4 %
	Passing 0.075 mm Sieve	5 - 35 %	Lime	
Grading for sands, silty sands and clayey sands	Maximum size	1 – 10 mm	Hydrated calcium lime (See standard specification)	
	Passing 0.075 mm Sieve	Max. 40 %		
Plasticity Index		Max. 12 %	Amounts usually required:	2 – 4 %
Plasticity Modulus		Max. 250		
Organic Matter		Max. 1 %	Treated Material	
Extra Requirements for Lime Treatment	Passing 0.425mm sieve	Min. 15 %	HIG160: CBR of Laboratory mix at 95 % MDD (modified AASHTO) and 7 days cure + 7 days soak 160 %. PI max 6. PM max 250.	
	Plasticity Index	Min. 10		

TABLE 4502/6: REQUIREMENTS FOR HMS1 MATERIAL

Material Before Treatment			Cement / HRB	
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.			Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.	
Material Classification		Min G45 or GCS-A to GCS-D.	Estimated amounts required	GCS-A, GCS-B, GCS-C 1 - 2 %
Plasticity Index after 7 days cure and 7 days soak:		< 6		GCS-D or G45 2 - 3 %
Plasticity Modulus after 7 days cure and 7 days soak:		Max. < 250	Treated Material	
			UCS (MPa): 7 days cure + 7 days soak 1.0 – 2.5 (max) MPa (Cylinder) or minimum CBR 160 %.	

TABLE 4502/7: REQUIREMENTS FOR HBS3 MATERIAL

Material Before Treatment		Cement / HRB		
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.		Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.		
Material Classification	Min G45 or GCS-A to GCS-D.	Estimated amounts required	GCS-A, GCS-B, GCS-C	2 - 3 %
Plasticity Index after 7 days cure and 7 days soak:	< 6		GCS-D or G45	3 - 4 %
Plasticity Modulus after 7 days cure and 7 days soak:	< 250	Treated Material		
		UCS (MPa): 7 days cure + 7 days soak 3 – 6 MPa (Cylinder). Strength ratio soaked/OMC > 0.8		

TABLE 4502/8: REQUIREMENTS FOR HBS6 MATERIAL

Material Before Treatment		Cement / HRB		
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.		Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.		
Material Classification	Min GCS-A, GCS-B, GCS-C	Estimated amounts required	GCS-A, GCS-B, GCS-C	3 - 4 %
Plasticity Index after 7 days cure and 7 days soak:	< NP	Treated Material		
Plasticity Modulus after 7 days cure and 7 days soak:	< N/A	UCS (MPa): 7 days cure + 7 days soak 6 – 9 MPa (Cylinder). Strength ratio soaked/OMC > 0.8		

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TABLE 4502/9: REQUIREMENTS FOR HBS9 MATERIAL

Material Before Treatment		Cement / HRB	
Experience has shown that materials which comply with the following requirements are generally suitable for improvement.		Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282.	
Material Classification	GCS-A	Estimated amounts required	4 - 5 %
Stone Grading		Coarse Aggregate	> 2 mm
Sieve (mm)	% Passing	Crushing Ratio	Min. 80 %
37.5	100	Flakiness Index	Max. 25 %
28	90 – 100	Los Angeles Abrasion	Max. 35 %
20	65 – 95	Aggregate Crushing Value	Max. 28 %
10	40 – 70	Combined Aggregate Requirements	
6.3	30 – 55	Fines (passing 0.425 mm)	Non-plastic
2	18 – 40	Sand Equivalent	Min. 40 %
1	13 – 32	S.S.S	Max. 12 %
0.425	9 – 24	Organic Matter	Max. 0.3 %
0.075	0 - 6	Treated Material	
Treated Material		UCS (MPa): 7 days cure + 7 days soak 9 – 15 MPa (Cylinder Strength). No result less than 6 MPa, No strength to exceed 15 MPa. Strength ratio soaked/OMC > 0.8	

TABLE 4502/10: REQUIREMENTS FOR BSM50 MATERIAL

Material Before Treatment		Bitumen Stabiliser and Active Filler	
Material Classification	Min G30, or recycled asphalt pavement	Bitumen Binder	
		Slow setting A3 and A4 anionic and K3 cationic emulsions, foamed bitumen.	
CBR after 4-day soak	Min 30 %	Lime for Pre-treatment and Active filler	
Plasticity Index	Max 12 %	Hydrated calcium lime (See standard specification) Amounts usually required: pre-treatment 1 to 2 % and maximum of 1 % as active filler.	
Organic Mater	Max 1 %		
Grading Modulus	1.2 – 2.7	Cement for Active Filler	
Recommended Residual Binder Content		Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282. Amounts required: Max 1 %	
Reclaimed asphalt pavement %	1.75 – 2.50		
Graded Crushed Rock %	2.25 – 3.00	Treated Material	
Gravels of CBR ≥ 30 %	2.5 – 3.25		
Gravels/sands of CBR ≥ 20 %	2.5 – 4.0		
The mix shall comply with the following specifications:			
Property	Specimen curing regime & moisture conditions		Spec.
ITS dry (kPa)	100 mm diameter Marshall specimen cured for 72 hours at 40°C		125 - 225
ITS wet (kPa)	100 mm diameter Marshall specimen cured for 72 hours at 40°C and soaked for 24 hours		50 - 100
UCS soaked (kPa)	UCS specimen cured for 72 hours at 40°C and soaked for 4 days		Min 500
CBR soaked (%)	CBR specimen cured for 72 hours at 40°C and soaked for 4 days		Min 50 %
TSR	Tensile Strength Ratio: (ITSwet/ ITSdry) × 100 %		Min 50 %

TABLE 4502/11: REQUIREMENTS FOR BSM100 MATERIAL

Material Before Treatment		Bitumen Stabiliser and Active Filler
Material Classification	Min G45, or recycled asphalt pavement	Bitumen Binder
		Slow setting A3 and A4 anionic and K3 cationic emulsions, foamed bitumen.
CBR after 4-day soak	Min 45 %	Lime for Pre-treatment and Active filler Hydrated calcium lime (See standard specification) Amounts usually required: pre-treatment 1 to 2 % and maximum of 1 % as active filler.
Plasticity Index	Max 10 %	
Organic Mater	Max 1 %	
Grading Modulus	1.2 – 2.7	
Recommended Residual Binder Content		
Reclaimed asphalt pavement %	1.75 – 2.50	Cement for Active Filler Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282. Amounts required: Max 1 %
Graded Crushed Rock %	2.25 – 3.00	
Gravels of CBR ≥ 30 %	2.5 – 3.25	
Gravels/sands of CBR ≥ 20 %	2.5 – 4.0	
Treated Material		
The mix shall comply with the following specifications:		
Property	Specimen curing regime & moisture conditions	Spec.
ITS dry (kPa)	100 mm diameter Marshall specimen cured for 72 hours at 40°C	200 - 275
ITS wet (kPa)	100 mm diameter Marshall specimen cured for 72 hours at 40°C and soaked for 24 hours	100 - 150
TSR	Tensile Strength Ratio: (ITSwet/ ITSdry) × 100 %	Min 60 %

TABLE 4502/12: REQUIREMENTS FOR BSM175 MATERIAL

Material Before Treatment		Bitumen Stabiliser and Active Filler
Material Classification	Min GCS-C, or recycled asphalt pavement	Bitumen Binder
		Slow setting A3 and A4 anionic and K3 cationic emulsions, foamed bitumen.
CBR after 4-day soak	Min 80 %	Lime for Pre-treatment and Active filler Hydrated calcium lime (See standard specification) Amounts usually required: pre-treatment 1 to 2 % and maximum of 1 % as active filler.
Plasticity Index	Max 6 %	
Organic Mater	Max 1 %	
Grading Modulus	1.2 – 2.7	
Recommended Residual Binder Content		
Reclaimed asphalt pavement %	1.75 – 2.50	Cement for Active Filler Portland cement (CEM I – 42.5 MPa) complying to KS EAS 18-1 or HRB complying with BS EN 13282. Amounts required: Max 1 %
Graded Crushed Rock %	2.25 – 3.00	
Gravels of CBR ≥ 30 %	2.5 – 3.25	
Gravels/sands of CBR ≥ 20 %	2.5 – 4.0	
Treated Material		
The mix shall comply with the following specifications:		
Property	Specimen curing regime & moisture conditions	Spec.
ITS dry (kPa)	100 mm diameter Marshall specimen cured for 72 hours at 40°C	≥ 275
ITS wet (kPa)	100 mm diameter Marshall specimen cured for 72 hours at 40°C and soaked for 24 hours	≥ 175
TSR	Tensile Strength Ratio: (ITSwet/ ITSdry) × 100 %	Min 70 %

4503 Construction

a. Preparing the Layer

For medium, heavy, and very heavy traffic roads, all material shall be mixed, batched, and moistened in a plant. For low-volume roads, where plant mixing, batching, and moistening is not feasible, the material to be stabilised shall be prepared and placed as specified in SECTIONS 3600 and 4100, and given at least one pass with a smooth-wheel roller. The material shall be damp.

b. Applying And Mixing In The Stabilising Agent

Mixing of gravel and soils with stabiliser and water in stationary or portable plant and laying with pavers shall be the default method. Alternatively, mixing shall be done by pulvimixer or equivalent plant approved by the Engineer, working over the full area and depth of the layer to be stabilised by means of successive passes of the equipment.

For any other method, approval must be sort from the Engineer.

Alternative method requiring the Engineer's approval

Where mixing on the road is employed the stabilising agent shall be spread uniformly over the full area of the prepared layer at the prescribed rate of application by means of an approved type of mechanical spreader in a continuous process, or it may be spread by other methods such as motor grader or by hand. Any equipment and method to be used shall be approved by the Engineer.

Immediately after the stabilising agent has been spread, it shall be mixed with the loose gravel for the full depth of treatment. Care shall be taken not to disturb the compacted layer underneath, nor to mix the stabilising agent in below the desired depth. Mixing shall be continued for as long as permissible within the stipulated time limits, and repeated as often as required to ensure a homogenous mix of the soil or gravel and the stabilising agent over the full area and depth of the material to be treated and until the resulting mixture is homogeneous and of uniform appearance throughout.

c. Watering

Immediately after the stabilising agent has been properly mixed with the soil or gravel, the moisture content of the mixture shall be determined, and the required amount of water shall be added.

Each application or addition of water shall be well mixed with the gravel or soil so as to avoid the concentration of water near the surface or the flow of water over the surface of the layer.

Particular care shall be taken to ensure satisfactory moisture distribution over the full depth, width and length of the section being stabilised and to prevent any portion of the work from getting excessively wet after the stabilising agent has been added. Any portion of the work that becomes too wet after the stabilising agent has been added and before the mixture has been compacted, will be rejected, and such portions shall be allowed to dry out to the required moisture content and shall then be scarified, re-stabilised, re-compacted and again finished off in accordance with the requirements specified herein, all at the expense of the Contractor. The water supply and watering equipment shall be adequate to ensure that all the water required will be added and mixed with the material being treated within a short enough period to enable compaction and finishing to be completed within the period specified in SUBCLAUSE 4503(g).

d. Compaction

During compaction the layer shall be continuously bladed by motor grader, and loss of moisture by evaporation shall be corrected by further light applications of water.

During compaction of the stabilised layers, the Contractor shall lightly harrow or scarify the crust before final rolling if so required by the Engineer, in order to prevent the formation of laminations near the surface of the layer. Final rolling shall be done with equipment that will give a smooth

surface finish which conforms to the surface tolerances specified. Low patches on the surface may not be filled after compaction. The minimum compaction requirements shall be as specified for the particular layer in the various sections of these Specifications.

A sufficient number of compacting units shall be employed on the work to ensure that, from the time the stabilising agent is first applied to the layer, the mixing process, watering, compacting, shaping and final finishing will be completed within the periods specified in SUBCLAUSE 4503(g).

e. Finishing at Junctions

Any finished portion of the stabilised layer adjacent to new work, which is used as a turn-round area by equipment in constructing the adjoining section, shall be provided with a protective cover of soil or gravel of at least 100 mm thick over a sufficient length to prevent damage to work already completed. When the adjoining section is being finally finished, such cover shall be removed to permit the making of a smooth vertical joint at the junction of the different sections. Material in the vicinity of the joint which cannot be processed satisfactorily with normal construction equipment shall be mixed and compacted with suitable hand-operated machines.

f. Curing the Stabilised Work

The stabilised layer shall be protected against rapid drying-out for at least seven days following completion of the layer.

The methods of protection may be any one or more of the following:

- i. The stabilised layer shall be kept continuously wet or damp by watering at frequent intervals. This method will be permitted for up to a maximum period of 24 hours, but one of Methods (ii) or (iii) shall be applied as soon as the moisture content of the stabilised layer so permits. Work which is not kept continuously wet or damp but is subjected to consecutive wet-dry cycles, may be rejected by the Engineer should they consider the layer to have been adversely affected.
- ii. The stabilised layer shall be covered with the material required for the following layer while the stabilised layer is still in a wet or damp condition. The material forming the protective layer shall be watered at such intervals as may be required to keep the stabilised layer continuously wet or damp, and in dry weather this shall be done at least once in every 24 hours.
- iii. The stabilised layer shall be covered with a curing membrane consisting of a spray-grade emulsion or cutback bitumen applied at the rate specified or instructed by the Engineer. The provisions of SECTION 4100 shall apply with changes as required to the application of a curing membrane. Cutback bitumen may be used instead of bitumen emulsion if trials show no adverse effect to the stabilised layer, such as loosening of the surface, and the result is to the full satisfaction of the Engineer.

No additional payment will be made for curing as described above, except that the application of a curing membrane when specified or ordered by the Engineer shall be paid for separately under SECTION 4100.

g. Construction Limitations

For cemented layers, the stabilising agent shall be applied only to an area of such size that all processing, watering, compacting and finishing can be completed within the period given in TABLE 4503/1.

TABLE 4503/1: CONSTRUCTION LIMITATIONS

Stabilising Agent and Material Class	Maximum Time for Completion After Stabilising Agent Comes in Contact With the Material to be Stabilised
Cement	2 hours
Lime	4 hours

No stabilisation shall be applied when the moisture content of the material to be stabilised exceeds the optimum moisture content by more than 2 % of the dry mass of material. No stabilisation shall be done when weather conditions may adversely affect the stabilising operations in the opinion of the Engineer. Excessive drying out or rain falling on the working area during the process of stabilisation may be sufficient cause for the Engineer to order any affected areas to be reconstructed at the Contractor's own cost.

No traffic or any equipment not actually used for processing the layer may be allowed to pass over the freshly spread stabilising agent. Only equipment required for curing or priming may be allowed over the treated layers during the specified curing period. Where water spraying equipment causes damage to the layer, the Contractor shall carry out watering by side-spraying tankers travelling off the stabilised layer or alternative methods employed to the satisfaction of the Engineer.

h. Quality of Materials and Workmanship

The Contractor shall keep detailed records of the quantities of stabilising agent applied to the road and the volume of material stabilised and shall make these records available to the Engineer. The Contractor shall also monitor the rate of application when using bulk spreading equipment, by taking a canvas patch or tray test every 200 metres or as required by the Engineer.

All spreader equipment shall be calibrated and approved by the Engineer before use on the road.

The requirements for testing compaction control shall be in accordance with **SERIES 1800**.

i. Compaction Requirements

The minimum required compacted density for pavement layers made of natural gravel shall comply with a lower specification limit of 97 % of MDD AASHTO T180 compaction, unless in the opinion of the Engineer the compaction is adversely affecting the gravel, in which a lower specification limit shall be specified, so long as the strength criterion is met.

j. Defective Work or Materials

Any material or work which does not comply with the requirements specified shall be removed and replaced with new materials or be repaired as specified to comply with the specified requirements if the Engineer permits.

4504 Mechanical Modification

Mechanical modification shall consist of the addition of an approved soil binder to material to improve its load bearing capacity, plasticity index, grading and other properties, or the mixing of material originating from various sources, as described hereafter.

a. Modifying Soil and Gravel by the Addition of a Soil Binder

This process involves the addition and mixing of an approved soil binder, which shall not exceed 20 % by mass of the total mixture, to the material to be improved.

The material to be treated shall be prepared, broken down and spread to the required loose thickness, all as specified in **SECTION 3500**. An approved binder material shall then be spread over the prepared material at the required rate, and the materials shall be mixed by a suitable method by motor grader, disc harrow and/or other suitable plant until the binder material is homogeneously mixed with the material being treated. The mixed materials shall then be watered, mixed and compacted as described in **SECTION 3500**.

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b. Mixing Materials from Various Sources

The mixing of materials from various sources requires the material from the first source to be dumped onto the road, prepared, broken down and spread in a layer of uniform thickness, after which it is lightly rolled with a steel-wheeled roller. The material from the second source shall then be dumped onto the road, prepared, broken down and evenly spread, after which the two materials shall be thoroughly mixed as described in SUBCLAUSE 5208(a).

The mixing of materials from different sources will apply only when the smallest component of the mixture exceeds 20 % of the total mass of the mixture. If not, the process will be regarded as the addition of a soil binder as described above in SUBCLAUSE 4504 (a).

c. Recombining Recovered Material

Where specified in the project specifications or required by the engineer, recovered material shall be recombined to comply with the requirements of the layer for which it is destined.

4506 Bituminous Stabilisation**a. Preparing the Material**

For medium and high-volume roads, all material shall be mixed, batched, and moistened in a plant. For low-volume roads, the material to be stabilised shall be prepared and placed as specified in CLAUSE 4503, and shall be ploughed into furrows. The moisture content of the material shall be just below the optimum moisture content during mixing-in of the stabilising agent. Immediately before the stabilising agent is applied, the material shall again be lightly wetted. No dry material whatsoever may then be present.

b. Mixing in the Additive

Where an additive (lime, cement, etc) has been specified, or if so required by the engineer, it shall first be spread and mixed in as described in CLAUSE 4503. Separate payment will be made for providing, applying and mixing-in the additives.

c. Heating and Diluting the Bituminous Stabilising Agent

The bituminous stabilising agent shall be heated as specified in CLAUSE 5305.

During dilution of the bituminous emulsion with water, care shall be taken to prevent its breaking. This will mean that clean water shall be added gradually during constant stirring of the emulsion or its circulation by pumps.

d. Applying the Stabilising Agent

After preparing the material, the stabilising agent shall be uniformly applied by an approved binder distributor (in accordance with SUBCLAUSE 4103(a)) in a continuous process at the prescribed rate of application over the full area of the layer. Multiple applications may be necessary. In such cases it shall be ensured that the moisture escaping on account of drying-out is replaced by water being applied. Care shall be taken not to allow the stabilising agent to run from the layer before it has been mixed in.

The stabilising agent shall be diluted with water to obtain a better distribution.

In cases where, in the opinion of the engineer, it is impracticable to apply the stabilising agent by mechanical binder distributor, hand distributors may be used.

Where so required by the engineer, a certain part (not more than 10 % of the total quantity) of the stabilising agent shall be sprayed onto the surface in a diluted form (with a maximum of 2 parts of water to 1 part of bituminous stabilising agent) immediately, before the final finishing of the layer.

The stabilising agent shall, immediately after each application, be mixed with the loose material, to the full depth of the treated layer. This work shall be done carefully so as not to disturb the underlying compacted layer and as not to mix in the stabilising agent deeper than the required

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depth. During mixing-in, the moisture content of the material shall be immediately below or at optimum moisture content. Mixing shall be proceeded with for so long as may be necessary and shall be repeated as frequently as may be necessary to ensure the thorough, uniform and proper mixing of the gravel or the aggregate and the stabilising agent over the full surface and depth of the material to be treated, until the resulting mixture is homogeneous and has the same appearance throughout without any individual spots of the stabilising agent being visible, and until the mixture has reached the required moisture content of compaction.

Mixing shall be done by road grader, disc harrow, rotary mixer or similar plant, which will work the layer to be stabilised by way of successive passes over its full surface and depth.

Mixing may also be done in a central batch-mixing plant, but the contractor shall not be entitled to payment for extra overhaul or other costs arising from this method of work.

e. Compaction

The provisions of SUBCLAUSE 3503(f) shall apply. The moisture content during the compaction of stabilised layers shall not exceed the optimum of the gravel or aggregate. However, the engineer may amend these required moisture contents.

The engineer may prescribe or permit a limited amount of slushing as specified in SUBCLAUSE 3604(c) so as to ensure a higher density and/or better finish.

However, slushing, preferably after an initial drying out period, shall be limited so as to bring just sufficient fine material to the surface for improving rough spots, but not in excess. Fine material may not be swept from the road.

Where the required densities for a pavement layer in accordance with the modified AASHTO density is specified, the standard density as well as the field densities shall be determined on the material as obtained from the road, and the standard density or the field densities shall not be adjusted on account of the presence of bituminous stabilising agents.

Where, however, the required density has been specified in accordance with the apparent density of the material, the apparent density shall be determined at a specified testing location, or a representative sample of the aggregate without any addition of bituminous stabilising agent, and the value thus obtained shall be adjusted to make provision for the specified percentage of bituminous stabilising agent to be added, but no adjustment shall be made for making provision for the presence of bituminous stabilising agent in regard to such values as are obtained for field densities.

f. Finishing at Junctions

The junctions of sections shall be finished in accordance with SUBCLAUSE 4503(e) for obtaining an even and well-compacted joint and so as not to cause damage to the adjacent parts of the sections.

g. Construction Limitations

- When gravel is being stabilised with a bituminous emulsion, the layer shall be mixed and compacted within 24 hours.
- Limited slushing shall be done within 48 hours.
- Where crushed stone is stabilised with bituminous emulsion and used for repairing sub-base or base layers, it shall be mixed in, placed, and compacted within 5 hours.

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Natural Crushed Stone & Stabilised Pavement Layers | 4500 | Bound and Stabilised Materials

4506 Stabilisation Work In Restricted Areas

a. General Requirements

The provisions of SUBCLAUSE 5208 (c) in regard to work in restricted areas shall apply.

Where existing and new work are joined (longitudinal joints and others), material shall be satisfactorily mixed and compacted without any permeable or loose patches. CLAUSE 5209 shall apply.

In regard to the curing of stabilised layers in restricted areas, the construction of the subsequent layers may be commenced as soon as practicable with the permission of the Engineer.

b. Chemical Stabilisation

Where pavement layers are to be widened, no chemical stabilising agent may be spread or mixed beyond the required width. The contractor will not be permitted to mix material for stabilisation on adjacent surfaces unless he has obtained prior permission from the Engineer.. Where the existing surfaces of the road may not be used for this purpose, the contractor shall apply other approved methods of mixing.

Payment over and above payment for work in restricted areas will not be considered for additional overhaul or other costs arising from this manner of mixing or working.

c. Bituminous Stabilisation

No mixing of material with bituminous stabilising agent will be permitted on the existing surfacing without permission of the Engineer, and then only where such surface is required to be resealed or provided with a resurfacing layer. Where restricted areas are such that mixing in them will not be practicable and/or mixing on adjacent surfaces is not permitted, mixing shall be done in a central mixing plant. In the case of smaller quantities, approved concrete mixers may be used.

Payment over and above payment for work in restricted areas will not be considered for additional overhaul or other costs arising from this manner of mixing or working.

4507 Construction Tolerances

a. Rate Of Application

i. Chemical stabilising agents

The average rate of application of a chemical stabilising agent, when applied by mechanical bulk-spreading equipment and measured by the canvas-patch method, shall be equal to the specified rate of application, and not exceed by more than 5 % of the specified rate of application, measured over any section not exceeding 1.0 km in length, and no single measurement shall show a value deviating by more than 20 % from the specified rate.

When hand spotted, stabilising agents shall be spread exactly to the specified rate of application.

ii. Bituminous stabilising agents

The average rate of application of bituminous stabilising agent as measured in the binder distributor shall be within 5 % of the specified rate of application.

b. Uniformity of Mix (chemical stabilisation)

One of the following test methods, as prescribed in the project specifications, shall be applied to assess the uniformity of mix:

- i. The quantity of cementitious binder in the mixed material as determined during sampling and testing as specified in SUBCLAUSE 8110(a), shall be within the limits specified in the statistical judgement plan described in CLAUSES 8206 or 8305.

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Natural Crushed Stone & Stabilised Pavement Layers | 4500 | Bound and Stabilised Materials

Samples for the determination of the uniformity of mix shall be taken immediately after the material has been mixed with the water and stabiliser and spread, but before the layer is compacted, and the contractor shall therefore make the necessary arrangements timeously and allow for the time to collect the samples.

As described in SUBCLAUSE 8110(a), test results shall be adjusted to make allowance for the presence in the material to be stabilised, of minerals which affect the test results. The above requirements for uniformity of mix shall be applied only on condition that the variation in these adjustments falls within the limits specified in CLAUSE 8110. The coefficient of variation may not exceed 0.3 (30 %) for material mixed on the spot, and 0.2 (20 %) for material mixed in a mixing plant.

- ii. The quantity and distribution of the effective cementitious binder in the mixed material shall be deemed acceptable if the resultant unconfined compressive test results of samples randomly selected immediately prior to the compaction of a stabilised construction lot, and covering the area on either side of the diagonal dividing such a lot, satisfy the statistical assessment criteria for the method outlined in the project specifications. The target value for the primary variation, required to perform the relevant calculations, shall be agreed based on the outcome of an acceptable trial section, and shall fall within the following applicable ranges:

Number of Stabiliser type Permissible range traffic lanes for setting target value of the primary variation for cementation.

2	LIME	0.3 to 0.7
3	LIME	0.3 to 0.7
2	OPC (or blends)	0.4 to 1.0
3	OPC (or blends)	0.5 to 0.9

Where the primary variation obtained for the trial section, falls outside the specified range, a new trial section will be required.

4508 Measurement And Payment

a. General

The curing membrane, where required, shall be paid for under CLAUSE 4412. The stabiliser agent shall in all cases be paid for separately under ITEM 45.03. The process of stabilisation may be paid for in one of the two alternative ways given below, as specified in the Special Specifications and the Bill of Quantities:

- As an **extra-over** rate for admixture of the stabiliser and curing, where all costs for furnishing the natural gravel layer has been paid for already under SECTION 3500 or SECTION 4400 of these Specifications as relevant, or
- As a payment for **full cost** of providing the material to be stabilised, admixture of stabiliser, compaction and curing, however at separate payment for the stabiliser.

b. Alternative Payment as an Extra-Over Rate

Item	Unit
45.01 Chemical Stabilisation, Extra-Over the Relevant Pay Item For Stabilising Materials Already Paid For Under SECTION 3500 or SECTION 4400	
(a) Earthworks Materials	Cubic Metre (m ³)
(b) Pavement Materials	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the layers treated as instructed by the Engineer.

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Natural Crushed Stone & Stabilised Pavement Layers | 4500 | Bound and Stabilised Materials

The bid rates for chemical stabilisation under Item 45.01 shall be paid as an extra-over the rate bid for constructing the un-stabilised layers. The bid rate for chemical stabilisation shall therefore include full compensation for spreading and mixing the stabilising agent, curing the stabilised sections, any extra water required, and all materials, supervision, labour, plant, equipment, tools and incidentals (extra over those provided for in the rates bid for constructing the un-stabilised layer) necessary for completing the specified work, but excluding the cost of supplying the stabilising agent. No distinction shall be made in respect of the type of stabilising agent used, the time for completion or the specific layer being stabilised, and the extra over rate bid shall apply to any combination of these.

When payment for overhaul is specified in the Special Specifications, the rates paid for under SECTION 3500 or 4400 shall include a free haulage distance as defined in SECTION 1600 for the respective layer being stabilised.

When payment for overhaul is not specified in the Special Specifications, the rates shall include for all transportation of the material.

c. Alternative Payment as a Full Cost Rate

Item	Unit
45.02	Chemical Stabilisation, Payment for Full Cost of Providing:
(a)	Stabilised Layer Inclusive Of Curing Material Class HIG50 Cubic Metre (m ³)
(b)	Stabilised Layer, Inclusive Of Curing Material Class HIG60 Cubic Metre (m ³)
(c)	Stabilised Layer, Inclusive Of Curing Material Class HIG100 Cubic Metre (m ³)
(d)	Stabilised Layer, Inclusive Of Curing Material Class HIG160 Cubic Metre (m ³)
(e)	Stabilised Layer, Inclusive Of Curing Material Class HMS1 Cubic Metre (m ³)
(f)	Stabilised Layer, Inclusive Of Curing Material Class HBS3 Cubic Metre (m ³)
(g)	Stabilised Layer, Inclusive Of Curing Material Class HBS6 Cubic Metre (m ³)
(h)	Stabilised Layer, Inclusive Of Curing Material Class HBS9 Cubic Metre (m ³)
(i)	Stabilised Layer, Inclusive Of Curing Material Class BSM50 Cubic Metre (m ³)
(j)	Stabilised Layer, Inclusive Of Curing Material Class BSM100 Cubic Metre (m ³)
(k)	Stabilised Layer, Inclusive Of Curing Material Class BSM175 Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the layers treated as instructed by the Engineer.

The bid rates for chemical stabilisation under ITEM 45.02 shall include full compensation for procuring, breaking down, placing, spreading and mixing the stabilising agent, curing the stabilised sections, any extra water required, and all materials, supervision, labour, plant, equipment, tools and incidentals compacting, testing the material including the protection and maintenance of the layer, all as specified.

When payment for overhaul is allowed for in the Special Specifications, the rates shall include a free haulage distance as defined in SECTION 1600.

When payment for overhaul is not allowed for in the Special Specifications, the rates shall include for all transportation of the material.

d. Payment for the Stabiliser Agent

Item		Unit
45.03	Chemical Stabiliser Agents:	
(a)	Slaked Road Lime	Tonne (t)
(b)	Normal Portland Cement	Tonne (t)
(c)	Other Stabilising Agent (State Type)	Tonne (t)

The unit of measurement shall be the tonne of stabilising agent.

The quantity shall be determined in accordance with the authorised rate of application within the layer concerned.

The bid rates shall include full compensation for providing the stabilising agent at the Works irrespective of the rate of application specified or ordered by the Engineer.

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Natural Crushed Stone & Stabilised Pavement Layers | 4500 | Bound and Stabilised Materials

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SECTION 4600 Handpacked Stone

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4601 Scope

This section sets out the methods for laying and compacting handpacked stone.

4602 Material Requirements

Handpacked Stone (HPS) shall comply with the specifications set out in TABLE 4602/1.

Dry and Wet-Bound Macadam shall comply with the specifications set out in TABLE 4602/2.

TABLE 4602/1: REQUIREMENTS HANDPACKED STONE

Parent Rock				
Properties		Class A	Class B	Class C
UCS at 7 days soak		Min 20 MPa	Min 10 MPa	Min 3 MPa
CBR at 95 % MDD of AASHTO T180 and 4 days soak		Min 80 %	Min 60 %	Min 50 %
Los Angeles Abrasion		Max 50 %	Max 50 %	Max 60 %
Aggregate Crushing Value		Max 35 %	Max 35 %	Max 40 %
Plasticity Index		Max 10 %	Max 10 %	Max 10 %
Application				
Base		TC10	TC3	TC1
Sub-base		-	TC10	TC1-TC3
Stone Dimensions			Filler (0/10 mm Aggregates)	
Dimension	150 mm Stone	200 mm Stone	Sieve Size (mm)	% Passing
Length	150	200	10	100
Width	100 - 150	100 - 200	6.3	90 - 100
Breadth	100 - 150	100 - 200	4	75 - 95
			2	50 - 70
			1	33 - 50
			0.425	20 - 33
			0.300	16 - 28
			0.150	10 - 20
			0.075	6 - 12

TABLE 4602/2: REQUIREMENTS DRY AND WET-BOUND MACADAM (MAC)

Parent Rock			
Properties	Class A	Class B	Class C
LAA Max.	30	35	40
ACV Max.	25	28	30
SSS Max.	12	12	12
FI Max.	20	25	30
CR Min.	100	100	80
PI Max.	NP	NP	NP
Sand E Min.	40	40	40
Application			
Base	TC30	TC10	TC3
Sub-base	TC50 – TC150	TC30	TC10
Particle Size Distribution			
Aggregates (20/75 mm Aggregates)		Filler (0/5 mm Aggregates)	
Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
75	100	2	100
50	85-100	1	85-99
37.5	35-70	0.425	55-90
28	0-15	0.150	25-45
20	0-10	0.075	0-10

4603 Placing And Compaction

a. Hand Packed Stone

The stones shall be laid by hand and tightly packed using stones of maximum size of either 150 or 200 mm. The larger stones are packed with the longer dimensions placed vertically with the base at the bottom and the voids in between filled with the smaller stone driven with the apex facing down. The layer shall be proofrolled with a steel wheeled roller with a minimum axle load of 8 tonnes in the presence and approval of the Engineer.

Compaction shall be by a steel-wheeled roller of at least five tonnes per metre width of roll. It shall consist of four static runs or until there is no movement under the roller. There shall follow vibratory compaction until an average dry density of 85 % minimum of specific gravity of the stone has been achieved. No result shall be below 82 % of specific gravity.

After compaction a filler of crushed rock fines or sand shall be spread over the surface and brushed into the joints. The surface shall be vibrated using a vibratory plate compactor to ensure complete filling of spaces within the hand packed stone surface matrix by the fine aggregates. Where necessary, further sand or fines shall be added and the surface re-vibrated.

The filler shall be free from foreign matter and fines passing 0.425 mm sieve shall be NON-PLASTIC.

b. Dry Bound and Wet Bound Macadam

The dry-bound Macadam process involves laying single-size crushed stone of 75- or 50-mm nominal size in a series of layers, to achieve the design thickness. The compacted thickness of each layer should not exceed twice the nominal stone size. Each layer of coarse aggregate should be shaped and compacted, and then the fine aggregate should be spread onto the surface and vibrated into the interstices to produce a dense layer. Any loose material remaining is brushed off and final compaction carried out, usually with a heavy smooth-wheeled roller. This sequence

is then repeated until the design thickness is achieved. Economy in the production process can be achieved if layers consisting of 50 mm nominal size stone and layers of 37.5 mm nominal size stone are both used. This allows the required total thickness to be obtained more precisely and better overall use made of the output from the crushing plant.

Water-bound Macadam is similar to dry-bound Macadam. It consists of two components, namely a relatively single-sized stone with a nominal maximum particle size of 50 mm or 37.5 mm and well graded fine aggregate (grouting sand) that passes through the 5.0 mm sieve. The coarse material is usually produced from quarrying fresh rock. The crushed stone is laid, shaped, and compacted, and then fines are added, rolled, and washed into the surface to produce a dense material. Care is needed in this operation to ensure that water-sensitive plastic materials in the sub-base or subgrade do not become saturated. The compacted thickness of each layer should not exceed twice the maximum size of the stone. The fine material should preferably be non-plastic and consist of crushed rock fines or natural, angular pit sand.

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Natural Crushed Stone & Stabilised Pavement Layers | 4600 | Handpacked Stone

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SECTION 4700 Rectification of Pavement Layers

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4701 Scope

This section sets out the methods for rectification of pavement layers constructed outside permitted geometric tolerances. Where any tolerances in SECTION 1900 are exceeded, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement courses in the manner described below.

4702 Rectification Measures

a. Sub-base and Base Course

Where the levels or widths are out of tolerance and the courses consist of unbound (i.e. natural or graded stone) material, the full depth of the material shall be reworked to specification. The area treated shall be at least 30 m long and 3 m wide or such area to be determined by the Engineer as necessary to obtain compliance with this Specification.

Where the courses consist of cement or lime treated stabilised material or lean concrete the full depth of the layer shall be removed from the pavement and replaced to specification. The area treated shall be at least 5 m long and the full width of the paving laid in one operation. If areas are corrected within 7 days of laying no construction traffic or compaction plant shall use the surrounding satisfactory areas during that period.

For bituminous bases the full depth of layer shall be removed and replaced with fresh material laid and compacted to specification. Any area so treated shall be at least 5 m long and the full width of the paving laid in one operation.

Where the results of the construction control tests for any of the base or sub-base materials are less than that specified, the full depth of the layer shall be reworked to specification in case of unbound material and removed and replaced to specification in case of cemented and bituminous materials. The area treated shall be the whole section submitted for approval or, following a retest, such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

b. Asphalt Concrete Surfacing

Where the levels or widths are out of tolerance the full depth of the layer shall be removed and replaced with fresh material laid and compacted to specification. The area rectified shall be the full width of the paving laid in one operation and at least 15 m long.

Where the results of the construction control tests for the wearing course are less than that specified the full depth of the layer shall be removed and replaced to specification. The area treated shall be the whole section submitted for approval or, following a retest, such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

4703 Measurement And Payment

The Contractor shall be deemed to have allowed in their general rates and prices for the cost of complying with the requirements in this section and no additional payment will be made.

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Natural Crushed Stone & Stabilised Pavement Layers | 4700 | Rectification of Pavement Layers

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Natural Crushed Stone & Stabilised Pavement Layers | 4700 | Rectification of Pavement Layers

SERIES 5000 Bituminous Surface Treatments, Seals and Pavement Layers

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SECTION 5100 General Requirements for Bituminous Materials

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5101 Scope

This section comprises all the general requirements for bituminous binder and aggregate common to SECTIONS 5200 to 5800 inclusive.

5102 Bituminous Binder Specifications

a. General

The various bituminous binders specified shall comply with the relevant specifications as stated in TABLE 5102/1 or equivalent standards according to the Special Specifications and on the approval of the Engineer:

TABLE 5102/1: SPECIFICATIONS FOR BITUMINOUS BINDERS

Type of Binder	Specification
Penetration grade bitumen	ASTM D946/BS EN 12591
Polymer modified bitumens	BS EN 14023
Performance grade bitumen	AASHTO M320
Polymer Modified Cutbacks	BS EN 15322
Cutback bitumen - Medium curing	ASTM D2027 /AASHTO M82
Bitumen emulsions - Cationic	ASTM D3910/BS EN 13808
Bitumen emulsions - Anionic	BS 434

All bituminous binders shall comply with the relevant requirements set out in SECTION 1700 of this Specification.

The Type and grade of bituminous binders to be employed for the specific project shall be described in the Special Specifications.

Representative test certificates showing all relevant properties of the adhesion agent and bitumen shall be submitted for approval of the Engineer.

Such certificates shall be submitted minimum 28 days prior to proposed use or as required by the Engineer to conduct further testing of the materials. Samples of the materials shall be submitted together with the test results if required by the Engineer. New test certificates and samples shall be provided for approval in the event of changes in type or source of adhesion agent, bitumen grade, crude oil source, refinery equipment or refinery method, or as deemed necessary by the Engineer.

b. Pre-construction Binder Investigations

The Contractor shall immediately after signing of contract prepare pre-construction binder investigations, including:

1. Identification of a capable and independent bitumen testing laboratory for comparative testing of binders.
2. Collection of samples of potential bitumen.
3. Documentation of sample origin, including:
 - The refinery (name of owner(s) and full address).
 - Date, and time of sampling.
 - Point of sampling, (tank number, flow line valve, truck, drum, etc.).
 - Person responsible for sampling.
 - Production data:
 - i. Production date.
 - ii. Manufacturing method (direct vacuum distillation, propane precipitation, etc.).
 - iii. Feed stock data.
 - iv. Batch ID No.
 - v. Composition of product (raw materials, additives, etc.).
 - vi. Product characteristics (penetration, softening point, etc.).
 - vii. Storage temperature.

The sample should be accompanied with a signed certificate from the manufacturer with the above-mentioned information and a declaration that the sample to be tested is representative of their production and that a corresponding product will be available to the project during the construction period.

4. Prepare a bitumen testing programme according to the present Specifications.
5. The Contractor shall test the bitumen samples in accordance with this Specification and send the results to the Engineer for approval.

5103 Bituminous Binder Storage and Handling

When carried in bulk containers, records of binder temperature and time in a manner acceptable to the Engineer shall be kept. Any bituminous binder not conforming to the requirements of **CLAUSE 5104** may be rejected by the Engineer as unsuitable for use in the Works.

The bitumen storage area and heating station shall be kept neat and tidy. The storage area shall be cleared of vegetation and the drums stacked on their sides and only in small quantities with gaps between each stack to reduce fire risk.

Bitumen distributors and boilers shall be kept clean, at all times. When changing the grade of bitumen and at the end of each day's work, all boilers and distributors shall be thoroughly cleaned out with a solvent. The flushings from boilers and distributors shall not be poured over the area indiscriminately, but shall be led by drainage channels to disposal pits, care being taken that flushings do not find their way into stormwater ditches or streams.

All boilers, pre-heating pits, tools, and plant shall be kept scrupulously clean.

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When filling the bitumen distributor from the boilers or bulk containers, the bitumen shall be passed through a filter of fine wire gauze.

On completion of the Works, the disposal pits and drainage channels shall be filled in, topsoiled and the site left clean and tidy.

5104 Heating of Bituminous Binder

During storage the temperature of the bituminous binder shall be kept as low as possible, consistent with reasonable pumpability.

The bituminous binder shall be heated in boilers or bulk storage containers, equipped with adequate pumps and accurate thermometers. No bitumen shall be heated in a boiler when the thermometer is broken or inaccurate.

The minimum pumping temperatures, the range of spraying temperatures and the maximum heating temperatures of cut-backs, penetration grade bitumens and emulsions are given in TABLE 5104/1.

TABLE 5104/1: GENERAL TEMPERATURE REQUIREMENTS FOR BITUMINOUS BINDERS

Binder	Temperature (°C)			
	Minimum Pumping	Spraying		Maximum Heating
		Slot-jets	Atomising jets	
Cut-back MC 30	10	35 - 45	50 - 60	65
Cut-back MC 70	25	55 - 65	70 - 85	85
Cut-back MC 250	45	80 - 90	90 - 110	110
Cut-back MC 800	60	100 - 115	120 - 135	135
Cut-back MC 3000	80	125 - 135	153 - 150	150
Cut-back 800/1400 (France)	90	135 - 145	145 - 160	160
Bitumen 400/500	95	140 - 150	160 - 170	170
Bitumen 280/320	100	150 - 160	160 - 170	170
Bitumen 180/200	105	155 - 165	160 - 170	170
Bitumen 80/100	115	160 - 170	160 - 170	170
Bitumen 60/70	120	Not sprayed	Not sprayed	170
Bitumen 40/50	125	Not sprayed	Not sprayed	175
Emulsion K1-70	15	75 - 85	75 - 85	95
Emulsion **K1-60	-	-	-	95

* These spraying temperatures are for guidance only since the optimum spraying temperature depends on the temperature/viscosity relationship of the bitumen.

** The minimum pumping and spraying temperatures for K1-60 shall be in accordance with the manufacturer's recommendation.

The manufacturer's guidance on applicable temperatures must always be sought.

For slot-Jets the viscosity for spraying shall be 70 to 100 centistokes and for atomising jets 35 to 60 centistokes.

No penetration grade bitumen, cut-back bitumen, or emulsion shall be heated above the maximum temperature given above and any that is overheated shall be removed from the Site and disposed of by the Contractor.

The rates of application of binder specified or instructed by the Engineer refer to volumes of binder corrected to 15.6°C using the Standard Petroleum Measurement Table (ASTM D 1250).

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Bituminous Surface Treatments, Seals & Pavement Layers | 5100 | General Requirements

5105 Adhesion Agent

Where required the adhesion agent shall be of an approved type and shall be used in accordance with the manufacturer's instructions and as instructed by the Engineer.

5106 Construction Limitations

No bituminous construction work will be permitted in adverse weather conditions (rain, high wind speeds in excess of 30 km/hr) or whenever so instructed by the Engineer.

Bituminous material, except for bitumen emulsions and certain types of prime coat if instructed by the Engineer, shall not be applied on a damp surface.

The following limitations shall generally apply:

1. Whenever the temperature of the road surface falls below the specified temperature for the binder to be applied or will probably fall below the required temperature before spraying the binder, no binder shall be sprayed;
2. No bituminous work shall be done during foggy or rainy weather and, when a cold wind is blowing, the above temperatures as specified in the sub-sections below, shall be increased by 3°C to 6°C;
3. When strong winds (more than 30 km/h) are blowing which are likely to interfere with the proper execution of the work, no sealing, especially spraying of binder, shall be done;
4. No sealing shall be done when rain or cold temperature is imminent;
5. No sealing shall be done when the surface of the layer is visibly wet, i.e. more than damp;
6. No sealing shall be done after sunset. A lighting system to be approved by the Engineer in the event of working before sunrise and after sunset.

5107 Protection Of Kerbs, Channels, Road Furniture, Etc.

Kerbs, channels, manholes, guard rails, bridge railings and any other structures, adjoining seals to be constructed, shall be protected from soiling. The Contractor shall replace at their own cost any items that have been soiled.

5108 Safety Precautions

The Contractor shall take every precaution to avoid fire or health hazards. He shall always ensure that:

1. Bitumen is heated only to the temperature required for the particular application;
2. Hot bitumen never comes in contact with water;
3. Suitable protective clothing and gloves are used when handling hot bitumen; and
4. Dust is reduced to a minimum.

Great care is required when using rapid-curing cut-back, because of the highly flammable nature of the solvent.

5109 Measurement and Payment

No separate measurement and payment shall be made for complying with the requirements of CLAUSES 5101 to 5107 inclusive of this Specification and the Contractor shall be deemed to have allowed in their rates in SECTIONS 5200 to 5800 inclusive of SERIES 5000 of this Specification for the costs of complying with the requirements of CLAUSE 5101.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5100 | General Requirements

SECTION 5200 Prime Coat & Tack Coat

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5201 Definitions

A prime coat means an application of low viscosity bituminous binder to an absorbent non-bituminous surface. If the prime coat is to be trafficked, it shall be covered with blinding material. The minimum period after priming and before application of blinding shall be 4 hours.

A tack coat shall mean a light application of bituminous binder to a bituminous or concrete surface.

5202 Materials For Prime Coat and Tack Coat

For prime coat, the binder shall be a medium-curing cut-back MC30 or MC70 unless otherwise instructed by the Engineer.

For tack coat, the following types of binders may be used:

1. Medium curing cut-backs (MC250, MC800 or MC3000).
2. Quick breaking emulsions (A1 or K1).
3. A3 Anionic emulsion diluted with water.
4. Polymer-modified emulsions.

The rate of spray will depend on the surface texture. It is usually between 0.3 and 0.8 l/m².

In case of emulsion diluted with water, it shall be applied a sufficient time before laying the bituminous mixture to allow the emulsion to break and the water to evaporate and run off.

Blinding material if required shall consist of fine aggregate, or sand, or crusher dust and shall contain not more than 15 per cent retained on a 6.3 mm sieve. The blinding material if required by the Engineer will be specified in the Special Specification.

5203 Preparation Of Surface

The surface to be sprayed shall be thoroughly cleaned by sweeping with mechanical brooms and/or washing or other approved means. All laitance of soil or binder material, loose and foreign material shall be removed.

All loose material shall be swept clear of the layer to expose the full width of the layer.

The surface to be sprayed shall be checked for line, camber and level, and the surface corrected, made good as necessary and approved by the Engineer before any bituminous spray is applied.

The Engineer's approval, or otherwise, of the surface will be given immediately prior to the Contractor's intention to start spraying.

Unless otherwise directed by the Engineer, immediately prior to the application of prime coat, the surface of the layer shall be lightly sprayed with water to give complete coverage of the layer, but in no case saturated.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5200 | Prime Coat & Tack Coat

In order to bring the surface to be primed to the condition required, water shall be applied in small increments by a distributor. Any water on the surface after spraying shall be allowed to drain away before the prime coat is applied.

5204 Spraying Of Prime Coat And Tack Coat

As soon as possible after the surface to be sprayed has been prepared as specified in [CLAUSE 5103](#) and approved by the Engineer, the prime or tack coat shall be sprayed on to it at the specified rate. Spraying shall be carried out not later than 12 hours after the surface has been prepared.

The quantity of binder used shall give complete coverage of the surface with a slight trace of run-off in places. Should the specified rate of spray appear to be incorrect, the Contractor shall immediately stop spraying, inform the Engineer and amend the spray rate as instructed by the latter.

The edge of the area shall be marked out with a line of string or wire pegged down at intervals not exceeding 15 m on straights or 7.5 m on curves.

Bitumen shall be sprayed from a pressure distributor and no hand spraying shall be permitted except in small areas, or to make good a defective area caused by a blocked nozzle.

The nozzles shall be arranged to give a uniform spray and shall be tested prior to spraying by discharging on to suitable material (such as building paper, metal sheets, etc...) or into purpose made troughs. Testing shall not take place on the road, and any bitumen spilt on the ground shall be cleaned off.

If during spraying, a nozzle becomes blocked or develops a defect, the spraying shall be immediately stopped, any area incompletely sprayed shall be made good with a hand spray, and the machine repaired before further spraying is commenced.

When commencing and stopping spraying, sheets of building paper or metal at least 2 m wide shall be spread across the full width to be sprayed to give a clean sharp edge.

The metal sheets used for stopping and starting work shall be cleaned after each run and the troughs used for testing shall be cleaned at the end of each day's work.

During spraying all kerbs, road furniture, culvert headwalls, tree boles and the like which are liable to be disfigured by splashing of bitumen shall be protected, and any such feature which is accidentally marred by bitumen shall be cleaned off with a suitable solvent or made good.

5205 Curing and Blinding Of Prime Coat

If, after the application of the prime coat, the bituminous material fails to penetrate within the time specified or if the road must be used by traffic, blinding material shall be spread in the amount required to absorb any excess bituminous material and to protect the primed surface.

Blinding material shall be spread from trucks in such a manner that no wheel will travel on uncovered bituminous material.

Unless the Engineer permits otherwise, all loose material on the sprayed surface, including any blinding material, shall be removed before any further layer of the pavement is laid.

5206 Tolerances

The rate of application of bituminous binder across the width of each spray run shall not vary by more than $\pm 10\%$ of the rate ordered and the average rate of binder for each single run of the spray truck shall be at least equal to the rate ordered. Tray tests should be taken at least once a day during priming operation to check calculations based on dipping of spray trucks.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5200 | Prime Coat & Tack Coat

5207 Measurement And Payment

Item		Unit
52.01	Prime Coat:	1 Litre (l) of each type of bituminous binder

Item		Unit
52.02	Tack Coat:	1 Litre (l) of each type of bituminous binder

Prime coat or tack coat shall be measured by the litre of each type of bituminous binder calculated as the product of the area in square metres instructed to be sprayed and the instructed rate of application in litres/square metre, corrected to 15.6°C.

The rate for prime coat or tack coat shall include for the cost of providing, hauling and spraying the prime or tack coat at the instructed application rate, blinding and complying with the requirements of CLAUSES 5102, 5103, 5104, 5105 and 5106 of this Specification.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5200 | Prime Coat & Tack Coat

SECTION 5300 Surface Dressing

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5301 Definitions

A single surface dressing means an application of bituminous binder to any kind of road surface followed immediately by a single layer of uniform sized chippings.

A multiple surface dressing means two or more surface dressings placed one on the other.

5202 Materials For Surface Dressings

a. Binder

The binder will generally be a suitable cationic quick- breaking emulsion such as K1-70, 80/100, 150/200 penetration grade bitumen, a medium- curing cut-back MC 3000 blended to the approval of the Engineer, or a polymer-modified binder. The type of binder will be specified in the Special Specification.

b. Chippings

i. Hardness, soundness, shape and cleanliness

The chippings shall consist of crushed stone, cubical in shape and free from visible stone dust and harmful material such as clay, salt, organic matter or other deleterious substances. The percentage passing the 0.075 sieve shall not exceed 0.5 % by weight.

The chippings shall comply with the requirements given in TABLE 5302/1, for the appropriate class as specified in the Special Specification.

TABLE 5302/1: GENERAL REQUIREMENTS FOR CHIPPINGS

Chipping Class	1	2	3	4
LAA Max.	20	25	30	35
ACV Max.	16	20	23	26
SSS Max.	12	12	12	12
FI Max.	20	20	25	25

ii. Angularity

The minimum size of the stone to be crushed to produce the chippings shall be at least 4 times the maximum size of the chippings.

iii. Grading

TABLE 5302/2: GRADING REQUIREMENTS FOR CHIPPINGS

Sieve Size (mm)	Percentage by weight passing (Nominal Sizes)			
	14/20	10/14	6/10	3/6
28	100	-	-	-
20	80 - 100	100	-	-
14	0 - 30	85 - 100	100	-
10	0 - 7	0 - 30	85 - 100	100
6.3	-	0 - 7	0 - 30	85 - 100
5	-	-	0 - 10	-
3	-	-	-	0 - 30
2	0 - 2	0 - 2	0 - 2	0 - 10
0.5	-	-	-	0 - 2

5303 Rate of Application of Binder and Chippings

The rate of spray of binder and the size and rate of spread of chippings shall be as specified in the Special Specification or as instructed by the Engineer.

Tray tests shall be carried out at least once per day during surface dressing operations to check spray and spread rates calculated from spray truck dippings and chip-spreader coverage, and more frequently when a number of short lengths are being surface dressed. Spray truck dippings shall be taken for each length sprayed and chip-spreader coverage shall be checked each day chipping operations are in progress.

5304 Crushing, Screening, Washing and Stockpiling Chippings

The construction plant provided and the methods of operating it shall be such as will produce chippings which meet the specified requirements of SUBCLAUSE 5202(b). This may require washing the chippings to meet the cleanliness requirements.

The Contractor shall comply with SECTION 3400 of this Specification when stockpiling chippings. If required the stockpile area shall be surfaced with 100 mm thickness of gravel or other material, acceptable to the Engineer. Any contaminated chippings shall not be used in the Works. After use, the stockpile area shall be cleared, topsoiled and left neat and tidy.

5305 Precoated Chippings

The bituminous binder used for precoated chippings shall be a medium curing cut-back MC30 or a semi-stable or stable emulsion such as anionic A2 or A3 or cationic K2 or K3 unless otherwise instructed by the Engineer. The amount of bituminous binder used to precoat chippings shall be specified in the Special Specification or shall be as instructed by the Engineer.

Precoating shall be carried out in a mixing machine acceptable to the Engineer.

The precoated chippings shall not be tacky and liable to agglomerate. The chippings precoated with cut-back or emulsion shall be stockpiled for the lapse of time required by the solvents or water to evaporate.

The precoated chippings shall be kept free of contamination by dust or other deleterious matter.

5306 Construction Plant For Surface Dressing

a. Bitumen Distributors

Bitumen distributors shall be truck mounted and shall have sufficient power to maintain uniform speeds for the proper application of the binder. The truck shall be equipped with an accurate tachometer showing the driver the speed in metres per minute. The truck shall be fitted with a gauge bar and chain or any other acceptable device clearly visible to the driver to enable them to follow the required edge. The distributor tank shall have a capacity of at least 4,000 litres and shall be fitted with a device for indicating the quantity in the tank at any time. It shall be equipped with heaters capable of maintaining temperatures up to 200°C and be fitted with an accurate thermometer.

The circulation system shall permit pumping around the tank and around the spray bar without actually spraying. Spray bars shall be available for spraying in widths varying from 0.5 m to 4 m and shall be adjustable transversely so that the operator can follow the required edge independently. The spray nozzles shall be arranged to give a uniform spray and the shut-off shall be quick-acting with an anti-drip device. The pressure in the spray bar shall be sufficient to give a good distribution and spraying of the binder.

Distributors shall be capable of applying bituminous binder within the limits of +/- 10 % of the specified rate of application over any portion of the surface.

Distributors shall be checked and calibrated before starting any work or when required by the Engineer. This shall include the calibration of all the metering devices and checking the uniformity of the transverse distribution of spray.

All distributors shall be furnished with a "rate of spray/machine speed" chart.

b. Chip-spreaders

Mechanical chip-spreaders shall be capable of spreading the chippings uniformly over variable widths, from 0.5 to 3.5 m, at the rates specified.

The number and output of chip-spreaders shall be sufficient to ensure that chippings are spread immediately after the bituminous binder has been applied.

Chip-spreaders shall be checked and calibrated before starting any work or when required by the Engineer.

c. Rollers

The main rolling shall be carried out with self-propelled pneumatic tyred rollers, having a wheel-load of more than 2 tonnes. The tyres shall be smooth and their pressure shall be more than 0.4 N/mm².

Steel-wheeled rollers shall not be used until all excess chippings have been removed and insufficiently chipped areas have been chipped over and then only in tandem with pneumatic tyred rollers or where approved by the Engineer. Only steel-wheeled rollers weighing less than 8 tonnes (total weight) will be accepted.

The number and output of rollers shall be sufficient to ensure that rolling does not lag behind spreading. Two pneumatic tyred rollers shall be used for each chip-spreader.

d. Miscellaneous Equipment

Sufficient trucks and loading machinery shall be employed to ensure an adequate, prompt and continuous supply of chippings. Rubber tyred mechanical rotary brooms towed by or mounted on rubber tyred vehicles shall be provided.

All labour working with or on bitumen shall be provided with protective clothing and footwear.

5307 Preparation of Surface

Immediately before spraying, all loose material and foreign matter shall be removed by thorough brushing with mechanical brooms and/or washing or other acceptable methods. All hardened mud or other foreign matter shall be loosened by scraping before sweeping. The debris shall be deposited well clear of the surface to be sprayed.

Any defect of the surface shall be made good as instructed by the Engineer and no binder shall be sprayed until the surface has been approved by the Engineer. The Engineer's approval or otherwise of the surface will be given immediately prior to the Contractor's intention to start spraying.

5308 Application of Surface Dressing

As soon as possible after the surface has been prepared and approved, the binder shall be uniformly sprayed at the specified rate. Spraying shall not be carried out later than 12 hours after the surface has been prepared.

The spraying width shall normally be one lane width so that construction traffic may run over the other lane

Immediately after the binder has been sprayed, clean dry chippings shall be uniformly applied at the specified rate by the use of as many mechanical chip-spreaders as necessary to match the rate of spraying. The elapsed time between the spraying of binder and the spreading of chippings shall in no case exceed one minute.

Should it become apparent that the supply of chippings is about to fail, the binder spraying shall be immediately stopped and shall not resume until an adequate supply of chippings is assured.

The correct rate of spread is generally assessed visually, as providing complete coverage, with the film of binder still visible between the chippings. Should the coverage appear to be incorrect, the Contractor shall immediately inform the Engineer, who will amend the rate of spread accordingly. Any excess of chippings shall be removed by hand and any insufficiently chipped area shall be chipped over by hand, so that adequate coverage is obtained. Brooming of the material to effect redistribution of chippings will not be permitted.

Rolling shall begin immediately after the chippings have been spread and, in no case, later than two minutes after the application of binder.

Rolling shall continue until all chippings are firmly embedded into the binder and until all excess chippings have been removed or insufficiently chipped areas have been chipped over. The number of passes shall be agreed with the Engineer. Usually, each point shall receive at least 6 passes of the pneumatic tyred roller.

Excessive rolling, resulting in the crushing of chippings, shall be avoided.

The roller speed shall not exceed 8 km/h, unless otherwise directed by the Engineer.

Additional rolling on a previously completed section shall be given later in the heat of the day by pneumatic tyred rollers in tandem with steel three wheeled rollers unless otherwise instructed by the Engineer.

5309 Aftercare and Control of Traffic

The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the stones being whipped off.

The Contractor shall erect temporary restriction signs, barriers and removable bumps or any other device, as instructed by the Engineer, to prevent vehicles travelling too fast over the newly laid

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Bituminous Surface Treatments, Seals & Pavement Layers | 5300 | Surface Dressing

surface dressing. Vehicle speed shall be restricted to a maximum of 30 km/h, until there is sufficient adhesion to ensure that the chippings will not be dislodged by faster vehicles.

After traffic has been permitted to run on the surface dressing for a period of at least two weeks and when instructed by the Engineer, all loose chippings shall be swept and taken away. Windrows of loose chippings shall not be allowed to accumulate at the sides of the road.

5310 Tolerances

The final average overall width of the surface dressing measured at six equidistant points over a length of 100 m shall be at least equal to the width specified or instructed. At no point shall the distance between the centreline of the road and the edge of the surface dressing be narrower than that instructed by more than 13 mm.

The rate of application of binder across the lane width shall not vary by more than +/-10 % of the rate ordered and for each length of lane sprayed in a single pass the average rate of binder application shall be not less than the rate ordered.

The average rate of application of chippings along and across the lane width for each single pass of the chip-spreader shall not vary by more than +/-10 % of the rate ordered.

5311 Measurement and Payment

Item	Unit
53.01 Seal Coat:	1 Litre (l) of each type of bituminous binder for each seal coat

Seal coats shall be measured by the litre, for each type of bituminous binder for each seal coat, calculated as the product of the area in square metres instructed to be sprayed and the instructed rate of application in litres/square metre, corrected to 15.6°C.

The rate for the seal coat shall include for the cost of preparation of the surface to receive the binders, providing, hauling and spraying the bituminous binder at the instructed application rate and complying with the requirements of SECTION 5100 and SECTION 5300 of this Specification.

Item	Unit
53.02 Chippings:	m ³ of each nominal size for each class

Chippings shall be measured by the cubic metre of each nominal size for each class calculated as the product of the area in square metres instructed to be covered and the reciprocal of the instructed rate of application in square metres/cubic metre or the actual rate of application in square metres/cubic metre whichever calculation gives the lower volume.

The rate for chippings shall include for the cost of providing, hauling spreading and rolling the chippings at any instructed application rate, all hauls as necessary and complying with SECTION 5100 and SECTION 5300 of this Specification.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5300 | Surface Dressing

SECTION 5400 Sand Seals

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5401 Definition

A sand seal means an application of bituminous binder covered with aggregate as specified below.

5402 Materials For Sand Seal

a. Binder

The binder shall be a medium-curing cut-back MC800 or MC3000 or K1-70 cationic emulsion unless otherwise instructed by the Engineer.

b. Aggregate

The aggregate shall consist of sand, or fine screenings, free from organic matter, clay and other deleterious material. The fines (passing a 0.425 mm sieve) shall be non-plastic. The Sand Equivalent shall exceed 40.

The grading shall be as in TABLE 5402/1 below.

TABLE 5402/1: GRADING OF AGGREGATE FOR SAND SEAL

Sieve (mm)	% by Weight Passing
6.3	100
5	95 - 100
4	90 - 100
2	50 - 95
1	20 - 80
0.6	10 - 50
0.425	3 - 25
0.3	0-15
0.15	0-8
0.075	0-5

5403 Rate Of Application Of Binder And Fine Aggregate

The rate of spray of binder and the rate of spread of the fine aggregate shall be as specified in the Special Specification or as instructed by the Engineer.

During the sand sealing operation tray tests to determine spray and spread rate shall be carried out at least once per day

5404 Construction

The surface to be covered shall be prepared in accordance with [CLAUSE 5307](#).

The binder shall be uniformly sprayed at the specified rate. The fine aggregate shall be uniformly

spread and rolled, all in accordance with **CLAUSE 5308**, except that the fine aggregate shall be spread in excess of that required to cover the binder.

5405 Aftercare and Control Of Traffic

The road shall be opened to traffic when instructed by the Engineer.

Traffic speed shall be restricted as per **CLAUSE 5309** for as long as the Engineer may require.

Any whipped-off aggregate shall be broomed back onto the road, as many times as are necessary for it to adhere fully to the binder.

5406 Tolerances

Sand seal shall be constructed within the same width tolerance as given in **CLAUSE 5310** for surface dressing.

The rate of application of binder and aggregate across the lane width shall not vary by more than +/-10 % of the rate ordered. The average rate of application of binder for a single pass of the spray truck shall be not less than the rate ordered. The average rate of application of sand for a single pass of the spreader shall not vary by more than +/-10 % of the rate ordered.

5407 Measurement and Payment

Item	Unit
54.01 Bituminous Seal Coat:	1 Litre (l) of each type of bituminous binder

Bituminous Seal coats shall be measured by the litre for each type of bituminous binder calculated as the product of the area in square metres instructed to be sprayed and the instructed rate of application in litres/square metre corrected to 15.6°C.

The rate for the bituminous seal coat shall include for the cost of preparation of the surface to receive the binder, providing, hauling and spraying the bituminous binder at the instructed application rate and complying with the requirements of **SECTION 5100** and **SECTION 5400** of this Specification.

Item	Unit
54.02 Aggregate:	Cubic Metre (m ³)

Aggregate shall be measured by the cubic metre calculated as the product of the area in square metres instructed to be covered and the reciprocal of the instructed rate of application in square metres/cubic metre or the actual rate of application in square metres/cubic metre whichever calculation gives the lower volume.

The rate for aggregate shall include for the cost of providing, hauling spreading and rolling the aggregate at any instructed application rate, brooming back whipped-off aggregate, and complying with **SECTION 5100** and **SECTION 5400** of this Specification.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5400 | Sand Seals

SECTION 5500 Gravel Seal

5501	Definition	317
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5501 Definition

A gravel seal means an application of bituminous binder covered with graded granular material.

5502 Materials For Gravel Seal

a. Binder

The binder shall be a medium curing cut-back MC800, MC3000, or 150/200 penetration grade unless otherwise instructed by the Engineer.

b. Aggregate

i. Source of material

The Contractor shall be responsible for locating suitable sources of material for the gravel seal. Notwithstanding [CLAUSE 3402](#) of this Specification such sources whether or not requiring drilling and blasting for the extraction of the material shall be termed as quarries and shall be provided in accordance with [SECTION 3400](#) of this Specification.

ii. Material

The cover aggregate shall consist of graded gravel or graded crushed stone or a mixture of these and shall be free from organic matter, clay and other deleterious material. Its hardness shall be as follows:

Los Angeles Abrasion: 40 % maximum

Aggregate Crushing Value: 30 % maximum

The cover aggregate shall have a grading within and approximately parallel to the envelope given in [TABLE 5502/1](#).

TABLE 5502/1: GRADING OF AGGREGATE FOR GRAVEL SEAL	
Sieve (mm)	% by Weight Passing
20	100
14	65 - 95
10	45 - 95
6.3	25 - 80
4	15 - 65
2	10 - 50
1	5 - 40
0.425	3 - 30
0.075	0-10

c. Adhesion Agent

The adhesion agent specified in the Special Specification or as instructed by the Engineer shall be added to the bituminous binder.

5503 Rate of Application of Binder and Fine Aggregate

The rate of spray of binder and the rate of spread of aggregate shall be as specified in the Special Specification or as instructed by the Engineer.

5504 Construction

The surface to be covered shall be prepared in accordance with **CLAUSE 5307**.

The binder shall be uniformly sprayed and the aggregate shall be uniformly spread and rolled in accordance with **CLAUSE 5308**.

5505 Aftercare and Control of Traffic

The road shall be opened to traffic when so instructed by the Engineer. The traffic speed shall be restricted as per **CLAUSE 5309** for as long as the Engineer may require.

5506 Tolerances

Gravel seal shall be constructed within the width tolerance given in **CLAUSE 5310**.

The rate of application of binder and aggregate across the lane width shall not vary by more than +/-10 % of the rate ordered. The average rate of application of binder for a single pass of the spray truck shall be not less than the rate ordered. The average rate of application of aggregate for a single pass of the spreader shall not vary by more than +/- 10 % of the rate ordered.

During gravel sealing operations tray tests to determine spray and spread rates shall be carried out at least once per day.

5507 Measurement and Payment

Item	Unit
55.01 Seal Coat:	1 Litre (l) for each type of bituminous binder

The seal coat shall be measured by the litre for each type of bituminous binder calculated as the product of the area in square metres instructed to be sprayed and the instructed rate of application in litres/square metre corrected to 15.6°C.

The rate for the seal coat shall include for the cost of preparation of the surface to receive the binder, providing, hauling and spraying the bituminous binder at any instructed application rate and complying with the requirements of **SECTION 5100** and **SECTION 5500** of this Specification

Item	Unit
55.02 Aggregate:	Cubic Metre (m ³)

Aggregate shall be measured by the cubic metre calculated as the product of the area in square metres instructed to be covered and the reciprocal of the instructed rate of application in square metres/cubic metre or the actual rate of application in square metres/cubic metre whichever calculation gives the lower volume. The rate for aggregate shall include for the cost of providing, hauling, spreading and rolling the aggregate at any Instructed application rate, and complying with **SECTION 5100** and **SECTION 5500** of this Specification.

SECTION 5600 Emulsion Slurry Seal

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5601 Definition

An emulsion slurry seal means a mixture of bitumen emulsion, fine aggregate, cement or lime and water prepared in a mixer and then spread on the road surface.

5602 Materials For Gravel Seal

a. Emulsion

The emulsion shall be either an anionic emulsion A4-60 (slow setting), cationic emulsion K1-60 (rapid-setting), or a slow acting cationic emulsion K3-65 unless otherwise instructed by the Engineer

b. Aggregate

The aggregates shall be free from organic matter, clay, silt or other deleterious matter. It shall have a sand equivalent of at least 40.

The grading curve shall be within one of the following envelopes as shown in TABLE 5602/1, as specified in the special specification.

TABLE 5602/1: GRADING OF AGGREGATE FOR SLURRY SEAL

Sieve (mm)	% by Weight Passing		
	Type I (Fine)	Type II (Normal)	Type III (Coarse)
10	-	-	100
6.3	-	100	80 - 95
5	-	90 - 100	70 - 90
2	100	60 - 87	40 - 65
1	60 - 85	40 - 67	25 - 45
0.425	30 - 48	22 - 38	15 - 28
0.3	25 - 42	18 - 30	12 - 25
0.15	15 - 30	10 - 20	7 - 18
0.075	10 - 20	5 - 15	5 - 15

c. Cement/Lime

Cement and lime shall comply with the requirements of SECTION 1600 of this Specification.

5603 Preparation Of The Slurry Mixture

The proportion by weight of dry aggregate of bitumen emulsion and cement or lime shall be specified in the special specification. These shall be termed the nominal proportions of bitumen emulsion and cement or lime.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5600 | Emulsion Slurry Seal

Water shall be added in significant quantity to obtain the correct slurry consistency as directed by the Engineer.

The slurry mixture shall be prepared in a slurry mixer acceptable to the Engineer. The mixer shall be charged with materials in the proportions specified.

The mixing cycle shall be sufficient to produce a uniform coating of the aggregate and a uniform consistency of the slurry. It shall continue until the slurry mixture is discharged into the spreader box or onto the road surface. The entire batch shall be discarded if there is evidence that the emulsion has broken. The slurry, ready for application, shall be a smooth, free flowing mixture throughout.

5604 Rate Of Application Of Slurry Mixtures

The rate of application of the slurry mixture shall be as specified in the special specification or as instructed by the Engineer

Tray tests shall be carried out at least once per day during slurry seal operations.

5605 Construction

Where a slurry seal is to be applied to a surface dressing the surface dressing shall be trafficked for a period of at least two weeks prior to application of the slurry.

The surface to be covered shall be prepared in accordance with [CLAUSE 5307](#).

The slurry mixture shall be evenly spread at the specified rate by a slurry machine, except in restricted areas where hand spreading may be permitted.

The surface immediately ahead of the spreader shall be slightly dampened, unless otherwise instructed by the Engineer. Unless otherwise directed by the Engineer, slurry seal shall be rolled with smooth tyred pneumatic rollers acceptable to the engineer. Rolling shall commence as soon as the slurry has set sufficiently to ensure that no rutting or pick-up will occur. The number of passes shall be as agreed with the engineer but usually each spot shall receive at least six passes of the pneumatic tyred roller

The finished slurry shall be of uniform surface texture and colour throughout the work. The finished surface shall be free from blow- holes and irregularities.

Labour-based Approach

The Contractor shall provide the following tools:

- Brooms and brushes for surface cleaning.
- Shovels and spades for material handling.
- Mixing pans or small mechanised concrete mixers.
- Buckets for measuring water and other materials.
- Squeegees and spreaders for slurry application.
- Hand-held rollers (if needed for compaction).
- Water cans or hoses for cleaning and adding water.
- Personal protective equipment (PPE).

The slurry is prepared by mixing bitumen emulsion, water, and aggregate in pre-determined proportions. This shall be done using mixing pans or small mechanised concrete mixers. The mix shall be uniform and homogenous with a consistent slurry-like texture before placing. To achieve this, water gradually to achieve the desired consistency.

The slurry shall then be spread evenly on the prepared road surface using hand tools such as squeegees, spreaders, or brooms. The slurry shall be applied in one continuous motion, ensuring uniform thickness without gaps or overlaps. The thickness of the slurry seal layer shall be as indicated in design drawings or as directed by the Engineer. After application, allow the slurry to cure. Depending on the ambient temperature, it may take a few hours to a full day for the slurry to set.

Light compaction shall be undertaken using small hand rollers to ensure bonding with the underlying surface. Traffic on the freshly applied slurry shall be restricted in accordance with [CLAUSE 5606](#).

5606 Curing And Control Of Traffic

All traffic shall be kept off the slurry seal until it has cured to a firm condition that will prevent pick-up of the mixture. Where two applications of slurry are required, the initial treatment shall be cured thoroughly prior to placing the succeeding application.

5607 Tolerances

Slurry seal shall be constructed within the same width tolerances given in [CLAUSE 5310](#).

The rate of application of slurry seal across the width of a lane sealed in a single pass shall not vary by more than +/-10 % of the rate ordered, and the average rate of application along the length of a single pass shall not be less than the rate ordered

5608 Measurement and Payment

Item		Unit
56.01	Slurry Seal:	m ³ of dry aggregates for each different mixture specified in the special specification

Slurry seal shall be measured by the cubic metre of dry aggregate for each different mixture calculated as the product of the area in square metres instructed to be covered and the reciprocal of the instructed rate of application in square metres/cubic metre of dry aggregate or the actual rate of application in square metre/cubic metre of dry aggregate whichever calculation gives the lower volume.

The rate for slurry seal shall include for the cost of preparation of the surface, providing bitumen emulsion and cement or lime at the nominal proportions specified, providing water as required, all haulage, mixing, laying and rolling and complying with the requirements of [SECTIONS 5100](#) and [SECTION 5600](#) of this specification and with the relevant clauses of the special specification.

Item		Unit
56.02	Variation in emulsion content:	1 (litre of each different emulsion)

Measurement of the variation in emulsion content shall be per litre of emulsion more than or less than the nominal proportion specified and the amount calculated by extending the quantity and the rate shall be added to or deducted from the total value of work certified.

Item		Unit
56.03	Variation in Cement or Lime Content:	1 Tonne of each type

Measurement of the variation in cement or lime content shall be per tonne of cement or lime more or less than the nominal proportion specified and the amount calculated by extending the quantity and the rate shall be added to or deducted from the total value of work certified.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5600 | Emulsion Slurry Seal

SECTION 5700 Bituminous Base Course & Asphalt Concrete Surfacing

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5701 Definition

This Section covers all the work in connection with the construction of bituminous base courses and asphalt concrete surfacing for new roads, pavement rehabilitation or maintenance. It includes the procuring and furnishing of aggregate and bituminous binder, mixing at a central mixing equipment, alternatively on the road, spreading and compaction of the mixture, all as specified for the construction of:

1. Asphalt surfacing (**Asphalt Concrete Type I, Asphalt Concrete Type II, Stone Mastic Asphalt, Gap-graded Asphalt, Sand Asphalt, and Cold Mix Asphalt**).
2. Hot mixed bituminous base (**Dense Bitumen Macadam, Enrobé à Module Élevé - EME [High Modulus Asphalt], Sand Bitumen Base**).

This section also covers the widening of bituminous layers.

This section also covers the recycling of bituminous materials by reprocessing recovered materials, adding fresh aggregate, bituminous binders and other agents for obtaining a bituminous mix, which will comply with the specified requirements, and placing the recycled material. The provisions of SECTION 5700 shall apply throughout to recycled bituminous materials, except where explicitly specified otherwise.

5702 Materials

a. General

Coarse and fine aggregate shall be clean and free from decomposed materials, vegetable matter and other deleterious substances and shall meet all relevant requirements in the Specifications

The coarse and fine aggregate shall be produced by crushing of rock obtained by blasting of hard solid rock formation. The crushing shall be by multi-stage equipment in order to produce aggregates of angular shape.

All materials shall be handled and stockpiled in a manner that will prevent contamination, segregation or damage. Stocks of cement and lime shall be rotated in a manner whereby it is used in the order in which it has been received.

The Contractor shall, as often as necessary, test and control the materials they produce or receive from suppliers to ensure that the materials always comply with the specified requirements.

The Contractor will not be expected to construct layers of which the compacted layer thickness is less than one and a half times the maximum aggregate size.

b. Bituminous Binders

The various bituminous binders specified shall comply with the relevant specifications as stated in SECTION 5100 or equivalent standards according to the Special Specifications and on the approval of the Engineer.

c. Aggregates

The aggregates employed for all the asphaltic pavement layers when tested shall conform to the following requirements unless otherwise stated in the individual clauses:

i. Aggregate Cleanliness

The Sand Equivalent of the fine aggregate shall be minimum 45. In addition less than 5 % of the fine aggregate shall pass the 0.075 mm sieve.

ii. Aggregate Particle Shape

The flakiness index when tested shall be a maximum of 25 %.

iii. Aggregate strength

The ACV of the coarse aggregate shall be max 30.

iv. Aggregate Absorption

The water absorption of the coarse aggregate shall not exceed 2 % by mass.

v. Aggregate Soundness

The magnesium sulphate soundness shall not exceed 12 %.

vi. Aggregate adhesion to bitumen: Coating and Stripping Test

The coating of the aggregates shall be greater than 95 %.

d. Materials Specifications for Asphalt Mixes

The materials specifications for asphalt surfacing mixes including grading of the combined aggregate and any filler added in an approved working mix shall be within the limits stated in TABLES 5702/1 - 5702/7 for the respective mixes.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5700 | Bituminous Base Course

TABLE 5702/1: SPECIFICATIONS FOR ASPHALT CONCRETE TYPE II

Bituminous Binder:

60/70 or 80/100 penetration grade bitumen at a content rate of 5.5 % – 7.5 % determined through mix design.

Aggregate Grading			Coarse Aggregate > 2 mm			
Sieve (mm)	Nominal Size (mm)		Aggregate Class	a	b	c
	0/10	0/14				
28	-	-	LAA Max.	30	35	40
20	-	100	ACV Max.	25	28	30
14	100	90 - 100	SSS Max.	12	12	12
10	90 - 100	70 - 95	FI Max.	20	25	25
6.3	62 - 90	55 - 85	Fine Aggregate < 2 mm			
4	50 - 80	46 - 75	Sand Equivalent Min.		40 %	
2	35 - 65	35 - 60	SSS Max.		12 %	
1	25 - 50	25 - 45	Mineral Filler			
0.425	14 - 33	14 - 32	Cement, Lime, Limestone or other mineral matter. Shall be non-plastic			
0.300	11 - 27	11 - 27	Passing 0.425 mm		100 %	
0.150	6 - 17	6 - 17	Passing 0.075 mm		75 %	
0.075	3 - 8	3 - 8	Bulk Density in Toluene		0.5 -0.9 g/ml	
0.075	3 - 8	3 - 8				
ACII Mix Requirements						
Crushing Ratio			60 %			
Marshall Stability			4 – 7 kN			
Flow Value			2 – 5 mm			
Voids in total mix			3 – 8 %			

TABLE 5702/2: SPECIFICATIONS FOR ASPHALT CONCRETE TYPE I WEARING COURSE

Bituminous Binder:

30/50, 60/70, and 80/100 penetration grade bitumen at a content rate of 5.5 % – 7.0 % determined through mix design. For Superpave, the binder is dependent on analysis of temperature data for the study site.

Aggregate Grading			Coarse Aggregate > 2 mm	
Sieve (mm)	Nominal Size (mm)		Crushing Ratio	100 %
	12.5	9.5	LAA Max.	30
50			ACV Max.	25
37.5			SSS Max.	12 %
25			FI Max.	20 %
19	100			
12.5	90 - 100	100	Fine Aggregate < 2 mm	
9.5	90	90 - 100	Sand Equivalent Min.	40 %
6.3				
2.36	28 - 58	32 - 67	Mineral Filler	
1			Cement, Lime, Limestone or other mineral matter. Shall be non-plastic	
0.300			Passing 0.425 mm	100 %
0.150			Passing 0.075 mm	75 %
0.075	2 - 10	2 - 10	Bulk Density in Toluene	0.5 -0.9 g/ml
Usual Bit. (%)	Min. 5.5 %	Min. 5.5 %		
Nominal Maximum aggregate size			12.5 mm	9.5 mm
Primary Control Sieve			2.36 mm	2.36 mm
PCS Control Point (% passing)			39	47
Mix Requirements (see Appendix D and E)				
Superpave:				
Compaction levels: Ninitial, Ndesign, and Nmaximum – See Appendix E of RDM 3.3				
Compactibility Test as in AASHTO R35 for choosing a trial mix (See Appendix E of RDM 3.3).				
Voids in total mix: 4 %.				
Grading as per the above envelopes.				
Trial Pavement Mixes:				
From Cores: Voids in compacted mixes: Maximum 6 % (average of at least 5 cores).				
Density: 96 % @ Ndesign and 98 % @ Nmaximum (See Appendix E of RDM 3.3)				
Performance Requirements for TC80 and higher:				
Hamburg Wheel Tracking Test: Max. rut = 15 mm at 60 °C after 10000 passes (5000 cycles)				
Fatigue test (4-point bending beam). Min. ratio of final stiffness to initial stiffness after 1 million cycles @400 microstrain = 50 %				
Dynamic Creep Test: Min. Creep Modulus at 40 °C = 10 MPa.				

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Bituminous Surface Treatments, Seals & Pavement Layers | 5700 | Bituminous Base Course

TABLE 5702/3: SPECIFICATIONS FOR ASPHALT CONCRETE TYPE I BINDER COURSE**Bituminous Binder:**

30/50, 60/70, and 80/100 penetration grade bitumen at a content rate of 5.0 % – 6.5 % determined through mix design. For Superpave, the binder is dependent on analysis of temperature data for the study site.

Aggregate Grading					Coarse Aggregate > 2 mm	
Sieve (mm)	Nominal Size (mm)				Crushing Ratio	100 %
	25	19	12.5	9.5	LAA Max.	30
50					ACV Max.	25
37.5	100				SSS Max.	12 %
25	90 - 100	100			FI Max.	20 %
19	90	90 - 100	100		FI Max.	12 %
12.5			90 - 100	100	Fine Aggregate < 2 mm	
9.5			90	90 - 100	Sand Equivalent Min.	40 %
6.3						
2.36	19 - 45	23 - 49	28 - 58	32 - 67	Mineral Filler	
1					Cement, Lime, Limestone or other mineral matter. Shall be non-plastic	
0.300						
0.150					Passing 0.425 mm	100 %
0.075	1 - 7	2 - 8	2 - 10	2 - 10	Passing 0.075 mm	75 %
Usual Bit. (%)	Min. 5.0	Min. 5.0	Min. 5.5	Min. 5.5	Bulk Density in Toluene	0.5 -0.9 g/ml
Nominal Maximum aggregate size		25.0 mm	19.0 mm	12.5 mm	9.5 mm	
Primary Control Sieve		4.75 mm	4.75 mm	2.36 mm	2.36 mm	
PCS Control Point (% passing)		40	47	39	47	
Mix Requirements (see Appendix D and E)						
Superpave:						
Compaction levels: Ninitial, Ndesign, and Nmaximum – See Appendix E of RDM 3.3						
Compactibility Test as in AASHTO R35 for choosing a trial mix (See Appendix E of RDM 3.3).						
Voids in total mix: 4 %.						
Grading as per the above envelopes.						
Trial Pavement Mixes:						
From Cores: Voids in compacted mixes: Maximum 6 % (average of at least 5 cores).						
Density: 96 % @ Ndesign and 98 % @ Nmaximum (See Appendix E of RDM 3.3)						
Performance Requirements for TC80 and higher:						
Hamburg Wheel Tracking Test: Max. rut = 15 mm at 60 °C after 10000 passes (5000 cycles)						
Fatigue test (4-point bending beam). Min. ratio of final stiffness to initial stiffness after 1 million cycles @400 microstrain = 50 %						
Dynamic Creep Test: Min. Creep Modulus at 40 °C = 10 MPa.						

TABLE 5702/4: SPECIFICATIONS FOR ASPHALT CONCRETE AND MASTIC ASPHALT MIXES

Bituminous Binder:

Polymer modified binder, 40/50 or 60/70 penetration grade bitumen at a content rate of minimum 5 % determined through mix design.

Aggregate Grading					Coarse Aggregate > 2 mm	
Sieve (mm)	Nominal Size (mm)				Crushing Ratio	100 %
	0/9.5	0/12.5	0/19		LAA Max.	35
50					ACV Max.	28
37.5					SSS Max.	12 %
25			100		FI Max.	25 %
19		100	90 - 100		FI Max.	12 %
12.5	100	90 - 100	50 - 88		Fine Aggregate < 2 mm	
9.5	90 - 95	50 - 80	25 - 60		Sand Equivalent Min.	40 %
6.3						
2.36	30 - 50	20 - 35	20 - 28		Mineral Filler	
1	20 - 30	16 - 24	16 - 24		Cement, Lime, Limestone or other mineral matter. Shall be non-plastic	
0.300	- 21					
0.150	- 15		-		Passing 0.425 mm	100 %
0.075	8 - 12	8 - 11	8 - 11		Passing 0.075 mm	75 %
Usual Bit. (%)	Min. 6.2	Min. 5.8	Min. 5.4		Bulk Density in Toluene	0.5 -0.9 g/ml

Mix Requirements (see Appendix D and E)**Designed in similar way as Asphalt Concrete Type II**

Marshall Stability: Min. 6 kN

Marshall Quotient: >2.5

Voids in mineral aggregate: >17 Voids in total mix: 3 % - 5 %

Voids filled with bitumen: 71 %-92 %

ITS wet/dry ratio: 70 %

Dust to binder ratio = 1.0-1.5

Binder film thickness: >8 µm

Fibre content: 0.3 % to 0.5 %

Performance Requirements for TC80 and higher:

Hamburg Wheel Tracking Test: Max. rut = 15 mm at 60 °C after 10000 passes (5000 cycles)

Fatigue test (4-point bending beam). Min. ratio of final stiffness to initial stiffness after 1 million cycles @400 microstrain = 50 %

Dynamic Creep Test: Min. Creep Modulus at 40 °C = 10 MPa.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5700 | Bituminous Base Course

TABLE 5702/5: SPECIFICATIONS FOR GAP-GRADED ASPHALT

Bituminous Binder:

60/70 penetration grade bitumen at a content rate determined through mix design.

Aggregate Grading			Coarse Aggregate > 2 mm			
Sieve (mm)	Nominal Size (mm)		Agg. class	a	b	c
	Coarse Aggregate	Fine Aggregate	LAA Max.	30	35	40
19	100		ACV Max.	25	28	30
12.5	38 - 100		SSS Max.	12	12	12
9.5	0 - 69		FI Max.	20	25	25
2.36	0 - 2		Fine Aggregate < 2 mm			
1.18		100	Sand Equivalent Min.		40 %	
0.425		70 - 97	SSS. Max		12 %	
0.300		49 - 93	Mineral Filler			
0.150		16 - 58	Cement, Lime, Limestone or other mineral matter. Shall be non-plastic			
0.075		0 - 20				
			Passing 0.425 mm		100 %	
			Passing 0.075 mm		75 %	
			Bulk Density in Toluene		0.5 -0.9 g/ml	

Gap Mix Requirements (see Appendix D and E)

Marshall Stability	3 – 9 kN
Flow Value	2 – 6 mm
Marshall Quotient	2.0 (kN/mm)
Voids in mortar of mix	3 – 9 %
Filler/bitumen ratio	0.9 – 1.3

Mix Design:

1. Prepare mixture of fine aggregate and filler to give 1:6 ratio by mass of filler to fine aggregate retained on 0.075 mm sieve. Determine the optimum bitumen content which gives maximum Marshall Quotient.
2. By adding coarse aggregate and reducing bitumen content, the Marshall Quotient may be increased to the specified value. 20 % coarse aggregate will increase quotient by a factor of approx. 1.5, 30 % by 1.9, 40 % by 2.4 and 55 % by 3.0. For an increase in coarse aggregate the revised bitumen content is given by:

Nominal bitumen content = (Optimum bitumen content (100-S)/100) + 2.3(S)/100. Where S = % of coarse aggregate added.
3. Prepare mixes in accordance with BS 594 at nominal bitumen content from (2) to check specified requirements.

TABLE 5702/6: SPECIFICATIONS FOR SAND ASPHALT

Bituminous Binder:

60/70 or 80/100 penetration grade bitumen at a content 6 % – 10 % rate determined through mix design.

Aggregate Grading		Aggregate	
Sieve (mm)	% by Weight Passing	Sand Equivalent Min.	40 %
		SSS Max	12 %
10	100	Mineral Filler	
6.3	95 - 100	Cement, Lime, Limestone or other mineral matter. Shall be non-plastic	
2	70 - 100		
1	47 - 95	Passing 0.425 mm	100 %
0.425	20 - 75	Passing 0.075 mm	75 %
0.300	15 - 60	Bulk Density in Toluene	0.5 -0.9 g/ml
0.150	8 - 30		
0.075	4 - 12		
Uniformity Coefficient: Min. 5			
Sand Asphalt Mix Requirements			
Marshall Stability		3 – 9 kN	
Flow Value		2 – 6 mm	
Marshall Quotient		5 – 10 %	

TABLE 5702/7: SPECIFICATIONS FOR COLD MIX ASPHALT

Cationic emulsion K3-65 (slow setting) or anionic emulsion A3, and suitable aggregates

Aggregate Grading			Aggregate Requirements	
Sieve (mm)	% by Weight Passing		LAA Max.	40
	0/10	0/14	ACV Max.	30
20	100	100	SSS Max.	12
14	100	90 - 100	FI Max.	25
10	90 - 100	70 - 95	Sand Equivalent	Min 40
6.3	62 - 90	55 - 85	Binder Content	
4	50 - 80	46 - 75	0/10 Aggregates	6 – 7.5 %
2	35 - 65	35 - 60	0/14 Aggregates	5.5 – 7.0 %
1	25 - 50	25 - 45	Properties of Compacted Mix	
0.425	14 - 33	14 - 32	Modified Marshall Stability at 50 blows, 24 hr oven cure at 40°C and 1 hr soak (N)	Min 3000
0.300	11 - 27	11 - 27		
0.150	6 - 17	6 - 17	Voids in Total Mix (%)	3 – 8
0.075	3 - 8	3 - 8	Flow (mm)	2 – 5
Mineral Filler			Stability loss after immersion (%)	Max 50
Cement, Lime or other non-plastic materials			Aggregate Coating (%)	Min 50

e. Materials Specifications for Asphalt Bases

The materials specifications for asphalt base mixes including any filler added in an approved working mix shall be within the limits stated in TABLES 5702/8 - 5702/1 for the respective mixes. The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in CLAUSE 5713.

For recycled asphalt the nominal mix ratios of recovered asphalt, new aggregate, new bituminous binders, and active mineral filler to be used for bidding purposes, shall be as specified in the Special Specifications.

TABLE 5702/8: SPECIFICATIONS FOR DENSE BITUMEN MACADAM

Bituminous Binder:

30/50, 50/70, and 80/100 penetration grade bitumen at a content rate of minimum 4 % determined through mix design.

Aggregate Grading			Coarse Aggregate > 2mm		
Sieve (mm)	Nominal Size (mm)		Crushing Ratio	100 %	
	37.5	25	LAA Max.	30	
50	100		ACV Max.	25	
37.5	90-100	100	SSS Max.	12 %	
25	- 90	90 - 100	FI Max.	20 %	
19		-	Fine Aggregate < 2 mm		
12.5			Sand Equivalent Min	40 %	
9.5			Mineral Filler		
6.3			Cement, Lime, Limestone or other mineral matter. Shall be non-plastic		
2.36	15 - 41	19 - 45			
1			Passing 0.425 mm	100 %	
0.300			Passing 0.075 mm	75 %	
0.150			Bulk Density in Toluene	0.5 -0.9 g/ml	
0.075	0 - 6	1 - 7	Nominal Max. Aggregate Size	37.5 mm	25.0 mm
Usual Bit. (%)	Min. 4 %	Min. 4 %	Primary Control Sieve	9.5 mm	4.75 mm
			PCS Control Point (% passing)	47	40

Mix Requirements

Marshall

Compactability Test as in Part 1 of BS 5835 to be used in choosing a bitumen content for a trial mix. Voids in total mix: 3 % - 8 %.

As an alternative to the above grading, the Bailey Method may be used to determine a suitable grading.

Trial Pavement Mixes:

From Cores: Voids in compacted mixes: Maximum 7 % (average of at least 5 cores).

Marshall Stability: 9 kN @ 2x 75 blows, Flow = 2-4 mm, Dust/Binder ratio = 0.6 to 1.2

Indirect tensile strength: Min. 800 kPa @ 25 °C.

Tensile strength ratio (wet/dry): Min. 80 %

Superpave:

Compaction levels: Ninitial, Ndesign, and Nmaximum – See Appendix E of RDM 3.3

Compactability Test as in AASHTO R35 for choosing a trial mix (See Appendix E of RDM 3.3).

Voids in total mix: 4 %.

Grading as per the above envelopes.

Trial Pavement Mixes:

From Cores: Voids in compacted mixes: Maximum 6 % (average of at least 5 cores).

Density: 96 % @ Ndesign and 98 % @ Nmaximum (See Appendix E of RDM 3.3)

Performance Requirements for TC80 and higher:

Hamburg Wheel Tracking Test: Max. rut = 15 mm at 60 °C after 10000 passes (5000 cycles)

Fatigue test (4-point bending beam). Min. ratio of final stiffness to initial stiffness after 1 million cycles @400 microstrain = 50 %

Dynamic Creep Test: Min. Creep Modulus at 40 °C = 10 MPa.

TABLE 5702/9: SPECIFICATIONS FOR ENROBÉ À MODULE ÉLEVÉ (EME)

Bituminous Binder:

10/20 or 20/30 penetration grade bitumen at a content rate of minimum 4 % determined through mix design.

Aggregate Grading				Coarse Aggregate > 2mm	
Sieve (mm)	Nominal Size (mm)			Crushing Ratio	100 %
	0/10	0/14	0/20	LAA Max.	35
50				ACV Max.	28
40				SSS Max.	12 %
31.5			100	FI Max.	25 %
20		100	90 - 99	Fine Aggregate < 2 mm	
14	100	90 - 99	70 - 95	Sand Equivalent Min	40 %
10	90 - 99	-	55 - 90	Mineral Filler	
6.3	60 - 80	42 - 65	42 - 75	Cement, Lime, Limestone or other mineral matter. Shall be non-plastic	
4	35 - 65	-	-		
2	27 - 42	19 - 42	18 - 35	Passing 0.425 mm	100 %
0.250	8 - 18	8 - 18	8 - 18	Passing 0.075 mm	75 %
0.063	5 - 9	5 - 9	5 - 9	Bulk Density in Toluene	0.5 - 0.9 g/ml
Bit. (%)	Min. 5.5	Min. 5.3	Min. 5.1		
Gyratory Comp.	80	100	120		

Mix Requirements

Hamburg Wheel Tracking Test: Maximum proportional deformation (%) = 7.5 at 60 °C.

Minimum laboratory dynamic modulus (4-point bending beam): = 8000 MPa @ 20 °C and 5 Hz

Voids in total mix: 3 % - 5 %

TABLE 5702/10: SPECIFICATIONS FOR SAND BITUMEN MIX USING SILTY CLAYEY SAND

Bituminous Binder:

Emulsion or cut-back bitumen at a content 2.5 % – 5 % rate determined through mix design.

Sand		Bituminous Binder	
Passing 0.075 mm:	Max. 10 % - 30 %	Anionic emulsion A3 or cut-back MC 250 or MC 800 Usual amount: 2.5 % - 5 % (residual)	
Liquid Limit:	Max. 40		
Plasticity Index:	Max. 15		
Sand Mix Requirements		TC10	TC3-TC1
Marshall Stability (kN): Minimum		5.25	3.75
Flow Value (mm)		2 - 4	2 - 5
Water absorbed after 7 days soak (Max. %)		4	4

TABLE 5702/11: SPECIFICATIONS FOR SAND BITUMEN MIX USING SILTY CLEAN SAND**Bituminous Binder:**

60/70 or 40/50 penetration grade bitumen at a content 3 % – 4.5 % rate determined through mix design.

Sand		Bituminous Binder	
Free of soluble salts, organic and other deleterious matter.		Bitumen 40/50 or 60/70 pen or emulsion A2 or A3 Usual amount: 3 %-4.5 % (residual)	
Passing 0.075 mm	Max. 20 %	Mineral Filler	
Sand Equivalent:	Min. 30	Cement, Lime, Limestone or other mineral matter. Shall be non-plastic	
		Passing 0.425 mm	100 %
		Passing 0.075 mm	75 %
Sand Mix Requirements		TC10	TC3-TC1
Marshall Stability (kN): Minimum		3	2.5
Flow Value (mm)		2 - 4	2 - 5

f. Requirements for Hot Mixed Dense Bituminous Macadam (DBM) for Base Course

The materials specifications for dense bituminous macadam (DBM) for base course mixes including any filler added in an approved working mix shall be within the limits stated in TABLES 5702/8. The 25 mm nominal size followed by double surface dressing may also be accepted, at the discretion of the Engineer, as surfacing for heavily trafficked roads.

g. Aggregates and Mix Design Requirements For Bitumen Stabilised Materials (BSM)**i. General**

The aggregate shall be natural gravel, crushed material or approved material milled off existing pavement layers. Unless otherwise approved by the Engineer the material shall be placed in stockpile prior to mixing with bitumen.

All operations to produce, stockpile and lay bituminous base course and shall be carried out in a manner which ensures a homogeneous mixture with even distribution of additives, bitumen and water without segregation or contamination or excessive variations in moisture contents within the material. All aggregate shall be free from lumps, soft or unsound particles, clay or other deleterious material. The aggregates shall be free of organic matter and the flakiness index shall not exceed 35 %.

Unless otherwise approved by the Engineer the aggregate shall be screened into a minimum of two fractions before use. Minimum one fraction shall be free of fines within a tolerance of maximum 5 % passing the 2.0 mm sieve. The fractions shall be combined to achieve the required grading uniformly throughout the production of bituminous base. The mix design shall be based on laboratory tests of parallel sets of representative samples with a minimum of 5 different bitumen contents respectively. The mix design shall adequately show test results that can be expected on material produced within the tolerances given. The mix design shall give one moisture content and one bitumen content for the proposed mix recipe.

ii. Aggregate strength

The TFV of the coarse aggregate used in cold mixed bituminous base course, when determined dry in accordance with BS EN 1097-2 or equivalent, shall not be less than:

- 110 kN for Traffic Load greater than 1×10^6 M CESA
- 80 kN for Traffic Load less than 1×10^6 M CESA

The appropriate Traffic Load Class shall be as given in the drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply. The wet strength shall not be less than 75 % of the dry strength.

iii. Properties of mixed material

The grading of the combined aggregate including any filler added in an approved working mix shall be within the limits stated in SUBCLAUSE 4202 (C) for the respective mixes. The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in SUBCLAUSE 5713(b).

For materials specifications see tables in SUBCLAUSE 4202 (C).

h. Filler

If the grading of the combined aggregates for asphalt surfacing mixes shows a deficiency in fines an approved filler may be used to improve the grading. Filler may consist of active filler as defined hereinafter or of inert material such as rock dust having the required grading necessary to improve the grading of the combined aggregates. In no instance shall more than 2 % by mass of active filler be used in asphalt mixes. Inert filler such as rock dust used to improve grading shall not be subject to this limitation.

The Engineer may order the use of any active filler to improve the adhesion properties of the aggregate. Active filler shall consist of, hydrated lime, Portland cement or any other approved by the Engineer. Individual materials shall comply with the requirements of the relevant specifications for such material.

Active filler shall have at least 70 % by mass passing the 0.075 mm sieve, all passing the 0.600 mm sieve and a bulk density in toluene falling between 0.5 and 0.9 g/ml. The voids in dry compacted filler shall be between 0.3 % and 0.5 %, when tested in accordance with BS EN 1097-4.

Active fillers for use in bituminous base courses shall be introduced to the mix prior to wetting with the binder. Only active filler added on the instructions of the Engineer, for the purpose of improving adhesion, will be paid for. No payment will be made for filler added to improve the grading.

i. Asphalt Reinforcing

Asphalt reinforcing shall be of the type specified in the Special Specifications and shall be obtained from an approved manufacturer.

Where the use of reinforcing for asphalt has been specified, the Contractor shall, at least three months before the material is to be used, submit samples of the type they intends to use, together with complete specifications of the material, as well as the manufacturer's instructions for use, to the Engineer for approval. Contractor shall test the material at an approved laboratory and submit the results to the Engineer.

j. Recycling

i. Recovered asphalt

The Engineer will test the existing asphalt in any part of the road and determine its suitability for recycling before removal. He may instruct the Contractor to drill additional cores at specified points. Recovered asphalt intended for recycling shall be stored separately from other asphalt, and the Engineer may also direct different types of asphalt to be stored separately.

The recovered asphalt shall be free from any underlying base material and other foreign matter.

Asphalt milled out shall be of a maximum size of 28 mm, unless another maximum size has been approved by the Engineer.

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Asphalt not milled out shall be broken down in an approved manner so that it can be properly remixed in an equipment to the satisfaction of the Engineer. Mixes of recycled asphalt containing fragments of recovered asphalt exceeding 28 mm in size, will not be accepted.

Payment for recovered asphalt will distinguish between milled out and non-milled out material.

Samples shall be taken from the recovered asphalt intended for recycled mixes in the stockpile and shall be tested for grading and quality of the aggregate, binder content and properties of the binder.

ii. Bituminous binders

The provisions of **CLAUSE 5702** shall apply. The grade of new binder used in the recycled asphalt mix shall be such that the mix of new and residual binder will comply with the requirements of the Special Specifications. Recycling agents such as blended oils and other additives shall not be used without prior approval by the Engineer.

iii. New aggregate

New aggregate required for use in recycled asphalt mixtures shall comply with the requirements of **CLAUSE 5702**.

iv. Combined aggregate

The aggregate mix obtained from new aggregate and the aggregate in the recovered asphalt including any mineral filler, an approved quantity of which may be added in accordance with **CLAUSE 5702**, shall comply with the requirements specified in the Special Specifications for the relevant recycled asphalt layer.

v. Hot in-situ surface recycling

With regard to new binder, recycling additives, new asphalt, new aggregate or combinations of these materials, hot in-situ surface recycling shall comply with the requirements in the Special Specifications.

vi. Cold in-situ recycling

Cold in-situ pavement recycling shall comply with the requirements in the Special Specifications.

5703 Mix Design And Properties Of Mixed Materials

The Asphaltic mix design shall be carried out in accordance with the current edition (28 days prior to tendering) of one of the following standards:

1. Marshall Mix Design: Asphalt Institute Manual Series, MS-2;
2. Superpave™ Mix Design: Asphalt Institute Manual Series, SP-2.

In general, the Marshall Mix Design method shall be employed unless the Superpave™ method is particularly specified.

5704 Composition Of Mixtures For Bituminous Base Course And Surfacing

The rates of application and mix proportions of bituminous binder, aggregates and fillers which are given in this specification are nominal rates and proportions and shall only be used for tendering purposes. The rates and proportions actually used shall be determined to suit the materials used and conditions prevailing during construction and any approved variation on a nominal mix in the bitumen content or active filler content shall be the subject of an adjustment in payment for binder or active filler variations as described in **CLAUSE 5715**.

Before production or delivery of the bituminous material the Contractor shall submit samples of the materials they proposes to use in the mix, together with the proposed mix design as determined by an approved laboratory, to the Engineer in accordance with **CLAUSE 1708**, so that the Engineer

may test the materials and confirm the use of the proposed mix if they are satisfied that it meets the specified requirements.

A mix design shall be submitted for the approval of the Engineer for each new material source the Contractor proposes to use or when significant changes in the material properties are encountered within a material source or as deemed necessary by the Engineer. Any proposed change of mix design for use in Permanent Works shall be notified to the Engineer for their approval minimum 7 days in advance of proposed use.

As soon as the materials become available the Contractor shall produce a working mix with the approved equipment in accordance with the design mix.

The working mix shall again be tested by the Contractor for compliance with the design requirements. Samples of the working mix shall also be made available to the Engineer, who will authorise the use of the working mix proportions finally approved for use.

The composition of the approved working mix shall be maintained within the tolerances given in TABLES 5713/1, 5713/2, and 5713/3.

The design of the bituminous mixes shall be in accordance with the relevant design guidelines and the mix properties and requirements shall be as specified in the Special Specifications.

5705 Construction Equipment

a. General

The Contractor shall submit to the Engineer full details of the Construction Equipment they proposes to use and the procedures the Contractor proposes to adopt for carrying out the Permanent Works. The Engineer shall have access at all times to construction equipment for the purpose of inspection.

All equipment shall be designed and operated to produce a mixtures complying with the requirements of this specification. The construction equipment used in the mixing, transportation, laying, and compaction of bituminous materials shall be of adequate rated capacity, in good working order and subject to approval by the Engineer. Obsolete and worn-out equipment will not be allowed onsite.

Prior to the start of the work the Contractor shall supply the Engineer with copies of the manufacturer's handbooks and copies of check lists where applicable pertaining to the mixing, remixing and paving equipment, containing details of the correct settings and adjustments of the equipment.

Any alteration which has been or is being effected to any construction equipment, and which does not comply with the specifications of the manufacturer, shall be brought to the notice of the Engineer.

b. Mixing Equipment

i. General

Mixing of the bituminous mixture shall be carried out in appropriate equipment acceptable to the Engineer.

ii. Stationery or portable mixing equipment

Bituminous mixture shall be mixed by means of an approved type mixer of proven suitability for producing a mixture complying with all the requirements of the Specifications.

The mixing equipment may be either automatically or manually controlled. Two control operators shall be provided.

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The heating system of the tanks storing the binder shall be designed that the binder will not be degraded during heating. A circulating system for the binder shall be provided which shall be of adequate size to ensure the proper and continuous circulation between storage tanks and mixer during the entire operating period.

Binder storage tanks shall be fitted with thermometers designed to provide a continuous record of the temperature of the binder in the tank. Copies of these records shall be supplied to the Engineer on a daily basis.

Satisfactory means shall be provided to obtain the proper amount of binder in the mix within the tolerances specified, either by weighing or volumetric measurements. Suitable means shall be provided for maintaining the specified temperatures of the binder in the pipelines, weigh buckets, spray bars and other containers or flowlines.

In the case of a drum type mixer, the system shall control the cold feeding of each aggregate fraction and of the filler by mass, by means of a load cell or another device regulating the feed automatically, and by immediately correcting any variation in mass which results from moisture or from any other cause. The cold feed shall be regulated automatically in regard to the binder feed so as to maintain the required mix proportion.

Suitable dust collecting equipment shall be fitted to prevent pollution of the atmosphere in accordance with the provisions of any local Act governing pollution.

The fuel chosen and control of the burner shall be such as to ensure the complete combustion of the fuel in order to prevent pollution of the atmosphere and the aggregate.

iii. Recycling

In addition to the requirements set out in **CLAUSE 5705** the mixing equipment shall be specially adapted to deal with recycling and any such adjustments shall be in accordance with the instructions of the manufacturer of the mixing equipment on the approval of the Engineer. The recovered asphalt portion of the mix shall not be exposed directly to the heating source whilst the feeding rate and proportioning shall be accurately controlled. Before work is commenced, the Contractor shall submit full details of their mixing equipment to the Engineer for approval.

c. Spreading Equipment, Pavers

The bituminous material shall be laid by an appropriate type of self-propelled mechanical spreader of a type approved by the Engineer and shall be kept in a good running condition and adjusted correctly according to the manufacturer's specifications.

The pavers shall be equipped with a powerful tamper and vibrating screed. The pavers shall be capable of laying the material to widths, lines, grades cross-fall and thickness within the specified tolerances without causing separation, dragging or other surface defects.

All pavers used for laying Permanent Works shall be fitted with automatic electronic screed controls to maintain the required levels, cambers and cross-falls. Where skids are used they shall be at least 9 m long or as specified by the Engineer.

The paver shall be constructed in such a manner that the asphalt can be tipped from the trucks into the hopper without any spillage.

Where levelling beams on multiple skids or sliding beams are used they shall be at least 9 m long.

d. Compaction Equipment

Compaction shall be done by means of approved flat steel wheeled, vibratory or pneumatic-tyred rollers, sufficient in size and numbers to achieve the specified density through the entire depth of the layer. Minimum one roller shall be pneumatic tyred with a weight of minimum 2.5 tonnes per wheel and not less than 18 tons total un-ballasted weight. The frequency as well as the amplitude of vibratory rollers shall be adjustable. Vibratory rollers shall be used only where there is no danger of damage being done to the layer, structures of bridge decks, or other layers.

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It will be indicated in the Special Specifications whether vibratory compaction equipment may be used on bridge decks and what the constraining parameters will be. The rollers shall be self-propelled and in good working condition, free from backlash, faulty steering mechanism and worn parts.

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Rollers shall be equipped with adjustable scrapers to keep the drums clean and with efficient means of keeping the wheels wet to prevent mixes from sticking to the rollers. No leakage of any nature may occur in the rollers.

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Rollers shall not be left stationary on fresh mat, compacted or not.

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e. Binder Distributors

Where bituminous binders are to be sprayed onto areas before laying the asphalt is done, the binder distributors shall comply with **CLAUSE 5103**.

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f. Vehicles

All vehicles used for transporting asphalt shall be insulated. Delivery trucks should be fitted with rear spill trays to facilitate transfer of material to paver without spillage.

All vehicles used for transporting asphalt shall be fitted with canvas for transport in excess of 10 km or when weather conditions demand such cover in the opinion of the Engineer. Such covers shall be securely fixed over the asphalt from time of departure at the storage or mixing equipment until immediately prior to discharge of the asphalt into the paver.

g. Construction Equipment For Recycled Asphalt

Construction equipment for producing, hauling and placing the recycled asphalt shall comply with the provisions of **SUBCLAUSES 5705(a) to 5705(f)**, as applicable, and subject to the following additional requirements:

The mixing equipment shall be capable of producing asphalt mixes with or without recovered material. Where necessary, the mixing equipment shall be specially adapted to deal with recycling, and any such adjustments shall be made in accordance with the instructions of the manufacturer. The equipment, with any necessary adjustments, shall be so designed, equipped and used that the measuring, heating and mixing of the material will give a uniform asphalt mix which complies with all the specified requirements in regard to temperatures within the limits necessary for properly placing and compacting the asphalt in accordance with the specified requirements. Before work is commenced, the Contractor shall submit full particulars of the mixing equipment to the Engineer.

5706 General Limitations and Requirements and the Stockpiling of Mixed Material

a. Weather Conditions

i. General

Bituminous material may be mixed and placed only under favourable weather conditions, and shall not be mixed or placed when rain is imminent or during wet conditions.

ii. Hot mixes (AC [Marshall & Superpave™ Mixes], DBM)

The following wind and temperature conditions are regarded as being suitable for paving work with hot mixed material:

While the air temperature is rising, work may be performed at temperatures of:

- 6°C with an allowable wind velocity of less than 25 km/h
- 10°C with an allowable wind velocity of less than 55 km/h, or for asphalt with a compacted thickness of less than 30 mm with an allowable wind velocity of less than 25 km/h.

With falling air temperatures, work must be stopped when the temperature reaches 6°C regardless of the wind velocity and may not be restarted before the temperature is definitely rising.

iii. Cold mixes

The Contractor's attention is drawn to the fact that cold mixed material is likely to be pervious until sealed. Damage to unsurfaced layers may occur in wet weather. Due allowance should be provided in the programme of works during rainy seasons, such that exposure of un-sealed layers are kept to a minimum. Time limits for the laying operation are given in SUBCLAUSE 5712(b). The time limits are applicable only in dry weather working conditions. Allowance to weather conditions in the programme of works may include reduction of these maximum time limits and/or complete stoppage of the laying operations in wet weather.

b. Moisture Content

The mixing and placing of asphalt will not be allowed if the moisture content of the aggregate affects the uniformity of temperature or if free water is present on the working surface, or when the moisture content of the underlying layer, in the opinion of the Engineer, is too high.

No surfacing shall be placed unless the moisture content of the upper 50 mm of the base course is less than 50 % of the optimum moisture content as determined by the Engineer. No overlay shall be placed immediately after a rainy spell on an existing partly cracked and/or highly permeable surfacing resulting in the trapping of moisture in the pavement structure. A minimum delay of 24 hours or such extended period as ordered by the Engineer shall apply.

c. Surface Requirements

i. General

Any defects of the surface shall be made good and no bituminous material shall be laid until the surface has been approved by the Engineer.

ii. Correction of base courses, or sub-base in the case of bituminous base course.

The base course (after the prime coat has been applied) or the sub-base, as the case may be, shall be checked for smoothness and accuracy of grade, elevation and cross-section. Any portion of the base or sub-base, as the case may be, not complying with the specified requirements, shall be corrected with asphalt at the Contractor's own expense, until the specified requirements are met. The Engineer may, however, at their sole discretion, allow minor surface irregularities to remain, provided they can be taken up in the following asphalt layer without adversely affecting that layer.

The bituminous material used for the correction of the base or sub-base, shall be the same mixture as specified for the surfacing or as directed by the Engineer, and the maximum size of aggregate used shall be dictated by the required thickness of the correction in each case.

Notwithstanding these provisions for the correction of the base or sub-base, the Engineer reserves the right to order the removal and reconstruction of the layer or of portions of the base and sub-base layers not complying with the specified requirements, instead of allowing the correction of substandard work with asphalt material.

iii. Cleaning of the surface

Immediately before applying the tack coat, before the application of the asphalt, the surface shall be cleaned of all loose or deleterious material by means of a rotary broom, and hand brooms, compressed air or as required to the satisfaction of the Engineer.

Where the prime coat (if any) has been damaged, it shall be repaired by hand brushing or spraying priming material over the damaged portions.

The prime coat shall be sufficiently dry before the tack coat and/or the asphalt may be applied. The Contractor's programme shall allow for delays that are a function of the type of prime, rate of application, base porosity and moisture content, and climatic conditions.

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iv. Tack coat

A tack coat shall be applied to the surface to be paved in accordance with the specifications, and drawings or as instructed by the Engineer.

The tack coat shall consist of a slow-set bituminous emulsion diluted with potable water and shall be applied at a rate of 0.55 l/m² residual bitumen or as directed by the Engineer.

Portions of kerbing and guttering, bridge kerb and railing which will be exposed, shall be protected in terms of SECTION 2300 when the tack coat is applied.

The tack coat shall not be applied more than 24 hours before the paving is done.

v. Preparation for placing overlays

The provisions of SECTION 5800 shall apply to any surface to be covered with overlays. The type of treatment to be applied, if any, will be specified in the Special Specifications or instructed in writing by the Engineer.

vi. Preparation where asphalt layers are to be widened or where surfacing over a section of the road width requires replacement.

The existing asphalt shall be removed as described in SECTION 3300, where applicable, or as instructed by the Engineer.

Where a road has to be widened, the overlay shall be cut back not less than 100 mm from the existing edge. Unless otherwise indicated on the Drawings or instructed by the Engineer. Asphalt joints may not fall within a wheel track.

d. Storage

i. Hot mixes (AC, [Marshall & Superpave™ Mixes] DBM)

Mixing shall not be allowed to take place more than four hours before paving begins unless provision has been made for storage. Storage of mixed material will only be permitted in approved hoppers, which are capable of maintaining the temperature of the mix uniform throughout.

in any case storage will not be permitted for a period longer than 12 hours after mixing, unless otherwise approved by the Engineer.

ii. Cold mixes (BSM)

The material for use in Permanent Works shall not be laid on the same day as it is mixed unless otherwise approved by the Engineer.

The length of time for mixed material to remain in stockpile before laying in Permanent Works shall not be more than 7 days after mixing. Should the Contractor propose to use material which has been stockpiled for longer than 7 days, then the Engineer may allow a trial section to be constructed if the proposal is to their satisfaction. The Engineer may subsequently allow the material to be used in Permanent Works if the outcome of the Trial Section is to their satisfaction.

All equipment used for stockpiling and transportation of the mixture shall have buckets that are cleaned of all foreign material, fuel, lubricants or other contamination before use.

5707 Producing and Transporting The Mixture

a. Mixing and Storage Temperatures of Binder

Bituminous binders shall be stored at temperatures not exceeding those given in TABLE 5707/1 or the Special Specifications, or as stated by the supplier, and the aggregate and bituminous binders shall be heated at the mixing equipment to such temperatures that the mixed product shall have a temperature within the range given in TABLE 5707/1. The manufacturers storage and mixing temperatures shall take precedent.

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TABLE 5707/1: TEMPERATURE RANGES FOR BITUMINOUS BINDERS

Bitumen Type, Pen. Grade	Max. Storage Temperature of Binder (°C)		Temperature Range of Mix (°C)
	Over 24 hrs	Under 24 hrs	Continuously graded mixes
20/30 pen	150	180	150 - 175
40/50 pen	145	175	140 - 165
60/70 pen	135	175	135 - 160
80/100 pen	125	175	

b. Production of the Mixture**i. Hot mixes using batch equipment****1. Heating the aggregate**

The aggregate shall be dried and heated so that, when delivered to the mixer, its temperature shall be between 0°C and 20°C lower than the maximum temperature indicated in TABLE 5707/1 for the mixture. The moisture content of the mix shall not exceed 0.5 %.

2. Batching

Each fraction of the aggregate and binder shall be measured separately and accurately in the proportions by mass in which they are to be mixed. If filler is used, it shall be measured separately on a scale of suitable capacity and sensitivity. The error in the weighing apparatus used shall not exceed 2 % for each batch.

3. Mixing

The aggregate, filler and binder shall be mixed until a homogeneous mixture is obtained in which all particles are uniformly coated. Care shall be taken to avoid excessively long mixing times which can cause hardening of the binder.

ii. Hot mixes using drum-type mixer equipment

The aggregate and filler shall be accurately proportioned and conveyed into the drum-mixing unit. The calibrated amount of binder shall be sprayed onto the aggregates at the correct position so that no hardening of the binder shall take place. A homogeneous mixture and uniform coating of binder must be achieved and the moisture content of the asphalt mixture shall not exceed 0.5 %. Once the final mix temperature has been agreed upon it may not be altered without the prior consent of the Engineer.

iii. Cold mixes using stationary, portable or in-situ mixing equipment

Mixing of bituminous base for use in Permanent Works shall only be carried out in mixing equipment approved by the Engineer and on the basis of an approved mix design. Any proposed change of mix design for use in Permanent Works shall be notified to the Engineer for approval minimum 7 days in advance of proposed use.

The length of time for storage of additives from the moment of mixing with hot bitumen until mixed with aggregates shall be limited to maximum 2 hours, unless otherwise approved by the Engineer. Such approval shall be subject to proof that adhesion properties are adequate at the time of mixing bitumen with aggregate.

c. Transporting the Mixture

The mixture shall be transported from the mixing equipment to the Works in trucks complying with the requirements of CLAUSE 5705. Deliveries shall be made so that spreading and rolling of all the mixtures prepared for a day's run can be completed during daylight, unless artificial lighting, as approved by the Engineer, is provided. Any asphalt which has become unusable in the opinion of the Engineer due to rain or any other cause will be rejected. Hauling over freshly laid material is not permitted.

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The mix at delivery to the paver shall be not more than 10°C below discharge temperature at the mixing equipment. The minimum temperature for the commencement of breakdown rolling shall be determined on trial sections. Mix loads of temperature less than the minimum temperature shall be disposed of.

If there is consistent failure to meet the temperature requirement the paving operations shall be suspended until suitable measures are taken by the Contractor to ensure that the temperature requirements are met.

Hauling equipment for bituminous mixes shall have isolated, tight, clean and smooth beds, which are periodically coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type of cover which shall be used to cover the material upon loading at the mixing equipment and shall not be removed until the mix is discharged into the paver.

The Engineer may instruct that hauling equipment shall have an engine exhaust system blowing the gas vertical not to cause inconvenience to the paving crew.

d. Recycled Asphalt

The provisions of SUBCLAUSES 5707(a) to 5707(c) shall apply with changes as required.

At least four weeks before paving with recycled material commences, the Contractor shall submit to the Engineer full particulars regarding the recycling methods they intends to use.

Where recovered asphalt material is taken from a stockpile, it shall be done by excavating from the pile over its full depth. Where segregated material is fed into the mixing equipment, the Engineer will have the right to order the work to cease and to instruct the Contractor to remix the stockpile, retest the mixed material and redesign the asphalt mixture all at their own cost.

5708 Spreading The Mixture

a. General

i. The paver, general

The paver shall be kept in good working order, and adjustment of the screed tamping bars, feed screws, hopper feed, etc, shall be checked frequently to ensure uniform spreading of the mix.

If segregation or other imperfections occur, the spreading operations shall immediately be suspended until the cause is determined and corrected.

The mixer capacity and the operating speed of the paver are to be so co-ordinated as to ensure continuous laying and to avoid intermittent stopping of the paver.

Unless otherwise stated in the Special Specifications the paver shall be equipped to provide automatic control of levels and cross-section. In the case of asphalt base construction, automatic control shall be run off guide wires and in the case of surfacing and overlays skids or guide wires shall be used.

ii. Workmanship

The bituminous layer shall be laid and compacted in one or more layers giving a total thickness as specified.

The addition and removal of material behind the paver shall normally not be allowed and the paver shall be capable of spreading the mixture to the correct amounts that will provide the required compacted thickness and surface evenness without resorting to spotting, picking-up or otherwise shifting or disturbing the mixture.

Repairs to joint and isolated surface irregularities may be carried out by hand or other suitable methods at a thickness other than the above, subject to approval of the Engineer.

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On restricted areas, inaccessible to the paving equipment used, the mixture may be placed by hand or other means to obtain the specified results. Paving shall be carried out in a manner which will avoid segregation and which will allow control of levels.

Paving shall be carried out with good workmanship for such operations. This requirement includes, but is not restricted to, particular attention to the following:

- Paving shall commence at the bottom of the grades and the lower edges of superelevated curves
- Paving shall be done upgrade on grades steeper than 5 %
- The paver shall be operated in a manner that provides the maximum possible degree of compaction exerted by the screed, evenly distributed across and along the layer.
- Spreading shall be so arranged that longitudinal joints do not coincide with joints in lower layers of asphalt base or surfacing.

The mixture shall be delivered continuously to the paver to avoid stop-go paving operations. The temperature of the mixture shall be controlled by measuring in a random pattern in the truck immediately before emptying, and shall not be less than the minimum temperature defined during the trial section.

The adjustment of the screed, tamping bars, feed screws, hopper feed, etc. shall be checked frequently to ensure uniform pre-compaction and spreading of the mixtures.

If segregation occurs, the spreading operations shall immediately be suspended until the cause is determined and corrected.

The pavers shall be equipped with 60° sloped side plates on the screed to confine and to form a stable and neat permanent outer shoulder edge. Spreading shall be so arranged that longitudinal joints do not coincide with joints in the lower layers.

iii. Base course thickness paved in one operation

Base course with a compacted thickness greater than 100 mm may only be placed to its full thickness in one layer if site trials show that satisfactory finish, evenness and compaction of the full thickness can be achieved and the result is to the satisfaction of the Engineer.

iv. Base course thickness, first layer

No bituminous base course material shall be placed as the first layer of the base course in a compacted thickness less than 60 mm or less than three times the aggregate's maximum particle size, whichever is smaller.

v. Base course thickness, following layers

Following layers to be placed on freshly laid bituminous base course layers may be placed in a compacted thickness less than the above subject to satisfactory results of site trials and on approval of the Engineer, but not less than twice the maximum aggregate size for materials.

vi. Weather

Paving shall stop when rain is imminent and compaction of all laid material shall be completed immediately.

vii. Hot mixes, special requirements

The temperature of hot mixtures shall be controlled by measuring in a random pattern in the truck immediately before emptying, and shall not be more than 10°C below the minimum temperature specified for mixing in TABLE 5707/1.

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viii. Cold mixes: special requirements

No cold mixed bituminous base course material shall be laid unless the moisture content is within the specified limits. Should the moisture content of stockpiled materials fall outside these limits, the Contractor may propose methods to bring the moisture content back to comply with the requirements.

The Engineer may then allow a Trial Section as described in **CLAUSE 5711** to be constructed if they are satisfied with the proposal. The Engineer may subsequently allow the material to be used in Permanent Works if the outcome of the Trial Section is to their satisfaction.

b. Overlays

In the case of overlays, guide wires will be required during the placing of the mix if specified in the Special Specifications. In all cases, including levelling courses, the paver shall be provided with skid beams with electronically controlled equipment which can ensure a constant crossfall and can even out local irregularities.

c. Restricted Areas

Bituminous material shall be placed in restricted areas with the aid of smaller specially equipped pavers, hand tools, or other approved equipment. The space concerned shall be properly filled with asphalt, without leaving any gaps between the fresh asphalt and existing pavement layers.

All the relevant provisions in regard to temperature, mix composition, uniformity, etc, shall remain applicable, but layer thickness and control shall be such that the requirements for compaction and surface tolerances can still be attained where bituminous material is laid in restricted area.

d. Recycled Asphalt

The provisions of **SUBCLAUSES 5708(a) to 5708(c)** shall apply unless otherwise stated below.

Where the average thickness of a completed asphalt layer exceeds the specified thickness, and/or recovered asphalt has been wasted indiscriminately, and, if in the opinion of the Engineer it has resulted in a deficiency of recovered material, the Contractor shall supplement such deficiency at their own cost with a quantity of similar or better material equal to the quantity wasted, as determined by the Engineer.

5709 Joints

All joints between adjacent sections of the work shall be made by cutting back the layer against which the material is to be placed unless otherwise approved by the Engineer. All loose and incompletely compacted material shall be removed. A cutting wheel shall be used for cutting longitudinal joints.

Joints shall be either at right angles or parallel to the centre line, and joints in the final layer of the surfacing shall, where possible, correspond with the lane markings. Joints in lower layers shall be offset not less than 150 mm on either side of the edges of the traffic lanes.

Before a new layer is placed next to an existing layer, the cut edge of the existing layer shall be painted with a coat of bituminous emulsion of the same type and application rate as used for the tack coat.

Joints shall be neat and shall have the same texture and density as the remainder of the asphalt course. All joints shall be marked out with chalk lines prior to cutting.

The outside edges of the completed asphalt course shall be trimmed along the shoulder, and parallel to the centre line, to give a finished width, as shown on the Drawings, within the tolerances specified.

Any fresh mixture spread accidentally onto existing work at a joint shall be carefully removed by brooming it back with stiff brooms onto the uncompacted work, so as to avoid the formation of irregularities at the joint. Whenever the paving operation is stopped due to lack of mixture, the Contractor shall form a proper joint as specified above, if directed by the Engineer.

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The paved pre-compacted "over height" after the screed shall be carefully determined on the trial sections (with e.g. 10, 20 and 30 mm over height) and properly implemented for satisfactory joint construction.

Joints shall have the same texture and density as the remainder of the asphalt course.

5710 Compaction

The mix shall be rolled immediately after it has been laid by vibratory, steel wheel and pneumatic-tyred rollers in a sequence predetermined and approved during the laying of trial sections. Such rolling shall commence and be continued only for so long as it is effective and does not have any detrimental effect. The use of pneumatic-tyred rollers for continuously-graded non-homogeneous modified binders shall be assessed in the trial section.

The minimum temperature of the mixture at the commencement of compaction shall be 125 °C when 80/100 or 180/200 pen bitumen is used. The minimum temperature at completion of compaction shall be 80 °C when 80/100 or 180/200 pen bitumen is used. Typical compaction temperatures are usually in the range of 135-155 °C for both unmodified and modified binders. The temperature specified by the manufacturer shall take precedent. In the absence of manufacturer data, the compaction temperature shall correspond to the range of viscosity of 2 to 20 Pa.s.

As many rollers shall be used as are necessary to provide the specified pavement density and the required surface texture. During rolling of surfacing only, the roller wheels shall be kept moist with only sufficient water to avoid picking up the material.

After longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides and gradually progress towards the centre of the pavement, except on super-elevated curves, or where the area to be paved has a straight cross-fall, when rolling shall begin on the low side and progress to the higher side, uniformly lapping each preceding track, covering the entire surface. During breakdown rolling, the rollers shall move at a slow but uniform speed (not to exceed 5 km/h) with the drive roller nearest the paver, unless otherwise specified on account of steep gradients.

No movement of the asphalt layer shall occur under steel wheel rollers once the asphalt temperature has dropped to below 100°C. Three-wheeled steel rollers, with large diameter rear wheels are preferable to tandem rollers and may be used in conjunction with pneumatic tyred rollers, provided pick-up of the asphalt on the wheels does not occur.

The sequence of rollers used in compaction is at the discretion of the Contractor provided the completed pavement shall have a density as measured on recovered cores equal to or greater than the nominal density specified in TABLE 1717/1 and assessed by the statistical method defined in SECTION 1800.

The Contractor shall utilise a calibrated nuclear gauge for process control during compaction operations unless otherwise allowed in the Special Specifications. Notwithstanding this requirement, the acceptance control carried out for compaction by the Engineer, shall still be based on cores taken from the compacted layer.

The nuclear device shall:

- Be operated by a suitably trained technician.
- Comply with all the safety regulations of the relevant regulatory Authority.
- Be certified to be suitably calibrated.

The portion of trial section having the desired surface texture shall be designated as a reference for what is required in the permanent work.

The following requirements shall apply to rolling and compacting generally:

- The material shall not be excessively displaced in a longitudinal or transverse direction especially when changing gears, stopping or starting rollers.
- No cracks or hair cracks shall be formed and the bond with the underlying layer shall not be broken.
- The density shall be uniform over the whole area of the layer and extend over the full depth of the layer.
- Rollers shall not be left standing on the asphalt layer before it has been fully compacted.
- In restricted areas where the specified rollers cannot be used, compaction shall be carried out with hand-operated mechanical compaction equipment or approved smaller vibratory rollers. The prescribed density requirements remain applicable throughout, over the full layer thickness, irrespective of the method of compaction.

An adequate number of roller passes shall be used to provide the specified pavement density. The density shall be uniform over the whole area of the layer, as well as at the joints after approximately 10 cm back-cutting of tentative free edges.

The tyre pressure of pneumatic-tyred rollers shall be adjusted to the maximum that the mixture can carry without excessive displacement of the asphalt layer.

The Contractor shall, when necessary only employ approved slippage agents for the rollers. Diesel will under no circumstances be accepted.

The provisions of **CLAUSE 5710** shall apply with changes as required, and with the approval of the Engineer, to recycled asphalt.

5711 Laying Trial Sections

A trial section of minimum 100 m length shall be constructed prior to the use of any new mix design, when there are changes in the type or numbers of construction equipment, or as required by the Engineer. The trial section shall demonstrate that the materials, equipment and procedures proposed are adequate to achieve a bituminous layer in accordance with the Specifications and to the satisfaction of the Engineer.

Any bituminous material laid in a trial area that forms part of the Permanent Works and subsequently found unacceptable, shall be removed or made good to comply with the Specifications.

The Engineer may require a number of different binder contents, and a number of different moisture contents in the case of cold mixed material, to be incorporated in one such trial section to verify the laboratory design.

Cores extracted from the completed trial section and in locations determined in a stratified randomly sampled manner.

Only when such a trial section has been satisfactorily laid and finished, and complies with the specified requirements will the Contractor be allowed to commence with construction of the permanent work.

If the Contractor should make any alterations in the methods, processes, equipment or materials used, or if the Contractor is unable to comply consistently with the Specifications, the Engineer may require that further trial section be laid before allowing the Contractor to continue with the permanent work. Any work that does not comply with the Specifications shall be removed or made good to comply with the Specifications to the satisfaction of the Engineer.

The trial sections shall be laid where indicated by the Engineer. The Contractor shall prepare the surface on which to lay the trial section and shall also, if required by the Engineer, remove the trial section after completion and restore the surfaces on which it was constructed, at their own cost.

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The Contractor shall for each trial section prepare a plan for execution of the trial. It shall at least include the following subjects:

1. Date and time, location, sketch of location, type of asphalt
2. Preparation of surface, spray rate of tack coat or prime coat and curing time
3. Mixing and paving temperature, cooling rate, infrared camera photos and locations for temperature control
4. Paving speed, tamper settings and type/angle of screed side plates
5. Illustrate intended rolling pattern for at least 3 levels of compaction efforts (medium, high and extra high) and describe methods to record and control number of passes and the rolling pattern actually used
6. Joint construction method, over height of the second paving lane, control of the over height
7. Core drilling and test programme for testing of the mix and the finished pavement. The programme shall include recovered binder and mix properties, wheel track rutting test
8. Programme for instruction of every person involved in the trial section.

The activity plan for the trials shall be forwarded to the Engineer for approval not less than 7 working days before the planned trials.

The Contractor shall assess back-cuttings and separately document that finished joints satisfy the compaction requirements by taking asphalt cores at a distance of 50 mm from joints and tentative free edges.

The trial sections shall include continuous measurements of asphalt temperatures to determine the rate of cooling and the time available for compaction.

No payment shall be made for trial sections and the Contractor must allow for all costs in their rates.

5712 Protection and Aftercare

a. General

The Contractor shall protect the bituminous base course and asphalt surfacing from all damage until the work is finally accepted by the Employer and the Contractor shall maintain the surfacing work until the issue of the taking over certificate. Any damage occurring to the completed base or surfacing, excepting fair wear and tear on surfacing during the defect liability period, or any defects which may develop due to faulty workmanship, shall be made good by the Contractor at their own expense and to the satisfaction of the Engineer.

Bituminous base courses shall be covered with the surfacing within 7 days of laying. Prior to construction of the surfacing, the base must have been dry (free of rain) for at least 48 hours.

Traffic can under normal conditions be allowed on to the fresh layer immediately after compaction is completed unless otherwise directed by the Engineer.

b. Special Requirements For Cold Mixed Base Course Material

Traffic can under normal dry conditions be allowed on the fresh layer immediately after the compaction is completed unless otherwise directed by the Engineer.

Where the base course is placed in more than one layer, no more than 7 days shall elapse between completion of consecutive layers. No more than 14 days shall elapse from completion of the base course until the surface dressing is constructed.

The time limits in the above paragraph are applicable only in dry weather working conditions. The Contractor's attention is drawn to the fact that the material is likely to be pervious until sealed.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5700 | Bituminous Base Course

Damage to unsurfaced layers may occur in wet weather. Due allowance should be provided in the programme of works during rainy seasons, such that exposure of un-sealed layers are kept to a minimum. This may include reduction of the above maximum time limits and/or complete stoppage of the laying operations in wet weather.

If the times specified above are not adhered to the Contractor shall place tack coat or priming in accordance with this Specification on approval of the Engineer without additional costs to the Employer.

Approved crusher dust or clean sand shall at no additional costs to the Employer be evenly spread at a rate of 0.005 m³/m² immediately following the spraying of tack coat.

Notwithstanding the above, construction of consecutive layers or surface dressing shall not be unduly delayed. In no case shall more than 90 days elapse since completion of the previous layer.

5713 Construction Tolerances and Finish Requirements

a. Construction Tolerances

Construction tolerances and finish shall meet all relevant requirements in SECTION 1900. The riding quality of the final layer shall be to the satisfaction of the Engineer.

b. Grading

The combined aggregate and filler grading shall not deviate from the approved target grading for the working mix by more than that given in TABLES 5713/1 and 5713/2 respectively for Asphalt Concrete surfacing and bituminous base course materials.

TABLE 5713/1: AGGREGATE AND FILLER GRADING FOR ASPHALT SURFACING

Size Of Aggregate: Material Passing Through The Following Sieves (mm)	Permissible Deviation From The Approved Target Grading
37.5	± 4.0
28	± 4.0
20	± 5.0
14	± 5.0
10	± 5.0
6.3	± 5.0
5	± 4.0
2.00	± 4.0
1.18	± 4.0
0.600	± 4.0
0.300	± 3.0
0.150	± 1.5
0.075	

TABLE 5713/2: AGGREGATE AND FILLER GRADING FOR BITUMINOUS BASE MATERIALS

Size Of Aggregate: Material Passing Through The Following Sieves (mm)	Permissible Deviation From The Approved Target Grading	
	Individual sample	Average of three consecutive samples
Sieve 5 mm and larger	± 15	± 10
Sieve smaller than 5 mm and larger than 0.075 mm	± 10	± 5
Sieve 0.075 mm	± 4	± 2

c. Binder Content

i. Hot mixed material

The binder content shall be controlled to comply with the limits given in **CLAUSE 1800**.

ii. Cold mixed material

The maximum accepted deviation in bitumen content of cold mixed bituminous base course material compared to that of the approved Mix Design is given in **TABLE 5713/3** or according to the Special Specifications.

TABLE 5713/3: ACCEPTANCE LIMITS FOR BITUMEN CONTENT FOR COLD MIXED BITUMINOUS BASE MATERIALS

Size of sample, number of tests (no)	Max. deviation of sample average from the specified bitumen content (in % bitumen)	Max. deviation of any single value from the specified bitumen content (in % bitumen)
5 or less	0.30	0.70
6	0.28	0.68
7	0.26	0.66
8	0.24	0.64
9	0.22	0.62
10 or more	0.20	0.60

5714 Sampling And Testing

a. General

All sampling and testing shall be carried out in accordance with sampling and testing standards laid down in the Specifications, or equivalent approved by the Engineer.

b. Coring of Asphalt Layers

The Contractor shall provide suitable coring machines capable of cutting 100 mm diameter cores from the completed asphalt layers.

The cost of extracting cores for process control in accordance with the Specifications shall be included in the Contractor's prices for the construction of asphalt pavement layers and will not be paid for separately.

Cores in the carriageway lanes shall be taken at the outer permanent edge, at the centre of the paved lane and at the longitudinal joint. Cores at the outer edges and at the joints shall be taken 50 mm from the edge after back-cutting as directed. Cores in the shoulders shall be taken 300 mm from the outer shoulder edge and 50 mm from the longitudinal joints to the carriageway pavement.

All core holes shall be neatly repaired with asphalt and compacted to the specified density. The cores shall be filled with the same mix as used for the layer tested.

c. Laboratory Testing

Testing shall be carried out by the Contractor at the site laboratory or an external laboratory approved by the Engineer. All operations of the testing shall be available for inspection by the Engineer at all times and the Contractor shall give notice well in advance of all testing as required by the Engineer. All test results shall at all times be available to the Engineer.

All test results representative for Permanent Works shall meet the relevant requirements in the Specifications within the tolerances specified and shall be approved by the Engineer.

In case the tests disclose non-conditional properties of the test specimens, additional tests shall be carried out by the Contractor as required by the Engineer.

Test results (laboratory readings and measurements) as well as calculated results in digital form shall be submitted daily to the Engineer in continuously updated summary sheets.

5715 Measurement And Payment

Item	Unit
57.01 Bituminous Base Course:	
(a) Hot Mix (State Type, Maximum Compacted Thickness, Type Of Bitumen And Maximum Size Of Aggregate)	Cubic Metre (m ³)
(b) Cold Mix (State Type, Maximum Compacted Thickness, Type Of Bitumen And Maximum Size Of Aggregate)	Cubic Metre (m ³)
(c) Bitumen For Bituminous Base Course Mixes (State Type Of Bitumen)	Cubic Metre (m ³)

Item	Unit
57.02 Asphalt Concrete Surfacing:	
(a) Asphalt Concrete Surfacing (State Type Of Binder And Maximum Size Of Aggregate)	Cubic Metre (m ³)
(b) Bitumen For Asphalt Concrete Surfacing (State Type Of Bitumen)	Tonnes (t)

The unit of measurement for bituminous mixes shall be the cubic metre constructed to the thickness specified, compacted on the road as specified, calculated as the product of the length instructed to be laid and the compacted cross-sectional area shown on the Drawings or instructed by the Engineer.

The binder for asphalt concrete surfacing is paid for separately for material produced and placed as specified and accepted by the Engineer. The quantity calculated from the recipe of the mix design, at asphalt density, shall be used in the calculation of the binder quantity. A new mix design and recipe shall be prepared if, in the opinion of the Engineer, this is warranted due to significant variations in mix density or other material properties

The bid rate for bituminous mixes shall include for procuring, preparing the surface to the satisfaction of the Engineer, providing, heating, drying or adding water as required, mixing, transporting, laying and compacting the mix in accordance with the Specifications and to the satisfaction of the Engineer. The rate shall also include for trials sections, process control testing, protecting and maintaining the work as specified.

No payment will be made for material wasted.

Item	Unit
57.03 Tack Coat of A3 or A4 Slow-Set Bitumen Emulsion:	Litre (l)

The unit of measurement shall be the litre of residual slow-set bitumen emulsion applied as specified. The bid rate shall include for the cleaning the surface to the satisfaction of the Engineer, procuring, furnishing and application of the material as specified.

Item	Unit
57.04 Additives (State Type)	Kilogramme (kg)

Additives except binder, aggregate, filler or water shall be paid for separately where these are specified or instructed by the Engineer. The quantity shall be calculated as the kilogram used in accordance with the recipe of the mix design, on approval of the Engineer.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5700 | Bituminous Base Course

SECTION 5800 Surfacing of Bridge Decks

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5801 Scope

This section covers the construction of a bituminous surfacing on bridge decks where shown on the Drawings or ordered by the Engineer.

5802 Materials

Bituminous binders and aggregate shall comply with the requirements of SECTIONS 5200 and 5300 for asphalt surfacing and seals respectively.

5803 Preparation On Surface

Before the surfacing is constructed, the concrete deck shall be thoroughly cleaned by washing and brushing to remove all loose material. After drying, a tack coat consisting of bituminous cationic emulsion shall be applied to the surface at a rate of 0.4 l/m² residual bitumen. The tack coat shall then be allowed to dry.

5804 Type And Thickness Of Surfacing

The type and nominal thickness of the surfacing shall be as specified.

Before commencing with the construction of the surfacing, the actual levels of the bridge deck shall be determined by means of accurate levelling. The levels and grades to which the surfacing is to be constructed shall be as shown on the Drawings or as indicated by the Engineer. If the levels of the concrete deck as constructed by the Contractor deviate by more than the specified tolerances from the specified levels, the Contractor shall construct a levelling layer at their own cost. The nominal size of the aggregate in the levelling layer shall be 10 mm.

5805 Construction

Irrespective of the type of seal applications on the road on both sides of the bridge, asphalt surfacing shall be constructed in accordance with SECTION 5200, and seals in accordance with SECTION 5300.

5806 Surface Tolerances

The completed surfacing shall comply with the requirements for base of SECTION 1900 in respect of surface tolerances for grade, smoothness, cross-section and width.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5800 | Surfacing of Bridge Decks

5807 Measurement And Payment

Item		Unit
58.01	Surfacing On Bridge Deck (State Type And Thickness):	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of surfacing completed in accordance with the Specifications to the nominal thickness indicated on the Drawings or to the instruction of the Engineer.

The bid rate shall include full compensation for procuring and furnishing all materials, heating the binder and aggregate, mixing, transporting, placing and compaction of the material, and the provision and application of the surfacing. The rate shall also include full compensation for variations in thickness within the specified tolerance for bridge deck levels and for cleaning of the surface to the satisfaction of the Engineer and the application of a tack coat.

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SECTION 5900 Treatment Of Surface Defects, Patching, Repairing Edge-Breaks And Crack Sealing

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5901 Scope

This section covers the work in connection with the treatment of existing road surfaces prior to the application of a seal or asphalt surfacing, patching, repairing edge breaks and crack sealing.

Provision is made for treating existing seals exhibiting any of the following defects:

1. Existing surface is deficient in binder.
2. Marked differences in texture occur over the surface.
3. The existing surface is open-textured.
4. The surface is uneven on account of bumps, slacks, etc.
5. Edges require trimming and/or repairs.

Patching shall be any work to existing pavement layers (and in exceptional cases to fills and the formation) with the purpose of repairing local failures, and which is carried out in an area having a width of less than 1.0 m, or a length of less than 25 m or an area of less than 100 m². This does not include the repair of edge breaks, pre-treatment of the road surface, or the rehabilitation of concrete pavements.

Patching involves excavating the existing failed sections and reconstructing the excavated fills and pavement layers with the specified pavement material. Backfilling with asphalt will be measured and paid for under SECTION 5200.

Compensation for work in restricted areas shall not be applicable to patching and repairing edge breaks.

Note: SECTION 5300: Seals: Materials and general requirements shall apply to this SECTION.

5902 Materials

The material shall comply with the requirements specified for the various types of material in the appropriate sections of the Specifications and the Special Specifications.

The following grades of binder may be used. The actual type or grade used shall be as specified in the Special Specifications or the Bill of Quantities or as ordered by the Engineer.

a. Binder for fog spray (Treatment Type 1)

30 % or 60 % cationic or anionic spray-grade bituminous emulsion.

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b. Tack-coat Binder (Treatment Type 2)

60 % bituminous emulsion (Treatment Type 2).

30 % bituminous emulsion (Treatment Types 3 and 4).

c. Slurry Binder (Treatment Type 3)

60 % stable grade bituminous emulsion.

d. Binder for Asphalt Skim Coat (Treatment Type 4)

80/100 penetration grade bitumen.

e. Screed (Treatment Type 5)

30 % bitumen emulsion shall be used for the tack coat, and the binder for the asphalt shall be approved grade of penetration grade bitumen unless otherwise specified.

f. Binder for Asphalt used in Reconstructing Pavement Edges

60 % stable grade bituminous emulsion for tack coat and 80/100 penetration-grade bitumen in asphalt

g. Rubber Pellets

Rubber pellets for crack sealing shall be obtained by processing rubber tyres. The rubber shall be granulated and free from fibres, steel wire and other impurities. The rubber crumbs shall pass through a 2.00 mm sieve.

h. Herbicide

Herbicide shall be a non-selective environmentally compatible herbicide approved by the Engineer.

5903 Construction Equipment

All equipment shall be suitable for the specified use and working areas and shall be capable of obtaining the specified results.

a. Planing Machine

The machine shall be of a design which will be suitable for planing the existing surfacing in order to remove and irregularities and to leave an even surface without tearing the underlying material. An approved milling machine may be used.

Before planing may start, the Contractor shall demonstrate to the Engineer that the machine is capable of executing the work in accordance with the Special Specifications.

b. Patching and Repairing Edge Breaks

Only approved cutting or sawing equipment may be used for cutting or sawing asphalt layers. The equipment shall be capable of cutting asphalt layers to depths of 200 mm in one operation without fragmenting the material, and in straight lines within the required tolerances.

The following Items of construction equipment shall also be available and in good working order:

- i. A vibratory roller having a mass approximately one tonne, with an adjustable amplitude and frequency of vibration.
- ii. A mobile compressor capable of producing at least 3 m³/minute compressed air at 750 kPa.
- iii. Appropriate paving breakers.
- iv. Manually operated pneumatic compactors as required.
- v. Appropriate concrete mixers.

c. Crack Sealing

Over and above the equipment normally used for surface treatments, the following additional equipment shall be available for crack sealing:

- i. Special spraying equipment with 2 mm nozzle openings and provided with spare nozzles.
- ii. Special heating equipment where appropriate for cleaning cracks, and custom-built applicators for applying sealants to cracks.

5904 Treatment Of Surface Defects

Before any treatment is carried out, the area to be treated shall be cleaned and prepared and any major failures shall be repaired as specified in the Special Specifications.

a. Treatment Type 1 (Fog Spray)

This treatment shall be applied where the existing surface is deficient in binder.

The treatment shall consist of the application of a fog spray of the specified grade of emulsion to the existing surface by means of a pressure distributor at the rates of application as directed by the Engineer, in widths that may vary from 0.5 m to 4.0 m.

The application rate of the fog spray shall have a range of 0.3-0.5 L/m² of residual bitumen depending on the surface texture. For fine textured surfaces such as asphalt 0.3L/m² is adequate and for coarse textures surface dressings, e.g., 13 mm stone, penetration macadam, etc. 0.5 L/m² recommended. The application rate shall be approximately 1L/m² of the emulsion with 60 % bitumen further diluted 50/50 with water. The guiding principle shall be the maximum applicable possible without causing the fog spray to flow on the surface of the road.

b. Treatment Type 2 (Sand Seal)

This Treatment, or a sand seal as specified in SECTION 5600, is intended for application where marked differences in texture occur in the existing surfacing, in order to obtain a uniform texture before resealing.

A tack coat of the specified type and grade of emulsion shall be applied to the surface as specified in SUBCLAUSE 5307(b) followed by an application of crusher sand. The crusher sand shall be the medium grade specified for slurry in CLAUSE 5302, but shall be on the coarse side of the grading envelope.

The nominal rates of application shall be:

- Emulsion 0.7 litres net bitumen per m².
- Aggregate 0.004 m³/m².

The actual rates of application shall be as instructed by the Engineer.

It can be anticipated that spraying and spreading will have to be carried out in narrow bands varying in width from 0.5 m to 4.0 m. The emulsion shall be allowed to break before the aggregate is applied.

As soon as the aggregate has been applied, the distribution thereof shall be corrected by light hand brooming or by means of a light broom drag.

Rolling shall be carried out as specified in SUBCLAUSE 5307(b). Any excess aggregate remaining on the road after it has been opened for two days or more shall be removed.

c. Treatment Type 3 (Slurry Seal)

This treatment shall be used when an existing surface treatment, which is open-textured or exhibits cracking, requires treatment with bituminous slurry.

Prior to Treatment with a slurry, the surface shall be sprayed with a tack coat of 30 % bitumen emulsion at the rate prescribed by the Engineer.

A distinction shall be made in respect of the payment for the following two methods of construction:

- Where the slurry can only be applied by hand methods or where the Engineer so directs or where it is specified that the slurry shall be applied by hand methods.
- Where the slurry can be applied mechanically with a spreader box.
- The slurry shall be prepared, mixed and applied as specified in SECTION 5600, with the following exceptions:
- Slurry to be applied by hand may be mixed in a suitable concrete mixer.
- When applied by hand with brooms or rubber squeegees, the slurry shall be worked into cracks and other open areas until a sound, uniform surface is obtained.

The slurry shall, in the case of application by spreader box, be applied in a single layer at a nominal rate, for bidding purposes, of 0.004 m³/m².

d. Treatment Type 4 (Asphalt Skim Coat)

This treatment is intended for use where the road surface is uneven or contains slacks, bumps or minor rutting caused by deformation of the pavement layers, but not by failure of these layers.

The surface to be treated shall, after having been cleaned and prepared, be given a tack coat of 30 % bitumen emulsion at rates directed in the field by the Engineer.

Asphalt shall consist of a medium or fine-grade asphalt surfacing mix manufactured as specified with 6 % of 80/100 penetration-grade bitumen and 1.0 % active filler. The actual composition of the mix shall be as dictated by the required thickness of the asphalt layer, or as directed by the Engineer.

The asphalt shall be applied as specified in SECTION 5200 in thicknesses varying between 6 mm and 25 mm depending on the nature of the irregularities that occur so that the final surface will conform to the surface tolerances for cross-section and smoothness as specified in CLAUSE 5213. Where the thickness of asphalt required exceeds 25 mm, it shall be laid in separate layers each not exceeding 25 mm thickness.

If the final surfacing shows signs of ravelling, disintegration, or an uneven surface, the surface shall be given a Type 3 Treatment or removed and replaced, all at the Contractor's cost.

e. Treatment Type 5 (Asphalt Screeding)

This treatment is used where the road surface is uneven and where depressions, humps or small grooves occur, which, in the opinion of the Engineer, are the result of the deformation of the pavement layers, but not of structural failure of the pavement.

Where both planing and screeding are specified, the screed shall be placed after the planing has been completed. Where milling is required, it shall be done in accordance with the requirements of CLAUSE 5903.

The existing surface shall be swept clean or cleaned by other approved methods to be free from dust, soil, gravel, loose stones or any other undesirable material. A tack coat of 30 % anionic stable-grade emulsion shall then be applied at a rate prescribed by the Engineer.

The bituminous material used for the screed shall be asphalt or coarse slurry as specified in the Special Specifications.

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Bituminous Surface Treatments, Seals & Pavement Layers | 5900 | Treatment of Surface Defects...

5905 Patching

a. Demarcation

The Engineer will demarcate any failed areas to be repaired, and shall instruct the Contractor in regard to the repair work to be done.

The Contractor shall give adequate notice to the Engineer of their intention to commence with repair work on any specific section of the road so that the Engineer will have sufficient time to demarcate the areas to be patched and repaired.

In addition to their specified responsibilities for the accommodation of traffic, the Contractor shall also be responsible for traffic accommodation during the demarcation work.

b. Excavating Pavement Material

In addition to the provisions of this section the various provisions of SECTIONS 3200, 3300, 3600, 5100 and 5200 amongst others shall apply with changes as required.

c. Excavating Pavement Material

Unless otherwise instructed by the Engineer, the patching shall have a neat rectangular shape. The existing material shall be excavated and removed to the full specified depth. Asphalt layers and surfacing shall be cut with approved sawing equipment.

Excavation for patching shall be cut with side slopes of approximately 90° to the horizontal

Where required, excavation shall be done with approved milling equipment in accordance with SECTION 3600.

Excavated material from each pavement layer shall be placed in separate stockpiles adjacent to the patch. The stockpiled material shall be re-used or spoiled in an approved manner in accordance with the Engineer's instructions. Stockpiled material shall not be spoiled next to the road.

After completion of the excavation to the specified depth, the Engineer shall be afforded the opportunity to examine it. Where required, the floor of the excavation shall be compacted to the specified density for the layer concerned.

d. Backfilling Excavations

- i. Excavations shall be backfilled with pavement material as specified in the Special Specifications or as ordered by the Engineer, and the backfilling shall be compacted and finished to the required levels. The requirements for material quality, compaction and finish specified in relevant sections shall remain applicable. Untested material from the sides of the road shall not be used.
- ii. Stabilised materials shall be mixed in concrete mixers or by other approved equipment.
- iii. Unless otherwise specified in the Special Specifications, the base shall be backfilled in accordance with the following requirements.
 1. The base material shall be placed in a concrete mixer, and water shall be added to moisten the material. Mixing may also be carried out by hand.
 2. For emulsion-treated base A suitably diluted 60 % stable grade anionic bitumen emulsion shall be added at the specified rate, usually 4-6 % residual bitumen by mass of dry material. Portland cement shall be added at a rate of 1.5-2 % by mass of the dry material before adding water, unless otherwise specified by the Engineer. During mixing the fluid content (water plus emulsion) shall not exceed the optimum fluid content (optimum moisture content (OMC) + percentage residual bitumen) of the base. Mixing shall continue until a uniform mix of the base material and the emulsion is obtained

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3. For Hydraulically bound material (cement stabilised base) Approximately 4-6 % cement shall be added to natural gravel or sandy material and mixed until homogeneous. 4 % cement is adequate for strong gravels and 6 % cement is appropriate for sandy material. Water shall be added and the moisture content after mixing shall be close to or slightly wet of OMC. Once the moisture is uniformly distributed the material shall be placed immediately into the hole and compacted in layers not exceeding 150 mm in thickness. .
4. Graded crushed stone (GCS) can be used to backfill potholes. For replacement of damaged existing GCS reuse or recycle the material by remixing and recompacting. Where GCS is used to replace other materials, ensure that it is properly sealed to prevent accumulation of water in the GCS because of its high porosity and permeability. For highly trafficked roads 2 % cement may be added to the GCS, moistened, mixed and compacted.
5. For replacement of bitumen asphalt layers. During pothole patching damaged asphalt layers shall be replaced with new asphalt layers unless otherwise specified by the Engineer. The mix design shall be determined in the laboratory . For low to medium trafficked roads cold mix can be applied. For highly trafficked roads hot mix asphalt is recommended.
6. The Contractor shall place and spread the stabilised material or asphalt by hand in layers of appropriate thickness, usually not exceeding 150 mm, though 100 mm thickness is more ideal. This is because only light compaction equipment can be used in small and confined places.. Each layer shall be compacted with a hand-operated self-propelled vibratory roller or a vibrating plate compactor to the specified density. The process of placing, spreading and compacting shall be repeated until the required total thickness of layer is obtained.

The stabilised materials shall be placed at a fluid content not exceeding the optimum fluid content for the base course.

The finished surface of patching shall be a minimum of 2 mm and a maximum of 5 mm above the adjacent existing pavement. The ideal height above the existing surface shall be 3 mm.

e. Restrictions

Unless otherwise instructed in writing by the Engineer, the excavation, backfilling and all patching work, complete as specified, for any patch shall be carried out and completed on the same day. Special attention shall be given during patching to controlling and protecting traffic, as specified.

5906 Repairing Edge Breaks

This treatment is intended for use where trimming and/or repair of the edges of the surfaced area is required, including restoring the road edges to the true edge lines of the original road or to such other edge line as may be required.

Where the existing edge of the surfacing is sound but exceeds the required width by more than 150 mm, the excess surfacing shall be cut back to the required width keeping it parallel to the centre line of the road.

Where the edges of the surfacing have broken away or where the surfacing is narrower than the required new width, the existing broken edges shall be cut back until a sound edge can be obtained.

Where the edge of the surfacing, as cut back, requires building up to bring it to the required width, all material between the edge of the surfacing and the line to which the surfacing has to be built up, shall be removed to a depth of 60 mm below the final road surface or until firm material is found, and the surface so enclosed shall be cleaned, watered and primed at a rate of 0.6 l/m² with a A3 anionic emulsion diluted with one part of water to one part emulsion. The enclosed surface may also be compacted with suitably sized vibratory rollers to ensure a sound surface.

The edges shall then be built up with the asphalt specified for Treatment Type 4 and shall be well compacted by means of a suitable vibratory roller or compactor. The built-up edges shall be finished neatly to the required line and levels.

5907 Crack Sealing

a. General

The types of cracks treated will be specified in the Special Specifications as well as RDM 5.1 and RDM 5.2. The Engineer will instruct the Contractor regarding the type of treatment to be used in the various cases.

b. Preparation

The cracks shall be blown clean with compressed air, and all foreign and loose material shall be removed from the cracks.

c. Narrow Cracks (less than 2 mm in width)

They are difficult to seal effectively.

Consider using the following seals:

- i. Emulsion slurry seal
- ii. A mixture of fluid cutback bitumen and sand
- iii. A mixture of rubber latex and bitumen emulsion (1 part to 10 parts)

d. Medium Cracks (2 mm to 5 mm in width)

They may be sealed with emulsion slurry or rubber bitumen sealing compound.

e. Large Cracks

These are usually accompanied by distortion and require more extensive treatment (removal and replacement of defective areas or overlay). If there is no displacement or distortion the procedure given below shall be followed.

f. Application

After the primer has been applied, anionic stable grade emulsion shall be mixed with synthetic modifiers, as set out in the Special Specifications, and applied by means of pneumatic spraying equipment or other approved equipment at the rate given in the Special Specifications.

Where the cracks are to be rolled, the Contractor, in accordance with the Special Specifications or the prescriptions of the Engineer, shall treat the cracks as described below.

Where "Volcano" cracks occur and these require to be flattened, in accordance with the Special Specifications or the prescriptions of the Engineer, the Contractor shall treat the cracks as follows:

- The cracks shall initially be treated for cleaning out and priming the crack as described above.
- The surface on either side of the crack shall be sprayed with an approved rejuvenator for a width of 300 mm on either side of the crack and allowed to soften the existing surface.
- The crack shall then be filled with cold rubber slurry which shall be worked in with rubber squeegees. Any excess slurry shall be removed from the sides of the crack.
- Once the emulsion has broken, the crack can be rolled with a pedestrian vibratory roller until a smooth finish is obtained.

For other cracks, the instructions of the Engineer shall be implemented. Cracks shall be treated with cold rubber slurry, hot bitumen rubber, or any other approved sealant.

Where, in the opinion of the Engineer, the above treatments are not suitable for the existing cracks, the Contractor shall treat the cracks in accordance with the instructions of the Engineer.

i. Rubber slurry

The rubber slurry mixture shall be proportioned as follows (by volume):

- 10.0 parts of rubber crumbs
- 4.5 parts of 60 % anionic stable grade bitumen emulsion
- 0.2 parts of Portland cement
- Parts of SBR (net rubber) (anionic emulsified rubber)

Water may be added to improve workability. The mixture shall be neatly worked into the cracks by rubber squeegees. Excess slurry shall be removed from the surface as soon as the emulsion has broken.

ii. Bitumen rubber

Bitumen rubber may be used only where the Contractor is able to convince the Engineer that the Contractor is able to mix, heat and apply the material satisfactorily.

The bitumen rubber shall be mixed on the site or at another approved locality on condition that the Contractor is able to propose efficacious methods for controlling both the mixing process and the end product.

Approved heating equipment and mechanical equipment for mixing and applying the mixture shall be used.

The rubber content of the mix shall be at least 25 % by mass of the total bitumen-rubber mix.

iii. Other sealants

Other approved sealants shall comply with and be applied in accordance with the requirements of the Special Specifications.

g. Restrictions

Cracks may be sealed only where the temperature of the road surface exceeds 10°C.

Crack sealing may not be done within three days after rain has fallen on the site unless otherwise instructed by the Engineer.

The Contractor shall note that a single application of crack sealant is usually insufficient and that the application will have to be repeated.

5908 Opening To Traffic

The road shall be left open to traffic for such period as the Engineer may direct before further surface treatment work is carried out.

5909 Joints And The Protection Of Kerbs

The requirements of SUBCLAUSE 5307(b) regarding joints between sprays and the protection of kerbs, channels, etc, shall be observed.

5910 Measurement And Payment

Item	Unit
59.01 Treatment Type 1 (Fog Spray):	
(a) 30 % Bitumen Emulsion	Litre (l)
(b) 60 % Bitumen Emulsion	Litre (l)

The unit of measurement for Treatment Type 1 (Fog Spray) shall be the litre of bituminous emulsion sprayed at application rates as instructed by the Engineer, measured at spraying temperature.

The bid rates shall include full compensation for cleaning and preparing the existing surface, for furnishing the material and applying the fog spray and for all other incidentals necessary for completing the work as specified.

Item		Unit
59.02	Treatment Type 2: (Application Of Sand Seal):	
(a)	Binder (State Type)	Litre (l)
(b)	Sand	Cubic Metre (m ³)

The unit of measurement of binder shall be the litre, measured at spraying temperature. The unit of measurement for the sand shall be the cubic metre of sand applied to the road as specified.

The bid rates shall include full compensation for procuring and furnishing the material and applying the binder, including all preparatory work to the surface prior to application of the binder.

The bid rate shall include full compensation for supplying the sand, washing, screening and preparing the sand, applying the sand as specified, as well as brooming the sand back onto the surface as often as is required.

Item		Unit
59.03	Treatment Type 3: (Slurry) (State Nominal Application Rate):	Square Metre (m ²)

The unit of measurement shall be the square metre of completed and accepted slurry seal according to drawings or where directed by the Engineer.

The bid rate shall include full compensation, inter alia, for furnishing all materials, marking the centre line or reference lines, spraying of binder, spreading of aggregate, rolling, removing of dust or deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface, and all other incidentals necessary for completing the work as specified.

The bid rates shall include full compensation for procuring and furnishing the material including all preparatory work to the surface prior to application of the seal.

Item		Unit
59.04	Variation In The Rate Of Application Of The Slurry:	Cubic Metre (m ³)

The unit of measurement for slurry variations shall be the cubic metre of saturated fine aggregate.

Payment for variations shall be made as specified in [CLAUSE 1212](#).

Item		Unit
59.05	Treatment Type 4 (Asphalt Skim Coat):	
(a)	Tack Coat Using 30 % Bitumen Emulsion	Litre (l)
(b)	Continuously-Graded Asphalt	Cubic Metre (m ³) of Compacted Layer

The unit of measurement for the tack coat shall be the litre of emulsion applied, measured at spraying temperature. The unit of measurement for asphalt shall be the tonne of asphalt laid according to the Specifications.

The bid rate for tack coat shall include full compensation for procuring, furnishing and applying the tack coat and demarcating the areas to be sprayed, and for all incidentals necessary for completing the work as specified.

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The bid rate for asphalt shall include full compensation for procuring, furnishing and mixing all the materials required for applying the asphalt, and for all transport and other incidentals necessary to complete the work as specified.

Item	Unit
59.06	Treatment Type 5 (Screed):
(a)	Tack Coat Using 30 % Bitumen Emulsion Litre (l)
(b)	Continuously-Graded Asphalt (specify grade) Cubic Metre (m ³) of Compacted Layer
(c)	Coarse Grade Slurry Cubic Metre (m ³)

The unit of measurement for the tack coat shall be the litre of emulsion applied, measured at spraying temperature. The unit of measurement for asphalt shall be the tonne of asphalt laid according to the Specifications. The unit of measurement for coarse grade slurry shall be the cubic metre of aggregate mix used in the slurry.

The bid rate for tack coat shall include full compensation for procuring, furnishing and applying the tack coat and demarcating the areas to be sprayed, and for all incidentals necessary for completing the work as specified.

The bid rate for asphalt shall include full compensation for procuring, furnishing and mixing all the materials required for applying the asphalt, and for all transport and other incidentals necessary to complete the work as specified.

The bid rate for slurry shall include full compensation for all materials, equipment and labour for producing and applying the slurry, irrespective of the number of applications required to attain the required thickness.

Item	Unit
59.07	Sawing Asphalt Or Cemented Pavement Layers For Patching:
(a)	Continuously-Graded Asphalt:
i	Not Exceeding 50 mm Linear Metre (m)
ii	Exceeding 50 mm But Not Exceeding 100 mm Linear Metre (m)
ii	Exceeding 100 mm Linear Metre (m)
(b)	Cemented Pavement Layers To An Average Depth:
i	Not Exceeding 50 mm Linear Metre (m)
ii	Exceeding 50 mm But Not Exceeding 100 mm Linear Metre (m)
ii	Exceeding 100 mm Linear Metre (m)

The unit of measurement shall be the linear square metre of sawcut calculated in accordance with the authorised length of sawcut and the average saw depth measured after excavation of the material.

The bid rate shall include full compensation for all equipment, labour supervision, materials, transport and for all incidentals for sawing the asphalt and the cemented pavement layers, complete as specified and prescribed by the Engineer.

Item	Unit
59.08	Excavation In Existing Pavements For Patching In:
(a)	Asphalt Layers Cubic Metre (m ³)
(b)	Cemented Layers Cubic Metre (m ³)
(c)	Other Layers (Specify Type) Square Metre (m ²)

The unit of measurement shall be the cubic metre of material excavated from the existing pavement. The quantity shall be computed in accordance with the authorised dimensions of the excavation.

The bid rate shall include full compensation for demarcating the excavation, excavating the material, placing the excavated material in temporary stockpiles, spoiling of material in the stockpiles where ordered by the Engineer, including haul over a free-haul distance of 1.0 km, complete as specified.

Payment will not distinguish between the different types of pavement material excavated.

Item	Unit
59.09	Backfilling Of Excavations For Patching With:
(a)	Chemically Stabilised Pavement Material (Specify The Pavement Material And The Stabilising Agent) For A Patch With A Surface Area:
i	Not Exceeding 5 m ² Cubic Metre (m ³)
ii	Exceeding 5 m ² But Not Exceeding 100 m ² Cubic Metre (m ³)
ii	Exceeding 100 m ² Cubic Metre (m ³)
(b)	Base Course Material Stabilised With Bituminous Emulsion (Specify The Emulsion) For A Patch With A Surface Area:
i	Not Exceeding 5 m ² Cubic Metre (m ³)
ii	Exceeding 5 m ² But Not Exceeding 100 m ² Cubic Metre (m ³)
ii	Exceeding 100 m ² Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of the specified chemically or bitumen stabilised pavement material placed in accordance with the specified requirements. The quantity will be computed in accordance with the authorised dimensions of the layer.

The bid rates shall include full compensation for providing all the material, irrespective of its origin, including gravel (notwithstanding the provisions of SECTION 1600), for all mixing, placing, compacting and finishing as specified in this section and other appropriate sections of the Specifications, for all transport, work in restricted areas, and also for all machinery, equipment, labour, supervision and other incidentals for executing the work as specified.

The bid rate shall also include full compensation for chemical or bituminous stabilisation, including amongst others the provision and application of the stabilising agents.

Item	Unit
59.10	Compacting the Floor of Excavations for Patching: Square Metre (m ²)

The unit of measurement shall be the square metre of excavation floor compacted on the instruction of the Engineer, and the quantity shall be computed in accordance with the authorised dimensions of the excavation floor.

The bid rate shall include full compensation for compacting the floor of excavations complete as specified.

Payment will not distinguish between the various methods of compaction or various density requirements.

Item	Unit
59.11	Edge Breaks:
(a)	Trimming Edges of Existing Surfacing Metre (m)
(b)	Reconstructing Edges from Continuously-graded Asphalt Cubic Metre (m ³) of Compacted Layer

The unit of measurement for trimming edges shall be the metre of pavement edge cut back and trimmed as specified. The unit of measurement for reconstructing pavement edges shall be the tonne of continuously-graded asphalt furnished and compacted as specified.

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The bid rate for trimming the edges shall include full compensation for cutting back the edges as directed, and removing and dumping of all excavated and loose material in an approved waste site.

The bid rate for reconstructing pavement edges shall include full compensation for compacting the surface on which the new edge is to be constructed and procuring, furnishing and mixing all materials and compacting and trimming the asphalt to the required lines and levels. It shall also include full compensation for applying a tack coat of emulsion to the surface to be treated.

The bid rates shall include full compensation for all transport, handling, labour, material and all incidentals necessary to complete all the work specified in the treatment of edge breaks.

Item	Unit
59.12 Cleaning The Cracks With Compressed Air:	Kilometre (km)

The unit of measurement for cleaning the cracks with compressed air shall be the kilometre of road along which all the cracks have been blown clean.

The bid rate shall include full compensation for providing all equipment, labour, supervision and incidentals for blowing clean the cracks over the full width of the road to the satisfaction of the Engineer.

Item	Unit
59.13 Applying Bituminous Binders, And Sealants For Sealing Cracks:	
(a) Multi-Surface Primer (Type Indicated)	Litre (l)
(b) Anionic Stable-Grade Emulsion Mixed With Synthetic Modifiers	Litre (l)
(c) Hot Bitumen Rubber	Litre (l)
(d) Other Specified Agents (Type Indicated)	Litre (l)

The unit of measurement shall be the litre of material applied as specified or as instructed by the Engineer.

The bid rates shall include full compensation for providing, mixing, heating (where required) and applying all the materials specified, and for all equipment, labour, supervision and incidentals for completing the work. No additional payment shall be made for multiple applications of material, and payment will not distinguish between the various types, widths or lengths of cracks.

Item	Unit
59.14 Cold Rubber-Slurry for Sealing Cracks	Cubic Metre (m ³)

The unit of measurement for crack treatment with rubber slurry shall be the cubic metre of fine rubber crumbs used for preparing the mix.

The bid rate shall include full compensation for procuring and providing all the material, including emulsion synthetic modifiers, cement and water, and for mixing and applying the mixture, and for all equipment, labour, supervision, and incidentals for executing the work in accordance with the specifications.

Payment will not be made for redundant rubber pellets or redundant mixture or for mixture, which in the opinion of the Engineer has been wasted.

Item	Unit
59.14 Rolling the Cracks	Metre (m)

The unit of measurement shall be the metre of crack rolled to the satisfaction of the Engineer.

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SECTION 6100 Fixed & Slip Form Paver Laid Concrete Pavement

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6101 Scope

This section covers all the material requirements and work pertaining to the construction of paver laid concrete on new supporting layers or existing concrete or asphalt layers and include, inter-alia, the following pavement types:

1. Jointed unreinforced concrete (JUC) pavement – with or without dowels, for new construction or overlays.
2. Jointed reinforced concrete (JRC) pavement for new construction or overlays.
3. Roller compacted concrete (RCC) pavements for new construction or overlays.
4. Continuously reinforced concrete base (CRCB) for new construction or overlays.
5. Continuously reinforced concrete pavement (CRCP) for new construction or overlays.

It includes, inter alia, the specifications for materials, manufacture and construction requirements as relevant to the specific pavement as prescribed.

It should be noted that even if the main concrete pavement is paver laid, there may be occasions where the concrete shall be placed, compacted and finished using manual labour e.g. where the slabs are too small or irregular (at edges or junctions, etc), or the site is so restricted as to render the use of the methods described herein impracticable.

6102 Materials

a. Cementitious Materials

Cementitious materials used for concrete shall comply with KS EAS 18-1 with a strength class of 32.5 or greater, and a class of strength gain N (ordinary early strength) or R (high early strength). Masonry cement shall not be used. The cement type and class incorporated in the mix shall be appropriate to the type of pavement to be constructed and the placing, finishing and saw cutting constraints envisaged.

Blends of cement complying with KS EAS 18-1 and supplementary cementitious materials complying with the above standards may be used subject to a maximum of 20 % of the total cementitious content.

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TABLE 6102/1: MECHANICAL & PHYSICAL REQUIREMENTS GIVEN AS CHARACTERISTICS VALUES

Strength Class	Compressive Strength (MPa)				Initial Setting Time	Soundness (expansion)
	Early Strength		Standard Strength			
	2 days	7 days	28 days		Minutes	mm
32.5 N	-	≥ 16.0	≥ 32.5	≤ 52.5	≥ 75	≤ 10
32.5 R	≥ 10.0	-				
42.5 N	≥ 10.0	-	≥ 42.5	≤ 62.5	≥ 60	
42.5 R	≥ 20.0	-				
52.5 N	≥ 20.0	-	≥ 52.5	-	≥ 45	
52.5 R	≥ 30.0	-				

All cementitious materials shall be protected from moisture until used, and there shall be sufficient facilities to ensure that the cementitious materials to be used in the work are kept separate from each other and from other cementitious materials.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather. Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation but shall not be stacked against outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. No stack of cement bags shall exceed 3 m in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks. Cement from broken bags shall not be used in the works. Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weatherproof silos which shall bear a clear indication of the type of cement contained in them. Where cementitious materials are stored in a silo, the silo must be emptied before using the silo for a different cementitious material. Blended cements with a percentage of SCM (Supplementary Cementitious Materials) differing by more than 2 % shall be considered different cementitious materials.

The cementitious binder shall comprise either cement, complying with KS EAS 18-1, or an approved site blend of such cement and supplementary cementitious materials that take appropriate cognisance of environmental conditions, durability and strength requirements. The site blending of cement with supplementary cementitious materials shall only be conducted on the basis of an acceptable quality assurance system approved by the Engineer.

The contractor shall keep a full record of all data relevant to the manufacture, delivery, testing and use of all cement used in the works and shall provide the engineer with two copies thereof.

b. Water

Water for use in mixing concrete and mortar and for curing and related purposes shall be obtained from a source approved by the Engineer and shall comply with the requirements of BS EN 1008.

Water shall be clean, fresh and free from detrimental concentrations of acids, alkalis, salts, sugar and other organic or chemical substances that could impair the durability and strength of the concrete or the imbedded steel. The Contractor shall prove the suitability of the water by way of tests conducted by an approved laboratory. For reinforced and prestressed concrete the chloride

content of the mixing water shall not exceed 500 mg/l when tested in accordance with EN 196-21 or equivalent.

c. Aggregates For Concrete

i. General

Aggregates shall comply with the requirements in TABLE 6102/2 is reproduced here.

TABLE 6102/2: SPECIFICATIONS APPLICABLE TO STONE, AGGREGATE SANDS AND FILLERS

No.	Test Name/Property	Reference to Standard Test Method	
		Test Method	Specification
1	Sampling and sample preparation	BS EN 932-1	N/A
2	Particle size distribution (PSD)	BS EN 933-1	NMPS 37.5 mm
3	PSD for filler aggregates (air jet sieving)	BS EN 933-10	NMPS 0.063 mm
4	Fines content	BS EN 933-1	Max 6 % by mass
5	Fines quality	BS EN 933-9	Non-plastic
6	Flakiness index for coarse aggregates	BS EN 933-3	Max. 35 %.
7	Shape index for coarse aggregates	BS EN 933-4	Max. 25 %
8	Shell content for coarse aggregates	BS EN 933-7	Max 8 %
9	Particle density and water absorption	BS EN 1097-6	WA. Max 2.5 %
10	Loose bulk density and voids	BS EN 1097-3	N/A
11	Water content	BS EN 1097-5	Max. 2.5 %
12	Drying shrinkage	BS EN 1367-4	Max 0.040 %
13	Aggregate impact value (AIV)	BS EN 1097-2, CI 6	Max. 30 %
14	Los Angeles Abrasion For coarse aggregates < 37.5 mm For coarse aggregates > 20 mm	AASHTO T96/ASTM C131/ ASTM C535	Max. 50 %
15	Aggregate abrasion value (AAV)	BS EN 1097-8, annex A	Max. 15 %
16	Polished stone value (PSV)	BS EN 1097-8	Min. 65 %
17	Water soluble chloride content	BS EN 1744-1, cl 7	Max. 500 mg/l
18	Water soluble sulphate content	BS EN 1744-1	Max. 0.2 %
19	Sodium Sulphate Soundness	AASHTO T104/ASTM C88	Max 12 %
20	Organic impurities in sand	AASHTO T21 (ASTM C40)	Max 0.3 %

Aggregates shall not contain any deleterious quantities of organic material, particularly pieces of timber, grass or similar matter as assessed by visual inspection, which will cause unacceptable surface defects when they float to the top of fresh concrete during vibration.

Both coarse aggregate and fine aggregate (sand) shall comply with the requirements of BS EN 12620 or equivalent, subject to the following:

The average 28 day drying shrinkage of three concrete samples made from each of the required three concrete mixtures for preparing the compressive strength and flexural strength samples in accordance with the requirements set out in SECTION 1700 (Testing of Materials and Workmanship) shall not exceed 0.040 %. Drying-shrinkage tests shall be conducted in accordance with BS EN 12390-16 or equivalent. Where the drying shrinkage exceeds the specified maximum value, either alternative aggregates shall be used, further investigations undertaken, or evidence shall be produced with a view to confirming the suitability of the aggregates proposed for use. Any variation to the specification should be subject to approval of the engineer.

ii. Alkali-aggregate reaction

Where there is any risk of a particular combination of aggregate and cement giving rise to a harmful alkali-aggregate reaction, the proposed combination shall be tested in accordance with BS EN 12620. Where the result indicates such potential reaction, the aggregate, shall be replaced so that an acceptable combination may be obtained.

iii. Coarse aggregate

1. Hardness

Tests for hardness include: The Los Angeles Abrasion AASHTO T96, ASTM C131, ASTM C535) or Aggregate Abrasion Value test (BS EN 1097-8, annex A).

2. Flakiness Index

The flakiness index of the coarse aggregate, as determined in accordance with KS 1238-6-1 / BS EN 933-3 shall not exceed 35 %.

3. Nominal Maximum Particle Size (NMPS)

The maximum nominal particle sizes of the coarse aggregate fraction in the mix shall be as follows:

- Slab thickness ≥ 175 mm: 37.5 mm, plus one or more of the following 20.0 mm, 14.0 mm and 10.0 mm.
- Slab thickness ≥ 150 mm & < 175 mm: 28.0 mm (Where recommended by an approved laboratory and approved by the Engineer, smaller sizes of aggregate, nominal 20.0 mm and/or 14.0 mm sizes shall be provided).
- Slab thickness ≥ 100 mm & < 150 mm: 20 mm (Where recommended by an approved laboratory and approved by the Engineer, smaller sizes of aggregate, nominal 14.0 mm and/or 10.0 mm sizes, shall be provided).
- Slab thickness < 100 mm: 14.0 mm (Where recommended by an approved laboratory and approved by the Engineer, smaller sizes of aggregate, nominal 10.0 mm and/or 7.1 mm shall be provided).

4. Fine Aggregate

The fine aggregate shall be either a natural or crusher-produced sand or a blend of natural and crusher sands. Where a mixture is used, the quantity passing through each of the 0.150 mm and 0.075 mm sieves shall not exceed the relevant interpolated values for the approved blend. Where required by the Engineer the fine aggregate shall contain more than 20 % quartz by mass.

d. Admixtures to Concrete

No admixtures shall be used without the written permission of the Engineer. The admixtures proposed for use shall be assessed during the mix design process and construction of the trial section.

All admixtures for concrete shall comply with the requirements of KS 2770, BS EN 934, ASTM C494 or AASHTO M194 or equivalent. Admixtures shall be approved by the Engineer and

1. Shall Be Compatible With The Exposure Environment and Cementitious Binder Composition.
2. Shall Have No Deleterious Effects On The Steel Or Concrete, and Shall Not Contain Any Chlorides, Nitrates, Sulphides Or Sulphites, Which May Be Detrimental.
3. Shall Generally Be Supplied In Liquid Form.
4. Shall Be Accurately Dispensed By A Mechanical Dosing Unit In A Manner Appropriate To The Method Batching E.g. Dry Versus Wet Batching. Under No Circumstances Shall An Admixture be dispensed directly onto the dry mix component.
5. Where specified, air entraining agents may alternatively comply with the requirements of BS EN 934, ASTM C260 or AASHTO M154 or equivalent.

Where combinations of two or more admixtures are utilised, they shall be tested for compatibility. The total amount of admixtures shall not exceed the maximum dosage recommended by the admixture producer and also shall not exceed 5 % by mass of the total cementitious binder, unless the influence of the higher dosage of admixture on the performance and durability of the concrete is established and taken into account.

If the total quantity of liquid admixture equals or exceeds 3 litres per cubic metre of concrete, then the admixture quantity shall be included in the water content of the concrete mixture when calculating the water: cementitious binder ratio.

The alkali content (Na_2O -equivalent) of all admixtures shall form part of the calculation of the alkali content of concrete in order to limit the degree of reactivity as specified in SECTION 7000.

Where so specifically specified, or proposed by the Contractor, any chemical or air-entraining admixtures used shall comply with the requirements of BS EN 934-3 and shall be of an approved type and brand. In addition, admixtures shall be subject to such tests as may be prescribed by the Engineer, carried out at an approved testing laboratory at the Contractor's expense to determine the effect of the admixture on the concrete mix including early strength development. Admixtures containing calcium chloride shall not be used.

Admixture properties shall be uniform throughout their use in the work and stored and dispensed in liquid form.

If more than one admixture is used, the admixtures must be compatible with each other such that the desirable effects of all the admixtures used are realised.

Admixtures shall be utilised in compliance with the manufacturer's written instructions. The instructions shall include a statement that the admixture is compatible with the types and quantities of cementitious material intended for use.

If the use of admixtures is not specified, the dosage thereof shall be as recommended by the admixture manufacturer to achieve any enhanced fresh or final concrete characteristics required.

e. Bituminous Prime/Bond Coat

For JUC and JRC concrete pavements (unless otherwise specified in the Contract Documentation) a bituminous prime/bond coat shall be applied to the completed cementitious stabilised or asphalt sub-base layer in accordance with the requirements of SECTION 5000 (Bituminous surface treatments, seals and pavement layers).

For RCC, CRCB and CRCP concrete pavements a slip membrane (prime or bond coat) is not required under the main pavement but may be required at each end (i.e. terminations).

For details of the prime coat material, see SUBCLAUSE 5204(a).

f. Reinforcing Steel, Tie-Bars and Dowels

1. Dimensions

The dimensions for reinforcing steel, tie-bars and dowels shall be as indicated on the drawings.

2. Reinforcing steel and tie bars

Reinforcing steel, tie-bars, tie wire, etc shall comply with the requirements of KS 22, KS 105, KS 106, KS 2712, KS EAS 412.

Reinforcing steel bars (i.e. rebar) shall be deformed (e.g. ribbed) weldable reinforcing steel bars.

Tie-bars shall be deformed (e.g. ribbed) weldable reinforcing steel bars, except that any tie-bars intended to be bent and subsequently straightened shall be hot-rolled deformed mild-steel bars. The use of plate type tie bars shall be approved by the Engineer.

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Mild steel refers to a specified characteristic strength of 250 N/mm². High yield steel refers to a specified characteristic strength of 460 N/mm² for bars of up to 16 mm size, and 425 N/mm² for bars over 16 mm (KS 106).

3. Welded steel fabric

Welded steel fabric shall comply with the requirements of BS 4483.

4. Dowel bars at transverse joints

Dowel bars shall be mild-steel bars having a smooth, circular section complying with BS EN 13877-3 or equivalent. Dowel bars shall be straight and free from irregularities and without any burred ends and shall have their sliding ends sawn and bevelled. Cropping of dowels shall not be permitted.

The free or un-bonded end of the dowel shall be coated with a bond-breaking coating, as directed by the Engineer, to prevent the concrete from adhering to it. The coating or sheath shall cover at least two-thirds of the dowel length. The bond-breaking coating shall be an approved synthetic material applied at a thickness of 0.5 mm in accordance with the manufacturer's recommendations. The sheath shall be a tough polyethylene material with an average thickness of 1.0 mm ± 0.2 mm.

The use of alternative plate dowels shall be approved by the Engineer.

g. Curing Compound

The curing compound used shall be a resin-based curing compound containing no water and which complies with the requirements of ASTM C 309, except that the water loss requirement be substituted with the efficiency-index as determined in accordance with BS 7542. The colour shall preferably be white-pigmented. The efficiency-index shall exceed 90 % at an application rate of 0.2 l/m². A recent certificate not older than 3 months from an approved testing laboratory shall be submitted, certifying that the curing compound complies with the specifications. Further testing shall be conducted at regular intervals.

The curing compound shall be capable of hardening within 30 minutes of having been applied and of being sprayed onto a wet surface without loss of stability, change in colour or becoming less efficacious. This characteristic shall also be confirmed by the approved testing laboratory.

h. Materials for Joints

1. Joint filler for expansion joints

Joint filler for expansion joints shall be manufactured from a closed-cell polyethylene and the filler strips shall be provided with tear-off cover strip. The joint filler shall comply with the requirements of AASHTO M 153 or equivalent, and the particular type used shall be subject to the Engineer's approval. Joint filler for isolation joints shall be pre-formed expansion joint filler for concrete paving (bituminous type) complying with ASTM D 8139, D 1751 or D 994 or equivalent.

Alternatively Preformed Sponge Rubber, Cork, and Recycled PVC Expansion Joint Fillers may also be used complying with ASTM D 1752 or Closed-Cell Polyolefin Expansion Joint Fillers complying with ASTM D 7174 or equivalent.

2. Joint sealant

The joint sealant should comply with BS EN 14188-2 (cold applied joint sealants) or BS EN 14188-1 (Hot applied joint sealants) or BS EN 14188-3 (preformed joint seals) or equivalent.

i. Silicone Sealant

If a silicone sealant is specified by the Engineer, then the joint sealant shall be silicone specifically formulated for use on concrete. The use of acid cure sealants shall not be permitted.

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Silicone joint sealant must be compatible with the surface it is applied to and have properties shown in the TABLE 6102/2 below.

TABLE 6102/3: PROPERTIES OF SILICON JOINT SEALANT		
Test Name/Property	Test Method	Specification
Tensile stress, 150 % elongation, 7-day cure at 25°C ± 2°C and from 45 % to 55 % Relative Humidity	ASTM D 412 (Die C)	0.31 MPa max.
Flow at 25°C ± 2°C with 15 % slope channel A	ASTM C 639	Must not flow from channel
Extrusion rate through 3.18mm opening at 0.62 MPa at Material temperature - 18°C	ASTM C 603	Min. 75 g/min
Extrusion rate through 3.18mm opening at 0.62 MPa at Material temperature 38°C	ASTM C 603	Max. 250 g/min
Relative density /Specific gravity	ASTM D 792 Method A	1.01 to 1.51
Durometer hardness, at -18°C, Shore A, cured 7 days at 25°C ± 2°C	ASTM C 661	10 to 25
Ozone and UV resistance, after 5,000 hours	ASTM C 793	No chalking, cracking or bond loss
Tack-free at 25°C ± 2°C and 45 to 55 % Relative Humidity	ASTM C 679	Less than 75 minutes
Elongation, 7 day cure at 25°C ± 2°C and 45 to 55 % Relative Humidity	ASTM D 412 (Die C)	500 % min.
Set to Touch, at 25°C ± 2°C and 45 to 55 % Relative Humidity	ASTM D 1640	Less than 75 minutes
Shelf Life, from date of shipment	--	6 months min.
Bond, to concrete mortar-concrete briquettes, air cured 7 days at 25°C ± 2°C	AASHTO T 132	0.34 MPa min.
Movement capability and adhesion, 100 % extension at - 18°C after, air cured 7 days at 25°C ± 2°C, and followed by 7 days in water at 25°C ± 2°C	ASTM C 719	No adhesive or cohesive failure after 5 cycles
Colour		Grey

The Contractor shall submit a certificate, less than six months old, from an approved testing laboratory, certifying that the sealant conforms to all the specified requirements.

The silicone sealant shall be applied by pumping the sealant from a storage container using compressed air powered pumping equipment and applied to the joint slot using nozzles designed to ensure that the slot is filled with sealant as indicated on the drawings. Application of the sealant into the joint slot by hand shall not be permitted.

ii. Additional materials for joint sealing

Backer rods shall comply with ASTM D 5249, Type 1 or equivalent. The backer rod diameter shall be at least 25 % greater than the saw cut joint width. Backer rod material shall be expanded, cross-linked, closed-cell polyethylene foam.

The sealant shall be supported by a bond breaker backing strip, and, unless otherwise recommended by the manufacturer and approved by the Engineer, the faces of the joint groove shall first be treated with an appropriate primer.

Supporting and priming materials shall be compatible with adjacent materials or surfaces in contact with the materials and shall be in accordance with the recommendations by the manufacturer and subject to approval by the Engineer. Any primer used shall form a barrier layer between the silicone and the concrete.

iii. Materials for cleaning, repairing and resealing of existing joints and cracks

Materials used for cleaning existing joints and for repairing and sealing or resealing joints and cracks shall comply with the provisions of the Contract Documentation. Cleaning agents shall be such that they will not stain the concrete or cause the existing bituminous or other material to soak into the concrete.

iv. Liquid sealant for joints between concrete or asphalt pavement

The liquid sealant used in joints between concrete and asphalt pavement shall be of the hot-poured type and shall comply with the requirements as may be set out by the Engineer.

6103 Construction Equipment

a. General

The Contractor shall ensure the equipment and tools intended for use shall meet the following requirements:

1. The capability for handling the proposed materials and performing all parts of the work within the specifications.
2. Production rates of such capacity that the paver operates continuously and at a constant rate of production, with starting and stopping reduced to a minimum.

Before any concrete may be cast, the Engineer shall approve:

- i. The concrete source,
- ii. Batching methodology,
- iii. All assembled side-forms, guide wires and/or rails and the paving train configuration.

For this purpose, the Engineer shall be given sufficient notice and opportunity to inspect the planned methodology and equipment. Approval by the Engineer shall not relieve the Contractor of any of their obligation to construct the concrete pavement in accordance with the specified quality, dimensions and relevant tolerances.

b. Concrete Batching Plant

The intended concrete batching plant or supply source shall be of sufficient capacity to ensure that, as far as practically possible, there is an uninterrupted supply of concrete during paving operations. Concrete may be produced in either of the following manner:

1. Batching on site by an approved and dedicated plant,
2. Sourced from a ready-mix commercial supplier.

Where concrete is supplied from a commercial source, the supplier shall ensure compliance with the requirements of BS EN 206. The Contractor shall have full responsibility to implement process control testing in accordance with the specifications. Commercial concrete suppliers shall ensure that the plant, measuring, mixing, transporting and associated processes are audited by a recognised independent body in accordance with the following requirements for commercially sourced concrete:

- i. ISO 9002 (Standardisation - Guidelines for the application of ISO 9001);
- ii. ISO 14001 (Environmental management systems);
- iii. ISO 39001 (Road traffic safety management);

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- iv. ISO 22965-2 (Concrete Pt2: Specification of constituent materials, production of concrete and compliance of concrete) or ISO 9001 (Quality management system for concrete production).

c. Fixed Form Paving

1. Fixed forms (side forms)

Before any side-forms may be ordered or brought onto the site, particulars regarding the side-forms shall have been approved by the Engineer. Side-forms and rails shall be so designed, manufactured, set and supported that the completed concrete pavement will comply with all the requirements of **CLAUSE 6105**. When assessed with a 3.0 m straight-edge, the top edge of the form shall not deviate by more than 3.0 mm at any place, and the sides by not more than 6.0 mm. The sides shall not deviate by more than 3.0 mm from the vertical. The maximum height that the side-forms may be raised in order to achieve the specified layer thickness shall be 15 mm.

The wheels of spreading, compaction, finishing machines and frame-mounted covers shall not run directly on the top surface of the side-forms but on rails rigidly attached to the forms, unless the forms are specially made to double as rails.

There shall be sufficient length of side forms available and provided so that it is not necessary to remove them less than 12 hours after placing the concrete. All forms shall be thoroughly cleaned and treated with an approved releasing agent prior to reuse.

2. Paving train

The equipment shall be of such dimensions and arrangement so as to cover the full width of the pavement strip being placed with the minimum amount of hand work required. The paving train shall essentially consist of the following items of equipment:

i. Hopper/spreader

A purpose made spreader/hopper running on rails and capable of spreading the delivered concrete laterally and evenly to a uniform un-compacted density over the entire surface of the slab without segregation.

ii. Consolidation/compaction equipment

Consolidation of the concrete shall be executed by appropriate mechanical surface vibrators, internal vibrators and tampers. The power supply to the vibrators shall cut out automatically as soon as the compaction equipment stops moving. Suitable internal vibrators shall be used against the side-forms and at joint assemblies to ensure full compaction throughout the pavement layer. For the surface vibrators, a frequency of not less than 3,500 impulses per minute shall be utilised. For internal type vibrators, a frequency of not less than 5,000 impulses per minute for tube vibrators and not less than 7,000 impulses per minute for spud vibrators shall be utilised.

Where spud-type internal vibrators adjacent to forms are utilised, either hand-operated or attached to spreaders or finishing machines, a minimum frequency of 3,500 impulses per minute shall be used. The Contractor shall measure and record the frequency of internal vibrators in plastic concrete and submit data to the Engineer. Where spud vibrators are mounted such that the free tip trails, they shall be spaced at a maximum interval of 750 mm.

iii. Initial finisher

The surface of the concrete shall be finished smooth and true to grade and level by means of an initial finishing machine equipped with a transverse or oblique oscillating beam. The machine shall be capable of being readily adjusted for changes in slab thickness, cross-fall, height and tilt.

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iv. Final finisher

The final finish of the surface shall be carried out by a machine which incorporates twin oblique oscillating finishing beams. The beams shall be readily adjustable for both height and tilt. The leading beam shall be vibrated. The beam shall be supported on a carriage with two wheels on either side at least 3.5 m apart in the longitudinal direction. The oscillating beams shall be of rectangular section, spanning the full width of the slab and each weighing not less than 170 kg/m.

v. Frame mounted canopy.

The Contractor shall provide a frame mounted canopy to protect the plastic finished concrete from any damage as a result of rain or other unfavourable weather conditions. The length of the protective canopy shall be appropriate to the expected production rates.

d. Slip-form Paving**1. Slip-form paver**

The Contractor shall provide a slip-form paver that is self-propelled and equipped to spread, strike-off, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the equipment in such a manner that a minimum amount of hand-finishing will be necessary to provide a dense and homogeneous pavement. The equipment shall be of such dimensions and arrangement so as to cover the full width of the pavement strip being placed.

The paving equipment shall be adjustable as to crown and super elevation and capable of shaping and consolidating the concrete into a dense and stable mass to the required cross-section. Any crown adjustments shall be readily controllable for accuracy in crown transitions.

The paver shall operate on tracks having sufficient contact area to prevent track slippage under load. The length of ground contact per track and the arrangement of tracks shall be adequate to meet the straightedge and other riding-quality requirements specified.

Spreading shall be accomplished by either:

- Oscillating screeds,
- An extrusion device, or
- A combination of both.

If necessary, the slip-form paver shall be equipped with traveling side forms of sufficient dimension, strength and of proper shape in order to support the concrete laterally for a sufficient length of time during placing and finishing.

2. Electronic control systems

Where a slip-form paver is used, the alignment levels for placing the concrete, shall be controlled automatically from guide wires by sensors attached at the four corners of the slip-form paving machine. The alignment and level of ancillary machines for finishing, texturing and curing shall be automatically controlled relative to the guide wires and to the surface and edges of the slab. Guide wires shall be so designed, manufactured and fixed such that the paver will be capable of producing a completed slab which will comply with the requirements of **CLAUSE 6105**.

Other control methods, such as a string-less paving system incorporating appropriate 3D/GPS technology may be permitted after assessment and approval by the Engineer.

e. Burlap Drag Equipment

Unless otherwise authorised by the Engineer, the burlap drag shall be attached to the front of the texturing machine or to an additional machine which spans the full width of the concrete pavement and is placed in such a way that the full width of the concrete pavement is covered in one operation and, when not in use, the entire drag can be lifted clear off the pavement.

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The dimensions of the burlap drag shall be such that at least 1.0 m of the material is in contact with the surface of the concrete pavement measured in the direction in which the drag is being moved. The burlap drag shall consist of at least two layers of approximately 340 g/m² burlap with the bottom layer at least 150 mm longer than the top layer at the dragging end. However, if the required texture is not obtained, then at the discretion of the Engineer, the number of layers may be increased to four. The transverse threads of the trailing 150 mm to 300 mm of the burlap drag shall be removed.

f. Texture Grooving Equipment

Unless otherwise approved, the required tine texturing shall be effected by means of a machine which spans the full width of the concrete pavement, and which is guided in regard to both level and direction by the rails in the case of fixed form construction, or by the paver guide wires in the case of slip form construction.

The grooving tines shall be made from individual flat spring steel approximately 0.6 mm in thickness and 3.0 mm in width, 125 mm in length and spaced at between 12 mm and 25 mm in an approved random pattern. The Engineer may, however, require a different random pattern or equal spacing of the tines during the course of the work, and provision shall be made to supply different sets of combs as required. No additional payment will be made for the first two changes in the spacing of the tines. The comb frame for applying the texturing shall be at least 2.0 m wide. It must also be possible to adjust the combs to a lower position in order to compensate for wear.

Where so specified in the Contract Documentation, the fresh concrete shall be broom textured utilising appropriate equipment just prior to applying the curing compound.

g. Applicator for Curing Compound Membrane

The Contractor shall provide equipment for applying the curing compound that is self-propelled and capable of uniformly applying the curing compound at the specified rate. The equipment shall be capable of continuously stirring the curing compound by effective mechanical means to keep the pigmentation in suspension. The curing compound shall be thoroughly atomised during the spraying operation so that the finished surface appearance of the fresh concrete will not be marred. The entire surface of the pavement shall be covered by a single pass of the machine and, with slip-form type paving, shall also include the vertical exposed faces. Spray nozzles shall be equipped with appropriate wind guards to ensure uniform application.

Hand operated power-spray equipment may be used to apply curing compound to areas where it is impracticable to operate the self-propelled equipment.

h. Equipment for Paving Small or Narrow Areas

For minor roads, variable width areas, other than mainline, ramps, and shoulders, the Engineer will not require the full slipform paver as specified for the standard run of paving. In such instances the Contractor shall utilise appropriate hand equipment and construction methods as prescribed in [CLAUSE 6104](#) in order to achieve the desired final product as specified. The Contractor shall provide a comprehensive method statement and quality plan to the Engineer for approval prior to commencing with any such work.

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6104 Execution Of The Works

a. Preparing the Underlying Layers

As stated in **RDM3 Part 5: Rigid Pavement Design**, the layer beneath a concrete pavement (JUC, JRC, RCC, CRCB & CRCP) needs to be either an F4 (bound) or F5 (bound). It should have a Surface Modulus of 200 MPa (F4 bound) or 400 MPa (F5 bound) and include a non-erodible bound layer at the top (this can be asphalt or more usually cement-bound material).

For CRCB and CRCP designs, a Foundation of F4 (bound) is usually used for design traffic up to 100 M CESA. Above 100 M CESA, either F4 (bound) or F5 (bound) can be used (see **SECTION 5.7.1**) See Details of Bound and Stabilised Materials, see **CLAUSE 4500**.

For low volume roads (<1M CESA) where a concrete pavement is required, it would normally be constructed using a Jointed Unreinforced Concrete (JUC) pavement. A gravel sub-base may be used for cost reduction purposes, **ONLY** for a low volume road, but it should be noted that this would be unlikely to last as long as one constructed with a bound sub-base.

For each natural subgrade class, the material/thickness of additional layers that are required to achieve a Foundation Class F4 (bound) and F5 (bound) are shown in **TABLE 4.3** (from **RDM Volume 3 Part 3**). The stiffness requirements and minimum CBR strength for foundation classes F4 (bound) and F5 (bound) are shown in **TABLE 4.4** (from **RDM Volume 3 Part 3**).

The sub-base usually needs to be wider than the concrete base that is to be built on it. This width will depend upon the type (and make) of paver to be used. The manufacturer should be consulted. For slip form paving the sub-base will probably need to be approximately 1 m wider than the slab width (on each side) and for fixed-form paving the sub-base will probably need to be approximately 350 mm wider than the slab (on each side).

For concrete pavements, only F4 and F5 foundations should be used, and the capping must be HBS3 or higher quality BOUND material. To achieve this for S1 and S2 subgrades, they must first be improved to S3 (F1) or S4 (F2) subgrade class before final improvement to F4 and F5.

The layers under the concrete slab shall be constructed in accordance with the relevant standard specifications, and any additional relevant Contract Documentation as may be prescribed, up to the level of the underside of the concrete slab. The surface of the layer directly below the concrete should not be smooth, loose or show signs of lamination.

The Contractor shall note the provisions of **SECTION 4000** in regard to the use of construction tolerances for successive pavement layers and shall make provision in their prices for any additional concrete which may be necessary in respect of irregularities in the layer underlying the concrete pavement.

b. Applying the Prime or Bond Coat

For details on prime/bond coat materials see **SUBCLAUSE 5204 (a)**.

For JUC and JRC concrete pavements (unless otherwise specified in the Contract Documentation) a bituminous prime coat shall be applied to the completed cementitious stabilised or asphalt sub-base layer in accordance with the requirements of **SECTION 5000** (Bituminous surface treatments, seals and pavement layers). Where the underlying sub-base layer consists of asphalt, a bituminous bond coat shall be applied in accordance with the relevant requirements of **SECTION 5000**. The nominal application of 0.3 l/m² net bitumen shall be applicable in each instance. Before any pavement concrete is placed, the prime or bond coat shall be cured and shall be checked. Any areas having deficient or poor application, or where damaged, shall be repaired as directed by the Engineer. The coated surface shall then be thoroughly cleaned and shall be dry before any reinforcing steel, tie bars, dowels or concrete may be placed.

For RCC, CRCB and CRCP concrete pavements a slip membrane (prime or bond coat) is not required under the main pavement but may be required at each end (i.e. terminations).

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c. Wetting the Sub-base

Wetting the sub-base before adding the concrete layer is often required in order to reduce water loss from the wet concrete, which could have a negative effect on the curing process and lead to cracking and/or lower strength concrete.

The sub-base beneath a concrete pavement is usually a bound material to reduce erosion and provide uniform support to the concrete and may have an added prime/bond coat.

If the sub-base is cement-bound material without a prime/bond coat then it should be wetted. If the sub-base is cement bound material with a prime/bond coat or it is asphalt then it does not need to be wetted.

For low volume roads, where a granular sub-base is used, then wetting is required.

Water should comply with SUBCLAUSE 6102 (b). Wetting comprises keeping the sub-base continuously wet for a period of at least one hour before the concrete is placed. Immediately before the concrete is placed, the excess water shall be broomed off the sub-base ahead of the paver to ensure that the sub-base will still be damp when the concrete is placed. No puddles of water or deleterious matter shall be left on the sub-base.

d. Batching and Mixing of Concrete

1. General

Concrete may be batched at a dedicated mixing plant on site or supplied by a commercial ready mix facility. In either instance the concrete shall conform to the requirements as listed in SECTIONS 7200, 7300 and 7400. All constituent materials shall be stored and handled so that their properties do not change, for example due to climate conditions, intermingling or contamination, and that their conformity with the respective standard is maintained.

2. Cement and supplementary cementitious materials

For cementitious material details see SUBCLAUSES 6102(a). Cement and supplementary cementitious materials stored on the site shall be kept separately under cover which provides adequate protection against moisture and other factors which may promote deterioration of the cement or supplementary cementitious material.

Cement and supplementary cementitious material may only be used if stored and maintained at a temperature less than 45°C. In hot weather concreting conditions, the cement and supplementary cementitious material storage facilities shall be painted with white high solar reflectance paint and insulated to reduce any temperature rise in the stored cement or supplementary cementitious material.

Cement or supplementary cementitious material supplied in bags shall be closely and neatly stacked, separately to a height not exceeding 12 bags and arranged so that they will not be in contact with the ground, the floor or the walls, and can be used in the order in which they were delivered to the site.

Cement or supplementary cementitious material supplied in bulk shall be stored separately in waterproof containers so designed as to prevent any dead spots from forming, and the cement or supplementary cementitious material drawn for use shall be measured by mass.

Cement shall not be kept in storage for longer than 8 weeks without the Engineer's permission, and different brands or types of the same brand of cement or supplementary cementitious material shall be stored separately.

3. Aggregates

For details of aggregate materials see SUBCLAUSE 6102(c). Aggregates of different nominal sizes, sources or types shall be stored separately. Intermixing of different materials and contamination by foreign matter shall be avoided. Aggregates exposed to a chloride (XS) environment shall be covered to protect them from salt contamination. Sufficient quantity of

fine aggregate shall be stockpiled on site and handled in a manner that ensures the thorough mixing of the various deliveries in order to achieve a stable fineness modulus within the specified limits.

In hot weather concreting conditions, both the coarse- and fine-aggregate stockpiles shall be shaded from the sun. When the ambient temperature reaches and at all times when it exceeds 30°C, only the coarse aggregate shall be sprayed with water to assist cooling by evaporation. Water shall be delivered by means of an approved water droplet sprayer system. The Contractor shall ensure adequate drainage of the aggregate stockpile area.

Where concrete is batched on site, the aggregates shall be stored in bins with a minimum 150 mm thick concrete floor constructed below the aggregate stockpile to prevent contamination during the storage and handling the aggregate. The floor slab shall be appropriately sloped to facilitate drainage of the stockpile area. A 3.0 m wide concrete apron slab shall be constructed around the entrance and outer edge of the aggregate stockpile area and sloped for drainage away from the main stockpile area. The aggregates shall be tipped on the concrete apron slab to prevent contamination during the process of tipping and hoisting the aggregate.

4. Water

For details of water see [SUBCLAUSE 6102\(b\)](#). In hot weather concreting conditions, the sides and tops of water tanks for mixing water, including pipework leading to and from tanks, shall be insulated.

5. Storage capacity

The storage capacity provided and the quantity of material stored, whether cement, supplementary cementitious materials, aggregates, admixture or water, shall be sufficient to ensure that no interruptions to the progress of the work will be occasioned by any lack of materials.

6. Deteriorated material

Deteriorated or contaminated or otherwise damaged non-conforming material shall not be used in concrete. Such material shall be removed from the site without delay.

7. Proportioning the components

i. Cementitious binder

Where cementitious binder is supplied in standard bags, the bags shall be assumed to contain 50 kg for batching purposes. Cementitious binder taken from bulk storage containers and from partly used bags shall be batched by mass, accurate to within 2 % of the required mass.

ii. Water

The mixing water for each batch shall be measured, either by mass or by volume, accurate to within 2 % of the required quantity. The quantity of water added to the mix shall be adjusted to make allowance for any moisture in the aggregates.

iii. Aggregates

All aggregates for concrete shall be measured separately by mass, except as otherwise provided in this [CLAUSE](#), accurate to within 3 % of the required quantity.

iv. Admixture

For details on admixture materials see [SUBCLAUSE 6102\(d\)](#). All admixtures shall be dispensed in quantities accurate to within 2 % by mass of the desired quantity. The mechanical dosing unit shall be checked daily for accuracy using a nominal dispensing volume, typically 2 litres, or as recommended by the dosing unit manufacturer or admixture supplier. At least once a week, the dosing unit shall be checked for accuracy using the full dispensing volume suited to the concrete mixing procedures employed on site, typically for 6 cubic metre concrete batch mixed by a standard mixing truck and proportionally for other standard batch volumes.

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e. Mixing the Concrete**i. General**

Mixing the material for concrete shall be conducted by an experienced operator. Unless otherwise authorised, mixing shall be carried out in a mechanical mass batch-mixer of an approved type which will be capable of producing a uniform distribution of ingredients throughout the batch.

ii. Charging the mixer

The sequence of charging the ingredients shall be subject to approval by the Engineer, and, unless otherwise instructed, the same sequence of charging the ingredients shall be maintained. Fibres, pigments and colouring agents shall be added to the mix in a manner that ensures that they are uniformly dispersed in the mix.

The volume of the mixed material by batch shall not exceed the volume recommended by the manufacturer of the mixer.

iii. Mixing and discharging

The period of mixing shall be measured from the time when all the materials are in the drum until the commencement of discharge.

The mixing period for the materials shall be at least 90 seconds and may be reduced only if the Engineer is satisfied that the reduced mixing time will produce concrete with the same strength and uniformity as concrete mixed for minimum 90 seconds. The reduced mixing time, however, shall be not less than 50 seconds or the manufacturer's recommended mixing time, whichever is the longer. A suitable timing device shall be attached to the mixer to ensure that the minimum mixing time for the materials has been complied with.

The first batch to be run when starting with a clean mixer, shall contain only 75 % of the required quantity of coarse aggregate to make provision for coating the mixer drum.

Discharge shall be so carried out that no segregation of the materials will occur in the mix. The mixer shall be emptied completely before it is recharged with fresh materials.

iv. Maintaining and cleaning the mixer

If the mixer has stopped running for a period in excess of 30 minutes, it shall be thoroughly cleaned out with particular attention being given to the removal of any build-up of materials in the drum, in the loader, and around the blades or paddles.

Before any concrete is mixed, the inner surfaces of the mixer shall be cleaned and all hardened concrete shall be removed. Worn or bent blades and paddles shall be replaced.

f. Transporting the Concrete

Concrete shall be so transported to its final position that segregation or loss of any of the ingredients, or contamination, will be prevented, and that the mix is of the required workability at the point and time of placing.

The Contractor will be permitted to use appropriate truck mixers which agitate previously mixed concrete in transit.

The fresh concrete shall be protected against rain, heat, direct sunlight and/or evaporation by means of covers on all open vehicles. No additional water may be added in transit or where delivered.

The time lapse from the moment when the cement and aggregate are intermingled up to the time of placing and compacting the concrete shall not exceed 60 minutes when concrete is transported in truck agitators, and shall not exceed 45 minutes in mild weather, or 30 minutes when the concrete temperature is 30°C or higher, when transported in ordinary trucks.

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g. Placing, Compacting and Finishing Concrete

1. General requirements for both side-form and slip-form paving

i. Maintaining continuity during placing

The Contractor shall make adequate advance arrangements for preventing delay in delivering and placing the concrete. An interval of more than thirty minutes between the placing of any two consecutive batches or loads of concrete shall constitute sufficient reason for the Engineer to have the paving operations stopped, and the Contractor shall, then at their own expense, make a construction joint in the concrete already placed, at the location and of the type directed by the Engineer. Paving operations shall be continuous, and the rate of paving shall be adjusted to suit the rate of delivery of the concrete.

ii. Time for placing and compacting

The placing, compacting and finishing of the concrete shall be carried out as quickly as possible such that, in any transverse section of the pavement, the concrete shall be fully compacted and finished within 2 hours of having been mixed. This time shall be reduced by half an hour for every 5°C by which the concrete temperature is above 20°C at the time of placing, unless otherwise permitted by the Engineer.

Unless adequate lighting facilities, approved by the Engineer, are provided beforehand by the Contractor, the placing of concrete pavement shall cease in good time so that the finishing operation can still be completed during daylight hours.

iii. Compacting

The concrete shall be fully compacted by means of approved equipment and shall be free from honeycombing and planes of weakness. The average amount of air voids in concrete cores shall not exceed 1.5 % when measured by the visual assessment method described in BS EN 12350.

Over-vibration resulting in segregation, surface laitance, or leakage (or any combination of these) shall not be acceptable.

No paving in the downhill direction will be allowed if tearing of the concrete occurs. The Contractor shall take the necessary measures to the satisfaction of the Engineer to prevent tearing of the concrete, for example by carrying out the paving in the uphill direction.

iv. Width of placing

The width of concrete pavement strip to be placed in a single uninterrupted operation shall be as agreed with the Engineer so that longitudinal construction joints do not, as far as practical, fall within the wheel paths of the relevant lanes.

v. Placing of tie bars

Tie-bars shall be placed as indicated on the drawings and shall be placed at right angles to joints. Tie-bars shall be free from paint, grease or other matter which may affect bonding with the concrete.

At longitudinal construction joints, one half of each tie-bar shall be supported on the sub-base by means of suitable stools, while the other half shall project into the adjacent lane through the side forms. The arrangement, spacing and fixing of the tie bars and stools shall be such that they shall be supported in position without deflection or displacement when a dead load of 100 kg is applied or during placement and compaction of the concrete. Mild steel tie-bars at longitudinal joints may be bent parallel to the edge of the first lane constructed and later straightened into its final position before the concrete of the adjacent lane is placed. The method of fixing and supporting the tie-bars shall be approved by the Engineer. Where tie-bars are bent and later straightened, due to traffic accommodation constraints, any damage to the concrete shall be made good by the Contractor.

At longitudinal weakened-plane hinge joints the bars shall be firmly supported in position by steel supporting devices fixed to the sub-base. If the paver or other paving equipment is equipped with a device for placing tie-bars into the plastic concrete, then this device may be used only after it has been demonstrated that the tie-bars will be located in their correct positions after the slab has been compacted and finished.

vi. Placing of dowel bars

Dowel bars shall be installed at locations as indicated on the drawings. Dowels shall be fixed rigidly both in horizontal and vertical alignment parallel to the centre line of the road and the surface of the slab, by robust supporting frames or cradles which do not project within 150 mm of the joint and are left permanently in place. The frames shall be fixed to the subbase so that they will be stable and remain undisturbed during paving operations. The free end of the dowel shall not be tack-welded to the frame but shall be held in position by soft binding wire. Dowels may be mechanically inserted, in which case no frames will be required for securing the dowels, provided that conclusive evidence is submitted that the proposed method is an accepted method and has already been used successfully. Dowel alignment shall be accurate to within the tolerance given in SECTION 6103.

vii. Placing of continuous reinforcing steel in continuously reinforced concrete pavement

The continuous steel reinforcement shall be free from dirt, oil, paint, grease or other organic materials, which may adversely affect or reduce the bond with the concrete. Loose surface rust caused by lengthy storage shall be removed.

The arrangement, spacing and fixing of the chairs or stools shall be such that the reinforcement shall be supported in position without deflection or displacement when a dead load of 100 kg is applied or during placement and compaction of the concrete. The chairs shall be so supported as to prevent them overturning on the sub-base when the paving train passes over them.

viii. Placing of steel mesh in jointed concrete pavement

The welded steel mesh reinforcement detail shall be as indicated on the drawings. The steel shall be free from dirt, oil, paint, grease or other organic materials which may adversely affect or reduce the bond with the concrete. Loose surface rust caused by lengthy storage shall be removed. The steel mesh sheets shall be handled with care so that they remain reasonably flat and free from distortions. The sheets shall be free from kinks or bends that will prevent them from being properly assembled and installed. The arrangement and spacing and fixing of the chairs or stools shall be such that the reinforcement shall be supported in position without deflection or displacement during placement and compaction of the concrete. The reinforcement shall not straddle intended joints.

ix. Burlap drag finish

This texture shall be obtained by first applying a burlap-drag, as specified in SUBCLAUSE 6103(e), as a finish to the concrete surface. The first pass of the burlap drag shall be made as soon as construction operations permit and before the wet sheen has disappeared from the surface. Burlap dragging shall be repeated until a gritty and uniform texture having the required finish and depth of texture has been obtained.

Every morning the burlap drag shall be wetted and shall kept moist throughout the day. At the end of each day's production the burlap mats shall be cleaned or discarded and replaced with new burlap if cleaning is not possible.

x. Surface texturing

After completing the burlap finish described above, the pavement surface shall be further textured by means of a metal tined grooving comb/rake. The direction of the texturing shall usually be at right angles to the longitudinal axis of the pavement. If diagonal transverse

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joints are used in JUCP, then the transverse texturing shall be parallel to them. Surface texturing shall extend over the full width of the pavement.

The surface texture shall be applied and completed before the concrete is so hard that the surface will be torn and coarse aggregate unduly loosened during texturing. When measured with a suitable depth gauge, the grooves shall be not less than 2.0 mm and not more than 4.0 mm in depth.

After the concrete has hardened, all loose particles generated by the cutting of the grooves shall be broomed off the surface with stiff hand brooms or mechanically-operated rotary brooms.

The Engineer may permit the use of texturing equipment other than a metal tined grooving comb, provided that it produces a texture similar to that produced by the metal tines.

Texturing the surface with hand-held brooms or combs shall be allowed only where the pavement is so small or irregular, or the site is so restricted as to make the use of the texturing machine impracticable, or in cases of mechanical breakdown of the texturing machine, in which case it may be used for the required texturing of concrete already placed. The brush or comb to be used then shall be of the same type and width used in the machine. In order to ensure straight grooves the comb shall be operated against a straight-edge placed at right angles to the pavement centre line. The same requirements regarding groove dimensions or texture depth as for machine-texturing shall apply.

xi. Curing

Immediately after the completion of texturing, a preferably white-pigmented curing compound complying with the requirements of SECTION 6102 (g), and in accordance with the direction of the manufacturer, shall be applied.

In the case of slip-form paving, the exposed surfaces, including the sides of the slab, shall be treated immediately after carrying out the required texturing of the surface. In the case of side-form paving, the surface shall be treated immediately after the texturing has been completed and the sides of the panels after the side formwork has been removed.

The curing compound shall be sprayed onto the surface at a rate of 0.35 l/m² or as directed by the Engineer by means of a mechanical distributor capable of producing a fine fog-type of spray which will not damage the surface of the concrete. The curing compound shall be applied in two layers with the distributor moving in opposite directions for the two applications. Coverage shall be uniform over the entire surface and the rate of application of the curing compound shall be carefully controlled.

During spraying operations the curing compound shall be continuously stirred mechanically to keep the pigmentation in suspension. The spray nozzles shall be adequately protected against wind.

After shutting off the spray nozzles, no dripping of curing compound on the concrete surface may occur. If necessary, the Contractor shall provide drip pans suspended below the nozzles to prevent dripping of the curing compound onto the pavement.

The curing membrane shall be maintained intact for at least seven days after the concrete has been placed. Any damage to the curing membrane shall be repaired by hand-spraying the affected areas.

Areas inaccessible to the mechanical distributor such as odd-shaped areas, those with varying widths/shapes or the sides of the slabs after removal of the form work, shall be sprayed with curing compound by means of approved hand spraying equipment, at the specified rate of application.

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2. Fixed form (side form) paving

i. Side form set up

The side forms shall be accurately set to line and grade and in such a manner that they rest firmly, throughout their entire length, upon the sub-base surface. The forms shall be connected neatly and tightly, and braced in order to resist the pressure of the equipment operating on the forms. The Contractor shall obtain the Engineer's approval of the alignment and grade of all forms immediately prior to the placing of concrete.

Any voids between the established grade of the form line and the layer on which it is supported shall be caulked with a stiff mortar consisting of one part of rapid-hardening cement and 3 parts of sand by volume and finished vertically on the inside. The mortar shall have hardened sufficiently before any concrete is cast against it. The rails, side-forms and running surface shall be kept clean in front of the wheels of all paving equipment.

As an exception, when placing forms on a cement-treated or asphalt sub-base layer, the Contractor may use wedging, provided that the wedging system used adequately supports the forms without causing detrimental deflection under the weight of the paving equipment.

A sufficient number of forms shall be available on site at all times to ensure that at least 150 m of formwork can be accurately set and maintained true to line and grade in advance of the point where concrete is being placed. Sufficient forms shall also be provided so that it is not necessary to remove them less than 12 hours after placing the concrete. All forms shall be thoroughly cleaned and treated with an approved releasing agent prior to reuse.

ii. Placing and spreading the concrete

The concrete shall be spread uniformly by means of a purpose-made mechanical hopper spreader running on rails and capable of spreading the concrete uniformly to a specified level and to a uniform un-compacted density over the entire surface of the slab. The machines shall be capable of being rapidly adjusted for changes in slab thickness or cross-fall.

iii. Compaction

Compaction of most unreinforced and reinforced concrete pavements shall be carried out by the paver using vibration or by a combination of mechanical surface vibration, internal vibration and tamping. The paver shall compact the concrete over the full paved width. The power supply to the vibrators shall cut out automatically as soon as the compaction equipment stops moving. Suitable internal vibrators shall be used against the side-forms and at joint assemblies to ensure compaction throughout the pavement layer.

For Roller Compacted Concrete (which is unreinforced, but a very stiff mix) the concrete is compacted by the paver and then further compacted using vibratory rollers followed by a PTR (Pneumatic Tyred Roller) if required and, if necessary, finished with a static roller for an even finish. For RCC pavements, it has been found that rolling alone often does not introduce enough cracks, so additional crack control joints should be installed in the freshly laid concrete after the initial paver compaction but before rolling. Transverse joints (grooves) should be formed at 2.5 m centres ± 0.3 m in the fresh material – these should be straight vertical grooves not more than 20 mm wide, to a depth of between one quarter and one third of the layer thickness over the full width of the pavement.

iv. Final finishing

The surface of the concrete shall be finished smooth and true to grade and level by means of an initial finishing machine equipped with a transverse or oblique oscillating beam. The final finish of the surface of the slab shall be carried out by a machine which incorporates twin oblique oscillating finishing beams. The beams in the case of both machines shall be readily adjustable for both height and tilt, and the leading beam shall be vibrated. The beam shall be supported on a carriage with two wheels on either side, at least 3.5 m

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apart in the longitudinal direction. The oscillating beams shall be of rectangular section, spanning the full width of the slab and each weighing not less than 170 kg/m.

Hand-finishing of the concrete surface shall be reduced to the absolute minimum and shall be used only to correct minor imperfections and marks on the surface. Before the concrete starts setting, all pavement edges, and the edges of joints, shall be rounded off to the prescribed radius.

After finishing, the Contractor shall test the concrete surface with a straight-edge of at least 3.0 m in length. Irregularities indicated by the straight-edge shall be removed with a long-handled hand-operated scraping straight-edge of at least 3.0 m length. A gangplank shall be used when walking on the concrete.

Before the concrete starts setting, all pavement edges, and the edges of joints, shall be rounded off to the required radius.

v. Constructing the pavement in more than one contiguous strip

Where concrete is placed adjacent to an existing pavement, that part of the paving equipment running on the existing pavement shall have flanged wheels on flat-bottom section rails weighing not less than 15 kg/m or by replacing the flanged wheels on that side of the machines by smooth flangeless wheels. Before the paving operation commences the surface regularity of the existing pavement shall comply with SUBCLAUSE 6105 and be thoroughly cleaned and brushed to remove all extraneous materials. The wheels shall run at a distance of not less than 300 mm from the edge of the pavement to prevent the pavement edge from spalling or cracking.

Where visible cracks occur or any other damage is done to the pavement, further work involving the paver shall be suspended immediately. The Contractor shall repair all damage at their own cost.

vi. Removal of side forms

Side-forms shall not be removed before the concrete has hardened sufficiently to prevent damage being done to the sides and loosening of tie-bars or dowels, if any, and not earlier than 12 hours after the completion of the construction of the slab. The side forms shall also be removed in sufficient time to permit the sawing of transverse joints up to the edges of the concrete slab. The tie-bars and/or the concrete shall not be damaged during removal of the side-forms.

3. Slip-form paving

i. Placing and spreading

The paver shall include a spreader box or auger capable of distributing the delivered concrete evenly to the specified level and to a uniform un-compacted density over the entire surface of the slab. The machines shall be capable of being rapidly adjusted for changes in slab thickness or cross-fall requirements.

ii. Compaction

The slip-form paver shall compact the concrete over the full paved width by means of internal vibration only, or by a combination of internal and surface vibration. The vibration shall be variable with a maximum energy output of at least 2.5 kN per metre width of slab per 300 mm depth for a laying speed of up to 1.5 m per minute or pro rata for higher speeds.

For Roller Compacted Concrete (which is unreinforced, but a very stiff mix) the concrete is compacted by the paver and then further compacted using vibratory rollers followed by a PTR (Pneumatic Tyred Roller) if required and, if necessary, finished with a static roller for an even finish. For RCC pavements, it has been found that rolling alone often does not introduce enough cracks, so additional crack control joints should be installed in the

freshly laid concrete after the initial paver compaction but before rolling. Transverse joints (grooves) should be formed at 2.5 m centres ± 0.3 m in the fresh material – these should be straight vertical grooves not more than 20 mm wide, to a depth of between one quarter and one third of the layer thickness over the full width of the pavement.

iii. Finishing

The level and grades of the surface shall be automatically controlled within the prescribed tolerances by means of a sensing device running on guide wires or a suitable 3D stringless system as approved. The consistency of the concrete shall be so controlled that the edge slump will not exceed the tolerance specified in SECTION 6103. If approved by the Engineer, metal side-forms of sufficient thickness and stability may be used to maintain the proper shape and line.

After the concrete layer has been completed by the finishing devices incorporated in the slip-form paving equipment, the surface of the concrete shall be checked by means of a straight-edge of not less than 3.0 m in length. High spots indicated by the straight-edge shall be removed by hand floats.

After the final finishing and texturing of the concrete, but before curing, the pavement edges shall be rounded manually to the prescribed radius.

iv. Constructing the concrete pavement in more than one contiguous strip

Except for the wheels, which shall, in the case of slip-form pavers, be replaced with rubber cushioned crawler tracks, the provisions of SECTION 6103 shall apply when concrete is being placed in more than one contiguous strip.

v. Track support

The Contractor shall ensure at their cost ensure that adequate track support is provided to suit the needs of the slip-form paver, either by extending the upper pavement layers or by providing alternative support layers.

4. Placing, compacting and finishing with hand equipment

Where the slabs are too small or irregular, or the site is so restricted as to render the use of the methods described herein impracticable, concrete shall be placed, compacted and finished using manual labour.

5. Joint forming

i. Construction joints

Construction joints shall be made only in accordance with the details and in the positions shown on the drawings or determined by the Engineer. Where the pavement is constructed in more than one strip, longitudinal construction joints shall be constructed, and where edge slump in excess of 6.0 mm occurs with slip-form paving, the sides of the pavement shall be supported by an approved method.

Transverse construction joints shall be formed at the end of a day's work or where necessary on account of any unavoidable suspension of work.

The upper edges of the pavement shall be rounded off or chamfered at a construction joint as shown on the drawings. Where sealing of the construction joint is required, the groove may be sawn only after seven days' curing of the concrete.

ii. Longitudinal hinge joints

Longitudinal hinge joints shall be provided where the pavement is constructed in widths of two or more lanes at a time.

Longitudinal joints may be achieved by either saw cutting or the use of crack inducers.

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If saw-cutting, then all longitudinal joints shall initially be sawn to the depth indicated in the design drawings, and not more than 3.0 mm wide. In sealed joints the top portion of the groove shall be reamed out to the specified final width and depth shown in the design drawings not sooner than 7 days after the initial sawing.

Sawing shall be done at an appropriate time, dependant on the cement type used and ambient temperatures to prevent longitudinal cracking from occurring, but not later than 24 hours after concrete placing.

The widths and depths of the groove and the joint filler shall be in accordance with the drawings. The width tolerances for hinge joints shall be as prescribed out in [CLAUSE 6105](#).

Deformed steel tie bars shall be installed where indicated on the drawings.

iii. Transverse contraction joints

Transverse joints may be achieved by either saw cutting or the use of crack inducers.

If saw-cutting then all transverse joints shall initially be sawn to the depth indicated in the design drawings, and not more than 3.0 mm wide. In sealed joints the top portion of the groove shall be reamed out to the specified final width and depth shown in the design drawings not sooner than 7 days after the initial sawing.

The exact time and sequence of sawing shall be determined by the Contractor, bearing in mind the risk of excessive ravelling and spalling with early sawing, and the risk of cracking with delayed sawing, but shall be sawn not later than 24 hours after the concrete has been placed.

When the pavement is constructed in more than one strip, the transverse joints opposite those which have opened in the adjacent pavement shall be sawn within the first 24 hours. The Contractor may initially omit up to two consecutive planned contraction joints and shall saw such joints within 48 hours of the concrete having been placed, but before uncontrolled cracking takes place.

Joints shall be sealed in accordance with the details shown on the drawings or as specified in the Contract Documentation.

iv. Expansion joints

Expansion joints shall be constructed in accordance with the details shown on the drawings. The joint filler shall comply with the requirements of [SUBCLAUSE 6102 \(h\)](#) and holes for the dowels shall be accurately drilled. The filler for each joint shall be supplied in a single piece for the full depth and width required for the joint unless otherwise authorised by the Engineer. Where the use of more than one piece is authorised for a joint, the abutting ends shall be securely fastened, and held accurately in shape, by stapling or by another suitable method acceptable to the Engineer.

The joint filler together with the sealing groove shall completely separate adjacent slabs. Any loose-fitting dowel bars and any spaces between the sub-base and the filler shall be caulked with joint-filler material after the joint has been assembled.

If expansion joints incorporate dowels, the dowels shall be encased at one end in a close-fitting cap. The cap shall be placed on the free half of each dowel which half shall be coated as late as possible before concreting, with a bond-breaking coating or sleeve which complies with the requirements of [SUBCLAUSE 6102 \(f\)](#).

The sealing groove in the upper portion of the expansion joints shall be sealed with a preformed neoprene compression seal or any other appropriate sealant prescribed or approved. See [SUBCLAUSES 6102 \(h\) and 6104 \(g\)\(6\)](#).

v. Sawing of contraction joints

The Contractor shall be responsible for determining the optimum time for the sawing of contraction joints (if required). This shall depend on the strength gain characteristics of the cementitious products incorporated in the concrete mix, the hardness of the aggregate and weather conditions at the time of placing. The Contractor shall use the type of blade and equipment best suited to the hardness of the concrete, type of aggregate and the site conditions in order to prevent uncontrolled cracking and any spalling adjacent to the joint being sawn.

Sufficient standby power saws shall be held available by the Contractor, ready for use, at all times when concrete is being placed in the pavement. Immediately after sawing, the joint grooves shall be washed out with a jet of clean water to remove all fine material which shall be appropriately disposed of at an approved site. The joints shall then be sealed temporarily by means of an approved material, flush with the permanent surface.

No traffic of any kind shall be allowed on the pavement until all the joints have been permanently sealed.

6. Joint sealing

Joints shall be permanently sealed before the pavement is opened to any traffic.

i. Sealant Materials

The joint sealant and appurtenant materials shall be as specified in SUBCLAUSE 6102(h). The dimensions and positions of the sealant and appurtenant materials shall be as shown on the drawings, or as approved by the Engineer.

ii. Sealant Installation

Just prior to sealing, the joint grooves shall be reamed to their prescribed final dimensions and shall then be cleaned by means of a high-pressure jet of water over the full depth of the joints to remove all fine matter and to produce dust-free joint grooves. Immediately before the supporting material is supplied, the grooves shall be dried by means of oil-free compressed air at a pressure of 700 kPa. Compressors shall be equipped with an apparatus which removes water and oil from the compressed air. Where a primer is required, it shall be applied before the supporting materials are installed.

After the joints have been finally cleaned and the primer (if any) has been applied, a supporting backing cord shall be installed by means of an approved rolling tool in the prescribed positions. Where the joints are dirty, wet or moist, the supporting material shall be removed, the joints cleaned and dried, and fresh material applied.

The procedure(s) to be followed by the Contractor to prevent the sealant from being spilt onto the concrete pavement shall be subject to approval by the Engineer. The silicone sealant shall be pumped continuously directly into the joints with a suitable pneumatically driven pump. Sealing shall be done from the upper surface of the supporting material. Immediately after installation and before a skin appears, the surface of the sealant shall be worked to compact the sealant and to press it against the sides of the joint and to ensure that the prescribed clearance under the road surface is obtained. As an alternative to separate installation and finishing of the sealant, an approved injection nozzle incorporating a finishing apparatus may be used, in which case only closed-cell polyethylene may be used as supporting material. Further directions supplied by the manufacturer shall be strictly complied with, particularly with regard to temperatures for application, opening to traffic, and safety aspects. No traffic shall be permitted to pass over a sealed joint before the sealant is able to withstand the penetration of foreign matter.

The top surface of the sealant shall be not less than 5.0 mm and not more than 7.0 mm below the paved surface. All surplus sealant and other foreign matter shall be removed from the concrete pavement surface in accordance with the directions of the manufacturer of the sealant.

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iii. Liquid sealant for joints between concrete and asphalt pavements

These joints shall be sealed with a hot-poured joint-sealing compound as specified in **CLAUSE 6105**. Prior to application, the joints shall be clean and free from water. Curing compound adhering to joint walls shall be removed by sandblasting or with an abrasive wheel. Dirt, dust and laitance shall be blown out of the joint with oil-free compressed air at a pressure of at least 700 kPa immediately before the sealing operation. The sealant shall be applied in accordance with the manufacturer's instructions, particularly in regard to the temperature of application, which shall be strictly controlled.

h. Opening to Traffic

This will depend on the type of concrete, concrete strength, slab shape (long, narrow slabs at an edge or junction may be more susceptible to damage), etc. A roller compacted concrete pavement can be walked on almost immediately (compared to 24-48 hrs for conventional concrete) and hence a RCC pavement can be trafficked earlier than a conventional concrete pavement.

No vehicle shall be permitted to travel over the completed surface within 7 days after it has been completed. The Engineer may, at their discretion, allow light vehicles to use the road before the end of the curing period if this is necessary as part of the works.

The pavement can be opened to traffic after 14 days, or sooner as directed by the Engineer.

6105 Workmanship

a. Process control

The Contractor shall conduct a sufficient number of tests necessary for ensuring compliance with the requirements, as specified in this section, during all phases of the work. Accelerated 20-hour compressive-strength tests as described in **SECTION 1700** (Testing of Materials and Workmanship) shall be conducted regularly with a view to predicting the 28-day compressive strength of the concrete in consultation with the Engineer. Where the accelerated tests indicate that the required 28-day compressive strengths will not be attained, the Contractor shall immediately effect the necessary changes to the materials and/or mix proportions in order to ensure that further work will comply with the requirements.

b. Acceptance Control

Routine inspection and testing will be carried out by the Engineer to determine whether the quality of materials and workmanship complies with the requirements of this section. The lot sizes and sampling for compressive strength shall be done in accordance with **SECTION 1800**.

In addition to the above, the following shall also apply:

- i. The relationship between the 28-day compressive and the 28-day flexural strengths of the concrete established by the preliminary tests shall be monitored during paving operations by regular tests at the discretion of the Engineer.
- ii. For this purpose, sets of three beams and three cubes shall be manufactured from the same batch of concrete and tested for flexural and compressive strength respectively. If the test results indicate a relationship which deviates from that established by the preliminary tests, the specified compressive strength, as specified in **SECTION 1800** shall be adjusted accordingly.
- iii. Where air entrainment has been included in the specification, and any test for air content shows a value falling outside the specified limits, the quantity of air-entraining agent added to the concrete mix shall be adjusted, until the air content of the concrete is within the specified limits.

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c. Construction Tolerances

The work in this section shall be constructed to the tolerances given below:

i. Level and grade

The pavement level and grade lot shall comply with the requirements specified if at least 90 % of all levels are within the H90 tolerance of 15 mm before any level correction is made. Individual spots where levels deviate by more than the H max tolerance of 20 mm shall be repaired as agreed to by the Engineer to bring the levels within the H90 tolerance.

The levels shall be taken in a random pattern or as directed by the Engineer, before and after the concrete layer has been constructed, at exactly the same positions. The number of measurements representing the lot shall be a minimum of 30 or more.

ii. Layer thickness

Layer thickness shall be established from the difference in actual levels as measured before and after the concrete layer has been constructed as described above. In addition to the thickness from levels, the Engineer can request cores from the lot where the average of 4 measurements per core will be reported for thickness at the position of the core.

The layer shall comply with the requirements specified if at least 90 % of the thicknesses measured for the lot:

- Are equal to or thicker than the specified thickness minus the D_{90} tolerance of 14 mm
- The mean layer thickness for the lot is not less than the specified thickness minus the deviation tolerance of 1.0 mm and
- Individual spots where the thickness is less than the specified thickness minus the D_{max} tolerance of 18 mm be repaired as agreed to by the Engineer to bring them within the D_{90} tolerance.

iii. Grade

Deviations from the specified longitudinal grade on account of deviations from the specified levels shall not exceed those relevant requirements given in SECTION 1800.

iv. Width of pavement

The average width shall be at least equal to the specified width and the edge of the pavement shall not deviate by more than 25 mm from the specified positions.

v. Joints

Joints shall not deviate by more than 10 mm from their specified positions in the pavement or by more than 10 mm from the edge of a 3.0 m straight-edge placed so as to touch the line of the joint. Neither shall the line of a joint be discontinuous. The tolerance for the groove width of sawn joints shall be as follows:

- Longitudinal hinge joints ± 0.5 mm
- Transverse contraction joints ± 0.5 mm

vi. Cross-section

When tested with a 3.0 m straight-edge placed at right angles to the road centre line, the surface shall not deviate from the bottom of the straight-edge by more than 6.0 mm.

vii. Surface regularity

Surface regularity or roughness can be measured using one or a combination of instruments, as specified in the Contract Documentation viz:

- Inertial High speed profilometers (IRI)
- Direct Contact Devices (IRI)
- Rolling straight edge

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1. Inertial Profiler

The operations and calculations in Average 100 m IRI values for three runs. The assessment of the data for compliance shall be in accordance with SECTION 1800.

2. Direct Contact Device

The operations and calculations in Average 100 m IRI values for three runs. The assessment of the data for compliance shall be in accordance with SECTION 1800.

3. Rolling Straight Edge

The number of irregularities in excess of a setting of 3.0 mm shall not exceed 8 over 100 m sections and not exceed an average number of 5 per 100 m taken over 300 – 600 m sections. Any individual irregularity when measured with the rolling straight edge or a 3.0 m straight edge when laid parallel to the road centre line shall not exceed 7.0 mm.

viii. Dowels

Dowels shall be positioned at the depth specified, measured from the surface level of the slab, within a tolerance of ± 10 mm. They shall be aligned parallel to: (a) the finished surface of the slab, (b) the centreline of the carriageway and (c) to each other within the following tolerances:

1. Dowels supported on cradles, prior to construction of the slab:

All dowels in a joint shall be within ± 2.0 mm per 300 mm length of bar. No individual dowel shall differ in alignment from an adjoining bar by more than 3.0 mm per 300 mm length of bar in either the horizontal or vertical planes.

2. Dowels supported on cradles or mechanically installed, after construction of the slab.

Dowels in a joint shall be within ± 2.0 mm per 300 mm length of bar. No individual dowel shall differ in alignment from an adjoining bar by more than 6.0 mm per 300 mm length of bar in either the horizontal or vertical planes.

3. All dowels shall be equally positioned about the intended line of the joint within a tolerance of ± 25 mm.

4. Random checks of the dowels positioning shall be ordered by the Engineer by taking cores at the position of the bar ends. The coring shall be measured and paid for separately.

6106 Measurement And Payment

The tendered rate for each Item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision necessary to carry out the activity or construct the works under the relevant pay Item, unless otherwise stated.

No extra over payment shall apply to work carried out in restricted areas for work carried out in conformance to this section. The rates tendered for the payment Items shall include full compensation for any work in restricted areas.

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay Items as he deems appropriate: setting out the works, protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities, any specified work in confined or restricted areas, loading of any materials, hauling of any materials where the material is moved over a distance of less than, 1.0 km, transporting materials from commercial sources irrespective of the haul distance, removal or any surplus material imported to complete the works.

Item	Unit
61.01	Construction Of Jointed Unreinforced Concrete Pavement (JUCP) (Excluding Texturing And Curing):
(a)	JUCP Without Dowels: Hand Laid Construction (State Nominal Thickness) Square Metre (m ²)
(b)	JUCP With Dowels: Hand Laid Construction (State Nominal Thickness) Square Metre (m ²)
(c)	JUCP Without Dowels: Paver Laid Construction (State Nominal Thickness) Square Metre (m ²)
(d)	JUCP With Dowels: Paver Laid Construction (State Nominal Thickness) Square Metre (m ²)
(e)	Additional Concrete Placed To Thicken Up The Slab At Joints As Specified In The Contract Documentation Cubic Metre (m ³)

Item	Unit
61.02	Construction Of Jointed Unreinforced Concrete Pavement (JRCP) (Excluding Texturing And Curing):
(a)	JRCP With Dowels: Paver Laid Construction (State Nominal Thickness) Square Metre (m ²)

Item	Unit
61.03	Construction Of Roller Compacted Concrete Pavement (RCCP) (Excluding Texturing And Curing):
(a)	RCCP Without Dowels: Paver Laid Construction (State Nominal Thickness) Square Metre (m ²)

Item	Unit
61.04	Construction Of Continuously Reinforced Concrete Base (Excluding Texturing And Curing):
(a)	Continuously reinforced Concrete Base (CRCB): Paver Laid Construction (State Nominal Thickness) Square Metre (m ²)

Item	Unit
61.05	Construction Of Continuously Reinforced Concrete Pavement (Excluding Texturing And Curing):
(a)	Continuously reinforced Concrete Pavement (CRCP): Paver Laid Construction (State Nominal Thickness) Square Metre (m ²)

The unit of measurement for payment ITEMS 61.02 to 61.06 shall be the square metre of concrete pavement placed and finished in accordance with the works requirements. The quantity shall be calculated from the authorised dimensions of the completed surface, except when the Engineer requires or the drawings show local deviations from the specified thickness, such as at bridge approach slabs. The volume of concrete in such cases shall be converted into an equivalent area in square metres based on the specified thickness of the slab.

The tendered rate shall include full compensation for procuring and furnishing all the materials, storing the materials, providing all plant, determining the mix proportions, mixing, transporting, placing and finishing the concrete, including formwork, repairs done to defective work, protecting the pavement against damage, construction joints and process control.

The tendered rate shall also include full compensation for the provision of any additional width required by the Contractor to the earthworks and/or pavement layers to suit the particular requirements of the paving equipment. It shall also include full compensation for the removal of the additional widening which extends beyond the limits of the specified cross-section.

The quantity of additional concrete over and above the specified layer thickness and required at thickened joints shall be the cubic metre of concrete determined from the dimensions as detailed in the Contract Documentation.

The tendered rates shall also include full compensation for constructing concrete pavements which cannot be constructed with conventional plant, as envisaged in this section.

Item	Unit
61.06 Texturing And Curing The Concrete Pavement:	
(a) Burlap-Dragged and Tine Grooved Texture	Square Metre (m ²)
(b) Burlap-Dragged and Broom Finish Only	Square Metre (m ²)

The unit of measurement for texturing and curing shall be the square metre of completed pavement which has received the specified surface texturing, and which was cured as specified. The quantity shall be calculated from the specified horizontal dimensions of the completed concrete surface in the case of texturing and from the specified horizontal dimensions of the completed concrete surface, plus the surface area of the slab sides, in the case of curing.

The tendered rate for texturing shall include full compensation for providing the plant and equipment required and for applying the specified surface texture.

The tendered rate for curing shall include full compensation for providing the curing compound and its application as specified at the specified nominal rates of application by means of an approved pressure distributor. The tendered rate shall also include compensation for spraying the curing compound in unsealed joints after the sawing has been completed.

Item	Unit
61.07 Variation in the rate of Application of the Curing Compound:	Litre (l)

The unit of measurement in respect of increases or decreases in the rate of application of the curing compound from the nominal application as specified, shall be the litre.

Item	Unit
61.08 Joints:	
(a) Expansion Joints Complete (Excluding Dowels)	Metre (m)
(b) Longitudinal Hinge Joints:	
i Sealed Hinge Joints (Indicate Type And Reference To Drawings)	Metre (m)
ii Un-Sealed Hinge Joints (Indicate Type And Reference To Drawings)	Metre (m)
(c) Sealed Transverse Contraction Joints Sawn In Two Separate Operations (Widths As Shown On The Drawings)	Metre (m)
(d) Dowel Bars: Mild Steel Inserted In New Concrete (Indicate Diameter, Length and Position On Drawings):	
i Inserted By Mechanical Dowel Bar Inserter	Number (No.)
ii Pre-Installed On Approved Frame	Number (No.)
(e) Tie-Bars: Installed In New Concrete (Indicate, Diameter And Length):	
i Mild Steel	Number (No.)
ii High Tensile Steel	Number (No.)
(f) Forming And Sealing Joints Between Asphalt And Concrete Pavements	Metre (m)

The unit of measurement for joints in the pavement shall be the metre of completed joint, except that dowel bars and tie-bars across joints shall be measured separately by the numbers of each type installed.

Construction joints as such shall not be measured for payment and their cost shall be deemed to be included in the rate tendered for the concrete pavement. However, if the position of a longitudinal construction joint coincides with that of a hinge joint, the Contractor will be paid at the rate tendered for the type of hinge joint replaced by the construction joint, provided that the requisite number and sizes of tie bars for the hinge joints are installed. Where the hinge joint replaced by the construction joint is a sealed hinged joint, the construction joint shall be sawn and sealed, in which case the Contractor will be paid at the tendered rate for sawn and sealed hinge joints.

The tendered rates for expansion joints shall include full compensation for forming the joint, complete with joint filler, rounding or chamfering the corners (if required) and installing the seal.

The tendered rates for longitudinal hinge joints shall include full compensation for sawing the joint (if required) and supplying and inserting the seal (if required).

The tendered rate for transverse contraction joints shall include full compensation for sawing the joint and installing the specified type of seal, including appurtenant materials, and for temporarily sealing the joint with paper rope.

The tendered rates for dowel bars and tie-bars shall include full compensation for supplying, cutting, placing, holding the bars in position, including a supporting framework or cradles where required, and fixing the end caps and bond breaking materials to dowels.

The tendered rate for forming and sealing the joints between asphalt and concrete pavements shall include full compensation for supplying all the necessary plant and materials, for forming a joint to the required dimensions in the asphalt seal, cleaning the joint and sealing.

Item	Unit
61.09 Steel Reinforcement in Concrete Pavements:	
(a) Mild Steel Bars	Tonne (t)
(b) High Tensile Steel Bars	Tonne (t)
(c) Welded Steel Fabric	Kilogram (kg)

The unit of measurement for steel bars shall be the tonne of reinforcing steel in place in accordance with the drawings or as authorised.

The unit of measurement for welded steel fabric shall be the kilogram of welded steel fabric in the panels of concrete paving which require non- contiguous reinforcement as specified. The quantity shall be calculated from the area of the mesh used in accordance with the drawings or as authorised.

The tendered rates shall include full compensation for supplying, delivering, cutting, bending, welding, placing and fixing the steel reinforcement, including all tying wires, spacers and waste.

The tendered rates shall include full compensation for drilling the cores and, where applicable, having them tested by an approved laboratory, and for all labour, transport, testing charges and other incidentals, save only the cost of providing a core-drilling machine on the site, which shall be paid for separately. It shall also include compensation for restoring the concrete pavement where holes were drilled.

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SECTION 6200 Segmental Block Paving Layers

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6201 Scope

This section covers the furnishing of materials and the construction of segmental block paving for roads.

6202 Definitions

Segmental block paving – a system of individual shaped blocks arranged to form a continuous hard-wearing and durable surface.

6203 Materials

a. Concrete Beams, Kerbs And Channelling

Cast in situ concrete edge beams or intermediate beams shall be constructed in accordance with the provisions SECTION 2000, as relevant. Prefabricated kerbing and channelling shall comply with the requirements of SECTION 2000, or as specified in the Particular Specification.

Backing concrete (also known as haunching) is used to support kerbs or edgings. It involves installing concrete behind the kerbs or edgings to provide stability and prevent movement.

The backing should extend up to around two-thirds of the height of the kerb or edging.

b. Bedding Sand

Bedding sand shall not contain any silt, clay or other deleterious impurities. The sand shall comply with the following grading requirements in TABLE 6203/1.

TABLE 6203/1: GRADING REQUIREMENTS FOR BEDDING SAND

Sieve Size (mm)	Percentage Passing by Mass
7.1	100
5.0	95-100
2.0	80-100
1.0	50-85
0.600	25-60
0.300	10-30
0.150	5-15
0.075	0-10

c. Precast Concrete Paving Blocks

Precast concrete paving blocks shall comply with the requirements of BS EN 1338. The blocks shall be of the class, type and thickness specified in the Particular Specification. The surface texture and colour of all blocks shall be uniform.

d. Recycled Plastic Blocks

Plastic paving blocks shall comply with the requirements of KS 2913 or equivalent.

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e. Natural Stone

Hand-cut natural stones or 'Cobblestones' are square or rectangular shaped, hand-cut natural stone blocks that are uniform in shape and generally 100-150 mm in size. They should comply with KS 965 and KS 2249. For further information see BS 7533 or equivalent.

f. Jointing Sand

100 % of the sand used to fill the joints between the concrete blocks shall pass through a 1.0 mm sieve and between 10 % and 15 % of it shall pass through a 0.075 mm sieve.

g. Herbicide and Pesticide

Any herbicide and pesticide used shall be environmentally friendly and shall be subject to the Engineer's approval.

6204 Construction Equipment

A suitable vibrating-plate compactor shall be supplied operating at a frequency of 65 Hz to 100 Hz and a low amplitude. Its plate surface shall be 0.2 m² to 0.4 m² and it shall develop a centrifugal force of 7 kN to 16 kN.

6205 Execution Of The Works**a. Preparing The Underlying Layers**

The underlying pavement layer/s shall be as specified in the Contract Documentation. They shall be constructed and prepared in accordance with the requirements for the relevant pavement layers in **SERIES 3000** and **5000** of these specifications, or as may be specifically otherwise prescribed in the Particular Specification. Where specified by the Engineer, the prepared surface shall be treated with approved herbicide and pesticide before the layer of sand for bedding is placed.

For Low volume roads (< 1M CESA), a waterproofing layer in the form of a sprayed cutback bitumen seal (e.g. MC30) should be applied to the foundation before the bedding sand layer is added. For medium to high volume roads (1-10 M CESA), this waterproofing layer may be omitted as a cement bound or asphalt base is required under the sand layer which should act as a waterproofing layer.

b. Concrete Edge And Intermediate Beams

Cast in-situ or prefabricated concrete edge beams or intermediate beams shall be constructed on the underlying pavement layer in accordance with the details shown on the drawings. No paving blocks shall be laid before the edge and intermediate beams have developed sufficient strength to withstand the construction forces.

Refer to **SUBCLAUSE 6203 (a)**.

It is important to get the kerb levels (or gaps in the kerb) correct such that water can run off the pavement surface without ponding.

c. Bedding Sand

A layer of bedding sand complying with the requirements of **SECTION 6203** shall be placed on top of the prepared surface of the underlying pavement layer. It shall be accurately levelled to an un-compacted thickness of 25 mm (± 5.0 mm), or as specified, so that the concrete paving blocks will have the correct level after compaction. The bedding sand shall be placed immediately before the concrete paving blocks are laid and shall be allowed to dry out to permit upward creep during compaction. The sand shall not be compacted before the blocks have been laid.

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d. Laying of the Blocks

The blocks shall be laid in the pattern shown on the drawings or as directed by the Engineer. Unbroken blocks shall be laid first and the filler pieces afterwards. Filler pieces shall be neatly sawn or hewn to fit exactly into the space to be filled. Any space of which the size is less than 25 % of the size of an unbroken block, shall be filled with 35 MPa concrete. The size of the joints between blocks shall be between 2.0 mm and 4.0 mm, and the top faces of the blocks shall be flush.

It is important to get the level of the blocks in relation to the kerbs (or gaps in the kerb) correct such that water can quickly run off the pavement surfacing without ponding.

After the paving blocks have been laid, the pavement shall be compacted by two passes of a suitable vibrating-plate compactor operating at a frequency of 65 Hz to 100 Hz and a low amplitude.

After compaction of the pavement as described above, jointing sand shall be spread and brushed into the joints until the joints have been properly filled. Any surplus sand shall then be broomed off and the pavement shall then be subjected to two further passes by the plate vibrator. Jointing sand shall not be hosed into the joints. The block paving shall be inspected after 2 months, and the joints shall be re-sanded where required.

6206 Tolerances

The completed concrete block paving shall comply with the following construction tolerances:

a. Line of pattern

- i. Maximum deviation from a 3.0 m straight edge: 3.0 mm
- ii. Maximum deviation from a 20 m straight line: 10 mm

b. Vertical deviation from a 3.0 m straight edge

- i. At the edge beams: 3.0 mm
- ii. Elsewhere: 3.0 mm

c. Differences in the surface levels

- i. Between adjacent units: 2.0 mm

6207 Measurement and Payment

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay Items as they deem appropriate:

- i. No separate payment will be made for setting out the works.
- ii. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
- iii. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay Items.
- iv. No separate payment will be made for the loading of any materials.
- v. No separate payment will be made for the hauling of any materials.
- vi. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.

vii. No separate payment will be made for the removal or any surplus material imported to complete the works.

viii. The tendered rate for each Item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision necessary to carry out the activity or construct the works under the relevant pay Item, unless otherwise stated.

No extra over payment shall apply to work carried out in restricted areas for work carried out in conformance to this section. The rates tendered for the payment Items in this section shall include full compensation for any work in restricted areas.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum Item.

Item	Unit
62.01 Concrete Kerbing (Class of Concrete Indicated for Cast in Situ Concrete):	
(a) Description of Type with Reference of Drawing	Metre (m)
(b) Etc. for Other Types	Metre (m)

The unit of measurement shall be the metre of concrete kerbing, or a combination kerbing and channelling, complete as constructed, measured along the front face of the kerb.

The bid for each metre of concrete kerbing and/or kerbing channelling combination shall include full compensation for the necessary excavation and preparation of bedding, backfilling, formwork, finishing and for procuring, furnishing and installing all materials, kerbing and channelling and protecting it against staining, supporting the kerbs with cast in-situ concrete and filling and painting all joints, all complete as specified.

Item	Unit
62.02 Cast In Situ Concrete Edge and Intermediate Beams	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of concrete placed in edge and intermediate beams. The quantity shall be calculated from the dimensions shown on the drawings or as authorised by the Engineer.

The tendered rate shall include full compensation for furnishing all materials, and constructing the edge and intermediate beams complete as specified, including all excavation and backfilling in all classes of material.

Item	Unit
62.03 Segmental Block Paving:	
(a) Concrete Block Paving (Indicate Class, Type And Thickness Of Blocks)	Square Metre (m ²)
(b) Etc. for Other Types	Square Metre (m ²)

The unit of measurement shall be the square metre of completed concrete block paving. The quantity shall be calculated from the dimensions shown on the drawings or authorised by the Engineer. The tendered rate shall include full compensation for furnishing all materials, constructing the sand bedding, laying and compacting the concrete pavement blocks, filling the joints with jointing sand and for all other work necessary to complete the concrete block paving as specified.

The tendered rate shall include full compensation for furnishing all materials, constructing the sand bedding, laying and compacting the concrete pavement blocks, filling the joints with jointing sand, and for all other work.

Item		Unit
62.04	Contractor's Charges And Profit Added To The Prime Cost Sum For Provision And Application Of Approved Herbicide And Pesticides:	Prime Cost Sum Percent (%)

Payment under the prime cost sum for providing pesticides and herbicide and the Contractor's costs and profit in this respect shall be made in accordance with the provisions of the general conditions of contract, but, in addition, the Contractor's tendered rate for costs and profit shall include full compensation for applying the chemicals as specified.

Item		Unit
62.05	Re Sanding Of Joints In Segmental Block Paving:	
(a)	Concrete Block Paving (Indicate Class, Type And Thickness Of Blocks)	Square Metre (m ²)

The unit of measurement shall be the square metre of completed concrete block paving where re-sanding (filling) of the jointing sand is required after initial completion of the work. The quantity shall be calculated from the dimensions shown on the drawings or authorised by the Engineer. The tendered rate shall include full compensation for furnishing all materials to refill the joints with jointing sand where required.

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SERIES 7000 Structures

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7101 Scope

This section covers all foundation work which, for the purposes of these Specifications, shall comprise those elements of construction below the level of the bottom surface of the footings, the pile-capping slabs or the caisson cover slabs, collectively hereinafter referred to as base or bases, which shall include all the associated temporary works. Foundations for prefabricated culverts are not included but are specified in SECTION 2200.

7102 Materials

a. General

Material used in the permanent foundation work shall comply with the requirements specified in this specification.

b. Rock (for rock fill)

Boulders, cobbles or gravel shall be unweathered, angular, natural or quarried material of such quality that they will not disintegrate on exposure to water or weathering processes. There shall be no inclusions of clay, silt, sand or organic material within or adhering to the materials used.

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Suitable rock sources shall consist of materials as classified in BS EN ISO 14689 with properties defined for particular uses as detailed in the Special Specifications. Where the Specifications are silent, the selected material shall be approved by the Engineer following testing.

The mass and/or grading requirements for rock fill shall be as provided in the Special Specifications or on the Drawings or as given elsewhere in these Standard Specifications.

c. Crushed Rock

Crushed rock used for the construction of rock fill shall originate from sound un-weathered rock approved by the Engineer. The rock fill material shall be made of strong, hard, durable and clean pieces of sound rock of strength class R4 or higher classified according to TABLE 7115/1.

d. Granular Fill

Granular material used for constructing compacted granular fill layers shall be approved granular material of at least gravel sub-base G30 quality as defined in CLAUSE 4203, compacted to achieve a density and strength appropriate for the design load.

e. Sand Fill

Sand used for filling caissons shall be clean, well graded medium to coarse quartz sand free from lumps of clay or organic or other deleterious matter. The sand type should comply with the requirements of BS EN 12620. Alternative sand types may be proposed but will be subject to the approval of the Engineer

f. Structural Steel

Steel piles shall comply with the requirements of relevant Kenyan Standards and, where more specific detail is required, reference shall be made to: BS EN 10025 part 1 to 6, BS 7668, , BS EN 10029 and BS EN 10210 part 1 and 2. Equivalent Standards may be required in accordance with alternative grades of steel specified on the Drawings. I and H sections shall comply with the requirements of BS EN 10365 and BS EN 10034. Sheet piles shall comply with BS EN 1993-5.

In the manufacture of precast concrete piles and jointed precast concrete segmental piles, fabricated steel components shall comply with BS EN 10025-1 and BS EN 10025-2, Grades S275 or S355, cast steel components with BS EN 10293 and ductile iron components with BS EN 1563 material designation symbol EN-GJS-350-22, EN-GJS-400-15, EN-GJS-400-10.

Fabricated sections shall comply with the details shown on the Drawings and the requirements of SECTION 7700.

g. Permanent Pile Casings

Permanent pile casings shall be sufficiently rigid so as not to deform permanently or damage during handling and construction. The casings and their joints shall be sufficiently watertight to prevent the fluid components of the concrete from leaking during the placing of the concrete or from the ingress of groundwater prior to concreting. Where steel casings contribute to the strength of the pile, the casings shall have a minimum wall thickness of 4.5 mm and shall comply with the requirements of ASTM A 252 or equivalent. Welded joints shall comply with the requirements of SECTION 7700.

h. Driven Pile Casings

Driven pile casings shall have sufficient strength to withstand driving forces and provide adequate resistance to distortion from the effects of driving of adjacent piles. They shall be sufficiently watertight to prevent water leaking through the casing walls, prior to and during the placing of concrete.

i. Grouting

i. Cement grout

Cement grout shall meet the appropriate requirements of SUBCLAUSE 7503(g).

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ii. Proprietary brand grout

Proprietary brand grout shall be prepared and used strictly in accordance with the instructions of the manufacturer and conform with BS EN 934.

iii. Bentonite

Bentonite suspensions may be used to counterbalance hydrostatic forces where soil conditions and the groundwater table impose restrictions on pile construction methods. The bentonite used shall be subject to appropriate testing and the Contractor's Quality Control procedures. Bentonite shall be provided in bags and the source of the material shall be to the approval of the Engineer.

7103 General

a. Subsurface Data

The provisions of **CLAUSE 1203** shall apply in regard to any information supplied regarding any subsurface conditions likely to be encountered.

If it is found during the course of excavating, founding-pile or caisson work that the soil or founding conditions differ greatly from those shown on the Drawings, the Contractor shall immediately notify the Engineer.

The Engineer shall, as often as he may deem necessary during the course of excavation, be entitled to call on the Contractor to conduct additional foundation investigations and/or tests at or below the intended founding levels in order to establish safe bearing pressures and founding depths.

b. Channel Preservation

The flow of any watercourse and the conservation of marine and freshwater life at the site shall be maintained at all times. Access to cofferdams, artificial islands and piling platforms shall be effected without unnecessarily disrupting the flow of the watercourses at the point of crossing, unless otherwise specified.

Precautions shall be taken by the Contractor to maintain water quality standards. Water contaminated with silt shall be settled in ponds before being pumped into streams. Water contaminated with chemicals shall be purified before being returned to the stream or disposed of in an appropriate manner as directed by the Engineer.

Precautions shall be taken by the Contractor to ensure that the natural pH, electrical conductivity and other indicators as prescribed for the water are not raised or lowered.

On completion of the work surplus excavated materials including materials excavated from caisson compartments and holes for piles, materials used in cofferdams and other temporary works, as well as in-situ material, shall be removed and disposed of by the Contractor. The channel shall be reinstated to the level of the original bed or such elevation as may be agreed to by the Engineer or required for stream channelisation.

7104 Access And Drainage

a. General

This clause covers the provision of access, including the construction of cofferdams, and draining the excavations. Where it is unnecessary to provide access in terms of **SUBCLAUSE 7104(b)**, the Contractor shall be paid separately for draining the excavations.

After completion of the permanent works, all temporary works shall be completely removed, the ground levelled and the site left in a neat and tidy condition to the satisfaction of the Engineer. Where this is impracticable, such portions as have not been removed, shall be dealt with in accordance with the Engineer's instructions.

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b. Access

Where temporary banks or artificial islands are constructed to afford access to the location where structural members, piles or caissons are to be constructed, the banks or islands shall be adequately compacted with a working platform at surface sufficient to safely support any constructional plant and provide temporary storage for materials required for incorporation in the works. The Contractor shall submit a detailed design and construction method statement giving details materials to be used, dead and live loads, bearing capacity and expected settlement, for the approval of the Engineer.

When constructing temporary banks or artificial islands no separate payments will be made for any obstructions, hard or unsuitable material encountered in the excavation works or in borrow areas used.

c. Cofferdams

Design and construction of any cofferdams shall comply with the requirements of BS EN 12812 or equivalent. Before commencing construction, the Contractor shall submit drawings to the Engineer showing complete details of the cofferdams and the method of construction proposed.

d. Drainage

The Contractor shall adopt suitable, effective drainage methods for preventing the ingress of water into excavations to allow works to proceed in dry conditions.

The drainage measures, with the exception of pumping, shall be maintained until backfilling has been completed. Between the various construction stages pumping may be interrupted if the Engineer is satisfied that the works will not be adversely affected.

7105 Excavation**a. General**

This work shall include excavations, not provided for elsewhere in these Specifications, which are required for founding the structures as well as for any excavations required for demolition, extension or modification of existing bridges and culverts.

Excavation required for diverting, channelling or widening streams within 5 m of concrete structures shall be measured and paid for under ITEM 71.02. Excavations beyond the 5 m limit shall be measured and paid for under the appropriate Items of SECTIONS 2100 and 3500.

b. Surface Levels to be Agreed

Prior to commencing with any excavation, the Contractor shall notify the Engineer in good time to ensure that levels can be taken of the undisturbed ground surface. These levels shall be agreed and used as the datum level for measurement of excavation work.

c. Excavation

Where casting of concrete against the excavated earth faces is not permissible, or where formwork has to be provided, the extremities of the excavation for purposes of measurement and payment, shall be the finished faces of the concrete or steel. The excavations shall be constructed to the minimum dimensions required for placement of formwork and to provide batters for the safety of workers entering the excavation. Additional working space shall be provided between edge of excavation and the footing for the ease of labour movement for fixing and removing shuttering boards, pouring of concrete and compaction of concrete.

Over-excavation (overbreak) in hard or soft material shall be backfilled with the same class of concrete as that in the base or with mass concrete fill as specified or as directed by the Engineer.

Where blasting is required, the Contractor shall complete the entire foundation excavation before the construction of any permanent concrete work is commenced, unless otherwise approved by the Engineer.

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Boulders, logs or any other unsuitable material excavated shall be removed from the site.

When suitable material for foundations is encountered at the design level, it shall be cut and trimmed to a clean surface, either level, stepped or serrated, as may be required.

Where unsuitable material is encountered at the design level work shall proceed in accordance with **CLAUSE 7109** and as directed by the Engineer.

d. Classification Of Excavated Material

All excavations for the foundations of structures shall be classified into “soft material” and “hard material” in accordance with **CLAUSE 3603**.

e. Blasting

Where blasting is permitted, it shall be carried out in accordance with the requirements of **CLAUSE 1226**.

f. Deterioration of Foundation Excavations

Where materials susceptible to softening in the presence of water or mechanical degradation when exposed to the atmosphere, are found at foundation level, the excavation shall be excavated to the final slope and level immediately before the concrete blinding is placed. In deep or wide excavations appropriate precautions shall be taken to prevent heave.

Where the bottoms or sides of excavations, in which bases are to be cast, are softened due to the negligence of the Contractor in allowing storm or other water to enter the excavations, the softened material shall be removed and replaced with foundation fill as directed by the Engineer, at the Contractor's expense.

g. The Safety of Excavations

The Contractor shall take the necessary precautions to safeguard the stability and safety of the excavations and adjacent structures.

No person's safety shall be jeopardised neither shall any situation be allowed to arise which may result in damage of whatsoever nature. The Contractor must ensure that no one enters an excavation deeper than 1.20 m unless the sides of the excavation are supported sufficiently to prevent collapse

Precautionary measures taken by the Contractor shall comply with the appropriate legal provisions.

h. Inspection

No concrete shall be placed before the excavation has been properly cleaned by the Contractor and inspected and approved by the Engineer.

i. Excavation by Hand

The Contractor shall provide all necessary excavation plant, labour and hand tools for both mass excavation and minor finishing or clearing jobs in excavations which are otherwise being done by mass excavation plant.

The Contractor may elect to undertake any excavation by hand and their method statement and programme will provide for the procedure selected. The Contractor's rate for excavation works shall include for hand excavation where necessary or selected. No additional payment shall be made.

7106 Founding

Variations in the anticipated founding conditions may result in changes to the dimensions and founding levels specified or shown on the Drawings.

The Contractor shall undertake such varied work for each foundation, base or caisson during construction as instructed by the Engineer.

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The Contractor shall not be entitled to any additional payment as a consequence of any such variation in the dimensions or founding depths over and above that provided for in **CLAUSE 7118**, irrespective of the stage of construction at the time the instruction to make the variation is given.

No bases, caissons or piles shall be founded unless authorised by the Engineer. Each founding level shall be accurately measured and recorded by the Contractor and agreed with the Engineer.

7107 Utilisation of Excavated Material

Excavated material and material recovered from temporary works shall, if suitable, be utilised for backfill. Material unsuitable for use as backfill or in excess of the required quantity, shall be removed from the site or utilised as directed by the Engineer.

Excavated material not used for backfill or not taken to spoil but used in the construction of embankments or other parts of the work, as directed by the Engineer, will be paid for under foundation excavation as well as under the relevant Item for the purpose for which it is used.

The free haul distance on excavated material and imported material for backfill shall be determined according to **SUBCLAUSE 1602 (g)**.

Excavated and stockpiled material shall be so placed as not to endanger the uncompleted structure either by direct pressure or indirectly by overloading the fills contiguous to the structure, or in any other way.

7108 Backfill and Fill Near Structures

a. General

When backfill and fill are placed, the following precautionary measures shall be taken:

- i. The material shall be placed simultaneously, in so far as is possible to approximately the same elevation on both sides of any structure. If conditions require the backfill or fill to be placed appreciably higher on one side than on the other the additional material on the higher side shall not be placed until authorised by the Engineer.
- ii. The material behind abutments directly restrained at the top by the superstructure e.g. portal type of structures, shall be placed as shown on the Drawings or as directed by the Engineer.
- iii. The material behind the walls of portal structures shall not be placed until the top slab has been placed and cured for the specified length of time, unless otherwise authorised by the Engineer.

b. Backfill

Excavated areas around structures shall be backfilled with approved material in horizontal layers not exceeding 150 mm in thickness after compaction. Each layer shall be moistened or dried to the optimum moisture content for the material and then compacted to a density of not less than 95 % MDD of AASHTO T180 for cohesive soils and gravels and not less than 100 % MDD of AASHTO T180 for cohesionless sands, or the density of the surrounding soil whichever is the least, except that, in the road prism, the material shall be compacted to a density of not less than 95 % MDD of AASHTO T180.

Timbering and sheeting left in for the purpose of supporting the excavation shall be eased up 150 mm at a time in step with the backfill layer. Where instructed by the Engineer, timbering or sheeting shall be left in place.

Where instructed, or shown on the Drawings, selected granular fill material and/or porous filter material approved by the Engineer shall be placed. A sliding form or other approved means shall be used during backfilling such that the porous filter is brought up and compacted at least 150 mm ahead of the selected granular fill material and that the selected granular fill is brought up and compacted at least 150 mm ahead of the adjacent earthworks fill.

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c. Fill

The interface between selected granular material described in this section of the Specification and the adjacent earthworks under **SERIES 3000** of this Specification shall be as shown on the Drawings or as instructed by the Engineer. Where selected granular fill material is not instructed the Contractor shall backfill the excavation behind and around the structure and up to ground level using the excavated material. Above ground level the Contractor shall use the same material as that being used for the adjacent embankment.

d. Fill Within Restricted Area

That part of the fill within a horizontal distance of 3 m from the vertical and inclined concrete faces of the structure and that part between the pillars of the spill-through abutments or that part shown on the Drawings, shall be termed "fill within restricted area".

Fill within the restricted area shall comply with the requirements of **SECTION 3600** except that it shall be compacted to a density of not less than 95 % MDD of AASHTO T180. In order to achieve the specified density the Contractor shall, where necessary, import material of suitable quality.

Unless otherwise directed by the Engineer, only mechanical compaction equipment that is pushed or drawn by hand shall be used to achieve the required density within a horizontal distance of 3 m from any concrete structure. Fill in spaces below concrete soffits that are inaccessible for mechanical compaction equipment shall be constructed by methods specified or as approved by the Engineer.

7109 Foundation Fill

If it is found that the material at the founding depth shown on the drawings does not have the required bearing capacity the excavations shall be deepened or widened at the discretion of the Engineer to provide adequate bearing capacity for the design load. Where greater depths are excavated the Engineer may order the Contractor to make up the difference in levels with foundation fill.

Where the foundation fill consists of rock or crushed stone, it shall be constructed in accordance with the requirements of the Special Specifications or as directed by the Engineer. Foundation fill consisting of granular material shall be constructed in layers not exceeding 150 mm in thickness after compaction. Each layer shall be moistened or dried to the optimum moisture content for the material and compacted to a density of not less than 95 % MDD of AASTO T180 for cohesive soils and gravels, and not less than 100 % MDD of AASHTO T180 for cohesionless sands. Mass concrete fill to be used shall be of the class or mix of concrete fill as specified or directed by the Engineer.

Unless otherwise specified or directed by the Engineer, foundation fill constructed from crushed rock or compacted granular material shall be defined by a prism with vertical sides. The base of the prism lies in the founding plane and coincides with the base of a prismoid with trapezium-shaped inclined sides which extend downwards and outwards at an angle of 300 (or the internal angle of friction of the fill, whichever shall be the greater), with the vertical from each outer edge of the underside of the footing down to the founding level. The upper plane of the prism lies in the plane of the underside of the footing.

Concrete blinding which complies with the requirements shown on the Drawings shall be placed underneath all bases except where mass concrete fill is used or where authorised by the Engineer that this need not be done.

Where a base is required to be constructed on mass concrete fill, the mass concrete fill shall be constructed accurately to the final levels of the underside of the base.

7110 Grouting Of Rock Fissures

Where specified, fissures in the rock below and around the bases shall be sealed by pressure grouting with a neat cement grout or sand-cement grout or with a proprietary brand grout as specified.

The water to cement ratio of the grout shall be approved in advance by the Engineer.

The extent of the fissuring shall be established by means of Lugeon tests (water testing under pressure).

Holes of at least 40 mm in diameter shall be drilled at places indicated by the Engineer and grout shall then be pumped into these holes under suitable pressures. Grouting shall be done in 3 m stages or as otherwise specified, to the maximum depth ordered. Care shall be taken to avoid further fracturing of the rock strata by excessive grouting pressures.

Grouting of the rock fissures shall be done by specialised operators with adequate experience in this class of work. The grouting shall be carried out in accordance with BS EN 12715.

7111 Foundation Dowels

Where required, foundation dowels of specified material, diameter and length shall be installed at the positions and to the dimensions shown on the Drawings or as directed by the Engineer. After exposing, clearing and trimming the rock formation, holes with specified diameters and depths shall be drilled in the rock. After the holes have been cleared and pre-wetted, they shall be filled with grout. Within 15 minutes of having been filled with grout, dowel bars shall be carefully driven into the holes. The cement and water in the grout shall be mixed in the ratio of 50 kg of cement to 20 litres of water and an approved expanding additive which complies with the requirements of SUBCLAUSE 7402(e) shall be added.

The dowels shall comply with the requirements of CLAUSE 7305.

7112 Foundation Lining

Where specified or directed by the Engineer, foundation linings shall be installed as described hereafter. The Engineer shall have the right to order the use of linings against the sides of excavations and the undersides of bases if deemed necessary and also under slabs. Linings may be adopted in lieu of formwork and concrete blinding where appropriate.

All surfaces to be lined shall be covered with an approved sheeting to provide a clean impervious layer. The material shall be of sufficient strength to provide a durable working surface and to support the concrete and reinforcement without tearing. The joints of the material between strips shall have a 150 mm overlap and the lining shall be held firmly in position by nails, pegs, etc.

Polyethylene sheeting with a thickness of 0.150 mm is generally considered to be adequate for use below bridge approach slabs and bases if required.

7113 Foundation Piling Preliminary Items

a. General

This CLAUSE covers the construction of bearing piles of concrete, steel, timber or a combination of these materials.

b. Piling layout

The piling layout, the minimum pile size and/or bearing capacity and type, together with the steel reinforcement and class of concrete required for concrete piles, shall be as shown on the Drawings and/or as otherwise detailed in the Special Specifications.

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c. Alternative Designs For Piling and Piling Layouts

i. Submission

The priced Bill of Quantities submitted for alternative designs shall be compiled strictly in accordance with the relevant measurement and payment CLAUSES of these Specifications.

Where pay Items defined in these Specifications have been omitted, it shall mean either that the Items do not apply, or that where the Engineer requires work falling under such Items to be done, it shall be done without any cost to the Employer. The inclusion of 'rate-only' Items will not be permitted.

Where pay Items not defined in these Specifications are used, the measurement and payment requirements for such Items shall be specified in detail by the Contractor. In the absence of such definitions, or in the case of any ambiguity, the alternative specifications shall be approved by the Engineer.

Except in piling-only Contracts or where otherwise provided in the Special Specifications, the Contractor shall price the Bill of Quantities for the original design irrespective of whether or not an alternative design is offered.

ii. Design

The critical design-load combinations acting upon the underside and the centre of gravity of the pile-capping slab, the maximum permissible settlement of the pile-capping slab, and the technical data required for designing alternative piles and or piling layouts will be indicated on the Drawings. Alternative designs shall comply with the provisions of SECTION 1200 and the prescriptions set out below.

For alternative designs submitted the Contractor shall submit with their bid a detailed description of the method of analysis used in the design of the piles and the pile group layouts. The average length of pile and/or of the piles per group on which the quantities in the Bill of Quantities for the alternative designs are based shall be stated in each case. The type of pile offered shall be defined in terms of size, materials, working and ultimate loads.

The Contractor shall be responsible for and shall bear the cost for redesigning, drafting and submitting the detail drawings for any structural element affected by the alternative pile design. Any additional costs related to the construction of such element as compared to the original design shall be for the account of the Contractor.

The Contractor shall, as specified in CLAUSE 1220 for alternative designs, submit to the Engineer at least eight weeks prior to work being commenced, drawings detailing the piling-group layout and piles, incorporating such amendments to their original design as may be required by the Engineer, and drawings detailing the amendments required to the pile-capping slab dimensions and reinforcement as a result of the layout of the piles, all as applicable.

No work of whatsoever nature shall be commenced on the piling until the Drawings have been submitted and have been approved by the Engineer in writing. After approval of the Drawings, no departure therefrom shall be made without the authorisation of the Engineer.

iii. Basis of payment

Where the quantities in the Bill of Quantities referred to in SUBCLAUSE 7113(c), differ from the number of piles and the average pile length given in the submission for the alternative pile design, the Engineer shall accept the sum in the Bill of Quantities, correct the quantities, and adjust the rates for the applicable pay Items accordingly.

iv. Design responsibility

Approval of alternative designs shall in no way relieve the Contractor from responsibility for adequate design and construction of the Works nor shall any of the provisions of this SUBCLAUSE 7113(c) relive the Contractor of their obligations under the relevant provisions of the General Conditions of Contract.

d. Details to be furnished by the Contractor

In all cases where the choice of the type of pile to be used is left to the Contractor, full particulars, specifications, calculations and drawings of the piles proposed for use by the Contractor shall be submitted with the bid. The Contractor shall submit to the Engineer a fully detailed method statement for construction of the piles two weeks before any piles are driven or holes are formed. The method statement shall describe, inter alia:

- i. How the piles and casings will be installed or the holes will be formed;
- ii. How the piles and casings will be installed or the holes will be made through identified obstructions;
- iii. The expected size of the bulbous base, under ream, rock socket, etc, if any;
- iv. How concrete is to be placed and compacted in the case of cast in situ piles;
- v. How reinforcing steel is to be placed and held in place during the placing and compaction of the concrete in cast in situ piles;
- vi. Details of permanent casing, if any;
- vii. For driven piles:
 - The weight of the piling hammer;
 - The set during the last ten blows;
- viii. The mix design for the concrete together with an adequate quantity of cement and aggregate to enable the Engineer to conduct the necessary tests.

The Contractor shall submit any further details as may be required by the Special Specifications or requested by the Engineer.

e. Pile-installation Plant And Equipment

The pile-installation rigs, leaders, frames or other plant and associated equipment used for driving the piles or forming the holes or for other methods of sinking the piles shall be in a good working condition and to the prior approval of the Engineer and shall be licensed, have current certification for lifting and safety and in all ways comply with relevant legal requirements.

The piling rigs or installation frames shall be so designed as to ensure that piles can be installed in their proper positions and true to line and slope within the required tolerances.

The Contractor shall supply all necessary plant and testing equipment, kentledge, load frames and instruments required for the prescribed investigations tests and inspections.

f. Piling Platforms and Mats

Piling platforms shall include the prepared in situ material or artificial islands or any structure (excluding the piling equipment) constructed for gaining access to the positions where the piles are to be installed and for carrying out the piling operations.

Structural piling platforms shall be rigid. Floating barges used for piling operations shall afford sufficient stability to enable piles to be properly installed.

The Contractor shall submit full details of the design of any working platforms or piling mats demonstrating that an adequate Factor of Safety will be in operation under the most onerous dead and live loading configuration for the piling rig or frame selected for the work.

On completion of the piling, the Contractor shall remove all the platforms and reinstate the site to the satisfaction of the Engineer.

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g. Setting Out

The Contractor shall set out the pile positions and shall stake these positions with a durable marker. Where the level from which the piling is undertaken is above the underside of the pile capping slab, due allowance shall be made for the offset of raking piles so that the pile at the underside of the pile-capping slab will be in the correct position.

h. Ground Surface For Foundation Piling

Before starting any piling work, the Contractor shall give 24 hours notice to the Engineer in to ensure that levels of the ground surface be taken in order that an average ground surface from which the piling is to be measured can be established and agreed upon by the Engineer and the Contractor. Where foundation piling at a site is preceded by excavation or the construction of fill, which may be designed to act as the piling mat, the surface from which the piling is to be done shall be formed as near as possible to the underside of the pile-capping slab as directed by the Engineer.

7114 Types Of Piles**a. Bored Cast In Situ Concrete Piles****i. Reinforcement**

Reinforcement shall not be placed in the pile holes until immediately before concreting. Before the reinforcement is placed in position, all mud, water, and any loose or soft material shall be removed from the hole.

Steel reinforcing shall be accurately maintained in position without damage being done to the sides of the hole or the reinforcing itself. Spacers shall be used to keep the reinforcing steel at the required distance from the inside face of the pile casing and wall of the pile hole. The details of the reinforcement cages and spacers shall be such as to ensure satisfactory distribution of concrete without risk of creation of voids, segregation or honeycombing during placement.

Pile reinforcement will not be shown in the bending schedules. Only the number, diameter and type of bars and their arrangement will be shown on the Drawings. The Contractor, with the permission of the Engineer, may replace the bars shown on the Drawings with bars of different diameters and spacing and of different types, on a basis of equivalent strength.

The reinforcement shall be assembled in cages, which shall be sufficiently robust to prevent their permanent deformation during handling. In the case of cast in situ piles, the inner sides of the cages shall be left unrestricted for the placing of the concrete.

The longitudinal bars shall project above the cut-off point by the distance shown on the Drawings, or by 40 times the bar diameter if no dimension has been given.

Splicing of the reinforcing may be necessary or ordered and the Contractor shall keep available on the site sufficient steel reinforcing so that an additional length of pile reinforcing cage can be assembled whenever necessary.

The assembly of this additional reinforcing shall be carried out expeditiously and before any concreting of any specific pile commences. If splices have to be provided, the longitudinal bars shall overlap for a distance of 40 bar diameters, or as required by the Engineer.

ii. Concreting of piles

The concreting of the piles shall not be commenced before the Engineer's permission has been given.

Except in self-supporting pile holes, a temporary or permanent casing shall be installed for the full depth of the hole to prevent lumps of material from falling from the sides of the hole into the concrete. Where concrete is to be placed under drilling mud the temporary casing may be omitted, except at the top end of the hole.

The concrete mix design shall be so proportioned as to be of sufficient strength, but shall be sufficiently workable to enable satisfactory placement, and, where self-compacting concrete is not used, it shall be thoroughly compacted by approved means. Extraction of the temporary casing during placement of the concrete shall be such that no damage is caused to the pile and the advancing concrete level is at all times kept considerably above the temporary casing's trailing edge. Concrete shall generally be placed in the dry, but where this is impracticable; it shall be placed by tremie. The method of placement shall be agreed with the Engineer and shall ensure that segregation does not occur.

The requirements of SUBCLAUSE 7407(c) together with the following requirements shall apply when concrete is placed under water or bentonite (drilling mud) by tremie:

1. The cement content shall be not less than 400 kg/m³ and the slump shall be such that the concrete of the specified strength and desired density can be obtained.
2. The hopper and tremie shall be a closed unit which cannot be penetrated by water.
3. The tremie shall be at least 150 mm in diameter for 20 mm aggregate and of greater diameter for larger aggregates.
4. The concrete shall be so placed as to prevent the mixing of water and concrete. The tremie shall at all times penetrate into the concrete.
5. Placing the concrete in that part of the pile below the water level in the casing shall be done in one operation, and the same method of placing the concrete shall be maintained throughout.
6. All tremies shall be scrupulously cleaned before and after use.
7. Before placing the concrete in the water, the Contractor shall ensure that no silt or other materials have collected at the bottom of the hole, and where drilling mud is used, the Contractor shall ensure that no drilling mud suspension with a relative density exceeding 1.3 has collected at the bottom of the hole. Concrete shall be placed in a manner that prevents segregation.

b. Auger Piles

Piles may be constructed using rotary flight augers with concrete placed through a central stem.

The Contractor shall provide full details of the equipment to be used and demonstrate to the Engineer that adequate monitoring devices are installed and functioning to control the pressure and head of concrete and ensure that augers are not withdrawn in an uncontrolled manner. Continuous logs of pressure, depth and flow of concrete shall be provided for every pile together with rates of penetration and extraction of the auger.

c. Precast Concrete Piles

i. General

The piles shall be of reinforced or prestressed concrete and shall be manufactured, handled, stored and installed in accordance with BS 8004, unless otherwise specified.

ii. Manufacture

The piles may be manufactured in a factory or a casting yard on the site of the Works. The Contractor shall ensure that the factory or casting yard will at all reasonable times be accessible for inspection by the Engineer.

The relevant requirements of SECTION 7400 shall apply to the concrete work.

Reinforcement shall comply with the requirements of BS 8004.

The piles shall be cast on a rigid horizontal platform in approved moulds. Particular care shall be taken to keep the reinforcement, coupler sockets and pile shoes accurately in position. Adequate provision shall be made for lifting the piles.

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Each pile shall be clearly marked with the date of casting, a reference number, and from the tip of the pile at 1.0 m intervals, with distance marks.

Piles shall be cured for a period sufficient to develop the strength required to withstand, without damage to the pile, the stresses caused by handling, transporting, storing and driving. The piles shall not be driven before the concrete in the pile has attained the specified 28-day strength.

iii. Handling, transport and storage

Care shall be taken at all stages of lifting, handling and transporting to ensure that the piles are not damaged or cracked.

Piles shall be stored on firm ground which will not settle unequally under the weight of the stack of piles. The piles shall be placed on timber supports which are cut square and levelled and spaced so as to avoid undue bending in the piles. The supports in the stack shall be located vertically above one another.

iv. Lengthening of precast piles

Piles shall be lengthened where required by such means and methods as approved by the Engineer. Care shall be taken to ensure that the additional length of pile joined is truly axially in line with the original pile within the tolerance requirements for straightness set out in SUBCLAUSE 1904(a).

Proprietary jointing systems will be approved subject to any tests that may be required by the Engineer which may include full scale load tests to check the performance of a jointed pile in bending.

Driving shall not be resumed until the pile extension and any grout or bonding agent used has attained the required strength.

d. Steel Piles

Steel piles shall be proprietary sheet piles, or of standard circular pipe, I or H-section construction.

Hollow steel piles may be filled with cast in situ concrete and designed to act as a composite member with load being carried proportionately between the steel and concrete elements

In order to combat corrosive ground or water conditions or to reduce friction forces, piles may require a bituminous or other proprietary surface coating. Full details of any such coating shall be provided unless already prescribed in the Special Specifications or on the Drawings. Alternatively, the cross-sectional area of the steel shall be adapted to the aggressiveness of the subsurface conditions to compensate for possible reduction in the pile wall thickness caused by abrasion and corrosion during the service life of the pile. In marine conditions a cathodic protection system shall be adopted.

e. Timber Piles

i. General

Timber piles shall be of pressure treated round timber approved by the Engineer and shall be manufactured, handled and installed in accordance with EN 1995-1-1 and BS EN 12699 unless otherwise specified.

The execution of timber pile shall conform to BS EN 12699.

Preservation treatment of timber piles shall be carried out in accordance with the recommendations of BS 8417, BS 144 or BS 4072.

All preservation products shall be applied in accordance with the manufacturer's instructions. Certificate of treatment must be obtained by the Contractor and presented to the Engineer for all treated timber. The type and method of treatment must be compatible with the type of timber and use to which the timber so treated is to be put.

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All materials and work shall be in accordance with BS EN 1995-1-1 and BS EN 12699.

Timber grading shall comply with the general requirements stated within BS EN 14081-1.

Hardwoods shall be used for all permanent piles. Softwoods may be used for temporary structures subject to the approval of the Engineer.

Timber piles for permanent structures shall only be used below the lowest anticipated ground water table or free water level during the life time of the structure unless adequate protection is provided.

An Environmental Impact Assessment shall be made prior to approval of the use of timber piles.

ii. Manufacture and testing

The piles may be manufactured in a factory or treated on the site of the Works in accordance with BS EN 12699 and BS 8417, unless otherwise specified.

When required, the Engineer will order, and the Contractor shall carry out tests on the timber piles in accordance with BS EN 14081-1 to ensure that the timber is fit for the purpose for which it is to be used.

The Contractor shall ensure that the factory or treatment yard will at all reasonable times be accessible for inspection by the Engineer.

The piles shall be treated and stored in a horizontal position and protected from the weather.

Each pile shall be clearly marked with the date of manufacture, type of tree, date of treatment, a reference number, and from the tip of the pile at 1.0 m intervals, with distance marks.

Piles shall be seasoned for a period sufficient to develop the strength required to withstand, without damage to the pile, the stresses caused by handling, transporting, storing and driving. The piles shall not be driven before they have attained the specified strength.

iii. Handling, transport and storage

Care shall be taken at all stages of lifting, handling and transporting to ensure that the piles are not damaged or cracked.

Piles shall be stored on firm ground which will not settle unequally under the weight of the stack of piles. The piles shall be placed on timber supports which are level and spaced so as to avoid undue bending in the piles. The supports in the stack shall be located vertically above one another.

iv. Lengthening of timber piles

Piles shall be provided in one piece unless otherwise specified. Piles shall be lengthened by splicing where required by such means and methods in accordance with BS EN 12699 or as instructed by the Engineer. The splicing shall be capable of resisting safely any stresses which may develop during lifting, driving and under loading. Care shall be taken to ensure that the additional length of pile joined is truly axially in line with the original pile within the tolerance requirements for straightness set out in SUBCLAUSE 1904(a). Driving shall not be resumed until the pile extension and any bonding agent used has attained the required strength.

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7115 Installation Of Piles

a. Driving

i. Pile hammers, leaders and frames

Piles and pile casings shall be driven with a gravity hammer, a rapid-action power hammer or by other approved means. Selection of an appropriate hammer shall be the Contractor's responsibility and he shall provide calculations demonstrating that the type of hammer will be capable of efficiently driving the piles to the depths specified without damaging the pile in any way.

Pile driving leaders shall be constructed in such a manner as to afford freedom of movement of the hammer and shall be held in position to ensure adequate support for the pile or pile casing during installation. Inclined leaders shall be used for installing raking piles.

The heads of precast concrete piles shall be protected with packing of resilient material, care being taken to ensure that it is evenly spread and held in place. A helmet shall be placed over the packing, and a dolly of hardwood or other material not thicker than the diameter of the pile shall be placed on top.

ii. Water jetting

The Contractor may employ water jetting to install piles in granular material. Jetting shall be discontinued before the leading end of the pile reaches a depth of 80 % of the anticipated final depth or at a depth agreed with the Engineer. After jetting, piles or their casings shall be driven to the required depth, level or set.

iii. Installation sequence

Unless otherwise specified or ordered the sequence for installing the piles shall be to the Contractor's programme. However, the sequence for driving the piles in a group shall be programmed to minimise the creation of consolidated blocks of ground into which piles cannot be driven or which cause fictitious penetration values. Piling shall generally commence at the centre of the group and be progressively extended to the perimeter unless otherwise instructed by the Engineer.

The installation of piles shall be undertaken in such a manner that structural damage, distortion or positioning defects will not be caused to previously installed piles or casings.

iv. Heaving of piles

In soils in which the installation of piles may cause previously installed piles to heave, accurate level marks shall be placed on each pile immediately after installation and all piles that have heaved shall be re-driven to the required resistance, unless re-driving tests on neighbouring piles have shown this to be unnecessary. Piles shall not be concreted neither shall any pile-capping slab be constructed until the piles within a heave-influence zone have been re-driven as required.

v. Bulbous bases

Where required, bulbous (enlarged) bases shall be formed after the driven casing has reached the required depth. The base shall be formed by progressively displacing the surrounding subsoil with concrete placed by the repeated action of a gravity hammer. The size of the base will depend on the compressibility of the surrounding subsoil but shall in no case have a diameter of less than 1.5 times the diameter of the pile.

vi. Piling alignment

Where the inclination of a precast concrete pile deviates from the correct slope during installation, the pile shall not be forced into the correct position. The slope of the guiding frame shall be adjusted so as to coincide with the actual inclination of the pile to prevent bending of the pile. Where the verticality or the inclination of the installed pile falls outside the specified tolerances, the pile will be classified as being defective.

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b. Augering and Boring

i. Auger and bore pile holes

The augering and boring of pile holes shall be carried out as expeditiously as local conditions permit taking due account of services or other restrictions on the site.

Holes shall be cleaned after augering and boring to obtain a clean and level surface.

Where indicated by the Engineer, suitable casing shall be installed in those parts of the augered holes where the sides are in danger of caving in before the concreting has been completed.

During extraction of the casing, care shall be taken to avoid lifting the concrete and damaging the pile.

The use of water for augering and boring holes shall not be permitted unless approved by the Engineer. Surface water shall not be allowed to enter the hole.

ii. Under-reaming

Where required, the holes shall be enlarged or belled out to form an under ream. The earth excavated shall be removed in a manner which will not damage the walls of the hole.

The shape of the under ream shall be a truncated cone of which the base diameter depends on the bearing capacity of the founding material, but it shall be not less than twice the shaft diameter. The base angle of the cone between the inclined face and horizontal plane shall be not less than 60°.

No workmen shall be allowed to enter under reamed bases to pile shafts and, where this type of pile is approved, the Contractor must provide remote cleaning tools and CCTV or other monitoring devices which can show the cleanliness of the pile base before concreting commences.

iii. Inspecting preformed holes

Equipment for inspecting the pile shafts shall be provided and operated in accordance with BS 8008 Safety Precautions and Procedures for the Construction and Descent of Machine-Bored Shafts for Piling and Other Purposes or similar document.

Immediately before the reinforcement is to be installed or the concrete placed, the Engineer shall be informed thereof with a view to inspecting the pile holes. When piles are to be under-reamed, the excavation shall be inspected twice by the Engineer, firstly to ascertain that suitable founding material has been obtained before under-reaming may start, and, secondly, after the under-reaming has been completed for approval to be given by the Engineer for casting the pile.

c. Rock Sockets

Rock formations of adequate strength, quality and thickness for carrying the specified load shall be drilled with appropriate equipment to the required dimensions.

The socket thus formed shall be cleaned of all loose material and inspected prior to placement of concrete.

d. Obstructions

i. Definitions

1. Identified obstructions

Identified obstructions shall mean any obstruction described on the Drawings or in the Special Specifications and for which provision for payment has been made in the Bill of Quantities in respect of penetrating or removing the obstructions.

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2. Unidentified obstructions

Where provision has been made in the Bill of Quantities in terms of ITEM 71.17 for penetrating identified obstructions and obstructions not described are encountered, such obstructions shall be classified as unidentified obstructions. The penetration of such obstructions shall be paid for under ITEM 71.18 subject to the condition that the rate of penetration drops below that achieved for identified obstructions when the same method and effort are used, or subject to additional methods and effort over and above those required for identified obstructions being required for penetrating the obstruction.

or

Where no provision has been made in the Bill of Quantities for penetrating identified obstructions and obstructions are encountered and, after resorting to the methods specified in the submission in terms of SUBCLAUSE 7113(d), it is found to be impossible to form the holes in the proper positions and at the proper inclinations and depths, and the Contractor has to resort to additional methods for forming the pile holes successfully, such obstructions shall be classified as unidentified obstructions.

ii. Classification of materials

For piling, only the following classification of materials shall apply to the identification and description of obstructions.

1. Matrix

The matrix shall comprise that part of the material which will pass through a sieve with 50 mm x 50 mm openings.

2. Cobbles

Coarse material which will pass through a 200 mm x 200 mm opening, but will not pass through a 50 mm x 50 mm opening. The cobbles shall be obtained from material with at least Class R2 hardness as defined in TABLE 7115/1.

3. Boulders

Boulders shall mean any rock mass of hardness of at least Class R2 which will pass through a square opening with dimensions equal to the maximum size boulder specified in the Bill of Quantities but will not pass through a 200 mm x 200 mm opening.

4. Rock formation

A rock formation shall be any rock mass with hardness of at least Class R2 which will not pass through a square opening with dimensions equal to the maximum size boulder specified in the Bill of Quantities.

Where a boulder is cut through and part of it is left imbedded in the wall of the hole, such boulder obstruction shall be classified as rock formation.

For the identification of rock in terms of this clause, the classification in TABLE 7115/1 shall apply.

A scale of strength, based on the uniaxial compressive test is shown in the following table based on BS 5930. The strength of a rock material determined in the uniaxial compression or point load test is dependent on the moisture content of the specimen, anisotropy and the test procedure adopted, all of which influence the classification. The use of simpler index tests in the field is recommended to provide additional data and as a check on the manually assessed strengths; the Point Load Test and Schmidt Hammer are amongst the more commonly used. The size and shape of lumps, strength of operator, weight of hammer and surface on which lumps rest affect the assessment of the strength. It is therefore vital that each description is calibrated by strength determinations.

TABLE 7115/1: ROCK CLASSIFICATION

Class	Term for use in field or based on measurement	Definition for field use	Definition on basis of Unconfined Compressive strength measurements (MPa)
R1	Extremely weak	Can be indented by thumbnail. Gravel size lumps can be crushed between finger and thumb.	0.6 - 1.0
R2	Very weak	Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife.	1 - 5
R3	Weak	Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer.	5 – 25
R4	Medium strong	Cannot be scraped with pocket knife. Can be fractured with a single firm blow of geological hammer.	25 – 50
R5	Strong	Requires more than one blow of geological hammer to fracture.	50 – 100
R6	Very strong	Requires many blows of geological hammer to fracture.	100 – 250
R7	Extremely strong	Can only be chipped with geological hammer	> 250

iii. Driven displacement and prefabricated piles

Where obstructions make it difficult to install driven displacement and prefabricated piles in the positions and at the inclinations shown and to the proper lengths by the methods specified in the submission in terms of SUBCLAUSE 7113(d), the Contractor shall resort to additional methods which are suitable for the type of pile. If the successful installation of a pile proves to be impossible after such methods have been tried, the Engineer may order an additional pile or piles to be installed.

All such work and additional piles shall be paid for in accordance with the bid rates where applicable, or where they do not apply, under ITEM 71.19.

iv. Auger and bore pile holes

Where identified or unidentified obstructions are encountered when shaping holes for piles, payment for penetrating the obstructions shall be made against the appropriate pay Items.

e. Determining Pile Lengths

The design of the piles and pile groups, and the quantities in the Bill of Quantities are based on the subsurface data shown on the Drawings.

The Engineer will determine the depth of piles as work proceeds.

Where variations in the subsurface water and/or soil conditions occur, the Engineer shall be informed immediately.

If the Contractor is not satisfied that the piles will be capable of carrying the specified loads at the depth determined by the Engineer he may, in consultation with the Engineer, lengthen the piles to reach a suitable founding depth. Where the Engineer and the Contractor cannot agree on the founding depth, the Engineer may require the Contractor to:

- i. Undertake additional foundation investigations and/or core drilling in accordance with SUBCLAUSES 7103(a) and 7115(i) respectively, and/or
- ii. Install one or more test piles and conduct a load test in accordance with SUBCLAUSE 7116(a). The Engineer will prescribe the positions for each test pile. Test piles shall comply with the specified requirements for piling.

f. Piling Data

The Contractor shall provide daily records of work done and materials and labour utilised. Weekly summaries of production and individual pile records shall also be submitted. Inter alia, the following data on each pile installed shall be recorded in a form approved by the Engineer:

- i. The effort used for driving the pile and the resistance to penetration at founding level.
- ii. A description of subsurface material, the presence of ground water and the quality of material on which the pile is founded.
- iii. The quality of the materials used in the construction or manufacture of the pile, as well as of the permanent casing if used. The method of placing and compacting the concrete in cast in situ piles.
- iv. The method of founding of the piles e.g. bulbous bases, underreams, rock sockets, etc, and their dimensions.
- v. The design working load of the pile.
- vi. The length of the pile and the accuracy of installation in respect of position and inclination.
- vii. Nominal dimensions and type of pile.
- viii. Length and details of any temporary and permanent casings used.
- ix. Date of piling, pile reference number and pile location (sketch) relative to the other piles of the same set.

g. Stripping the Pile Heads

Precast and timber piles shall be installed to a level of at least 0.6 m above the cut-off level, and cast in situ piles shall be cast to a level of at least 150 mm above the cut-off level. The excess concrete shall be so stripped off that only sound concrete will project into the pile-capping slab.

The method of breaking the pile head shall be approved by the Engineer. Proprietary methods may be adopted including inserts in cast in-situ piles. For conventional break out the cut-off plane shall be marked by cutting a 20 mm deep groove with a grinding-machine around the full circumference of the pile.

Heavy concrete demolishing equipment may not be used for the stripping of pile heads. All loose aggregate shall be removed from the cut-off plane.

The concrete shall be so stripped off that the pile below the cut-off level will not be damaged, or, should defective concrete be found in the completed pile, the damaged or defective concrete shall be cut away by the Contractor at their own cost and replaced with new concrete well bonded to the old concrete, or the pile shall be replaced as directed by the Engineer.

The main reinforcement of the piles shall extend at least 40 times the diameter of the main reinforcing bar beyond the cut-off level into the pile-capping slab or as otherwise instructed. This reinforcement shall be left straight unless otherwise directed by the Engineer.

The cut-off level for piles shall be the level shown on the Drawings.

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h. Construction of Pile-capping Slab

The Contractor shall not construct the pile-capping slab before the Engineer has confirmed, in writing, that all the relevant load and/or integrity tests have been completed and the piles have been accepted.

i. Core Drilling

The Engineer may instruct core drilling to be done with a view to obtaining cores of the founding formation and/or of the concrete in the completed structural member. In the case of piling, the core drilling may precede the piling or may be done through the completed pile, as specified, or as instructed by the Engineer.

The Contractor shall supply the necessary construction plant on the site for drilling under the above conditions. The plant and techniques used shall be suitable for ensuring 100 % core recovery. The diameters, depths and lengths of the cores shall be in accordance with the specifications or the instructions of the Engineer.

The Contractor shall keep accurate records of the drilling, which, together with the cores, shall be handed over to the Engineer. The cores shall be placed in the correct sequence in a clearly identified wooden core box with a lid.

7116 Testing Of Piles**a. Integrity testing****i. Method of testing**

Where integrity testing is called for, the method to be adopted shall be one of the following, as specified:

1. Impulse method;
2. Sonic Echo, Frequency Response or Transient Dynamic steady state vibration method;
3. Sonic logging method.

Other methods may be considered subject to satisfactory evidence of performance. Particular requirements are detailed in the Special Specifications.

ii. Age of piles at time of testing

In the case of cast-in-place concrete piles, integrity tests shall not be carried out until the number of days specified have elapsed since pile casting.

iii. Preparation of pile heads

Where the method of testing requires the positioning of sensing equipment on the pile head, the head shall be broken down to expose sound concrete and shall be clean, free from water, laitence, loose concrete, over-spilled concrete and blinding concrete and shall be readily accessible for the purpose of testing.

iv. Specialist Sub-contractor

The testing shall be carried out by specialist personnel or an independent integrity testing firm, subject to demonstration of satisfactory performance on other similar contracts before the commencement of testing.

Where required in the Special Specifications, the Contractor shall submit the name of the specialist or integrity testing firm, a description of the test equipment, a test method statement and a programme for executing the specified tests prior to commencement of the Works.

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v. Interpretation of tests

The interpretation of tests shall be carried out by competent and experienced persons. The Contractor shall give all available details of the ground conditions, pile dimensions and construction method to the specialist before the commencement of integrity testing in order to facilitate interpretation of the tests.

vi. Report

Preliminary results of the tests shall be made available within 24 hours of carrying out the tests. The test results and findings shall be recorded and made available within 10 days of the completion of each phase of testing. The report shall contain a summary of the method of interpretation including all assumptions, calibrations, corrections, algorithms and derivations used in the analyses. If the results are presented in a graphical form, the same scales shall be used consistently throughout the report. The units on all scales shall be clearly marked.

vii. Anomalous results

In the event that any anomaly in the acoustic signal is found in the results indicating a possible defect in the pile the Contractor shall demonstrate that the pile is satisfactory for its intended use or shall carry out remedial works to make it so. Sonic logging tubes shall be grouted up after the Contractor has demonstrated that the pile is satisfactory.

b. Static Load Tests

i. General

The Engineer may order certain selected piles to be load tested. The procedure for loading tests shall comply with the requirements of BS 8004 and SECTION 7100. During the period of testing, driving of other piles or other activities which may affect the testing shall cease.

The Engineer may specify Maintained Load (ML) or Constant Rate of Penetration (CRP) Tests.

No working pile shall be used as an anchor pile. Where anchor piles or earth anchors are required for providing reaction, they shall be at least three test pile diameters and no less than 2.0 m distant from the perimeter of the test pile and be so placed as to have a minimal effect on the test results. The minimum distance of the anchor piles to the test piles shall be confirmed and approved by the Engineer.

The Contractor shall provide the complete testing assembly, the necessary constructional plant, equipment, instruments and labour for carrying out the test and for determining accurately the settlement of the piles under each increase or decrease of load. The test assembly, constructional plant, equipment and instruments used shall be subject to the approval of the Engineer.

ii. Test data

Within 24 hours of having completed the tests a preliminary copy of the test records shall be made available which shall show:

1. For a ML test; for each stage of loading, the period for which the load was held, the load and the maximum pile movement at the end of the stage.
2. For a CRP test; the maximum load reached and a graph of load against penetration.

The complete set of recorded data as detailed in the Special Specifications or requested by the Engineer shall be provided within 7 days of completion of the test.

iii. Loading

For ML tests the maximum test load applied in a proof test (working piles) shall be equal to the sum of the design verification load (DVL) plus 50 % of the specified working load (SWL).

The loading and unloading shall be carried out in stages as shown in TABLE 7116/1.

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TABLE 7116/1: MINIMUM LOADING TIMES FOR PILE TEST

Load*	Minimum Time of Holding Load
25% DVL	30 minutes
50% DVL	30 minutes
75% DVL	30 minutes
100% DVL	6 hours
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour
100% DVL	1 hour
100% DVL+ 25% SWL	1 hour
100% DVL+ 50% SWL	6 hours
100% DVL + 25% SWL	10 minutes
100% DVL	10 minutes
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour

*SWL denotes specified working load; DVL denotes design verification load.

The loading regime for CRP tests shall be defined by the Engineer unless otherwise provided in the Special Specifications. Soil conditions actually encountered in the test pile bore or established by test drilling at the site will be considered by the Engineer prior to confirmation of the loading regime. Loading shall be continued until one of the following results is obtained:

1. The maximum required test load as given in the Special Specifications or by the Engineer is reached
2. A constant or reducing load has been recorded for an interval of penetration of 10 mm
3. A total movement of the pile base equal to 10 % of the base diameter, or any other greater value of movement specified has been reached.

The load shall then be reduced in five approximately equal stages to zero load, penetration and load at each stage and at zero load being recorded.

c. Defective Piles

The test pile and the piles represented by the test pile shall be classified as defective if shown to be unable to achieve either the DVL or permissible settlement with the required minimum Factor of Safety.

Defective piles shall also include piles damaged beyond repair, piles with structural defects, or piles which do not comply with the tolerance requirements of SECTION 7800.

Any piles deemed to be defective may be downgraded and utilised in the works at the discretion of the Engineer. If required, the defective piles shall be corrected by the Contractor at their own cost, by applying one of the following methods approved by the Engineer:

- i. Extracting the pile and replacing it with a new pile.
- ii. Installing a new pile adjacent to the defective pile.
- iii. Lengthening the pile to the correct length if defective in length only.
- iv. Altering the design to fit in with the new conditions caused by the defective pile(s).

7117 Caissons

a. General

Caissons shall, for the purposes of these Specifications, be hollow concrete vessels which are wholly or partly constructed at a higher level and lowered by internal excavation or kentledge to the desired founding level to form structural bearing members. Caissons may be of circular, rectangular or any other shape and may contain one or more excavation compartments, all as detailed on the Drawings.

Unless otherwise specified hereafter, the provisions of BS 8004 shall apply for the construction of caissons.

The Contractor shall submit a detailed method statement for the Works for the approval of the Engineer prior to commencement of work. This shall include all necessary provisions for Health and Safety and a risk assessment. If the Contractor intends to adopt pneumatic methods (with use of a compressed air chamber) he must employ specialist personnel experienced in this type of work.

b. Construction and Sinking

A firm base shall be prepared on which the cutting edge of the caisson shall be laid horizontally. The level of the base shall be determined and shall be agreed between the Engineer and the Contractor, and shall serve as the ground surface from which the excavation inside the caisson will be measured.

Successive stages of the caisson shall be of convenient height, or as directed by the Engineer, and shall be lined up accurately with the preceding stages.

All precast elements shall have properly constructed joints in accordance with the Drawings to ensure that they fit correctly.

For in-situ phase construction, all construction joints in the walls shall be reinforced and the joints shall be made as specified in [CLAUSE 7408](#).

The lowest element of every caisson, which contains the cutting edges, shall be cured for at least four days or shall have attained at least 50 % of the specified 28 day strength before sinking is commenced. Subsequent elements shall be cast in sufficient time to ensure adequate strength for safely resisting the applied forces.

During construction and sinking the caissons shall be maintained in a vertical alignment.

The position and inclination of each caisson shall be determined accurately by measurement after every 2 m of sinking, or after sinking through the depth of one element, whichever distance is the smaller.

With a view to eliminating excess friction, the Contractor may use bentonite or a similar lubricant or a water-jet system.

Excavation inside caisson compartments shall, unless otherwise specified herein, comply with the provisions of [CLAUSE 7105](#).

In multi-compartmented caissons, the excavation in any one compartment shall not be taken deeper than 0.6 m below that in any other compartment, except where necessary for correcting deviations.

Cutting edges shall be frequently inspected or probed to locate obstacles, which shall be removed immediately.

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The Contractor shall supply all grabs, pumps, diving gear and other constructional plant required for sinking and founding all caissons and shall allow the Engineer to use the diving suit and equipment for inspection purposes.

The Contractor shall employ a competent diver to carry out work under water and shall make provision in the rates bid for the respective Items for this cost.

Where the caisson strikes a hard inclined layer and work has to be carried out below the cutting edge, such work shall be measured and paid for under the relevant Items of **CLAUSE 7118**, and, where no applicable Items exist, such work shall be paid for as extra work.

c. Founding

The soil or rock strata at the founding level, if sloping and/or irregular, shall in so far as is possible be cut to as nearly level a surface as possible until the entire cutting edge is evenly and firmly supported. Subject to the approval of the Engineer, blasting may be used for this purpose. If blasting techniques are required, only light charges may be used and the caisson shall be protected against damage by suitable cushioning.

Should the sloping surface be of hard rock which cannot be cut or broken by any safe and feasible means, the foundation shall be built up by means of a solid wedge of concrete which fills the entire space between the bedrock surface and the horizontal plane through the cutting edge. This concrete shall be of the same class as that specified on the Drawings or in the Bill of Quantities for the concrete seal.

The rock or hard material on which the structure is to be founded shall be completely uncovered. The founding surface shall be cleared of all loose material before inspection by the Engineer immediately prior to casting the concrete seal.

No concrete shall be placed in the wedge or the seal before the Engineer has inspected and approved the foundation. For this purpose the Contractor shall adequately dewater the caisson to enable the Engineer to conduct the inspection.

In the event of a caisson not being vertical or in its correct position when it has reached the required depth, or in the event of a caisson being cracked during the sinking process, the Contractor shall complete the necessary remedial work to the satisfaction of the Engineer at their cost.

d. Data

The Contractor shall provide the Engineer with a complete record of the strata encountered during excavation with levels related to an agreed datum. In addition, a daily record shall be kept showing full details of work undertaken, labour and plant utilised and the rate of sinking achieved.

e. Filling the Caissons

i. Concrete seal

The seal shall be constructed of mass concrete of the class specified and shall be placed in accordance with the dimensions and levels shown on the Drawings or as prescribed by the Engineer.

If this seal cannot be placed in the dry and has to be placed under water, the method of placing this concrete shall be approved by the Engineer. The Contractor shall cease placing the concrete under water when sufficient concrete has been placed to seal the foundation effectively.

After the concrete has been placed, the concrete seal and the head of water over it shall remain undisturbed for a period of at least seven days after which the caisson shall be dewatered by pumping for inspection. If water is found to be leaking into the caisson the process of sealing as specified herein shall be continued until the water level within the caisson does not rise at a rate exceeding 10 mm per hour or other rate to be agreed with the Engineer.

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The relevant requirements of SUBCLAUSE 7114(a) (ii) shall apply for placing concrete under water. For concrete placed under water by methods other than by tremie, the cement content shall be 20 % more than the quantity required for ordinary concrete of the same mix but shall be not less than 450 kg/m³ of concrete. The mix design may include additives and shall be approved by the Engineer.

ii. Filling

Subsequent to inspection of the caisson compartments above the concrete seal, the compartments shall be filled with sand of an approved grading and moisture content.

The first 2 m of filling above the concrete seal shall be lowered gently into position. The sand may then be poured from the top and compacted sufficiently to prevent settlement while the cover slab concrete is being placed.

The top of the sand fill within the caisson shall be finished off to the level specified below the underside of the caisson cover slab.

f. Stripping

Where the walls of the caisson have been overbuilt, the concrete shall be stripped to the required level without damage being done to the concrete below the cut-off level. The longitudinal reinforcement of the caisson shall project above the cut-off level by a distance of at least 40 times the bar diameter.

g. Concrete Blinding Below the Caisson Cover Slabs

A concrete blinding of the specified thickness and class of concrete shall be provided to the level shown on the Drawings over the area covered by the cover slab, including the area within the caissons on top of the sand filling, except where the underside of the cover slab is being formed with formwork.

h. Environmental Considerations

Water quality and marine life shall not be adversely affected in any way during operations.

Where adverse impacts have been indicated in the Environmental Impact Assessment Report, the Contractor shall carry out such measures as required to mitigate and minimise negative impacts to the water quality and marine life.

The Engineer shall approve all methods that the Contractor proposes according to the Environmental Impact Assessment Report.

7118 Measurement and Payment

Item	Unit
71.01 Additional Tests and Investigations:	
(a) Additional Tests and Investigations	Provisional Sum
(b) Other Additional Investigations	Provisional Sum

A provisional sum shall be provided in the Bill of Quantities to cover the cost of this work.

The work authorised by the Engineer shall be paid for in accordance with the provisions of the Conditions of Contract.

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Item	Unit
71.02 Excavation:	
(a) Excavation In Soft Material Situated Within The Following Successive Depth Ranges:	Cubic Metre (m ³)
i 0 m up to 2 m	Cubic Metre (m ³)
ii 2 m up to 4 m	Cubic Metre (m ³)
ii Further Increments of 2 m	Cubic Metre (m ³)
(b) Extra-Over SUBITEM 71.02(a) For Excavation In Hard Material Irrespective Of Depth	Cubic Metre (m ³)

The limits for the successive depth ranges shall be measured down from the surface levels described in SECTION 7100 to the founding level agreed on.

In the case of excavations that are required for diverting, channelling or widening watercourses, the successive depth ranges for those portions of the excavations that are within 5 m of a concrete structure shall be measured from the surface levels agreed on to the invert level of the channel or watercourse.

The unit of measurement shall be the cubic metre of material, measured in the original position before excavation. The quantity of excavation for each depth range shall be calculated from the neat outlines of the base or floor and the depth of excavation completed within each range.

Irrespective of the total depth of the excavation, the quantity of material within each depth range shall be measured and paid for separately.

At the concrete faces for which formwork has to be provided, additional excavation shall be included in the rate for excavation measured to the concrete perimeter. Provision for working space and for making excavations safe will be allowed for in the rate given by the Contractor.

Where foundation fill is constructed in an excavation, the quantity of excavated material measured for payment shall be the material excavated between the average ground level, as described in SUBCLAUSE 7105(b), and the founding level, from a prism with vertical sides, as described in CLAUSE 7109 or as prescribed by the Engineer.

In no case shall any of the following excavations be included in the measurement for payment:

- i. The volume of excavation in excess of the above mentioned limits.
- ii. The volume included within the excavated road prism, contiguous channels, ditches, etc, for which payment is provided elsewhere in the Specifications.

The bid rates shall include full compensation for excavation in each class of material, the spoiling or stockpiling of materials, the hauling of excavated material for the free haul distance as defined in SUBCLAUSE 1602(c), any additional excavation the Contractor may require for additional working space outside the authorised limits, trimming and cleaning the bottoms and sides of excavations, and strutting, shoring and safeguarding the excavations.

If after a foundation excavation has been completed, cleaned and trimmed ready for concrete blinding, the Engineer orders further excavations to be made on account of changed dimensions and/or founding conditions, an extra over payment (SUBITEM 71.02(b)) on the additional excavation measured for payment shall be payable in full compensation for any incidentals to the Contractor over and above the normal excavation costs.

Item	Unit
71.03 Access and Drainage:	
(a) Access	Lump Sum
(b) Drainage, Where No Lump Sum Access Has Been Provided	Lump Sum

The bid lump sum shall include full compensation for providing access which, inter alia, shall include constructing temporary banks, artificial islands and/or cofferdams; their protection, safeguarding and maintenance; draining and keeping dry the working areas; draining the excavations within the access; and any incidentals in respect of work to be done below standing water.

75 % of the lump sum will be paid when the access has been constructed. The remaining 25 % will be paid after the access has been removed.

Payment will be made for this work by way of a lump sum for each structure or SERIES of structures appearing separately in the Bill of Quantities. The lump sum shall be paid on a pro rata basis as the work progresses.

The bid lump sum shall include full compensation for draining by pumping or in any other way and for any other work necessary for keeping the excavation dry or for working in the dry.

Item	Unit
71.04 Backfill to Excavations Utilising:	
(a) Material From The Excavations	Cubic Metre (m ³)
(b) Imported Material	Cubic Metre (m ³)
(c) Soil Cement	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of backfill material measured in the excavation, excluding the volume occupied by the structure. The quantity measured shall be calculated from within the neat outlines defined for the excavation under ITEM 71.02 and the height to which the backfilling is constructed. The volume occupied by the structure shall be subtracted when calculating the volume of backfilling.

The height shall be determined by the upper surface of the road prism or the reference ground surface (SUBCLAUSE 7105(b)), whichever is the lower.

The bid rates shall include full compensation for furnishing and placing all materials within the entire excavation, transporting the material and preparing, processing, shaping, watering, mixing and compaction of the material to the specified densities.

No overhaul shall be paid.

Item	Unit
71.05 Foundation Fill Consisting of:	
(a) Rock Fill	Cubic Metre (m ³)
(b) Crushed Stone Fill	Cubic Metre (m ³)
(c) Compacted Granular Material	Cubic Metre (m ³)
(d) Mass Concrete (Class Indicated)	Cubic Metre (m ³)
(e) Concrete Blinding (Thickness and Class of Concrete Indicated)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of approved material placed and compacted below the bases as specified or where directed by the Engineer.

The quantity of foundation fill to be measured for payment shall be the material contained within the prism specified in CLAUSE 7109 or shall otherwise be the quantity to the outlines shown on the Drawings or as directed by the Engineer.

The bid rates shall include full compensation for procuring, furnishing, transporting, placing and compaction of the material.

No overhaul shall be paid.

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Item		Unit
71.06	Establishment On The Site For The Drilling Of Holes (Type Of Drilling Indicated):	Lump Sum

The bid lump sum shall include full compensation for establishment on the site, moving to individual bridge positions and the subsequent removal of all special plant for drilling the holes and additional plant for carrying out operations, the cost of which does not vary with the actual amount of work to be done.

This work will be paid for by way of a lump sum, 75 % of which will become payable when all the equipment is on the site and the first hole has been drilled. The remaining 25 % will become payable after all the holes have been drilled and the equipment has been removed from the site.

Item		Unit
71.07	Drilling Of Holes (Diameter And Type Of Drilling Indicated):	Metre (m)

The unit of measurement shall be the metre of hole drilled.

The bid rate shall include full compensation for drilling and clearing the holes as specified, equipment moving and setting up in position, drilling and clearing the holes as specified. Where no provision has been made for payment in the Bill of Quantities under ITEM 71.09, the bid rate shall also include full compensation for work falling under that Item.

Item		Unit
71.08	Grouting (Type Of Grout And For Which Purpose It Is Required Indicated):	Kilogram (kg)

The unit of measurement for grouting shall be the kilogram of cement or proprietary brand of grout mix as may be applicable used in the grouting operation.

The bid rate shall include full compensation for providing the equipment and all the material, and mixing and pumping the grout into the prepared holes in accordance with the instructions of the Engineer, and also for the water-pressure tests.

Item		Unit
71.09	Dowel Bars (Type, Diameter And Length Of Dowel Bars Together With Type Of Grout, Indicated):	Kilogram (kg)

The unit of measurement for the dowel bars shall be the kilogram of bars provided and secured in position. The bid rate shall include full compensation for supplying all the material and positioning and grouting the dowel bars as specified.

Item		Unit
71.10	Foundation Lining (Type Of Material And Thickness Indicated):	Square Metre (m ²)

The unit of measurement for foundation lining shall be the square metre of concrete surface lined.

The bid rate shall include full compensation for procuring, furnishing, lapping and placing all material and for all labour and incidentals required for completing the work as specified.

Item		Unit
71.11	Establishment On The Site For Piling:	Lump Sum

The bid lump sum shall include full compensation for generally levelling the piling site, establishing on the site and subsequently removing all structural platforms, rafts, piling mats and all special constructional plant and equipment for foundation piling and for carrying out operations, the cost of which does not vary with the actual amount of piling done.

This work will be paid for by way of a lump sum, 50 % of which will become payable when all equipment is on the site and the first pile has been installed. The second instalment of 25 % of the lump sum will be payable after half the total number of piles have been installed, and the final instalment of 25% after all the piles have been completed and the equipment has been removed from the site.

Item	Unit
71.12 Moving To, And Setting Up The Equipment At Each Position For Installing The Piles:	Number (No.)

The unit of measurement shall be the number of positions to which the installation equipment has to be moved and set up in position. The quantity measured shall be the number of piles installed plus the number of piles redriven on the instruction of the Engineer, plus any piles provided in addition for load tests, which do not form part of a specific pile group.

Item	Unit
71.13 Augered Or Bored Holes For Piles With A Diameter Of (Diameter Indicated) Through Material Situated Within The Following Successive Depth Ranges:	
(a) Augered Holes:	Metre (m)
i 0 m up to 10 m	Metre (m)
ii Exceeding 10 m, up to 15 m	Metre (m)
iii Further Increments of 5 m	Metre (m)
(b) Bored Holes:	Metre (m)
i 0 m up to 10 m	Metre (m)
ii Exceeding 10 m, up to 15 m	Metre (m)
iii Further Increments of 5 m	Metre (m)

The limits for the successive depth ranges shall be measured down from the average ground surface (SUBCLAUSE 7113(h)) to the agreed founding level (CLAUSE 7106).

The unit of measurement shall be the metre of hole, including the depth of the bulbous base formed, as may be applicable. The depth of the bulbous base shall be deemed to be equal to the diameter of a sphere, the volume of which shall be equal to the quantity of compacted concrete in the bulbous base.

Irrespective of the total depth of the hole, the quantity within each depth range shall be measured and paid for separately.

The bid rates for forming augered holes shall include full compensation for augering and disposing of surplus material resulting from the hole having been formed.

The bid rates for forming bored holes shall include full compensation for boring, supplying, installing and extracting the driven temporary casing as well as for disposing of surplus material resulting from the hole having been formed.

Item	Unit
71.14 Driving The Temporary Casing For Driven Displacement Piling Systems For Forming Holes For Piles With A Diameter Of (Diameter Indicated) Through Material Situated Within The Following Successive Depth Ranges:	
(a) 0 m up to 10 m	Metre (m)
(b) Exceeding 10 m, up to 15 m	Metre (m)
(c) Further Increments of 5 m	Metre (m)

The limits for the successive depth ranges shall be measured down from the average ground surface to the agreed founding level (CLAUSE 7106).

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The unit of measurement shall be the metre of hole plus the depth of bulbous base formed as may be applicable. The depth of the bulbous base shall be deemed to be equal to the diameter of a sphere, the volume of which shall be equal to the quantity of compacted concrete in the bulbous base. Irrespective of the total depth of the hole, the quantity within each depth range shall be measured and paid for separately. The bid rates shall include full compensation for supplying, driving and subsequently extracting the temporary casing.

Item	Unit
71.15 Manufacturing, Supplying And Delivering Prefabricated Piles (Type And Size Indicated)	Metre (m)

The unit of measurement shall be the metre of accepted prefabricated pile delivered on the site in accordance with the Engineer's written instructions.

The bid rate shall include full compensation for supplying all the materials, manufacturing, transporting and delivering to the point of use and handling the prefabricated piles.

Item	Unit
71.16 Installation Of Prefabricated Piles (Type And Size Indicated) Through Material Situated Within The Following Successive Depth Ranges:	
(a) 0 m up to 10 m	Metre (m)
(b) Exceeding 10 m, up to 15 m	Metre (m)
(c) Further Increments of 5 m	Metre (m)

The limits for the successive depth ranges shall be measured down from the average ground surface to the founding depth agreed on (CLAUSE 7106).

The unit of measurement shall be the metre of prefabricated pile installed. That part of the prefabricated pile projecting above the average ground surface shall not be measured and paid for.

Irrespective of the total length of pile installed, the quantity installed within each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for hoisting and driving the pile.

Item	Unit
71.17 Extra Over ITEM 71.16, Irrespective Of The Depth To Form Augered And Bored Pile Holes Through Identified Obstructions Consisting Of:	
(a) Dense Gravel With An "N" Value Greater Than 50 Or Coarse Gravel And Cobbles With Maximum Gravel Content Of Less Than (Maximum Percentage Indicated)	Metre (m)
(b) Boulders (Description Of And Maximum Size Indicated)	Metre (m)
(c) Rock Formation (Description And Class Of Rock Indicated)	Metre (m)

The unit of measurement shall be the metre of pile hole formed through the identified obstruction, measured from the depth at which the identified obstruction is encountered to the depth at which normal auger drilling or boring can be resumed or another type of identified obstruction is encountered.

The bid rates shall include full compensation for all additional work and incidentals required for forming the pile hole through the identified obstruction.

Where obstructions other than those provided for in ITEM 71.19 can be identified, they shall be described on the Drawings and/or in the Special Specifications. Provision therefore shall be made in the Bill of Quantities under extensions to ITEM 71.19.

Item	Unit
71.18 Forming Augered And Bored Pile Holes Through Unidentified Obstructions	Provisional Sum

A provisional sum shall be allowed in the Bill of Quantities for covering the cost of this work.

Payment for the work authorised by the Engineer shall be in accordance with the provisions of the Conditions of Contract.

Item	Unit
71.19 Driving Temporary Casings For Driven Displacement Piling Systems Or Installing Prefabricated Piles Through Identified Or Unidentified Obstructions	Provisional Sum

A provisional sum shall be allowed in the Bill of Quantities for covering the cost of this work.

The method of payment for the work authorised by the Engineer shall be in accordance with the provisions of the Conditions of Contract.

Item	Unit
71.20 Extra over ITEMS 71.16, 71.17 and 71.19 for Raking Piles	Provisional Sum
(a) Holes For Piles Of (Diameter And Rake Indicated)	Metre (m)
(b) Temporary Casing For Driven Displacement Pile Systems (Diameter And Rake Indicated)	Metre (m)
(c) Prefabricated Piles (Type, Size And Rate Indicated)	Metre (m)

The bid rates shall include full compensation for all additional work and incidentals for forming the pile holes or for driving and later extracting the temporary casing, or for installing prefabricated piles to the rake shown.

Item	Unit
71.21 Forming Underreams For Piles Of (Diameter Indicated)	Number (No.)

The unit of measurement shall be the number of pile holes underreamed. The bid rate shall include full compensation for all work to be done in forming the underreams, but shall exclude the concrete work.

Item	Unit
71.22 Forming The Bulbous Bases For Piles Of (Diameter Indicated)	Number (No.)

The unit of measurement shall be the number of bulbous bases formed.

The bid rate shall include full compensation for all work to be done in forming the bulbous bases but shall exclude the concrete work.

Item	Unit
71.23 Socketing Piles Into Rock Formation (Class Of Rock And Length Of Socket Indicated)	Number (No.)

The unit of measurement shall be the number of sockets, the length of which shall be not less than the specified length, formed in rock, the hardness of which shall be not less than that of the specified class of rock.

The bid rate shall include full compensation for all work to be done for drilling into the rock formation.

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Item		Unit
71.24	Installing And Removing Temporary Casings In Augered Holes For Piles Of (Diameter Indicated)	Metre (m)

The unit of measurement shall be the metre of temporary casing installed as directed by the Engineer or shown on the Drawings. Only the installed temporary casing below the average ground surface (SUBCLAUSE 7113(h)) shall be measured for payment.

The bid rate shall include full compensation for supplying, installing and removing the temporary casings.

Item		Unit
71.25	Installing Permanent Pile Casing for Piles of (Diameter Indicated)	Metre (m)

The unit of measurement shall be the metre of permanent casing installed as instructed by the Engineer or shown on the Drawings. The bid rate shall include full compensation for supplying and installing permanent pile casing.

Item		Unit
71.26	Steel Reinforcement In Cast In Situ Piles:	
(a)	Mild-Steel Bars	Tonne (t)
(b)	High-Yield-Stress-Steel Bars (Type Indicated)	Tonne (t)

The unit of measurement for steel bars shall be the tonne of reinforcement in place in accordance with the Drawings or as authorised.

Ties and other steel used for keeping the reinforcing steel in position shall be measured as steel reinforcing under the appropriate item.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial welds, placing and fixing the steel reinforcing, including all tying wires, spacers and waste.

Item		Unit
71.27	Cast In Situ Concrete In Piles, Underreams, Bulbous Bases and Sockets (Class Of Concrete Indicated)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of concrete placed in the cast in situ piles underreams, bulbous bases and sockets. The quantity shall be calculated from the nominal pile diameter and length of pile from the founding level to the specified cutting-off level, plus the additional quantity of concrete in the under-ream and bulbous base as may be relevant.

The bid rate shall include full compensation for supplying and storing all material, providing all constructional plant, mixing, transporting, placing and compacting the concrete, curing the concrete and repairing defective concrete. Payment shall distinguish between the different classes of concrete.

Item		Unit
71.28	Extra Over ITEM 71.30 For Concrete Cast Under Water	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of concrete cast under water, the quantity being calculated as for ITEM 71.30.

The bid rate shall include full compensation for all additional work, incidentals and extra cement or additives required for placing the concrete under water.

Item		Unit
71.29	Splicing/Coupling Prefabricated Piles For Lengthening (Size Of Pile Indicated)	Number (No.)

The unit of measurement shall be the number of splices/couplings in prefabricated piles for each size of pile. The bid rate shall include full compensation for all work required for splicing/coupling the piles in accordance with the Specifications.

Item		Unit
71.30	Stripping/Cutting The Pile Heads (Type And Diameter/Size Of Pile Indicated)	Number (No.)

The unit of measurement shall be the number of heads of each type and diameter/size of pile stripped/cut.

The bid rate shall include full compensation for providing all tools and stripping/cutting the pile heads.

Item		Unit
71.31	Establishment On The Site For The Load Testing Of Piles	Lump Sum

The bid lump sum shall include full compensation for the establishment on the site and subsequently removing all the special constructional plant and equipment required for conducting the load tests on piles. This cost does not vary with the number of load tests to be conducted.

Payment for this work shall be made by way of a lump sum, 100% of which will be paid after the testing assembly has been completely assembled and the first load test has been started.

Item		Unit
71.32	Load Tests On Piles (Compression/Tension Test, Diameter/ Size, Specified Working Load Indicated)	Number (No.)

The unit of measurement shall be the number of load tests conducted on the instruction of the Engineer, for each specified working load.

Test piles, but not anchor piles and anchors, shall be measured as specified above for permanent piles. Anchor piles and anchors shall be deemed to form part of the testing equipment under this Item.

The bid rate shall include full compensation for installing the anchor piles and anchors where necessary; conducting load tests, and processing and submitting the results.

Item		Unit
71.33	Establishment On The Site For Core Drilling	Lump Sum

The bid lump sum shall include full compensation for the establishment on the site and subsequently removing all the equipment required for conducting the core drilling. This cost does not vary with the quantity of work to be done. This work shall be paid for by way of a lump sum, 100 % of which will become payable when the equipment has been set up at the first location and drilling has started.

Item		Unit
71.34	Moving The Equipment To And Assembling It At Each Location Where Cores Are To Be Drilled	Number (No.)

The unit of measurement shall be the number of locations to which the core-drilling equipment is to be moved and at which it has to be assembled.

The bid rate shall include full compensation for the cost of moving and assembling the equipment.

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Item	Unit
71.35 Drilling the Cores (Diameter Indicated) in:	
(a) Concrete	Metre (m)
(b) Founding Formation	Metre (m)
i Irrespective Of Hardness	Metre (m)
ii With a Hardness of (Hardness Indicated)	Metre (m)

The unit of measurement shall be the metre of hole drilled. The bid rate shall include full compensation for drilling, recovering and packing the cores, keeping the drilling records, providing core boxes, providing and installing the casings, and backfilling the holes with grout.

Item	Unit
71.36 Formwork For Caissons (Class Of Finish Indicated)	Square Metre (m ²)

The unit of measurement shall be the square metre of formwork, and only the area of formwork in contact with the finished face of the concrete shall be measured. Formwork for construction joints shall be measured for payment under Class F1 surface finish but shall be measured only for construction joints shown on the Drawings or as prescribed by the Engineer.

The bid rate shall include full compensation for supplying all the materials, erecting the falsework and formwork, constructing the forms, forming the grooves, fillets, chamfers, stopends for construction joints, treating the forms, all accessories, and stripping and removing the formwork after completion of the work. Payment for formwork shall be made only after the formwork has been stripped and the surface finish approved.

Item	Unit
71.37 Steel Reinforcement for Caissons:	
(a) Mild Steel Bars	Tonne (t)
(b) High Yield Stress Steel Bars (Type Indicated)	Tonne (t)

The unit of measurement for steel bars shall be the tonne of reinforcement in place in accordance with the Drawings or as may have been authorised.

Ties and other steel used for positioning the reinforcing steel shall be measured as steel reinforcing under the appropriate item.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial welding joints, placing and fixing the steel, including all tying wire, spacers and waste.

Item	Unit
71.38 Cast In Situ Concrete In Caissons And Concrete Seals (Class Of Concrete Indicated)	Cubic Metre (m ³)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Concrete quantities in the caissons shall be calculated from the dimensions shown on the Drawings or authorised by the Engineer, and the length of the caisson from the founding level to the specified cut-off level. The quantity of concrete in the concrete seal shall be calculated in accordance with the dimensions shown on the Drawings or authorised by the Engineer.

The bid rate shall include full compensation for procuring and furnishing all the materials, storing the material, providing all constructional plant, mixing, transporting, placing and compacting the concrete, all sealing, curing the concrete and repairing defective concrete. Payment shall distinguish between the different classes of concrete.

Item	Unit
71.39 Cutting Edge For (Diameter/Size Indicated) Caissons	Number (No.)

The unit of measurement shall be the number of caissons provided with cutting edges, irrespective of the material they have been constructed of.

The bid rate shall include full compensation for manufacturing, supplying, delivering and installing the complete cutting edge as well as for joining the cutting edge to the caisson unit. Where the cutting edge is of concrete and forms part of the bottom element, the bid rate shall include full compensation for all additional work required for completing the element.

Item	Unit
71.40 Sinking (Diameter/Size Indicated) Caissons Through Material Situated Within The Following Successive Depth Ranges:	
(a) 0 m up to 5 m	Metre (m)
(b) Exceeding 5 m and up to 10 m	Metre (m)
(c) Further Increments of 5 m	Metre (m)

The limits of the successive depth ranges shall be measured down from the firm horizontal base (SUBCLAUSE 7117(b)) to the agreed founding level (CLAUSE 7106).

The unit of measurement shall be the metre of caisson sunk.

Irrespective of the length of caisson sunk, the quantity for each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for locating and holding in position, dewatering, pumping, kentledge and lubricating the sides of the caisson, and for all work in connection with the sinking of the caisson which is not paid for elsewhere.

Item	Unit
71.41 Excavation for Caissons:	
(a) Excavating Soft Material Situated Within The Following Successive Depth Ranges:	Cubic Metre (m ³)
i 0 m up to 2 m	Cubic Metre (m ³)
ii Exceeding 2 m, up to 4 m	Cubic Metre (m ³)
iii Further Increments of 2 m Depths	Cubic Metre (m ³)
(b) Extra Over SUBITEM 71.44(a) For Excavation In Hard Material Irrespective Of Depth	Cubic Metre (m ³)

The limits for the successive depth ranges shall be measured down from the firm horizontal base (SUBCLAUSE 7117(b)) to the excavated level inside the caisson.

The unit of measurement shall be the cubic metre of material, measured in the original position before excavation. The quantity of excavation for each depth range shall be calculated from the gross area of the caisson in plan and the depth of excavation completed within each depth range.

Irrespective of the total depth of excavation, the quantity of material within each depth range shall be measured and paid for separately. The bid rates shall include full compensation for excavation in the classified material, spoiling or stockpiling the material, hauling the excavated material for the free haul distance according to SUBCLAUSE 1602(c), trimming the bottom of the excavation, dewatering, pumping and removing the material leaking into the caisson before sealing.

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Item		Unit
71.42	Filling the Caissons:	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of sand placed above the concrete seal in the caisson compartments.

The bid rate shall include full compensation for supplying and placing the sand, transporting the material and compaction of the material as specified.

No overhaul shall be paid.

Item		Unit
71.43	Stripping The (Size Of Caisson Indicated) Caisson Heads:	Number (No.)

The unit of measurement shall be the number of caissons of each size stripped.

The bid rate shall include full compensation for cutting away, trimming and disposing of the concrete removed.

Item		Unit
71.44	Establishment On The Site For The Integrity Testing Of Piles	Lump Sum

Item		Unit
71.45	Integrity Tests On Piles (Type Of Test To Be Defined):	Cubic Metre (m ³)

The bid rates shall include full compensation for procuring and furnishing all materials, constructional plant, equipment, labour and incidentals for performing the prescribed integrity tests, complete as specified.

SECTION 7200 Falsework, Formwork & Concrete Finish

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7201 Scope

This section covers the design, supply, erection and removal of all falsework and formwork used in the construction of permanent work. This section also describes the classes of surface finishes on formed and unformed concrete surfaces.

7202 Materials

a. General

The materials used in the construction of falsework and formwork shall be suitable for the purpose for which they are required and be of such quality as to produce the specified standard of work. The type, grade and condition of the material shall be subject to the Engineer's approval.

b. Falsework

The timber, structural steel and scaffolding used shall be free from defects that may prejudice the stability of the falsework. The jacks, devices, clamps and fittings shall all be in a good working order and of adequate design and strength.

c. Formwork

i. Timber

1. Tongue-and-groove boarding

Tongue and-groove boarding or grooved boards and plastic foam strips shall be used for smoothest possible board marked finishes. Suitably dried timber shall be used which will not warp, distort or cause discolouration of the concrete. The boards shall be of uniform width and as specified on the Drawings or in the Bill of Quantities or as prescribed by the Engineer. Boards shall be supplied in lengths not shorter than 3 m.

2. Plywood

Exterior grade plywood shall be used. Panels shall be used with the grain of the outer face parallel to the span. The maximum curvature of any plywood sheet shall be defined in relation to the sheet thickness and direction of grain. All sheets in any continuous curved form shall be aligned with the grain in the same direction.

ii. Steel forms to exposed surfaces

For classes F2 and F3 surface finish as defined in SUBCLAUSE 7207, the individual panels shall be assembled sufficiently rigidly and so clamped as not to deform or kick during handling, vibration or under the pressure of the wet concrete.

The surfaces of forms which are to be in contact with the concrete shall be clean, free from deposits or adhering matter, ridges or spatter which will impart irregularities and blemishes to the concrete surface, and shall also be free from indentations and warps. Mould oil with rust inhibiting properties shall be used.

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iii. Void formers

Void formers used in permanent work shall be subject to the approval of the Engineer.

Where void formers of a special design are required, details thereof will be specified.

Void formers shall be manufactured from material which will not leak, tear or be damaged during the course of construction and shall be of such tight construction as to prevent undue loss of the mortar component of the concrete through leakage. The units shall be sufficiently rigid so as not to deform during handling or under the pressure of the wet concrete.

For mild-steel spiral-lock-formed void formers, the metal thickness shall be as follows, unless otherwise specified:

1. Unbraced void formers

- 0.6 mm for diameters of up to 600 mm.
- 0.8 mm for diameters exceeding 600 mm and up to 800 mm.
- 1.0 mm for diameters exceeding 800 mm and up to 1000 mm.

2. Braced void formers

- 0.6 mm for diameters of up to 800 mm.
- 0.8 mm for diameters exceeding 800 mm and up to 1000 mm.
- 1.0 mm for diameters exceeding 1000 mm and up to 1200 mm.
- 1.2 mm for diameters exceeding 1200 mm.

The thickness specified for braced void formers shall apply to formers internally braced with timber or equivalent braces. The braces shall be at spacing not exceeding 2 m and not further than 1.0 m from the end of each unit. Timber cross braces shall consist of members with cross-sectional dimensions of at least 50 mm x 50 mm.

All hollow void-former units shall be provided with a 12 mm diameter drainage hole at each end.

iv. Chamfer and recess fillets

Timber fillets used for forming chamfers and recesses on exposed surfaces shall be made from new material unless otherwise authorised.

v. Jack rods for sliding formwork

The jack rods, base plates and couplers shall be strong enough to carry the design load under all operating conditions without buckling, distorting or causing damage to the concrete. Jack rods which are to remain permanently embedded in the concrete shall comply with the requirements of CLAUSES 7303 and 7305. Under no circumstances shall bent rods be used in the work.

The jack rods used shall have a diameter of at least 25 mm.

vi. Permanent Formwork

Permanent formwork (also known as Stay-in-Place formwork) is a structure that is used to contain the green concrete placed in order to mould it into the required dimensions and support it until it is able to support itself and can be participating or non-participating permanent formwork. The participating permanent formwork is a structurally participating element forming an integral connection with the permanent works. The non-participating permanent formwork is not structurally participating in the permanent works.

Typical participating permanent formwork used for bridge deck include precast reinforced concrete planks. Typical non-participating permanent formwork include glass fibre reinforced concrete (GRC), glass reinforced plastic (GRP) and profiled steel sheeting (PSS) systems.

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7203 General

Notwithstanding approval given by the Engineer for the design and drawings prepared by the Contractor and the acceptance of the falsework and formwork as constructed, the Contractor shall remain solely responsible for the safety and adequacy of these temporary works and the Contract Insurances shall fully indemnify the Employer and Engineer in this respect.

For Works on, over, under or adjacent to any railway line which is controlled by a Rail Authority, the Contractor shall comply, inter alia, with the requirements for the preparation and submission of drawings for falsework and formwork, and the submission of certificates for the proper construction thereof, all in accordance with the relevant Rail Authority Specification.

After having constructed the falsework and formwork, and prior to placing the reinforcing steel and/or the concrete, the Contractor shall inspect the falsework and formwork to confirm that the work complies in all respects with the Specifications. Dimensions shall be checked, unevenness of surface shall be corrected, and special attention paid to the adequacy and tightness of all bolts, ties and bracings as well as to the soundness of the foundations.

The Contractor shall give the Engineer at least 24 hours notice of intention to place the concrete to enable the Engineer to inspect all aspects of the completed work.

Wherever these Specifications or the Special Specifications or Drawings are silent in relation to the temporary or permanent works the relevant clauses of BS EN 1992 (Eurocode 2 – Design of Concrete Structures) shall apply.

7204 Design

a. General

The Contractor's design and drawings of the falsework and formwork shall comply with all statutory requirements which may be additional to those of the Contract.

The Engineer may require the Contractor to submit, at least 14 days before approval is required, all the design details and drawings of the falsework and formwork for any structure.

b. Falsework

The Contractor shall assess the allowable bearing pressure on the foundation material and shall design the footings and falsework to prevent overloading, differential settlement and unacceptable overall settlement in both wet and dry conditions.

In designing the falsework, cognisance shall also be taken of the redistribution of load that may occur due to temperature variations, wind forces, the prestressing of curved and skewed structures, stage construction, flooding and debris.

Particular attention shall be given to providing transverse and diagonal bracing as well as rib stiffeners on cross bearers.

c. Formwork

i. General

Formwork shall be so designed as to be sufficiently rigid to ensure that the specified dimensional tolerances can be achieved under the combined action of self-weight, dead load and imposed loads. The design shall consider loads resulting from the hydrostatic forces from wet concrete and the layer thickness of the concrete cast in one operation and the method of placing and compaction including impact of falling concrete and vibrations from compactive effort.

ii. Sliding formwork

The Contractor shall be responsible for the design of any sliding formwork. Prior to fabrication or bringing the sliding formwork and any additional equipment to the site, the Contractor shall

submit drawings of the complete sliding formwork assembly to the Engineer for approval. The drawings shall show full details of the forms, jacking frames, access ladders, hanging platforms, safety rails and curing skirts as well as details of the jacks and jack layouts.

The Contractor shall be required to submit to the Engineer, before slide casting commences, a method statement describing in detail: the sliding techniques; jacking procedure; methods of keeping the formwork level; the procedure to be adopted to prevent bonding of the concrete to the forms and a method for releasing the forms in the event of bonding; the instrumentation and monitoring of the slide casting and correcting for verticality, twisting and levelness; any other details required by the Engineer.

The formwork panels shall be inclined to give a small taper, the forms being slightly wider at the bottom than at the top.

The taper shall be so designed as to produce specified concrete thickness at the mid-lift level of the form.

The spacing of the jacks with their jack rods shall be so designed that the dead load of the sliding-formwork assembly, the frictional load, and the weight of materials, personnel and equipment will be evenly distributed and within the design capacity of the jacks used.

iii. Permanent formwork

The Contractor shall be responsible for the design of any permanent formwork. The Contractor shall submit design and drawings with full details of the permanent formwork to the Engineer for approval prior to execution of works. The permanent formwork shall meet the design requirements of strength and serviceability for actions during execution and in service. The construction sequence and the behaviour of the formwork during construction shall be considered in the design and to be checked for the design actions according to **RDM 4.2**.

The thickness at any point of precast reinforced concrete plank permanent formwork (floor plates) shall not be less than 60 mm. Upper surface of the floor plates used in bridges shall be always rough or indented.

Deflection limits for the permanent formwork shall be determined taking into account appearance and the movement of the formwork relative to the reinforcement. Deflection of the permanent formwork between completion of concreting and four hours later, with due allowance for the effect of creep, should not exceed 1/300 of the span. The formwork may be pre-cambered by not more than 1/150 of the span of the formwork unit.

The participating reinforced concrete plank permanent formwork, where used, shall meet the requirements of cover to reinforcement and concrete quality relevant to the environmental exposure class. A minimum of 20 mm cover shall be provided from upper surface of the participating concrete plank to the reinforcement in the in-situ concrete slab above.

Where non-participating permanent formwork systems are used, the relevant exposure class shall be applied to the in-situ concrete above the permanent formwork for cover requirements and concrete quality, ignoring the presence of the permanent formwork. A minimum of 20 mm cover shall be provided from upper surface of the non-participating permanent formwork to the reinforcement in the in-situ concrete slab above.

7205 Construction

a. Falsework

Falsework shall be erected in accordance with the approved drawings incorporating such modifications as required by the Engineer.

The Contractor shall take precautions to prevent deterioration of the foundations during the course of construction.

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The falsework shall incorporate features that will permit adjustment to the alignment of the formwork to counter the expected settlement and deflection under load.

b. Formwork

i. General

Formwork shall be erected to levels calculated from the information given on the Drawings. The levels shall be adapted to make provision for the specified precamber where required as well as for the expected deflection and settlement of the fully loaded falsework and formwork. The levels shall be set out and checked at intervals not exceeding 2.5 m.

For constructing the formwork, the Contractor may, subject to the provisions of **CLAUSE 7202**, use any material suitable for and compatible with the class of surface finish and dimensional tolerances specified for the particular member.

Formwork shall be sufficiently rigid to maintain the forms in their correct position, shape and profile and shall be of such tight construction that the concrete can be placed and compacted without undue loss or leakage of the mortar component of the concrete.

The joints between contiguous formwork elements shall be of a tight fit and, where necessary, the joints shall be caulked, taped or packed with a sealing gasket, all at no extra cost. Paper, cloth or similar material shall not be used for this purpose.

The formwork construction shall permit accurate erection and easy stripping without shock, disturbance or damage to the cast concrete. Where necessary, the formwork assembly shall permit the removal or release of side forms independently of the soffit forms.

Metal supports, ties, hangers and accessories embedded in the concrete shall be removed to a depth of not less than the cover specified for the reinforcement. No wire ties shall be used. The resultant voids shall be filled.

All external corners shall be chamfered by fillet strips being fixed into the corners of the formwork to form 25 mm x 25 mm chamfers. Re-entrant angles need not be chamfered unless specified.

Where polystyrene or similar material, susceptible to damage is used, it shall be lined with a hard surface on the side to be concreted. The hard material shall be sufficiently resilient to ensure that the required quality of work can be achieved.

Where detailed on the Drawings or provided for in the Special Specifications, all formwork ties shall be provided with recoverable truncated cones between sleeve ends and formwork faces to ensure that sleeve ends are not exposed on concrete surfaces. The cones shall have a minimum depth of 15 mm. The resultant voids shall be filled.

ii. Formwork to enclosed surfaces

The formwork and boards shall be so arranged as to form a uniform and regular pattern in line with, and perpendicular to, the main axis of the member unless otherwise approved or directed by the Engineer.

Joints between contiguous members shall, after caulking, taping or sealing, be treated to prevent blemishes, stains and undue marks from being imparted to the concrete surface.

Bolt and tie positions shall be so arranged that they conform to the symmetry of the formwork panels or boards. Bolt and rivet heads which will be in contact with the formed surface shall be of the countersunk type and shall be treated to prevent marks from forming on the concrete surface.

The formwork at construction joints shall be braced to prevent steps from forming in the concrete surfaces at the joints between successive stages of construction. Where moulding or recess strips are specified, they shall be neatly butted or mitred.

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iii. Formwork for open joints

The requirements for formwork for open joints shall, unless otherwise specified, apply only to cases where the distance between opposite concrete surfaces is equal to or less than 150 mm.

Formwork for open joints shall be constructed to produce a Class F1 surface finish to concealed surfaces or a Class F2 or F3 surface finish corresponding to the in-plane surface finish of the bordering concrete surfaces. The material used and construction of the formwork shall permit its complete removal to form the open joint.

No solvent shall be used to remove formwork unless approved by the Engineer.

iv. Openings and wall chases

Openings and wall chases shall be provided only where indicated on the Drawings or as authorised by the Engineer. Frames for openings shall be rigid and firmly secured in position to prevent their moving. Temporary holes shall be so formed that they will not create an irregular pattern in relation to the rest of the exposed, formed concrete surface.

v. Sliding formwork

1. Constructional plant and equipment

Unless otherwise specified in the Special Specifications, hoisting equipment for sliding formwork, which operates stepwise with upward movements of between 10 mm and 100 mm will be acceptable. However preference shall be given to the use of linked hydraulic or pneumatic jacks which are reversible and driven by an electrically operated pump and which can hoist at a steady rate. The jacks shall have independent controls for regulating vertical and horizontal alignment. The jacking system shall ensure that the sliding-formwork assembly can be hoisted evenly.

The use of hoisting systems which operate without jack rods shall be subject to the approval of the Engineer.

All equipment shall be thoroughly tested and inspected before installation and shall be maintained in a good working order throughout the entire sliding operation.

The Contractor shall keep adequate back-up constructional plant, equipment and quantities of materials on the site to ensure that the slide casting can proceed without interruption.

2. Instrumentation and monitoring

The Contractor shall supply and install suitable instrumentation on the sliding platform and foundations and against the sides of the structure for monitoring the height, verticality, levelness and twisting, at regular distances. The equipment used, its utilisation and the frequency of recording any readings shall be approved by the Engineer. The Contractor shall be responsible for all monitoring work and shall ensure that records of all readings and measurements taken are filed systematically and are at all times available to the Engineer and the person in control of the sliding operation.

Unless otherwise specified, the verticality of the structure shall be controlled with laser alignment apparatus or optical plummets and the levelness of the sliding forms with a water-level system with reference control points placed at strategic locations.

Height and verticality shall be monitored at intervals not exceeding four hours. The readings shall be plotted immediately on graphs. When the structure is more than 10 mm out of vertical, the Engineer shall be notified immediately.

3. Supervision

During the entire period of the sliding operation a competent person who is fully acquainted with the sliding technique and the Contractor's methods of construction shall be in attendance on the sliding platform and in control of the sliding operations.

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4. Construction

The jacking frame shall be constructed with adequate clearance between the underside of the cross members and top of the formwork to allow the horizontal reinforcement and embedded items to be correctly installed. A control procedure shall be agreed upon by the Contractor and the Engineer to ensure that all the reinforcement is placed. At all times there shall be horizontal reinforcement above the level of the top of the formwork panel.

Guides shall be provided to ensure that the vertical reinforcement can be correctly placed and the specified concrete cover over the reinforcement maintained.

Where the jack rods are to be recovered, adequate precautions shall be taken for their removal to prevent damage being caused to the concrete.

Where jack rods occur at openings or wall chases, adequate lateral support shall be provided to prevent buckling. Equipment and material shall be so distributed on the working platforms that the load will be evenly distributed over the jacks.

Guard plates shall be provided at the tops of the forms to the outside walls to prevent the concrete from falling down the outside.

The framework, forms and platforms shall be regularly cleared and the accumulation thereon of redundant concrete prevented.

The Contractor shall take all precautions to prevent contamination of the concrete by leaking oil or other causes.

5. The sliding process

The Contractor shall give the Engineer 24 hours' notice of intention to commence slide casting. Permission to commence shall not be given by the Engineer before the sliding-formwork assembly is fully operative and the complete stock of all materials required for the slide casting as well as back-up constructional plant and equipment are on the site.

The Contractor shall ensure that the rate of sliding is such that the concrete at the bottom of the formwork has obtained sufficient strength to support itself and all loads which may be placed on the concrete at the time, and that the concrete does not adhere to the sides of the forms.

The slide-casting operation shall be continuous, without any interruptions, until the full height of the structure has been reached, and shall be geared and organised so as to maintain an average rate of sliding of 350 mm per hour or such other rate appropriate for the concrete design and set to be approved by the Engineer.

6. Interruptions

When the sliding operations are delayed for more than 45 minutes, the Contractor shall prevent adhesion of the setting concrete to the formwork panels by easing the forms or moving them slightly every 10 minutes, or alternatively, where reversible jacks are used, by lowering the forms by 10 mm to 25 mm. Wherever interruptions occur, emergency construction joints shall be formed and treated in accordance with [CLAUSE 7408](#). Before concreting is restarted, the form shall be adjusted to fit snugly onto the hardened concrete so as to prevent steps from being formed on the exposed concrete surface. When slide casting is recommenced, care shall be taken to prevent the fresh concrete from being lifted off the old concrete.

vi. Void formers

Void formers shall be secured in position at regular intervals to prevent displacement and distortion during concreting. The void formers shall be supported on precast concrete blocks or rigid welded steel cradles, all subject to approval by the Engineer. The ties securing the

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void formers shall be attached to the formwork and cross bearers of the falsework. The void formers shall not be tied to or supported on the reinforcement.

Fibre-cement plates shall be supported so that the plate spans in the direction parallel to the orientation of the fibres. Asbestos is a banned and dangerous substance; as such asbestos fibres shall NOT be used.

vii. Preparing the formwork

Before any reinforcement is placed into position within formwork the latter shall be thoroughly cleaned and then dressed with a release agent. The agent shall be either a suitable oil incorporating a wetting agent, an emulsion of water suspended in oil or a low viscosity oil containing chemical agents. The Contractor shall not use an emulsion of oil suspended in water nor any release agent which causes staining or discolouration of the concrete, air holes on the concrete surface, or retards the set of the concrete.

Proprietary release agents shall be applied strictly in accordance with the manufacturer's instructions, and every precaution shall be taken to avoid the contamination of the reinforcement, pre-stressing tendons and anchorages.

Before the concrete is placed, all dirt and foreign matter shall be removed from the forms and the forms shall be thoroughly wetted with water.

viii. Permanent formwork

Prior to placing permanent formwork, the recess space in precast concrete beams intended to receive the formwork shall be inspected to confirm they have been well formed and that any dressing-off is carried out before placing the formwork to ensure an even seating.

The gaps between permanent formwork units shall be adequately sealed to prevent leakage through the gaps.

The precast reinforced concrete plank permanent formwork (floor plates) shall comply with BS EN 15050.

For composite steel and concrete structures where permanent formwork is used, a suitable compressible construction seal shall be placed between the steel member and the permanent formwork where they overlap, to prevent leakage of grout during subsequent concreting operations. On completion of the curing of the concrete a suitable proprietary adhesive sealant shall be placed along the external interface between the steelwork and the permanent formwork to prevent ingress of moisture. The sealant shall be compatible with the surfaces it will be in contact with and shall have comparable durability to the corrosion protection to the steelwork. In the case of the use of weather resistant steels no sealant shall be provided.

Profiled steel sheeting (PSS) permanent formwork systems shall not contain indentations which may form a shear connection with the in-situ concrete, unless otherwise specified. Protective treatment on edges and adjacent surfaces, including the edges of PSS which have been damaged by cutting, shall be restored.

Only single skin panels, either flat sheet or corrugated, shall be used for glass fibre reinforced concrete (GRC) permanent formwork. Polystyrene formers shall not be used in the corrugations of GRC permanent formwork. When ribbed glass reinforced polymer (GRP) permanent formwork is used, there shall be no filler materials such as expanded polystyrene placed between the GRP ribs, which would prevent full contact between the deck concrete and the surface of the ribbed panels.

Permanent formwork panels which have dimensions that do not comply with manufacturers' dimensional tolerances shall not be used in the works. Damaged panels including those that are cracked, split or have, in the case of the GRP type, exposed steel in the ribs, shall not be used in the works.

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Formwork panels shall be thoroughly cleaned to remove all traces of oil or grease. Any glass fibre reinforced cement (GRC) panel which cannot be cleaned by following the manufacturers' recommendations shall be replaced.

7206 Removal Of Falsework And Formwork

Falsework and formwork shall not be removed before the concrete has attained sufficient strength to support its own weight and any loads which may be imposed on it. In the absence of other information, for ordinary structural concrete made with Portland cement or Sulphate-resisting Portland cement of strength class 42.5 or above, the period before removal shall be in accordance with the minimum periods given in TABLE 7206/1. The TABLE 7206/1 relates to the surface temperature of the concrete but, when this cannot be obtained, air temperature may be used. The TABLE 7206/1 shall not be used if accelerated curing method or sliding forms are used.

It may be possible to use shorter periods before striking formwork by determining strength of the concrete in structural element. Where the concrete compressive strength is conformed by tests on concrete cubes stored under conditions that simulate the field conditions, formwork supporting concrete in bending may be removed when the cylinder/ cube strength is 12/15 N/mm² or the strength needed by design engineer, whichever is greater provided that removal at this time will not result in unacceptable deflection.

Formwork shall be removed only with the permission of the Engineer. The work of striking after the receipt of such permission shall be carried out in a controlled manner under the supervision of a competent foreman.

Where the Engineer considers the Contractor's proposals for the removal of formwork to be premature either on account of the weather or for any other reasons, he may order the Contractor to delay such removal and the Contractor shall have no claim for delay as a consequence thereof.

TABLE 7206/1: MINIMUM PERIOD BEFORE REMOVING FALSEWORK AND FORMWORK – PORTLAND CEMENT OR SULPHATE RESISTING PORTLAND CEMENT CONCRETE

Falsework And Formwork For	Minimum Period Before Removal		
	Surface Temperature Of Concrete		
	16°C	7°C	T°C (Any Temperature Between 0°C & 25°C)
Vertical formwork to columns, walls and large beams	12 hours	18 hours	300/(t+10) hours
Soffit formwork to slabs	4 days	6 days	100/(t+10) days
Props to slabs	10 days	15 days	250/(t+10) days
Soffit formwork to beams	9 days	14 days	230/(t+10) days
Props to beams	14 days	21 days	360/(t+10) days

Falsework and formwork shall be carefully removed without exposing the cast concrete to damage, disturbance or shock.

On continuously reinforced concrete structures the falsework and supporting formwork shall not be removed before the concrete of the last pour has reached the appropriate minimum age given in TABLE 7206/1 or the appropriate minimum strength. Where the structure is constructed in stages, the falsework and supporting formwork shall be removed as specified or authorised.

On prestressed-concrete structures the falsework and supporting formwork shall be removed after the full prestressing force relating to the particular stage of construction has been applied, unless otherwise specified or authorised.

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7207 Formed Surfaces, Classes Of Finish

a. General

In addition to complying with the tolerances specified in **CLAUSE 1904**, the surface finish on formed concrete surfaces shall also comply with the following requirements.

b. Class F1 Surface Finish

After repair work has been done to surface defects in accordance with **SUBCLAUSE 7208(b)**, no further treatment of the as-stripped finish will be required. This finish is required on concealed formed surfaces.

Surfaces that in the final stage will be covered with backfill shall have a finish of Class F1.

c. Class F2 Surface Finish

This finish shall be equivalent to that obtained from the use of square-edged timber panels and boards wrought to the correct thickness, or shutter boards or steel forms arranged in a regular pattern. This finish is intended to be left as struck but surface defects shall be remedied in accordance with **SUBCLAUSE 7208(b)**.

Although minor surface blemishes and slight discolouration will be permitted, large blemishes and severe stains and discolouration shall be repaired where so directed by the Engineer. This surface finish is intended for exposed formed surfaces that cannot readily be seen by the general public as in the case of culverts, remote structures and structures to which access is restricted.

d. Class F3 Surface Finish

This finish may be achieved by first producing a Class F2 surface finish with joint marks which form an approved regular pattern to fit in with the appearance of the structure. All projections shall then be removed, irregularities repaired and the surface rubbed or treated to form a smooth finish of uniform texture, appearance and colour. High quality steel forms or other forms with linings which may be neoprene, rubber or other approved, may be used to produce an F3 finish. Steel forms manufactured specifically for the project shall be approved by the Engineer.

An F3 surface finish is required on all exposed formed surfaces unless a Class F2 finish is specified.

e. Curved Surfaces

Plywood formwork or prefabricated steel forms may be used. Plywood shall be bent as described in **SUBCLAUSE 7202 (c)**. Class F2 finishes may be formed by dressing of tight surfaces formed on a face built up of splines cut to make the required curved surface. Any linings used to provide the final surface upon which the concrete is formed shall not bulge, wrinkle or otherwise deform when subjected to temperature and moisture changes.

f. Board Surface Finish

This finish shall be similar to F2 but obtained by using tongue-and-groove timber boarding arranged in an approved regular pattern. The finish is intended to be left as struck but surface defects shall be remedied in accordance with **SUBCLAUSE 7208(b)** and large fins trimmed where directed by the Engineer.

g. Treatment After Casting

The Special Specifications shall detail any treatments that may be required to give architectural finishes. These may include acid etching; blasting using sand or other abrasives; grinding or polishing; mechanical fracturing using scabbling or hammering tools.

h. Protecting The Surfaces

The Contractor shall ensure that all concrete surfaces are protected from rust marks, spillage and stains of all kinds and other damage during construction. The Contractor shall ensure that colour variations and physical irregularities are kept within acceptable limits in accordance with normal good practise.

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i. Tolerances

Where precast units have been set to a specified tolerance, further adjustments shall be made as necessary to produce a satisfactory straight or curved line. When the Engineer has approved the alignment, the Contractor shall fix the units so that there is no possibility of further movement.

TABLE 7207/1: TOLERANCES

Class of finish	Tolerances in mm (See Note)		
	A	B	C
F1	10	10	+25 to -10
F2	5	10	+ / - 15
F3	2	5	+ / - 10

Note: The tolerances A, B and C given in the table are defined as follows:

A is an abrupt irregularity in the surface due to misaligned formwork or defects in the face of the formwork.

B is a gradual deviation from a plane surface as indicated by a straight edge 3 m long. In the case of curved surfaces the straight edge shall be replaced by a correctly shaped template.

C is the amount by which the whole or part of a concrete face is displaced from the correct position shown on the Drawings.

7208 Remedial Treatment Of Formed Surfaces

a. General

Agreement shall be reached between the Engineer and the Contractor regarding any remedial treatment to be given after the surfaces have been inspected immediately after the formwork has been removed. The treatment shall be carried out without delay by the Contractor at their expense. No surfaces may be treated before inspection by the Engineer. Any concrete which is found to have been treated before inspection by the Engineer may be rejected.

b. Repairs to Surface Defects

Surface defects such as small areas of honeycombing, cavities produced by form ties, large isolated blow-holes, broken corner edges, etc, shall be repaired with mortar having a cement to sand ratio equal to that of the concrete being repaired.

For the repair of large or deep areas of honeycombing and defects, special approved methods and techniques such as pressure grouting, use of epoxy bonding agents, etc, may be used.

Where the extent of honeycombing or defects is deemed by the Engineer to be of such a degree that doubt exists about the effectiveness of repair work the Contractor shall perform a load test in accordance with SUBCLAUSE 7414(b) at their cost. If the test is not undertaken or fails to prove the structural safety of the repaired member, the structure shall be rebuilt in part or in full at the Contractor's cost.

Where the concrete has been damaged by adhesion to the formwork panel, the cracked and loose concrete shall be removed; or where the fresh concrete has lifted off at construction joints, the crack shall be scraped out immediately on both sides of the wall to a depth of at least 50 mm. The cavities so formed shall then be repaired as described above.

c. Rubbing the surfaces

If the finish of exposed formed surfaces does not comply with the requirements for uniformity of texture, appearance and colour, the Contractor shall, when so instructed by the Engineer, rub down the exposed surfaces of the entire structure or of any part of it as specified below.

The surface shall be saturated with water for at least one hour. Initial rubbing shall be done with a medium-coarse carborundum stone and application of a small amount of mortar having a sand to cement ratio equal to that of the concrete being repaired. Rubbing shall be continued until all form marks, projections and irregularities have been removed and a uniform surface has been obtained. The paste produced by the rubbing shall be left in place. The final rubbing shall be

carried out with a fine carborundum stone and water. This rubbing shall continue until the entire surface is of a smooth, even texture and is uniform in colour. The surface shall then be washed with a brush to remove surplus paste and powder.

Where the concrete surfaces formed by sliding formwork require treatment to achieve the surface finish specified for the member, the concrete shall, as soon as the surfaces under the formwork are exposed, be floated with rubber-lined floats to the desired finish.

7209 Unformed Surfaces: Classes Of Finish

a. Class U1 – Screeded Surface Finish (rough)

This surface finish is required on those portions of bridge decks or culvert decks which are to receive bituminous or concrete surfacing or which are to be covered by backfilling material.

Where the placing and compacting of the concrete have been completed as specified in **CLAUSE 7407**, the top surface shall be screeded off with a template to the required cross-section and tamped with a tamping board to compact the surface thoroughly and to bring mortar to the surface, so as to leave the surface slightly rough but generally at the required elevation.

b. Class U2 Floated Surface Finish

This surface finish is required on footways, the tops of wing walls and retaining walls, exposed concrete shoulders and unpaved areas on bridge decks, and the inverts of box culverts.

The surface shall first be given a Class U1 surface finish and after the concrete has hardened sufficiently, it shall then be wood-floated to a uniform surface free from trowel marks.

c. Class U3 Trowelled Surface Finish (smooth)

This surface finish shall be made at bearing areas and the tops of concrete railings, exposed upper surfaces of floor slabs and upper surfaces in contact with water. The surface shall first be given a Class U1 surface finish, and after the concrete has hardened sufficiently, it shall be floated with a steel float to a smooth surface to within the dimensional tolerances specified in **SUBCLAUSE 1904(h)**.

Rubbing with carborundum stone after the concrete has hardened shall be allowed but under no circumstances will plastering of the surface be permitted.

d. Class U4 Brushed Surface Finish (textured)

For non-skid surfaces such as on footways, bridge decks and exposed culverts, the surface shall be brought to a Class U2 finish and shall then be given a broom finish. The corrugations so produced shall be approximately 1.0 mm deep, uniform in appearance and width and shall be perpendicular to the centre line of the pavement.

Other surface finishes may be required which shall be detailed in the Special Specifications or on the Drawings.

7210 Measurement and Payment

Item	Unit
72.01 Formwork To Provide (Class Of Finish Indicated As F1, F2, F3 Or Board) Surface Finish To (Description Of Member To Which Applicable)	Square Metre (m ²)

Item	Unit
72.02 Vertical Formwork To Provide (Class Of Finish Indicated As F1, F2, F3 Or Board) Surface Finish To (Description Of Member To Which Applicable)	Square Metre (m ²)

Item		Unit
72.03	Horizontal Formwork To Provide (Class Of Finish Indicated As F1, F2, F3 Or Board) Surface Finish To (Description Of Member To Which Applicable)	Square Metre (m ²)

Item		Unit
72.04	Inclined Formwork To Provide (Class Of Finish Indicated As F1, F2, F3 Or Board) Surface Finish To (Description Of Member To Which Applicable)	Square Metre (m ²)

The unit of measurement shall be the square metre, and only the actual area of formwork in contact with the finished face of the concrete shall be measured. Formwork for the different classes of finish shall be measured separately. Formwork for construction joints shall be measured for payment under Class F1 surface finish, but only formwork for mandatory construction joints shall be measured for payment.

The bid rates shall include full compensation for procuring and furnishing all materials required, erecting the falsework and formwork, constructing the forms, forming the grooves, fillets, chamfers and stop-ends for construction joints, treating and preparing the forms, all bolts, nuts, ties, struts and stays, stripping and removing the formwork after completion of the work, all labour, equipment and incidentals, and rubbing and surface treatment. Payment of 80 % of the amount due for formwork will be made when the formwork has been removed, and payment of the remaining 20 % will be made on approval of the concrete surface finish.

Note: Vertical and horizontal formwork shall be the formwork of which inclination of the finishing surface in relation to the horizontal level shall be larger and smaller than 40° respectively. Inclined formwork shall be the formwork described as such in the Bill of Quantities.

Item		Unit
72.05	Permanent Formwork (Description Of Member To Which Applicable)	Square Metre (m ²)

The unit of measurement shall be the square metre of concrete area formed with permanent formwork.

The bid rates shall include full compensation for procuring and furnishing all the materials required, installing the formwork, and labour, equipment and incidentals.

Item		Unit
72.06	Formwork To Form Open Joints (Description Of Member To Which Applicable, And Location)	Square Metre (m ²)

The unit of measurement shall be the square metre of concrete area formed.

Surfaces formed prior to the construction of the final surface for completing the joint, shall be measured under ITEMS 72.01, 72.02, 72.03 or 72.04, as may be applicable.

The bid rate shall include full compensation for procuring and furnishing all the materials required, constructing the formwork and subsequently removing all the material within the joint space, as well as labour, equipment and incidentals. Payment for formwork to open joints shall be made only after the forms and filler material have been completely removed and approval of the surface finish has been obtained.

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Item		Unit
72.07	Establishment On The Site For Sliding Formwork Operations	Lump Sum

The bid lump sum shall include full compensation for the establishment on the site and the subsequent removal of the complete sliding-formwork assembly, special constructional plant and equipment and incidentals for the sliding work, the cost of which does not vary with the actual amount of sliding work done.

This work will be paid for by way of a lump sum, 75 % of which will become payable when the sliding-formwork assembly and constructional plant and equipment have been fully installed at the first structural member on the site. The remaining 25 % will become payable after all sliding work has been completed and the said Items have been removed from the site.

Item		Unit
72.08	Transporting To And Setting Up The Sliding Formwork Assembly At (Description Of Each Structure)	Number (No.)

The unit of measurement shall be the number of structures to which the complete sliding-formwork assembly has to be transported and set up in position ready to be commissioned.

The bid rate shall include full compensation for all costs involved in dismantling, transporting and erecting of the complete sliding-formwork assembly.

Item		Unit
72.09	Forming The Concrete By Sliding Formwork For (Description Of Each Structure And Class Of Surface Finish To Exposed Surfaces Indicated)	Metre (m)

The unit of measurement shall be the metre height of each structure formed by sliding formwork. The quantity measured shall be the actual height of each structure formed by the sliding technique.

The bid rate shall include full compensation for sliding, instrumentation and monitoring, the maintenance of the complete sliding-formwork assembly and constructional plant and equipment, supplying, installing and recovering the jack rods, floating, repairing and treating the concrete surfaces, forming the emergency construction joints, and all labour, equipment and incidentals.

SECTION 7300 Steel Reinforcement for Structures

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7301 Scope

This section covers the furnishing, inspection, testing, certification and placing of reinforcing steel in concrete structures.

7302 Materials

a. Steel Bars

All hot rolled and cold worked steel reinforcing bars shall comply with the requirements of BS 10080 and BS 4449 Grades B500B or B500C or comply equivalent standard on the approval of the Engineer unless otherwise noted on the Drawings. For each consignment of steel reinforcement delivered on the site, the Contractor shall submit a certificate issued by a recognised testing authority to confirm that the steel complies with the specified requirements.

b. Welded Steel Fabric

Welded steel fabric reinforcement shall be Grades B500A, B500B or B500C comply with the requirements of BS 10080 and BS 4483 or equivalent as approved by the Engineer. The steel fabric reinforcement shall have a minimum nominal bar size of 6 mm (8 mm for Grade B500A).

c. Mechanical Couplers

Mechanical couplers are used for splicing of reinforcing bars for the purpose of providing transfer of axial tension and/or compression from one bar to the other. All mechanical couplers used for splicing of reinforcing steel bars for concrete shall be subject to the approval of the Engineer and installed according to the manufacturer's instructions.

The couplers shall comply with the requirements of BS 8597 or equivalent as approved by the Engineer. The sampling, testing and evaluation of conformity shall be carried out in accordance with BS 8597.

i. Slip under static forces

The slip value in tension or compression measured for a simple coupler, consisting of no more than two load transmitting components, shall not exceed 0.10 mm.

ii. Strength under static forces

Tensile strength of the mechanical splice, for reinforcing bars to standard BS 4449, shall meet the requirements according to TABLE 7302/1.

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TABLE 7302/1: TENSILE STRENGTH REQUIREMENTS FOR MECHANICAL SPLICES

Grade	Minimum Tensile Strength R_m (MPa)
B500A	525
B500B	540
B500C	575

If couplers are used to connect bars of different diameters, the tensile strength shall be checked using the nominal cross-sectional area of the smaller reinforcing bar.

iii. Ductility under static forces

When mechanical splice tested for ductility, the total elongation at maximum force, A_{gt} , developed in the bar shall be measured and recorded. The A_{gt} shall not be a cause of rejection.

d. Definitions

For this SECTION 7300, the following definitions shall apply:

i. Bar

Ribbed reinforcing steel manufactured in straight lengths.

ii. Coil

Single length of reinforcing steel wound in concentric rings.

iii. Decoiled product

Reinforcing steel manufactured in coils and subsequently straightened for further processing.

iv. Ribbed reinforcing steel

Reinforcing steel with at least two rows of transverse ribs, which are uniformly distributed over the entire length.

v. Nominal size

The diameter of a circle with an area equal to the effective cross-sectional area of the bar.

vi. Batch

Any quantity of bars, coils or decoiled products of one nominal diameter and one cast, produced by one manufacturer, presented for examination at any one time.

vii. Characteristic strength

The value of yield strength having a prescribed probability of not being attained in a hypothetical unlimited test series. The characteristic value is the lower limit of the one sided statistical tolerance interval at which there is a 90 % probability (i.e. $1 - \alpha = 0.90$) that 95 % ($p = 0.95$) of the values are at or above this lower limit. This definition refers to the long term quality level of production.

7303 Storing The Materials

Reinforcing steel shall be stacked off the ground and, in aggressive environments, shall be stored under cover. It shall be protected at all times from contamination and corrosion.

7304 Inspection, Testing And Certification Of Steel For The Reinforcement Of Concrete

a. Product characteristics

i. Chemical composition

The values of individual elements and the values of the carbon equivalent shall not exceed the limits specified in TABLE 7304/1. In addition, all other internationally added elements, except those included within the carbon equivalent formula, shall be below the limit values specified in TABLE 7304/2.

The carbon equivalent value C_{eq} shall be calculated using the following formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

Where;

Mn = The percentage manganese content.

Cr = The percentage chromium content.

V = The percentage vanadium content.

Mo = The percentage molybdenum content.

Cu = The percentage copper content.

Ni = The percentage nickel content.

TABLE 7304/1 : CHEMICAL COMPOSITION (MAXIMUM % BY MASS)

	Carbon*	Sulphur	Phosphorus	Nitrogen**	Copper	Carbon equivalent
Cast analysis	0.22	0.05	0.05	0.12	0.80	0.50
Product analysis	0.24	0.055	0.055	0.014	0.85	0.52

* It is permitted to exceed the maximum values of carbon by 0.03% by mass, provided that the carbon equivalent value is decreased by 0.02% by mass.

** Higher nitrogen contents are permissible if sufficient quantities of nitrogen binding elements are present.

TABLE 7304/2: ELEMENT LIMITING VALUES (MAXIMUM % BY MASS)

Specified Element		Limit Value % by Mass
Al	Aluminium	0.30
B	Boron	0.0008
Bi	Bismuth	0.10
Co	Cobalt	0.30
Cr	Chromium	0.30
Cu	Copper	0.40
La	Lanthanides (each)	0.10
Mn	Manganese	1.65*
Mo	Molybdenum	0.08
Nb	Niobium	0.06
Ni	Nickel	0.30
Pb	Lead	0.40
Se	Selenium	0.10
Si	Silicon	0.60
Te	Tellurium	0.10
Ti	Titanium	0.05
V	Vanadium	0.10
W	Tungsten	0.30
Zr	Zirconium	0.05
Others (except carbon, phosphorus, sulphur, nitrogen, each)		0.10

* Where manganese is specified only as a maximum, the limit value is 1.80%.

During the product analysis, if any bar that falls outside the maximum specified limits in TABLE 7304/1, shall be deemed not to conform to BS 4449 standard.

In cases of dispute, where a product analysis falls outside the maximum limits specified in TABLE 7304/1, the procedure defined in SUBCLAUSE 7304(e) shall be applied to determine whether the material conforms to BS 4449 standard.

ii. Mechanical properties

Bars, coils and de-coiled products should be free from features such as seams, porosity, segregation and non-metallic inclusions, etc., where they would cause the product to fail to meet the specified mechanical properties.

1. General

The characteristic value is (unless otherwise indicated) the lower or upper limit of the statistical tolerance interval at which there is a 90 % probability ($1 - \alpha = 0.90$) that 95 % ($p = 0.95$) or 90 % ($p = 0.90$) of the values are at or above the lower limit or at or below the upper limit respectively. This quality level refers to the long-term quality level of production

2. Conditions of testing

The conditions of testing for the determination of mechanical properties shall conform to TABLE 7304/3.

TABLE 7304/3: CONDITIONS OF TESTING FOR THE MECHANICAL PROPERTIES

Manufacturing and Delivery Conditions	Conditions of Testing
Produced in straight lengths by hot rolling	As delivered* or aged**
Produced in straight lengths by cold working	Aged**
Produced as coil and delivered decoiled	Aged**
Produced and delivered as coil	Aged**

* Aged in the case of dispute

** Aging method: heat the test piece to 100 °C, maintain at this temperature (± 10 °C) for a period of 60 (+15/-0) min, and then cool in still air to room temperature. The method of heating is left to the discretion of the manufacturer.

3. Tensile properties

The specified values for the tensile properties (R_e , R_m/R_e , A_{gt} , and where relevant $R_{e,act}/R_{e,nom}$) shall be the corresponding specified characteristic value with $p = 0.95$ for R_e , and $p = 0.90$ for A_{gt} , R_m/R_e , and $R_{e,act}/R_{e,nom}$. The values R_e and R_m shall be calculated using the nominal cross-SECTIONal area of the product. For yield strength (R_e), the upper yield strength (R_{eH}) shall apply. If a yield phenomenon is not present, the yield strength (R_e) from the 0.2 % proof strength ($R_{p0.2}$) shall be determined. The absolute maximum permissible value of yield strength is 650 MPa.

Where,

R_e = Yield strength.

R_{eH} = Upper yield strength.

R_m = Tensile strength.

R_m/R_e = Ratio of tensile strength/ yield strength.

$R_{p0.2}$ = 0.2 % proof strength.

$R_{e,act}$ = Actual value of yield strength.

$R_{e,nom}$ = Specified value of yield strength.

A_{gt} = Percentage total elongation at maximum force.

The characteristic tensile properties shall be as specified in TABLE 7304/4 below.

TABLE 7304/4: CHARACTERISTIC TENSILE PROPERTIES

Steel grade	Yield strength, R_e	Tensile / yield strength ratio, R_m/R_e	Total elongation at maximum force, A_{gt} %
B500A	500	1.05*	2.5**
B500B	500	1.08	5.0
B500C	500	$\geq 1.15, < 1.35$	7.5

* R_m/R_e characteristic is 1.02 for sizes below 8 mm.

** A_{gt} characteristic is 1.0% for sizes below 8 mm.

4. Fatigue strength

a. General

Reinforcing bars, coils and decoiled products shall be subject to fatigue testing. When submitted to axial force controlled fatigue testing, using a stress ratio ($\sigma_{min}/\sigma_{max}$) of 0.2, and stress range as given in TABLE 7304/5, test samples shall survive five million stress cycles.

TABLE 7304/5: FATIGUE TEST CONDITIONS

Bar size (mm)	Stress Range MPa
≤ 16	200
$> 16, \leq 20$	185
$> 20, \leq 25$	170
$> 25, \leq 32$	160
> 32	150

b. Bars and coils

Reinforcing bars from each production site shall be subject to fatigue testing, to determine the fatigue characteristics of a particular geometrical shape and process route. The fatigue properties for each steel grade and process route shall be established at an applicable testing laboratory, initially by testing samples selected from the upper, middle and bottom of the product diameter range. At least once a year, samples shall be tested from different bars or coils of one diameter from each process route. Test samples shall be selected so that all diameters for each process route shall be tested over a five-year period.

c. Decoiled products

Decoiled products, from each production site, shall be subject to fatigue testing. Initially, samples shall be taken from each production site from one decoiling machine type from the largest diameter produced. At a frequency of at least once per year, samples of one diameter shall be selected for test from each production site, from one decoiling machine. Sampling shall be carried out in such a way that the combination of material manufacturing route, type of decoiler and individual machines are covered over a five-year period.

d. Sampling

Each test unit shall comprise ten test specimens. For each diameter, from each test unit, five bars shall be selected for test. The test specimens shall not exhibit isolated defects that are not characteristic of the product from which they are selected.

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e. Retests

The products shall be deemed to conform to BS 4449 if all five test pieces endure five million stress cycles.

If one of the five test pieces produces a valid failure, a further five samples from the test unit shall be tested. If one of these further samples fails the test, then the material shall be deemed not to conform to this standard, and an investigation shall be carried out and appropriate actions shall be taken. If all five further test pieces endure five million stress cycles, then the material shall be deemed to comply with BS 4449 standard.

In the case of any failure, the test shall be considered invalid if it is initiated from a defect unique to the test piece or in the area within $2d$ of the testing machine grips (where d is the nominal bar diameter); in this case a further single test shall be carried out.

5. Bend performance

The bend performance shall be demonstrated by means of the following rebend test.

Bend the test pieces through an angle 90° , around a mandrel with a diameter not exceeding those specified in TABLE 7304/6, age the test piece and then bend back by at least 20° .

After the test, the specimen shall show no sign of fracture or cracks visible to a person of normal or corrected vision.

TABLE 7304/6: MANDREL DIAMETER FOR REBEND TEST

Nominal Diameter d , mm	Maximum Mandrel Diameter
≤ 16	4d
> 16	7d

All test pieces shall fulfil these requirements.

iii. Dimensions, mass per metre and tolerances

1. Preferred diameter, nominal cross-sectional area and mass per metre

The range of nominal diameters shall be 6 mm to 50 mm. The preferred nominal diameters are 8, 10, 12, 16, 20, 25, 32 and 40 mm. If a bar smaller than 8 mm is required, the recommended diameter is 6 mm. If a bar larger than 40 mm is required, the recommended diameter is 50 mm. Where coil or bar is supplied for the manufacture of welded fabric to BS 4483, then preferred nominal diameters are 6, 7 and 9 mm. If coil or decoiled product smaller than 8 mm is required, the recommended diameter is 6 mm.

The values for the nominal cross-sectional area and mass per metre of preferred diameters shall conform to the values in TABLE 7304/7. The values of nominal mass per metre are calculated from the nominal cross-sectional area on the basis that steel have a mass of 0.00785 kg/mm^2 per metre run.

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TABLE 7304/7: NOMINAL CROSS-SECTIONAL AREA AND MASS PER METER		
Nominal Diameter (mm)	Cross-sectional Area (mm ²)	Mass per Metre (kg)
6*	28.3	0.222
7*	38.5	0.302
8	50.3	0.395
9*	63.6	0.499
10	78.5	0.617
12	113	0.888
16	201	1.58
20	314	2.47
25	491	3.85
32	804	6.31
40	1257	9.86
50*	1963	15.41

* Preferred diameters for the manufacture of welded fabric to BS 4483 only.

2. Tolerances

The permissible deviation from nominal mass per metre shall conform to the values in TABLE 7303/8. No individual bar shall be outside the tolerances.

TABLE 7304/8: TOLERANCE ON NOMINAL MASS PER METRE	
Nominal Diameter (mm)	Tolerance on mass per metre (%)
≤ 8 mm	± 6.0
>8 mm	± 4.5

3. Length

The nominal length of bars shall be agreed at the time of enquiry and order. The permissible deviation from nominal length shall be +100/-0 mm. Other tolerances may be agreed at the time of enquiry and order.

4. Coil mass

The nominal coil mass shall be agreed at the time of enquiry and order.

iv. Bond strength and surface geometry

1. General

Ribbed bars are characterised by their surface geometry, by means of which bond with the concrete is achieved. Bond property requirements of ribbed reinforcing steels according to BS 4449, shall be based on surface geometry, or by means of the bond test provided in Annex A of BS 4449:2005+A3:2016. Bond property requirements based on surface geometry are preferred.

2. Surface geometry

(a) General

Ribbed steels are characterised by the dimensions, number and configuration of transverse and longitudinal ribs. Bars, coils and decoiled products shall have two or more rows of transverse ribs uniformly distributed around the perimeter. Within each row the ribs shall be uniformly spaced. Longitudinal ribs can be present or not.

The values for the spacing, height and rib inclination of transverse ribs shall be within the ranges given in TABLE 7304/9.

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TABLE 7304/9: RANGES FOR THE RIB PARAMETERS

Rib height, h	Rib spacing	Rib inclination, β
$0.03d$ to $0.15d$	$0.4d$ to $1.2d$	35° to 75°

The characteristic relative rib area shall meet the requirements of TABLE 7304/10. The characteristic values in TABLE 7304/8 are for $\rho = 0.95$.

TABLE 7304/10: CHARACTERISTIC RIB AREA

Nominal bar size, d mm	Relative Rib Area
$d \leq 6$	0.035
$6 < d \leq 12$	0.040
$d > 12$	0.056

(b) Transverse ribs

The projection of the transverse ribs shall extend over at least 75 % of the circumference of the product, which shall be calculated from the nominal diameter.

The transverse rib flank inclination α shall be greater than or equal to 45° , and the transition from the rib to the core shall be radiused.

(c) Longitudinal ribs

Where longitudinal ribs are present, their height shall not exceed $0.10d$, where d is the nominal diameter of the product.

b. Inspection and Testing

i. General

Reinforcing steel shall be produced under a permanent system of routine inspection and testing, which shall include evaluation of specified properties, as described in SUBCLAUSE 7304(b)(ii) and (iii).

ii. Sampling and testing

For the verification of standard properties, sampling and testing shall be as specified in 1) and 2) below:

1. Bars and coils

The test unit shall be the cast or part quantity of the cast.

The rate of testing shall be as follows:

For chemical composition, one analysis per test unit. The chemical composition (cast analysis) of the steel shall have been determined by the steel producer.

For rebend tests, nominal mass per metre and surface geometry, one test piece per test unit and nominal diameter.

For tensile tests, one test piece per 30 t with at least three test pieces per test unit and nominal diameter. Where bars and coils are produced for the manufacturer of welded fabric only, one tensile test piece shall be taken per 30 t produced.

2. Decoiled products

The processor of products in coil shall ensure that the decoiled products continue to meet the specified property requirements of the appropriate grade. Inspection and testing of decoiled reinforcing bars shall include as a minimum:

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- Visual inspection for surface geometry damage of every coil processed;
- Surface geometry measurement on at least one sample per day and produced size;
- Tensile testing at a frequency of at least one sample per machine type (roller or spinner) per week from each of two processed sizes. The sampling shall be such that all machines and sizes are covered in a six- month period. Only one sample shall be taken from each coil.

Testing may be carried out either by the processor using its own resources (internal or external) or by the processor in co-operation with the coil manufacturer. The tests shall not be seen as release tests, but as the basis for the assessment of the long-term quality level (LTQL) as described in SUBCLAUSE 7304(C).

iii. Evaluation of test results

1. Tensile properties

Where the characteristic value C_v is specified as a lower limit, the results shall be deemed to conform to BS 4449 if either:

(a) all individual values are greater than or equal to the specified characteristic value C_v ;
or

(b) $\bar{x} \geq C_v + a_1$

Where,

a_1 is 10 MPa for R_e , zero for R_m/R_e and 0% for A_{gt}

and individual values are greater than or equal to the minimum values given in TABLE 7304/11.

TABLE 7304/11: ABSOLUTE MINIMUM AND MAXIMUM VALUES OF TENSILE PROPERTIES

Performance characteristic	Minimum value			Maximum value		
	B500A	B500B	B500C	B500A	B500B	B500C
R_e , MPa	485	485	485	650	650	650
R_m/R_e	1.03*	1.06	1.13	N/A	N/A	1.38
A_{gt} , %	2.0**	4.0	6.0	N/A	N/A	N/A

* 1.01 for sizes below 8mm

** 0.8% for sizes below 8mm

Where the characteristic value C_v is specified as an upper limit (i.e. for R_m/R_e of grade B500C), the results shall be deemed to conform to BS 4449 if either:

(a) all individual values of R_m/R_e are equal to or lower than the specified upper characteristic value of 1.35;

or

(b) $\bar{x} \leq 1.35$ for R_m/R_e and all individual values for R_m/R_e are equal to or lower than the maximum value given in TABLE 7304/11.

2. Bond performance, geometry and mass per metre

In the rebend test, all test pieces shall fulfil the requirements of SUBCLAUSE 7304(a)(ii)(5).

In testing the surface geometry, the results shall meet the requirements of SUBCLAUSE 7304(iv).

In testing the mass per metre, no individual value shall be outside the tolerance specified in SUBCLAUSE 7304(a)(iii)(2).

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3. Retests

If any test specimen fails to meet the yield strength, tensile/yield strength ratio, total elongation at maximum force, rebend or rib geometry requirements, two additional test specimens shall be taken from different bars of the same batch to undergo tests. If both additional test specimens pass the retests, the batch shall be deemed to conform to BS 4449 standard. If either of the additional test specimens fails the retests, the batch shall be deemed not to conform to BS 4449 standard.

iv. Traceability and test reports

Delivered batches shall be identifiable and traceable to the manufacturer and to their production data. The manufacturer shall establish and maintain the records required and shall identify the products and their delivery documentation accordingly.

For each delivery, manufacturers shall supply the following information:

1. the cast number and cast analysis, including all specified elements and elements used in the calculation of the carbon equivalent value, and all intentionally added elements;
2. The carbon equivalent value;
3. The results of the tensile and rebend tests;
4. The mass per metre;
5. The manufacturing process route; and
6. The rolled on mill mark.

c. Assessment Of The Long Term Quality Level

i. Material produced under a third party product certification scheme

The results of tests on all test units of continuous production shall be collected and statistically evaluated for R_e , A_{gt} and R_m/R_e taking either the number of results corresponding to the preceding six months operation or the last 200 test results, whichever is greater.

ii. Determination of the long term quality level

The evaluation shall be carried out per nominal diameter.

The following requirement shall be satisfied for R_e , A_{gt} and R_m/R_e :

$$\bar{x} - k s \geq C_v$$

Where;

\bar{x} = The average value.

s = The estimate of the standard deviation of the population.

k = The coefficient listed in TABLE 7304/12 for R_e , and in TABLE 7304/13 for A_{gt} and R_m/R_e

C_v = The specified characteristic value.

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TABLE 7304/12: COEFFICIENT k AS A FUNCTION OF THE NUMBER OF TEST RESULTS n For a Reliable Failure Rate of 5% ($P = 0.95$) at a Probability of 90% ($1 - \alpha = 0.90$)

n	k
5	3.40
6	3.09
7	2.89
8	2.75
9	2.75
10	2.57
11	2.50
12	2.45
13	2.40
14	2.36
15	2.33
16	2.30
17	2.27
18	2.25
19	2.23
20	2.21
30	2.08
40	2.01
50	1.97
60	1.93
70	1.90
80	1.89
90	1.87
100	1.86
150	1.82
200	1.79
250	1.78
300	1.77
400	1.75
500	1.74
1000	1.71
∞	1.64

TABLE 7304/13: COEFFICIENT k AS A FUNCTION OF THE NUMBER OF TEST RESULTS n For a Reliable Failure Rate of 5% ($P = 0.95$) at a Probability of 90% ($1 - \alpha = 0.90$)

n	k
5	2.74
6	2.49
7	2.33
8	2.22
9	2.13
10	2.07
11	2.01
12	1.97
13	1.93
14	1.90
15	1.87
16	1.84
17	1.82
18	1.80
19	1.78
20	1.77
30	1.66
40	1.60
50	1.56
60	1.53
70	1.51
80	1.49
90	1.48
100	1.47
150	1.43
200	1.41
250	1.40
300	1.39
400	1.37
500	1.36
1000	1.34
∞	1.28

iii. Material not covered by a third party product certification scheme

The material not covered by a third part product certification scheme shall be assessed by acceptance tests on each batch in accordance with SUBCLAUSE 7304 (f).

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d. Test Methods

The tensile test for the determination of tensile properties (R_e , R_m/R_e and A_{gt}), the rebend test, the axial fatigue test, the measurement of the surface geometry and the determination of the relative rib are f_R , the determination of deviation from nominal mass per meter and the methods for chemical analysis shall be in accordance with BS EN ISO 15630-1. The conditions of testing for the mechanical properties are provided in TABLE 7304/3.

e. Verification Of Properties In The Case Of Dispute**i. Mechanical properties**

1. Whenever the determination of a property specified in these specifications as a characteristic value creates a dispute, the value shall be verified by selecting and testing three test pieces from various pieces from the batch under examination.

If one test result is less than the specified characteristic value, both the test piece and the test method shall be carefully examined. If there is a local fault in the test piece or reason to believe that an error has occurred in the test, the test result shall be ignored. In this case a further single test shall be carried out.

If the three valid test results are equal to or greater than the specified characteristic value, the batch shall be deemed to conform to this standard. If not, the requirements of (2) below shall apply.

2. If above requirement in (1) above is not fulfilled, 10 additional test pieces shall be selected from different bars, coils or decoiled products in the batch.

The batch shall be deemed to conform to this standard if the average test result of the 10 test pieces is higher than the characteristic value and the individual values are higher than the minimum and lower than the maximum values given in TABLE 11.

If not, the batch is rejected.

3. Whenever the determination of rebend characteristics is a cause for dispute, they shall be verified by selecting and testing three specimens from different bars, coils or decoiled products in the batch. If all three specimens pass the tests, the batch shall be deemed to conform, otherwise the batch shall be deemed not to conform to BS 4449 standard.

ii. Product analysis

If during product analysis, a single sample falls outside the maximum deviation limits for the composition range of a specified element, given in TABLE 7304/1, further samples shall be selected from the remainder of the batch as follows:

- At least two samples from the same cast for delivered masses up to 5 t;
- At least five samples from the same cast for delivered masses up to 20 t;
- At least eight samples for delivered masses over 20 t.

If any of the further samples analysed fall outside the maximum product analysis levels given in TABLE 7304/1 for any element, the batch shall be deemed not to conform to BS 4449 standard.

f. Material Not Covered By A Third Party Product Certification Scheme**i. General**

Material not covered by a third party product certification scheme shall be assessed by acceptance tests on each batch. Sampling and testing shall be carried out by an independent organisation at the producer's works or in the Contractor's yard.

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ii. Extent of sampling and testing

For testing purposes, the batch shall be divided into test units with a maximum mass of 100 *t*. Each test unit shall comprise products of the same steel grade and nominal diameter from the same cast. The manufacturer shall certify that all products in the test unit originate from the same cast.

Test specimens shall be taken from each test unit as follows:

1. Fifteen specimens from different bars, for testing in accordance with SUBCLAUSE 7304(f)(iii)(1) and (2);
2. Two test specimens, from different bars, for testing in accordance with SUBCLAUSE 7304(f)(iii)(3).

Preparation of the test specimens shall be carried out as described SUBCLAUSE 7304(a)(ii)(2).

iii. Properties to be tested

Specimens selected in accordance with SUBCLAUSE 7304(f)(ii) shall be tested for the following.

1. Inspection by variables:

- Yield strength R_e ;
- Tensile/yield ratio R_m/R_e ;
- Total elongation at maximum force A_{gt} .

2. Inspection by attributes:

- Behaviour in the rebend test;
- Deviations from the nominal mass per metre;
- Bond strength and surface geometry.

3. Chemical composition according to the product analysis:

All elements listed in SUBCLAUSE 7304(a)(i) and the carbon equivalent shall be determined.

4. Fatigue properties:

The fatigue properties of reinforcing steels shall be determined for each size and defined bar shape in the batch. Sampling and testing shall be carried out in accordance with SUBCLAUSE 7304(a)(ii)(4).

The test procedure shall be as described in SUBCLAUSE 7304(d).

iv. Evaluation of results

1. Inspection by variables

Inspection by variables shall be carried out as follows:

(a) The following shall be determined for the performance characteristics listed in SUBCLAUSE 7304(f)(iii)(1):

- all individual values for each of the performance characteristics;
- the mean value m_{15} of each of the performance characteristics; and
- the standard deviation S_{15} for each performance characteristic.

The test unit shall be deemed to conform to BS 4449 Standard if the following conditions are met:

$$m_{15} - 2.33 \times S_{15} \geq C_v \text{ for } R_e, \text{ and}$$

$$m_{15} - 1.87 \times S_{15} \geq C_v \text{ for } R_m/R_e \text{ and } A_{gt}.$$

(b) If the conditions for the performance characteristics stated above in (a) are not fulfilled, a secondary calculation (the acceptability index k) shall be determined, where:

$$k = \frac{m_{15} - C_v}{S_{15}}$$

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If $k \geq 2$ for R_e , and $k \geq 1.6$ for R_m/R_e and A_{gt} , testing shall continue. Forty-five further test specimens shall be taken and tested from different bars in the test unit, so that a total of 60 test results are available ($n = 60$).

The test unit shall be deemed to conform to BS 4449 Standard if the following conditions are fulfilled:

$$m_{60} - 1.93 \times S_{60} \geq C_v \text{ for } R_e, \text{ and}$$

$$m_{60} - 1.53 \times S_{60} \geq C_v \text{ for } R_m/R_e \text{ and } A_{gt}.$$

2. Inspection by attributes

Inspection by attributes shall be carried out as follows. When testing the properties listed in SUBCLAUSE 7304(f)(iii)(2), either:

- (a) all the results determined on the 15 test specimens shall conform to BS 4449 standard; or
- (b) if a maximum of two of the 15 results do not conform to BS 4449 Standard, 45 further test specimens shall be taken and tested from different bars in the test unit, making 60 test results available; the unit shall be deemed to conform to BS 4449 Standard if no more than two of the 60 test specimens fail the tests.

3. Fatigue properties

The batch shall be deemed to conform to BS 4449 Standard if it conforms to SUBCLAUSE 7304(a)(ii)(4).

v. Test Report

A test report shall be produced containing the following data:

1. The place of manufacture of the reinforcing steels;
2. The nominal diameter of the steel;
3. The grade of the steel;
4. The marking on the steel;
5. The cast number;
6. The date of testing;
7. The mass of the test unit; and
8. The individual test results for all the properties specified in SUBCLAUSE 7304(f)(iii)

7305 Bending The Reinforcing Steel

Reinforcement shall be cut or cut and bent to the dimensions shown on the bending schedules and in accordance with BS 8666 or BS EN ISO 3766 or as prescribed by the Engineer.

No flame-cutting of high-tensile steel bars shall be permitted except when authorised.

All bars with less than 32 mm in diameter shall be bent cold and bending shall be done slowly, a steady, even pressure being exerted without jerking or impact.

If approved, the hot bending of bars of at least 32 mm in diameter will be permitted, provided that the bars do not depend on cold working for their strength. When hot bending is approved, the bars shall be heated slowly to a cherry-red heat (not exceeding 840°C) and shall be allowed to cool slowly in air after bending. Quenching with water shall not be permitted.

Already bent reinforcing bars shall not be re-bent at the same spot without authorisation.

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7306 Surface Condition

When the concrete is placed around the reinforcing steel and/or dowels, the reinforcing steel and/or dowels shall be clean, free from mud, oil, grease, paint, loose rust, concrete droppings, loose mill scale or any other substance which could have an adverse chemical effect on the steel or concrete, or which could reduce the strength of bond.

7307 Placing And Fixing

Reinforcement shall be positioned as shown on the Drawings and shall be firmly secured in position within the tolerance given in SUBCLAUSE 1904(f) by being tied with 1.6 mm or 1.25 mm diameter annealed wire or by suitable clips being used, or, where authorised, by tack welding. Any cover and spacer blocks required to support the reinforcement shall be as small as may be consistent with their use and shall be of an approved material and design.

The concrete cover over the projecting ends of ties or clamps shall comply with the specifications for concrete cover over reinforcement detailed in SUBCLAUSE 7308.

Where protruding bars are exposed to the elements for a long period, the bars shall be adequately protected against corrosion and damage and shall be properly cleaned before being permanently encased in concrete.

In members which are formed with sliding formwork, spacer ladders for placing and fixing the wall reinforcement shall be used at spacings indicated on the Drawings or as prescribed by the Engineer. The spacer ladders shall consist of two bars 3.7 m in length with ties 4 mm in diameter welded to them to resemble a ladder. The ties shall be spaced at multiples of the horizontal bar spacing in the wall, and shall be used to secure the horizontal reinforcement. The laps in the horizontal reinforcement shall be staggered to ensure that no part of two laps in any four consecutive layers lie in the same vertical plane.

7308 Cover And Supports

The term "cover" in this context shall mean the minimum thickness of concrete between the surface of the reinforcement and the face of the concrete.

The minimum nominal cover shall be as shown on the Drawings. Where no cover is indicated, the minimum nominal cover provided shall be at least equal to the appropriate values greater of the following.

- i. Diameter of the bar; if maximum aggregate size ≤ 32 mm
- ii. Diameter of the bar + 5 mm; if maximum aggregate size > 32 mm
- iii. 10 mm
- iv. Minimum cover required from durability aspects

An allowance of 5 mm to 15 mm is added in above values depending upon the Quality Assurance.

The minimum cover required from durability aspects depends upon the environmental exposure conditions to which the structure is exposed and various other factors. The different environmental exposure conditions according to BS EN 206:2013+A2:2021 and BS 8500-1:2015+A2:2019 are shown in TABLE 7308/1.

The minimum values of cover required from durability aspects for different exposure conditions, normal weight concrete with 20 mm maximum size aggregate for a design period of 50 year and 100 years according to BS 8500-1:2015+A2:2019 are shown in TABLE 7308/3 and TABLE 7308/4.

The nominal cover should be at least 40 mm for concrete cast against prepared ground (including blinding) and 75 mm for concrete cast directly against soil.

The cover shall be increased by the expected depth of any surface treatment, e.g. when concrete is bush hammered or when rebates are provided.

Additional cover as prescribed by the Engineer shall be provided if porous aggregates are used.

The cover blocks or spacers required for ensuring that the specified cover is obtained shall be of a material, shape and design acceptable to the Engineer.

Concrete spacer blocks shall be made with 5 mm maximum sized aggregate and shall be of the same strength and material source as those of the surrounding concrete. The blocks shall be formed in specially manufactured moulds and the concrete compacted on a vibratory table, and cured under water for a period of at least 14 days, all to the satisfaction of the Engineer.

Ties cast into spacer blocks shall not extend deeper into the spacer block than half the depth of the spacer block.

The Contractor shall provide stools as shown on the Drawings, or where they are not detailed on the Drawings, wherever the Engineer requires them to be installed. The stools shall be suitably robust, and fixed securely so that they cannot swivel or move. The stools shall have sufficient strength to perform the required functions, taking into account amongst others temporary loads such as the weight of workmen and wet concrete, and forces caused by vibrators and other methods of compacting the concrete.

TABLE 7304/9: RANGES FOR THE RIB PARAMETERS

Class Designation	Description of Environment	Informative examples where exposure classes may occur
1. No risk of corrosion or attack (X0 class)		
X0	<ul style="list-style-type: none"> For concrete without reinforcement or embedded metal: all exposures except where there is freeze/thaw, abrasion or chemical attack. For concrete with reinforcement or embedded metal: very dry. 	<ul style="list-style-type: none"> Unreinforced concrete surfaces inside structures. Unreinforced concrete permanently submerged in non-aggressive water. Unreinforced concrete surfaces in cyclic wet and dry conditions not subject to abrasion, freezing or chemical attack. Reinforced concrete surfaces exposed to very dry conditions.
2. Corrosion induced by carbonation (XC classes) (Where concrete containing reinforcement or other embedded metal is exposed to air and moisture)		
XC1	<ul style="list-style-type: none"> Dry or permanently wet 	<ul style="list-style-type: none"> Reinforced and prestressed concrete surfaces inside enclosed structures except voided superstructures and areas of structures with high humidity. Reinforced and prestressed concrete surfaces permanently submerged in non-aggressive water.
XC2	<ul style="list-style-type: none"> Wet, rarely dry 	<ul style="list-style-type: none"> Reinforced and prestressed concrete surfaces permanently in contact with soil not containing chlorides
XC3	<ul style="list-style-type: none"> Moderate humidity 	<ul style="list-style-type: none"> External reinforced and prestressed concrete surfaces sheltered from, or exposed to, direct rain Reinforced and prestressed concrete surfaces subject to high humidity (e.g. poorly ventilated bathrooms, kitchens) Reinforced and prestressed concrete surfaces exposed to alternate wetting and drying
XC4	<ul style="list-style-type: none"> Cyclic wet and dry 	<ul style="list-style-type: none"> Interior concrete surfaces of pedestrian subways not subject to de-icing salts, voided superstructures or cellular abutments Reinforced or prestressed concrete surfaces protected by waterproofing

3. Corrosion induced by chlorides other than from sea water (XD classes)

(Where concrete containing reinforcement or other embedded metal is subject to contact with water containing chlorides, including de-icing salts, from sources other than from sea water)

XD1	<ul style="list-style-type: none"> Moderate humidity 	<ul style="list-style-type: none"> Concrete surfaces exposed to airborne chlorides Reinforced and prestressed concrete wall and structure supports more than 10 m horizontally from a carriageway Bridge deck soffits more than 5 m vertically above the carriageway Parts of structures exposed to occasional or slight chloride conditions
XD2	<ul style="list-style-type: none"> Wet, rarely dry 	<ul style="list-style-type: none"> Reinforced and prestressed concrete surfaces totally immersed in water containing chlorides Buried highway structures more than 1 m below adjacent carriageway
XD3	<ul style="list-style-type: none"> Cyclic wet and dry 	<ul style="list-style-type: none"> Reinforced and prestressed concrete walls and structure supports within 10 m of a carriageway Bridge parapet edge beams Buried highway structures less than 1 m below carriageway level Reinforced pavements and car park slabs

4. Corrosion induced by chlorides from sea water (XS classes)

(Where concrete containing reinforcement or other embedded metal is subject to contact with chlorides from sea water or airborne salt originating from sea water)

XS1	<ul style="list-style-type: none"> Exposed to airborne salt but not in direct contact with sea water 	<ul style="list-style-type: none"> External reinforced and prestressed concrete surfaces in coastal areas
XS2	<ul style="list-style-type: none"> Permanently submerged 	<ul style="list-style-type: none"> Reinforced and prestressed concrete surfaces completely submerged and remaining saturated, e.g. concrete below mid-tide level
XS3	<ul style="list-style-type: none"> Tidal, splash and spray zones 	<ul style="list-style-type: none"> Reinforced and prestressed concrete surfaces in the upper tidal zones and the splash and spray zones including exposed soffits above sea water

5. Freeze/Thaw attack (XF classes)

The thickness at any point of precast reinforced concrete plank permanent formwork (floor plates) shall not be less than 60 mm. Upper surface of the floor plates used in bridges shall be always rough or indented.

XF1	<ul style="list-style-type: none"> Moderate water saturation, without de-icing agent 	<ul style="list-style-type: none"> Vertical concrete surfaces as facades and columns exposed to rain and freezing Non-vertical concrete surfaces not highly saturated, but exposed to freezing and to rain or water
XF2	<ul style="list-style-type: none"> Moderate water saturation, with de-icing agent 	<ul style="list-style-type: none"> Concrete surfaces such as parts of bridges, which would otherwise be classified as XF1, but which are exposed to de-icing salts either directly or as spray or run-off
XF3	<ul style="list-style-type: none"> High water saturation, without de-icing agent 	<ul style="list-style-type: none"> Horizontal or nearly horizontal concrete surfaces, which are exposed to freezing whilst wet Concrete surfaces subjected to frequent splashing with water and exposed to freezing
XF4	<ul style="list-style-type: none"> High water saturation, with de-icing agent or sea water 	<ul style="list-style-type: none"> Horizontal concrete surfaces, such as roads and pavements, exposed to freezing and to de-icing salts either directly or as spray or run-off Concrete surfaces subjected to frequent splashing with water containing de-icing agents and exposed to freezing

6. Chemical attack (XA classes)

Where concrete is exposed to chemical attack from natural soils and ground water.

XA1	• Slightly aggressive chemical environment	<ul style="list-style-type: none"> The thickness at any point of precast reinforced concrete plank permanent formwork (floor plates) shall not be less than 60 mm. Upper surface of the floor plates used in bridges shall be always rough or indented.
XA2	• Moderate aggressive chemical environment	
XA3	• Highly aggressive chemical environment	

TABLE 7308/2: LIMITING VALUES FOR EXPOSURE CLASSES FOR CHEMICAL ATTACK FROM NATURAL SOIL AND GROUND WATER

Chemical characteristic	XA1	XA2	XA3
Ground water			
SO ₄ ²⁻ mg/l	≥ 200 and ≤ 600	> 600 and ≤ 3000	> 3000 and ≤ 6000
pH	≤ 6.5 and ≥ 5.5	< 5.5 and ≥ 4.5	< 4.5 and ≥ 4.0
CO ₂ mg/l aggressive	≥ 15 and ≤ 40	> 40 and ≤ 100	> 100 up to saturation
NH ₄ ⁺ mg/l	≥ 15 and ≤ 30	> 30 and ≤ 60	> 60 and ≤ 100
Mg ²⁺ mg/l	≥ 300 and ≤ 1000	> 1000 and ≤ 3000	> 3000 up to saturation
Soil			
SO ₄ ²⁻ – mg/kg * total	≥ 2000 and ≤ 3000**	> 3000** and ≤ 12000	> 12000 and ≤ 24000
Acidity according to Baumann Gully ml/kg	> 200	Not encountered in practice	

* Clay soils with a permeability below 10-5 m/s may be moved into a lower class.

** The 3000 mg/kg limit shall be reduced to 2000 mg/kg, where there is a risk of accumulation of sulphate ions in the concrete due to drying and wetting cycles or capillary suction.

TABLE 7308/3: DURABILITY RECOMMENDATIONS FOR REINFORCED OR PRESTRESSED CONCRETE ELEMENTS WITH AN INTENDED WORKING LIFE OF AT LEAST 50 YEARS

Nominal cover mm	Compressive strength class, maximum water-cement ratio and minimum cement or combination content for normal-weight concrete with 20 mm maximum aggregate size											Cement/ combination type*
	15 + Δc _{dev}	20 + Δc _{dev}	25 + Δc _{dev}	30 + Δc _{dev}	35 + Δc _{dev}	40 + Δc _{dev}	45 + Δc _{dev}	50 + Δc _{dev}	60 + Δc _{dev}	70 + Δc _{dev}	80 + Δc _{dev}	
Corrosion induced by carbonation (XC exposure classes)												
XC 1	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	All
XC2	—	—	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All
XC3/4	—	C40/50 0.45 340	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All except IVB P, IVB Q, IVB V
—	—	—	C40/50 0.45 340	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	IVB P, IVB Q, IVB V
Corrosion induced by chlorides other than sea water (XD exposure classes) adequate for any associated carbonation induced corrosion (XC classes)												
XD1	—	—	C40/50 0.45 360	C32/40 0.55 320	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	All
—	—	—	—	C40/50 0.45 380	C32/40 0.50 340	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	CEM I, IIA, IIB M, IIB S, CEM I SR0, CEM I SR3
XD2	—	—	—	C35/45 0.40 380	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIA
—	—	—	—	C32/40 0.40 380	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIB, IVB P, IVB Q, IVB V
—	—	—	—	—	—	C45/55 0.35 380	C40/50 0.40 380	C35/45 0.45 360	C35/45 0.45 360	C35/45 0.45 360	C35/45 0.45 360	CEM I, IIA, IIB M, IIB S, CEM I SR0, CEM I SR3
XD3	—	—	—	—	—	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIA
—	—	—	—	—	—	C32/40 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C25/30 0.50 340	C25/30 0.50 340	C25/30 0.50 340	IIB, IVB P, IVB Q, IVB V

A dash (—) indicates that greater cover is recommended.

* For Cement/ combination types, refer BS 8500-1:2015+A2:2019, TABLE A.6

TABLE 7308/3: DURABILITY RECOMMENDATIONS FOR REINFORCED OR PRESTRESSED CONCRETE ELEMENTS WITH AN INTENDED WORKING LIFE OF AT LEAST 50 YEARS

Nominal cover mm	Compressive strength class, maximum water-cement ratio and minimum cement or combination content for normal-weight concrete with 20 mm maximum aggregate size											Cement/ combination type*
	30 + Δc _{dev}	35 + Δc _{dev}	40 + Δc _{dev}	45 + Δc _{dev}	50 + Δc _{dev}	55 + Δc _{dev}	60 + Δc _{dev}	65 + Δc _{dev}	70 + Δc _{dev}	75 + Δc _{dev}	80 + Δc _{dev}	
Corrosion induced by chlorides from sea water (XS exposure classes) adequate for any associated carbonation induced corrosion (XC)												
XS 1	—	—	—	C45/55 0.35 380	C40/50 0.40 380	C35/45 0.45 360	C32/40 0.50 340	C28/35 0.55 320	C28/25 0.55 320	C28/35 0.55 320	C28/35 0.70 320	CEM I, IIA, IIB M, IIB S
	C40/50 0.35 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIIA
	C35/45 0.40 380	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P or Q ≥25% pozzolana, IIB V ≥25% fly ash, IIIA ≥46% ggbs
	C32/40 0.40 380	C25/30 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIIB
XS 2	—	—	—	—	—	—	C45/55 0.35 380	C40/50 0.40 380	C40/50 0.40 380	C35/45 0.45 360	C32/40 0.50 340	CEM I, IIA, IIB M, IIB S
	—	—	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIIA
	—	C50/50 0.35 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P or Q ≥25% pozzolana, IIB V ≥25% fly ash, IIIA ≥46% ggbs
	—	C35/45 0.35 380	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIB P, IIB Q, IIB V, IIIB
XS 3	—	—	—	—	—	—	—	—	—	—	C45/55 0.35 380	CEM I, IIA, IIB M, IIB S
	—	—	—	—	C40/50 0.35 380	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIIA
	—	—	—	C40/50 0.35 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P or Q ≥25% pozzolana, IIB V ≥25% fly ash, IIIA ≥46% ggbs
	—	—	—	C35/45 0.35 380	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIB P, IIB Q, IIB V, IIIB

A dash (—) indicates that greater cover is recommended.

* For Cement/ combination types, refer BS 8500-1:2015+A2:2019, TABLE A.6

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Structures | 7300 | Steel Reinforcement for Structures

TABLE 7308/4: DURABILITY RECOMMENDATIONS FOR REINFORCED OR PRESTRESSED CONCRETE ELEMENTS WITH AN INTENDED WORKING LIFE OF AT LEAST 100 YEARS

Nominal cover mm	Compressive strength class, maximum w/c ratio and minimum cement or combination content for normal weight concrete with 20 mm maximum aggregate size												Cement/ combination type ⁺
	15 + Δc _{dev}	20 + Δc _{dev}	25 + Δc _{dev}	30 + Δc _{dev}	35 + Δc _{dev}	40 + Δc _{dev}	45 + Δc _{dev}	50 + Δc _{dev}	55 + Δc _{dev}	60 + Δc _{dev}	70 + Δc _{dev}	80 + Δc _{dev}	
Corrosion induced by carbonation (XC exposure classes)													
XC 1	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	C20/25 0.70 240	All
XC 2	—	—	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All
XC3/4	—	—	—	C40/50 0.45 340	C35/45 0.50 320	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	All except IVB P, IVB Q, IVB V
	—	—	—	—	C40/50 0.45 340	C35/40 0.50 320	C32/40 0.55 300	C28/35 0.60 280	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	C25/30 0.65 260	IVB P, IVB Q, IVB V
Corrosion induced by chlorides other than sea water (XD exposure classes) adequate for any associated carbonation induced corrosion (XC)													
XD1	—	—	—	C45/55 0.40 380	C40/50 0.45 360	C35/45 0.50 340	C32/40 0.55 320	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	C28/35 0.60 300	All
XD 2	—	—	—	—	—	C35/45 0.45 360	C32/40 0.50 340	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	C28/35 0.55 320	CEM I, IIA, IIB M, IIB S, CEM I SR0, CEM I SR3
	—	—	—	—	—	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIIA
	—	—	—	—	—	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIB, IVB P, IVB Q, IVB V
XD3	—	—	—	—	—	—	—	—	C45/55 0.35 380	C40/50 0.40 380	C35/45 0.45 360	C35/45 0.45 360	CEM I, IIA, IIB M, IIB S, CEM I SR0, CEM I SR3
	—	—	—	—	—	—	—	—	C40/50 0.35 380	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	IIB P, IIB Q, IIB V, IIIA
	—	—	—	—	—	—	—	—	C32/40 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C25/30 0.55 320	IIB, IVB P, IVB Q, IVB V

A dash (—) indicates that greater cover is recommended.

* For Cement/ combination types, refer BS 8500-1:2015+A2:2019, TABLE A.6

TABLE 7308/4: DURABILITY RECOMMENDATIONS FOR REINFORCED OR PRESTRESSED CONCRETE ELEMENTS WITH AN INTENDED WORKING LIFE OF AT LEAST 100 YEARS

Nominal cover mm	Compressive strength class, maximum water-cement ratio and minimum cement or combination content for normal-weight concrete with 20 mm maximum aggregate size												Cement/ combination type*	
	25 + Δc _{dev}	30 + Δc _{dev}	35 + Δc _{dev}	40 + Δc _{dev}	45 + Δc _{dev}	50 + Δc _{dev}	55 + Δc _{dev}	60 + Δc _{dev}	65 + Δc _{dev}	70 + Δc _{dev}	75 + Δc _{dev}	80 + Δc _{dev}		
Corrosion induced by chlorides from sea water (XS exposure classes) adequate for any associated carbonation induced corrosion (XC)														
XS 1	—	—	—	—	—	—	—	—	—	C45/55 0.35 380	C40/50 0.40 380	C35/45 0.45 360	C32/40 0.50 340	CEM I, IIA, IIB M, IIB S
	—	—	C40/50 0.35 380	C40/50 0.35 380	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIA
	—	—	—	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P or Q ≥25% pozzolana, IIB V ≥25% fly ash, IIIA ≥46% ggbs
	—	—	—	C35/45 0.40 380	C30/37 0.45 360	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V
XD2	—	—	—	—	—	—	—	—	—	—	—	—	—	CEM I, IIA, IIB M, IIB S
	—	—	—	—	—	C40/50 0.35 380	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C28/35 0.50 340	C25/30 0.55 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIA
	—	—	—	—	C40/50 0.35 380	C35/45 0.40 380	C32/40 0.45 360	C28/35 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IB P or Q ≥25% pozzolana, IIB V ≥25% fly ash, IIIA ≥46% ggbs
	—	—	—	—	C35/45 0.35 380	C32/40 0.40 380	C28/35 0.45 360	C25/30 0.50 340	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	C20/25 0.55 320	IIB P, IIB Q, IIB V, IIB B
XS3	—	—	—	—	—	—	—	—	—	—	—	—	—	CEM I, IIA, IIB M, IIB S
	—	—	—	—	—	—	—	—	C40/50 0.35 380	C40/50 0.35 380	C40/50 0.35 380	C32/40 0.45 360	C28/35 0.50 340	IIB P, IIB Q, IIB V, IIA
	—	—	—	—	—	—	—	—	C40/50 0.35 380	C35/45 0.40 380	C40/50 0.35 380	C25/30 0.55 320	C25/30 0.55 320	IIB P or Q ≥25% pozzolana, IIB V ≥25% fly ash, IIIA ≥46% ggbs
	—	—	—	—	—	—	—	—	C35/45 0.35 380	C32/40 0.40 380	C28/35 0.45 320	C25/30 0.55 320	C25/30 0.55 320	IIB P, IIB Q, IIB V, IIB B

A dash (—) indicates that greater cover is recommended.

* For Cement/ combination types, refer BS 8500-1:2015+A2:2019, TABLE A.6

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7309 Laps And Joints

Laps, joints, splices and mechanical couplings shall be applied only by the specified methods and at the positions shown on the Drawings or as authorised.

7310 Welding

Reinforcement shall be welded only where shown on the Drawings or as authorised.

Flash butt welding shall be done only with the combination of flashing, heating, upsetting and annealing to the satisfaction of the Engineer, and only those machines which control this cycle of operations automatically shall be used.

Metal-arc welding of reinforcement shall be done in accordance with BS EN 1011-1 and BS EN 1011-2, and with the recommendations of the reinforcement manufacturers, subject to approval by the Engineer and the satisfactory performance of trial joints. Hot-rolled high-yield-stress steel shall be preheated to between 240°C and 280°C and only low-hydrogen electrodes may be used.

Trial welding joints shall be made on the site in circumstances similar to those which will govern during the making of production welding joints by the person who will be responsible for the production welding joints.

Other methods of welding e.g. resistance welding, may be used subject to approval by the Engineer and to their satisfactory performance in trial joints.

Welded joints shall be full-strength welds and their strength shall be assessed by destruction tests on samples selected by the Engineer.

7311 Measurement and Payment

Item	Unit
73.01 Steel Reinforcement for:	
(a) Description Of Portion Of Structure To Which Applicable:	Tonne (t)
i Mild Steel Bars	Tonne (t)
ii High-Yield-Stress-Steel Bars (Type Indicated)	Tonne (t)
iii Welded Steel Fabric	Tonne (t)
(b) Etc. For Other Structures Or Parts Of Structures	Tonne (t)

The unit of measurement for steel bars shall be the tonne of reinforcing steel in place in accordance with the Drawings or as authorised.

The unit of measurement for welded steel fabric shall be the tonne of welded steel fabric in place, the quantity of which shall be calculated from the area of the mesh used in accordance with the Drawings or as authorised.

Ties, stools and other steel used for positioning the reinforcing steel shall be measured as steel reinforcement under the appropriate item.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial weld joints, placing and fixing the steel reinforcement, including all tying wire, spacers and waste.

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SECTION 7400 Concrete for Structures

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7401 Scope

This section covers the manufacture, transport, placing and testing of concrete used in the Works where plain, reinforced or prestressed concrete is specified.

7402 Materials

a. Cement

Cement used for concrete shall be any of the following:

- i. Common cements and combinations complying with the requirements of KS-EAS 18, BS EN 197-1 or equivalent standard on approval of the Engineer.
- ii. Sulphate-resisting common cements conforming to the requirements of KS-EAS 18 or BS EN 197-1, but only where shown on the Drawings or instructed by the Engineer.
- iii. In prestressed concrete members or units, the use of Portland blast-furnace cement will not be permitted. A 50/50 mixture of Portland cement and ground granulated blast-furnace slag may be used only if authorised in the Special Specifications or by the Engineer.

b. Aggregates

Both coarse aggregate and fine aggregate (sand) shall comply with the requirements of BS EN 12620 or equivalent, subject to the following:

- i. The properties of aggregates shall meet the requirements of TABLE 7402/1.

TABLE 7402/1: PROPERTIES OF AGGREGATE FOR CONCRETE

Parameter	Limiting Value
Drying shrinkage	$\leq 0.075 \%$
Flakiness index of coarse aggregate	$\leq 35 \%$
Los Angeles abrasion coefficient	$\leq 40 \%$
Oven dried particle density	$\geq 2000 \text{ kg/m}^3$

- ii. Aggregates shall not contain any deleterious amounts of organic materials such as grass, timber or similar materials and shall be free from clay, shale, pyrites and all other impurities.

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- iii. Where there is any danger of a particular combination of aggregate and cement giving rise to a harmful alkali-aggregate reaction, the particular combination shall be tested in accordance with BS EN 12620, and, where the result points to such reaction, either the aggregate or the cement or both shall be replaced so that an acceptable combination may be obtained.
- iv. The fineness modulus of the fine aggregate shall not vary by more than ± 0.2 from the approved modulus.
- v. The coarse part of aggregate shall be roughly cubical in shape and free from excess flat and/or elongated particles.

c. Water

Water for use in mixing concrete and mortar and for curing and related purposes shall be obtained from a source approved by the Engineer and shall comply with the requirements of BS EN 1008.

Water shall be clean, fresh and free from detrimental concentrations of acids, alkalis, salts, sugar and other organic or chemical substances that could impair the durability and strength of the concrete or the imbedded steel. The Contractor shall prove the suitability of the water by way of tests conducted by an approved laboratory. For reinforced and prestressed concrete the chloride content of the mixing water shall not exceed 500 mg/l when tested in accordance with BS 6068-2.37.

d. Admixtures

Admixtures shall not be used in concrete without the approval of the Engineer who may require that tests be conducted before the admixtures be used to prove their suitability. Admixtures, if their use is allowed, shall comply with the following requirements:

- i. Admixtures shall be used only in liquid form and shall be batched in solution in the mixing water by a mechanical batcher capable of dispensing the admixture in quantities accurate to within 5 % of the required quantity.
- ii. All admixtures shall comply with the requirements of ASTM C-494/C 494M or AASHTO M-194 or BS EN 934 or equivalent and shall be of an approved brand and type.
- iii. Air entraining agents shall comply with the requirements of ASTM C-260 or AASHTO M-154 or equivalent.
- iv. Admixtures shall not contain any chlorides.

e. Curing agents

Curing agents shall be tested in accordance with ASTM C-156 and shall comply with the requirements of ASTM C-30907, except that the loss of water within 72 hours shall not exceed 0.40 kg/m². Only approved curing agents shall be used.

Curing agents shall be clear or pigmented as specified or required by the Engineer. A certificate from an approved testing laboratory stating that the curing compound complies with the specified requirements shall be submitted to the Engineer.

Irrespective of the above specifications being met, the curing compound shall be the type that can be applied to a wet surface without loss of stability or impairment of its water retention properties.

7403 Storing The Materials

a. Cement

Cement stored on the site shall be kept under cover which provides adequate protection against moisture and other factors which may promote deterioration of the cement.

If more than one type of cement is to be used in the Works, the storage space shall be suitably subdivided to the satisfaction of the Engineer and great care shall be exercised to ensure that different types of cement do not come into contact with each other. The Engineer shall be furnished with the means of identifying the various consignments of cement delivered.

When the cement is supplied in bags, the bags shall be closely and neatly stacked to a height not exceeding 12 bags and arranged so that they will not be in contact with the ground or the walls and can be used in the order in which they were delivered to the site.

Cement shall not be kept in a temporary store except where it is necessary for the efficient organisation of the mixing plant, and only when the prior approval of the Engineer has been obtained.

Where silos are used for the storage of cement, each silo shall be completely separate and fitted with a filter or an approved alternative method of dust control. Each filter or dust control system shall be of sufficient size to allow delivery of cement to be maintained at a specified pressure and shall be maintained to prevent undue emission of dust to prevent interference with weighing accuracy by build up of pressure. Cement drawn for use from silos shall be measured by weight and not by volume.

Cement shall not be kept in storage for longer than eight weeks without the Engineer's permission, and different brands and/or types of the same brand of cement shall be stored separately.

b. Aggregates

Aggregates of different nominal sizes shall be stored separately and in such a manner as to avoid segregation occurring. Intermixing of different materials and contamination by foreign matter shall be avoided. Aggregates exposed to a saline environment shall be covered to protect them from salt contamination.

Where concrete is batched on site, the aggregates shall be stored in bins with a 3 m wide concrete apron slab constructed around the outer edge of the aggregate stockpile area, to prevent contamination during the process of tipping and removing the aggregate. The aggregates shall be tipped on the concrete apron slab. The storage bin shall have a concrete floor of 150 mm thickness.

The Contractor may be required to carry out on Site supplementary processing and/or effective washing of aggregates where in the opinion of the Engineer such action is necessary to ensure that all aggregates comply fully with the requirements of this Specification at the time when concrete materials are batched and mixed. Methods used for processing and washing aggregates shall be subject to the approval of the Engineer.

c. Storage Capacity

The storage capacity provided and the quantity of material stored (whether cement, aggregates or water) shall be sufficient to ensure that no interruptions to the progress of the work will be occasioned by the lack of any materials.

d. Deteriorated Material

Deteriorated or contaminated or otherwise damaged material shall not be used in concrete. Such material shall be removed from the site without delay.

7404 Concrete Quality

a. General

The Contractor shall be responsible for the design of the concrete mix and for the proportions of the constituent materials necessary for producing concrete which complies with the requirements specified below for each class of concrete.

The Contractor shall obtain the Engineer's approval of their concrete mix proportions at least 30 days prior to its use in the Works.

Before starting with any concrete work on the site, the Contractor shall submit, for approval, samples of the constituent materials of the concrete and a statement of the mix proportions which the Contractor proposes to use for each class of concrete indicated in the Bill of Quantities.

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Where any change occurs in the material sources, the aggregate sizes, or any other components of the concrete, the above procedure shall be repeated.

The samples submitted shall be accompanied by evidence that they comply with the requirements for the various materials specified. The statement regarding the mix proportions shall be accompanied by evidence establishing that concrete made from the materials in the proposed proportions will have the specified properties.

Evidence shall be in the form of:

- i. A statement regarding the test results, which shall be furnished by an approved laboratory; or
- ii. An authoritative report on previous use of and experience in regard to the material.

The actual mix proportions used as well as any changes thereto shall be subject to the Engineer's approval, but such approval shall not in any way relieve the Contractor of their responsibility for producing concrete with the specified properties.

The Contractor is cautioned that the quality of cement may vary considerably from consignment to consignment so as to necessitate adjustments in the cement content of mixes. In order to ensure a uniform quality of concrete, the Contractor shall obtain from the manufacturer the data regarding the relevant cement quality for each consignment with a view to ascertaining the required adjustment in the cement content. This information shall be submitted to the Engineer.

b. Strength Concrete Classification

Concrete for use in the Works shall comply with the requirements of BS EN 206-1. The concrete strength class according to BS EN 206:2013+A2:2021 shall be classified as shown in TABLE 7404/1 herein. The class of concrete to be used in each part of the Works shall be as stated in the Bill of Quantities or on the Drawings.

Concrete strength is denoted by concrete strength class (C) which relate to characteristic cylindrical strength f_{ck} or cube strength $f_{ck, \text{cube}}$ determined at 28 days. Characteristic strength shall be defined as that value of the cube strength below which not more than 5% of the results of all possible cylindrical or cube strength measurements of the specified concrete are expected to fall.

For example for concrete Class C20/25, the notation 'C' refers to normal weight concrete strength class, first number '20' refers to characteristic cylindrical strength f_{ck} , second number '25' to characteristic cube strength $f_{ck, \text{cube}}$.

The aggregate size shall be selected complying the requirements in accordance with SUBCLAUSE 7402(b).

TABLE 7404/1: CLASSES OF CONCRETE		
Compressive Strength Class	Minimum Characteristic Cylinder Strength f_{ck} in N/mm ²	Minimum Characteristic Cube strength $f_{ck,cube}$ in N/mm ²
C8/10	8	10
C12/15	12	15
C16/20	16	20
C20/25	20	25
C25/30	25	30
C28/35	28	35
C30/37	30	37
C32/40	32	40
C35/45	35	45
C40/50	40	50
C45/55	45	55
C50/60	50	60
C55/67	55	67
C60/75	60	75
C70/85	70	85
C80/95	80	95
C90/105	90	105
C100/115	100	115

Notes:

The appropriate concrete strength class, maximum water-cement ratio and minimum cement content shall be according to SUBCLAUSE 7308, TABLE 7308/3 and TABLE 7308/4 depending upon the environmental exposure condition, cover to reinforcement and intended working life.

The recommended minimum strength class to be used in reinforced concrete road bridges is C25/30. The minimum concrete grade for pipe bedding or surround for pipe culverts shall be C20/25.

The cement content for any class of concrete shall not exceed 500 kg per cubic metre of concrete.

c. Durability Concrete

Exposure conditions are chemical and physical conditions to which the structure is exposed in addition to the mechanical actions.

Environmental conditions are classified according to TABLE 7308/1.

Constituents of concrete shall not contain harmful ingredients in such quantities as may be detrimental to the durability of the concrete or cause corrosion of the reinforcement and shall be suitable for the intended use in concrete.

In such cases, characteristic compressive strengths should be:

- The specified 28-day characteristic cylindrical or cube compressive strength, or
- A characteristic cylindrical or cube compressive strength corresponding to the designated maximum water: cement ratio, or
- A characteristic cylindrical or cube compressive strength corresponding to the designated cementitious content.

The environmental exposure classes, indicative strength classes for the particular environmental exposure classes, nominal cover to reinforcement, maximum water-cement ratio and minimum cement content shall be as indicated in TABLE 7308/1, TABLE 7308/3 and 7308/4 for durability aspects.

Following additional tests may be required to carry out from considerations of durability.

- i. Rapid chloride permeability test: in accordance with ASTM C1202.
- ii. Water penetration test: in accordance with BS EN 12390-8.
- iii. Water absorption test: in accordance with BS 1881-122.
- iv. Initial surface absorption test: in accordance with BS 1881-208.

d. Bleeding

The concrete shall be so proportioned with suitable materials that bleeding is not excessive.

e. Consistency and Workability

The concrete shall be of suitable workability for the nature of the work to be executed without the excessive use of water so that it can be readily compacted into the corners of the formwork and around the reinforcement, tendons and ducts without the material segregating. The maximum free water: cement ratio under any circumstances is 0.5.

Slump measurements obtained in accordance with the test method described in BS EN 12350-2 on concrete used in the Works shall fall within the ranges specified in TABLE 7404/4.

TABLE 7404/4: SLUMP VALUES

Type of Construction	Slump (mm) ¹	
	Max.	Min.
Prestressed concrete	75	25
Concrete nosings and prefabricated units	75	50
Mass concrete	100	25
Reinforced concrete footings, cast in situ piles (except dry-cast piles), slabs, beams and columns	125	50

¹ Where high-frequency vibrators are used, the values shall be reduced by one-third.

f. Sulphate Content

Excessive amount of sulphate is derived from aggregates or other constituents in concrete can cause disruption due to expansion. The total water-soluble sulphate content of the concrete mix, expressed as SO₃, shall not exceed 4% by mass (m/m) of the cementitious binder content of the mix. The sulphate content shall be calculated as the total from the various constituents of the mix using the following test methods:

- i. Sulphate content (as SO₃) in cement according to BS EN 197-1 shall be as under:

Property	Test Standard	Cement Type	Strength class	Requirement*
Sulphate content (as SO ₃)		CEM I CEM II** CEM IV CEM V	32.5 N	≤ 3.5%
			32.5 R	
			42.5 N	
			42.5 R	≤ 4.0%
			52.5 N	
			52.5 R	
		CEM III***	All	

* The requirements are given as percentage by mass of the final cement.

** Cement types CEM II/B-T and CEM II/B-M with a T content > 20% may contain up to 4.5% sulphate (as SO₃) for all strength classes.

*** Cement type CEM III/C may contain up to 4.5% sulphate.

- i. Sulphate content (as SO_3) in mixing water according to EN 1008 shall be as under:

Property	Test Standard	Requirement*
Sulphate content (as SO_4^{2-})	EN 196-2	≤ 2000 mg/litre
Conversion of sulphate: $\text{SO}_4 \times 0.833 = \text{SO}_3$		

- ii. Sulphate content (as SO_3) in natural aggregate according to BS EN 206 and EN 12620 shall be as under:

Property	Test Standard	Requirement*
Acid Soluble Sulphate content: (as SO_3)	BS EN 1744-1	$\leq 20.8\%$ by mass

g. Pumped Concrete

Where pumping of the concrete is approved by the Engineer, the concrete mix to be pumped shall be so designed that:

- Settlement will not exceed 125 mm;
- Graded aggregate and suitable admixtures be used, wherever necessary, with a view to improving the pumpability of the mix; and
- Shrinkage capacity shall not be excessively higher than that of ordinary concrete mixes.

7405 Measuring The Materials

a. Cement

Where cement is supplied in standard bags, the bags shall be ascertained to contain 50 kg. All cement taken from bulk-storage containers and from partly used bags shall be batched by weight, accurate to within 3 % of the required weight.

b. Water

The mixing water for each batch shall be measured, either by weight or by volume, accurate to within 3 % of the required quantity. The quantity of water added to the mix shall be adjusted to make allowance for moisture in the aggregates.

c. Aggregates

All aggregates for strength concrete shall be measured separately by weight, except as otherwise provided in this clause, accurate to within 3 % of the required quantity.

Aggregates for strength concrete may be volume batched subject to the approval of the Engineer, and on condition that the quantity of cement is increased, at the Contractor's own expense, by 25 kg/m^3 of concrete, over and above the quantity which would have been necessary were the aggregate to have been batched by weight.

Batching boxes for volume batching shall be filled without any tamping, ramming or consolidating the material (other than that occurring naturally during the filling of the container), and shall be screeded off level with their topmost edges.

Any adjustment to the volume shall be made by supplementary containers of a suitable size being used. Adjustments to the volume, by the incomplete filling of batching boxes to marks on their inside faces will not be permitted.

Fine aggregate shall be tested for bulking at the beginning of and halfway through each concreting shift, and adjustment shall be made to the batch volume to give the true volume required.

The measurement of cement in gauge boxes will not be permitted, and volume batching shall be so planned as to use full bags of cement.

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7406 Mixing

a. General

Mixing the material for concrete shall be conducted by an experienced operator. Unless otherwise authorised, mixing shall be carried out in a mechanical batch-mixer of an approved type which will be capable of producing a uniform distribution of ingredients throughout the batch.

b. Charging the Mixer

The sequence of charging the ingredients shall be subject to approval by the Engineer, and, unless otherwise instructed, the same sequence of charging the ingredients shall be maintained.

The volume of the mixed material by batch shall not exceed the volume recommended by the manufacturer of the mixer.

c. Mixing and Discharging

The period of mixing shall be measured from the time when all the materials are in the drum until the commencement of discharge.

Concrete shall be mixed in a modern batch type mixer which shall be to the approval of the Engineer. Mixing for each batch shall continue until there is uniform distribution of the materials and uniformity of colour and consistency of the concrete. Admixtures for which approval in writing has been given by the Engineer shall be introduced into concrete by means of automatic dosing equipment. Such equipment shall feed a fixed quantity of admixture into the mixing water before the latter is discharged into the mixer and shall be subject to the approval of the Engineer.

The mixing period for the materials shall be 90 seconds and may be reduced only if the Engineer is satisfied that the reduced mixing time will produce concrete with the same strength and uniformity as concrete mixed for 90 seconds. The reduced mixing time, however, shall be not less than 50 seconds or the manufacturer's recommended mixing time whichever is the longer. A suitable timing device shall be attached to the mixer to ensure that the minimum mixing time for the materials has been complied with.

The first batch to be run when starting with a clean mixer shall contain only 2/3 of the required quantity of coarse aggregate to make provision for "coating" the mixer drum. Discharge shall be so carried out that no segregation of the materials will occur in the mix. The mixer shall be emptied completely before it is recharged with fresh materials.

The Contractor shall take particular care to ensure that the mixer drum is washed and cleaned out immediately following the completion of each concreting operation or when changing a mix using a different type of cement.

Under certain conditions the Engineer may sanction hand mixing, in which case the concrete shall be made on a flat watertight platform or suitable area. The cement and aggregate shall be spread in thin layers and mixed dry until a uniform colour is obtained. Water shall be added and the mixture turned over at least three times or until the concrete is of uniform colour and consistency throughout.

d. Maintaining and Cleaning the Mixer

If the mixer has stopped running for a period in excess of 30 minutes, it shall be thoroughly cleaned-out particular attention being given to the removal of any build-up of materials in the drum, in the loader, and around the blades or paddles. Worn or bent blades and paddles shall be replaced.

Before any concrete is mixed, the inner surfaces of the mixer shall be cleaned and all hardened concrete removed.

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e. Standby Mixer

When sections are cast where it is important for the casting to continue without interruption, a standby mixer shall be held in readiness to run on 15 minutes notice should the stock mixers break down.

f. Ready-mixed Concrete

Where ready-mixed concrete is delivered at the site, the requirements of BS 8500-1 and 2 and BS EN 206-1 or equivalent shall have priority over the requirements specified in this section should inconsistencies occur.

7407 Transporting, Placing And Compacting**a. General**

Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by means that will prevent segregation or loss of any ingredient. Wherever practicable, concrete shall be emptied from a mixer directly into the skip which shall then be transported to the place of final deposit and the concrete shall be discharged as close as possible to its final position to avoid rehandling or flowing.

Should the Contractor propose to use concrete pumps for the transporting and placing of concrete he shall submit full details of the equipment and operating techniques he proposes to use for the approval of the Engineer.

Where concrete is conveyed by chuting or pumping, the plant used shall be designed to ensure continuous and unimpeded flow in the chute or pipe. The delivery end of the chute or pipe shall be thoroughly flushed with water before and after each working period and shall be kept clean. Water used for this purpose shall be discharged away from any permanent works.

Concrete shall not be placed in any part of the Works until the Engineer's approval has been given. If concreting is not started within 24 hours of approval having been given, approval shall again be obtained from the Engineer.

Concreting operations shall be carried out only during daylight hours unless proper lighting arrangements have been made and the lights are in working order before mixing of the concrete commences. Workmen shall not be allowed to work double shifts and the Contractor shall provide a fresh team for night shifts.

Sufficient material to afford full production to a concrete pour shall be available at the place of work prior to the commencement of concreting.

Placing and compacting the concrete shall at all times be under the direct supervision of an experienced concrete supervisor.

Once the casting of concrete has begun, it shall be carried out in a continuous process between construction joints. Concrete shall be placed within 60 minutes from the start of mixing. These times may be extended by the Engineer where a retarding admixture has been used. All excavations and other contact surfaces of an absorbent nature such as timber formwork shall be damp but no standing water shall be permitted to remain on these surfaces. The formwork shall be clean on the inside.

Water quality, freshwater life or any other sensitive environment shall not be adversely affected in any way.

b. Placing

Whenever possible, concrete shall be deposited vertically into its final position. Unless otherwise agreed by the Engineer on the basis of satisfactory site trials, concrete shall not be dropped into place from a height exceeding 1 metre. Where chutes are used, their length and slope shall

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be such as not to cause segregation, and suitable spouts and baffles shall be provided at the lower end to minimise segregation. The displacement of concrete by vibration instead of by direct placing is not permitted.

Except where otherwise agreed to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used and not more than 300 mm in all other cases.

Care shall be taken when casting bridge decks of a substantial thickness to avoid layering of the concrete, and the entire thickness shall be placed in one pass. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a construction joint has been formed or unless a retarding additive has been used in the concrete.

The pumping of concrete shall be subject to approval by the Engineer. Aluminium pipes shall not be used for this purpose.

c. Placing under water

Placing under water shall be allowed only in exceptional circumstances where it is not feasible to dewater the location before the concrete is placed. No concrete shall be placed in running water.

Underwater concrete shall be placed by means of tremies. Full details of the method proposed by the Contractor shall be submitted in advance for approval. Placing by skip or pipeline will also be considered under certain circumstances as approved by the Engineer.

During concreting by tremie, the pipe shall be kept filled with concrete at all times to prevent air and water from entering the tremie. When the tremie is charged, an approved sliding plug shall be used. Once concreting has begun by tremie, the discharge end of the tremie shall be kept well below the surface of the concrete. Should this seal be broken, the tremie shall be lifted and plugged before concreting is recommenced. Distribution of concrete by lateral movement of the tremie will not be permitted.

The concrete mix to be placed underwater shall be specially designed and approved for this purpose to ensure good flowability, plasticity and cohesion. Increased sand and cement contents over those of normal mixes will usually be required.

d. Compaction

The Contractor shall regard compacting of concrete as work of fundamental importance, the object of which is to produce a watertight concrete of maximum density and strength.

Concrete shall be fully compacted by approved means during and immediately after placing. It shall be thoroughly worked against the formwork, around reinforcement bars, tendons, ducts and embedded fittings and into corners to form a solid mass free from voids.

The concrete shall be free from honeycombing and planes of weakness, and successive layers of the same lift shall be thoroughly bonded together.

Unless otherwise permitted by the Engineer, concrete shall be compacted by means of vibrators of an approved design. Internal vibrators shall be capable of producing not less than 10,000 cycles per minute and external vibrators not less than 3,000 cycles per minute. A sufficient number of vibrators shall be used to handle the maximum rate of concrete production with an allowance for breakdowns and spares.

Vibration shall be applied by experienced labourers, and over-vibration resulting in segregation, surface water and leakage shall be avoided. Contact with reinforcement and formwork shall, in so far as is practicable, be avoided when internal vibrators are used. Concrete shall not be subjected to disturbance by vibration after achieving initial set to 24 hours of it having been compacted.

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Concrete that has partially set before placing shall not be used and shall be removed from site.

Whenever vibration is applied externally, the design of the formwork and positioning of vibrators shall be such as to ensure efficient compaction and avoidance of surface blemishes.

Special attention shall be given to the compaction of concrete in the anchorage zones and behind the anchor plates and in all places where high concentrations of reinforcing steel or cables occur.

Where the placing and compaction of concrete is difficult, a mix containing smaller sized aggregate may be used but only with the approval of the Engineer and after a mix containing such aggregate has been designed and tested.

When placing concrete against horizontal or inclined elements of waterstops, the latter shall be lifted and the concrete placed and compacted to a level slightly higher than the underside of the waterstop before releasing the waterstop to ensure complete compaction of the concrete around the waterstop.

e. Requirements In Respect Of Sliding Formwork

Where sliding formwork is used, the following additional requirements shall apply:

- i. The Contractor shall take all the necessary measures to ensure the continuity of operations. All the necessary lighting and standby equipment for mixing, hoisting, placing and compacting shall be provided and all the materials required for completing each structure shall be ready on the site before casting commences.
- ii. Concrete shall be cast in uniform layers in the formwork so that the level of the top surface of the concrete differs by no more than 250 mm between any two points in the formwork. In addition, the top level of the concrete shall never be so low down in the formwork as will cause structural instability in the formwork. The working platform shall be kept clean and no concrete which has dried out in part may be swept into the formwork.
- iii. The concrete shall be compacted during and immediately after placing. Care shall be taken not to damage or disturb previously placed concrete. To ensure the proper bonding of successive layers not more than one hour shall elapse between the placing of successive layers except where an approved admixture has been applied, in which case the delay may be amended in consideration of such circumstances.
- iv. The slump of concrete may be up to 150 mm should the approved method of sliding so require.

7408 Construction Joints

a. General

The Contractor shall submit for approval by the Engineer their proposals for the position of construction joints having due regard to any that may be shown in the drawings.

Concreting shall be carried out continuously up to the construction joints shown on the working drawings or as approved, except that if, because of an emergency (such as breakdown of the mixing plant or the occurrence of unsuitable weather), concreting has to be interrupted, a construction joint shall be formed at the place of stoppage and in the manner which will least impair the durability, appearance, and proper functioning of the concrete.

Unless otherwise shown on the Drawings, the exact position of horizontal construction joints shall be marked on the framework by means of grout checks in order to obtain truly horizontal joints.

Joint lines shall be clean, true and regular and, wherever possible, arranged to coincide with features of the finished work.

Stub columns, stub walls and stays on footings shall be cast integrally with the footings and not afterwards, even where another class of concrete is being used.

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In all cases vertical stop boards of a form to be approved by the Engineer shall be provided at the end of each section of work which is to be concreted in one operation, and the concrete shall be thoroughly consolidated against these stop boards.

b. Preparing the Surfaces

When the concrete has set and while it is still green, the surface film and all loose material shall be removed without disturbing the aggregate, by means of a water jet assisted by light brushing to expose the aggregate and leave a sound, irregular surface. Where this is not possible, the surface film shall be removed after the concrete has hardened, by mechanical means appropriate to the degree of hardness of the concrete so as to expose the aggregate and leave a sound, irregular surface. The roughened surface shall be washed with clean water to remove all laitance, dirt and loose particles.

Surface retarding agents may be used only with the approval of the Engineer.

c. Placing Fresh concrete at Construction Joints

Where fresh concrete is placed the same day as that on which the construction joint was formed, the fresh concrete shall be cast directly against the face of the construction joint.

When concreting recommences a day or more after the construction joint has been formed, the following procedure shall be followed:

- i. The construction joint shall be kept constantly wet for a period of at least six hours. The surface shall be in a saturated, surface dry condition when concreting has to recommence.
- ii. Any dirt, excess water and loose particles shall be removed prior to re-concreting being started.
- iii. For horizontal construction joints a 25 mm thick concrete layer of the same grade of concrete made richer by reducing the coarse aggregate content by 25% shall be placed on the joint plane immediately before concreting.
- iv. For vertical construction joints the fresh concrete shall be placed against a surface prepared in accordance with SUBCLAUSE 7408(b), which is in a saturated, surface-dry condition.

Epoxy resins specially designed for bonding old concrete to new shall be used at construction joints where so specified. The preparation of the construction joint surface and the application of the epoxy resin shall be strictly in accordance with the manufacturer's recommendations and the Engineer's instructions. The actual brand and type of resin used shall be subject to the Engineer's approval.

7409 Curing And Protecting

Formwork shall be retained in position for the appropriate times given in CLAUSE 7206, and as soon as may be practicable, all exposed concrete surfaces shall be protected from loss of moisture by one or more of the following methods:

a. Method 1

Retaining formwork in place for the full curing period.

b. Method 2

Ponding the exposed surfaces with water, except where atmospheric temperatures are low, i.e. less than 5°C.

c. Method 3

Covering it with sand or mats made from a moisture-retaining material, and keeping the covering constantly wet.

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d. Method 4

Constantly spraying the entire area of the exposed surfaces with water (only on surfaces where sand cover or ponding is impossible).

e. Method 5

Covering with a waterproof or plastic sheeting firmly anchored at the edges.

f. Method 6

Using an approved curing compound applied in accordance with the manufacturer's instructions, except that, where the surface has to be subsequently waterproofed, coated or gunited, this method may not be used.

g. Method 7

Steam curing the concrete (precast units).

h. General

The method of curing adopted shall be subject to the Engineer's approval and shall not cause staining, contamination, or marring of the surface of the concrete.

The curing period shall be continuous for at least seven days for concrete made with common cements, and at least 10 days if Portland blast-furnace cement or a 50/50 mixture of Portland cement and ground granulated blast-furnace slag is used. When the temperature of concrete falls below 5°C, these minimum curing periods shall be extended by the period during which the temperature of the concrete was below 5°C.

When sliding formwork is used, the concrete shall be protected against the weather and rapid drying out by means of a 4 m wide skirt attached to the lower perimeter of the formwork and hanging over the working platform. The skirt shall consist of hessian in the dry seasons and of canvas or other suitable material in the wet seasons. The skirt shall be weighted at the bottom to prevent it flapping in windy conditions.

The concrete shall be cured by means of a fog spray to keep it wet constantly for the periods stated above or until a curing compound is applied. Wetting the concrete by spraying shall be by means of a fixed spraybar along the full length of the sliding formwork. The spraybar shall be connected to a suitable high-pressure water supply. Wetting shall be discontinued when the ambient air temperature drops below 5°C, and care shall be taken by the Contractor to ensure that the water will not erode the surface of the fresh concrete.

7410 Adverse Weather Conditions**a. Cold weather**

Concrete shall not be placed during falling temperatures when the ambient air temperature falls below 7°C or during rising temperatures when the ambient air temperature is below 3°C. When concrete is placed at air temperatures below 5°C the concrete temperature shall not be below 10°C, for which purpose heating of the water and/or the aggregate shall be permitted. The Contractor shall make all the necessary arrangements for heating the material. Heated water and aggregate shall first be mixed and the cement shall then be added only while the temperature is below 30°C.

The temperature of placed concrete shall not be allowed to fall below 5°C until the concrete has attained a strength of at least 5 MPa, and the Contractor shall be responsible for all protective measures necessary to this end. All concrete damaged by casting at temperatures less than 5°C shall be removed and replaced by the Contractor at their own expense.

The Contractor shall provide a thermometer suitable for measuring the temperature of aggregates, and a maximum and minimum thermometer, which shall be hung in a position, indicated by the Engineer.

b. Hot weather

When the ambient air temperature exceeds 30°C during concreting, the Contractor shall take measures to control the temperature of the concrete ingredients so that the temperature of the placed concrete will not exceed 30°C unless otherwise determined by the Engineer. Such measures include spraying aggregate stockpiles with water to promote cooling down by evaporation and, where feasible, shading the stockpiles and the area where concreting is carried out. Curing shall commence immediately after concrete has been placed to prevent an excessive loss of moisture.

Formwork shall be shaded from direct exposure to the sun both prior to the placement of concrete and during its setting. The Contractor shall take appropriate measures to ensure that reinforcement in and projecting from the SECTION to be concreted is maintained at the lowest temperatures practicable.

c. Precautionary Measures For Using Sliding Formwork

During sliding operations in cold weather, the water only, or the water and the aggregate, shall be heated to ensure that the concrete temperature will not drop below 10°C until it has attained a strength of 5 MPa.

During cold weather the rate of sliding shall be suitably decreased to ensure sufficient strength in the concrete which leaves the bottom of the formwork.

7411 Pipes and Conduits

No pipes and conduits other than those shown on the Drawings shall be embedded in the concrete without the Engineer's approval. The clear space between such pipes or between such pipes and any reinforcing steel shall be at least 40 mm or the maximum size of the aggregate plus 5 mm, whichever is the greater. The thickness of the concrete cover over pipes and fittings shall be at least 25 mm.

The ends of all ferrules used for bracing formwork shall be neatly finished off to the details shown on the Drawings. Where no details are given on the Drawings, ferrules shall be cut back to a depth of at least the specified cover, and the holes shall be filled in with mortar and finished off flush with the concrete surface.

7412 Applied Loading

No load shall be applied to any part of a structure until the specified curing period has expired, after which applied loading shall be allowed only when approved by the Engineer. The Engineer's decision will be based on the type of load to be applied, the age of the concrete, the magnitude of stress induced and the propping of the structure. No structure shall be opened to traffic until test cubes made from the concrete in all parts of the structure have attained the specified minimum 28-day compressive strength.

The Contractor shall not permit backfilling around any structure incorporating a ground or floor slab before that slab has been cast and properly cured and the concrete has attained its specified 28-day strength.

7413 Precast Concrete

This clause applies to all reinforced and prestressed concrete members other than precast concrete piles, culverts and pipes in so far as they are dealt with separately elsewhere in these Specifications.

All precast members shall be manufactured in accordance with the requirements specified for cast in situ members in so far as these requirements are relevant. In addition, the following shall apply:

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- a. The Contractor shall take all necessary safety and precautionary measures during the handling and erection of precast members and for ensuring the stability of members as positioned and prior to their being cast in.
- b. Where precast concrete members have not been manufactured on the site, the manufacturer shall keep and make available to the Engineer complete records of all the concrete mixes and strength tests pertaining to the members cast. The Contractor shall notify the Engineer in advance of the dates on which members are to be cast so that arrangements for inspecting and testing the precast members can be made.

Precast concrete units shall not be moved or transported from the place of casting until they are properly cured and the concrete has achieved its specified 28-day strength.

- c. For the purposes of identification, all members shall be marked with paint in neat lettering with the member number shown on the Drawings or as agreed on and an identification number relating to the manufacturing records. Letters etc shall be so positioned as not to be visible when the structural member is placed in its final position in the completed structure.
- d. All precast members which have been chipped, cracked, warped or otherwise damaged to the extent that such damage will, in the opinion of the Engineer, prejudice the appearance, function or structural integrity of the members shall be rejected or, where so allowed, repaired to the satisfaction of the Engineer.

7414 Quality of Workmanship and Materials

a. Criteria for Compliance with the Requirements

Routine inspection and quality control will be done by the Engineer as specified in SECTION 7400. The criteria for compliance with the requirements specified for 28-day characteristic compressive strength shall be as specified in CLAUSE 7404 for full acceptance, and as specified in CLAUSE 7407 for conditional acceptance. The re-submission of concrete lots on the basis of cores for full or conditional acceptance shall not be allowed. The Contractor's attention is drawn to CLAUSE 7414. If the Engineer is satisfied that the requirements of the Contractor's quality control procedures have been met, the Engineer may decide at their discretion to use the Contractor's test results in the evaluation of the concrete.

b. Procedure in the Event of Non-Compliance with the Requirements

Any lot represented by test cubes failing to comply with the criteria specified for the characteristic strength shall be rejected, or the Engineer may allow, at their discretion, the following tests to be conducted in order to decide whether the concrete may be left in position at further reduced payment:

- i. The Engineer may allow the elements or units concerned to be cured for an additional period not exceeding 56 days. Thereafter the Contractor shall drill cores in accordance with BS EN 12504-1 or equivalent, and the Engineer will evaluate these cores in accordance with BS EN 13791 or equivalent.
- ii. Where the Engineer so directs, full-scale load tests shall be conducted in accordance with BS EN 1992 or equivalent to determine whether any particular structure or member can be left in position. The cost of such tests shall be for the Contractor's account regardless of the outcome of the tests.

In all cases where concrete has been supplied which fails to comply with the strength requirements, the Contractor shall immediately take the required remedial action by changing the mix proportions to obtain the required strength.

c. Tests Ordered by the Engineer

Where the routine testing of concrete cubes is not conducted on the site by the Engineer, he may order the Contractor to have the concrete cubes, which have been made by the Engineer, tested at an approved testing laboratory, in which case no separate payment will be made for such tests.

7415 Demolition and Removal of Existing Concrete

Where partial demolition is required for extension work to existing structures the first three paragraphs of **CLAUSE 2214** shall apply. In addition the following shall apply:

- a. The Contractor shall take great care to ensure that the reinforcement required to tie in the extension work is not cut off or damaged in the demolition process. Where reinforcement has been cut off, or where in the opinion of the Engineer, the reinforcement has been damaged to such an extent that it will not adequately perform its function, the Contractor shall, at his own expense, install dowel bars of the same diameter as the bar cut off or damaged, all to the satisfaction of the Engineer.
- b. Only hand operated breaking equipment shall be used for the demolition of concrete where extension work is required.

7416 Measurement and Payment

Item	Unit
74.01 Cast In Situ Concrete:	
(a) Class Of Concrete And Part Of Structure Or Use Indicated	Cubic Metre (m ³)
(b) Ditto For Other Classes Of Concrete And Other Uses Or Parts Of The Structure	Cubic Metre (m ³)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Quantities shall be calculated from the dimensions shown on the Drawings or as authorised. No deduction in volume measured for payment shall be made for the volume of any reinforcing steel, inserts and pipes or conduits under 150 mm in diameter embedded in the concrete.

The bid rate shall include full compensation for procuring and furnishing all the materials, storing the materials, providing all plant, mixing, transporting, placing and compacting the concrete, forming the inserts, construction joints (except mandatory construction joints) and contraction joints, curing and protecting the concrete, repairing defective surfaces, and finishing the concrete surfaces as specified. Payment shall distinguish between the different classes of concrete.

Item	Unit
74.02 Manufacturing Precast Concrete Members (Description Of Member With Reference To Drawing):	Number (No.)

The unit of measurement shall be the number of complete members or elements of each type and size in position in the Works.

The bid rate for each precast member shall include full compensation for concrete work, formwork, reinforcing steel and prestressing as required for manufacturing the member complete, excluding only prestressing in connection with in situ concrete cast subsequent to the placing of the precast members for which prestressing payment is separately provided elsewhere in the Bill of Quantities.

Item	Unit
74.03 Transporting And Erecting Precast Concrete Members (Description Of Member And Approximate Mass To Be Given)	Number (No.)

The unit of measurement shall be the number of precast concrete members of each type and size placed into position.

The bid rate for each precast member shall include full compensation for all work, costs and equipment required for transporting, erecting and placing into position the precast concrete members.

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Item		Unit
74.04	Epoxy Bonding Of New Concrete Surfaces To Old	Square Metre (m ²)

The unit of measurement shall be the square metre of new concrete surface bonded to old by means of an approved epoxy bonding agent as set out in the Specifications. The bid rate shall include full compensation for preparing the surfaces, furnishing and applying the bonding agent and for chamfering the concrete on visible joints, complete as shown on the Drawings.

Item		Unit
74.05	Extra Over ITEM 74.01 Or 74.02 For The Use Of Sulphate-Resistant Cement In Concrete	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of concrete manufactured with sulphate-resistant cement and placed in accordance with the details on the Drawings, or as instructed by the Engineer.

The bid rate shall be extra over each of the relevant rates for which sulphate resistant cement is used.

Item		Unit
74.06	Demolishing Existing Concrete:	
(a)	Plain Concrete (Member Indicated)	Cubic Metre (m ³)
(b)	Reinforced Concrete (Member Indicated)	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of plain or reinforced concrete demolished for each member or portion thereof scheduled separately in the Bill of Quantities.

This pay Item shall apply to box culverts only for the demolition of those portions of the culvert that are to be removed to facilitate extensions.

The bid rate shall include full compensation for all labour and constructional plant and equipment required to demolish the existing concrete and disposal of the product of the demolition to an approved disposal site. The bid rate shall also include full compensation for any necessary measures to ensure no debris falls into watercourses and for any debris that has fallen into watercourses to be recovered.

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SECTION 7500 Prestressing

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7501 Scope

This section covers the materials, equipment and work required for prestressing structural concrete members.

7502 Definitions

The following definitions shall apply to these Specifications:

a. Anchorage

Anchorage is the device comprising all the components and materials required for retaining the force in a tensioned tendon and to transmit this force to the concrete of the structure.

b. Anchorage Reinforcement

Anchorage reinforcement is the spiral and other reinforcement which forms part of the anchorage and is required for strengthening the anchorage and/or assisting in transmitting the tendon force to the concrete.

c. Bursting reinforcement

Bursting reinforcement is the reinforcing steel required in and adjacent to the anchorage zones to resist the tensile stresses induced in the concrete by the anchorage(s).

d. Cable

Cable is the tendon, together with the anchorage, sheathing and all fittings.

e. Characteristic Strength

Characteristic strength of prestressing steel is the manufacturer's guaranteed tensile strength below which no more than 5 % of the test results in a statistical population shall fall.

f. Duct

Duct is the void formed to house the tendon(s) and may be formed by coring, or by using sheaths or by way of extractable cores.

g. Prestress

Prestress is the stress induced in concrete by tensioned tendons.

h. Prestressed Concrete

Prestressed concrete is structural concrete in which effective internal stresses are induced by means of tensioned tendons.

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i. Pre-tensioned Concrete

Pre-tensioned concrete is prestressed concrete where the tendon is tensioned before the concrete has been cast.

j. Post-tensioned Concrete

Post-tensioned concrete is prestressed concrete where the tendon is tensioned after the concrete has hardened.

k. Pull-in

Pull-in is the elastic shortening of the tendon caused by relative movement between the anchorage or coupler components on account of seating and gripping action during or immediately after transfer.

l. Release

Release is the specified elastic shortening of the tendon at the anchorage achieved before or during transfer.

m. Sheath

Sheath is the tube or casing enclosing the tendon and which temporarily or permanently allows a relative movement between the tendon and the surrounding concrete.

n. Tendon

Tendon is the prestressing steel consisting of the bar, wire or strand individually placed, or of bars, wires or strands placed in a duct, all of which are tensioned to impart prestress to a concrete member.

o. Tensioning

Tensioning is the action of inducing and regulating the force in a tendon by means of tensioning and measuring equipment.

p. Transfer

Transfer in the case of post-tensioned concrete is the action of transferring the tensioning force from the tensioning equipment (jack) to the anchorage.

Transfer in the case of pre-tensioned concrete is the action of transferring the force in the tensioned tendon(s) to the concrete.

q. Bond Breaker

Bond breaker is the coating or sheath placed on a tendon to prevent it from bonding to the surrounding concrete.

r. Coupler

Coupler is the device comprising all components required to join two tendons.

s. Deflector

Deflector is the device used to deflect a tendon alignment within a structural element.

t. Transmission Length

Transmission length is the tendon length required to transmit via bond stresses the full force in the tendon to the concrete.

u. Precamber

Precamber is the allowance made into formwork to accommodate the slightly convex shape of a horizontal prestressed member.

7503 Materials

a. General

All materials and prestressing systems used in the prestressing of structural concrete members shall be subject to approval by the Engineer.

b. Prestressing Steel

i. General

The Contractor shall keep proper records of all material analyses and test certificates for the batches of prestressing steel used in the Works. Where required by the Engineer, the Contractor shall produce certificates from recognised testing authorities certifying compliance of the prestressing steel with the specified requirements.

Where prestressing steel is available in weld-free lengths (production lengths) and lengths containing welds (standard lengths), the batches delivered at the site shall be clearly labelled for identification purposes.

Under no circumstances shall prestressing steel after manufacture be subjected to heat treatment other than provided for in the Specifications.

ii. Steel bars

Hot rolled or hot rolled and processed high-tensile alloy steel bars for prestressing of concrete shall comply with the requirements of BS 4486 or EN 10138-4.

The type of prestressing steel shall be indicated in accordance with the requirements of CLAUSE 4.2 of BS 4486 e.g. BS 4486-RR-32-1230 for 32 mm diameter deformed bar with a characteristic strength of 1230 MPa.

CLAUSE 4 of EN 10138-4:2000 shall be referred to designate steel bars if complying with this standard.

iii. Steel wires and strands

Steel wire and strand for prestressed concrete shall comply with the requirements of BS 5896 or EN 10138-2 and 3.

The type of prestressing steel shall be indicated in accordance with the requirements of CLAUSES 11.1 and 12.1 of BS 5896 for wire and strands respectively, e.g.:

1. BS5896 Y1770C-7.0-T1 designating wire as:

BS5896: the number of this standard

Y1770C: the steel name consisting of:

The letter Y for prestressing steel.

The 1770 for nominal tensile strength in mpa.

The letter C for cold drawn wire.

7.0: the nominal diameter of the wire in mm.

T1 or T2: type of indent.

2. BS5896-Y1860S7-15.7-I designating strand as:

BS5896: the number of this standard

Y1860S7: the steel name consisting of:

The letter Y for prestressing steel.

The 1860 for nominal tensile strength in mpa.

The letter s for strand.

The 7 for number of wires in the strand.

Where appropriate, the letter G to indicate compacted strand.

15.7: the nominal diameter of the strand in mm.

Where necessary, the letter I to indicate indented.

CLAUSE 4 of EN 10138-2 and CLAUSE 5 of EN 10138-3 shall be referred to designate steel wire and strand if complying these standards.

iv. Straightness

Prestressing bars delivered at the site shall be straight. Only small adjustments for straightness may be made, which shall be done by hand on the site at a temperature above 5°C and under the supervision of the Engineer. Where heating of the bars is required, this shall be by means of steam or hot water. Bars bent in the threaded portion shall not be used.

Prestressing wire and strand shall be supplied in coils with a sufficiently large diameter to ensure that the wire and strand will reel off straight.

v. Surface condition

Prestressing steel shall be clean, free from faults or defects, and without any harmful films and matter which may impair adhesion to the grout or concrete. A film of rust is not necessarily harmful and may improve the bond. It may, however, increase the friction between the tendon and duct. The depth of imperfections or pits on the surface of prestressing steel shall not exceed 0.1 mm for wire with a diameter up to and including 8 mm, or 0.2 mm for bars or wire with a diameter exceeding 8 mm.

Tendons may be cleaned by wire brushing or by passing through a pressure box containing carborundum powder. Solvent solutions shall not be used for cleaning without the approval of the Engineer.

Prestressing steel shall be delivered at the site suitably protected against damage and corrosion. Such protection or the use of a corrosion inhibitor, where allowed by the Engineer, shall not have any deleterious effect on the steel or concrete or impair the bond between the two.

vi. Galvanising

Galvanised prestressing steel shall not be used unless specified. Under no circumstances shall prestressing steel be subjected to galvanising after manufacture.

vii. Welds

Prestressing steel used in structural prestressed concrete shall be weld-free. Where the steel is supplied in standard lengths, the welds shall be cut out and delivered to the Engineer.

c. Anchorages and Couplers

Anchorages and couplers to be used in prestressed concrete shall comply with the requirements of BS EN 13391 and shall be of a proved and approved type, constructed from durable material completely free from imperfections and shall not damage, distort or kink the prestressing steel in a manner that will result in ultimate tensile strength reduction. They shall resist, without failure and/or excessive deformation or relaxation of the force in the tendons, the full ultimate tensile strength of the tendons. The characteristic value for anchorages and couplers, determined in accordance with BS EN 13391, shall not be less than 90 %.

The anchorages shall effectively distribute the force in the tendon to the structural member, and the resulting local stresses and strains in the member shall be so limited as to prevent damage. Unless otherwise approved by the Engineer, all anchorages and couplers shall be provided with anchorage reinforcement.

Wedges and the insides of barrels or cones shall be clean to allow the free movement and seating of the wedges inside the taper.

The threads of bars, nuts, anchorages and couplers shall be suitably protected against damage and corrosion. The protection shall be removed at the last moment and the threads properly lubricated before use.

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d. Sheaths

Sheaths shall be grout-tight and of such material and configuration that bond forces can be transferred from the grout to the surrounding concrete. The properties of the sheath material shall be such that no corrosion attack of the prestressing steel will be induced. The sheath shall be sufficiently flexible to accept the required curvature without kinking, and strong enough to retain its cross-section and alignment and to resist damage on account of handling, transporting, tying and contact with vibrators during concreting. Unless otherwise approved by the Engineer the thickness of the metal of steel sheaths shall not be less than 0.4 mm.

Metal sheathing shall be delivered at the site suitably protected against damage and corrosion. At the time of incorporation into the structural member, the sheathing shall be free from loose mill scale, loose rust, lubricants and harmful matter.

Galvanised sheathing shall not be used unless specified.

Unless otherwise specified, the internal diameter of the sheath shall be at least 10 mm greater than the diameter of the tendon. For vertical tendons and where tendons are to be drawn into cast-in sheaths, the cross-sectional duct area shall be at least three times the cross-sectional area of the tendon.

e. Cable Supports

Supports of reinforcing steel or structural steel suitably braced to prevent buckling under load shall be used to support the cables. The cable saddles shall be rigid and secured in position by welding or by equivalent mechanical means to resist both gravitational and buoyancy forces.

Normal web reinforcement shall not be utilised to support cables.

Saddles for external cables shall be of special design and material to ensure low friction and to prevent the tendon or parts thereof from grooving the surface. The saddle plates shall be curved to the requisite radius to prevent the tendon or part thereof from bearing on the end of the plate and shall incorporate features to ensure that individual bars, wires and strands are seated separately.

f. Tendon Spacers

Tendon spacers used inside the ducts to separate individual bars, wires or strands of the tendon shall be of a proven and approved type and manufactured from material which will not induce corrosion of the prestressing steel.

g. Grout**i. Materials**

In addition to the requirements of SUBCLAUSE 7402(c), water shall not contain more than 500 mg of chloride ions per litre of water.

Only common cements which comply with the requirements of KS-EAS 18, BS EN 197-1 or equivalent shall be used. The temperature of the cement shall be less than 40°C, and the cement shall be stored in accordance with the requirements of SUBCLAUSE 7403(a).

Fine aggregate shall consist of siliceous granules, finely ground limestones, trass or very fine sand. The aggregate used shall pass through a 0.600 mm sieve. The use of fine aggregate shall be subject to the approval of the Engineer and shall be restricted to grout for ducts with a diameter exceeding 150 mm. The aggregate content in the grout shall not exceed 30% of the weight of the cement.

The use of admixtures shall be subject to tests having shown that their use improves the properties of the grout, e.g. by increasing workability, reducing bleeding, entraining air, or expanding the grout. Admixtures shall be free from any product liable to damage the steel or the grout itself, such as halides, nitrates, sulphides, sulphates, etc. The quantity of admixture to be used shall be in accordance with the manufacturer's instructions.

ii. Properties of the grout

The grout shall comply with BS EN 447 and have the following properties. Testing shall be in accordance with BS EN 445:

1. General

The total values of the chlorides, sulphates, sulphites and sulphurs occurring in the constituent materials shall be as under.

- Chloride (Cl^-) $\leq 0.10\%$ by weight of cement
- Sulphate (SO_{3-}) $\leq 4.5\%$ by weight of cement
- Sulphide-ions (S^{2-}) $\leq 0.01\%$ by weight of cement

2. Sieve test

The grout shall be tested according to BS EN 445 and no lump shall remain in the sieve.

3. Fluidity

The fluidity of the grout during injection period shall be measured by either one of the methods given in BS EN 445 and the grout shall have the following values given in TABLE 7503/1.

TABLE 7503/1: FLUIDITY TEST REQUIREMENTS FOR GROUT

Test method given in BS EN 445	Parameter	Immediate after mixing	30 min after mixing* or at specified by the group manufacturer
Cone	Time (in s)	$t_0 \leq 25 \text{ s}$	$1.2 t_0 \geq t_{30} \geq 0.8 t_0$ and $t_{30} \leq 25 \text{ s}$
Grout spread	a = average spread (in mm)	$a_0 \geq 140 \text{ mm}$	$1.2 a_0 \geq a_{30} \geq 0.8 a_0$ and $a_{30} \geq 140 \text{ mm}$

*Mixing time shall be measured from the time when all materials are in the mixer.

The fluidity measurements immediately after mixing are denominated as t_0 (cone method) and a_0 (grout spread method). Measurements made after 30 minutes of mixing i.e. 30 minutes after first measurements, are denominated as t_{30} and a_{30} . The grout shall be kept constantly in motion until sampling for measurement of as t_{30} and a_{30} .

4. Bleeding

The bleeding of the grout shall be sufficiently low to prevent excessive segregation and sedimentation of the grout materials.

When tested by the wick induced method given in EN 445 for the average of three results the bleeding shall not exceed 0.3 % of the initial volume of the grout after 3 h kept at rest

When tested by the inclined tube test method given in EN 445 the bleeding shall not exceed 0.3 % of the initial volume of the grout after 3 h kept at rest.

5. Volume change

The volume change assessed may be either an increase or decrease. When tested in accordance with the method given in BS EN 445, the volume change of the grout at rest for 24 hours shall be within the range of -1 % and +5 %.

6. Strength

The compressive strength of group assessed according to BS EN 445 shall not be less than 30 N/mm² at 28 days or 27 30 N/mm² if it is possible to estimate the likely 28 days strength at 7 days.

7. Setting time

The setting time of group shall be measured according to BS EN 196-3 and shall comply the following:

Initial set of the grout ≥ 3 h

Final set of the grout ≤ 24 h

8. Density

The density of group shall be measured in accordance with the method given in BS EN 445 and shall be declared.

h. Protecting Agents for Unbonded Tendons

The material used for permanent protection of unbonded tendons shall have the following properties:

- i. It shall remain free from cracks and shall not become brittle or fluid within the temperature range of -20°C to 70°C .
- ii. It shall be chemically stable and the Engineer shall approve its properties.
- iii. It shall be non-reactive with the surrounding materials, i.e. concrete, tendons, wrapping or sheathing.
- iv. It shall be non-corrosive or corrosion-inhibiting.
- v. It shall be impervious to moisture.
- vi. It shall be sufficiently tough to withstand the abrasion caused when a tendon, precoated with the material, is drawn into the sheath.
- vii. It shall have no appreciable shrinkage or excessive volume increase.
- viii. It shall have a suitable viscosity at ambient temperature or require only moderate preheating to permit injection.

i. Testing

Prestressing steel, anchorages and couplers, and grout shall be tested in accordance with the requirements of SUBCLAUSE 7503. Testing shall be carried out at the frequencies as directed by the Engineer.

7504 Equipment**a. General**

All equipment used shall be in a good working order and properly maintained.

b. Tensioning and Measuring Equipment

Tensioning and measuring equipment shall be such that the tendon force can be established to an accuracy of $\pm 2\%$ during any stage of the tensioning operation.

Unless otherwise authorised by the Engineer, the tensioning equipment shall be power driven and capable of gradually applying a controlled total force without inducing dangerous secondary stresses in the tendon, anchorage or concrete.

The force in the tendon during tensioning shall be measured by a direct-reading dynamometer or obtained direct from pressure gauges fitted in the hydraulic system to determine the pressure in the jacks.

Pressure gauges shall have concentric scale dials which comply with the requirements of BS EN 837-1. The dials shall not be less than 150 mm in diameter and the gauges shall be used within the range of 50 to 90 % of their full capacity at maximum service pressure.

When pressure gauges not using glycerine are used, a snubber or similar device shall be fitted to protect the gauge against any sudden release of pressure. Provision shall also be made for T-connections for the attachment, when required, for supplementary control gauges.

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Only self-sealing connections shall be used in the hydraulic circuit. Where the pressure input pipe is connected to the jack, a pipe rupture valve shall be installed in the circuit.

Tensioning equipment shall be calibrated before the tensioning operation and thereafter at frequent intervals, as directed by the Engineer, with a master gauge or proving ring, and the Engineer shall be furnished with a calibration chart. The load-measuring devices shall be calibrated to an accuracy of $\pm 2\%$.

The extension of tendons shall be measured to an accuracy of $\pm 2\%$ or ± 2 mm, whichever is the more accurate, and pull-in and release to an accuracy of ± 2 mm.

c. Grouting Equipment

i. Mixer

Mechanically operated mixers used shall be of a type capable of producing high local turbulence while imparting only a slow motion to the body of the grout.

The mixer shall be equipped with a screen with openings not exceeding 1.0 mm and shall be capable of consistently producing grout with a colloidal consistency.

ii. Agitator

Where the capacity of the mixer is insufficient to fill the duct completely with grout, an agitator shall be used.

Mechanical agitators used shall be capable of maintaining the colloidal condition of the grout fill during the storing and injection processes. The grout shall be delivered at the structure from the agitator, and the system shall make provision for re-circulating the grout from the pump back to the agitator.

iii. Injection Equipment

The pump shall be of the positive displacement type (piston, screw or similar type), capable of exerting a constant pressure of at least 10 bars on completely grouted cables and shall incorporate a safety device for preventing the build-up of pressure above 20 bars. The pump shall be fitted with a pressure gauge and a valve which can be locked-off without loss of pressure in the cable.

The pump shall be capable of delivering grout at a speed that will produce a speed of the grout in the cable of between 6 and 12 m/minute.

All connections in the pipes and between the pipe and the cable shall be airtight. Only bayonet, threaded, or similar types of connectors shall be used.

7505 Technical Data

The following technical data for pre-tensioned and post-tensioned structural members required for the Contract will be furnished on the Drawings:

a. Tendon Alignment

A diagram showing the alignment of each tendon or group of tendons in both the horizontal and vertical planes, together with the horizontal and vertical co-ordinates, and curve equations of the centroid of the tendon(s), as may be relevant.

b. Tendon System

The design shall be based on the system shown on the Drawings, but the Contractor may use any suitable system which will meet all the specified requirements, subject to approval by the Engineer.

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c. Tensioning the Tendons

Full particulars regarding the partial tensioning of the tendons, the stage during which the tendons shall be tensioned, and the sequence of tensioning to be followed.

d. Tensioning Force

The maximum tensioning force and the effective force at the live anchorages, after transfer, as well as the corresponding stress level in the prestressing steel, for each tendon or group of tendons. The forces will be given in MN units, and the stress levels will be expressed as a percentage of the characteristic strength.

e. Extension

The extension per tendon or group of tendons under the maximum tensioning force, together with the modulus of elasticity (E) on which it has been based. The release to be attained at each live anchorage as well as the pull-in for which provision has been made.

The Contractor shall show on their drawings the expected extension based on the actual modulus of elasticity of the strand as well as the expected wedge pull-in and any provision for shimming.

f. Prestressing Losses in Tendons

The losses allowed for in the design from the causes listed below will be given as follows:

i. Friction loss

The formula used for determining the tendon/duct friction loss together with the values adopted for the friction coefficient (m) caused by curvature, and the wobble factor (k) caused by unintentional variation from the specified alignment.

ii. Elastic deformation of concrete

The elastic factor, which, when multiplied by the compressive stress in the concrete adjacent to the tendon, will give the loss caused by the deformation of the concrete.

iii. Creep of the concrete

The creep factor, which, when multiplied by the compressive stress in the concrete adjacent to the tendon, will give the loss caused by the creep of the concrete.

iv. Shrinkage of the concrete

The stress loss in MPa caused by the shrinkage of the concrete.

v. Relaxation of prestressing steel

The stress loss in MPa at a stress level of 70 % of the characteristic strength of the prestressing steel caused by the relaxation of the prestressing steel.

g. Anchorages

The positions where loop or fan-type dead-end anchorage may be used.

h. Bursting Reinforcement

The bursting reinforcement for the prestressing system on which the design is based.

i. Precamber

The precamber at intervals not exceeding 0.25 times the span length.

j. Compressive Strength of the Concrete During Transfer

The compressive strength to be attained by the concrete in the relevant member before transfer may be effected.

7506 Prestressing System

The use of all prestressing systems will be subject to approval by the Engineer. Bidders are advised to obtain approval for the prestressing system they intend using, prior to submitting their bids.

Within one month of the bid having been awarded, or within a period agreed on with the Engineer, the Contractor shall submit full details regarding the prestressing system(s), materials and equipment they intends to use, as well as regarding the methods the Contractor he/she proposes to adopt in the prestressing and related operations.

The Engineer, at their own discretion, may call for further information in the form of detailed drawings, proof of successful previous use, performance certificates from an approved independent testing authority, and calculations substantiating the adequacy of the system. The Contractor shall furnish such information within two weeks of being called upon to do so or within a period agreed on with the Engineer. If, after investigating all the information, the Engineer is not satisfied that the prestressing of the structural member can be carried out satisfactorily with the prestressing system offered by the Contractor, the Engineer reserves the right to order the Contractor to use any system which is suited to the work and which is readily available to the Contractor.

Only minor alterations to the concrete dimensions shown on the Drawings will be considered in order to accommodate the prestressing system finally selected. Major alterations occasioned by the prestressing system offered by the Contractor and which is at variance with the tendon system specified in **SUBCLAUSE 7505(b)** shall be treated as alternative designs and shall be dealt with as specified in **CLAUSE 1209**.

7507 Drawings Prepared By The Contractor

All drawings prepared by the Contractor and submitted to the Engineer for consideration shall comply with the requirements of **CLAUSE 1210**.

The Contractor shall submit to the Engineer at least two months before they intends on commencing with the prestressing work, drawings detailing the layout and alignment for the individual tendons, the cable supports, modifications to the bursting and other reinforcement, anchorage recesses, tensioning sequence, tensioning loads and extensions, as well as requirements for controlling the tensioning operations. For the prestressing system finally selected, the technical data which are at variance with the information given on the Drawings shall be shown on the Drawings. Each tendon shall be separately numbered for identification.

Where required, the Contractor shall submit calculations in respect of the variation of the tendon force along the length of the tendon, the expected extension and the bursting forces.

After approval by the Engineer of the Drawings and calculations prepared by the Contractor, no departure shall be permitted from the forces, stresses and extensions shown thereon, without authorisation by the Engineer.

The prestressing work shall not be commenced before the relevant drawings have been accepted by the Engineer. The Contractor shall make full allowance in their bid rates for all costs in connection with the furnishing of information, making calculations, and preparing and submitting the Drawings. However, no allowance need be made for the cost of checking, undertaken by the Engineer, of drawings and calculations for work which does not qualify as an alternative design.

Alternative designs shall comply with the requirements of **CLAUSE 1209** and the relevant provisions of this SECTION.

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7508 Precasting

a. Casting Yard on the Site

Subject to approval by the Engineer, precast work may be done at any location selected by the Contractor.

Before the casting yard is established, the Contractor shall submit plans to the Engineer which demarcate the site and detail the layout of the Works, together with a flow diagram of the construction stages and storage.

b. Manufacture Off the Site

The Contractor shall notify the Engineer in advance of the dates when tensioning of tendons, casting of members and transfer, will be undertaken.

Within seven days of transfer, the Contractor shall submit to the Engineer a certificate giving the tendon force(s) and extension(s) attained as well as records of the cube crushing strength and age of concrete at transfer.

Test results relating to all aspects of the work shall be sent to the Engineer immediately upon their becoming available.

Where the Engineer requires tests to be conducted on completed members, no member to which the tests relate shall be dispatched to the site until the tests have been satisfactorily completed and the members accepted by the Engineer.

c. Manufacture

Before work is commenced, details of the manufacture and phasing of the work shall be submitted to the Engineer for approval. After approval, no changes shall be made to the methods or systems, without approval by the Engineer.

The Contractor shall ensure that the specified precamber is incorporated in the formwork. The magnitude of the precamber shown on the Drawings shall be subject to variation depending on the Contractor's construction programme; and the Contractor shall, before manufacture, ascertain in writing from the Engineer, the increase or decrease in precamber. This procedure shall also apply to the cases where no precamber has been specified.

Lifting and supporting the precast members shall be made only at the points marked and provided on the members.

Precast members which have not been fully tensioned or fully stage extensioned or which have ungrouted tensioned tendons shall not be handled without authorisation by the Engineer.

Where members with ungrouted tensioned tendons are handled, control shall be exercised to guard against possible slip of the tendon at the anchorage.

Prestressed precast concrete members shall also comply with the requirements of [CLAUSE 7413](#).

7509 Pre-Tensioning

During the period between tensioning and transfer, the force in the tendon shall be fully maintained by some positive means. At transfer, detensioning shall take place slowly to minimise any shock which could adversely affect the transmission length of the tendon.

In the long-line method of pre-tensioning, sufficient locator plates shall be distributed throughout the length of the bed to ensure that the straight tendons are maintained in their proper position during concreting. Where a number of units are manufactured in line, they shall be free to slide in the direction of their length so as to permit transfer of the tendon force to the concrete along the entire line.

In the individual-mould system, the moulds shall be sufficiently rigid to provide the reaction to the tendon force without distortion.

Where possible, the mechanism for holding down or holding up deflected tendons shall ensure that the part in contact with the tendon will be free to move in the line of the tendon so that friction losses are eliminated. If, however, a system is used which develops a frictional force, this force shall be determined by test and due allowance made thereof.

For single tendons, the deflector in contact with the tendon shall have a radius of not less than 5 times the tendon diameter for wire, or 10 times the tendon diameter for a strand, and the total angle of deflection shall not exceed 15°.

Transfer of the tendon force to the concrete shall be affected in conjunction with the release of hold-down and hold-up forces in accordance with an approved method.

Transfer shall not be effected until compressive-strength tests on the concrete show that the concrete of the particular member has attained a compressive strength of at least the compressive strength shown on the Drawings. The transmission length is affected by the concrete strength, and the necessary modification for the concrete strength at transfer shall be made in conjunction with the Engineer.

The tendons shall be cut off flush with the end of the member and the exposed ends covered with a heavy coat of approved bituminous material or epoxy resin. The cutting of the prestressing steel shall be performed with a high-speed abrasive cutting wheel. Flame cutting will not be permitted.

7510 Post-Tensioning

a. Storage, Handling and Protection

During storage, transit and construction and after installation, the sheaths, prestressing steel, anchorages and couplers shall be protected against corrosion, damage or permanent deformation. The manner and extent of protection required will depend on the environmental factors and the length of time before permanent corrosion protection is applied, and shall be to the satisfaction of the Engineer. Under severe corrosive conditions in damp and wet areas and under aggressive conditions, the materials shall be stored in weatherproof sheds. All materials shall be stored clear of the ground and while in storage shall not be enclosed to the weather.

When prestressing steel has been stored for a prolonged period and there is evidence of its deterioration, the Contractor may be called on to prove by tests that the quality of the steel has not been significantly impaired and that the prestressing steel still complies with the provisions of these Specifications.

Suitable protection shall be provided to the threaded ends of bars.

After fabrication, the cable ends shall be covered with protective wrapping to prevent the ingress of moisture into the duct.

When the tendon is to be left untensioned for a prolonged period after installation, precautions shall be taken to protect the tendon against corrosion. Corrosion inhibitors, oils or similar materials used as lubrication or to provide temporary protection shall be such that they can be completely removed before permanent protection is effected.

b. Fabrication

All cutting of prestressing steel shall be performed with a high-speed abrasive cutting wheel or by a method approved by the Engineer. Flame cutting will not be permitted.

Care shall be taken to prevent the prestressing steel or anchorages from coming into contact with splashes from flame-cutting or welding processes in the vicinity.

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Where possible, all bars, wires or strands tensioned in one operation shall be taken from the same parcel of prestressing steel. The tendon or cable shall be labelled to show the tendon or cable number, as well as identify from which parcel the steel has been taken.

Where bars, wires or strands in a tendon are not tensioned simultaneously, tendon spacers shall be used in accordance with the recommendations for the prestressing system or, in the absence thereof, as directed by the Engineer.

Cables shall be fitted at both ends with pipes with a diameter of at least 10 mm for the injection of grout or protection agents. The ends of the injection pipes shall be fitted with a clamp, valve or device capable of withstanding a pressure of at least 15 bars without loss of grout or protection agent.

Vent pipes with a diameter of at least 25 mm shall be provided in the duct at every high point, change of sheath cross-section and at such intermediate positions as may be shown on the Drawings or required by the Engineer. The vent pipes shall extend to at least 500 mm above the concrete and shall comply with the requirements for injection pipes.

Connections to, and joints in sheaths shall be made grout-tight by using special sheathing couplings and taping. With bonded cables, the length of taping shall not exceed six sheath diameters. Where over sleeves are used, equal overlaps shall be provided over each length of sheathing. Joints in adjacent sheaths shall be spaced at least 300 mm apart.

c. Installation

The installation of tendons shall not commence until the requirements of **CLAUSE 7507** have been complied with.

The cable, sheath or extractable core shall be accurately installed to the specified alignment and securely held in position both vertically and horizontally at intervals appropriate to its rigidity so as not to be displaced during concreting, either by the weight of the concrete or by buoyancy. The spacing of the cable supports shall furthermore ensure that the tendon can be installed to a smooth alignment without kinks and within the tolerance specified in **SUBCLAUSE 1904(g)**. Cable sheaths shall be supported and held in position by means of separate reinforcing steel supports with a diameter of not less than 16 mm. The transverse bars must be welded to the vertical bars or must rest on lugs welded to the vertical bars. The spacing of the vertical supports shall not exceed 1.0 m

Extractable cores shall not be coated with release agent unless approved by the Engineer.

Unless otherwise shown on the Drawings, the alignment of the tendon within a distance of 1.0 m from the live anchorage and/or coupler shall be straight. The tendon axis shall be set perpendicular to the bearing surface of its anchorage and firmly secured in position so as not to move during concreting. External anchorages shall be seated on a thin mortar bedding to bear evenly on the concrete bearing surface, and the tendon axis shall be perpendicular to the bearing surface of the anchorage.

Unless otherwise shown on the Drawings, the minimum concrete cover over the outside surface of the sheath or cable support shall comply with the requirements of **CLAUSE 7308**, except that, for sheaths, the cover shall not be less than 50 mm.

The spacing of cables will depend on the size of the cable and shall be such that the concrete can be properly placed and compacted.

Immediately before concreting, the Contractor shall inspect the sheaths for grout-tightness and shall seal all damaged and suspect sections.

External tendons shall be installed to the same standards and accuracy specified herein for internal tendons. The tendons shall be temporarily supported at regular intervals along the straight length between saddles. The supports shall consist of rigidly constructed frames secured to the concrete face.

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d. Concrete Strength

Full tensioning of all or some of the tendons shall not commence until the compressive-strength of the concrete is 35 MPa or the strength shown on the Drawings, whichever is the greater.

The compressive strength of the concrete shall be determined from cubes manufactured and tested in accordance with SUBCLAUSE 7404(b) which have been cured under the same conditions as the structural member which is to be prestressed. The number of concrete cubes required for this purpose shall be as agreed on with the Engineer.

Where initially all or some of the tendons are to be partially tensioned, tensioning shall not commence before the concrete has attained the compressive strength indicated on the Drawings.

e. Tensioning

i. Preparation

Within two hours of the concrete having been placed, the Contractor shall demonstrate that sheaths are free from obstructions, that extractable cores can be removed and, where the design permits, that all tendons are free to move in the ducts. All water in the ducts shall then be expelled with compressed air and the cables/ducts sealed until tensioning takes place.

Before tensioning is commenced, the side forms and other restraining elements shall be released or removed to give the structural member the freedom to deform under the induced force.

ii. Tensioning sequence

The sequence of tensioning to be followed shall be as shown on the Drawings and/or on drawings prepared by the Contractor in terms of CLAUSE 7507. The Contractor shall make allowance in their bid rates for all incidentals which they may have to incur as a result of having to tension fully only some of the tendons at any one stage or instant. Where partial tensioning of tendons is required, the work shall be executed in accordance with the details on the Drawings or as specified. The Contractor shall make provision in their bid rates for all incidentals he may have to incur as a result of having to tension partially only some or all of the tendons at any one stage or instant.

iii. Assembling the equipment, and safety precautions.

The tensioning and measuring equipment shall be assembled for tensioning in exactly the same way as they are assembled for calibration.

The Contractor shall take all the necessary safety precautions to prevent accidents caused by the malfunctioning or failure of any part of the equipment or material and shall accept full responsibility for injury sustained by persons or damage to property resulting therefrom.

iv. Friction

The Engineer may require the Contractor to perform friction tests on designated tendons and to revise the relevant theoretical extensions to compensate for the discrepancy between the values adopted in the design and the test results. Payment for these tests shall be made under ITEM 71.01.

Where applicable, allowance shall be made in the tensioning force to compensate for friction loss in the jack and in the anchorage.

v. Tensioning

Tensioning shall be carried out under the supervision of a technician skilled in the use of the prestressing system and equipment and the methods of tensioning to be adopted.

Tensioning shall not be commenced before the Engineer has been advised of each tensioning operation and has given approval for the work to be started.

The technician and operators shall be supplied with a schedule listing the sequence of

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tensioning the various tendons and a tensioning record sheet showing the theoretical gauge readings, jacking forces, extensions, release and pull-in for each tensioning operation. The record sheet shall furthermore provide room for entering the corresponding information recorded and observations made during tensioning. A graph of the tensioning force and/or gauge reading versus theoretical extensions shall, where required, be appended to the record sheet and the actual extensions measured for each load increment shall be plotted on the graph. Copies of the completed record sheets and graphs shall be submitted to the Engineer within 24 hours of each tensioning operation having been completed.

The Contractor shall note that the extensions shall be regarded as an indirect measurement of the tensioning force and shall serve as a control on the tensioning force applied.

The protruding ends of all bars, wires and strands shall be clearly marked for the accurate measurement of extension, release and pull-in.

Before tensioning is commenced on external tendons, a small load shall be applied to each tendon, commencing with the uppermost tendon. The force shall be sufficient to take up all slack and prevent entanglement of the tendons.

The jacking force shall be increased to approximately 5% to 10% of the final jacking force to take up the tendon slack and to determine the zero position for measuring the extension and to check the gripping devices and the position and alignment of the jacks. The load shall then be increased gradually to the full specified tensioning force while intermediate gauge readings and extensions are recorded at regular intervals.

The final stage of tensioning shall be deemed to have been satisfactorily accomplished when all the following requirements have been complied with:

1. The tendons have been tensioned to the required force.
2. The measured extension on individual tendons is within $\pm 6\%$ of the theoretical extensions.
3. The average variation between the measured and theoretical extensions of all the tendons in a structural member is less than $\pm 3\%$.
4. The release and/or pull-in is within ± 2 mm of the theoretical values.

Where the above conditions are not met individually and collectively, the Contractor shall immediately advise the Engineer and obtain a ruling as to the procedure to be followed.

In the event of the tendon friction being too high, the Contractor may, subject to approval by the Engineer, inject an approved lubricant into the sheath after first having detensioned the tendon.

The cost of the remedial and corrective measures and of the release and retensioning of tendons, which have been occasioned by failure of the operations to meet the above requirements shall be for the Contractor's account.

After the tensioning has been accepted by the Engineer, the Contractor may cut off the tendons behind the anchorage as described in SUBCLAUSE 7510(b).

f. Permanent protection and bonding of tendons

i. General

After tensioning, all tendons shall receive permanent protection against mechanical damage and corrosion.

Internal tendons shall be protected and bonded to the structural member by cement grout or, when permitted by the Engineer, by sand-cement grout. Where bond is not important, protection may be effected by the use of bitumen, petroleum-based compounds, epoxy resins, plastics and similar products, all complying with the requirements of SUBCLAUSE 7503(h) and subject to approval by the Engineer.

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Tendons located outside the structural section (i.e. external tendons) shall be encased with a dense concrete, dense mortar or material sufficiently stable and hard, all subject to approval by the Engineer. The encasement shall be of the thickness shown on the Drawings. Where bonding of the tendon to the structural concrete is required, this shall be achieved by bonding the concrete encasement to the structure with reinforcing steel as detailed on the Drawings.

Protection and bonding of the tendons shall be effected within seven days of the final tensioning of the tendons, or as specified on the Drawings, but shall not take place without the prior approval of the Engineer having been obtained.

After the permanent protection or bonding has been completed the anchorages shall be encased in concrete or grout which shall be bonded to the old concrete with epoxy resin designed for this purpose, or shall be completely coated with a corrosion-resistant material. The protection provided shall in all cases prevent the ingress of water or aggressive agents.

ii. Preparation of ducts

Before permanent protection and/or bonding of tendons is effected, the following precautions shall be taken:

1. The cables shall be checked for blockages by water or compressed air being injected.
2. Unlined ducts which are to be filled with grout shall be flushed with water to wet the concrete.
3. Temporary protection or lubricants which are incompatible with the permanent protection or bonding, shall be removed by flushing the duct with water or an inert solution, or by any suitable approved method.
4. On completion of the above, any excess fluid shall be expelled from the ducts by means of compressed air or shall be displaced by the protecting agent or grout, as may be relevant.
5. Any blockages, leakages or factors which in any way may affect the permanent protection or bonding shall immediately be reported to the Engineer.

iii. Mixing

1. Protecting agents

The mixing of protecting agents shall be strictly in accordance with the manufacturer's instructions.

2. Grout

The aggregate, if used, and the cement shall be measured by weight, and the water by weight or by volume.

The water:cement ratio by weight shall be as low as possible within the range between 0.36 to 0.45, and shall be consistent with the fluidity requirements of SUBCLAUSE 7503(g).

Where an admixture is used, it shall be dissolved in a part of the mixing water before it is added to the grout.

Mixing shall be commenced by two-thirds of the cement being added to the greater part of the mixing water, and, if used, an additive predissolved in part of the mixing water, and finally the remainder of the cement. Mixing shall continue for not longer than four minutes after which the grout shall be continually agitated at slow speed throughout the injection operation.

Where aggregate is used in the grout mix, the word "cement" in the preceding paragraph shall be replaced by the term "cement/aggregate component".

iv. Injection

1. General

The injection of permanent protecting agents or grout shall not commence before approval has been granted that the work may start.

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Before injection commences all air shall be expelled from the injection equipment and hoses and all connections checked for airtightness.

Injection shall take place from the anchorage or coupler, whichever is situated at the lower end of the cable. Grout injection shall proceed without any interruption until the cable has been completely filled and closed off.

2. Protecting agents

The injection of protecting agents shall be strictly in accordance with the instructions, and with the equipment specified by the manufacturer.

3. Grout

Immediately after mixing, and also during injection, the fluidity of the grout shall be tested at regular intervals in accordance with SUBCLAUSE 7503(g)(ii).

Injection shall be continuous at a rate of 6 to 12 m per minute. As soon as grout with the original consistency flows from the intermediate vent pipes they shall be successively closed. Injection shall continue until the grout flowing from the vent at the free end is of the same consistency as that of the injected grout. At this stage the vent shall be closed and the final pressure or a pressure of 5 bars, whichever is the greater, shall have been maintained on the grout column for five minutes before the valve at the injection end is closed.

All vents shall be kept closed and supported vertically until the grout has finally settled. On vertical cables, a riser pipe with funnel shall be fitted to the top anchor to ensure that the separated water migrates upwards and will not remain in the cable.

If an expanding agent is used in the grout mix, the air vents shall be re-opened after grouting to release any separated water, and shall then again be closed.

Unless a retarder is used in the grout mix, the grout not used within 60 minutes of mixing shall be discarded.

During the course of grouting, 100 mm cubes shall be made for testing in accordance with SUBCLAUSE 7503(g)(ii). Whilst the grout is being poured into the cube mould, the sides of the mould shall be slightly tapped to permit any entrapped air to escape.

Precautions shall be taken not to discharge the escaping grout onto railway lines, public roads, water courses or private property.

If a blockage occurs during the course of grouting, the grouting shall be stopped before the maximum grouting pressure is reached. The duct shall then be flushed out immediately and the blockage cleared.

Grouting shall not be carried out during very cold weather when the ambient air temperature drops below 5°C. Care shall be taken that the ducts are completely free from frost or ice before grouting commences after frosty weather.

7511 Loss Of Prestress

Any structural member which has lost all or part of its prestress through the failure or malfunctioning of any part of the prestressing component may be rejected by the Engineer and shall be removed from the Works unless approved remedial measures have been successfully carried out on the member.

No payment will be made in respect of such remedial work or loss suffered by the Contractor in this regard.

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7512 Measurement And Payment

Item		Unit
75.01	Prestressing Tendons:	
(a)	Longitudinal Tendons	Meganewton-Metre (MN-m)
(b)	Transverse Tendons	Meganewton-Metre (MN-m)
(c)	Vertical Tendons	Meganewton-Metre (MN-m)

The unit of measurement shall be the Meganewton-metre which is calculated as the product of the characteristic strength in megapascals of the prestressing steel, the cross-sectional area of the tendon in square metres and the length of the tendon in metres between the faces of the anchorages. In the case of fan and loop anchorages the "length of the tendon" shall include the length of tendon forming the loop or fan.

The bid rates shall include full compensation for preparing and submitting the Drawings, supplying, storing, handling and protecting all materials (excluding anchorages and couplers), fabricating, supporting and installing the cables; lubricating, permanently protecting and bonding the tendons, for the using of all the equipment, as well as for all work and incidentals required for completing the work as specified.

Item		Unit
75.02	Anchorage And Couplers:	
(a)	End Anchorage At Jacking	Meganewton (MN)
(b)	Anchorage At Dead End	Meganewton (MN)
(c)	Coupler At Jacking End	Meganewton (MN)
(d)	Coupler At Dead End	Meganewton (MN)

The unit of measurement shall be the Meganewton which is calculated as the product of the characteristic strength in megapascals of the prestressing steel and the cross-sectional area of the tendon in square metres, effectively anchored or coupled.

The bid rates shall include full compensation for supplying, storing, handling, fabricating and protecting the complete anchorage or coupler assembly, anchorage reinforcing, constructing the recesses for the anchorage or coupler, tensioning, anchoring and/or coupling, trimming the tendon ends, using all the equipment, as well as for all work and incidentals required for completing the work as specified.

The coupler shall include the complete assembly consisting of the anchorage built into the first-stage construction and the part coupled to it.

The bid rate for loop or fan anchorages shall exclude the cost of the length of tendon forming the loop or fan.

Item		Unit
75.03	Extra Over ITEM 75.02 For Partially Tensioning the Tendons	Meganewton (MN)

The unit of measurement shall be the Meganewton, which is calculated as for ITEM 75.02.

The bid rate shall include full compensation for the use of all equipment, as well as for all work and incidentals required for tensioning and anchoring the tendons to the specified partial force.

SECTION 7600 No-fines Concrete, Joints, Bearings, Parapets and Drainage for Structures

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7601 Scope

This section covers:

1. The manufacture and placing of no-fines concrete used in the works;
2. The supply and installation of all permanent joints which will permit relative movement between contiguous structural members;
3. The construction, supply and installation of bearings for structures;
4. The construction of parapets, railings and sidewalks on structures;
5. The construction and/or installation of drainage works such as weep holes, drainage pipes and gulleys, no-fines concrete blocks, filter lining and concrete channelling;

7602 No-Fines Concrete

a. Materials

Cement, aggregate and water shall comply with the requirements of **CLAUSE 7402**.

Each size of aggregate shall be a single size aggregate graded in accordance with BS EN 12620 or equivalent.

b. Classes of No-fines Concrete

No-fines concrete shall be classified by the prefix NF and the size of aggregate to be used. e.g. CLASS NF 19 means a no fines concrete with a 19.0 mm nominal size aggregate.

The volume of aggregate per 50 kg of cement for each class of concrete shall be as detailed in **TABLE 7602/1**.

TABLE 7602/1: VOLUMES OF AGGREGATE	
Class of Cement	Aggregate per 50 kg
NF38	0.33 m ³
NF19	0.30 m ³
NF13	0.27 m ³

c. Batching and Mixing

Cement shall be measured by weight or in full packets of 50 kg each and aggregate shall be measured by volume in approved measuring boxes or barrows.

The aggregate shall be moist or wetted before the cement is added. Where drum mixers are used, about 20 % of the water shall be poured into the drum before the aggregate and cement are loaded. The mixing time in the drum shall be about 45 to 50 seconds.

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The quantity of water added shall be just sufficient to form a smooth grout which will adhere to and completely coat each and every particle of aggregate, and which is just wet enough to ensure that, at points of contact of aggregate, the grout will run together to form a small fillet to bond the aggregate together. The mix shall contain no more than 20 litres of water for every 50 kg of cement.

Mixing shall be done in an approved batch-type mechanical mixer, but small quantities may be hand mixed.

d. Placing

No-fines concrete shall be placed in accordance with the procedure approved by the Engineer. It shall be placed in its final position within 15 minutes of having been mixed.

The concrete shall be worked sufficiently to ensure that it will completely fill the space to be concreted and that adjacent aggregate particles are in contact with one another. Excessive tamping shall be avoided and the concrete shall not in any circumstances be vibrated.

e. Protection

All no-fines concrete shall be protected from the elements' and loss of moisture. Protection against loss of moisture shall be accomplished by one or more of the following methods:

- i. Retaining formwork in place.
- ii. Covering enclosed surfaces with sacking or other approved material kept continuously wet.
- iii. Covering enclosed surfaces with plastic sheeting.

No-fines concrete placed during cold weather shall be adequately protected against frost for at least three days.

7603 Joints In Structures

a. Materials

i. General

All materials used in forming, constructing and sealing permanent joints as well as all proprietary or custom-built expansion-joint assemblies shall be subject to the approval of the Engineer.

When required by the Engineer, the Contractor shall submit test certificates issued by an approved, independent testing authority to confirm that the respective materials comply with the specified requirements, or a certificate by the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.

ii. Joint filler

Joint filler shall consist of sheets or strips of the following materials complying with the requirements of the relevant specifications listed:

1. Bitumen-impregnated fibreboard and bitumen impregnated corkboard - US Federal Specification HH-F-341 F or AASHTO Specification M-213.
2. Resin-impregnated corkboard - US Federal Specification HH-F-341F.
3. Flexible foams of expanded polyethylene, polyurethane, PVC or polypropylene – AASHTO Specification M-153.
4. Rigid foams of expanded polyethylene, polyurethane or polystyrene - or BS EN 13164.

Other joint filler materials may be used if approved by the Engineer after he has been furnished with full specifications and information by the Contractor.

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iii. Sealants

Thermoplastic hot-poured sealants shall comply with the requirements of US Federal Specification SS-S-1401 B, BS EN 14188-1 or AASHTO Specification M-173. The sealants shall be of the rubberised bituminous type containing a minimum of 20 % natural or synthetic rubber.

Thermoplastic cold-applied sealants shall comply with the requirements of BS EN 14188-2 or US Federal Specification SS-S-156. The sealant shall be of the rubberised bituminous type containing a minimum of 20 % natural or synthetic rubber.

Thermosetting chemically curing sealants shall comply with the requirements of ASTM C-920 or BS EN ISO 11600.

The final IRHD (International Rubber Hardness Degree) hardness of the sealant shall be 20 ± 5 .

Silicone sealants shall comply with the requirements of the Special Specifications.

Other sealants may be used if approved by the Engineer after they have been furnished with full information and specifications by the Contractor.

iv. Waterstops

Waterstops shall be of natural rubber or flexible PVC and of the type specified or shown on the Drawings.

Natural-rubber waterstops shall comply with the requirements of BS 6213.

Flexible PVC rubber waterstops shall comply with the requirements of BS 2571:1990.

v. Accessory material

1. Primers

Where a primer is to be used in conjunction with the sealant, it shall be of the prescribed proprietary material.

2. Bond breakers

Polyethylene tape coated paper, metal foil or similar material may be used where bond breakers are required.

3. Backup material

Backup material shall consist of a compressible material of correct width and shape to ensure that, after installation, it will be in approximately 50 % compression and the sealant can be formed to the specified depth.

Backup materials shall be compatible with the sealant used. Material containing bitumen or solvents shall not be used with thermosetting chemically curing sealants.

vi. Cover plates

1. Steel cover plates shall be of minimum grade S235 which complies with the requirements of BS EN 10025.
2. Galvanising shall comply with the requirements of BS EN ISO 1461 and BS EN 10240 or equivalent.
3. Anchor bolts shall be of stainless steel Grade 302 S.21, which complies with the requirements of BS EN 10083 (various dates)/BS EN 10088 or equivalent.

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b. Filled and Unfilled Joints

i. General

Wherever polystyrene or similar material susceptible to damage is used for forming joints it shall be lined with a hard surface on the side to be concreted. The hard surface shall be sufficiently resilient to ensure that the joint and surfaces can be formed free from defects.

ii. Filled joints

Filled joints shall be accurately formed to the dimensions shown and with the filler material specified on the Drawings. The filler shall be secured in position such that it will not be displaced during concreting or thereafter if the filler is to remain permanently in the joint.

Where the removal of the filler is required, it shall be done prior to the installation of the proprietary joint.

iii. Unfilled joints

Unfilled joints shall be accurately formed to the dimensions given on the Drawings and all external corners chamfered or rounded for at least 5 mm. The concrete face against which the fresh concrete is placed shall be treated in good time with an approved bond breaker.

c. Concrete Nosings

Concrete nosings forming the edges of expansion joints shall be constructed as follows:

- i. After the concrete in the structural member has hardened sufficiently the protruding ends of the reinforcing steel shall be bent flat onto the concrete surface of the formed recess.
 - ii. Before the asphalt surfacing is laid the recess shall be filled with well-compacted crusher run, sand or weak mortar. The Contractor shall ensure that the concrete surfaces of the recess and the reinforcing steel are not contaminated with bituminous agents. The asphalt surfacing shall then be laid continuously over the joint.
 - iii. The asphalt surfacing shall be cut with a diamond saw blade to correspond to the width of the nosing and all material shall be removed from the nosing recess. The concrete surfaces of the recess shall then be roughened to expose the aggregate and leave sound, irregular surfaces. The reinforcing steel shall then be bent, fixed and placed as shown on the Drawings.
 - iv. The prepared concrete surfaces of the recesses shall be treated with an approved epoxy-resin adhesive, immediately before the concrete nosings are cast. Opposite concrete nosings, separated by a joint filler strip, shall be cast simultaneously in accordance with SUBCLAUSE 7408(c), and compacted with a vibrator. The nosing shall be screeded flush with the premix surfacing and be given a Class U2 surface finish.
 - v. Curing shall be in accordance with CLAUSE 7409(f), Method 6.
 - vi. After three days, the gap between the nosings shall be enlarged to the requisite dimensions by cutting both sides with parallel diamond saw blades. The depth of the saw cut shall be such that a ledge is formed along the lower edge of the cut on which the sealer unit can be supported.
 - vii. The exposed corners of the nosings shall be ground to a 10 mm chamfer.
 - viii. After the joint has been sealed, the wearing surface of the nosings shall be treated with a bituminous primer to the satisfaction of the Engineer.
- Unless otherwise specified, traffic shall not be permitted to pass over the joint before the concrete in the nosing has achieved its specified 28-day strength.

Unless otherwise indicated on the Drawings, the concrete used in the construction of the nosings shall be Class C35/45 and shall have a slump of not less than 50 mm and not exceeding 75 mm.

Concrete nosings shall be constructed under the direct supervision of experienced and skilled personnel.

d. Plug Type Expansion Joints

Plug type expansion joint systems shall be constructed in accordance with the details on the Drawings and the specifications and instructions of the manufacturer.

e. Sealing the Joints

i. General

Sealed joints shall be made watertight over the full length of the joint, including the full height of the kerbing, unless otherwise prescribed in the Special Specifications. Unless a waterstop is equipped with an effective watertight interlocking system for joining sections, all joints in waterstops shall be bonded or fused to have a tensile strength of at least 50 % of that of the unjointed material. At intersections and abrupt changes of direction, waterstops shall be jointed with prefabricated junction pieces.

Restrictions on joint width and on the temperature at the time of installing the sealant or seal will be shown on the Drawings. In the absence of such restrictions on the Drawings, and unless otherwise specified, installation shall be carried out only within the temperature range between 5°C and 30°C.

ii. Preparing the joints

Sawn joints shall be cut at a suitable time so as to avoid edge spalling or ravelling.

After the temporary filler material has been removed or the excess concrete has been broken out, the inside faces of the joint shall be wire brushed or sand-blasted to remove all laitance and contaminants. The joint shall then be cleaned and blown out with compressed air to remove all traces of dust. Solvents shall not be used for removing contaminants from the concrete and porous surfaces.

The Contractor shall ensure that primers are applied only to surfaces which are absolutely dry. The primer shall be applied strictly in accordance with the manufacturer's instructions. Unless otherwise specified, the primer shall be applied within the temperature range of 10°C and 40°C, and the sealant shall be applied after the curing period of the primer and within the period when the primer remains active.

iii. Sealants

Sealants shall be applied strictly in accordance with the manufacturer's instructions by a person skilled in the use of the particular type of sealant. Trapping of air and the forming of voids in the sealant shall be avoided. The sealant shall be finished to a neat appearance to the specified depth.

Thermoplastic hot-poured sealants shall not be poured into the joints when the temperature of the joint is below 10°C. The safe heating temperature shall not exceed the specified pouring temperature by more than 10°C.

Two-part thermosetting chemically curing sealants shall not be applied after expiry of the specified pot-life period which commences once the base and activator of the sealant have been combined.

iv. Waterstops

Waterstops shall be securely and accurately located in position so that they will not be displaced or deformed during construction.

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f. Proprietary Expansion Joints

i. General

The use of any type of expansion joint shall be subject to approval. Contractors shall obtain approval for the type of expansion joint they intend using at tender stage prior to submitting their bids.

ii. Dimensions

The Contractor shall note the overall dimensions of the expansion joints and the limiting dimensions of that portion of the concrete structure which is to accommodate the joints. No alterations to the concrete which will be visible in the final structure or major re-arrangement of the prestressing anchorages will be permitted in order to accommodate joints of excessive size.

All joints to be installed skew shall be accurately dimensioned to ensure compliance with the requirements of **SUBCLAUSE 7603(h)**.

Unless otherwise specified, proprietary expansion joints shall include the complete expansion-joint assembly, traversing the entire roadway, kerbs, sidewalks and median, and shall include the coping and parapet cover plates as well as the drainage system to drain the expansion joint.

iii. Design and manufacture

The expansion joint shall be designed to withstand the movements, displacements and rotations specified on the Drawings in conjunction with the loads described in the code of practice adopted for the design of the structure without exceeding in any member the requirement for serviceability limit state. Any strengthening of the supporting member required to resist forces imparted by the joint to the structure shall be for the Contractor's account.

The specified movements, displacements and rotations shall be withstood without the efficacy or riding quality of the joint being impaired.

The joint shall be vibration free, resistant to mechanical wear and other forms of abrasion, and shall resist corrosion. It shall have good riding characteristics, shall be highly skid resistant, silent, and of watertight construction or have provision for the disposal of water, debris or grit collecting in the joint. It shall be of a construction that will facilitate easy inspection, maintenance and repair.

Apart from stainless steel, all steel surfaces shall be prepared in accordance with the requirements of **SUBCLAUSE 7807(b)** and sprayed with a galvanising coat which complies with the requirements of BS EN ISO 14713 or equivalent for Zn 150 coverage. All enclosed surfaces sprayed with zinc shall, within four hours, be covered with a sealant suitable for use with the zinc and the subsequent layer. Two coats of chlorinated rubber paint with a combined dry-coat thickness of not less than 150 microns shall then be applied. They shall be of two different colours.

Prior to manufacture of the joints, the Contractor shall submit for approval detail drawings in accordance with the requirements of **CLAUSE 1210** of each expansion joint. The expansion joints delivered at the site shall be suitably marked to show clearly the sequence and position of installation.

g. Handling and Storage

The Contractor shall supply the expansion joints complete including bolts, nuts, sealants, plugs and all other accessories for the effective installation of the joints. The expansion joints and its components shall be packaged as per manufacturers instructions in order to prevent damage during transportation and during storage period.

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The conditions for transportation and storage shall be as per manufacturer's specifications. The expansion joint material shall be handled with care and stored under cover by the Contractor to prevent damage. Special care shall be taken to store the components which are sensitive to temperature and conditions of storage (e.g. resin, primer and glue). Where the components include chemicals, flammable components or other potentially hazardous materials, the specific guidance on restrictions and/or conditions shall be provided by the manufacturer for handling, transport and storage of these components.

h. Installing the Expansion Joints

Proprietary expansion joints shall be installed by approved specialist subcontractors only. Installed proprietary expansion joints shall have a 15 year written guarantee. No expansion joint or part thereof shall be installed prior to the construction of the final surfacing.

The expansion joint shall form an even surface with the road surface on either side and the deviation across and along the expansion joint shall comply with the requirements of SUBCLAUSE 1731(b) for surface regularity measured by a 3 m straight-edge.

On completion of the installation of the proprietary expansion joints, the Contractor shall submit to the Engineer a certificate from the manufacturer or supplier of the joints, certifying acceptance of the installation, only if the manufacturer installed the joints. Notwithstanding the issuing of such certificate, it shall not relieve the Contractor of their responsibilities under the Contract. No separate payment will be made for the inspection of the joints and the issuing of the certificate by the manufacturer or supplier. It will be regarded as an obligation of the Contractor to be covered by the contract prices paid for joints.

i. Testing and Acceptance

The expansion joints and joint sealant shall conform to the following requirements.

TABLE 7603/1: CONFORMITY REQUIREMENTS FOR EXPANSION JOINTS

Test No	Expansion Joints	Conformity Requirements According to
1	General requirements	ETAG no. 032 Part-1
2	Buried expansion joint	ETAG no. 032 Part-2
3	Flexible plug expansion joint	ETAG no. 032 Part-3
4	Nosing expansion joint	ETAG no. 032 Part-4
5	Mat expansion joint	ETAG no. 032 Part-5
6	Cantilever expansion joint	ETAG no. 032 Part-6
7	Supported expansion joint	ETAG no. 032 Part-7
8	Modular expansion joint	ETAG no. 032 Part-8
9	Joint sealant	BS EN 14188 Part 1 to Part 3

7604 Bearings For Structures

a. Materials

i. General

When requested by the Engineer, the Contractor shall submit test certificates from an approved, independent testing authority to show that the respective materials comply with the specified requirements, or a certificate from the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.

Unless otherwise specified, all the materials used for manufacturing the bearings shall comply with the requirements of BS EN 1337-2, BS EN 1337-3, BS EN 1337-5.

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ii. Roofing felt

Roofing felt shall be 3-ply and comply with the requirements of BS 8217 or equivalent for Type 1 roofing felt.

iii. Elastomer

The elastomer used in the manufacture of bearings shall be natural rubber or synthetic rubber.

Natural rubber shall comply with the requirements of BS 1154 for specified IRHD hardness.

Synthetic rubber shall comply with the requirements of BS 2752 for specified IRHD hardness.

iv. Stainless steel plate

The texture of the sliding surface of stainless steel plate used in conjunction with PTFE to form low-friction sliding surfaces shall be equal to or better than 0.2 mm Ra in accordance with the requirements of BS 1134.

v. Stainless steel dowels and bolts

Stainless steel used for the manufacture of dowels and anchor bolts shall comply with the requirements of BS EN 10088 for Steel 316S16.

vi. Mortar

Mortar beddings for seating the bearings shall be composed of an approved sand and either cement or epoxy resin, or may consist of an approved proprietary mortar. The mortar shall comply with the following strength requirements:

1. Sand-cement mortar

The 7-day compressive strength of 150 mm cubes made from the mortar and cured in a moist atmosphere for the first 24 hours and afterwards in water at 20°C shall be not less than 1.5 times the average contact stress under the bearing or 15 MPa, whichever is the greater.

2. Sand-epoxy resin mortar.

The cured compressive cube strength of the mortar shall be not less than two times the average contact stress under the bearing, or 20 MPa, whichever is the greater.

3. Proprietary mortar

The strength requirements for proprietary mortars shall be in accordance with either SUBCLAUSE 7604(a)(vi)(1) or (2) as may be relevant.

b. Concrete Hinges

Concrete hinges shall be constructed in accordance with the details shown on the Drawings.

Construction joints shall not be formed in the throat area. Where a joint is necessary, it shall be formed as a recess below the throat, level with the top reinforcement mat. The width of the recess shall be slightly greater than that of the throat.

Care shall be taken to eliminate the formation of shrinkage cracks within the throat.

During construction, adequate bracing and support shall be provided to the satisfaction of the Engineer to prevent rotation in the throat from the time of casting to completion of the structure incorporating the hinge. During the course of construction the hinge shall not be subjected to conditions which will induce tensile stresses in the throat area. Upon completion of the structural members incorporating the hinge, the space around the throat shall be filled and sealed with an approved compressible material.

c. Roofing Felt

Roofing felt used as bearing strips shall consist of at least three layers.

Where lubricated linings are specified, the roofing felt shall be saturated with motor oil and then liberally dusted with graphite powder before it is laid on the bearing surface.

d. Elastomeric Bearings

i. Technical data

The following technical data for the elastomeric bearings will be supplied on the Drawings, and shall also be supplied on drawings prepared by the Contractor for submission to the Engineer:

1. Design loads and deformations

The critical design-load combinations and co-existing rotations and horizontal displacements for each bearing or each group of identical bearings.

2. Size and construction of bearing

The size and construction of the bearing shall be designated by:

$$L \times B \times n(t)$$

Where,

L = Length of bearing in the transverse direction, in mm.

B = Width of bearing in the span direction, in mm.

n = Number of elastomer layers.

t = Thickness of individual elastomer layers, in mm.

The steel plates shall be encased in a 3 mm thick elastomer layer.

3. Hardness and type of elastomer

The IRHD hardness and type of elastomer, i.e. natural or synthetic rubber, from which the specified bearings are to be manufactured.

4. Identification

Each bearing shall be identified by a number.

ii. Alternative bearings

Where alternative bearings are offered by the Contractor, they shall be designed in accordance with the requirements of BS EN 1337-2, BS EN 1337-3, BS EN 1337-4, BS EN 1337-5 for the loadings and deformations shown on the Drawings.

Where a bearing consisting of a type of rubber is offered which differs from that which is specified, the bearing shall be redesigned to make provision for the variation in hardness and/or type of rubber.

iii. Inspection and testing

On completion of the manufacture of the bearings, the Contractor shall submit bearings selected by the Engineer, or specially manufactured bearings to serve as samples as authorised by the Engineer, to an independent testing authority for testing.

The testing facilities of the manufacturer or supplier may be used if so approved and on condition that the tests are conducted in the presence of the Engineer.

The Engineer shall determine which tests are to be conducted, and the tests shall comply with the appropriate requirements of SUBCLAUSE 7604(a). Payment will be made under ITEM 71.01 for these tests, for bearings damaged, and for sample bearings.

Copies of test results and certificates for the above mentioned tests shall be submitted by the Contractor to the Engineer in good time to enable the Engineer to assess the information before the bearings are installed.

The dimensional tolerances for the bearings shall comply with the requirements of SUBCLAUSE 1904(e).

Before the bearings are dispatched to the site of the Works, each bearing, with the exception of large bearings as provided for in the Special Specifications shall be subjected simultaneously to a vertical load equal to 150 % of the maximum design load, and to a shear distortion equal to 150 % of the maximum design value. The bearings shall be visually inspected for defects by the Engineer or their nominee and shall not at any stage under this test show any cracks visible to the naked eye or any other defects. The cost of this testing shall be included in the rate bid for Item 71.01.

The Engineer may instruct that one bearing of each consignment shall be cut open, at the Contractor's expense, with a view to a visual assessment of the bonding and the thickness of layers.

e. Proprietary Bearings

i. General

This CLAUSE covers custom-built bearings and bearings manufactured under licence, except elastomeric bearings. Combined bearings, consisting of an assembly of an elastomeric bearing in conjunction with a low-friction sliding or mechanical component shall fall under this CLAUSE.

The bidder may base their bid on any bearing which complies with the specified requirements, provided that the efficacy of the bearing has been verified by tests and successful previous use. Evidence hereof as well as information on the durability and suitability of the bearings for the specified use shall be submitted to the Engineer for consideration.

Details of the product guarantee shall be submitted with the bid.

ii. Drawings and approval

Prior to manufacturing the bearings, the Contractor or their nominee shall submit the following information to the Engineer for consideration:

1. The manufacturer's specification containing detailed information on the design standards, materials, manufacture and technical data.
2. Drawings complying with the provision in CLAUSE 1210 showing the bearing construction and installation details.
3. Friction properties based on actual tests conducted on the relevant materials.

iii. Technical requirements

The following technical requirements will be supplied on the Drawings, and shall also be supplied on the Drawings prepared by the Contractor for submission to the Engineer:

1. Design loads and movement

The maximum and minimum vertical loads and co-existing horizontal loads as well as the maximum horizontal load and co-existing vertical load. The maximum values in each direction of the reversible and irreversible movements and the rotation about each axis.

2. Identification

Identification of each bearing by a number, data on the degree of freedom of movement (fixed, multi-directional or unidirectional bearings) and the type of bearing (spherical, elastomer-pot, etc) shall appear on each bearing.

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iv. Design

The bearings shall be designed in accordance with the requirements and recommendations of BS EN 1337. The following shall also be complied with:

1. The average pressure on the area of the elastomer shall not exceed 25 MPa under the serviceability Limit State, unless otherwise prescribed by the Engineer.
2. The maximum average contact stress and maximum edge stress on the concrete or mortar bedding shall not exceed 0.5 and 0.6 times the 28-day cube characteristic compressive strength under the serviceability Limit State respectively, unless otherwise prescribed by the Engineer.
3. The bearing pad shall be of dimensions as will fit into the space allowed for its installation. Major alterations to the contiguous members will not be permitted.

v. Construction

Unless otherwise specified, the following shall be complied with:

1. The thickness of the elastomer disc shall be not less than 0.076 times its diameter.
2. Approved lubricants only shall be used on the PTFE sliding surfaces.
3. The bearing shall be provided with tight-fitting seals to prevent the ingress of dust or deleterious matter onto the moving parts. The seals shall be of an approved type and sufficiently durable to last in excess of 50 years.
4. The assembled bearing shall be supplied with welded or bolted lugs or straps, temporarily securing the moving parts firmly in position to ensure that no undesirable relative movement occurs before or during construction.
5. The bearing shall be recessed into adaptor plates or be of such construction as to facilitate removal of the bearing from the installed position without damage to any part of the bearing or the surrounding material after the relevant structural member has been raised by 15 mm or the distance specified.
6. Anchors and holding-down bolts shall be of the specified material.
7. Corrosion protection of all exposed steel surfaces, with the exception of the stainless-steel sliding plate, shall involve the following treatment:
 - 7.1 Preparing the surfaces by abrasive blasting to a finish equal to the *Sa3* finish of BS EN ISO 8501-1, Swedish Standard SIS 05 59 00 or equivalent.
 - 7.2 Spraying the surfaces with zinc to comply with the requirements of BS EN ISO 2063 or equivalent on approval of the Engineer for Type *Zn* 150 surfacing.
 - 7.3 Coating the zinc-sprayed surfaces within four hours with a sealer compatible with the zinc and the subsequent coats of paint.
 - 7.4 Applying a coat of chlorinated rubber paint with a minimum of 75 mm of dry-film thickness and of a colour which differs from that of the final coat of paint.
 - 7.5 Applying a final coat of chlorinated rubber paint with a minimum of 75 mm of dry-film thickness and of dark grey colour.
 - 7.6 Surfaces in contact with concrete shall be sprayed with zinc so that it complies with the requirements of BS EN ISO 2063 or equivalent on approval of the Engineer for Type *Zn* 150 surfacing.

vi. Inspection and testing

The Engineer may require tests to be conducted to verify compliance of the bearing with the specifications and/or its satisfactory performance under the design loads. Payment for this testing will be made under ITEM 71.01.

Test certificates of all the tests conducted shall be submitted to the Engineer.

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The Contractor shall give the Engineer at least seven days notice prior to final assembly of the bearings to enable the Engineer to inspect the bearings at the factory.

Under no circumstances shall bearings be taken apart and reassembled on the site, except where it is an unavoidable feature of the installation procedure, in which case the dismantling, installation and reassembly shall be under the supervision of qualified personnel.

Rehabilitation, modification and repair work to bearings shall be carried out only in the factory or in an approved engineering Works.

f. Dowels and Guides

Where dowels and guides are used in conjunction with bearings they shall not complicate or prevent the removal of the bearings.

g. Storage and Handling

The bearings shall at all times be stored under cover and clear of the ground, away from sunlight, heat, oils and chemicals deleterious to the bearings. The bearings shall not be stacked in a manner or on a surface which will cause distortion of the bearings.

The bearings shall be handled with care to ensure that they are not subjected to impact loads or any other conditions which may be harmful.

h. Installation

The concrete surfaces of elements required to receive bearings shall comply with the requirements of SUBCLAUSE 7209(c). Plastering of the surface will not under any circumstances be permitted.

Before the mortar bedding is constructed, the concrete surface shall be chipped back to expose the aggregate and leave a sound irregular surface. Bonding of the mortar bedding to the concrete surface shall be in accordance with the manufacturer's recommendations and the Engineer's instructions.

Unless otherwise shown on the Drawings, the bearings shall be installed on a horizontal plane and shall be in full contact with the concrete and bedding surfaces.

To accommodate soffit irregularities and camber in the case of precast members, the member shall be lowered onto a mortar skim on top of the bearing. The member shall then be propped until the mortar skim has hardened into a wedge.

The bearings shall be accurately installed to the specified level, alignment and orientation, all within the construction tolerances set out in SUBCLAUSE 1904(h) and the details shown on the Drawings.

Where the bearing has long sliding plates, the latter shall be rigidly supported to prevent their being distorted under the weight of the wet concrete and the construction loads. Before the bearing is incorporated into the structure, it shall be cleaned to remove all deleterious substances and adhering matter, after which it shall be wrapped in polyethylene sheeting and so sealed as to prevent the ingress of mortar and/or slush onto the bearing during the course of construction.

After installation, the polyethylene wrapping shall be removed, the bearing and the space around the bearing thoroughly cleaned and the lugs removed as prescribed by the Engineer.

On completion of installation of proprietary bearings, the Contractor shall submit to the Engineer a certificate from the manufacturer or supplier of the bearings certifying acceptance of the installation, only if the manufacturer installed the bearings. The issuing of such a certificate shall not relieve the Contractor of their responsibilities under this Contract. No separate payment will be made for the inspection of the bearings by the manufacturer or supplier and the issuing of the certificate.

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i. Testing and acceptance

The bearings shall conform to the following requirements.

TABLE 7604/1: CONFORMITY REQUIREMENTS FOR BEARINGS

Test No	Expansion Joints	Conformity Requirements According to
1	General requirements	BS EN 1337 Part-1
2	Elastomeric bearings	BS EN 1337 Part-3
3	Pot bearings	BS EN 1337 Part-5
4	Roller bearings	BS EN 1337 Part-4
5	Rocker bearings	BS EN 1337 Part -6
6	Spherical and Cylindrical PTFE bearings	BS EN 1337 Part -7
7	Guide bearings and Restraint bearings	BS EN 1337 Part -8
8	Sliding elements	BS EN 1337 Part -2

7605 Parapets, Railings and Sidewalks

a. Materials

i. Concrete

All concrete work shall be carried out in accordance with the requirements of SECTIONS 7200, 7300, 7400 and CLAUSE 7603.

ii. Structural steel

Structural steel work shall comply with the provisions of SUBCLAUSE 7702(a).

iii. Mortar

Mortar shall comply with the requirements of SUBCLAUSE 7604(a)(vi).

b. Concrete Parapets

Concrete parapets shall be either cast in situ or precast or a combination of the two as shown on the Drawings. Where possible, precast elements shall be placed with the unformed surface downwards or outwards.

Concrete parapets shall be constructed after the removal of the falsework and the completion of the prestressing but not before the bridge deck has been accurately measured so as to determine the final lines and levels.

Service ducts in parapets and blocks shall be fixed and cast into position in accordance with the requirements of CLAUSE 7411 and the details shown on the Drawings.

The pipes and fittings to be used for the construction of the ducting shall be rigid PVC pipes and fittings with flexible rubber joints which comply with the requirements of BS EN 1452-1, BS EN 1452-2, BS EN 1452-3 or equivalent. Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt, concrete, etc, from entering the ducts. Two strands of 2.5 mm diameter galvanised steel wire shall be threaded through each duct. The strands shall extend 2 m beyond each end and be wedged firmly into position with the wooden stoppers. Inspection eyes for the ducts shall be constructed in accordance with the details shown on the Drawings.

No separate payment will be made for service ducts in parapets and end blocks and the rates bid for the parapets and end blocks shall include full compensation for the provision and installation of service ducts complete with stoppers, draw wire and inspection eyes.

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c. Steel Railings

All steelwork shall be manufactured in accordance with the requirements of SECTION 7700.

A mortar bed, not less than 10 mm in thickness, shall be provided below all steel base plates over the full dimensions of the plate. The sides of the beds shall be neatly chamfered at 45°. All open spaces between the bolt and the sides of the holes in the base plate shall be filled with an approved sealant.

Steelwork which is to be cast or grouted into concrete shall be completely painted to a distance of 75 mm in the concrete or grout, and shall be cleaned of all loose rust, mill scale, oil or other material which may impair the bond between the concrete and steel.

All steelwork shall be painted in the shop and on site in accordance with the provisions of SECTION 7800. Surfaces which will be inaccessible after erection of the units shall be painted before erection commences. If called for on the Drawings or in the Bill of Quantities, steelwork shall be galvanised and painted. Galvanising shall be done after fabrication, in accordance with BS EN ISO 1461 or equivalent for Type A1 articles.

d. Numbers for Structures**i. Number plates**

Number plates shall be fixed in the positions and according to the method of fixing shown on the Drawings.

ii. Painted numbers

The surface onto which the numbers are to be painted shall be prepared in accordance with the requirements of SUBCLAUSE 7809(a). The background shall be of at least two coats of the prescribed paint. The letters and figures shall be in accordance with the details given on the Drawings and shall be written at the prescribed positions with a template.

iii. Numbers shaped in concrete

Bridge numbers shall be placed and shaped in accordance with the requirements shown on the Drawings. The minimum concrete cover over the steel reinforcement behind the numbers shall not be less than the prescribed cover for the structural member in question.

e. Concrete Footpaths

After completion of the prestressing (if any) and the removal of the formwork, the footpaths and kerbing shall be constructed, but not before the bridge deck has been accurately surveyed to establish final lines and levels.

The previously cast bridge deck area shall be prepared as specified in CLAUSE 7408 to receive the footpath concrete.

Forms shall be accurately set to the final lines and levels and shall be firmly held in position during the placing of the concrete. Stops at the ends of sections shall be accurately placed to ensure that joints between adjacent sections will be truly perpendicular to the surface of the concrete and at right angles to the edge of the road or to the skew angle of the deck at the expansion joint.

After removal of the forms, the enclosed surfaces of the kerbs and copings shall be rubbed and finished in accordance with the requirements of SUBCLAUSES 7208(a), 7208(c) and 7209(b). All edges shall be rounded to a radius of 20 mm unless otherwise shown on the Drawings.

f. Concrete Surface Finish Requirements

All formed concrete surfaces shall have a Class F3 surface finish as specified in SUBCLAUSE 7207(d) and all unformed concrete surfaces shall have a Class U2 surface finish in accordance with SUBCLAUSE 7209(b).

g. Transition Blocks

Transition blocks shall be constructed in accordance with the details shown on the Drawings.

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h. Nose Endings

Nose endings of balustrades shall be constructed in accordance with the details on the Drawings.

7606 Drainage For Structures**a. Weep Holes, Drainage Pipes and Channelling**

Weep holes shall not be placed within 40 mm of any reinforcement and shall be carefully cleaned and kept clean. Drainage pipes shall be of the material prescribed on the Drawings, and the interior surface shall, on completion, be smooth and clean.

Cast in situ concrete channelling shall be provided next to the kerbing if shown on the Drawings and according to the details provided. Concrete work shall be carried out in accordance with the provisions of SECTION 7400 and channelling shall be given a Class U3 surface finish as specified in SUBCLAUSE 7209(c). The channelling shall be bonded to the bridge deck concrete in accordance with the provisions of CLAUSE 7408.

b. No-fines Concrete Blocks

Blocks shall be of the class of prescribed no-fines concrete and to the required dimensions and shall be placed in advance of backfilling.

No-fines concrete shall comply with the requirements of CLAUSE 7602.

c. Synthetic-fibre Filter Fabric

Synthetic-fibre filter fabric shall be of the type and grade shown on the Drawings or specified in the Special Specifications. Filter fabric shall be placed as shown on the Drawings and shall be protected against sunlight and mechanical damage during storage and installation.

The fabric shall comply with the requirements of SUBCLAUSE 2104(a).

d. Filter Gravel In Drainage Strips Behind Walls

The gravel used in drainage strips shall comply with the requirements for 20 mm nominal size aggregate. The aggregate shall be wrapped in synthetic-fibre geotextile and placed in accordance with the details shown on the Drawings or as instructed by the Engineer.

The fabric shall comply with the requirements of SUBCLAUSE 2104(a).

7607 Measurement and Payment

Item	Unit
76.01 Cast In Situ No-Fines Concrete:	Cubic Metre (m ³)

The Provisions Of CLAUSE 7416 ITEM 74.01 Shall Apply With Changes As Required.

Item	Unit
76.02 Precast No-Fines Concrete Units (Class Of Concrete And Description Of Unit)	Number (No.)

The unit of measurement shall be the number of complete units of each size and type in position in the Works.

The bid rate for each precast concrete unit shall include full compensation for providing all the materials, labour, plant and formwork required for manufacturing the unit complete as shown on the Drawings and for transporting and placing the unit in position.

Item	Unit
76.03	Proprietary Expansion Joints:
(a)	Prime Cost Sum Allowed For Purchasing And Taking Delivery Of Expansion Joints Prime Cost Sum Prime Cost Sum
(b)	Percentage On Prime Cost Sum For Charges And Profit Percent (%)

A Prime Cost Sum shall be allowed for payment for actual costs of purchasing and taking delivery of proprietary expansion joints. A percentage on the prime cost sum shall cover the Contractor's charges and profit for purchase and delivery of the joints.

Item	Unit
76.04	Installation Of Proprietary Expansion Joints:
(a)	Description Of Joint Measured Per Metre Metre (m)
(b)	Description Of Joint Measured By Number Number (No.)

The unit of measurement shall be either the metre of complete joint of each type installed or the number of complete joints of each type installed. The bid rates shall include full compensation for supplying all materials not covered under ITEM 76.03, transporting, handling and storing, and all labour, equipment, shaping the recesses, and incidentals required for installing the expansion joint complete in accordance with instructions. Separate payment shall not be made for supplying and/or installing the seal in proprietary expansion joints or the seal between concrete or synthetic nosings.

The cost of forming the open joint(s) shall not be included in the rates bid for ITEM 76.04 as payment for this work shall be made under ITEM 72.06.

The bid rate shall be final and binding, irrespective of the type or make of joint finally installed.

Item	Unit
76.05	Expansion Joints:
(a)	Description Of Joint Measured Per Metre Metre (m)
(b)	Description Of Joint Measured By Number Number (No.)

The unit of measurement shall be the metre of complete expansion joint of each type installed or the number of completed joints of each type installed.

The bid rates shall include full compensation for supplying all the materials, manufacturing the expansion joint, transporting, handling and storing, and all labour equipment, shaping the recesses, and incidentals required for installing the expansion joint complete in accordance with instructions. Separate payment shall not be made for supplying and/or installing the seal in proprietary expansion joints or the seal between concrete or synthetic nosings.

The cost of forming the open joint(s) shall not be included in the rates bid for ITEM 76.05 as payment for this work shall be made under ITEM 72.06.

Item	Unit
76.06	Filled Joints:
(a)	Description Of And Thickness Of Joint Filler For Joints Measured Square Metre (per m ²)
(b)	Description Of And Thickness Of Joint Filler For Joints Measured Per Metre Metre (m)

The unit of measurement shall be the square metre of filled joint calculated from the surface area of the joint. Where the filled joint is 150 mm or less in depth, the unit of measurement shall be the metre of filled joints measured along the joint centre line. Concrete surfaces formed prior to the

construction of the final surface for completing the filled joint shall be measured under ITEMS 72.01, 72.02, 72.03 or 72.04, as may be applicable.

The bid rates shall include full compensation for supplying and installing the joint filler and all materials not covered under ITEM 76.08, and for all labour and incidentals required for completing the filled joint as prescribed.

Item	Unit
76.07 Unfilled Joints:	
(a) Description Of Joint For Joints Measured	Square Metre (per m ²)
(b) Description Of Joint For Joints Measured Per Linear Metre	Metre (m)

The unit of measurement shall be the square metre of unfilled joint, calculated in accordance with the joint area. Where, however, the depth of the joint is 150 mm or less, the unit of measurement shall be the metre of unfilled joint measured along the joint centre line. Concrete areas formed before the final surface is constructed to complete the unfilled joint, shall be measured under ITEMS 72.01, 72.02, 72.03 or 72.04, as may be applicable.

The bid rates shall include full compensation for providing and applying the bond breaker and all materials not paid for under ITEM 76.08, also for the labour and incidentals required for completing the unfilled joint as prescribed.

Item	Unit
76.08 Sealing Joints With:	
(a) Sealant (Description Of Joint, Sealant And Size)	Metre (m)
(b) Seal (Description Of Joint, Sealant And Size)	Metre (m)
(c) Waterstop (Description Of Joint, Waterstop And Size)	Metre (m)

The unit of measurement shall be the metre of sealant, seal or waterstop of each type installed.

The bid rates shall include full compensation for supplying all materials, forming or cutting the concrete to the required shape and size, all labour, equipment and incidentals required for sealing the joint complete in accordance with the prescriptions, and for all waste materials.

Item	Unit
76.09 Proprietary Bearings:	
(a) Prime Cost Sum Allowed For Purchasing And Taking Delivery Of Bearings	Prime Cost Sum
(b) Percentage On Prime Cost Sum For Charges And Profit	Percentage (%)

A Prime Cost Sum shall be allowed for payment for actual costs of purchasing and taking delivery of proprietary bearings, complete with anchor bolts and/or dowels. A percentage on the prime cost sum shall cover the Contractor's charges and profit for purchase and delivery of the bearings.

Item	Unit
76.10 Installing The Proprietary Bearings (Description Of Each Type, And State Class):	Number (No)

The unit of measurement shall be the number of complete bearings of each type and class installed.

The bid rate shall include full compensation for supplying all the materials not covered under ITEM 76.09, constructing the bedding, transporting, handling and storing, and all labour, equipment and incidentals required for installing the bearings complete as detailed.

The bid rate shall be final and binding, irrespective of the type or make of bearing finally installed.

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Item	Unit
76.11 Bearings (Description Of Each Type And Class):	Number (No)

The unit of measurement shall be the number of complete bearings of each type and class installed.

The bid rate shall include full compensation for supplying all the materials, including anchor bolts and/or dowels, constructing the bedding, manufacturing the bearings, transporting, handling and storing, and all labour, equipment and incidentals required for installing the bearings complete as detailed.

Item	Unit
76.12 Concrete Hinges:	
(a) Description Of Hinge Measured Per Metre	Metre (m)
(b) Description Of Hinge Measured By Number	Number (No.)

The unit of measurement shall be either the metre of complete hinge of each type manufactured and installed or the number of complete hinges of each type manufactured and installed.

The bid rates shall include full compensation for supplying all materials, including formwork, manufacturing the hinges, transporting, handling and storing, sealing the hinges, and all labour, equipment and incidentals required for installing the hinges complete as detailed.

Item	Unit
76.13 Bearing Strips (Description Of The Material And Number Of Layers)	Square Metre (m ²)

The unit of measurement shall be the square metre of bearing area lined with the specified material irrespective of the number of layers placed.

The bid rate shall include full compensation for supplying all the materials, transporting, handling and storing, and all labour and incidentals required for installing the bearing strips complete as detailed.

Item	Unit
76.14 Dowels/Guides (Description Of Each Type)	Number (No.)

The unit of measurement shall be the number of dowels/guides of each type installed.

The bid rate shall include full compensation for supplying all materials, including anchor bolts, manufacturing the dowels/guides, transporting, handling and storing, and all labour, equipment and incidentals required for installing the dowels/guides complete as detailed.

Item	Unit
76.15 Concrete Parapets:	Metre (m)

The unit of measurement for concrete parapets shall be the metre of concrete parapet complete in accordance with the Drawings. Concrete parapets shall include all work above the top level of the sidewalks or, where not placed on a sidewalk, above the top of the bridge deck concrete, wingwalls or retaining walls and shall also include any kerbing and coping forming an integral part of the concrete parapet.

The bid rate for concrete parapets shall include full compensation for all concrete, formwork, service ducts, drawing wires and accessories. The rates will exclude only the cost of reinforcing steel as this will be measured and paid for under ITEM 73.01.

Item	Unit
76.16 Steel Railings (Type Described):	Metre (m)

The unit of measurement for steel railings shall be the metre of railing complete in accordance with the Drawings.

The bid rate for steel railings shall include full compensation for all steelwork and corrosion protection, including fastenings, anchor bolts, mortar bedding, etc, as may be required for erecting the railings.

Item	Unit
76.17 End Blocks:	Number (No)

The unit of measurement of bridge end blocks shall be the number of end blocks constructed complete in accordance with the Drawings.

The bid rate shall include full compensation for all materials, labour, plant, and other incidentals required for constructing the end blocks complete as specified, excluding only reinforcing steel.

Item	Unit
76.18 Number for Structures:	
(a) Number Plates	Number (No.)
(b) Painted Numbers	Number (No.)
(c) Numbers Formed in Concrete	Number (No.)

The unit of measurement shall be either the number of bridge number plates provided and installed, or the number of complete numbers painted on the structures, or the number of complete numbers formed in concrete. A bridge number may consist of a combination of letters and digits; e.g. B1533.

The bid rates shall include full compensation for providing and installing either the number plates, or preparing the surface and painting the numbers, or forming the numbers in concrete, and for all material, labour and equipment required in this connection.

Item	Unit
76.19 Drainage Pipes and Weep Holes:	
(a) Drainage Pipes	
i Type and Size Indicated	Metre (m)
ii Type and Size Indicated	Number (No.)
(b) Weep Holes	
i Type and Size Indicated	Metre (m)
ii Type and Size Indicated	Number (No.)

The unit of measurement shall be either the metre of pipe/weep hole or the number of pipes/weep holes of each type and size of pipe/weep hole completed.

The bid rates shall include full compensation for supplying all the materials, manufacturing and installing the pipes and making weep holes.

Item	Unit
76.20 Drainage Gulleys (Description of Each Type Given):	Number (No.)

The unit of measurement shall be the number of drainage gulleys of each type installed.

The bid rate shall include full compensation for providing all the material and manufacturing and installing the drainage inlets.

Item	Unit
76.21 Synthetic-Fibre Filter Fabric (Type Indicated And Description):	Square Metre (m ²)

The unit of measurement shall be the square metre of filter fabric installed as specified, including the specified overlap.

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The bid rate shall include full compensation for supplying, cutting, lapping and installing the filter fabric, and for waste material.

Item	Unit
76.22 Concrete Channelling (Size Indicated):	Metre (m)

The unit of measurement shall be the metre of completed concrete channelling of each size constructed.

The bid rate shall include full compensation for providing all the material, all labour equipment and expenses required for completing the work.

Item	Unit
76.23 Crushed Stone In Drainage Strips:	Cubic Metre (m ³)

The unit of measurement shall be the cubic metre of crushed stone placed in position as specified, in accordance with the details shown on the Drawings or instructed by the Engineer.

The bid rate shall include full compensation for procuring, furnishing and placing the crushed stone, and for wrapping it in synthetic-fibre geotextile as specified. The geotextile will be measured for payment under ITEM 76.21.

Item	Unit
76.24 Nose Endings Of Balustrades:	Number (No.)

The unit of measurement shall be the number of nose endings constructed complete in accordance with the details shown on the Drawings.

The bid rate shall include full compensation for all labour, constructional plant and materials required, for filling the recesses with concrete or nosing material, 20 mm x 20 mm plastic joint seal between the end block and the transition block, steel cover plate complete with anchor bolts, and all incidentals required for constructing the nose endings complete.

Item	Unit
76.25 Concrete Transition Blocks (Length Indicated):	Number (No.)

The unit of measurement shall be the number of each size of concrete transition block constructed complete in accordance with the details shown on the Drawings.

The bid rate shall include full compensation for all labour, constructional plant, materials and all incidentals required for constructing the transition blocks.

SECTION 7700 Structures Steelwork

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7701 Scope

This section covers the manufacture, transport and erection of structural steelwork for minor structures, e.g. overhead road-sign structures. It does not apply to major steel structures such as steel bridges, which will be covered in the Special Specifications where work of this nature is required.

7702 Materials

The following definitions shall apply to these Specifications:

a. Structural Steel

Structural steel shall comply with the following requirements:

BS EN 10025 part 1 to 6, BS 7668, BS EN 10029, BS EN 10210 part 1 and 2 or equivalent.

The dimensions and properties of rolled steel SECTIONS shall comply with the prescriptions given in the structural steel tables issued by the British Standards Institution or equivalent.

b. Steel Tubes

Steel tubes shall comply with the requirements of BS EN 39 or equivalent.

c. Bolts, Nuts and Washers

Ordinary bolts and nuts shall be bolts and nuts used for transferring forces by tensile stress, compressive stress and shear stress without any friction-grip action being considered. Ordinary bolts and nuts shall comply with BS 3692 or BS 325 or equivalent. Washers for ordinary bolts and nuts shall comply with the requirements of BS EN 2138 or equivalent.

High-strength friction-grip bolts, nuts and washers shall comply with the requirements of BS EN 14399 part 1 to 10, or equivalent.

Other approved friction-grip fasteners equal to the above may be used.

d. Rivets

Mild-steel rivets shall comply with the requirements of BS 1109/ ASTM A502 or equivalent. High-tensile rivets shall be so manufactured that they can be driven and their heads formed satisfactorily without the physical properties of the steel being impaired.

e. Welding Consumables

Welding electrodes shall comply with the requirements of BS EN ISO 2560 equivalent.

The welding consumable and welding procedures for arc welding of steels shall comply with the requirements of EN ISO 14555 and EN ISO 13918 or equivalent

The quality, handling and storage of all consumables shall be so as to achieve the desirable properties of the weld metal.

The welding consumables used shall be appropriate to produce weld metal which will yield all the weld-metal test specimens as specified in BS EN 1043-1, BS EN 1043-2 BS EN 1320:1 having both minimum yield and minimum tensile strengths not less than those of the parent metal.

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f. Test Certificates

The Contractor shall submit test certificates, as required by the Engineer, of the structural steel and anchor bolts that will be used.

7703 Codes Of Practice

The design, where undertaken by the Contractor, of all work shall comply with the requirements of **RDM 4.2** and BS EN 1993-1 to 10. Equivalent standards may be used with the approval of the Engineer.

7704 Shop Details

Where shop details have not been furnished on the Drawings, the Contractor shall prepare shop details in accordance with the provisions of **SECTION 1200**. Shop details shall be approved and signed by the Engineer prior to the fabrication of any Items.

7705 Fabrication And Assembly**a. General**

All structural steel both before and after fabrication shall be within the tolerances specified in **SUBCLAUSE 1904(g)** and shall be flat, straight (unless required to be formed to another shape) and free from twists.

b. Marking the Steel

At all stages of fabrication, all structural steel shall be clearly marked by grade by means of a suitable marking system.

c. Cutting

Steel shall be cut by sawing, shearing with shears, cropping, or flame-cutting.

Edges shall be free from any defects or distortions and all burrs, notches and similar defects shall be removed.

All structural welds shall be full-strength joints.

d. Holes for Fasteners

Holes for fasteners shall not be formed by flame cutting. Holes in light members not thicker than 12 mm or the diameter of the hole, whichever is the smaller, may be punched.

Holes for fasteners of up to 25 mm in diameter shall not be more than 2 mm larger than the diameter of the fastener and holes for larger fasteners not more than 3 mm larger than the diameter of the fastener.

Holes for friction-grip fasteners shall be in accordance with BS EN 14399 part 1 to 10 or equivalent.

All burrs shall be removed from holes before assembly.

e. Joints in Compression

The abutting surfaces of joints dependent on contact for the transmission of load shall be accurately prepared so that the full area intended for bearing will be in contact as specified in **SUBCLAUSE 1904(g)**.

f. Hollow SECTIONS

Unless protection against corrosion is provided by other means, the interior of any hollow SECTION shall be sealed to prevent the ingress of moisture. Where a sealed hollow member is holed for a fastener or pin, precautionary measures shall be taken to prevent the ingress of water to the interior of the member. Vent holes for galvanising shall be sealed after galvanising has been completed.

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g. Alignment of holes

All matching holes for fasteners or pins shall be accurately aligned so that the fasteners can be inserted freely through the assembled members in a direction at right angles to the faces in contact. Drifting for aligning the holes shall not distort the metal or enlarge the holes.

h. Welding

Welding shall be done in accordance with the requirements of BS EN 1011.

The welding techniques shall be such as to avoid undue distortion and to minimise shrinking stresses.

All slag shall be removed.

Where required for certain welding:

- i. The manufacturer shall hold a valid welding-procedures certificate in accordance with BS EN ISO 15607 or equivalent for Grade B welding joints, and the welding shall be done by a welder qualified in accordance with BS EN 287 or equivalent;
- ii. Or, the welder shall hold a valid certificate of competency in accordance with BS 4872-1 or equivalent for the specified type of welding.

i. Bolting

The jointed parts shall be firmly drawn together. Where necessary, tapering washers shall be used for each bolt head and nut to transfer the compressive stress over its full surface. Where bolt holes have greater than normal clearance, washers shall be placed under the bolt heads and nuts.

The length of each bolt shall be such that, after tightening, at least one full thread projects through the nut on the outside and at least one full thread (in addition to the thread run-out) remains clear between the nut and the bolt head.

j. Friction-grip fastening

The use of friction-grip bolts shall be in accordance with BS EN 14399 or equivalent. Where use is made of equivalent types of friction-grip fasteners, they shall comply with the requirements of BS EN 14399 or equivalent for equivalent fasteners and shall be installed in accordance with the appropriate requirements of BS EN 14399 or equivalent.

k. Riveting

Wherever possible, riveting shall be done with pneumatic equipment.

Riveted units shall have all parts firmly drawn together and aligned before riveting. Every rivet shall, when driven, completely fill the hole and shall have a well-formed head or, if countersunk, fill the countersink completely.

All loose, eccentric-headed, badly formed, burnt or otherwise defective rivets shall be cut out and replaced.

l. Trimming

All fabricated steel work shall be neatly trimmed so as not to show any sharp edges. Acute angles shall be rounded off to a radius of at least 1.0 mm.

m. Corrosion prevention**i. Painting**

Before removal from the place of manufacture the steelwork shall be painted as specified in SECTION 7800.

Where the finishing coats are to be applied on the site, the shop painting shall include the application of an undercoat as specified in SECTION 7800.

Galvanised steel shall not be painted unless painting is specifically called for in the specifications.

ii. Sprayed metal coatings

Where the sprayed metal coating of steel surfaces is called for, it shall be done in accordance with the requirements of BS EN ISO 14713 or equivalent. The type of metal used shall be as specified, and, unless otherwise specified, the metal coating shall comply with the requirements of Type Al 150 or Type Zn 150.

iii. Galvanising

Where the galvanising of structural steelwork is required, the members shall be hot-dip galvanised. Structural steel members shall be given an 85 mm coating or such other thickness as may be specified, in accordance with BS EN ISO 1461 or equivalent and sheet steel and strip a Class M coating in accordance with BS EN 10346 or equivalent.

All nuts, bolts, screws and threaded articles shall be hot-dipped galvanised in accordance with the appropriate requirements of BS EN ISO 1461 or equivalent for Type C1 or Type C2 articles.

Cut ends and small damaged areas shall be repaired by the application of a zinc-rich paint or by zinc spraying.

n. Built-up Sections

In addition to the requirements of SECTION 7700, built-up sections shall be produced in accordance with Drawings and Special Specifications to the Engineer's approval.

7706 Erection

a. General

Where specified, details of the method of erection shall be submitted to the Engineer for approval.

All structural steel shall be stored, transported, handled and erected so as not to subject it to undue stress or damage.

Erection over traffic is not permitted, and a temporary diversion for traffic shall be provided.

Provision for traffic accommodation will be paid for in accordance with the appropriate Items under SECTION 1500.

b. Safety During Erection

During the erection of a structure, the steelwork shall be bolted, braced or otherwise secured so as to make adequate provision for all erection loads.

c. Alignment

Each part of a structure shall be aligned as soon as possible after erection. Members shall not be permanently connected until sufficiently large members of the structure have been aligned, plumbed, levelled, and temporarily secured to prevent their displacement during the erection or alignment of the remainder of the structure.

d. Corrections

Drift pins, jacking equipment and the like shall not be used for bringing improperly fabricated members into place. A moderate degree of cutting and reaming may be done to correct minor misfits if, in the opinion of the Engineer, this will not be detrimental to the appearance or strength of the structure. The burning of holes will not be permitted without written approval.

e. Repairs To Painting And Site Painting

Repairs to painting and site painting shall be effected in accordance with the provisions of CLAUSE 7807.

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f. Grouting

The grout shall be poured under and around the base plates of columns after the steelwork has been finally checked for alignment and height, and after the approval of the Engineer has been obtained to proceed with the grouting. The column base plates shall be supported by the top and bottom nuts and by steel wedges. The area under the steel shall be thoroughly cleaned and shall be dust and oil-free, and the concrete shall be thoroughly rinsed with water to leave the surface clean and moist.

The grout shall be an approved non-shrinking, pourable, cementitious grout. The grout shall be prepared and applied strictly in accordance with the manufacturer's recommendations and the Engineer's directives.

Leak-proof formwork shall be used for the pourable grout, and all corners shall be chamfered. The surface finish shall be Class F2 and Class U2 as applicable.

7707 Testing**a. Testing by the Engineer**

The Engineer may nominate a testing authority to inspect the Works and to conduct such tests as they deem to be necessary to test compliance with the specifications. Where required, test samples of welds shall be prepared by the Contractor, free of charge.

Payment for these tests shall be made under ITEM 71.01.

b. Quality Control

Welds shall be regularly inspected and tested by the Contractor in terms of his obligations in regard to process control, as described in **CLAUSE 1706**. This shall include visual inspection of welds to ensure that no undercutting, uneven lengths, porosity, or evidence of cracking occurs and that full fusion of the metals has been achieved. In doubtful areas, cores containing weld metal and adjacent parent material shall, if so required by the Engineer, be cut out, polished and examined and the hole repaired.

At least 30 % of the welds shall be examined by ultrasonic or radiographic means. If more than 5 % of the examined welds show unsatisfactory results, additional examinations covering all welds shall be performed. Certificates of the examination confirming that the steel plates and welds comply with the requirements of BS EN ISO 15607 or equivalent shall be submitted to the Engineer.

The cost of testing shall be deemed to be included in the rate bid for **ITEM 77.01** Structural steel.

7708 Measurement and Payment

Item		Unit
77.01	Structural Steel:	
(a)	Structure/Article Described	Tonne (t)
(b)	Structure/Article Described	Metre (m)
(c)	Structure/Article Described	Number (No.)

The unit of measurement shall be either the tonne or the metre of erected permanent steel structures or articles, or the number of erected permanent steel structures or articles. Where the unit of measurement is the tonne the weight of the steel waste caused by punching, drilling, sheared edges, milling or planning, or metal cut-outs shall not be deducted, and the weight of rivets, bolts, nuts, washers, welding fillets or temporary bracing shall not be added. In computing the weight of steel, the nominal weight per unit of length or area will be used and tolerances and other permissible deviations will be ignored.

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The bid rates shall include full compensation for preparing shop details where not provided on the Drawings, the supply of all the required materials, fabrication, process control, loading, transporting to the site, off-loading, and erecting. It shall also include full compensation for all nuts, bolts, washers, rivets, cutting, waste, and any temporary bracing necessary for transporting and erecting.

The bid rate shall also include full compensation for supplying and pouring the specified grout under and around the base plates of steel columns, for procuring and supplying all the necessary labour, constructional plant, tools and materials, as well as waste, formwork for the grout, and finishing to obtain the required surface finish for the grout under and around base plates of steel columns.

Item		Unit
77.02	Anchor Bolts:	
(a)	Description Of Each Assembly, And Grade/Type Of Steel, Diameter And Length Indicated	Kilogram (Kg)
(b)	Description Of Each Assembly, And Grade/Type Of Steel, Diameter And Length Indicated	Number (No.)

The unit of measurement shall be either the kilogram of installed anchor-bolt assemblies or the number of installed anchor-bolt assemblies.

The bid rates shall include full compensation for the materials, fabrication, handling, transporting and installing the anchor-bolt assemblies, including corrosion protection.

Item		Unit
77.03	Corrosion Protection:	
(a)	Sprayed-On-Metal	
i	Type Of Metal And Thickness Or Type Symbol Of Coating Indicated)	Tonne (T)
ii	Type Of Metal And Thickness Or Type Symbol Of Coating Indicated	Metre (m)
ii	Type Of Metal And Thickness Or Type Symbol Of Coating Indicated	Number (No.)
(b)	Hot-Dip Galvanising:	
i	Type Of Metal And Thickness Or Type Symbol Of Zinc Coat Indicated	Tonne (T)
ii	Type Of Metal And Thickness Or Type Symbol Of Zinc Coat Indicated	Metre (m)
ii	Type Of Metal And Thickness Or Type Symbol Of Zinc Coat Indicated	Number (No.)

The unit of measurement shall be either a tonne or a metre of steel structures or articles protected against corrosion, or the number of steel structures or articles protected against corrosion. The quantities are calculated as specified in ITEM 77.01.

The bid rates shall be extra over the rates for ITEM 77.01 and shall include full compensation for applying the specified corrosion protection, including surface preparation, materials, labour, tools, equipment and all incidentals required.

Note: Payment for painting shall be made under ITEM 78.01.

SECTION 7800 Painting

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7801 Scope

This section covers the painting of structural steel, guard rails, overhead road sign supports and other structures according to the requirements of the various sections of these Specifications where painting is called for. It does not include the treatment of timber posts which are included under SUBCLAUSE 8202(b).

7802 Material

Paints shall comply with the requirements of the following Specifications:

a. Primers

- i. Zinc-chromate primers for steel: BS 4652 or equivalent
- ii. Wash primer (metal etch primer): BS EN ISO 12944-5 or equivalent
- iii. Calcium-plumbate primer: BS 3698 or equivalent
- iv. Two-pack Zinc-rich epoxy primer: BS EN ISO 12944-5 or equivalent

b. Undercoat

BS 7664 or equivalent.

c. Finish Coats

- i. Decorative enamel for interior and exterior: BS EN 13300 or equivalent
- ii. High-gloss paint: BS EN 13300 or equivalent
- iii. Micaceous iron-ore-pigmented paint: BS EN ISO 10601 or equivalent
- iv. Baking enamels: BS EN ISO 4528 or equivalent
- v. Emulsion paint for exterior use (polyacrylic): BS EN 998-2 or equivalent
- vi. Chloro-rubber paint: BS 2008 or equivalent
- vii. Bituminous aluminium paint: BS 6949 or equivalent

d. Other

- i. Epoxy-tar paints: BS 5493 or equivalent
- ii. Bonding liquid for concrete surfaces: BS EN 1504 or equivalent
- iii. Bituminous-emulsion paint shall consist of a stable bituminous emulsion with a minimum of 45 % of bitumen and about 5 % of approved fibre.

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7803 General

All paint shall be obtained only from suppliers approved by the Engineer. Unless otherwise agreed by the Engineer, all paints forming part of any one paint system shall be obtained from the same source. Paints shall be supplied in sealed containers of not more than 5 litres capacity and shall be used in strict rotation. Unless otherwise agreed by the Engineer samples of paint of not less than 2 litres capacity shall be submitted for testing to the Engineer or their nominated testing authority.

Paint shall be stored on site under cover and in conditions as recommended by the manufacturers.

Paint shall be stored in such a manner that each batch can be issued for use in the order of delivery.

A separate store shall be provided for cleaning solvents used for brush or other cleaning purposes. Cleaning solvents shall not be stored where paint or paint thinners are stored or where paint is prepared for application.

Paints with a limited safe shelf life shall not be used after the period stated in the manufacturer's data sheets.

Inflammable material shall be stored in accordance with the appropriate regulations.

Flat and gloss paints shall not be boxed up together and skinned ullages shall be discarded.

No paint shall be applied to surfaces containing physically adhering contaminants such as oil, grease, dirt, marking material, water-soluble salts, wax, paint and temporary protectives, or to surfaces containing chemically bonded contaminants such as rust, mill scale, slag and flux.

All surfaces which are to be painted shall be dry. Unless otherwise stated, subsequent coats of paints shall be applied over dry paint surfaces.

All traces of soluble salts and corrosive airborne contaminants shall be thoroughly washed from the surface prior to painting, and the surface shall be dried and painted immediately afterwards.

Where surfaces are to be welded, unless otherwise specified, no paint shall be applied within 75 mm of the weld position.

After the welding has been completed, the welds and adjacent parent metal shall be completely deslagged, and the surfaces shall then be inspected and approved by the Engineer. All spatter shall be removed prior to the surfaces being painted. The weld area shall be abrasive-blasted and/or ground and all contaminants such as flux shall be removed prior to the surface being painted.

Surfaces which are to rest on concrete or other floors shall receive all the prescribed coats of paint prior to the member being erected.

Damaged paint areas shall be cleaned, rust spots removed and the surface primed again so that the patch painting covers the damaged areas and extends over a strip of 20 mm beyond each damaged area.

Where the shop coat is allowed to age for a few months before the next layer of paint is applied, light sanding with sandpaper or rubbing with steel wool and scrubbing with clean water with a bristle brush shall be carried out.

Steel to be embedded in concrete shall be entirely painted to a distance of 50 mm within the concrete, measured from the concrete outer surface.

All epoxy coating shall be carried out by a specialist firm or contractor approved by the Engineer. With its quotation the specialist firm shall be required to submit a letter of guarantee that the product it proposes to supply when applied in accordance with this specification and any additional specifications which shall be quoted by the firm will withstand the environmental service conditions to be encountered. The Contractor shall quote the guarantee period in number of years from time of application of the coating.

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The paint manufacturer's instructions shall be strictly adhered to.

Painted steel members shall be stacked so as to be off the ground.

Friction-grip surfaces shall not be painted but shall be treated in accordance with the Special Specifications.

Implementation of the manufacturer's recommendations concerning health and safety aspects of paints approved by the Engineer for use on the works shall be mandatory under this contract.

7804 Applying The Paint

Unless otherwise specified, paint may be applied either by brush, spray or roller method, or by any combination of these three methods.

Where brushes are used, they shall have sufficient body and length of bristle for spreading the paint in a uniform coat. Paint shall be evenly spread and thoroughly brushed out. If brush marks are visible, it will be considered that the paint has been improperly applied, and the paint will not be accepted.

On all surfaces which are inaccessible to painting by regular painting equipment, the paint shall be applied by bottle brushes, sheepskin daubers, or by any other acceptable method so as to render the required coating of paint.

If spray methods are used, the operator shall be thoroughly experienced. Runs, sags, thin areas in the paint coat, skips, or where air bubbles have formed or the paint has delaminated, shall be considered as being unsatisfactory, and the Contractor will be required to repaint the surface by brush.

A water trap and an air-regulating valve acceptable to the Engineer shall be furnished and installed on the equipment used for spray-painting.

Mechanical mixers shall be used for mixing paint properly when no ready-mixed paints are used. Prior to application, the paint shall be remixed for a sufficient length of time to mix the pigment and vehicle thoroughly. Paint shall be constantly kept well stirred to keep the pigments in suspension during its application. All skins in the paint shall be removed by screening. If it cannot be removed effectively, the paint and paintwork already completed may be condemned at the discretion of the Engineer.

No thinners or cleaners shall be employed other than those recommended by the paint manufacturer and to the Engineer's approval.

Paint shall not be applied when the temperature of the surface to be painted is less than 3°C above dew point or when the temperature of the steel is below 5°C or above 35°C, unless otherwise prescribed by the Engineer.

Paint shall not be applied in fog or mist, when it is raining or when rain is expected, or when the relative humidity is above 90 %.

7805 Protecting The Works During Painting Operations

All necessary precautions shall be taken by the Contractor before the commencement of any painting activities to ensure that no damage or disfigurement of any kind is caused thereby to any part of the works. If in the opinion of the Engineer the precautions taken are inadequate the Contractor shall at their own expense make all such improvements as the Engineer directs.

The Contractor shall protect all parts of the structure against disfigurement by spatters, splashes and/or smirches of paint or of paint materials. The Contractor shall be responsible for any damage to, or paint on, or contamination to vehicles, persons or property, including plants and animals, as a result of their operations, and the Contractor will be required to provide protective measures at their own cost to prevent such damage.

Any unsightly paint stains shall be removed by the Contractor at their own cost.

If passing traffic creates sufficient dust to harm or spoil the appearance of painted surfaces, the Contractor shall sprinkle the adjacent roads and shoulders with water at their own cost, for a sufficient distance on each side of the location where the painting is being done, to keep the dust away from freshly painted surfaces. The Contractor shall at their own cost, also furnish and post DRIVE SLOWLY signs and take other necessary precautions to prevent dust and dirt from adhering onto freshly painted surfaces.

7806 Preparing Surfaces For Painting

The Contractor shall regard the preparation of surfaces to be painted as a work of fundamental importance the object of which is to ensure the production of sound, clean, smooth and dry surfaces. The preparation shall have no detrimental effect on the sub strata to be painted nor shall it be prejudicial to subsequent painting operations.

In addition to the specific processes described below and/or in the manufacturer's instructions and specifications all surfaces shall be cleaned free from all dirt, grease, oil or other deleterious matter both before the application of primer and between subsequent successive coats of paint.

All surfaces prepared and made ready for painting shall be to a standard approved by the Engineer before painting work is begun.

7807 Painting Structural Steel

a. General

This SECTION includes the painting of steel guardrail posts, steel road sign supports and steel sign face frames, where required.

The surface preparation, priming and application of an undercoat shall be carried out under cover at the fabricator's works. Where possible, all painting shall be done at the fabricator's works but, where this is not feasible, the Engineer may permit the application of the finishing coats on the site, in which case an undercoat shall be applied at the fabricator's works prior to the members being despatched to the Works.

Unless otherwise specified, the protection described in SUBCLAUSES 7807(c), (d) and (e) shall be applied to all steelwork. Corrosion protection of steelwork exposed to aggressive or severe conditions shall comply with the requirements of the Special Specifications.

b. Surface Preparation

i. New structures

After all cutting, drilling, welding and punching have been completed, it shall be ascertained that all sharp edges have been uniformly rounded off and smoothed down. All physically adhering contaminants shall be removed and the surface shall then be abrasive-blasted to Sa 2½ finish in accordance with the BS EN ISO 8501-1, BS EN ISO 8501-1 supplement 2001 "second quality" or equivalent. The profile limit of the surface finish shall be between 30 microns and 60 microns. The abrasive-blasting profile shall be measured in accordance with BS EN ISO 8503-3, BS 7079-C3 or equivalent and shall comply with BS EN ISO 8503-1, BS 7079-C1 or equivalent.

No abrasive-blasting shall be done during rainy weather or when corrosive air conditions prevail.

Unless the application of a primer follows within four hours of abrasive blasting and before any oxidation of the prepared surface takes place, the abrasive-blasted surface shall immediately after abrasive blasting be given one coat of a wash primer.

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ii. Existing structures

The surface preparation of existing structures shall be carried out on site in accordance with BS EN ISO 8504-1, BS 7079-D1 or equivalent.

c. Primer

The prepared surface shall be given two coats of a zinc-chromate primer in accordance with BS 4752 or equivalent. The first coat shall be applied within 12 hours in the case of wash-primed surfaces and within four hours, but before any oxidation of the surface takes place, in the case of abrasive-blasted surfaces that have not been wash-primed. A fast-drying zinc chromate in accordance with BS 4752 or equivalent, may be used as primer. In all cases the dry-film thickness shall not be less than 30 microns per coat.

When steel has to be welded after the primer has been applied, the steel shall be left unpainted for a distance of 75 mm from the weld joint unless a weldable type of paint has been used. The welds shall be treated in accordance with the instructions of **CLAUSES 7803 and 7807**.

d. Undercoat

Where the finishing coats are to be applied on the site, the primed surfaces shall be given one coat of a universal undercoat with a suitable colour in the fabricator's shop before despatch. The undercoat shall be applied as soon as the prime coat has dried sufficiently. The dry-film thickness shall not be less than 25 microns.

e. Finishing Coat

Two finishing coats of high-gloss structural paint (BS EN ISO 12944 or equivalent) of the specified colour shall be applied to leave a dry-film thickness of not less than 25 microns per coat.

Where the finishing coats are applied on the site, the undercoat shall be lightly sanded and the members washed and cleaned of all contaminants. The first finishing coat shall be applied as soon as the structural members are dry.

Where specified in the Special Specifications, the second finishing coat shall consist of a micaceous iron-ore-pigmented structural paint of the specified colour to a dry-film thickness of not less than 30 microns. Unless otherwise specified, the second finishing coat shall be applied within 48 hours of the application of the first finishing coat.

The dry-film thickness of the total paint system shall not be less than 110 microns when no undercoat is used and not less than 135 microns when an undercoat is used. Where the second finishing coat is an iron-ore-pigmented paint, these thicknesses shall be increased by 5 microns.

f. Mating Surfaces

When mating surfaces are brought together, both surfaces shall already have been covered with all the specified coats of paint, but, where this is impossible, each surface shall be given a copious coating of primer and the surfaces drawn up while the paint is still wet.

g. Back-to-back Members And Areas Not Easily Accessible

Back-to-back members and areas not easily accessible shall be fully coated with all the specified coats of paint up to and including the finishing coats before erection.

h. Damaged Areas

Damaged areas shall be treated as follows:

Sand down to bright metal and clean. Spot prime with two coats and sand down lightly when hard. Rinse off with water and allow to dry. Apply two finishing coats.

i. Structural Steel To Be Embedded Below Ground

Those parts of structural-steel members to be embedded in soil and all bases to a height of 500 mm shall be given two coats of an epoxy-tar prime instead of the zinc-chromate prime specified for other surfaces.

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j. Epoxy Coating Work Generally

In addition to the general requirements of this specification the following conditions shall apply wherever epoxy coating work is being carried out:

1. The work shall be illuminated to the satisfaction of the Engineer.
2. Forced draught ventilation to the approval of the Engineer shall be used wherever required for the needs of personnel or for drying out surfaces.
3. Operatives shall work in pairs.

The Contractor shall demonstrate all methods, equipment and materials before any work commences. Sample areas of substrate shall be prepared and coated as required by the Engineer and for their approval.

There shall be strict control of surface cleanliness between primer and epoxy coating and between coats of the same. Vacuum removal of dust and sand shall be employed and contamination shall be removed as specified in appropriate preparation clauses herein. Where dirt or dust has become trapped in the painted surface it shall be removed with suitable abrasive paper. The surface being painted shall be free of visible moisture throughout these operations.

The paint shall be applied only to clean dry primed or previously coated surfaces. Any thick runs or collections of paint shall be removed before they harden.

Not less than two coats shall be applied over the primer by airless spray; not less than 3 by brush.

Each coat shall be distinctly different in colour from the primer or previous coat. The colour of the final coat shall be as required by the Engineer.

Each coat shall be seen to have completely covered the preceding coat without "misses" or pinholes or any areas visibly low in thickness. A high voltage pin hole detector shall also be used to determine the integrity of the coats.

The coat manufacturer shall stipulate primer and epoxy recoat intervals for all curing temperatures likely to be encountered and these shall be adopted with a maximum tolerance of +4 hours. Where this is exceeded, the surfaces to be recoated shall first be suitably abraded to remove gloss and give a good key.

7808 Painting Guard Rails**a. General**

This section covers the painting of guardrails, should it be prescribed. The painting of steel guardrail posts is covered in SUBCLAUSE 7807 and the treatment of timber guardrail posts is covered in SUBCLAUSE 8202(b).

b. Surface Preparation and Priming

All dirt, loose mill scale and loose corrosion products shall be removed by hand or power tools and all rust and mill scale by pickling, after which the surface shall be rinsed. A neutralising rinse shall also be applied, or the surface shall be phosphated.

c. Priming

Apply two coats of zinc-chromate primer to a dry-film thickness of not less than 20 microns per coat.

After the prime coats have hardened, the guard rails may be transported to the site.

d. Storage on the Site

The primed guardrails shall be stored off the ground under cover and protected against rain and weather until erection. Guardrails shall be stacked individually and not nested so as to prevent corrosion during storage. The finishing coats shall be applied as soon as possible and the primed

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surfaces shall not be allowed to corrode as a result of prolonged exposure to the weather. Any guardrails showing signs of rust before the application of the finishing coats shall be rubbed down with steel wool or fine sandpaper until all rust is removed, and it shall then be recoated with a zinc-chromate primer.

e. Finishing

Before the first finishing coat is applied, the guard rails shall be thoroughly washed down to remove all traces of salt and/or other air-borne corrosive materials and all dirt or other contaminants.

As soon as the rinsed guard rails are dry, a finishing coat of aluminium paint or a white high-gloss enamel in accordance with BS 7664 or equivalent shall be applied to a dry-film thickness of not less than 25 micron. Within 48 hours this shall be followed by a second coat as described before.

The guard rails shall preferably be given both finishing coats before erection but, where this is impossible, the Engineer may permit the finishing coats to be applied after the guard rails have been erected, provided that all mating surfaces and spots which are not easily accessible are painted with the finishing coats before the guard rails are erected.

The total dry-film thickness of all coats of the paint shall not be less than 90 microns. All damaged spots shall be treated as specified in SUBCLAUSE 7807(h).

7809 Painting Concrete

a. Surface Preparation

The surface of the concrete to be painted shall be cleaned of all dust, loose particles, laitance, impurities and other deleterious materials, and then washed and allowed to dry.

Unless the surface is to be covered with a bituminous paint, all cracks, holes and cavities shall be filled with grout or an acrylic filler.

b. Sealing and Priming

The surface shall be sealed with an approved clear sealer which complies with CKS 574 or equivalent and then primed with a primer consisting of an undercoat diluted to 50 %.

c. Undercoat and Finishing

An undercoat shall be applied after priming, followed by two finishing coats of the prescribed paint.

d. Bituminous Paint

The surface shall be prepared in accordance with the requirements of SUBCLAUSE 7809(a). Before it dries out, a primer shall be applied in accordance with the instructions of the fabricator of the bituminous paint.

After the primer has been applied, two coats of bituminous paint shall be applied at the rate of 0.75 litre/m²/coat. No paint coat shall be applied unless the previous coat has dried out completely, and no paint shall be applied to the paintwork for so long as any moisture occurs on the surface.

7810 Painting Galvanised Surfaces

Galvanised surfaces shall be painted as specified in this section for steel surfaces, except that the surface preparation and priming shall be as follows:

a. Surface Preparation

Dirt and other adherent contaminating matter shall be removed from galvanised surfaces by brushing with wire or stiff bristle brushes or by other methods approved by the Engineer. Cleaning shall not damage the galvanising. Oil or grease shall be removed from galvanised surfaces by the application of an emulsion cleaner. Any zinc corrosion products remaining shall be removed by washing with sweet water and scrubbing with hard bristle brushes

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After being cleaned and degreased all galvanised surfaces shall be etched with T wash as described in BS EN ISO 12944. If any surface fails to turn black the cleaning degreasing and etching processes shall be repeated.

b. Priming

Two coats of calcium-plumbate primer shall be applied to a dry-film thickness of at least 25 micron.

The undercoat shall follow within one week of the primer.

7811 Painting Of Road Signs

The painting of ungalvanised steel road signs, supports, and sign face frames shall be carried out as specified for structural steel in [CLAUSE 7807](#).

The painting of galvanised steel road signs, supports and sign face frames shall be carried out as specified in [CLAUSES 7806 and 7807](#).

The back of all road sign faces shall be painted grey.

7812 Painting Of Timber

a. Surface Preparation

All dirt, peeling or cracking paint and other foreign matter shall be removed by wire brushing, scraping, approved wax-free flushable paint remover, or other approved means immediately prior to painting.

The moisture content of the timber shall not be more than 20 % at the time of applying the first coat.

All cracks, shakes or scars shall be filled with putty, flush to the surface, before painting.

The surfaces shall then be washed with G1 cleaner or an equivalent and allowed to dry.

b. Primer

One coat of wood primer shall be applied.

c. Finishing

Two coats of high gloss enamel shall be applied in the specified colour. They shall be of two different colours.

7813 Measuring Paint Thickness

The dry-film thickness of paint shall be determined in accordance with BS 3900-C5, BS EN ISO 2808 or equivalent.

At least 90 % of all thickness measurements shall comply with the minimum specified requirements. The thickness shall not in any case be less than 70 % of the specified thickness.

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7814 Measurement And Payment

Item		Unit
78.01	Painting:	
(a)	Describe Structure/Article	Square Metre (m ²)
(b)	Describe Structure/Article	Number (No.)
(c)	Describe Structure/Article	Metre (m)
(d)	Describe Structure/Article	Tonne (T)

The unit of measurement shall be the square metre of surface painted. Only the surface covered by the final finishing coat shall be measured.

The unit of measurement may also be the number of structures or articles painted, or a metre length of the structures or articles painted, or a tonne of the structures or articles painted, the quantities are calculated as specified in ITEM 77.01.

The bid rates shall include full compensation for surface preparation, applying all the coats of paint, repairing any damaged surfaces, and all materials and construction plant necessary for completing the work

Prestressed concrete is structural concrete in which effective internal stresses are induced by means of tensioned tendons.

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SECTION 7900 Reinforced Fill For Structures

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7901 Scope

This section covers the requirements in regard to the construction of reinforced fill structures.

7902 Reinforced Fill Structures Components

a. General

The Reinforced-fill structures (RFS) system shall be supplied from the manufacture approved by the Engineer.

The contractor must submit test certificates of representative samples for the fill reinforcement, connections to the facing panels and associated components demonstrating compliance with these specification to the Engineer. The test certificates must not be more than 12 months old.

b. Geosynthetic reinforcement

Geosynthetic reinforcement must be demonstrated by testing as sufficiently strong, stable and durable to satisfy the performance and design requirements of these Specification.

The short-term tensile strength of the geosynthetic reinforcement must be determined in accordance with BS EN ISO 10319. The minimum creep test duration for geosynthetic reinforcement is 10,000 hours. To ensure continuity of quality is being maintained, short-term creep tests of minimum duration 1000 hours must be carried out and shown to be compatible with the long-term results.

The Contractor must provide the following details and properties of any geosynthetic reinforcement:

1. Dimensions including cross-sectional dimensions of strip and grid materials;
2. Characteristic ultimate tensile strength - longitudinal and transverse (where geogrid is used);
3. Strain at both ultimate and nominated tensile strength, in both longitudinal and transverse directions where grid materials are to be used;
4. Creep-limited strength in the longitudinal axis at the specified design life;
5. Long term tensile strength at 5 % elongation (i.E. Initial and creep strain);
6. Minimum breaking load;
7. Considerations of and allowance for strength reduction over the life of the structure due to creep deformation and rupture;
8. Allowance for strength reduction due to variations in manufacturing process;
9. Allowances for extrapolation of uncertainties where test duration is less than the design life;
10. Material strength and durability testing for the effects of exposure to:
 - Water
 - Aggressive fluids
 - Aggressive soils
 - UV radiation
 - Temperature effects
 - Mechanical damage
 - Contact with the fill material(s) intended for use with the RFS;

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Testing must be carried out where appropriate to assess the influence of the following job specific environmental factors on the durability and performance of the geosynthetic reinforcement for the design life of the structure:

- Loading;
- Water and installation induced damage;
- UV exposure;
- Operational temperature;
- Chemical/bacterial composition of reinforced fill material; and
- Aggressive fluids.

c. Steel Reinforcement

Steel reinforcing must comply with the grade, thickness and galvanised coating thickness specified on the Drawings.

The carbon steel strip to be hot dip galvanised shall comply with BS EN 10025-1 and BS EN 10025-2, BS EN 10025-4. The steel should be of grade S235, S275, S420 or S460. The fabricated element shall be hot dip galvanised complying with BS EN ISO 1461 with average zinc coating weight for any individual test area shall not be less than 1000 g/m².

The zinc-aluminium thermal spray coatings applied to steel reinforcing for use in specific aggressive environment should conform with the requirements of BS EN ISO 2063.

d. Facia Panel

The concrete facing panels must meet the following requirements:

- Comply with the drawings;
- Be manufactured from reinforced concrete in accordance with **CLAUSE 7400**;
- Unless specified otherwise on the drawings, be finished to have uniform quality, texture, appearance and colour, consistently good quality to edge and joint details; and
- Not be lifted by connection points used to connect fill reinforcement to the facing panel unless connection points are certified and tested for this purpose.

Unless specified otherwise, the Contractor must produce a test panel comprising of at least one full facing panel and reinforcing anchor in accordance with these specifications. The accepted test panel must be preserved as a quality benchmark until completion of construction.

Testing of specimens cut from facing panels for compressive strength is permissible.

e. Connections

Materials connecting the wall facing panels with the reinforcing elements must be electrolytically compatible to ensure that corrosion will not be promoted through the use of dissimilar metals.

The nuts and bolts used to join ties and steel reinforcement shall conform with BS EN ISO 898-1. Steel components must be hot dipped galvanised in accordance with BS EN ISO 1461 (for steel) and BS EN ISO 10684 (for hexagonal bolts, nuts and washers) with a minimum average coating thickness equivalent to an application rate of 600 grams per square metre of zinc.

f. Other Materials

Bearing pads (i.e. the pad placed in the horizontal joint between panels to maintain the correct spacing between panels) must be:

- Either HDPE, neoprene or ethylene propylene diene monomer;
- Durable and inert;
- Resistant to creep rupture and environmental degradation; and
- Able to accommodate differential movements between adjacent panels, during construction as well as throughout their design life.

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Geotextile material placed behind the joints shall be in accordance with BS 8661.

Joint fillers and sealants must be composed of durable inert materials resistant to atmospheric degradation and must:

- Protect filter fabric from exposure to sunlight;
- Maintain the degree of permeability assumed in the design; and
- Retain soil fines.

Sealants must be polysulphide or polyurethane based elastomeric compounds.

g. Component Tolerances

The following tolerances apply to concrete components in RFS:

- Overall dimension: ± 5 mm
- Thickness: ± 5 mm
- Location of fasteners: ± 5 mm.

The following tolerance apply to the dimensions of metallic and geosynthetic reinforcement

- Length of reinforcement: + 50 mm, - 0 mm
- Width of reinforcement: + 5 mm, - 0 mm
- Thickness of reinforcement: + 1 mm, - 0 mm.

h. Handling and Storage

All prefabricated RFS components must be transported and stored carefully to minimise mechanical damage and deterioration, including protection of geosynthetic reinforcement elements from UV degradation.

7903 Fill Material

a. General

These specifications apply to the Reinforced Fill Material and to material placed in the drainage layer (where applicable).

The Quality Plan must include:

- Details of the type and source of the materials; and
- A sampling and test plan for the materials that demonstrates compliance with the specified standards, including the shear strength and effective angle of internal friction for the select fill.

The Contactor must submit a report of test results of representative samples for each of the material properties specified. At least 4 sample test results for angle of friction at constant volume, and 7 sample test results for the other properties must be submitted.

b. Reinforced Fill Material

The Reinforced Fill Material must:

- Be composed of inert, hard, durable granular material, with properties that will not cause deterioration of the RFS components;
- Be capable of being compacted in accordance with the specified requirements to form a stable mass of fill;
- Be free from organic or other deleterious material such as plastic, metal, rubber or other synthetic material, inorganic contaminants, dangerous or toxic material, or material susceptible to combustion;
- Not be derived from argillaceous rock, such as shales and claystones or other materials which are susceptible to breakdown into a friable material; and
- Not be steel furnace slag.

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If steel or polyester fill reinforcement is used, the Reinforced Fill Material must not contain recycled concrete or cement stabilised soil.

The Reinforced Fill Material must meet the physical properties requirements specified in the RFS design, including the angle of friction at constant volume and the design grading envelope, and must be compactable to a stable mass at the required density.

The characteristic value of the weight per unit volume of the Reinforced Fill Material must be within $\pm 5\%$ of the value specified in the RFS design. If these limits are exceeded, the Contractor must consult the designer regarding the implications for the design and any necessary action to be taken. Data for this assessment may be obtained from relative compaction tests carried out on the Works.

If the Reinforced Fill Material is designed to be free draining, its permeability must be greater than 10-5 m/s when compacted to a dry density ratio not less than 97 % or 90 % density index, whichever is applicable.

Unless specified otherwise in the RFS design, the Reinforced Fill Material must comply with the properties specified in TABLE 7903/1.

TABLE 7903/1: PARTICLE SIZE DISTRIBUTION REQUIREMENTS FOR FILL MATERIALS

Property	Requirement
Effective angle of internal friction/shearing resistance, ϕ_{rf}'	$\geq 34^\circ$
Maximum particle size, D_{max}	≤ 50 mm
Coefficient of uniformity, $C_u = d_{60}/d_{10}$	≥ 4
Plasticity index, P_I	$\leq 6\%$

Where geosynthetic fill reinforcement is used, the Reinforced Fill Material must meet the pH requirements shown in TABLE 7903/2.

TABLE 7903/2: ALLOWABLE PH LIMITS OF REINFORCED FILL MATERIALS FOR RFS SYSTEMS WITH GEOSYNTHETIC COMPONENTS

Soil Reinforcement Material Type	Allowable pH Limits in Fill Material
Polyester	4 - 9
HDPE	3 - 12

Where steel components are used in the RFS Systems, the Reinforced Fill Material and water used in construction must meet the chemical and electrical properties requirements according to BS EN 14475, as shown in TABLE 7903/3.

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TABLE 7903/3: CHEMICAL AND ELECTRICAL PROPERTIES OF FILLS FOR RFS SYSTEMS WITH STEEL COMPONENTS

Environment	Electro-chemical characteristics compatible with routine design		Allowable limits used with metallic reinforcement
Land based, out of water	pH	-	5 to 10
	Resistivity	Ω cm	> 1000
	Chlorides (Cl)	ppm	< 200
	Sulphates (SO ₄)	ppm	< 1000
In wresh water	pH	-	5 to 10
	Resistivity	Ω cm	> 3000
	Chlorides (Cl)	Ppm	< 100
	Sulphates (SO ₄)	ppm	< 500

Note 1: The above values are applicable for routine design, common applications in environment of normal aggressivity.

Note 2: Specific study is required for marine environment or fill of marine origin, industrial waste fills and environment of high aggressivity. Thicker strips or larger bars may generally needed.

Note 3: The measurement of pH should be carried out in all cases according to test in BS 1377, part 3, or equivalent national standard.

Note 4: The measurement of resistivity of a saturated sample by open container method should be carried out in all cases according to test in BS 1377, part 3, or equivalent national standard.

Note 5: The measurement of water-soluble chlorides is only required if the resistivity is less than 5000 ohm.cm. If so, appropriate methods are detailed in test in BS 1377, part 3, or equivalent national standard.

Note 6:

i) The measurement of water-soluble sulphates SO₄ is only required if the resistivity is less than 5000 ohm.cm. If so, appropriate methods are detailed in test in BS 1377, part 3, with the result expressed as SO₃ multiplied by 1.2, or equivalent national standard.

ii) The sulphate content should incorporate 3 times the possible sulphur content S-. The measurement of S- should be carried out if the origin of the fill raises the possibility of its presence. It should be carried out by a competent laboratory using a method such as that given in the Encyclopedia of Industrial Chemical Analysis.

iii) The limit for sulphates content assumes that there are no chlorides. Similarly, the limit for chlorides assumes there are no sulphates. For cases where both salts co-exist then the limits may be derived from the equation $(Cl)0.86 + 13(SO_4)0.32 = k$ with Cl and SO₄ in ppm, $(Cl) \geq 1$, $(SO_4) \geq 5$, and $k = 120$ for "out of water" conditions, $k = 95$ for parts of the structures in fresh water.

c. Drainage Layer Material

Material in the drainage layer must:

- Be clean, graded, hard and durable crushed stone or river gravel;
- Free of clay or perishable matter; and
- Conform to the requirements under SUBCLAUSE 2104 (a).

A suitable synthetic filter and separation fabric as specified in the RFS design or CLAUSE 2104 (a) must be installed.

d. Testing Frequencies

The frequency of testing of the Reinforced Fill Material must comply with SUBCLAUSE 1708 (b).

7904 Construction

a. General

The Contractor must construct the RFS in accordance with:

- Any requirements specified in the design;
- Any requirements specified by the manufacturer of the RFS system; and
- Requirements specified in these specifications.

In the event of an inconsistency, the above order of precedence will apply.

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Site preparation, excavation (including removal of any unsuitable material) and placing of fill material must be carried out in accordance with the applicable general earthworks specification and any requirements for foundation improvement specified in the design.

Any over-excavation (i.e. excavation below or beyond the excavation the design levels or dimensions) must be backfilled and compacted with material that is compatible with the RFS design and the foundation design.

Unless specified otherwise, the Contractor must arrange for a Professional Engineer to inspect the foundation and submit a report confirming that either the foundation complies with the RFS design or that additional treatment is required.

b. Base Strip Footings

Base strip footings must be constructed to the lines levels and dimensions shown on the drawings within the following tolerances:

- Plan dimension: - 5 mm
- Thickness: - 10 mm
- Reduced level of top surface of footing: ± 5 mm
- Maximum variation of top surface from a 3 m straight edge: ± 5 mm.

The concrete grade for base strip footing shall be as specified in the design, which must be cured for a minimum of 24 hours before placement of wall panels.

c. Erection of Facing Panels

If steel fill reinforcement is used, the reinforcement must be thoroughly washed with water complying with TABLE 7903/3. Washing of fill reinforcement made of other materials which are not susceptible to corrosion is not necessary, unless specified by the supplier.

The degree of inclination of the facing panels towards the fill must be adjusted where necessary as placement and compaction of fill material proceeds, to ensure that the specified tolerances are not exceeded.

On completion of the first course of facing panels, the panels must be inspected and surveyed before construction of the second course of facing panels.

Prior to placement of each course of facing panels, the level and alignment of the preceding course must be measured to verify that all positions, levels and dimensions of the facing panels are in accordance with the Drawings.

Adequate support of the facing panels must be provided at each stage of erection. The supporting course of facing panels must be shored to control movement during the placement and compaction of fill material.

Bearing pads must be placed between precast concrete panels to prevent them from sitting directly on each other. Bearing pads must be placed within 5 mm of the positions shown on the Drawings. Unless shown otherwise on the Drawings, bearing pads are not inserted in vertical joints.

A strip of geotextile material, at least 500 mm wide, must be placed between the back of the facing panels and the fill material, equidistant across all joints. If shown on the Drawings, a vertical strip drain, at least 300 mm wide, must be placed behind each vertical joint and covered by a non-woven geotextile.

Sealants may only be used where shown on the Drawings or to protect the geotextile from UV degradation. Sealants (including primers) must be applied in accordance with the manufacturer's recommendations. Sealants must not be used in the following applications:

- For joints which will be below finished ground level, or
- Where the RFS design requires the wall face to be free draining.

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d. Placement Of Fill Reinforcement And Compaction Of Reinforced Fill Material

Unless specified otherwise, the placement and compaction must be carried out in a direction parallel to the face of the structure and must be completed in stages to follow closely the erection of facing panels and placement of reinforcing elements.

Reinforcing elements and facing panels must not be damaged or displaced during placement and compaction of fill. Tracked machines or vehicles must not be operated directly on top of reinforcing elements which are not covered by at least 150 mm of fill material. No plant must be operated in a manner that would cause the displacement of fill reinforcement from the intended positions.

All vehicles and all construction equipment weighing more than 1500 kg must be kept at least two metres away from the facing panels (unless an alternative distance is specified in the design). Fill material within two metres of the facing panels must be compacted using one or more of the following methods:

- A vibro-tamper;
- A vibrating plate compactor roller with mass not exceeding 1000 kg; or
- A vibrating roller with a mass per metre of width of not more than 1300 kg and a total mass of not more than 1500 kg.

Where a compactor cannot reach the material behind the facing panel (e.g. inclined faces), alternative means such as stabilisation must be used to ensure the units are adequately supported.

RFS fill material must be placed and compacted with a moisture content not greater than the optimum moisture content. After compaction, the absolute value of density and / or the characteristic value of density ratio of the material must not be less than the values specified in the RFS design or elsewhere in the Contract documents.

Synthetic fill reinforcement must not be spliced or joined in the primary strength direction. Where connections are made of synthetic fill reinforcement such as geogrids, the geogrid layers must not be spliced or joined in the primary strength direction.

Fill reinforcement must be laid horizontally on the compacted fill at the location and levels specified in the Drawings. It must be connected securely to facing panels in accordance with the Drawings. Geosynthetic reinforcement must be pulled taut before placing the overlaying fill material. The method of fill placement and compaction must ensure that slack is not introduced into the fill reinforcement as fill is placed. The condition of the fill reinforcement and the connections to the facing panels at each level must be recorded just before covering.

Where overlapping of fill reinforcement is required e.g. for curved walls, a minimum thickness of 75 mm of compacted fill must be provided between the overlapping fill reinforcement.

The fixing of the fill reinforcement and placement of reinforced fill must be carried out in one plane at a time.

During construction, the earthworks fill material behind the RFS block must be maintained at the same level as the RFS block. Where the material is an existing earthwork or material slope which requires temporary support by shoring, the shoring must be removed in such a manner that the stability of the adjacent ground is maintained, the compacted fill material is not disturbed and the formation of voids is prevented.

At the end of each day's operations, the top layer of fill must be shaped to permit drainage away from the face and the remainder of the RFS.

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e. Capping, Filter and Drainage Materials

Filter and drainage materials must be constructed in accordance with the Drawings and/or the manufacturer's instructions. Where granular material is used as a drainage material, the drainage material must be compacted to the same requirements as Reinforced Fill Material. It must be constructed progressively in layers matching the Reinforced Fill Material.

If the surface above the RFS block is unpaved, an impermeable layer of fill material must be placed above the reinforced fill zone which prevents water infiltration into the RFS block. The material must be placed and compacted in accordance with the applicable general earthworks specification and any requirements specified in the design.

f. Tolerances

Construction tolerances measured immediately after completion of the RFS and the application of all dead load surcharges, must comply with TABLE 7904/1. Negative deviations are measured towards the RFS block. Where no other tolerance is given, a measurement (dimension, level, position) which falls within ± 6 mm of the required value must be deemed to be conforming. The Contractor must submit survey results, demonstrating compliance with TABLE 7904/1, to the Engineer.

Deformations in the face and top surface of the structure should be kept within acceptable limits. The following considerations may be used to determine these limits.

- The wall face should be visually acceptable and free from bulges, overhangs and erratic alignment.
- All tops should follow smooth curves or straights as specified in drawings.
- Construction sequence can be critical in ensuring that abutments should not deform thus causing movement of supported bank seats, closing of deck joints and axial loading of bridge decks in excess of those allowed for in the design.
- Wall faces should not deform and cause damage to the facing material. In the case of concrete facings this damage could include closure of joints, spalling of panel edges and panel cracking.

TABLE 7904/1: CONSTRUCTION TOLERANCES COMMONLY ACHIEVED FOR RETAINING WALLS AND ABUTMENTS

Element/Feature	Tolerance
1. Wall face	
(a) Location of plane of structure	± 50 mm
(b) Verticality	± 5 mm per metre height (1 in 200)
(c) Bilging (vertical) and bowing (horizontal)	± 25 mm in 4.0 m template
2. Top and bottom of wall	
(a) Walls adjacent to bridge abutments	± 15 mm
(b) Walls outside a distance equal to the height of the Reinforced Fill from bridge abutments	± 30 mm
3. Level of any point on wall	± 20 mm

Note: The face of segmental block walls are usually built at a batter often by setting back the face of a row of blocks from the previous layer of blocks. The tolerance for verticality in the TABLE is to be read as the tolerance from the intended designed face batter.

g. Monitoring

As a minimum, the performance of RFS wall must be monitored through the measurement of the deflection of the RFS wall facings. The contractor must provide reference points (survey points) vertically on the facing at a cross-section of the wall. The top survey point must be at one metre down from the top of the wall. The bottom survey point must be at one metre up from the bottom of the wall. The rest of the survey points must be at no greater than two metre intervals between the top and bottom points in a cross-section avoiding two points on one facing panel.

The x , y and z co-ordinates of each survey points must be measured to an accuracy of 5 mm. Sufficient control points must be established so that vertical and horizontal movement can be measured to an accuracy of 1 mm.

The minimum monitoring cross-section requirements are as given in TABLE 7904/2.

TABLE 7904/2: MINIMUM MONITORING CROSS-SECTION REQUIREMENTS	
Wall Height	Minimum number of monitoring cross-SECTION
6 m – 8 m	For every 100 m length of wall section within the wall height between 6 m and 8 m, at least one cross-section. The maximum height within the wall SECTION must be targeted.
> 8 m – 10 m	For every 75 m length of wall section within the wall height between >8 m and 10 m, at least one cross-section. The maximum height within the wall SECTION must be targeted.
> 10 m	For every 50 m length of wall section within the wall height >10 m, at least one cross-section. The maximum height within the wall section must be targeted.

In addition to the above, the contractor must provide additional monitoring cross-sections at high-risk areas such as follows:

- Wall curvature on plan – concave outwards (bowl facing backfill).
- Heavily loaded walls.
- Walls that are located at a high-risk area for example, close to public or heavy traffic.
- Walls that are located adjacent to other structures/utilities which may be affected by the wall movement.
- Walls subject to abutment/bridge horizontal loadings, and
- Walls where there is some uncertainty in the design/construction.

Monitoring of vertical and horizontal movement at the survey points must start as soon as the wall reaches the maximum height. The monitoring frequency must be as follows:

- Initially every two weeks for two months
- Then monthly for another two months, and
- Then three monthly for a period of 2 years or any other period specified in the contract.

After each measurement, the Contractor must plot the measurements on a log time scale plot and extrapolate these measurements in order to predict the position of the RFS at the end of its design life. The results of each measurement and the log time scale plot must be submitted to the Engineer within 14 days of each measurement.

7905 Measurements and Payments

Item	Unit
79.01 Construction Of Base Strip Footing Including Excavation:	Cubic Metre (m ³)

Item	Unit
79.02 Construction Of Reinforced Fill Wall Including Soil Reinforcing System As Per Specifications Using:	Cubic Metre (m ³)
(a) Geosynthetic Reinforcement	Square Metre (m ²)
(b) Steel Reinforcement	Square Metre (m ²)

Item	Unit
79.03 Construction Of Fill In Reinforced Soil Structure As Per Specifications:	Cubic Metre (m ³)

Item	Unit
79.04 Construction Of Counter Balance Slab And Barrier:	Cubic Metre (m ³)

The measurement for the construction of concrete base footing for placing the fascia elements shall be in cubic metres of finished concrete volume as shown on the drawings. The Item also includes the excavation and the steel reinforcement for the footing.

The measurement for the construction reinforced fill wall shall be in square metres of finished work of each face and shall be measured in the plane of the final inclination specified in the drawings. The measurement of length shall be the finished work along the length of the road. The measurement of height shall be along the slope and shall be measured from top of the footing on which the fascia element is placed to the top of the capping beam. The Item includes complete finished work including supply and erection of reinforced concrete fascia elements, soil reinforcement system, fasteners, nuts, bolts, connecting fascia elements with reinforcing elements, bearing pads, geotextile material placed behind joints, joint fillers and sealants, capping beam, etc. required to complete the work.

The measurement for fill material shall be the compacted volume of fill in cubic metres of fill including capping, filter and drainage materials in reinforced as well as in unreinforced zone of the fill.

The measurement of concrete counter balancing slab and barrier shall be in cubic metres of the concrete volume of the finished work as shown on the drawings including reinforcement.

The bid rates shall include full compensation for providing all materials, labour, plant, handling, storage, transportation, formwork, staging, construction, erection, etc. required to complete the work.

The rates shall include full compensation for design, drawings and testing of materials.

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SECTION 8100 Marker & Kilometre Posts

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8101 Scope

This section covers the furnishing and installation of new as well as removal, renovating and re-erection of existing kilometre and marker posts in position and in accordance with the dimensions as shown on the Drawings or as directed by the Engineer.

8102 Materials

a. Concrete

Concrete work shall be carried out in accordance with the provisions of SECTIONS 7200, 7300 and 7400.

b. Paint

Paint for marker and kilometre posts shall be non-reflectorised road-marking paint as specified in SECTION 8500. Paint for the recess in the marker posts shall be a retro-reflective paint as indicated in the Particular Specifications, or as directed by the Engineer. The paint for the engraved letters shall be black reflective paint.

8103 Fabricating

Marker and kilometre posts shall be fabricated to the dimensions shown on the Drawings in Class C16/20 concrete. The forms shall be smooth and shall have accurate dimensions. The mixture shall be placed in the forms and vibrated on a vibrating table or by other approved means. The posts shall be reinforced as shown on the Drawings and shall have an F3 surface finish as defined in CLAUSE 7207.

The posts shall be true to shape, smooth, and without any honeycombing or other blemishes.

The recess near the top of the kilometre post shall be engraved to a depth of 10 mm with text 17 mm thick and 100 mm high. The text in the upper portion of the recess shall comprise the three letter code for the designated town to which distances are to be given as shown on the drawings or directed by the Engineer, and the text in the lower portion of the recess shall comprise the numerals for the distance to the designated town in km. The upper and lower text shall be 50 mm apart.

8104 Spacing of the Marker and Kilometre Posts

The marker and kilometre posts shall be placed as shown on the Drawings, or as indicated by the Engineer.

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Ancillary Roadworks | 8100 | Marker & Kilometre Posts

8105 Erecting

Marker posts shall be erected after the seal has been completed. They shall be located at such spacing as the Engineer directs with their outside edges in line with the shoulder breakpoint. The edge on which the recess is located is the inner edge. The tops of the marker blocks shall be at a constant height above the centreline of the road.

Holes shall be neatly excavated to the dimensions shown on the drawings or as directed by the Engineer. The posts shall be placed vertical and square to the road centre line in a foundation of Class C16/20 concrete which shall completely fill the hole. The top surface of the concrete shall be equivalent to an F3 finish and levelled to ensure drainage profiles to match the surrounding road surface. Surplus excavated material shall be disposed of as directed.

The marker posts shall be painted immediately after placing.

Kilometre and marker posts shall be maintained and protected during the entire construction period and any that are damaged or broken before the certificate of completion has been issued, shall be repaired or replaced, as may be required, at the Contractor's own cost.

Kilometre posts shall be set out on the slope beyond the shoulder such that one apex of the post is at the outer edge of the shoulder and that the appropriate text is exposed to traffic. These posts shall be erected after the completion of the bituminous surfacing and shall be erected in the manner described for the marker posts.

8106 Measurement and Payment

Item	Unit
81.01	
(a)	New Marker Posts
(b)	Renovating And Re-Erection Of Existing Marker Posts
	Number (No.)
	Number (No.)

The unit of measurement shall be the number of marker posts supplied and erected in accordance with the Specifications.

The bid rate shall include full compensation for supplying all materials and labour, making and transporting the marker posts, setting out, excavating and backfilling all the holes and disposing of surplus excavated material, including all haulage, placing and painting the marker posts and all the equipment, the tools and incidentals necessary for completing and maintaining the Works described in this SECTION.

Item	Unit
81.02	
(a)	New Kilometre Posts
(b)	Renovating And Re-Erection Of Existing Kilometre Posts
	Number (No.)
	Number (No.)

The unit of measurement shall be the number of kilometre posts supplied and erected in accordance with the Specifications.

The bid rate shall include full compensation for supplying all materials and labour, making and transporting the kilometre posts, setting out, excavating and backfilling all the holes and disposing of surplus excavated material, including all haulage, placing and painting the kilometre posts and all the equipment, the tools and incidentals necessary for completing and maintaining the Works described in this section.

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SECTION 8200 Guardrails

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8201 Scope

This section covers the supplying, installing and maintaining of metal guardrails at locations and in accordance with the details, dimensions and design shown on the Drawings or as directed by the Engineer.

8102 Materials

a. Guardrails

Metal beam guard rails shall be corrugated sheet steel beams conforming to AASHTO M180 and shall be zinc coated after fabrication in accordance with ASTM A 653.

The dimensions of guardrails and end units shall be in accordance with the details shown on the Drawings.

Guardrails shall be supplied together with all the bolts, nuts, washers and fixing materials required, including the bolts for fixing the guardrails to the posts in accordance with AASHTO M180 and be zinc coated after fabrication in accordance with AASHTO M 232 Class C.

b. Guardrail Posts

i. Timber posts

Timber posts shall be supplied in lengths as shown on the Drawings and shall comply with the requirements of BS 5268-2 or equivalent.

Posts shall have a top diameter of not less than 150 mm. Posts with a top diameter up to 230 mm will be acceptable, provided that posts with widely varying diameters shall not be used together in the same length of guardrail.

Posts shall be drilled and shaped as shown on the Drawings and provided with the necessary bolts, nuts, washers and spacer blocks for fixing.

Timber posts and spacer blocks shall be treated in accordance with BS 8268-5 or equivalent, with a copper-chrome-arsenic compound for timber preservation, or with creosote, complying with BS 5268-5, or equivalent. Alternatively if so specified the preservative named in the Special Specifications shall be used. After the posts have been treated, they shall not be sawn, drilled or shaped.

Where the cutting of posts is unavoidable after treatment, the Engineer may permit the required length to be cut off from the bottom of a post, provided that the exposed area is subsequently thoroughly treated with creosote, or equivalent.

Timber posts shall not exhibit excessive cracking at the ends, particularly cracks aligned at an angle to the guardrail exceeding 45°. Posts which, in the opinion of the Engineer, exhibit a degree of cracking that would render them unfit for service during a shorter than normal life shall not be used.

ii. Steel posts

Steel posts shall be UNP steel profiles 120 x 85 x 7 mm or of the type and size shown on the Drawings or described in the Special Specifications. Steel posts should confirm to AASHTO M270 and shall be zinc coated in accordance with AASHTO M111.

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Ancillary Roadworks | 8200 | Guardrails

c. Galvanising

Unless specified otherwise in the Special Specifications, all guardrails, bolts, nuts and washers shall be galvanised with a hot-dip (galvanised) zinc coating, which complies with the requirements of AASHTO designation M232M/97 or equivalent.

Galvanised guardrails shall not be nested when stacked for storage.

d. Reflective Plates

V-shaped reflective plates shall be manufactured from 1.5 mm thick mild steel plate to the dimensions shown on the Drawings. When supplied with galvanised guardrails, they shall also be galvanised, and when supplied with painted guardrails, they shall be finished in white baked enamel. The outer surfaces shall be coated with engineering-grade retro-reflective material that complies with the provisions of BS EN 12899 – 3 or equivalent standards in the colours shown on the Drawings. Holes for fixing shall be drilled before the reflective plates are galvanised or painted.

e. Splices and End Connections

Splices and end connections shall develop full design strength of rail elements. End sections and terminal connectors shall confirm to AASHTO M 180, Class B, Type II.

f. Bolts and Nuts

Standard bolts and nuts shall confirm to ASTM A 307 and AASHTO M291 Grade A. High strength bolts shall confirm to AASHTO M164 or ASTM A 449.

8203 Construction**a. Erection**

The holes for the timber posts shall be of sufficient size to permit the proper setting of the posts and to allow sufficient room for backfilling the hole and tamping the filling. At least 1.0 m of a post shall be embedded in the ground.

The holes for the timber posts shall be spaced to suit the standard length of the guardrail supplied. Where shown on the Drawings or directed by the Engineer, posts shall be set at half the normal spacing. The hole for the concrete block at the end of a length of guardrail shall be neatly excavated and the top 120 mm shuttered.

The posts, spacer blocks (if applicable) and guardrails shall be completely erected and set true to line and level, so that the guardrails will be at the required height above the level of the completed road shoulder. Where jointed, the end of the guardrails which overlap on the side of the traffic shall point in the direction of the traffic movement. The guardrail shall be suitably braced to prevent any movement and all bolts shall be tightened prior to any holes being backfilled.

After the Engineer has approved the guardrails so erected, the holes shall be backfilled with a 12:1 soil-cement mixture. The material shall be mixed with the correct quantity of water to ensure that the mixture will be placed while at or near the optimum moisture content.

The mixture shall then be placed and thoroughly rammed in layers not exceeding 100 mm of compacted thickness. The approach ends, where the guardrail has to be bent down and anchored, shall be constructed as shown on the Drawings.

When the backfilling has been completed and the bracing removed, the posts shall be rigid and vertical, and the guardrail shall be true to line and level within a ± 20 mm tolerance and firmly fixed to the posts. Excess excavated material shall be disposed of as directed by the Engineer.

Steel posts shall be erected and fixed as shown on the Drawings.

All guardrails shall be erected with no projecting ends that may interfere with or endanger traffic. The edges and the centre of the guardrails shall touch either the spacer block or the post where

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no spacer blocks are used. Guardrails, if specified, shall be provided with end units as shown on the Drawings. All splices of guardrails shall be at posts and guardrails shall make contact over the entire area of the splice.

Reflective plates shall be fixed in accordance with the details shown on the Drawings. The reflective surfaces shall be arranged with the colours as shown on the Drawings.

When erection is complete and the section has been approved by the Engineer the nuts shall be spot welded to the guardrail or to the bolt to prevent theft. Galvanised coating damaged by spot welding or cutting shall be renovated either by the use of low melting point zinc alloy repair rods or powders made specifically for this purpose, or by the use of at least two coats of good quality zinc rich paint to BS 4652 or equivalent.

b. Painting

The following instructions shall apply where guardrails are to be painted:

- i. Before being fixed the guardrails shall be cleaned, primed and painted as specified in **CLAUSE 7808**. After erection, all abraded or damaged surfaces shall be repainted as specified in **CLAUSE 7808**. Galvanised guardrails shall not be painted.
- ii. When existing guardrails are required to be repainted they shall be thoroughly cleaned with wire brushes and descaled with suitable tools to remove all rust and loose and oxidised paint. They shall then be washed down with water, dried, and all exposed steel surfaces shall be given a coat of zinc based primer.
- iii. The entire prepared surface shall then be given a full coat of zinc-based primer and two coats of paint as specified in **CLAUSE 7808**.

8204 Finish Requirements

The completed guardrail shall have a neat appearance and shall not show any visible deviations from line and grade. The posts shall be straight and vertical. The guardrails shall not be warped but shall be in a vertical plane parallel to the road centre line except at flared terminal sections. The painted or galvanised surface on the guardrail shall be smooth, continuous and free from abrasions or scratches. Any damage to the surface shall be repaired at the Contractor's expense.

8205 Removing, Renovating and Re-Erecting Existing Guardrails

Every effort should be made to reuse existing guardrails rather than dispose of them and purchase new units. Where existing guardrails have to be removed, or removed and re-erected, or removed, renovated and re-erected, the three processes of removal, renovation and re-erection shall be carried out as follows:

a. Removing the Guardrails

All guardrails, reflective plates and end units shall be loosened. Posts shall be carefully dug out and the holes shall be filled and compacted in 150 mm layers. Items used for fixing, such as bolts, nuts and washers, together with the reflective plates, shall be placed into bags, after which all the material shall be transported to a store approved by the Engineer and all stored in groups by type.

Where material is intended for re-use, it shall first be unpacked for inspection by the Engineer for deciding which material will be suitable for re-use. Suitable material shall then be stored separately from material that is unsuitable for re-use.

b. Renovating the Guardrails

Guardrails, end units and steel posts suitable for reuse shall be taken to the workshop for cleaning and painting. Rust and existing paint shall be completely removed and minor indentations hammered out. The guardrails shall then be re-galvanised or receive surface treatment and be painted as described in **CLAUSE 7808**.

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Timber posts suitable for re-use shall be cleaned and treated with a timber preservative as described in SUBCLAUSE 8202(b). Bolts, nuts and washers to be re-used shall be cleaned and all rust removed, and shall then be oiled.

c. Re-erection

The guardrails shall be erected in the positions as indicated and all the removed material suitable for re-use, and new replacement material, shall be used. Re-erection shall be as specified for new guardrails, including fixing the retro-reflective plates.

8206 Measurement and Payment

Item	Unit
82.01 Guardrails on Timber Posts:	
(a) Galvanised	Metre (m)
(b) Painted	Metre (m)

The unit of measurement shall be the metre of guardrail as erected, excluding end units.

The bid rates shall include full compensation for furnishing all materials and labour and for erecting and painting and galvanising the guardrails, complete with posts, spacer blocks, bolts, nuts, washers and reinforcing plates, and excavating and backfilling the post holes and removing any surplus excavated material.

Item	Unit
82.02 Guardrails on Steel Posts:	
(a) Galvanised	Metre (m)
(b) Painted	Metre (m)

The unit of measurement shall be the metre of guardrail erected, excluding end units.

The bid rates shall include full compensation for furnishing all materials and labour and erecting and painting and galvanising the guardrail, complete with posts, spacer blocks, bolts, nuts, washers and reinforcing plates and excavating and backfilling the post holes including concrete backfill, and removing any surplus excavated material.

Item	Unit
82.03 Extra Over ITEMS 82.01, 82.02 And 82.11 for Horizontally Curved Guard-Rails Factory Bent to a Radius of Less Than 45 m	Metre (m)

The unit of measurement shall be the metre of curved guardrail erected and measured in place.

The bid rate extra over the rates bid for ITEMS 82.01, 82.02 and 82.11 shall include full compensation for incidentals in respect of supplying and erecting curved guardrails.

Item	Unit
82.04 End Units:	Metre (m)
(a) End sections Including Foundation In The Ground Where Single Guardrail sections Are Used (State Length)	Number (No.)
(b) End sections Including Foundation In The Ground Where Double Guardrail sections Are Used (State Length Of End section)	Number (No.)
(c) Cable Stays Complete With Anchor Block	Number (No.)

The unit of measurement shall be the number of end units of each type erected.

The bid rates shall include full compensation for all labour, constructional plant and materials required for installing the end units as shown on the Drawings, including posts and fittings and the bending of turned-down sections, excavations, concrete, backfilling, the removal of surplus backfill and bituminous sealing at posts where guardrail is erected through a bituminous surface.

Item		Unit
82.05	Additional Guardrail Posts:	Metre (m)
(a)	Timber	Number (No.)
(b)	Steel	Number (No.)

The unit of measurement for additional guardrail posts shall be the number erected over and above those erected in accordance with the normal spacing shown on the Drawings.

The bid rates shall include full compensation for supplying additional posts, excavating the necessary holes, erecting the posts and backfilling the holes.

Item		Unit
82.06	Reflective Plates	Number (No.)

The unit of measurement shall be the number of reflective plates installed.

The bid rate shall include full compensation for supplying all materials and labour required for manufacturing, painting and fixing the reflective plates as specified and as shown on the Drawings.

Item		Unit
82.07	Removing Existing Guardrails	Metre (m)

The unit of measurement shall be the metre of guardrail removed, and the quantity shall be measured between the terminal points of the sections removed, including the end units, but excluding the anchor blocks and anchor cables, if any, projecting beyond the end units.

The bid rate shall include full compensation for the work as described in SUBCLAUSE 8205(a), including loading, transporting to any point on the Site, and off-loading and stacking the material.

Item		Unit
82.08	Renovating Guardrail Material	Metre (m)
(a)	Guardrails Including End sections	Metre (m)
(b)	Posts Including Bolts, Washers And Nuts	Number (No.)

The unit of measurement for SUBITEM 82.08(a) shall be the metre of single guardrail, whether straight or bent renovated as specified, the length of which shall be measured in accordance with the measurements of the guardrail after dismantling. The unit of measurement for SUBITEM 82.08(b) shall be the number of treated posts.

The bid rates shall include full compensation for the work as specified in SUBCLAUSE 8205(b), including the loading, transporting to and from the workshops, off-loading and storing of the material.

Item		Unit
82.09	Re-Erection Of Guardrails With Recovered Material:	
(a)	Single Guardrail	Metre (m)
(b)	Double Guardrail	Metre (m)

The unit of measurement shall be the metre of single or double guardrail re-erected with used material and measured between the points where they are joined to the end units.

The bid rates shall include full compensation for re-erecting the guardrails as specified in SUBCLAUSE 8205(c), including the loading, transporting between any two points on the site and off-loading the material, and providing new fixing material. Payment shall be made separately for any new material required, including spacer blocks, but not for other fixing materials. Where sections are made entirely from new material, payment therefor shall be made under the appropriate Items for new guardrails.

Item	Unit
82.10 Re-Erection Of End Units With Recovered Material:	
(a) End Wings	Number (No.)
(b) Terminal sections With Single Guardrails	Number (No.)
(c) Terminal sections With Double Guardrails	Number (No.)
(d) Terminal sections Complete With Anchor Block	Number (No.)

The unit of measurement shall be the number of end units erected with recovered and, in part, new material.

The bid rates shall include full compensation for erecting the end units and for providing all anchors, fixing materials and anchor blocks. Apart from anchors, anchor blocks and fixing materials payment will be made separately for all new materials. End units made completely from new materials shall be paid for in accordance with the appropriate rates for new end units.

Item	Unit
82.11 New Material Required For The Re-Erection Of Guard-Rails With Recovered Materials:	
(a) Guardrails	Number (No.)
(b) Timber Posts	Number (No.)
(c) Steel Posts	Number (No.)
(d) Reflective Plates	Number (No.)
(e) Spacer Blocks	Number (No.)

The unit of measurement for SUBITEM 82.11(a) shall be the metre of guardrail provided, measured in accordance with the measurements of the loose guardrail. The unit of measurement for SUBITEMS 82.11(b), (c), (d) and (e) shall be the number of new timber posts, steel posts, reflective plates and spacer blocks provided, respectively.

The bid rates shall include full compensation for supplying the material as specified. ITEM 82.03 shall also apply to horizontally bent guardrail factory bent to a radius of less than 45 m.

Item	Unit
82.12 Drilling And Blasting Holes For Guardrail Posts	Number (No.)

The unit of measurement shall be the number of holes drilled and blasted with explosives in rock material which cannot be removed by auger.

The bid rate shall include full compensation for all drilling, explosives, materials, labour and equipment and all incidentals to be incurred for making holes in rock materials.

SECTION 8300 Fencing

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8301 Scope

This section covers the moving of existing fences and erecting new fences along the boundaries of the road reserve and elsewhere as indicated on the Drawings or as directed by the Engineer.

It also includes the erection and later removal of temporary fences and dismantling of existing fences and stacking of the fencing material.

Except when the Engineer allows otherwise temporary fences shall be erected before construction on a particular section of the road is commenced, or before temporary bypasses are opened to traffic.

This section also covers the construction of cattle grids.

8302 Materials

a. Straining Posts, Stays, Standards and Droppers

Straining posts, stays, standards and droppers shall be of the type and size indicated on the Drawings. Steel sections shall comply with the requirements of BS 4-1 or BS EN 10162 or equivalent and timber posts with the requirements of BS 8268-2 or equivalent. Timber posts shall be treated with a preservative in accordance with the requirements of SUBCLAUSE 8202(b).

Unless otherwise specified or shown on the Drawings, rolled steel posts shall be 15 or 22 kg/m rails as shown on the Drawings. Standards shall be 2.5 kg/m Y-sections or timber standards according to BS EN 14081 or equivalent.

Droppers shall be 0.86 kg/m ridgeback-pattern droppers or timber droppers according to BS 8268-2 or equivalent.

Tubular straining posts and stays shall be galvanised in accordance with BS EN 10240, BS EN ISO 1461 or equivalent for Class B1 articles, or shall be painted as specified in SECTION 7800 or as may be required on the Drawings, and shall have a wall thickness of at least 2.95 mm. Unless otherwise shown on the Drawings all tubular posts shall be provided with at least a 200 mm x 200 mm foot plate and a pressed steel or cast iron cap. Tubular stays shall have a nominal bore of at least 50 mm.

Rolled steel sections shall be provided with a bituminous protective coating or other approved material.

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b. Bolts for Stays

Bolts shall be galvanised steel bolts of the required length and of a diameter greater than 12 mm. All the necessary bolts, nuts and washers shall be supplied with each post.

c. Wire**i. Barbed wire**

Barbed wire shall comply with the requirements of BS EN 10223-1 or equivalent and shall be one or more of the following types:

1. High tensile grade single strand 3.15 mm x 2.5 mm oval-shaped wires, with a 2.81-mm equivalent diameter and fully galvanised.
2. High tensile grade single strand fully galvanised, 2.8 mm x 1.9 mm in diameter, oval-shaped wire, with a 2.31 mm equivalent diameter. This wire shall not be used within 500 mm above ground level where bush fires are common.
3. Mild steel grade double strand unidirectional twist wire, each strand 2.5 mm in diameter, for use at any height above ground. The wire shall be fully galvanised.

Barbs shall be manufactured from 2 mm galvanised wire and shall be spaced at not more than 150 mm intervals.

ii. Smooth wire

Smooth wire shall comply with the requirements of BS EN 10223-1 or equivalent and shall be of the types specified below:

1. Straining wire shall be 4 mm in diameter and fully galvanised.
2. Fencing wire shall be high tensile grade not less than 2.24 mm in diameter, fully galvanised.
3. Tying wire shall be not less than 2.5 mm in diameter mild steel galvanised wire for tying fencing wire to standards and droppers and 1.6 mm mild steel galvanised wire for tying netting and mesh wire to the fencing wire.

d. Diamond Mesh

Diamond mesh (chain link fencing material) shall comply with the requirements of BS 1722-1 or BS 1722-2 or equivalent. The width shall be as shown on the Drawings and the edge finish shall be clinched or barbed both sides.

The nominal diameter of the wire shall be 2.5 mm and the mesh size shall be 64 mm x 64 mm.

The wire shall be fully galvanised.

e. Wire Netting

Wire netting shall be fully galvanised mild steel wire with a minimum diameter of 1.8 mm with 75 mm hexagonal mesh.

The width shall be as shown on the Drawings.

f. Barbed Tape Concertina Wire

Barbed tape concertina wire shall comply with the requirements of BS EN 10223-1, or equivalent. The high tensile steel wire shall be heavily galvanised and the barbed tape and concertina clamps shall also be heavily galvanised. The diameter of the roll shall be 950 mm or 700 mm according to requirements.

g. Gates

Gates shall be manufactured to the dimensions shown on the Drawings.

Gates shall be complete in every respect, including hinges, washers, bolts and locking chains attached to the gate.

Gate posts shall not be used as straining posts and shall be according to BS 8268-2:2002 or equivalent.

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h. Timber Posts For Wire Mats

Timber posts for holding down wire mats where the fence crosses streams shall comply with the requirements of BS 8268-2 or equivalent and shall be in accordance with the requirements of SUBCLAUSE 8202(b).

i. Manufacturing tolerances for wire

The actual diameter of wire supplied shall nowhere be less than the specified diameter minus the following tolerances:

Specified diameter	Tolerance
1.00 - 1.80 mm	0.05 mm
2.00 - 2.80 mm	0.08 mm
3.15 - 4.00 mm	0.10 mm

8303 Types Of Fencing

The following types of fences shall be erected in accordance with the dimensions shown on the Drawings:

- Stock-proof fences.
- Vermin-proof fences.
- Pedestrian fences.
- Security fences.

Where existing fences have to be dismantled and re-erected, they shall be erected either to the same design as the original, but with such modifications as may be required by the Engineer, or they shall be erected up to one of the standards specified above as specified or instructed by the Engineer.

8304 Protecting Livestock

From the time of occupancy up to the date of Taking Over Certificate being issued to the Contractor, the Contractor shall take all measures necessary for preventing the ingress of vermin and for protecting and controlling livestock etc, on the sections of the properties affected by their operations. Gates shall be provided at the positions in existing fences wherever these are cut for gaining access. The Contractor shall ensure that all gates are kept closed except when in use to provide access for traffic. No fences shall be cut without the approval of the Engineer and consultation with the Owner of the fence.

Where alternative arrangements cannot be made, the Engineer may direct the Contractor to erect temporary fencing where necessary for the protection of livestock from vermin and/or to corral as necessary. Such fencing shall be of an adequate standard and shall be erected ahead of construction operations. The fencing shall be maintained in a good order during construction operations and on completion of the work it shall be removed from the site and all ground surfaces shall be restored. The Engineer may order that any permanent fencing which is required be erected ahead of construction operations, where practicable, instead of erecting temporary fencing.

Payment for the protection of livestock, excluding the erection of temporary fences, shall be included in the amounts bid for the Contractor's establishment on the site, as specified in SECTION 1300.

8305 Clearing The Fence Line

The fence line shall be cleared over a width of at least 1.0 m on each side of the centre line of the fence and ground surface irregularities shall be graded so that the fence will follow the general contours of the land. Clearing the line shall include the removal of all scrub, stumps, isolated boulders or stones and other obstructions which will interfere with the construction of the fence. Any trees shall be preserved wherever possible and shall not be cut down unnecessarily. Stumps within the

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cleared space shall be grubbed as described in SECTION 3100. The bottom of the fence shall be located at a uniform distance above the ground line in accordance with the requirements shown on the Drawings. All material removed shall be burnt or disposed of in disused borrow pits or at other locations approved by the Engineer.

Any areas outside the road reserve where clearing is not permitted by the Owner or is impracticable shall not be cleared if so directed by the Engineer.

8306 Erecting Straining Posts and Standards

Straining posts shall be erected at all terminal points, low points (as required), corners and bends in the fencing and at all junctions with other fences. Straining posts shall not be spaced further apart than shown on the Drawings. The length of posts above ground shall be such that the correct clearance between the lowest wire and the ground can be obtained.

Straining posts shall be accurately set in holes and shall be provided with concrete bases to the dimensions shown on the Drawings.

Holes shall be dug to the full specified depth. Where, on account of the presence of rock, the holes cannot be excavated by hand or by pneumatic tools and the Contractor has to resort to the use of explosives, separate payment shall be made for the drilling and blasting operations required.

All straining posts shall be braced by means of stays or anchors as shown on the Drawings or as directed by the Engineer. Tubular stays shall be bolted to the posts. Gateposts shall not be used as straining posts but at each gatepost a straining post shall be placed as shown on the Drawings.

Standards shall be firmly planted into the ground at the spacing shown on the Drawings or as directed by the Engineer. The spacing of standards between any two successive straining posts shall be uniform and not greater than that shown on the Drawings. In rock or hard material standards shall be either driven or set in holes drilled into the rock. The size of drilled holes shall provide a tight fit to the standards. Care shall be taken when driving standards to prevent their buckling or being damaged.

All straining posts and standards shall be accurately aligned and set plumb. Where veranda-type security fencing is used, the posts shall be planted with the overhang on the roadside and perpendicular to the direction of the fence. After the straining posts and standards have been firmly set in accordance with the foregoing requirements, fence wires shall be attached thereto at the spacing shown on the Drawings.

8307 Erecting Fence Wires

All fencing wire shall be tied to the sides of standards or posts to prevent the wires from being displaced or becoming loose. The wire shall be carefully tensioned without sagging and be true to line, care being exercised not to tension the wire to such an extent that it will break or that end, corner, straining or gate posts will be pulled out, or that it will be easily damaged during fires.

Each strand of fencing wire shall be securely tied in the correct position hard up to each standard with soft galvanised tying wire. The tying wire for each strand shall pass through a hole or notch in the standard, while the ends of the tying wire shall be wound at least four times around the fencing wire to prevent it from moving in a vertical direction.

At end, corner, straining and gate posts the fencing wire shall be securely wrapped twice around the post and secured against slipping by tying the end tightly around the wire by means of at least six neat tight twists.

Where high-tensile wire is used, two long twists may first be made followed by the six tight, neat twists around the post to prevent the wire from breaking at the first twist. When smooth wire is used, the loose end shall preferably be bent over and hooked into the notch between the fencing wire and the first twist.

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Splices in the fencing wire shall be permitted if made in the following manner with a splicing tool. The end of each wire at the splice shall be taken at least 75 mm past the splicing tool and wrapped around the other wire by not less than six complete turns with the two separate wire ends being turned in opposite directions. After the splicing tool has been removed, the space left by it in the spliced wire shall be closed by pulling the wire ends together. Unused wire ends shall be cut close so as to leave a neat splice.

The gaps between gate posts and the adjacent straining posts shall be fenced off with short lengths of fencing wires.

Droppers shall be tied to each fence wire with soft tying wire in the required position as specified for standards to prevent slippage in a vertical direction. The spacing of droppers between any two straining posts shall be uniform. Anchoring to structures shall be done as shown on the Drawings.

Barbed tape concertina wire shall be attached to the fence as shown on the Drawings at maximum spaces of 1.0 m between tying points. Barbed tape concertina wire rolls shall be spliced by overlapping for one full circle and tied at four evenly spaced points along the circumference. Spliced ends shall coincide with the positions of the standards.

8308 Erecting Diamond Mesh or Wire Netting

Where vermin proof, pedestrian or security fences are erected, or where instructed by the Engineer, wire netting or diamond mesh shall be stretched against the fence and properly tied to the fencing wire as shown on the Drawings. The diamond mesh or wire netting shall be secured by soft tying wire at 1.2 m centres along the top and bottom wires and at 3 m centres along each of the other fencing wires, unless otherwise shown on the Drawings.

In the case of vermin proof fencing, vermin shall be prevented from creeping under the fence by either one of the two methods described below as ordered by the Engineer:

- a. By folding back the bottom 130 mm of the wire netting so that it lies flat on the ground and by tightly packing stones (having a minimum dimension of 200 mm) end to end on this flap to secure it in position.
- b. By embedding the lower 130 mm of the wire netting in the ground and thoroughly compacting the earth around it on both sides, to secure the netting.

8309 Closing Openings Under Fences

At ditches, streams, drainage channels or other depressions where the fence cannot be erected so as to follow the general ground contour, the Contractor shall close the opening under the fence with horizontal barbed wires at 150 mm spacing. Stretched between additional posts or straining posts as shown on the Drawings or as directed by the Engineer. In the case of pedestrian, vermin-proof and security fences the opening shall be covered with strips of wire netting or diamond mesh 1000 mm wide, fixed to the barbed wires.

In the case of larger streams where damming of debris against the fence would constitute a hazard, the opening below the bottom fencing wire shall be closed with loose-hanging wire nets. For this purpose additional straining posts shall be planted on both sides of the stream with a cable consisting of at least five strands of smooth fencing wire stretched between them. Onto this cable vertical strips of diamond mesh hanging down to ground level shall be fixed. The edges of the various strips of diamond mesh shall be tied to each other so that the entire mat will be raised by water flowing underneath to leave a free stream area. These mats at streams shall be erected only when instructed by the Engineer. If it should be necessary to keep the bottoms of the mats on the ground, the Engineer may order that timber posts or pipes be fixed horizontally to the bottom ends of the diamond-mesh strips.

8310 Existing Fences

Where a new fence joins an existing fence whether in line or at an angle, the new fence shall be erected with a new straining post positioned at the terminal point of the existing fence.

Existing fences that are to be taken down or moved to a new location shall be dismantled. Material not required for re-erection or that is unsuitable for re-use shall be neatly stacked at approved locations in accordance with the Engineer's instructions. Fencing wire and wire netting shall be stacked clear of the ground. Payment will be made only for fences removed in accordance with the written instruction of the Engineer.

Where fences require moving, the Contractor shall re-use all the material, declared to be suitable for this purpose by the Engineer, plus such new material as may be required to erect the fence again to the standard specified for new fences. The Engineer shall not be responsible for any delays or costs arising from the breaking of re-used wire during straining.

8311 Erecting Gates

Gates shall be erected at the positions indicated by the Engineer. The gates shall be hung on gate fittings in accordance with the requirements shown on the Drawings. Gates shall be so erected as to swing in a horizontal plane at right angles to the gateposts, clear of the ground in all positions. In pedestrian and security fences the double swing gates shall leave a gap not exceeding 25 mm between them when closed and other gates shall not be further than 25 mm from the gate post when closed.

Gates shall be stock-proof to the same extent as the adjoining fence. The clearance below the gates shall not exceed 75 mm with the gates closed. Where the gate crosses a public road it shall be fitted with a disc or other device easily visible at night, as instructed by the Engineer.

8312 Temporary Fencing, Gates and Motor Gates

If required, the Contractor shall erect temporary fencing, gates and motor gates in accordance with the Drawings, Special Specifications or the Engineer's instructions. The material and erection shall be in accordance with the provisions of this section, but the material need not necessarily be new. Where used materials are offered, they shall be in a good condition and approved in advance by the Engineer.

When no longer required, the temporary fencing, gates and motor gates shall be dismantled and removed.

8313 Finishing Requirements

The completed fence shall be plumb, taut, true to line and ground contour, with all posts, standards and stays firmly set. The height of the lower fencing wire above the ground at posts and standards shall not deviate by more than 25 mm from that shown on the Drawings. Other fencing wires shall not deviate by more than 10 mm from their prescribed vertical positions.

The Contractor shall, on completion of each section of fence, remove all cut-offs and other loose wire or netting so as not to create a hazard to grazing animals or a nuisance to the Owners of the ground.

8314 Cattle Grids

A cattle grid is a structure that is designed to prevent the passage of cattle and other domestic animals while permitting other traffic to pass. Cattle grids are normally constructed across a road in connection with fencing and gates.

Cattle grids shall be constructed in conformity with the details, dimensions and design shown in the Drawings, and at locations shown in the Drawings or as directed by the Engineer.

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8315 Measurement And Payment

Item	Unit
83.01 Clearing The Fence Line, 2m Wide Strip:	Kilometre (km)

The unit of measurement for clearing the fence line shall be the kilometre of fence line measured along each fence line.

The bid rate shall be in full compensation for clearing the fence line as specified, including the removal of trees, stones, and other obstructions and the disposal of all waste material resulting from clearing operations, as may be directed. The removal of trees and stumps with a girth exceeding 1.0 m, if unavoidable, shall be paid for as specified in SECTION 3100.

Item	Unit
83.02 Supplying And Erecting New Fencing Material For New Fences And For Supplementing Material In Existing Fences Which Are Being Repaired Or Removed:	
(a) Barbed Wire (Grade, Size And Type Of Galvanising Indicated)	Kilometre (km)
(b) Smooth Wire (Grade, Size And Type Of Galvanising Indicated)	Kilometre (km)
(c) Diamond Mesh	Square Metre (m ²)
(d) Wire Netting	Square Metre (m ²)
(e) Barbed-Tape Concertina Wire	Kilometre (km)
(f) Steel And Timber Straining Posts, Including Anchors (Type, Size And Length And Whether Galvanised, Treated Or Painted Indicated)	Number (No.)
(g) Steel And Timber Standards (Length And Type Indicated)	Number (No.)
(h) Steel And Timber Droppers (Length And Type Indicated)	Number (No.)
(i) Timber Posts To Be Fixed To The Bottom Of Wire Mesh In Streams (Diameter Indicated)	Metre (m)

The quantity of material used shall be determined by measuring the quantities of individual Items of material used in the completed fence. The linear measurement of the completed fence shall not apply. The appropriate units of measurement are as follows:

i. Fencing wire (SUBITEMS 83.02 (a) and (b))

The unit of measurement shall be the kilometre of each type of fencing wire measured between end posts. Tying wire and wire used for anchoring the posts shall not be measured for payment.

ii. Diamond mesh and wire netting (SUBITEMS 83.02 (c) and (d))

The unit of measurement shall be the square metre of diamond mesh or wire netting, the quantity of which shall be calculated according to the prescribed width and the length between straining posts or gate posts, or the length of strips used for covering openings under fences, or the length used for covering the gates.

iii. Barbed-tape concertina wire (SUBITEM 83.02 (e))

The unit of measurement shall be the kilometre of fence provided with barbed tape concertina wire of which each concertina is opened to the maximum effective open concertina length as specified in the Drawings.

iv. Straining posts (SUBITEM 83.02 (f))

The unit of measurement shall be the number of posts, as follows:

All straining posts erected in accordance with the maximum specified spacing or such lesser

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spacing as authorised by the Engineer, all corner posts authorised by the Engineer, and all end posts. Gate posts for new gates shall not be measured for payment.

v. Standards and droppers (SUBITEMS 83.02 (g) and (h))

The unit of measurement shall be the number of standards and droppers erected to the maximum specified spacing or such lesser spacing as authorised by the Engineer.

vi. Timber posts to be fixed to the bottom of wire mesh in streams (SUBITEM 83.02 (ii))

The unit of measurement shall be the metre of timber post of every diameter erected in accordance with the Drawings and the instructions of the Engineer.

The bid rate for each straining post, standard, dropper, each kilometre of fencing wire and barbed-tape concertina wire, and each square metre of diamond mesh or wire netting and for each metre of timber post, shall include full compensation for providing all the materials, including all concrete, tying wire, straining wire, bolts, washers and nuts, for excavating or drilling holes for standards, for erecting the posts, standards and droppers and the complete putting up of the fence as specified and as shown on the Drawings. No separate payment will be made in respect of stone packing and/or trenching in the case of wire netting.

The bid rate for posts shall include full compensation for erecting the stays of the types shown on the Drawings.

Item		Unit
83.03	New Gates:	
(a)	Single Leaf (Size And Type Indicated)	Number (No.)
(b)	Double Leaf (Size And Type Indicated)	Number (No.)

The unit of measurement shall be the number of new gates erected. At pedestrian and security fences the pair of gates shall be measured as one.

The bid rates shall include full compensation for procuring and furnishing all material, including gates, gate posts, hinges, bolts, disks, concrete and straining wire, and for erecting the gates as specified and as shown on the Drawings. It shall not include compensation for any fencing wire or mesh fitted onto the gate.

Item		Unit
83.04	Moving Existing Fences And Gates:	
(a)	Fences:	Kilometre (km)
i	Stock-Proof Fences	Kilometre (km)
ii	Vermin-Proof Fences	Kilometre (km)
iii	Pedestrian Fences	Kilometre (km)
iv	Security Fences	Kilometre (km)
(b)	Gates	Number (No.)

The unit of measurement for moving existing fences shall be the kilometre of fence, the quantity of which shall be taken as the length of fence which has been put up permanently with material obtained from fences which have been dismantled elsewhere. Additional new material used during the re-erection of existing fences shall be measured under ITEM 83.02. The unit of measurement for moving gates shall be the number of gates moved.

The bid rate for each kilometre of existing fence moved or for each existing gate moved shall include full compensation for dismantling the old fence, coiling and stacking the material unsuitable for re-use, moving all material, including posts and wire and again putting up the fence or gate at the new position and the provision of binding, tying and straining wire. New material used for re-erection of old fences shall be paid for under ITEM 83.02.

The bid rate for each gate moved shall include full compensation for taking down the gate and re-erecting it where required, including all new bolts, nuts and other accessories required but excluding new gate posts.

Item	Unit
83.05 Dismantling Existing Fences	Kilometre (Km)

The unit of measurement shall be the kilometre of existing fencing and gates taken down and dismantled on the instruction of the Engineer.

The bid rate shall include full compensation for taking down existing fences and gates, coiling wires, rolling netting into rolls, transporting the material to designated sites and stacking the material.

Item	Unit
83.06 Providing Temporary Fences And Gates:	
(a) Stock-Proof Fence	Kilometre (Km)
(b) Vermin-Proof Fence	Kilometre (Km)
(c) Pedestrian Fence	Kilometre (Km)
(d) Temporary Gates (Type And Size Indicated)	Number (No.)
(e) Temporary Motor Gates	Number (No.)

The unit of measurement for SUBITEMS 83.06 (a), (b) and (c) shall be the kilometre of each type of temporary fencing erected on the instructions of the Engineer.

The bid rates shall include full compensation for providing all labour, new or suitable second-hand material, putting up the temporary fence and when no longer required, dismantling and removing it from the site to any new locality where it is required.

The unit of measurement for SUBITEM 83.06 (d) shall be the number of temporary gates provided by the Contractor.

The bid rate shall include full compensation for procuring, supplying and erecting new or second-hand gates, their later removal, and replacing the fence.

The unit of measurement for SUBITEM 83.06 (e) shall be the number of temporary motor gates provided by the Contractor.

The bid rate shall include full compensation for erecting the motor gates in accordance with the Drawings, by using new or second-hand material, and, if required, dismantling and removing the motor gates and again putting up any fencing removed from the positions where the motor gates have been erected.

General

Where new or second-hand material is used which has been provided by the Employer, e.g. material obtained from taking down existing fences, such material obtained from taking down the temporary fences or gates shall remain the property of the Employer. Material provided by the Contractor for temporary fences will similarly become the Contractor's property after the temporary fences have been dismantled.

Item	Unit
83.07 Ringbolts For Anchoring Fencing To Structures:	Number (No.)

The unit of measurement shall be the number of ringbolts supplied and fixed to the structure.

1000

The bid rate shall include full compensation for supplying and fixing ringbolts of the type shown on the Drawings to the structure, including, where necessary, drilling holes, anchorage, grouting ringbolts in with epoxy resin, and for all incidentals.

2000

Item		Unit
83.08	Drilling And Blasting Holes For Posts And Anchors:	Number (No.)

3000

The unit of measurement shall be the number of holes for posts and anchors made by drilling and/or blasting where excavation by hand or by pneumatic tools cannot be done economically.

4000

The bid rate shall include full compensation for drilling and blasting the holes and for all other expenses in connection with providing, storing, transporting and using explosives.

5000

Item		Unit
83.09	Cattle Grids (Indicate Type)	Number (No.)

6000

The unit of measurement shall be the number of cattle grids supplied; the type as indicated in the Drawings.

7000

The bid rate shall include full compensation for providing the materials and constructing the cattle grids, including excavation, construction, curing finishing and protection of the works as instructed by the Engineer.

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SECTION 8400 Road Signs

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8401 Scope

This section covers the supply and erection of permanent and temporary road traffic signs alongside and over the carriageway, ramps and cross roads at intersections and interchanges and at the locations indicated on the Drawings or as directed by the Engineer.

8402 Description

This work shall consist of furnishing and placing road signs, in accordance with these Specifications, at the locations and of the dimensions shown on the Drawings or as directed by the Engineer and in compliance with the **RDM Volume 6 Part 2: Traffic Signs**.

8403 Materials

Concrete for foundations shall be Class C25/30 to be mixed and placed as specified in SECTIONS 7100 and 7400 of these Specifications.

The material and fabrication of signs shall be as per the following standards:

TABLE 8403/1: SPECIFICATIONS & STANDARDS FOR THE MATERIAL & FABRICATION OF SIGNS		
Part	Material	Specification/ Standard
Plates & Support	Structural steel	KS 572
Post	Steel	KS EAS 134
	Galvanised Iron	KS 572
	Reinforced concrete	KS 1933
	Wooden post	KS 1608
Substrate / base material	Stainless Steel	ASTM A 240
	Carbon steel, Mild steel plates	ASTM A 516, grade 60 & 70
	Alloy steel plates	ASTM A387 Gr.2, 5, 9, 11, 12 & 22
	Aluminium	KS ISO 6362
	Aluminium Composite Materials (ACM)	ASTM D903, ASTM E638, ASTM C393
	Fibre Reinforced Plastic (FRP)	ISO 527
Retro reflective material	Retro reflective sheet	KS 814, ASTM D4956 Type XI
Fasteners - Nuts, bolts, washers	Steel (low carbon, medium carbon alloy or stainless)	ASTM A 516, ASTM A193, ASTM A194
Support / footing	Concrete	KS 95 for M25
	Reinforcing steel	KS EAS 412-2

Sign panels shall be fabricated on aluminium sheet, aluminium composite panel, fibre glass sheeting, or sheet moulding compound. Aluminium sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to KS ISO: 6361 parts 1 to 5736. Aluminium Composite Material (ACM) sheets shall be sandwiched construction with a thermoplastic core of Low Density Polyethylene (LOPE) between two thick skins/sheets of aluminium with overall thickness and 3 mm or 4 mm (as specified in the Contract), and aluminium skin of thickness 0.5 mm and 0.3 mm respectively on both sides.

The mechanical proportion of ACM and that of aluminium skin shall conform to the requirements given in TABLE 8403/2, when tested in accordance with the test methods mentioned against each of them.

TABLE 8403/2: SPECIFICATION FOR ALUMINIUM COMPOSITE MATERIAL (ACM)

Sl. No.	Description	Specification	
		Standard	Acceptable Value
A	Mechanical Properties of ACM		
1	Peel off strength with retro reflective sheeting (Drum Peel Test)	ASTM 0903	Min. 4 N/mm
2	Tensile strength	ASTM E8	Min. 40 N/mm ²
3	0.2% Proof Stress	ASTM E8	Min. 34 N/mm ²
4	Elongation	ASTM E8	Min. 6%
5	Flexural strength	ASTM 393	Min. 130 N/mm ²
6	Flexural modulus	ASTM 393	Min. 44.00 N/mm ²
7	Shear strength with Punch shear test	ASTM 732	Min. 30 N/mm ²
B	Properties of Aluminium Skin		
1	Tensile strength (Rm)	ASTM E8	Min. 65 N/mm ²
2	Modulus of elasticity	ASTM E8	Min. 70,000 N/mm ²
3	Elongation	ASTM E8	A50 Min. 2%
4	0.2% Proof Stress	ASTM E8	Min. 10 N/mm ²

Plate thickness: Shoulder mounted ground signs with a maximum side dimension not exceeding 600 mm shall not be less than 1.5 mm thick with Aluminium and 3 mm thick with Aluminium Composite Material. All other signs be at least 2 mm thick with Aluminium and 4 mm thick with Aluminium Composite Material. The thickness of the sheet shall be related to the size of the sign and its support and shall be such that it does not bend or deform under prevailing wind and other loads.

Retro-reflective sheeting: The retro-reflective sheeting used on the sign shall consist of the white or coloured sheeting having a smooth outer surface which has the property of retro-reflection over its entire surface. It shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for co-efficient of retro-reflection, day/night time colour luminous, shrinkage, flexibility, linear removal, adhesion, impact resistance, specular gloss and fungus resistance and its having- passed these tests shall be obtained from a Government Laboratory/Institute, by the manufacturer of the sheeting. The retro-reflective sheeting shall be either of Engineering Grade material with enclosed lens, High Intensity Grade with encapsulated lens or Micro-prismatic Grade retro-reflective element material.

High Intensity Grade Sheeting

High Intensity Grade (Type III): This high intensity retro reflective sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent waterproof plastic having a smooth surface or as an unmetallised micro prismatic reflective material element. The retro-reflective surface after cleaning with soap and water

and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in TABLE 8403/3.

TABLE 8403/3: ACCEPTABLE MINIMUM CO-EFFICIENT OF RETRO-REFLECTION FOR HIGH INTENSITY GRADE SHEETING (TYPE III) (Encapsulated Lens Type) (Candelas Per Lux Per Square Metre)

Observation Angle in Degrees	Entrance Angle in Degrees	White	Yellow	Orange	Green	Red	Blue	Brown
0.1° ^B	-4°	300	200	120	54	54	24	14
0.1° ^B	+30°	180	120	72	32	32	14	10
0.2°	-4°	250	170	100	45	45	20	12
0.2°	+30°	150	100	60	25	25	11	8.5
0.5°	-4°	95	62	30	15	15	7.5	5
0.5°	+30°	65	45	25	10	10	5	3.5

A. Minimum Coefficient of Retro-reflection (R_A) R / A ($cd \cdot lx^{-1} m^2$)

B. Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show no less than 90 percent of the values of retro-reflection indicated in the above table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

High Intensity Micro-Prismatic Grade Sheeting (HIP) (Type IV): This sheeting shall be of high intensity retro-reflective sheeting made of micro-prismatic retro-reflective element material coated with pressure sensitive adhesive. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in TABLE 8403/4.

TABLE 8403/4: ACCEPTABLE MINIMUM CO-EFFICIENT OF RETRO-REFLECTION FOR HIGH INTENSITY MICRO-PRISMATIC GRADE SHEETING (TYPE IV)(Candelas Per Lux Per Square Metre)

Observation Angle in Degrees	Entrance Angle in Degrees	White	Yellow	Orange	Green	Red	Blue	Brown
0.1° ^B	-4°	500	380	200	70	90	42	25
0.1° ^B	+30°	240	175	94	32	42	20	12
0.2°	-4°	360	270	145	50	65	30	18
0.2°	+30°	170	135	68	25	30	14	8.5
0.5°	-4°	150	110	60	21	27	13	7.5
0.5°	+30°	72	54	28	10	13	6	3.5

A. Minimum Coefficient of Retro-reflection (R_A) R / A ($cd \cdot lx^{-1} m^2$)

B. Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show no less than 90 percent of the values of retro-reflection indicated in the above table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

Prismatic Grade Sheeting

Prismatic Grade Sheeting (Type VIII): The reflective sheeting shall be retro reflective sheeting made of micro prismatic retro reflective material. The retro reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro reflection (determined in accordance with ASTM E 810) as indicated in TABLE 8403/5.

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Ancillary Roadworks | 8400 | Road Signs

Prismatic Grade Sheeting (Type IX): The reflective sheeting shall be retro-reflective sheeting made of micro prismatic retro-reflective material. The retro-reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM E 810) as indicated in TABLE 8403/6.

TABLE 8403/5: ACCEPTABLE MINIMUM CO-EFFICIENT OF RETRO-REFLECTION FOR PRISMATIC GRADE SHEETING TYPE A (TYPE VIII)(Candelas Per Lux Per Square Metre)

Observation	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow/Green	Fluorescent Yellow	Fluorescent Orange
0.1° ^B	-4°	1000	750	375	100	150	45	30	800	600	300
0.1° ^B	+30°	460	345	175	46	69	21	14	370	280	135
0.2°	-4°	700	525	265	70	105	32	21	560	420	210
0.2°	+30°	325	245	120	33	49	15	10	260	200	95
0.5°	-4°	250	190	94	25	38	11	7.5	200	150	75
0.5°	+30°	115	86	43	12	17	5	3.5	92	69	35

A. Minimum Coefficient of Retro-reflection (R_A) R / A ($cd \cdot lx^{-1} m^2$)

B. Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show no less than 90 percent of the values of retro-reflection indicated in the above table. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

TABLE 8403/6: ACCEPTABLE MINIMUM CO-EFFICIENT OF RETRO-REFLECTION FOR PRISMATIC GRADE SHEETING TYPE A (TYPE IX)(Candelas Per Lux Per Square Metre)

Observation	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Fluorescent Yellow/Green	Fluorescent Yellow	Fluorescent Orange
0.1° ^B	-4°	600	500	250	66	130	130	530	400	200
0.1° ^B	+30°	370	280	140	37	74	17	300	220	110
0.2°	-4°	380	285	145	38	76	17	300	230	115
0.2°	+30°	215	162	82	22	43	10	170	130	65
0.5°	-4°	240	180	90	24	48	11	190	145	72
0.5°	+30°	135	100	50	14	27	6.0	110	81	41
1.0°	-4°	80	60	30	8.0	16	3.6	64	48	24
1.0°	+30°	45	34	17	4.5	9.0	2.0	36	27	14

A. Minimum Coefficient of Retro-reflection (R_A) R / A ($cd \cdot lx^{-1} m^2$)

B. Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show no less than 90 percent of the values of retro-reflection indicated in the above TABLE. At the end of 10 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

Prismatic Grade Sheetting (Type XI): A Retro-reflective sheetting typically manufactured as a cube corner. The reflective sheetting shall be retro-reflective sheetting made of micro prismatic retro-reflective material. The retro-reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM E 810) as indicated in TABLE 8403/7.

TABLE 8403/7: ACCEPTABLE MINIMUM CO-EFFICIENT OF RETRO-REFLECTION FOR PRISMATIC GRADE SHEETING TYPE A (TYPE IX)(Candelas Per Lux Per Square Metre)

Observation	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow/Green	Fluorescent Yellow	Fluorescent Orange
0.1° ^B	-4°	830	620	290	83	125	37	25	660	500	250
0.1° ^B	+30°	325	245	115	33	50	15	10	260	200	100
0.2°	-4°	580	435	200	58	87	26	17	460	350	175
0.2°	+30°	220	165	77	22	33	10	7.0	180	130	66
0.5°	-4°	420	315	150	42	63	19	13	340	250	125
0.5°	+30°	150	110	53	15	23	7.0	5.0	120	90	45
1.0°	-4°	120	90	42	12	18	5.0	4.0	96	72	36
1.0°	+30°	45	34	16	5.0	7.0	2.0	1.0	36	27	14

A. Minimum Coefficient of Retro-reflection (R_A) R / A ($cd \cdot lx^{-1}m^2$)

B. Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheetting shall show no less than 90 percent of the values of retro-reflection indicated in the above table. At the end of 10 years, the sheetting shall retain at least 80 percent of its original retro-reflectance.

Adhesives: The sheetting shall have a pressure-sensitive adhesive of the aggressive-tack type requiring no heat, solvent other preparation for adhesion to a smooth clean surface, in a manner recommended by the sheetting manufacturer. The adhesive shall be protected by an easily removable liner (removable by peeling without soaking in water or other solvent) and shall be suitable for the type of material of the base plate used for the sign. The adhesive shall form a durable bond to smooth, corrosion and weather resistant surface of the base plate such that it shall not be possible to remove the sheetting from the sign base in one piece by use of sharp instrument. The sheetting shall be applied in accordance with the manufacturer's specifications.

Fabrication: Surface to be reflectorised shall be effectively prepared to receive the retro-reflective sheetting. The aluminium sheetting shall be de-greased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth plain surface before the application of retro-reflective sheetting. If the surface is rough, approved surface primer may be used. After cleaning, metal shall not be handled, except by suitable device or clean canvas gloves, between all cleaning and preparation operation and application of reflective sheetting/primer. There shall be no opportunity for metal to come in contact with grease, oil or other contaminants prior to the application of retro-reflective sheetting. Complete sheets of the material shall be used on the signs except where it is unavoidable. At splices, sheetting with pressure-sensitive adhesives shall be overlapped not less than 5 mm. Where screen printing with transparent colours is proposed, only butt joint shall be used. The material shall cover the sign surface evenly and shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheetting in the manner specified by the manufacturer.

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Messages/Borders: The messages (legends, letters, numerals etc.) and borders shall either be screen-printed or of cut out from durable transparent overlay or cut out from the same type of reflective sheeting for the cautionary/mandatory sign boards. Screen printing shall be processed and finished with materials and in a manner specified by the sheeting manufacturer. For the informatory and other sign boards, the messages (legends, letters, numerals etc.) and borders shall be cut out from durable transparent overlay film or cut-out from the same reflective sheeting only. Cut-outs shall be from durable transparent overlay materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer. For screen-printed transparent coloured areas on white sheeting, the co-efficient of retro-reflection shall not be less than 50 percent of the values of corresponding colour in TABLES 8403/3 to 8403/4 as applicable. Cut-out messages and borders, wherever used, shall be either made out of retro-reflective sheeting or made out of durable transparent overlay except those in black which shall be of non-reflective sheeting or opaque in case of durable transparent overlay.

Colour of Signs: Signs shall be provided with retro-reflective sheeting and/or overlay film/ screening ink. The reverse side of all signs shall be painted grey. Except in the case of railway level crossing signs the sign posts shall be painted in 250 mm side bands, alternately black and white. The lowest band next to the ground shall be in black. The colour of the material shall be located within the area defined by the chromaticity coordinates in TABLE 8403/8 and comply with the luminance factor when measured as per ASTM 0-4956.

TABLE 8403/8: COLOUR SPECIFIED LIMITS (DAYTIME)

Colour	1		2		3		4		Daytime Luminance Factor (Y%)	
	x	y	x	y	x	y	x	y	Min	Max.
White	0.303	0.300	0.368	0.366	0.340	0.274	0.329	0.329	15	-
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	24	45
Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771	2.5	11
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346	2.5	11
Blue	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216	1	10
Orange	0.558	0.253	0.636	0.364	0.570	0.429	0.506	0.404	12	30
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390	1	6
Fluorescent Yellow-Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	60	-
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	45	-
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	25	-

The colours shall be durable and uniform in acceptable hue when viewed in normal headlights at night. The Regulatory/Prohibitory and warning signs shall be provided with white background and red border. The legend/ symbol for these signs shall be in black colour. The Mandatory sign shall be provided with Blue background and white Symbols / letters.

Refurbishment: Where existing signs are specified for refurbishment, the sheeting shall have a semi-rigid aluminium backing or materials, pre-coated with aggressive-tack type pressure sensitive adhesive. The adhesive shall be suitable for the type of material used for the sign and should thoroughly bond with that material.

Bolts, Nuts and Washers: Bolts, nuts and washers shall be used to fix signs to the substrate and support. It shall conform to KS ISO 6362, ASTM A193, ASTM A194 and ASTM F436.

Overhead Signs

Scope: The work shall consist of fabrication, supply and installation of overhead traffic signs on roads.

Height: Overhead signs shall provide a vertical clearance of not less than 5.5 m over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. The vertical clearance to overhead sign structures or supports need not be greater than 300 mm in excess of the minimum clearance of other structures.

Lateral Clearance: The minimum clearance outside the usable roadway shoulder for signs mounted at the roadside or for overhead sign supports either to the right or left side of the roadway shall be 1.80 m. This minimum clearance of 1.80 m shall also apply outside of an unmountable kerb. Where practicable, a sign should not be less than 3 m from the edge of the nearest traffic lane. Large guide signs should be farther removed preferably 9 m or more from the nearest traffic lane, unless otherwise specified. Lesser clearances, but not generally less than 1.80 m, may be used on connecting roadways or ramps at inter-changes.

Where a median is 3.6 m or less in width, consideration should be given to spanning over both roadways without a central support. Where overhead sign supports cannot be placed at a safe distance away from the line of traffic or in an otherwise protected site, they should either be so designed as to minimise the impact forces or protect motorists adequately by a physical barrier or guard rail of suitable design.

Materials for Overhead Sign and Support Structures

Aluminium alloy or galvanised steel to be used as truss design supports. These shall be of sections and type as per structural design requirements as shown on the plans. After steel trusses have been fabricated and all required holes punched or drilled on both the horizontal truss units and the vertical and support units, they shall be galvanised. Where aluminium sheets are used for road signs, they shall be of smooth, hard and corrosion resistant aluminium alloy.

Size and Locations of Signs

The size of the signs, letters and their placement shall be as specified in the Contract drawings and Specifications. In the absence of details or for any missing details in the Contract documents, the signs shall be provided as directed by the Engineer.

The Contractor shall provide, at their own expense, the sign manufacturer's specifications and certificate for all materials proposed. The certificate shall indicate the name or brand of the materials to be furnished and give the results of tests proving the products meet the requirements of the specifications and Design manual and any other data requested by the Engineer. The certificate shall be issued in accordance with the requirements of the Kenya Bureau of Standards and shall legally bind the Manufacturer to compliance with the specifications.

The Contractor shall also provide from the sheeting manufacturer a seven-year warranty for satisfactory field performance of the finished signs in respect of retroreflective performance, colour, fungus resistance, and adhesion. The retro-reflective performance of the sign at the end of the warranty period should be specified in the warranty and the retro-reflective values should not be less than 75 % of the original values. Any sign that fails within that period shall be replaced at no cost to the Employer.

The Contractor shall not place any purchase order for road signs until the manufacturer's certificate and form of guarantee have been inspected by the Engineer and accepted.

At any time the Engineer may request any test they think is necessary to verify the compliance of the material with the Specifications.

All the tests shall be carried out in a specialised laboratory approved by the Engineer; this laboratory shall certify the results of the tests in question.

All the above-mentioned tests shall be at the expense of the Contractor.

8404 Construction

Road sign plates shall be manufactured from galvanised steel sheet of at least 1.4 mm thickness, or from aluminium alloy sheet of at least 2.5 mm thickness or such other material that is approved by the Engineer. For steel and aluminium plates, in order to deter theft, 10 mm diameter holes at 100 mm spacing shall be drilled through the plates prior to the application of any paint or reflective sheeting. Where there is high risk of theft / vandalism, use approved alternative materials of non-scrap value.

Sign plates manufactured from sheet material shall be stiffened when the maximum dimension of the sign exceeds 600 mm.

The stiffening of the sign may be in the form of a flange at least 15 mm deep on all edges or by means of mild steel or aluminium sections. Material for fixing such as brackets, socket caps, clips, screws, bolts, nuts and washers shall be corrosion resistant and to the Engineer's approval. Particular attention is required to avoid electrolytic reaction and corrosion between aluminium plates and fixings. Brass or copper will not be allowed for use in contact with aluminium.

The colours on all road signs, with the exception of black, will normally be reflectorised, unless otherwise specified or ordered by the Engineer. Reflective sheeting shall be applied by vacuum/heat application method. Retro reflective background material shall be pre applied to individual sections of large informative signs before assembly with the material taken around the face edges of each extension for at least 10 mm without damaging the material. Where possible, letters across the joint between two extrusions should be avoided.

Before painting all signs shall be pre-treated by an approved method and all frames, brackets, metal stakes, clips, screws, nuts, bolts, rivets, and washers shall be corrosion-proofed prior to painting. Pre-treatment and installation shall be compliant with FHWA NHI 05-036 March 2005.

The signs shall be supported on a medium gauge galvanised steel tube of not less than 75 mm outer diameter and securely bolted to it as shown on the Drawings. To avoid theft of the signs, the ends of bolts shall be hammered or spot-welded to prevent the nuts being removed.

Where details for the construction of sign faces, the framework of the sign faces and the attachment thereof to the supporting framework are not shown on the Drawings, the Contractor shall design these and submit the details to the Engineer for approval before manufacture.

Care shall be taken to prevent the forced rotation of the sign round the post. A steel bar of 16 mm diameter x 450 mm long shall be welded in the middle horizontally to the foot of the post to prevent the rotation of the post in its foundation. The length of the post shall be such that it is at least 0.65 m in the ground when the sign is at its correct height.

Additional road sign plates shall be provided and mounted on the support of the road sign, as directed by the Engineer.

Posts shall be thoroughly cleaned, free from grease, scale and rust and given at least one coat of rust inhibiting priming paint.

Posts and backs of signs, fittings, etc. shall be painted grey. The back of aluminium road signs will not require painting.

The foundations for road signs shall be as shown on the Drawings or as directed by the Engineer. Concrete foundations shall be poured using formwork.

After the concrete has set sufficiently the spaces around the concrete foundation shall be refilled to the required elevation with suitable material which shall be thoroughly tamped in layers of not more than 150 mm thickness.

All road signs shall be marked with the manufacturer's name or trademark, and year of make.

Mounting of the sign plate on the support shall be made by brackets, in accordance with the types proposed by the Contractor and approved by the Engineer, before the actual manufacture and erection in place.

The signs shall be erected at a distance from the edge of shoulder as shown on the Drawings or as directed by the Engineer.

The Contractor shall cut back trees and vegetation as may be necessary to ensure visibility of the signs.

All the signs and their support structures must be designed to accommodate dead and live loads including wind forces induced by gusts of 130 km/h.

Aluminium sign posts shall be in compliance with EN 12899-1 and be passively safe according to EN 12767. Pre-stressed concrete poles, fibre-reinforced concrete poles and wooded poles shall comply with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

The back side of the road signs should be painted in very bright colours to discourage theft.

8405 Storage and Handling

All road signs or parts of road signs shall be transported and handled so as to prevent any damage and deformation. All road signs shall be stored in a vertical position in a weatherproof storeroom. There shall be sufficient space between the road signs to permit free air circulation and moisture evaporation. Contact of road signs with treated timber, diesel, dirt or water shall not be permitted. When required, existing or newly erected road signs shall be fully or partially covered with burlap or other approved adequately ventilated material to obscure destinations that are temporarily inapplicable or irrelevant.

8406 Erecting Road Signs

a. Position

Road signs shall be erected in compliance with the requirements of the Road Design Manual Volume 6: Traffic Control Facilities and Communication Systems Design - Part 2 - Traffic Signs, and in the positions shown on the Drawings or otherwise indicated by the Engineer.

b. Excavation and Backfilling

Excavations for the erection of road signs shall be made according to the dimensions shown on the Drawings. Where the excavations are to be backfilled with soil, a 12:1 soil-cement mixture shall be made if required by the Engineer.

The soil or soil-cement mixture shall then be compacted by tamping at optimum moisture content in 100 mm thick layers in the excavation.

Where posts or structures are to be fixed in concrete, or where concrete footings are to be cast, the concrete, formwork and reinforcement shall comply with the requirements of SECTIONS 7200, 7300 and 7400. The holes shall be completely filled with concrete up to the level shown on the Drawings or indicated by the Engineer. The upper surface of the concrete shall be neatly finished with sufficient fall to ensure proper drainage.

c. Erection

Road signs shall be erected as shown on the Drawings or as directed by the Engineer. During erection the structural steelwork shall be firmly bolted and protected to prevent buckling or damage during erection.

Posts to which road signs are to be fixed shall be vertical and the undersides of road signs shall be horizontal after having been erected.

Where timber posts are used for erecting the signs, all holes that are drilled in the timber shall be impregnated with creosote.

d. Field Welding

All welding done during erection shall comply with the requirements for welding during manufacture.

e. On-site Painting

All painting done after the road signs have been erected shall comply with the requirements for painting during manufacture.

All places where the paintwork has been damaged during erection shall be repaired by the Contractor at their own cost to the satisfaction of the Engineer.

f. Time of Erection

Road signs shall be erected immediately prior to any use of the road by traffic

g. General

All destinations and route numbers shown on the Drawings shall be subject to amendment and confirmation of the details shall be obtained from the Engineer before any particular signs are made. Such amendments may only be available at a late stage in the works programme and the Contractor's programme shall allow for this situation.

8407 Protection and Maintenance

The Contractor shall protect the completed road signs against damage until they have been accepted by the Employer and shall maintain them until the defects Liability Certificate has been issued. Damage or defects caused by negligence or faulty workmanship shall be rectified by the Contractor at their own cost to the satisfaction of the Engineer.

8408 Dismantling, Storing and Re-Erecting Existing Road Signs

Where ordered by the Engineer, the Contractor shall dismantle existing road signs, store them, and re-erect them at new positions indicated.

Where required by the Engineer, the signs shall be repainted or repaired and new materials shall be used for part or all of the supporting structure.

8409 Measurement and Payment

The quantity to be measured for payment shall be:

1. The actual number of road signs complete in place, including support assembly and concrete foundation, and accepted.
2. The actual number of additional road sign plates complete in place, regardless of the sizes.
3. Guidance signs are to be measured as one sign per site with all names, route numbers and directional arrows shown on the one sign.

The quantities, determined as provided above, shall be paid for at the rate per unit of measurement for each of the pay Items listed below, that is shown in the Bill of Quantities, which price and payment shall be full compensation for furnishing and placing all materials, for all labour, equipment, tools and incidentals necessary to complete the work prescribed in this section, including all necessary excavation and backfilling.

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Item	Unit
84.01 Standard Road Sign:	
(a) Area Of Sign Less Than Or Equal To 1.0m ²	Number (No.)
(b) Area Of Sign More Than 1.0 M2 And Less Than Or Equal To 2.0m ² Provisional	Number (No.)

The unit of measurement shall be the number of signs of the stated size complete and erected.

Item	Unit
84.02 Additional Road Sign Plate:	Number (No.)

The unit of measurement shall be the number of standard size signs of approved materials as stated in the Specifications.

Item	Unit
84.03 Guidance Signs:	Square Metre (m ²)

The unit of measurement shall be the square metre of completed road signboard of approved materials.

The bid rates shall include full compensation for providing the completed road sign board, frame, fixing brackets, angle-irons, channel profiles, etc including painting, galvanising if specified, reflective lettering, symbols, legends and borders, attaching the road sign board to the road sign support, or to the overhead road sign structure, or to an over-bridge, and for all other materials and workmanship, brackets, bolts, nuts, etc, for the completion of the road sign boards as specified.

The rate for Guidance Signs and other Informative Signs shall include for the provision and erection of sign support in accordance with the Drawings.

Item	Unit
84.04 Dismantling, Storing And Re-Erecting Road Signs (Indicate Surface Area)	Number (No.)

The unit of measurement shall be the number of signs dismantled and stored and re-erected in each size group.

The bid rates shall include full compensation for dismantling and storing the road signs and supporting structures, transporting the material to a new location, re-erecting the road signs, and restoring the location where they were dismantled.

Payment for excavations, and the new material and concrete required for re-erecting the road signs shall be made under the appropriate Item, and any repairs and painting which may be necessary, shall be paid for as "extra work". No separate payment shall be made for new bolts and nuts required for such re-erection, the cost of which shall be included in the rates bid above.

Item	Unit
84.05 Removal of Obsolete Road Signs	Number (No.)

The unit of measurement shall be the number of signs dismantled and stored or disposed of as directed by the Engineer.

The bid rates shall include full compensation for dismantling and storing or disposing of the road signs and supporting structures as directed, and restoring the location where they were dismantled.

Item	Unit
84.06 Information Signs (Standard, State Area Of For Each Type)	Square Metre (m ²)

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The unit of measurement shall be the square metre of completed road signboard of approved materials.

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The bid rates shall include full compensation for providing the completed road sign board, frame, fixing brackets, angle-irons, channel profiles, etc including painting, galvanising if specified, reflective lettering, symbols, legends and borders, attaching the road sign board to the road sign support, or to the overhead road sign structure, or to an over-bridge, and for all other materials and workmanship, brackets, bolts, nuts, etc, for the completion of the road sign boards as specified.

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The rate for Information Signs and other Guidance Signs shall include for the provision and erection of sign support in accordance with the Drawings.

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SECTION 8500 Road Markings

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8501 Scope

This section covers the permanent marking of the road surface with white or yellow painted or thermoplastic lines or symbols, the supply and fixing of retro-reflective road studs and the construction of rumble strips and speed humps as indicated on the Drawings or as specified by the Engineer.

All road markings shall be of the standard information, regulatory, warning and guidance markings as detailed on the Drawings and in accordance with the **RDM Volume 6 Part 1: Road Marking** and **RDM Volume 6 Part 4: Other Traffic Control Devices**.

This section also covers the construction of rumble strips, speed humps, transverse bar marking and raised pedestrian crossings as indicated on the Drawings or as specified by the Engineer. The placement of transverse marking shall be as per **RDM 6.1** and **RDM 6.4** or as directed by the Engineer.

8502 Materials

a. Solvent Based Paint

The paint to be used for road marking shall be specifically manufactured for such purposes. The paint shall be internally reflectorised unless otherwise specified.

i. Road-marking paint

Paint shall comply with the requirements of KS EAS 927.

The paint shall be delivered at the Site in sealed containers bearing the name of the manufacturer and the type of paint. The viscosity of the paint shall be such that it can be applied without being thinned.

ii. Reflectorisation

Retro-reflective road-marking paint shall comply with the requirements of **SUBCLAUSE 8502 (a) (i)** above. The retro-reflective glass beads shall conform to the requirements of BS EN 1423 or equivalent, subject to a maximum nominal size of 0.8 mm.

iii. Colour

The colours to be used shall be as per BS 4800 Colour chart or as specified in Special Specifications.

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Ancillary Roadworks | 8500 | Road Markings

TABLE 8502/1: COLOUR SPECIFICATIONS

Colour	Reference number in BS 4800
White	00 E 55
Yellow	10 E 55
Blue	20 E 56
Green	14 E 53
Red	04 E 55

When required by the Engineer the Contractor shall submit with each consignment of paint delivered to the site, test certificates from an approved testing authority to show that the respective materials comply in all respects with relevant specifications. The testing of colour and luminance shall be as per KS EAS 928 Part 1.

b. Hot Applied Thermoplastic Paint

The material to be used shall be a thermoplastic reflectorised type of material specifically produced for the purpose. The material shall be applied to the pavement in a molten state by mechanical means.

i. Thermoplastic Material

The hot-melt thermoplastic road-marking material shall be of tropical grade with a softening point of the binder of 45° - 50°C. The binder shall be plasticised synthetic resin and the material shall be reflectorised by mixing in 20 % by mass Class A glass beads. The thermo-plastic road marking material shall consist of light-coloured aggregate, pigment and extender bound together with resin, elasticised with oil as necessary, in approximately the following proportions:

- Aggregate, including Ballotini beads: 60 %
- Pigment and extender: 20 %
- Binder: 20 %

The maximum size of aggregate shall be 2 mm.

Composition: The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in TABLE 8502/2.

TABLE 8502/2: PROPORTION OF CONSTITUENTS MARKING (percentage by weight)

Component	White	Yellow
Binder	18.0 min.	18.0 min.
Glass Beads	30 - 30	30 - 30
Titanium Dioxide	10.0 min.	-
Calcium Carbonate and Inert Fillers	42.0 max.	See Note below
Yellow Pigments	-	See Note below

Note: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this Specification are met.

Properties: The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3262-(Part I), shall be as below:

- a. **Luminance:** White: Daylight luminance at 45°-65 percent min. as per AASHTO M 249.
Yellow: Daylight luminance at 45°-45 percent min. as per AASHTO M249
- b. **Drying time:** When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to bear traffic in not more than 15 minutes.

- c. Skid resistance: not less than 45 as per BS:6044.
- d. Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.
- e. Softening point: $102.5^{\circ}\text{C} \pm 9.5^{\circ}\text{C}$ as per ASTM D 36.
- f. Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249

Storage life: The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/ Contractor.

Reflectorisation: Reflectorisation shall be by Ballotini beads to BS EN 1423:1998, which shall make up approximately 20 % by mass of the total mix, and shall be treated as part of the aggregate. The Ballotini shall be reasonably spherical and free from flaws and of a size suitable for this method of reflectorisation, subject to a maximum size of 2 mm.

Marking: Each container of the thermoplastic material shall be clearly and indelibly marked with the following information: Name, trade mark or other means of identification of manufacturer, Batch number, Date of manufacture, Colour (white or yellow), Maximum application temperature and maximum safe heating temperature

Sampling and Testing: The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

Reflectorising Glass Beads: The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions.

Specific Requirements

Gradation: The glass beads shall meet the gradation requirements for as given in TABLE 8502/3.

TABLE 8502/3: GRADATION REQUIREMENT OF GLASS BEADS		
Sleeve Size	Percentage Retained	
	Type 1	Type 2
1.18 mm	0 to 3	
850 micron	5 to 20	0 to 5
600 micron	-	5 to 20
425 micron	65 to 95	-
300 micron	-	30 to 75
180 micron	0 to 10	10 to 30
Below 180 micron	-	0 to 15

Roundness: The glass beads shall have a minimum of 70 percent true spheres.

Refractive index: The glass beads shall have a minimum refractive index of 1.50.

Free flowing properties: The glass beads shall be free of hard lumps and clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test.

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Test Methods

The specific requirements shall be tested with the following methods:

- a. **Free-flow test:** Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter dessicator which is filled within 25 mm of the top of a dessicator plate with sulphuric acid water solution (specific gravity 1.10). Cover the dessicator and let it stand for 4 hours at 20°C to 29°C. Remove sample from dessicator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be free of lumps and clusters and shall flow freely through the funnel.
- b. The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS:6088 and BS:3262 (Part I).
- c. The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of these Specifications. However, if so required, these tests may be carried out as directed by the Engineer.

ii. Colour

The colours to be used shall be as per BS 4800 Colour chart or as specified in Special Specifications (see TABLE 8502/1).

The testing of colour and luminance shall be as per KS EAS 928 Part 1.

iii. Skid resistance

The skid resistance of all types of marking material shall comply with the requirements of BS 7941-1 or BS 7941-2 or equivalent.

The Contractor shall submit for each consignment of thermoplastic material delivered to the Site the manufacturer's certificate to show that the materials comply in all respects with the relevant product specifications.

c. Cold Applied Reflective Paint

The work shall consist of marking traffic stripes using a solvent based cold applied paint, which shall be applied on the asphalt/cement concrete road surface by brush or by Road Marker (Spray equipment capable of spraying the paint on the road). Glass beads shall be subsequently spread pneumatically on to the paint when it is still wet so that the beads will be firmly held by the paint after drying. Colour of the paint shall be white or yellow as specified in the drawings or directed by the Engineer.

The cold applied paint material shall be homogeneously composed of binder, pigment, extenders and other additives as required for the formulation. The pigments and extenders shall be uniformly dispersed in the binder medium dissolved in organic solvents. The material shall be free from skin, dirt and foreign objects and shall comply with requirements indicated in TABLE 8502/4.

TABLE 8502/4: PROPORTION OF CONSTITUENTS OR PAINTS (percentage by weight)

Component	White	Yellow
Binder	25.0 min	18.0 min
Titanium Dioxide	20.0 min	-
Calcium Carbonate and Inert Fillers	16.0 min	29.0 min
Yellow Pigments	-	14.0 min

Properties: Non-Volatile Matter content by weight shall be a minimum of 65 percent as determined in accordance with test method ASTM D1644. The liquid paint shall have a density of 1.3 g/cc minimum as determined in accordance with test method ASTM D1475.

Appearance: Drying Time of the paint as determined by the test method ASTM D711 shall be a maximum of 20 minutes at a wet film thickness of 350 micron. The paint shall set to bear traffic after 40 minutes when the ambient temperature is higher than 24°C. The paint shall not be applied when the surface temperature of the road is higher than 40°C.

Properties of the Dried Paint Film: When tested using a sand abrasion tester as described in ASTM D968, the quantity of sand required for removal of a 75 micron thick unbeaded dry film shall be greater than 65 litres.

Elongation: The unbeaded dry film shall pass the test in accordance with ASTM D 1737 and ASTM D2205.

Water Resistance: The unbeaded dry film shall pass the test in accordance with ASTM 01647 and ASTM 02205.

Skid Resistance: Skid resistance for the beaded dry film shall be not less than 45 as per BS 6044.

Storage Life: The material shall meet the specifications for a period of one year. During this period, the paint material when stored in an airtight container shall not form skin. The material shall also not form a cake at the bottom of the container.

Minimum Thickness of the Unbeaded Cold Applied Paint Coat: shall not be less than 400 micron, and the minimum thickness of the dry unbeaded coat of paint shall not be less than 200 microns.

Retro-reflective Properties: The co-efficient of retro-reflection shall be as per EN 1436.

Marking: Each container of the thermoplastic material shall be clearly and indelibly marked with the following information: Name or trademark, Batch number, month of manufacture, Colour (white or yellow)

Sampling and testing: The cold applied reflective road marking paint shall be sampled and tested in accordance with appropriate ASTM/BS test methods. The contractor shall furnish to the Engineer a copy of certified test methods from the manufacturer of cold applied reflective road marking paint.

d. Road Studs

Road studs shall comply with the requirements of EN 1463-1, EN 1463-2 and ASTM D280 or equivalent and shall be of the size and type indicated on the Drawings or specified in the Special Specifications. The Contractor shall, prior to delivery, submit to the Engineer for approval, samples of the type of road studs they propose to use.

Plastic body of RPM/road stud shall be moulded from ASA (Acrylic Styrene Acrylonitrile) or HIPS (Hi-impact Polystyrene) or Acrylonitrile Butadiene Styrene (ABS) or any other suitable material approved by the Engineer. The markers shall support a load of 13,635 kg tested in accordance with ASTM D 4280. Reflective panels shall consist of number of lenses containing single or dual prismatic cubes capable of providing total internal reflection of the light entering the lens face. Lenses shall be moulded of methyl methacrylate conforming to ASTM D 788 or equivalent. The slope or retro-reflecting surface shall preferably be 35 ± 50 to base and the area of each retro-reflecting surface shall not be less than 13.0 sq.cm.

Optical Performance: For both unidirectional and bidirectional studs performance shall be as per BS EN 1463.

Tests: As per ASTM E 809 "Practice for Measuring Photometric Characteristics" or as recommended in BS:873-Part 4

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Solar Powered Road Studs

The solar studs shall be made of Aluminium alloy and poly carbonate material which shall be absolutely weather resistant and strong enough to support a load of 13,635 kg tested in accordance with ASTM 04280. Its colour may be white, red, yellow, green or blue or combination as directed by the Engineer. Its water resistance shall meet the requirements of IP 65 in accordance with IS:12063 Category 2 for protection against water ingress. The dimensions of solar studs shall not be less than 100 mm x 100 mm x 10 mm. It shall have super bright LEDs so as to provide long visibility from a distance of more than 800 m. Its flashing rate shall not be less than 1 Hz. Its should be able to give the prescribed performance in the temperature range of -40°C to +55°C. Its life shall be not less than 3 years.

e. Rumble Strips

Transverse Rumble strips shall be constructed of cast in-situ cement concrete or asphalt concrete, of low viscosity grade AC 10, as per AASHTO M226-80, having a high resistance to rutting and deformation. Asphalt contrite rumble strips shall be, in accordance with the requirements of SECTION 5200 of this Specification and as directed by the Engineer. Cement concrete rumble strips shall be in accordance with requirements of SECTION 6000 of this specifications and as directed by the Engineer.

Dimensions of rumble strips shall be as per **RDM Volume 6 Part 1: Road Marking Manual** or as directed by the Engineer.

Rumble strips can also be made of rubber, polyurethane or thermoplastic paint. These rumble strips shall be fixed using nail and installed with epoxy chemical and strong adhesive without damage to road or bridge, as directed by the Engineer.

Polyurethane rumble strips shall be modular in nature. Each module shall be of length 500 mm, width 100 mm and height 15 mm or as directed by the Engineer. Weight of each module should not be less than 470 gm. Five nails of 100 mm each should be used for installation of each module. Colour should be of yellow and black combination.

Plastic / Polyurethane rumble strips should be tested for impact as per ASTM D 256. Density should be as per ASTM D 792. UV stabilisation should be as per ASTM G 154 and hardness as per ASTM D 2240

Rumble strips can also be provided with multiple layers of reflectorised thermoplastic paint, either white or yellow in colour. The dimensions of the set of six strips shall be as per **RDM Volume 6 Part 1**.

f. Speed Humps

Permanent Speed humps shall be constructed of asphalt concrete in accordance with the requirements of SECTIONS 5100, 5200, 5300 and 5700 of these Specifications. Speed humps shall be painted as shown in **RDM Part 4 Volume 4: Other Traffic Control Devices** or as instructed by the Engineer.

Temporary speed humps can be made of plastic, rubber or a combination of the two or of recycled material. These can be modular in nature so that these can be placed as per the required width. Humps must be highly visible. Alternating black and yellow sections are a common option. Built-in reflective studs may also be included. The humps are to be secured to the underlying concrete or asphalt surface by using fixing bolts or anchors. The bolts pass through pre-drilled holes in the body of the plastic. Temporary humps are to be used in areas where vehicular speed is low. Use of temporary humps should be as directed by the Engineer.

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8503 Weather Limitations

Road marking material shall not be applied to damp surfaces or when the relative humidity exceeds 80 %, or at temperatures lower than 10°C, or when, in opinion of the Engineer, wind strength is such that it may adversely affect the road marking operations.

8504 Mechanical Equipment For Application Of Road Marking

The equipment shall consist of tools and equipment for cleaning the surfaces, a mechanical road painting machine or automatic self-propelled thermoplastic laying machine as the case may be and all additional hand-operated equipment necessary for completing the work.

The road marking machine shall be capable of applying the road marking at a speed of not less than 5.0 km/hr and it shall be provided with clearly visible amber warning flashing lights that shall always be in operation when the machine is working on the road.

8505 Surface Preparation

Road markings shall be applied to bituminous and Portland cement concrete surfaces after sufficient time has elapsed to ensure that damage will not be caused to the marking material by volatiles evaporating from the surfacing. In no case shall paint markings be applied until at least 30 days after the completion of Asphalt concrete surfacing and surface dressing to allow for adequate trafficking and embedding of chippings .

Before the marking material is applied the surface shall be clean and dry and completely free from any soil, grease, oil, acid or any other material that would be detrimental to the bond between the marking material and the surface. The surface where the marking material is to be applied shall be properly cleaned by means of watering, brooming or compressed air if required. A suitable primer shall be applied to concrete surfaces before thermoplastic marking material is applied.

8506 Setting-Out of Road Markings, Road Studs and Speed Reducing Measures

The lines, symbols, figures or marks shall be pre-marked by means of paint spots of the same colour as that of the final lines and marks. These paint spots shall be at such intervals to ensure that the road markings can be accurately applied and in no case shall they be more than 1.5 m apart. Spots shall be of approximately 10 mm in diameter or otherwise agreed with the Engineer.

The dimensions and positions of road markings shall be as shown on the Drawings or as specified in the appropriate statutory provisions and in accordance with the **Road Design Manual Volume 6, Part 1: Road Marking**. After spotting, the positions of the proposed road markings shall be indicated on the road. These painted pre-markings shall be approved by the Engineer prior to any road marking operations being commenced.

The positions and outlines of special markings shall be produced on the finished road in chalk and shall be approved by the Engineer before they are executed. Approved templates may be used on condition that the positioning of the markings is approved by the Engineer before marking is commenced.

The position of road studs shall be marked out on the road and shall be approved by the Engineer before they are fixed in position.

The position of rumble strips and speed humps shall be as shown in the Drawings and approved by the Engineer.

8507 Applying The Marking Material

Paint shall be stirred before application in accordance with the manufacturer's instructions

Before any road-marking machine is used on the permanent Works the satisfactory operation of the machine shall be demonstrated and the application rate checked on a suitable site that is not part of the permanent Works. Any adjustments required to the machine shall be followed by further testing. Only when the machine has been correctly adjusted and the Engineer has approved its use after testing may the machine be used on the permanent work. The operator shall be experienced in the use of the machine.

Where road marking paint is applied by machine it shall be applied in one layer. Where painting is done by hand it shall be applied in two layers and the second layer shall not be applied before the first layer has dried. As most road marking paint reacts with the bitumen surface of the road the paint shall be applied with one stroke only of the brush or roller.

Road-marking paint shall be applied at a nominal rate of 0.42 litre/m² or as directed by the Engineer.

Thermoplastic material shall be laid to a thickness of 4 mm ± 0.5 mm or as directed by the Engineer. The method of thickness measurement shall be in accordance with KS EAS 928 part 2.

Edge lines of thermoplastic material shall be broken by a 100 mm gap for every 10 m continuous line

Where acoustic lines of thermoplastic material are specified the types and dimensions of the lines and thickness of the marking material shall be as shown in the Drawings and as prescribed in the Special Specifications.

8508 Applying The Retro-Reflective Beads

Retro-reflective beads shall be applied by means of a suitable machine in one continuous operation immediately after the paint has been applied

The rate of application of the beads shall be 300 – 400 g/m² of paint or such other rate as the Engineer may direct.

8509 Placement Of Road Studs

Road studs shall be of the type and size specified in the **SUBCLAUSE 8502(c)** and shall be fixed in position as shown on the drawings or as directed by the Engineer.

The road studs shall be fixed by means of an appropriate adhesive in accordance with the manufacturer's instructions subject to such amendments to the method as may be required by the Engineer. The studs shall be protected against impact until the adhesive has hardened. Before fixing the road studs, the surface shall be thoroughly cleaned as specified in **CLAUSE 8505**.

Road studs must be protected during the course of marking of any lines and application of any surface treatments. Any road studs that become loose or are lost during the Defects Notification Period are regarded as defects.

8510 Tolerances

The figures, letters, signs, symbols, broken or unbroken lines or other marks shall be marked as shown on the Drawings and in accordance with the **RDM Volume 6 Part 1: Road Marking** or as may be otherwise directed by the Engineer.

Road markings shall be applied to accuracy within the tolerances given below:

a. Width

The width of lines and other markings shall not be less than the specified width, nor shall it exceed the specified width by more than 10 mm. i.e. -0/+10 % on 100 mm width.

b. Position

The position of lines, letters, figures, arrows, retro-reflective road studs and other markings shall not deviate from the true position by more than 100 mm in the longitudinal and 20 mm in the transverse direction.

c. Alignment of markings

The alignment of the edges of longitudinal lines shall not deviate from the true alignment by more than 10 mm in 15 m.

d. Broken lines

The length of segments of broken longitudinal lines shall not deviate by more than 100 mm from the specified length.

The length of segments and the gap between segments in broken lines shall be as indicated on the Drawings. If these lengths are altered by the Engineer the ratio of the lengths of the marked section to the length of the gap between marked sections shall remain the same.

Lines on curves, whether broken or unbroken, shall not consist of chords but shall follow the correct radius.

8511 Removal of Temporary and Rejected Road Markings

The Contractor shall remove existing obsolete markings from the road surface by means of sand blasting, milling or other approved method. The use of black paint or chemical paint remover to obliterate existing markings will not be permitted except where it is instructed by the Engineer as a temporary measure.

Rejected road markings and paint and marking material that has been splashed or dripped onto the pavement, kerbs, structures or other such surfaces shall be removed by the Contractor at their own cost as approved by the Engineer so that the markings or spilt paint will not be evident to the road user.

8512 Protection

After the road marking material has been applied it shall be protected against damage by traffic or other causes. The Contractor shall be responsible for erecting, placing and removing all warning boards, flags, cones, barricades and other protective measures which may be necessary in terms of any statutory provisions and/or as may be recommended in the **RDM Volume 6 Part 1: Road Marking**.

8513 Measurement And Payment

Item	Unit
85.01 Road-Marking Using Road-Marking Paint:	
(a) White Lines (Broken or Unbroken) (Width of Line Indicated)	Square Metre (m ²)
(b) Yellow Lines (Broken or Unbroken) (Width of Line Indicated)	Square Metre (m ²)
(c) Blue Marking	Square Metre (m ²)
(d) Green Marking	Square Metre (m ²)
(e) Red Marking	Square Metre (m ²)
(f) White Lettering and Symbols	Square Metre (m ²)
(g) Yellow Lettering and Symbols	Square Metre (m ²)
(h) Traffic-Island Markings (any Colour)	Square Metre (m ²)
(i) Kerb Markings (any Colour)	Square Metre (m ²)

The unit of measurement for painting the lines shall be in square metre. For each specified width of line, length shall be measured to arrive at the area of painting. The quantity paid shall be the actual length of line painted in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines, multiplied by the width of the line.

The unit of measurement for painting the lettering, symbols or traffic-island paintings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for painting the road markings shall include full compensation for procuring and furnishing all material and the necessary equipment, and for painting, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, and including setting out and pre-marking the lines.

Item	Unit
85.02 Road-Marking Using Retro-Reflective Road-Marking Paint:	
(a) White Lines (Broken or Unbroken) (Width of Line Indicated)	Square Metre (m ²)
(b) Yellow Lines (Broken or Unbroken) (Width of Line Indicated)	Square Metre (m ²)
(c) Blue Marking	Square Metre (m ²)
(d) Green Marking	Square Metre (m ²)
(e) Red Marking	Square Metre (m ²)
(f) White Lettering and Symbols	Square Metre (m ²)
(g) Yellow Lettering and Symbols	Square Metre (m ²)
(h) Traffic-Island Markings (Any Colour)	Square Metre (m ²)

The unit of measurement for painting the lines shall be the in square metre. For each specified width of line, length shall be measured to arrive at the area of painting. The quantity paid for shall be the actual length of line painted in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines, multiplied by the width of the line.

The unit of measurement for painting the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line painted in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines.

The bid rate per metre or per square metre as the case may be for painting the road markings shall include full compensation for procuring and furnishing all material, including the retro-reflective beads, and the necessary equipment, and for painting, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

Item	Unit
85.03 Road Marking Using Thermo-Plastic Road-Marking Material:	
(a) White Lines (Broken or Unbroken) (Width of Line Indicated)	Square Metre (m ²)
(b) Yellow Lines (Broken or Unbroken) (Width of Line Indicated)	Square Metre (m ²)
(c) Blue Marking	Square Metre (m ²)
(d) Green Marking	Square Metre (m ²)
(e) Red Marking	Square Metre (m ²)
(f) White Lettering and Symbols	Square Metre (m ²)
(g) Yellow Lettering and Symbols	Square Metre (m ²)
(h) Traffic-Island Markings (any Colour)	Square Metre (m ²)

The unit of measurement for marking the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line marked in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines. Approved types of acoustic lines, where specified and approved by the Engineer, shall be measured as continuous for payment purposes.

The unit of measurement for applying the lettering, symbols or traffic-island markings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for applying the road markings shall include full compensation for procuring and furnishing all material, and the necessary equipment, and for application, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

Item	Unit
85.05 Road Studs (Type Stated):	Number (No.)

The unit of measurement for road studs shall be the actual number of approved road studs placed.

The bid rate shall include full compensation for procuring and furnishing all the necessary material, labour and equipment, and for fixing and maintenance as specified. Distinction shall be made between various types of road studs.

Item	Unit
85.06 Removal of Existing, Temporary or Permanent Road Marking by:	
(a) Sandblasting	Square Metre (m ²)
(b) Over Painting as a Temporary Measure	Square Metre (m ²)
(c) Milling	Square Metre (m ²)

The unit of measurement shall be the square metre of road marking removed.

Item	Unit
85.07 Removal of Existing Road Studs	Number (No.)

The unit of measurement shall be the actual number of road studs removed.

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Item		Unit
85.08	Rumble Strips and Speed Humps:	
(a)	Rumble Strip (Specify Type/Size)	Metre (m)
(b)	Speed Hump (Specify Type/Size)	Metre (m)

The unit of measurement for rumble strips and speed humps shall be the linear metre of each individual rumble strip of the different types and speed humps constructed to the cross-sectional shape shown on the Drawings and in accordance with the instructions of the Engineer.

The bid rate for rumble strips shall include for preparing the surface, providing, mixing, transporting, laying and compacting the asphalt concrete mix for the rumble strips in accordance with the Drawings and to the satisfaction of the Engineer.

The bid rate for speed humps shall include provision of all materials, excavation, bedding, construction, and finishing the asphalt concrete speed humps in accordance with the Drawings and to the satisfaction of the Engineer. The rate shall also include for protecting and maintaining the work as specified. Road marking for speed humps and other speed reducing measures will be paid for separately.

SECTION 8600 Landscaping & Grassing

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8601 Scope

a. Scope

This section covers the landscaping of designated areas and the establishing of vegetation for functional and aesthetic purposes on cut and fill slopes, landscaped areas and such other areas where it may be required.

b. Definitions

Undesirable vegetation: Any declared noxious weeds, as well as any exotic tree, shrub, herb, grass or water plant which, in the opinion of the Engineer, may pose any problems in specified areas at certain times.

8602 Materials

a. Fertiliser/soil-improvement Material

The type of fertiliser/soil-improvement material to be used shall be one or more of the following types and any other type of fertiliser/soil-improvement material described in the Special Specifications or prescribed by the Engineer.

- i. Soil-improvement materials such as dolomitic lime, basic slag, gypsum, superphosphate and agricultural lime.
- ii. Fertilisers such as limestone ammonium nitrate, 2:3:2 (22) and 3:2:1 (25).

b. Grass Cuttings

Grass cuttings shall be fresh cuttings of an approved type of grass with sufficient root material to ensure good growth.

c. Grass Seeds

Only fresh certified seed shall be used and the types of seeds in the seed mixture shall be as specified in the Special Specifications.

Mixing the various types of grass seeds for obtaining the prescribed grass-seed mixture shall be done on the Site in the presence of the Engineer. Storing and identifying the grass seeds and the grass-seed mixtures on the Site shall be the responsibility of the Contractor.

The grass seed or seed mixture shall consist of local varieties of Vetiver, *Stenotaphrum secundatum*, *Cynodon dactylon* or *Pennisetum clandestinum* grass or other grass seeds approved by the Engineer.

d. Trees, Shrubs And Hedge Plants

Plants shall be of the variety and size shown on the Drawings or in the Special Specifications.

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The Contractor shall supply the number of plants as shown on the Drawings or in the Special Specifications and/or Bill of Quantities. Upon receipt of the plants the Contractor shall ensure that they are in good condition and free from plant diseases and the Contractor shall accept full responsibility for maintaining the plants in a good condition throughout the Contract and the Defects Notification Period. The plants shall be fully maintained and watered during this period and any loss of plants due to lack of care or disease shall be replaced at the Contractor's own cost.

Each plant shall be handled and packed in the approved manner for that species or variety and all the necessary precautions shall be taken to ensure that the plants will arrive at the site of the Works in a suitable condition for successful growth. Trucks used for transporting plants shall be equipped with covers to protect the plants from windburn. Containers shall be in a good condition.

Plants supplied by the Contractor shall be healthy, correctly shaped, and well rooted. The plants must be hardened off and be exposed to direct sunlight for at least 6 months prior to planting in the road reserve. Roots shall not show any evidence of having been restricted or deformed at any time. Plants shall grow well and shall be free from insect pests and diseases.

e. Grass Sods

Grass sods shall be either nursery-grown or bush sods as described below. Both types shall be harvested, delivered, planted and watered within 36 hours unless otherwise authorised by the Engineer. The grass sods shall be free from noxious weeds and diseases. Sods obtained from a nursery shall be in moist soil not less than 30 mm deep and sods taken from the bush in moist soil not less than 50 mm deep.

i. Nursery-grown sods

These sods shall be of the variety of grass specified in the Special Specifications unless the use of an alternative has been approved by the Engineer. The grass shall have been grown specifically for sod purposes, mown regularly and cared for to provide an approved uniformity to the satisfaction of the Engineer.

The grass seed or seed mixture shall consist of local varieties of *Stenotaphrum secundatum*, *Cynodon dactylon* or *Pennisetum clandestinum* grass or other grass seeds approved by the Engineer.

ii. Bush sods

These sods may be obtained from approved areas within or near the Site where a suitable type and density of grass and type of soil are found.

f. Anti-erosion Compounds

Anti-erosion compounds shall consist of an organic or inorganic material to bind soil particles together and shall be a proven product able to suppress dust and form an encrustation. The application rate shall conform to the manufacturer's recommendations. The materials used shall be of such a quality that grass seeds may germinate and penetrate the crust.

g. Topsoil

Topsoil shall consist of fertile loamy soil obtained from areas with good soil coverage of natural vegetation, preferably grasses. It shall be free from deleterious matter such as large roots, stones, refuse, stiff or heavy clays and the seeds of noxious weeds, which will adversely affect its suitability for purpose. Topsoil stripped from areas infested with weeds shall be stockpiled separately.

Topsoil shall be obtained from wherever suitable material occurs either in the road reserve or from areas where cuts and fills are to be constructed. Topsoil stripped from borrow areas may not be removed from that site for topsoiling of other areas but must be used to rehabilitate the borrow pit itself.

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The Engineer shall communicate their requirements to the Contractor regarding the quantity of topsoil which is necessary and the areas from which it shall be selected and removed by the Contractor. If the Contractor fails to conserve the topsoil as instructed, they shall obtain suitable substitute material from other sources at their own cost.

Where so specified, the Contractor shall procure and furnish topsoil from their own sources outside the Site, after such sources have been approved by the Engineer.

Topsoil shall be stockpiled in separate loose heaps as tipped from the trucks and shall not be stockpiled in heaps exceeding 2 m in height. Care shall be taken to prevent the compaction of the topsoil in any way, especially by trucks being driven over such material.

h. Manure

Manure shall, unless another type has been approved by the Engineer, be pure natural manure free from soil, weed seeds or other undesirable material. It shall not contain any particles that will not pass through a 50 mm screen and shall be approved by the Engineer before being delivered to the Site.

i. Compost

Compost shall be well decayed, friable and free from weed seeds, dust or any other undesirable materials. It shall not contain any particles that will not pass through a 50 mm screen and shall be approved by the Engineer before being delivered to the Site.

8603 Landscaping Areas

a. Shaping

Areas within the road reserve but outside the road prism which require shaping by means of bulk earthworks such as contoured areas at interchanges and intersections and rest areas which require earthworks shall be excavated, filled and compacted when required, and shaped to the correct contours to within a tolerance of plus or minus 150 mm. Such work shall be regarded as being earthworks and measurement and payment therefore shall be made under SECTION 3600, except that quantities may be measured by means of a grid system of levels taken at 10 m intervals before and after shaping or else it may be determined by levelled cross-sections.

b. Trimming

Trimming shall consist of trimming the existing or previously shaped ground to an even surface with the final levels generally following the original surface. Trimming shall normally be done by grader or in more confined or steep areas by bulldozer. In other circumstances approved by the Engineer such as where machine operations are not practicable because of confined spaces or steep slopes, trimming shall be done with hand tools. When trimming is done on slopes steeper than 1:3 the ridges shall be made parallel to the contour. Such ridges shall be approximately 100 mm wide, and the centres between the ridges approximately 400 mm. Trimming shall be done where instructed by the Engineer to areas inside the road reserve but outside the road prism, i.e. normally outside the tops of cuts or the toes of fills, but trimming of rock outcrops will not be required other than to remove loose material.

Trimmed surfaces shall be left slightly rough to facilitate a better binding with topsoil or the natural establishment of vegetation.

When subsequent grassing is required or when it is ordered by the Engineer, areas previously shaped shall be trimmed as described above to within a tolerance of plus or minus 100 mm with all undulations following a smooth curve. This tolerance shall apply only to areas where the final contours are given on the Drawings.

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During trimming all stones in excess of 100 mm in size and all excess material shall be removed. Areas which require grassing shall be trimmed in such a way that after cultivation and the application of topsoil the finished surface of the area shall be approximately 25 mm below the top of adjacent kerbing, channelling or pavement.

c. Plant rates

The Engineer shall be entitled to pay for shaping and trimming as described above on the basis of hourly plant rates. The motor grader and bulldozer to be provided shall each have a flywheel power of not less than 93 kW. All machines shall be in a good condition. Any labour or other plant required shall be paid for as extra work as specified in the Contract.

8604 Preparing Areas For Grassing

The various areas to be grassed shall be prepared as follows:

a. Soil Ripping

Where soil is too hard to be ploughed with a light tractor the soil shall be ripped up to a depth of 300 mm before it is loosened by plough to a depth of 150 mm.

b. Areas Which Do Not Require Topsoil

Where the areas to be grassed consist of organically suitable material the topsoil shall be loosened by ploughing to a minimum depth of 150 mm. All loose stones exceeding 50 mm in size on areas to be mowed by machine and falling within the road reserve and all stones exceeding 150 mm in size in other areas shall be removed.

c. Areas Which Require Topsoil

Where areas to be grassed consist of organically unsuitable material the surface shall be roughened to ensure a proper bond between the topsoil and the subsoil. If required the area shall be scarified as described in paragraphs (a) or (b) above.

Topsoil shall be placed on the prepared surfaces and trimmed to the uniform thickness required. The topsoil shall be scarified by means of hand raking or light rotavation and all stones removed as specified for areas not requiring topsoil as in subparagraph (b) above.

Areas that will be inaccessible for placement of topsoil after the construction works have been completed shall be covered with topsoil and protected against erosion during the course of construction works.

d. Fertilising

For all areas to be planted the Contractor shall have the top 150 mm of the prepared surface tested to determine the quantity and type of fertiliser which will be required for establishing proper growth conditions for the grass. The location of the soil sample taken shall be indicated on plans by the Contractor. The Contractor shall propose a suitable fertiliser and quantities thereof, based on the results of tests which shall together be submitted to the Engineer for approval. The fertiliser shall be evenly applied over all surfaces where grass is to be planted and shall then be thoroughly mixed with the soil to a depth of 100 mm either mechanically or manually. Where hydroseeding is to be performed the fertiliser may be mixed with the cellulose pulp and water used in hydroseeding.

It is anticipated that the fertiliser to be used will be of a type obtainable from local suppliers in Kenya.

e. General

After an area has been prepared for grassing the grassing shall be completed before crusting. Where a crust has been formed before grassing is done the Contractor shall loosen the crust by ploughing to a depth of 150 mm at their own cost.

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8605 Grassing And Sprigging

The method of establishing grass shall depend on the circumstances pertaining in specific areas and the Engineer shall decide which method is to be used. Provision is made for the following methods:

1. Planting grass cuttings.
2. Sodding.
3. Hydroseeding.
4. Topsoiling only, using, where available, topsoil selected for the presence of natural grass seeds.
5. Grassing with an approved grassing machine.
6. Hand seeding.
7. The use of any other method specified in the Special Specifications.

Unpaved side slopes, including cuttings, ditches and embankments within the road prism should be protected against erosion by water runoff. These areas of the earthworks shall be protected as specified and/or shown on the drawings in accordance with the following subclauses.

a. Planting Grass Cuttings

The areas to be grassed shall, unless already wet, be thoroughly watered before the cuttings are planted to ensure that the soil will be uniformly wet to a depth of at least 150 mm when the planting is done.

An approved variety of grass cuttings shall be evenly planted by hand or mechanically at a rate of at least 600 kg of cuttings per hectare. Fresh cuttings only shall be used. Any grass cuttings that have been allowed to dry out shall be discarded. Immediately after having been planted the grass cuttings shall be given a copious watering and when sufficiently dry shall be rolled with a light agricultural roller.

b. Sodding

Areas to be grassed by sodding shall be given a layer of topsoil of at least 50 mm in thickness unless, where suitable soil is present, the Engineer orders the topsoil to be omitted. The areas to be sodded shall be thoroughly watered beforehand so that it will be saturated to a depth of at least 150 mm during sodding. The surface shall be roughened slightly to ensure a good penetration of roots into the soil. Sods shall be protected against drying out and kept moist from the time of harvesting until they are finally placed.

The first row of sods shall, where possible, be laid in a straight line and if on a slope laid from the bottom upwards. The sods shall be butted tightly against each other and care shall be taken not to stretch or overlap the sods. Where a good fit cannot be obtained any intervening spaces shall be filled with topsoil. The next row shall be similarly placed tightly against the bottom row with staggered joints and so on until the entire area has been covered with sods. On steep slopes, when instructed by the Engineer, the sods shall be held in position by a sufficient number of wooden stakes approximately 300 mm long by 20 mm in thickness and these stakes shall be knocked into the subsoil to a depth of 100 mm or to a depth as required to provide anchoring.

The Contractor shall water the sods directly after they have been placed to prevent undue drying out. As sodding is completed, each section shall be lightly rolled and thoroughly watered.

c. Hydro-seeding

Where it is specified that hydro-seeding is to be carried out on topsoil the thickness of the topsoil shall be as indicated in the Special Specifications or as directed by the Engineer.

Areas to be hydro-seeded shall be given a layer of topsoil of 100 mm in thickness unless, where suitable soil is present, the Engineer orders the topsoil to be omitted or applied in reduced thickness.

The types and mixtures of seeds to be used shall be as indicated in the Special Specifications or shall be agreed on by the Engineer and the Contractor before any seed is ordered. The Contractor shall be solely responsible for establishing an acceptable grass cover and any approval by the Engineer of seed or seed mixtures intended for use by the Contractor shall not relieve them of this responsibility.

The seed mixture for hydro-seeding or hand seeding is to be applied at 45 kg/ha and is to consist of an appropriate seed mixture for the site conditions and climate with at least 10 % locally harvested grass seed. The details of the mixture shall be formulated during planning stages by the Contractor and approved by the Engineer.

All areas to be hydro-seeded or hand seeded are to be scarified forming horizontal drills running parallel to the contours. The drills are to be spaced at intervals of 150 to 250 mm apart. Seeding is to take place immediately after scarifying in order to avoid silting of the drills by rainwater.

A mulch shall be added to the hydro-seeding mix at an approved rate.

Hydro-seeding shall then be carried out with an approved hydro-seeding machine at a rate of application of not less than 38 kg of seed mixture per hectare unless otherwise indicated in the Special Specifications.

When the use of anti-erosion compounds is required and such compound is to be applied simultaneously with the hydro-seeding, it shall be mixed with the hydro-seeding mixture before application.

d. Topsoiling Only

Where the planting of grass or hydro-seeding can be dispensed with on account of favourable climatic and other conditions the Contractor may attempt to establish grass by topsoiling only. However this shall be undertaken entirely at the Contractor's risk after discussion with the Engineer. Topsoil shall be selected for the presence of natural grass and seeds and shall be removed and placed whenever possible at a time that would favour the establishing of grass. These areas shall be treated with an anti-erosion compound if so instructed by the Engineer.

After the topsoil has been placed it shall be lightly rolled and well watered and afterwards watered and mown to maintain the surface in an acceptable condition. The Contractor shall undertake this work whenever instructed by the Engineer.

The Contractor will remain responsible for establishing an acceptable grass cover as defined in SUBCLAUSE 8606(b) when this procedure is followed and will be responsible for the consequences of any omission to water, weed or mow the grass as instructed by the Engineer. However if after all reasonable care and attention has been given to the work the grass cover fails to become established then the Engineer may instruct the Contractor to adopt alternative methods for which they shall be paid.

No payment for grassing shall be made other than for placing topsoil and for mowing and watering the grass which will be paid for at the bid rates and for any replanting of grass on bare patches, repairs caused by erosion, and similar work which will be paid for as extra work as allowed for in the Contract.

e. Grassing With An Approved Grassing Machine

Grassing shall be done with an approved grass planter which plants the seeds in rows spaced not more than 250 mm apart. The planter shall plant the seeds approximately 6 mm deep and shall lightly compact the soil. The prescribed fertiliser may be distributed simultaneously with the grass planting.

f. Hand Seeding

If approved by the Engineer sowing may be done by hand. The seed shall be spread uniformly over the surfaces and then lightly raked into the soil.

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g. Other Methods

Whenever indicated in the Special Specifications other methods of grassing may be employed.

h. The grassing of borrow pits, temporary by-passes, camp sites, access roads and stockpile sites

Prior to any grassing that may be required on such areas the finishing-off of borrow pits as described under **CLAUSE 3405**, obliterating the by-passes and access roads as described in **CLAUSES 1815** and **8703** respectively and the clearing of camp sites as described in **SECTION 1300** shall have been carried out as specified in the relevant sections.

Note: With regard to **SUBCLAUSES 8605 (e)** and **(f)**, the areas to be grassed shall be prepared as described in **CLAUSE 8604** and the areas shall be thoroughly watered after completion of the operation. Also if so instructed by the Engineer, an anti-erosion compound shall be applied.

i. Sprigging**i. Description**

This work shall consist of planting sprigs in conformity with these Specifications at the locations shown on the Drawings or required by the Engineer for the protection of slopes against erosion.

ii. Materials**1. Sprigs**

Sprigs shall be healthy, living stems with attached roots of perennial turf-forming grasses harvested without adhering soil and obtained from approved sources in the locality of the work where the sod is dense and well rooted. The presence of weeds or detrimental materials will be cause for rejection.

The grass sprigging shall consist of local varieties of *Stenotaphrum secundatum*, *Cynodon dactylon* or *Pennisetum clandestinum* grass or other grass seeds approved by the Engineer.

2. Fertiliser

Fertiliser shall consist of an approved compound containing not less than 10 % nitrogen, 15 % phosphoric acid and 10 % pot-ash or similar approved composition.

iii. Construction**1. Topsoiling**

Where directed by the Engineer the face of slopes or benches shall be covered with a layer of topsoil, as described in **CLAUSE 8602 (g)**.

If topsoil is not available in the project area or soil and moisture conditions are generally not favourable for growth of grass, planting of grass should be tried on small sections of clay and sand slopes prior to planting of large areas.

All surfaces shall, immediately before planting, be reduced to a fine tilth to a depth of 150 mm and free from stones greater than 25 mm.

2. Fertilisation

Fertilisation shall be carried out with an even distribution. The rate of application shall not be lighter than 70 kg to 1000 square metres.

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iv. Sprigging

1. Harvesting sprigs

The Contractor shall obtain the Engineer's approval for the source of sprigs and shall notify the Engineer at least 5 days before the sprigs are to be harvested.

Sprigs that have dried out or are otherwise damaged during harvesting or delivery shall be rejected.

2. Planting sprigs

Planting of sprigs shall preferably be carried out at the beginning of a rainy season. Not more than 24 hours shall elapse between harvesting and planting sprigs.

Sprigging shall not be done during windy weather or when the ground is dry, excessively wet, or otherwise untillable. If the soil is not moist when the sprigs are being set water shall be applied until the soil is moist and in a workable condition. One or more of the following methods shall be used which shall be shown on the Drawings or ordered by the Engineer:

Row Sprigging: Furrows shall be opened along the approximate contour of slopes at the spacing and depth indicated on the Drawings or as instructed by the Engineer. Sprigs shall be placed at intervals not exceeding 150 mm in a continuous row in the open furrow and shall be covered immediately.

Spot sprigging: Spot sprigging shall be performed as specified under row sprigging, except that instead of planting in continuous rows groups of four sprigs or more shall be spaced 400 mm apart in the rows.

Alternative methods of planting shall be subject to the approval of the Engineer.

v. Maintenance of sprigged areas

The Contractor shall regularly water and maintain sprigged areas in a satisfactory condition for the duration of the Contract and until the end of the Defects Notification Period.

8606 Maintaining the Grass

a. Watering, Weeding, Mowing And Replanting

All sodded and grassed areas shall be adequately watered at regular and frequent intervals to ensure the proper germination of seeds and growth of grass until the grass has established an acceptable cover and thereafter until the beginning of the Defects Notification Period. The quantity of water and the frequency of watering shall be subject to the Engineer's approval. With hydro-seeding the commencement of watering may be postponed until a favourable time of the year, but watering shall in any case commence as soon as the seeds have germinated and growth has started.

The Contractor shall further mow the grass on all areas where grass has been established until the end of the Defects Notification Period and whenever so instructed by the Engineer. All grass cuttings shall be collected and disposed of if so directed by the Engineer. Weeds shall be controlled by approved means. Any bare patches where the grass has not taken or where it has been damaged or has dried out shall be re-cultivated, planted, sodded or hydroseeded at the Contractor's own expense.

All grassed areas shall have an acceptable cover as defined below at both the beginning and the end of the Defects Notification Period.

b. Acceptable Cover

An acceptable grass cover shall mean that not less than 75 % of the area grassed or hydro-seeded shall be covered with grass and that no bare patches exceeding 0.25 m² in any area of 1.0 m x 1.0 m shall occur. In the case of sodding, acceptable cover shall mean that the entire area shall be covered with live grass at the end of any period not less than three months after sodding.

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8607 Trees, Shrubs and Hedging Plants

a. Positions of Trees and Shrubs

Trees and shrubs shall be planted at locations shown on the Drawings or at other locations instructed by the Engineer.

b. Preparing Plant Holes

Unless otherwise directed by the Engineer, holes shall be spaced and prepared as follows:

- i. All holes shall have loosened sides and bottoms to prevent root balling of plants and trees.
- ii. Holes for hedge plants and shrubs shall be at least 500 mm diameter by 600 mm deep and 1.5 m from centre to centre. Alternatively a 500 mm wide trench 600 mm deep may be dug.
- iii. Holes for trees shall be at least 600 mm diameter by 700 mm deep.
- iv. The holes for plants shall be refilled with selected and approved topsoil thoroughly mixed with manure or compost (one heaped spadefull added to every plant hole) and, depending on soil-test reports, the required quantity and type of fertiliser.
- v. The holes shall be thoroughly watered before plants are placed. Where the soil is poorly drained 150 mm of crushed stone shall be placed at the bottom of the hole before it is filled with soil.

c. Planting

Before trees, shrubs and hedging plants are removed from their containers for planting, they shall be well watered.

Directly after having been planted each plant shall be well watered with a view to settling the soil. After the soil has settled, additional soil shall be added where necessary to bring the replaced soil in the hole to within 150 mm of the ground surface so as to ensure that sufficient water can be retained in the hole around the plant. All trees shall be tied to a suitable creosote-treated timber stake with a minimum diameter of 35 mm or other suitable stake as approved by the Engineer and firmly planted in the ground. The stake shall be 300 mm longer than the planted tree and its maximum length shall be 1.5 m above ground level. After planting the ground surface around the plant shall be covered with straw or grass or any other type of mulch to minimise evaporation.

d. Maintenance

During the Defects Notification Period the Contractor shall be responsible for watering the trees, shrubs and hedges and keeping the plants free from weeds and pests.

Every hedge, plant, tree or shrub which is not healthy or shows unsatisfactory growth shall be replaced by the Contractor at their own expense within one month of having been notified in writing by the Engineer.

8608 General

a. Time of Planting

Grass, trees and shrubs shall be planted as far as is practicable during periods of the year most likely to produce best growing results. The Contractor shall make every effort to programme operations in such a manner that grass, trees and shrubs shall be planted during this period.

b. Traffic on Grassed Areas

The Contractor shall not plant any grass until all the passage of road-building equipment has ceased. No road-building equipment, trucks or water carts shall be allowed onto areas which have been grassed and only equipment required for the preparation of areas, application of fertiliser, spreading of topsoil, watering and mowing will be allowed to operate on areas to be grassed. All damaged areas shall be reinstated by the Contractor at their own expense.

c. Erosion Prevention

During construction the Contractor shall protect all areas susceptible to erosion by installing all the necessary temporary and permanent drainage works as soon as possible and by taking such other measures as may be necessary to prevent the surface water from being concentrated in streams and from scouring the slopes, banks or other areas.

All side slope areas which consist of a sandy material shall be hydro-seeded with the addition of an anti erosion compound. The application rate will be as specified by the manufacturer. PAM (Polyacrylmide) or a suitable alternative may be used.

Payment for the supply of the anti erosion compound will be made under SUBITEM 86.08 (i) and (ii).

Vetiver zizanioides (Vetiver grass) is to be planted as a soil conservation system of "Vegetative Contour Hedges" to minimise the erosion potential of surface water run-off where directed by the Engineer. The Vetiver grass slips are to be separated from the grass clump and planted in rows running parallel to the contour and at spacings of 10-15 centimetres apart. The rows of Vetiver grass are to be spaced at distances varying between 1 and 5 metres on 1:1.5 to 1:4 side slopes. On gentle sloping areas the distances between the rows can increase up to 30 metres apart.

Vetiver Hedge Rows can be considered for protection to cut and fill slopes, bridge approach embankments, gullies and storm water and culvert outlets. Vetiver grass is available in Kenya.

Any runnels or erosion channels developing during the construction period or during the defects liability period shall be backfilled and compacted and the areas restored to the required profiles. The Contractor shall not allow erosion to develop on a large scale before effecting repairs and all erosion damage shall be repaired as soon as possible and in any case not later than three months before the termination of the Defects Notification Period. All topsoil or other material accumulated in side drains shall be removed at the same time. Topsoil washed away shall be replaced.

d. Proprietary Brand Materials Used For Erosion Prevention

Certain proprietary brands of materials may be necessary for erosion prevention to enable natural grass to become established. In such case the specific brand shall be as described in the Special Specifications. The method of applying the material, the required surface preparation, the type of material to be provided and the method of payment, shall be as set out in the Special Specifications.

The bid rates shall include full compensation for trimming the areas to the specified finish requirements and the removal of surplus material and stones. Payment shall distinguish between machine trimming, which can reasonably be done by bulldozer or motor grader, and hand trimming.

e. Responsibility For Establishing An Acceptable Cover

The Contractor shall be solely responsible for establishing an acceptable grass cover and for the cost of replanting grass or re-hydroseeding where no acceptable cover has been established. Where however, in the opinion of the Contractor, it is doubtful from the outset if it will be possible to establish an acceptable cover the Contractor may inform the Engineer of their reasons and the Engineer may, if they agrees, either adopt another method of grassing or agree to accept whatever cover can be obtained provided that all reasonable efforts shall be made to establish a good grass cover by the proposed method. Any such agreement shall be valid only if given in writing by the Engineer beforehand.

In the case of grassing by topsoiling only, the Contractor will not be held directly responsible for establishing an acceptable grass cover, but will be held responsible for the consequences of supplying workmanship which does not conform to the Specifications or for lack of proper care.

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f. Re-fertilising

Should it become necessary the Engineer may instruct the Contractor to undertake a re-fertilising programme on grassed areas during the twelve month Defects Notification Period. Payment for re-fertilisation will be made under SUBITEM 86.03(e).

8609 Measurement And Payment

Item	Unit
86.01 Trimming:	
(a) Machine Trimming	Square Metre (m ²)
(b) Hand Trimming	Square Metre (m ²)

Note: All bulk earth-moving operations as described under shaping in SUBCLAUSE 8603(a) shall be measured and paid for under SECTION 3600.

The unit of measurement for trimming shall be the square metre of area trimmed on the instruction of the Engineer including areas trimmed after having been shaped. No trimming within the road prism shall be measured for payment.

Item	Unit
86.02 Using Machines For Trimming Or Shaping (Alternative To SUBITEM 86.01(a)):	
(a) Bulldozer	Hour (h)
(b) Motor Grader	Hour (h)

The unit of measurement shall be the hour actually worked by each machine in trimming or shaping areas. Standing time will not be measured.

The bid rates shall include full compensation for furnishing and using the machines, including the cost of fuel, operators, remedying any defects, transporting the machine to and from the point where it is to be used, and for all other incidentals necessary for carrying out the work.

Item	Unit
86.03 Preparing The Areas For Grassing:	
(a) Ripping	Hectare (ha)
(b) Ploughing	Hectare (ha)
(c) Topsoiling Within the Road Reserve, Where the Following Materials Are Used:	
i Topsoil Obtained From Within the Road Reserve or Borrow Areas (Free-Haul 1.0 Km)	Cubic Metre (m ³)
ii Topsoil Obtained From Other Sources by the Contractor (Including All Haul)	Cubic Metre (m ³)
(d) Topsoiling of Borrow Pits by Using Topsoil Obtained From Borrow Areas or From The Road Reserve (Free-Haul 1.0 Km)	Cubic Metre (m ³)
(e) Providing And Applying Chemical Fertilisers and/or Soil-Improvement Material:	
i Lime	Tonne (t)
ii Super-Phosphate	Tonne (t)
iii Limestone Ammonium Nitrate	Tonne (t)
iv 2:3:2(22)	Tonne (t)
v 3:2:1(25)	Tonne (t)
vi Other Fertilisers and/or Soil-Improvement Materials if Required (Type Stated)	Tonne (t)
(f) Stockpiling Topsoil	Cubic Metre (m ³)

a. Ripping

The unit of measurement for ripping shall be the hectare of soil ripped. Only areas ripped on the written instructions of the Engineer shall be measured for payment.

The bid rate shall include full compensation for ripping, complete as specified.

Ploughing for loosening the soil will be paid for under SUBITEM 86.03(b).

b. Ploughing

The unit of measurement for loosening the topsoil by ploughing shall be the hectare of soil loosened and prepared in accordance with the Specifications. Only areas loosened by ploughing on the written instructions of the Engineer shall be measured for payment.

The bid rate shall include full compensation for loosening the topsoil by ploughing, removing stones, and levelling and trimming the surface.

c. Placing the Topsoil

The unit of measurement shall be the cubic metre of topsoil applied at the specified thickness or as directed by the Engineer measured in situ after the topsoil has been placed. The quantity shall be calculated from the net area of the topsoiled surface multiplied by the average thickness of the topsoil but before the grass sods are placed. Any topsoil placed in excess of the average thickness specified or prescribed will not be measured for payment.

Payment shall distinguish between topsoil obtained from designated areas within the road reserve or borrow areas and topsoil obtained by the Contractor from outside sources when sufficient topsoil is not available from the designated areas mentioned above. Payment shall further distinguish between topsoil applied to areas within the road reserve such as slopes and topsoil applied at borrow areas.

The bid rates shall include full compensation for excavating and loading the topsoil, any royalties or compensation that may be payable in the case of topsoil under SUBITEM 86.03(c), transport (except overhaul), off-loading, placing and spreading it to the required thickness, levelling it off to a smooth surface, for removing any stones as specified and for roughening the surface to be topsoiled.

The free-haul distance of topsoil obtained from the road reserve or borrow areas shall be 1.0 km. The bid rate for topsoil under SUBITEM 86.03(c) shall also include full compensation for transporting the topsoil to the point of eventual use.

d. Providing and Applying Fertiliser and/or Soil-improvement Material

The unit of measurement for fertiliser shall be the tonne of each type of fertiliser and/or soil-improvement material ordered and applied.

The bid rates shall include full compensation for furnishing the fertiliser and/or soil-improvement material, transporting it to the point of use, spreading and mixing it into the scarified soil or topsoil, irrespective of the method of application.

e. Stockpiling the Topsoil

The unit of measurement shall be the cubic metre of topsoil stockpiled on the written instructions of the Engineer where this operation is unavoidable despite proper advance planning. Only material actually loaded, transported to and stockpiled on sites designated for stockpiling will be measured but not any material merely pushed or bladed into heaps next to the area from which it is taken unless this was done with the prior approval of the Engineer and the material was stockpiled in an approved area.

The bid rate shall include full compensation for loading the topsoil, placing it in stockpile and for any payments to private Owners for the use of stockpile areas.

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Item	Unit
86.04 Grassing:	
(a) Planting Of Grass Cuttings (Type Of Grass As Indicated)	Hectare (ha)
(b) Sodding By Using The Following Types Of Sods:	
i Nursery Sods (Type Of Grass Specified)	Square Metre (m ²)
ii Bush Sods	Square Metre (m ²)
(c) Hydroseeding	
i Providing An Approved Seed Mixture For Hydroseeding	Kilogram (kg)
ii Hydroseeding	Hectare (ha)
(d) Planting Grass Seed With An Approved Grass-Planting Machine	Hectare (ha)
(e) Hand Sowing	Square Metre (m ²)
(f) Other Methods (Specify)	(Specify)

a. Planting Grass Cuttings

The unit of measurement for planting grass cuttings shall be the hectare of established grass with an acceptable grass cover.

The bid rate shall include full compensation for furnishing and planting the cuttings, watering, weeding, and replanting if necessary, and all other incidentals which may be necessary for establishing an acceptable cover and maintaining the grass, except mowing.

b. Sodding

The unit of measurement for sodding shall be the square metre covered with sods, which has an acceptable cover.

The bid rates shall include full compensation for procuring, excavating, loading, transporting, off-loading, placing and watering the sods, for replanting dead areas, for watering and weeding the grass, for supplying and placing timber stakes and for all other incidentals, except for mowing, which may be necessary for establishing an acceptable cover and maintaining the grass. Payment shall distinguish between nursery-grown sods and bush sods obtained from within the road reserve or borrow areas. In the case of bush sods the bid price shall include levelling-off and trimming areas from which the sods are taken.

c. Hydroseeding

- i. The unit of measurement for providing seed shall be the kilogram of seed of the specified seed mixture. The mass of any pulp added shall not be measured.

The bid rate shall include full compensation for procuring and furnishing the seeds.

- ii. The unit of measurement for hydro-seeding shall be the hectare of grass established by hydro-seeding, which has an acceptable cover.

The bid rate shall include full compensation for furnishing cellulose pulp and mixing it with seed and water and with any anti-erosion compound if required, applying the mixture, watering, weeding, re-hydro-seeding bare patches, and for any other work, except mowing, which may be necessary for establishing an acceptable cover and maintaining the grass.

d. Grassing With an Approved Grass Planter

The unit of measurement for planting any grass seeds by using an approved planter shall be the hectare of grass with an acceptable cover, where the seed has been planted with an approved planter.

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The bid rate shall include full compensation for all labour, material, equipment, weeding, and all incidentals which may be necessary for planting the grass seeds and establishing an acceptable grass cover. The bid rate shall also include full compensation for watering the planted areas until an acceptable grass cover has been established. Payment for the grass seed will be separate under SUBITEM 86.04(c).

e. Hand-sowing

The unit of measurement for hand-sowing the grass seeds shall be the square metre of grass with an acceptable covering on surfaces instructed by the Engineer to be hand-sown.

The bid rate shall include full compensation for all labour, materials, equipment, weeding, and all incidentals that may be necessary for planting the grass seeds and establishing an acceptable grass covering. The bid rate shall also include full compensation for watering the planted areas until an acceptable grass covering has been established. Payment for the grass seeds shall be separate under SUBITEM 86.04(c).

f. Other methods

Whenever other methods of grassing are indicated in the Special Specifications, measurement and payment shall be as specified.

g. General

Half the payments under ITEM 86.04 will become due when the grassing or hydroseeding has been done, and the remainder will become due when satisfactory cover has been established.

Item	Unit
86.05 Watering The Grass When Established By Topsoiling Only:	Kilolitre (kl)

The unit of measurement for watering areas which have been topsoiled on the instruction of the Engineer but which have not been hydro-seeded or planted with grass, shall be the kilolitre of water applied on the instructions of the Engineer and calculated from the number of tank loads applied, multiplied by the capacity of the tank used in each case.

The bid rate shall include full compensation for procuring, transporting and applying the water as specified.

Item	Unit
86.06 Watering The Already Planted Grass, Trees And Shrubs Planted During Periods Of Drought Experienced During The Growing Season:	Kilolitre (kl)

The unit of measurement for watering the grass, trees and shrubs shall be the kilolitre of water used.

The bid rate shall include full compensation for obtaining, transporting and applying the water.

The Contractor shall keep a careful record of the quantity of water used for watering the grass, trees and shrubs planted and shall submit such information to the Engineer on a daily basis. When there are times during the normal growing season when the monthly rainfall figure is less than 75 % of the monthly average, the Contractor will be compensated under this Item for the same percentage of the quantity of water used for watering as that for the monthly rainfall that fell short of the average rainfall.

Item	Unit
86.07 Mowing The Grass:	Hectare (ha)

The unit of measurement shall be the hectare measured each time when the grass has been cut which shall be in accordance with the performance specification for maintenance of the road reserve.

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The bid rate shall include full compensation for all plant, equipment and labour, required for every cutting of the grass and disposing of the grass cuttings.

Item	Unit
86.08 Anti-Erosion Compound (Specify):	Kilogramme (kg)

The unit of measurement shall be the kilogram net mass of anti-erosion compound used with the approval of the Engineer.

The bid rate for each kilogram of anti-erosion compound applied with the hydro-seeding or by itself shall include full compensation for furnishing the material and mixing and applying it during hydro-seeding or by itself.

Item	Unit
86.09 Trees And Shrubs:	
(a) Providing The Trees And Shrubs (Types Indicated)	Number (No.)
(b) Planting And Establishing:	
i Trees	Number (No.)
ii Shrubs	Number (No.)

Unit of measurement shall be the number of each species or variety of tree and shrub furnished and established.

The bid rate shall include full compensation for furnishing the plants at the point of final use including substitutes for plants which may become diseased or die.

The unit of measurement shall be the number of each type planted and established.

The bid rates shall include full compensation for excavating the holes to the specified dimensions, furnishing topsoil, wooden stakes, crushed stone, manure and compost and mixing them together with any fertiliser required for planting and refilling each hole with the topsoil mixture and other soil, for watering the plants until the end of the Defects Notification Period, furnishing and planting substitutes for plants that have died and for maintaining the plants as specified until the end of the Defects Notification Period, including any other incidentals which may be necessary for properly executing the work. Where the Employer furnishes the plants, the above rates shall also include full compensation for taking delivery of the plants, maintaining them as required, transporting them to point of final use, and for providing substitutes for plants which die or become diseased during storage.

Any chemical fertiliser and/or soil-improvement material required will be measured and paid for under SUBITEM 86.03(e).

Item	Unit
86.10 Extra Work For Landscaping:	Provisional Sum

The provisional sum allowed shall be expended at the discretion of the Engineer to cover the cost of work in addition to the scheduled Items which may be required in respect of shaping and trimming areas where plant is used at hourly rates, e.g. the cost of loading and transporting surplus material, establishing grass by topsoiling only, repairing erosion damage after topsoil has been applied or any other Items of work required for which no pay Items have been provided.

Payment shall be made as specified in SUBCLAUSE 1209(f).

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Item		Unit
86.11	Weeding All Grass-Seeded Areas And The Grass When Established By Topsoiling Only:	Hectare (ha)

The unit of measurement for weeding all grass-seeded areas that have been topsoiled on the instruction of the Engineer (but have not been hydro-seeded or planted with grass), shall be the hectare.

The bid rate shall include full compensation for weeding the prescribed areas in accordance with the Specifications.

h. Sprigging

Item		Unit
86.12	Sprigging:	Square Metre (m ²)

The quantity to be measured for payment shall be the number of square metres of sprigging which has been planted in accordance with these Specifications and accepted.

The quantity measured as prescribed above shall be paid for at the Contract unit price for the pay Item which price and payment shall be full compensation for furnishing and placing of all materials, fertilisers, water, labour, equipment, tools, transport and all costs necessary to complete the work as prescribed in this section.

i. Haulage

No overhaul shall be paid for any operations in this section.

Item		Unit
86.13	Soil Analysis Of Topsoil Taken From The Site:	Number (No.)

The quantity to be measured for payment shall be the number of soil analysis undertaken on topsoil samples taken from the Site in accordance with the Specifications or instructed by the Engineer.

The quantity measured as prescribed above shall be paid for at the bid rate, which price shall be full compensation for taking topsoil sample, laboratory testing and preparation of soil analysis report with recommendation on type and quantity of fertiliser / soil-improvement material, including all labour, equipment, tools, transport and all costs necessary to complete the soil analysis.

SECTION 8700 Finishing The Road, Road Reserve & Treating Old Roads

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8701 Scope

This section covers the final finishing and cleaning up of the road and road reserve after construction, and scarifying and treating old roads and temporary deviations.

This section does not cover the finishing which has to be done under SECTIONS 3100, 3400, 3600 and SECTION 8600, nor does it cover the finishing of temporary detours constructed by the Contractor for accommodation of traffic.

8702 Finishing The Road and Road Reserve

After completing the seal or surfacing, or gravel surface on gravel roads, the road and road reserve shall be cleared of all excess earth, stones, boulders, debris and other waste material resulting from the construction of the Works and disposed of in an approved waste site. All finishing and clearing not previously done or completed in accordance with the sections listed in CLAUSE 8701 above shall be completed. This specification, however, does not intend the finishing, clearing and maintenance which must be done as provided for in other sections of these Specifications to be postponed until the final finishing operations provided for in this section.

Culvert inlets and outlets, culvert barrels, and open drains shall be cleared of all debris, soil, silt and other material. The surfacing shall be cleared of all dirt, mud and foreign objects. Dragging, pushing or scraping material across the finished surfacing shall not be permitted.

All junctions, intersections, islands, kerbing and other elements making up the completed Works shall be neatly finished off.

The Contractor shall ensure that all declared noxious weeds have been removed from the road reserve and borrow pit areas. All noxious weeds shall be burnt to prevent the spread of the seed and cut stumps or coppice shall be sprayed with a suitable herbicide.

All soil, stones, boulders and indigenous plant material resulting from the finishing operations shall be disposed of at locations not visible from the road and where they will not pollute water sources or create a hazard for livestock or wildlife (e.g. old borrow pits). All other waste such as drums, excess steel, litter, etc., which cannot be sold or recycled shall be dumped in an approved waste site. The Contractor shall make arrangements with the Owners of properties on which such materials are to be deposited. Disposal shall be carried out in a neat and uniform manner. Any borrow pits used for material disposal shall be finished off as described in CLAUSE 3106. Any other areas used for material disposal shall be shaped so as to blend with the surrounding area and to permit the re-establishment of vegetation. Should the Engineer require landscaping and grassing to be undertaken it shall be done in accordance with SECTION 8600.

8703 Treating Old Roads

All old roads, temporary deviations, haul roads and construction roads shall, in so far as is practicable, be levelled with the original ground. Surfaces shall be scarified and broken up to a depth of 150 mm for promoting plant growth. The old roads shall be rehabilitated as shown in the Drawings or as directed by the Engineer and shall be re-vegetated in accordance with SECTION 8600.

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Ancillary Roadworks | 8700 | Finishing the Road....

Where required by the Engineer in order to prevent soil erosion, banks, dykes or ditches shall be constructed over the old road to dimensions to be instructed. All roads and temporary deviations treated as above shall be left in a neat and tidy state.

8704 Measurement and Payment

Item	Unit
87.01 Finishing The Road And Road Reserve:	
(a) Dual Carriageway Road	Kilometre (km)
(b) Single Carriageway Road	Kilometre (km)

The unit of measurement shall be the kilometre of road measured along the centre line. No separate measurement shall be made of ramps at interchanges.

The bid rates shall include full compensation for clearing, trimming, disposing of material, tidying and all other work to be done for finishing off the road and road reserve as specified.

Any landscaping and grassing shall be measured and paid for under SECTION 8600.

Item	Unit
87.02 Treatment Of Old Roads And Temporary Deviations:	Kilometre (km)

The unit of measurement shall be the kilometre of old road or temporary diversion treated.

Any landscaping and grassing shall be measured and paid for under SECTION 8600.

The construction of banks, dykes or ditches shall be measured and paid for under SECTION 2100.

The bid rate shall include full compensation for levelling and scarifying any surfaces and tidying old roads and temporary deviations as specified.

No payment will be made in regard to treating haul roads and construction roads, for which the Contractor shall make allowance in their rates for appropriate relevant Items of work for reinstatement and finishing.

SERIES 9000 Environmental, Health, Safety & Social Aspects

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SECTION 9100 Environmental Protection And Waste Disposal

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9101 Scope

This section covers the environmental and social protection measures and waste disposal methods to be undertaken by the Contractor for all work on the Contract. The obligations herein do not prejudice any other clauses in this Specification.

The provision of this section shall apply in respect of the Contractor, Sub-contractors and to any of their site personnel, workforce or suppliers, who are engaged in the execution of the works.

9102 General

The Contractor shall comply with the Statutory Regulations in force in Kenya regarding environmental protection and waste disposal and shall liaise with the National Environmental Management Authority (NEMA) and other responsible national and local authorities.

The Contractor shall prepare an Environmental and Social Management Plan (ESMP) for the project and their operations relating to the Environmental and Social Impact Assessment (EISA) studies and the approved Environmental and Social Assessment (ESIA). The Environmental and Social Management Plan shall outline the potential environmental hazards and risks and provide an action plan to deal with the hazards, minimise the risks and mitigate adverse environmental impacts, including a general decommissioning plan covering all relevant aspects of the project.

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Environmental, Health, Safety & Social Aspects | 9100 |

The EMP shall contain, at a minimum but not limited to, the following components:

1. An implementation timetable for the ESMP measures that are integrated with the Contractor's work plan and timetable for the construction activities;
2. A table that identifies the Environmental and Social Site Officer (ESSO) as well as the names and responsibilities of each member of the Contractor's team that will be in charge of implementing the ESMP;
3. An organisation chart showing ESSO reporting directly to the construction project manager. The ESSO shall be available to participate in weekly meetings with the Environmental Health and Safety Supervisor appointed by the Engineer;
4. The procedures the Contractor will use for internal communication and coordination about the application, monitoring and control of the EMP measures. These procedures should include – at a minimum – the dissemination of environmental information and the EMP among the Contractor's employees, ongoing recording of the implementation of environmental measures, and corrective actions that will be taken in the event of failure by the Contractor's staff to comply with environmental requirements;
5. Reporting procedures.

Any deviations from the approved ESMP Implementation Plan must be submitted to the Engineer for approval.

The Environmental and Social Management Plan shall be submitted to the Engineer not later than 4 weeks after the notice to commence the Works and, following approval of which, the Contractor shall be required to adhere to all aspects of the Plan.

The Contractor shall, for those of his activities which have or are likely to have an impact on the environment, keep records relating to:

1. The amount and types of waste and by-products generated by the activity.
2. The economic value of the activity.
3. The observable effects on the environment and the actions taken to avoid, minimise or eliminate these effects.
4. How far, in the opinion of the Contractor, the provisions of the Statute have been complied with.

The Contractor shall be required to submit environmental progress reports to the Engineer on a regular basis.

During the course of the project the Contractor shall when required prepare detailed, project specific Decommissioning Plan(s) covering all aspects of the project including but not limited to; quarries, asphalt plant, borrow-pits, road deviations, camp sites, workshop, fuel and lubricant depots, field laboratory equipment and its accessories, electricity lines, water supply, unused construction materials, and housing facilities. The Decommissioning Plans should be submitted to the Engineer who will forward them to the Employer. A copy of the decommissioning Plan(s) will be submitted by the Contractor to NEMA for approval.

The Contractor shall afford the officials of the relevant authorities' free access to inspect the project site, plant, workshops and the like to check whether the provisions in the Statute are being complied with.

The Contractor shall at the end of the project prepare and submit to the Engineer a final environmental management report detailing how the environmental issues have been addressed during the course of the project and how the decommissioning plan has been complied with. The Engineer shall, if satisfied with the Contractor's submissions and compliance with the environmental obligations, forward the Environmental Management Report to the employer and NEMA for approval and the issue of a Compliance Certificate.

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Environmental, Health, Safety & Social Aspects | 9100 |

9103 Responsibilities For Environmental Issues

a. Responsibilities of the Environmental, Health and Safety Supervisor (EHSS)

The Engineer shall on commencement of the project appoint an Environmental, Health and Safety Supervisor who shall have direct responsibility for supervising the implementation and monitoring of the Environmental and Social Management Plan.

The Environmental, Health and Safety Supervisor will be responsible for the practical implementation and monitoring of the Environmental Management Plan and shall report directly to the Engineer in this regard. The EHSS shall periodically inspect and monitor operations on and off site and shall take the necessary action where required to ensure compliance with the requirements of the Environmental and Social Management Plan. The EHSS shall attend all regular site Works meetings for reporting, discussing and reviewing the performance of the Environmental and Social Management Plan (which shall be a standard Item on the agenda) and, in addition, shall meet with the Contractor on a weekly basis for the same purpose.

b. Responsibilities of the Contractor

The Contractor, their Sub-contractors and employees shall, firstly, try to minimise the impact that may result of the project activities and secondly, adhere to the mitigation measures set down in these specifications to prevent harm and nuisances on local communities and to minimise the negative impacts to the environment.

The contractual obligations of the Contractor and their Sub-Contractors include but not limited to:

- i. Work within the scope of contractual requirements and other tender conditions;
- ii. Appoint an Environmental and Social Site Officer (ESSO) and a Health and Safety Officer (HSO);
- iii. Organise representatives of the maintenance/rehabilitation team to participate in the joint site inspections undertaken by the Supervisor;
- iv. Carry out any corrective actions instructed by the Engineer;
- v. Provide and update information to the EHSS regarding works activities which may contribute, or be continuing to the generation of adverse environmental conditions;
- vi. In case of non-compliances/discrepancies, carry out investigation and submit proposals on mitigation measures, and implement remedial measures to reduce environmental impact;
- vii. Stop maintenance/rehabilitation activities which generate adverse impacts upon receiving instructions from the Supervisor;
- viii. Propose and carry out corrective actions and implement alternative rehabilitation method, if required, in order to minimise the environmental impacts; identifying procedures applicable to the activities they control;
- ix. Compiling activity specific method statement to meet the procedures and targets;
- x. Submitting activity specific method statements to the EHSS for approval;
- xi. Devising a system for monitoring compliance with ESMP Implementation Plan;
- xii. Identifying environmental training needs and implementing the environmental awareness training program commissioned by the EHSS;
- xiii. Implementing corrective and preventative actions recommended by the EHSS;
- xiv. Review of EMP at monthly site meetings on site;
- xv. Review of EMP at weekly meetings on site with the EHSS; and
- xvi. Participating in external audits of the Environmental and Social Management Plan.

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c. Responsibilities of the Environmental and Social Site Officer

An Environmental and Social Site Officer (ESSO) must be appointed by the Contractor and approved by the Engineer; the ESSO will work in conjunction and close liaison with the EHSS and will be in charge of environmental and social issues at the construction site and will give instructions on the implementation of the environmental aspects during all project phases.

The ESSO will be familiar with and monitor and give recommendation on the execution of the Environmental and Social Management Plan (ESMP) and these responsibilities will include:

- i. Confirmation of legislative requirements for the construction works, and ensuring that appropriate permissions and permits have been obtained before commencing activities (eg for borrow pits and development of activities in the river bank);
- ii. Monitoring and ensuring compliance of all the workers to the specific contractual regulations;
- iii. Execution of environmental monitoring program;
- iv. Continuous contact with the subcontractors and with the local communities;
- v. Training of all the Contractor's workers and sub-contractors on environmental awareness and specifications as laid out in the contract; training sessions shall be held once every month for a minimum of one hour for each of the Contractor's Workforce and Key Employees;
- vi. Maintain a register of environmental training for site staff and sub-contractor's staff for the duration of the contract;
- vii. Ensuring that all the disturbed areas during construction phase are efficiently rehabilitated as soon as possible;
- viii. Establishing communication channels with local community, local authorities and other interested and affected parties;
- ix. Monitoring the effectiveness of the implementation of the ESMP;
- x. Undertake daily site inspections accompanied by the EHSS or their representative to monitor environmental performance and conformance with the Environmental Specifications;
- xi. Participating in Site Meetings and reporting in a prescribed format on a scheduled timing to agreed with the Engineer's Representative;
- xii. Notify the Engineer's Representative, verbally and in writing, immediately in the event of any accidents or infringements of the Environmental and Social Specifications and ensure appropriate remedial action is taken.
- xiii. Notifying the Engineer's Representative, verbally and in writing at least 10 working days in advance of any activity he has reason to believe may have significant adverse environmental and Social impacts so that mitigatory measures may be implemented timeously; and
- xiv. Recording, in writing, all communication/correspondence with all pertinent stakeholders and other parties on environmental issues.

9104 Landscape Preservation And Re-Vegetation

a. General

The Contractor shall exercise care to preserve the natural landscape and shall conduct construction operations so as to prevent any unnecessary destruction, scarring, or defacing of the natural surroundings in the vicinity of the work. Except where clearing is required for permanent works, approved construction roads, or excavation operations, all trees, native shrubbery, and vegetation shall be preserved and shall be protected from damage by the Contractor's construction operations and equipment. The edges of clearings and cuts through trees, shrubbery, and vegetation shall be irregularly shaped to soften the undesirable visual impact of straight lines. Movement of labour and equipment within the right-of-way and over routes provided for access to the work shall be performed in a manner to prevent damage to grazing land, crops, or property.

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Except as otherwise provided in these Specifications special reseeding or replanting will not be required; however, on completion of the work, all work areas not seeded shall be scarified and left in a condition which will facilitate natural re-vegetation, provide for proper drainage, and prevent erosion. All unnecessary destruction, scarring, damage, or defacing of the landscape resulting from the Contractor's operations shall be repaired, replanted, reseeded or otherwise corrected as directed by the Engineer, all at the Contractor's expense.

The species used for replanting must not be listed as a noxious weed and the seed blends used must not contain seeds from such species.

The use of fertiliser can only be carried out with the approval of the Engineer. In proximity to open water and where permeable soils are present near drinking water sources or aquifers, the use of fertilisers or manure is to be avoided. When available well decomposed compost should be used instead of manure.

The Contractor must not allow leachates to percolate to open water areas or otherwise cause nutrients to pollute any sub surface water bodies. The Engineer's approval should be obtained before application of any fertiliser.

b. Construction Roads

The location, alignment, and grade of construction roads shall be subject to approval of the Engineer. When no longer required by the Contractor, construction roads and surrounding areas shall be restored to the original contours and made impassable to vehicular traffic. The surfaces of such construction roads shall be scarified as needed to provide a condition which will facilitate natural re-vegetation, provide for proper drainage, and prevent erosion.

c. Construction Facilities

The Contractor's workshops, office, and yard area shall be located and arranged in a manner to preserve trees and vegetation to the maximum practicable extent. On abandonment, all temporary buildings, including concrete footings and slabs, and all construction materials and debris shall be removed from the site. The area shall be re-graded, as required, so that all surface drains blend with the natural terrain, and are left in a condition that will facilitate natural re-vegetation, provide for proper drainage, and prevent erosion.

d. Blasting Precautions

In addition to any requirements of local regulations, the Contractor shall adopt precautions when using explosives which will prevent scattering of rocks, stumps, or other debris outside the work area and prevent damage to surrounding trees, shrubbery, and vegetation.

e. Quarries, Borrow Pits And Storage Areas etc.

Problems with erosion in the borrow pit must be avoided by adopting an appropriate sequence of excavation and development of the borrow area. If necessary temporary banks or berms should be constructed together with any necessary surface drains.

When they are no longer required all quarry sites, asphalt plants, borrow pits and the like and areas used for the disposal or storage of surplus materials shall be reinstated by landscaping including the replacement and spreading of topsoil as directed by and to the satisfaction of the Engineer. Steep quarry walls shall be fenced to prevent livestock and people falling in the quarry. Permanent water holes shall be left unchanged unless very close to settlements. Under these circumstances the local people should decide on the future of the water holes.

Material not capable of supporting vegetation shall be used as fill and subsequently evenly covered with top soil. Spoil from road building, excess stockpiled material etc. can only be used for fill in the borrow pit, provided it does not effect the hydrology of the site. If approved by the Engineer any excess material remaining which cannot be disposed of by backfill to borrow areas may be graded out and scarified along contours in a manner such as to avoid erosion.

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Haul roads must be scarified and the ground rehabilitated to its original condition. Earth banks constructed to prevent erosion and all damaged fences and structures are to be reinstated.

Particular attention shall be given to re-establishing appropriate drainage around human habitation where ponding of water may create a health hazard. Erosion mitigation measures shall be given priority to ensure that natural or man-made drainage is not obstructed.

It must be noted that the Taking-Over Certificate will not be issued before rehabilitation, including proper reshaping and replanting, of borrow pits has been carried out to the satisfaction of the Engineer.

9105 Temporary Soil Erosion Control

a. Scope

These Works shall consist of temporary control measures, as shown on the Drawings or required by the Engineer during the process of the Works, to control soil erosion and water pollution, by use of berms, dykes, silt fences, brush barriers, dams, sediment basins, filter mats, netting, gravel, mulches, grasses, slope drains, and other erosion control devices or methods. Appropriate control measures will be required to avoid deposition or wash out from the Works of high concentrations of sediments into wetlands, swampy areas and other particularly sensitive areas.

The temporary erosion control provisions shall be coordinated with permanent erosion control features to assure economical, effective and continuous erosion control throughout the period of the Works and thereafter.

b. Construction

A schedule of proposed temporary (and permanent) soil erosion control Works shall be developed by the Contractor at the commencement of the Contract in consultation with the Engineer and to their satisfaction.

The Contractor shall carry out (and maintain) temporary erosion control to prevent soil erosion that will adversely affect construction operations, damage adjacent properties, or cause contamination of adjacent streams or other watercourses, lakes, ponds, swamps or other areas of water impoundment. Such Works may involve construction of temporary berms, dykes, dams, sediment basins, slope drains or use of temporary mulches, mats, seeding or other control devices or methods as necessary to control erosion. Cut and fill slopes shall be seeded and mulched as the excavation proceeds, to the extent considered desirable and practicable by the Engineer.

Temporary erosion control may include construction outside the right-of-way where such work is necessary, as a result of roadway construction, such as borrow pit and quarry operations, haul roads and equipment storage sites.

The Contractor shall incorporate all permanent erosion control features as shown on the Drawings into the Works at the earliest practicable time as outlined in their schedule, to minimise the need for temporary erosion control measures.

Where erosion is a problem, clearing and grubbing operations shall be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter if conditions permit; otherwise, temporary erosion control measures may be required between successive construction stages.

The Engineer will limit the area of clearing and grubbing, excavation, borrow and embankment operations in progress commensurate with the Contractor's capability in keeping the finished grading, mulching, seeding and other permanent erosion control measures current in accordance with the schedule. Should seasonal limitations make such co-ordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified.

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The Engineer may increase or decrease the amount of surface area of erodible earth material to be exposed at any one time by clearing and grubbing, excavation, borrow and fill operations as determined by their analysis of project conditions.

In the event that temporary erosion control measures are required due to the Contractor's negligence, carelessness or failure to install permanent controls as part of the Works, scheduled or ordered by the Engineer, such Works shall be carried out by the Contractor at their own expense.

The Works prescribed in this CLAUSE shall not be measured for direct payment, but shall be considered as subsidiary Works, the costs of which will be deemed to be included by the Contractor in their rates in the Bill of Quantities for other Items of work.

9106 Preservation Of Trees And Shrubbery

a. Preservation

All trees and shrubbery which are not specifically required to be cleared or removed for construction purposes shall be preserved and shall be protected from any damage that could be caused by the Contractor's construction operations and equipment. Special care shall be exercised where trees or shrubs are exposed to high risk of damage by construction equipment, blasting, excavating, dumping, chemical damage, or other operations; and the Contractor shall adequately protect such trees by use of protective barriers or other methods approved by the Engineer. The removal of trees or shrubs will be permitted only after prior approval by the Engineer.

The layout of the Contractor's construction facilities such as workshops, warehouses, storage areas, and parking areas; location of access and haul routes; and operation in borrow and spoil areas shall be planned and conducted in such a manner that all trees and shrubbery not approved for removal by the Engineer shall be preserved and adequately protected from either direct or indirect damage by the Contractor's operations. Except in emergency cases or when otherwise approved by the Engineer, trees shall not be used for anchorage. Where such use is approved, the trunk shall be wrapped with a sufficient thickness of approved protective material before any rope, cable, or wire is placed.

The Contractor shall ensure that their staff and workers who are resident within camps do not cut trees or shrubs for use as firewood for cooking or heating. Woody materials removed of necessity from construction sites, as described above, may be used with the approval of the Engineer.

b. Repair or Treatment of Damage

The Contractor shall be responsible for injuries to trees and shrubs caused by their operations. The term "injury" shall include, without limitation, bruising, scarring, tearing, and breaking of roots, trunk or branches. All injured trees and shrubs shall be repaired or treated without delay, at the Contractor's expense. If damage occurs, the Engineer will determine the method of repair or treatment to be used for injured trees and shrubs as recommended by an experienced horticulturist or a licensed tree surgeon provided by and at the expense of the Contractor. All repairs or treatment of injured trees shall be performed under the direction of an experienced horticulturist or a licensed tree surgeon provided by and at the expense of the Contractor.

c. Replacement

Trees or shrubs that, in the opinion of the Engineer, are beyond saving shall be removed and replaced early in the next planting season. The replacements shall be the same species, or other approved species, and of the maximum size that is practicable to plant and sustain growth in the particular environment. Replacement trees and shrubs shall be stayed, watered, and maintained for a period of 1 year. Any replacement tree or shrub that dies shall be removed and replaced, as directed by the Engineer, with such replacements being maintained for a period of 1 year from the date of replacement.

To obtain the maximum success with the planting, the trees shall be well suited for the environment. This will normally mean native species of trees or cultivated trees from local nurseries.

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9107 Prevention Of Water Pollution

a. General

The Contractor's construction activities shall be performed by methods that will prevent entrance, or accidental spillage, of solid matter, contaminants, debris, and other pollutants and wastes into streams, flowing or dry watercourses, lakes, and underground water sources. Such pollutants and wastes include, but are not restricted to, refuse, garbage, cement, concrete, sanitary waste, industrial waste, radioactive substances, oil and other petroleum products, aggregate processing tailings, mineral salts, and thermal pollution.

Dewatering work for structural foundations or earthwork operations adjacent to, or encroaching on, streams or watercourses shall be conducted in a manner to prevent muddy water and eroded materials from entering the streams or watercourses by construction of intercepting ditches, bypass channels, barriers, settling ponds, or by other approved means. Excavated materials or other construction materials shall not be stockpiled or deposited near or on stream banks, lake shorelines, or other watercourse perimeters where they can be washed away by high water or storm runoff or can in any way encroach upon the watercourse itself.

Turbidity increases in a stream or other bodies of water that are caused by construction activities shall be strictly controlled. When it is necessary to perform construction work in a water channel, the turbidity may be increased as approved by the Engineer for the shortest practicable period required to complete such work. Such construction work may include stream or river diversions, construction or removal of cofferdams, specified earthwork in or adjacent to a stream channel, pile driving, and construction of turbidity control structures. Mechanised equipment shall not operate in flowing water except as necessary to construct crossings or to perform the required work.

Wastewaters from aggregate processing, concrete batching, or other construction operations shall not enter streams, watercourses, or other surface waters without the use of such turbidity control methods as settling ponds, gravel-filter entrapment dikes, approved flocculating processes that are not harmful to fish, recirculation systems for washing of aggregates, or other approved methods. Any such wastewaters discharged into surface waters shall contain the least concentration of settleable material possible. For the purpose of these specifications settleable material is defined as that material which will settle from the water by gravity during a 1-hour quiescent detention period.

b. Compliance With Laws And Regulations

The Contractor shall comply with all applicable Kenyan laws, orders, regulations, and water quality standards concerning the control and abatement of water pollution.

Abstraction of both surface and underground water shall only be done with the consultation of the local community and after obtaining a permit from the relevant Water Authority.

If wells or other water sources are nevertheless polluted it is the responsibility of the Contractor to fully compensate for this and provide the consumers with clean drinking water from an unpolluted source if required in the opinion of the Engineer.

9108 Abatement Of Air Pollution

The Contractor shall comply with applicable Kenyan laws and regulations concerning the prevention and control of air pollution.

Notwithstanding the above in conduct of construction activities and operation of equipment, the Contractor shall utilise such practicable methods and devices as are reasonably available to control, prevent, and otherwise minimise atmospheric emissions or discharges of air contaminants.

The emission of dust into the atmosphere shall be strictly controlled during the manufacture, handling, and storage of concrete and road aggregates and the Contractor shall use such methods

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and equipment as are necessary for the collection and disposal, or prevention, of dust during these operations. The Contractor's methods of storing and handling cement and pozzolans shall also include means of eliminating atmospheric discharges of dust.

Equipment and vehicles that show excessive emissions of exhaust gases due to poor engine adjustments, or other inefficient operating conditions, shall not be operated until corrective repairs or adjustments are made.

Burning of materials resulting from clearing of trees and brush, combustible construction materials, and rubbish will be permitted only when atmospheric conditions for burning are considered favourable and when authorised by the Engineer. In lieu of burning, such combustible materials may be disposed of by other methods as provided in this SPECIFICATION. Where open burning is permitted, the burn piles shall be properly constructed to minimise smoke, and in no case shall unapproved materials, such as tires, plastics, rubber products, asphalt products, or other materials that create heavy black smoke or nuisance odours, be burned.

9109 Dust Abatement

During the performance of the work required by these specifications or any operations appurtenant thereto, whether on the right-of-way provided by the Employer or elsewhere, the Contractor shall furnish all the labour, equipment, materials and means required, and shall carry out proper and efficient measures wherever and as often as necessary to reduce the dust nuisance and to prevent dust which has originated from their operations from damaging crops, orchards, cultivated fields and dwellings, or causing a nuisance to persons or be detrimental to livestock. The Contractor will be held liable for any damage resulting from dust originating from their operations under these specifications on the right-of-way or elsewhere. The Engineer may direct sprinkling or other measures for dust abatement if necessary to obtain adequate control.

9110 Noise Abatement

The Contractor shall comply with applicable Kenyan laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise. The Contractor should adopt practical methods including limits on working hours, to minimise construction noise emanating from worksites that are within 100 m of noise sensitive institutions such schools, hospitals and places of worship. Noise meters shall be used to establish appropriate decibel levels for particular activities and acceptable limits set in consultation with those affected, the engineer and a representative of NEMA and/or the local government official responsible.

Workers shall be sufficiently supplied with ear protection and instructed in the use thereof. The Engineer or their representative responsible for Health and Safety on the Work site may instruct the Contractor to provide workers with ear protection if he considers it necessary.

Blasting, the use of jackhammers, pile driving, rock crushing, or other operations producing high-intensity impact noise may be performed at night only upon approval of the Engineer.

9111 Light Abatement

The Contractor shall exercise special care to direct all stationary floodlights to shine downward at an angle less than horizontal. These floodlights shall also be shielded so as not to be a nuisance to surrounding areas. No lighting shall include a residence in its direct beam.

The Contractor shall be responsible for correcting lighting problems when they occur as directed by the Engineer.

9112 Protection Of Wildlife

The Contractor shall ensure that the siting of their facilities such as workshops, camps, offices etc. and their activities do not jeopardise movements, eating reproductive habits or in any other way disturb animal life, other than common animals such as insects. The Contractor's staff and workers must not hunt or kill wild animals for game meat at any time unless licensed to do so or have other authority from the relevant Government Authority.

9113 Preservation Of Historical And Archaeological Data

The Contractor shall comply with the requirements of the General Conditions of Contract, or any instruction issued by the Engineer in this regard. Should the Contractor or any of their employees in the performance of this contract discover evidence of possible scientific, historical, prehistoric, or archaeological data he will notify the Engineer immediately giving the location and nature of the findings. Written confirmation shall be forwarded within 2 days. The Contractor shall exercise care so as not to damage artefacts or fossils uncovered during excavation operations and shall provide such cooperation and assistance as may be necessary to preserve the findings for removal or other disposition by the Employer.

Where appropriate by reason of a discovery, the Engineer may order delays in the time of performance, or changes in the work, or both. If such delays, or changes, or both, are ordered, the time of performance and contract price shall be adjusted in accordance with the applicable clauses in the Conditions of this Contract.

9114 Pesticides, Toxic Waste And Hazardous Substances

Pesticides include herbicides, insecticides, fungicides, rodenticides, piscicides, surface disinfectants, animal repellents, and insect repellents. Should the Contractor find it necessary to use pesticides in work areas of this contract, they shall submit a plan for such use to the Engineer for written approval.

The Contractor shall read and comply with all labelling requirements when using pesticides.

Toxic waste must be collected in appropriate containers (depending on the compound) and kept in an approved storage place. Depending on the compound in question different ways of disposal or destruction will be necessary.

It is the responsibility of the Contractor to seek the required permissions to handle substances or compounds that are defined as hazardous, i.e. the Contractor must be up to date on the definitions and regulations pertaining to hazardous substances. These are defined as substances (or compounds thereof) which may endanger the health of humans or animals or have a harmful impact on the environment by reason of its toxic, corrosive, irritant, sensitising, inflammable or radioactive nature. Hazardous substances are also such as deplete the ozone layer.

For hazardous substances a permit for possessing, handling, import etc. is needed. The Contractor must ensure that he obtains the necessary permits for hazardous substances from a Licensing Officer appointed by the Minister. The Contractor must allow a certified inspector to control the Contractor's handling of hazardous compounds.

9115 Cleanup And Disposal Of Waste Materials

a. Cleanup

The Contractor shall at all times keep the construction area, including storage areas used, free from accumulations of waste materials or rubbish.

All waste water and sewage from office, residential and mobile camps shall be piped to soak pits or other disposal areas constructed in accordance with local government regulations. Where and when such regulations require it the Contractor shall obtain a permit or other appropriate documentation approving the disposal methods being used.

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All used fuels, oils, other plant or vehicle fluids and old tyres and tubes shall be collected to a central disposal point on a regular basis and disposed of as specified below.

All household, office, workshop and other solid waste shall be collected to a central disposal area on a daily basis and disposed of in a manner approved by the Engineer.

Servicing of plant, equipment and vehicles shall, whenever possible, be carried out at a workshop area. This workshop area shall be equipped with secure storage areas for fuels, oils and other fluids constructed in such a way as to contain any spillages which may occur. A similar storage area shall be provided where used fluids can be stored securely prior to their disposal.

When servicing of plant, equipment and vehicles is carried out away from the workshop area it shall be done at locations and in such a manner as to avoid spillage and contamination of streams and other drainage courses. Any spillages shall be cleaned up by either burning in place or collecting the contaminated soils and burning them at the central disposal area, all to the satisfaction of the Engineer.

Prior to completion of the Works, the Contractor shall remove from the vicinity of the work site all plant facilities, buildings, rubbish, unused materials, concrete forms, and other like material belonging to them or used under their direction during construction. All work areas shall be graded and left in a neat manner conforming to the natural appearance of the landscape as provided elsewhere in the Specifications.

Any residue deposited on the ground from washing out transit mix trucks or any similar concrete operations shall be buried or cleaned up in a manner acceptable to the Engineer.

In the event of the Contractor's failure to perform the above work, the work may be performed by the Employer at the expense of the Contractor, and their final payment be adjusted accordingly or the Contractors surety or sureties shall be liable therefore.

b. Disposal of Waste Material

i. General

Waste materials including, but not restricted to, refuse, garbage, sanitary wastes, industrial wastes, and oil and other petroleum products, shall be disposed of by the Contractor. Disposal of combustible materials shall be by burying, where burial of such materials is approved by the Engineer; by burning, where burning of approved materials is permitted; or by removal from the construction area. Disposal of non-combustible materials shall be by burying, where burial of such materials is approved by the Engineer, or by removal from the construction area. Waste materials removed from the construction area shall be dumped at a licensed or otherwise approved dump.

ii. Disposal of material by burying

Only materials approved by the Engineer may be buried. Burial shall be in pits, the location, size and depth of which shall be approved by the Engineer. The pits shall be covered by at least 0.6 m. of earth material prior to abandonment.

iii. Disposal of material by burning

All materials to be burned shall be piled in designated burning areas in such a manner as will cause the least fire hazard. Burning shall be thorough and complete and all charred pieces remaining after burning, except for scattered small pieces, shall be removed from the construction area and disposed of as otherwise provided in this subclause.

The Contractor shall, at all times, take special precautions to prevent fire from spreading beyond the piles being burned and shall be liable for any damage caused by their burning operations. The Contractor shall have available, at all times, suitable equipment and supplies for use in preventing and suppressing fires and shall be subject to all laws and regulations locally applicable for pre-suppression, suppression, and prevention of fires.

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iv. Disposal of material by removal

Material to be disposed of by removal from the construction area shall be removed from the area prior to the completion of the Work under these specifications. All materials removed shall become the property of the Contractor.

Materials to be disposed of by dumping shall be hauled to an approved dump. It shall be the responsibility of the Contractor to make any necessary arrangements with private parties and with local officials pertinent to locations and regulations of such dumping. Any fees or charges required to be paid for dumping of materials shall be paid by the Contractor and shall be included in the prices bid in the Bill of Quantities for other Items of work.

9116 Reporting on Environmental and Social Matters

The reporting on environmental and social matters shall be undertaken as follows:

1. The ESSO shall complete a project Start-Up Inspection Sheet prior to the commencement of the contract (or at the site handover),
2. This inspection Sheet will be attached to the minutes of the first site meeting and forwarded to the EHSS,
3. The ESSO shall complete Routine Inspection Sheets monthly (or more often if required), which will form the basis of the environmental reporting required at site meetings,
4. The ESSO shall prepare and submit for approval a monthly ESMP implementation performance report in a format approved by the Engineer,
5. The ESSO shall complete a Site Closure Report on completion of the contract to be forwarded to the Engineer for approval,
6. The Contractor shall present monthly reports reflecting the performance of ESMP Implementation Plan. These reports will be subject to the approval by the Engineer, and
7. Instructions and communications on site to the Contractor, concerning environmental matters, shall be recorded in the site instruction book/site diary.

9117 Management of Environmental and Social Incidents

Procedures for the management of environmental and social hazards and incidents will be according to established best practice, by type, and will be documented in the ESMP Implementation Plan.

A report of all incidents will be presented and appropriate measures will be taken in each case to minimise any likely impacts.

The National Environmental Management Authority will be informed on any environmental incident, in accordance with the legal requirements.

The notification of an environmental incident and/or accidents will include but will not be restricted to the following aspects:

1. Location of the incident/emergency;
2. Relevant environmental authority;
3. Name and phone number of the designated contact person;
4. Time of the incident;
5. Suspected cause of the incident or emergency;
6. Environmental and social damage or disturbance caused or suspected to have been caused by the incident or emergency; and
7. Action taken to avoid future occurrence of the incident and to mitigate the impact caused by this incident.

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9118 Management Of Environmental and Social Complaints

The ESMP Implementation Plan will incorporate project Grievance Procedures, which may include grievances in relation to environmental management. The Grievance Procedures shall contain the following (amongst other):

1. Description of the issue/grievance;
2. Date of registration of the issue/grievance;
3. Identification of notifier of grievance;
4. Contact details of the person;
5. Description of the issue;
6. Proposed action to address the issue/grievance;
7. Expected time to address the issue/grievance;
8. Responsible person; and
9. Additional relevant information.

9119 Emergency Preparedness and Response

The ESMP will contain a Contingency, Accident, Emergency & Response Plan (CAERP) according to established best practice (for example the IFC/World Bank Environmental Health and Safety Guidelines).

The CAERP will be designed to reflect typical emergency situations associated with roads construction, maintenance and rehabilitation.

9120 External Audit and Report

In order to ensure that the Environmental and Social Management Plan is effectively implemented, it is important that regular external audits are carried out.

The Employer shall ensure that these external audits take place, and that a system for addressing any problems identified during these audits is formulated. The relevant documentation shall be kept on site and shall be available to the public.

The audits will be undertaken on at least a quarterly basis by an agent of the Employer in accordance with Terms of Reference agreed by Employer, the Engineer and the Contractor.

9121 Non-Conformities and Penalties

In cases of non-conformities detected by the Engineer directly or by the EHSS the Contractor shall be immediately notified verbally and confirmed in writing on prescribed notification forms within 48 hours.

The Contractor shall immediately take measures to rectify the problems identified by within the maximum of the grace periods indicated in the Environmental and Social Management Plan or such other time period as the Engineer reasonably will require.

In the case of matters relating to safety, the Contractor shall immediately rectify any problems identified by the Engineer. The decision as to whether a matter affects safety shall vest strictly and solely with the Engineer.

Should the Engineer be of the opinion that the environmental and social management measures are not being adhered to, and that the appropriate corrective action is not being implemented, the Engineer, advised by the EHSS, will be at liberty to instruct the Contractor to cease the related operations until the contractor complies with the relevant requirements. The contractor will not be entitled to any extension of time for such stoppages.

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Should the Contractor not comply with the instructions of the Engineer or fail to take corrective measures within the grace periods indicated for certain specific impacts as listed in the Environmental and Social Management Plan, penalties indicated in the same contractual document shall immediately be imposed. The imposition of the above penalties will not preclude the Engineer from stopping the works until the matter is rectified.

9122 Environmental and Social Management at Handover

Environmental and social management associated with the handover of the completed project must ensure that the following Items are addressed at closure and during the Defects Notification Period:

1. All cleared sites are rehabilitated with indigenous grass material;
2. All visible alien plants are removed from disturbed sites;
3. All recyclable rubble and waste, for example scrap metal, plastics and glass, are collected and disposed of through a registered recycling company;
4. All non-recyclable rubble and solid waste be collected and disposed of at a registered waste disposal facility; and
5. All borrow pits and quarries shall conform to the designed closure specifications, including drainage, slope stability, top-soiling and grass planting.

9123 Measurement and Payment

Item	Unit
91.01 Environmental And Social Management Plan And Reporting:	
(a) Preparation Of The Environmental And Social Management Plan	Lump Sum
(b) Submission Of Records And Periodic Reports	Lump Sum (monthly)
(c) Preparation Of Decommissioning Plan And Final Environmental And Social Management Report	Lump Sum

Payment for preparation of the Environmental and Social Management Plan and Report, Decommissioning Plan(s) and environmental and social records and reporting will be made at the lump sums entered in the Bill of Quantities for ITEM 90.01 on the following basis:

- a. The lump sum will be paid upon approval of the Contractor's Environmental and Social Management Plan.
- b. The lump sum will be paid on a pro rata basis over the period of the Contract upon submission of records on a monthly basis and interim reports as required by the Engineer or as detailed in the Special Specifications. Payment will be subject to the approval of the records and reports which shall be to the satisfaction of the Engineer.
- c. The final payment shall follow approval of NEMA and the issue of a Compliance Certificate.

No other payments will be made for any work included in this section. The costs of complying with these requirements shall be included in the Contractor's Lump Sums or rates for other Items of work.

SECTION 9200 Occupational Health & Safety, Hiv/Aids & Gender

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9201 Scope

The section covers measures and methods which the Contractor shall put in place to ensure Occupational Health and Safety (OHS), to prevent the spread of HIV/AIDS and STIs and to ensure equal employment opportunities for men and women as well as addressing their specific gender needs.

9202 General

The Contractor shall comply with among others the following Statutory Regulations, rules and bylaws with respect to OHS, HIV/AIDS and STI prevention, child protection and Gender equity:

- OHS:** The Occupational Safety and Health (Act 2007), the Fatal Accidents Act, the Public Health Act, the Factories and Other Places of Work Act, the Work injury benefits Act, the Trade Union Decree, the Employment Act and other statutory regulations, rules and bylaws that may be enacted from time to time by Government in respect of OHS.
- HIV/AIDS:** The HIV and AIDS Prevention and Control Act (2006) and the Employment Act obligates employees against discrimination against those with HIV and AIDS in employment opportunities. Further, the National multi-sectoral AIDS control approach (MAC) and the National Strategic Framework (NSF) for the HIV/AIDS prevention and care, which obligate line Ministries and the private sector to ensure that people living with HIV/AIDS are not discriminated against at the work places.
- Child Protection:** The Children Act, No. 29 of 2022 provides the legal basis against, child abuse, child labour, neglect, defilement, inhuman and degrading treatment, rape, gender-based violence, sex with minors and all forms of sexual abuse and harassment.
- Gender Equity:** The Employment Act, the National Commission on Gender and Development Act, and National Gender Policy (1997) and the Social Development Sector Strategic Investment Plan (2003) which provide for a legal basis for protecting women and their rights and to ensure affirmative action on the basis of gender. In addition the Act and the various policies provides for legal basis against discrimination in employment on the grounds of race, colour, sex, language, religion, nationality, ethnic or social origin, pregnancy and the like.

Together with the above, the Contractor's attention is also drawn to any current international protocols or convention on OHS to which the Government of Kenya is a signatory. In compliance with the above mentioned government and international regulations on OHS, HIV/AIDS and Gender equity and on the basis of available social impact assessment studies related to the project, the Contractor shall prepare an OHS, HIV/AIDS and Gender Management Plan which shall include details of measures he proposes to adopt in a bid to:

- Prevent and reduce accidents and injuries to the staff and workers and minimise health hazards to the adjacent community and general public.
- Prevent the spread of HIV/AIDS and STIs between their staff, labourers and the immediate local community.

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- c. Care for workers and staff who are infected with HIV/AIDS and STIs including provision of counselling and clinic services.
- d. Encourage the recruitment of men and women as well as addressing their specific gender working and living needs in the road construction environment.

The OHS, HIV/AIDS and Gender Management Plan shall be submitted to the Engineer not later than 4 weeks after the notice to commence the Work.

9203 Occupational Health And Safety

The Contractor shall ensure, so far as is reasonably practicable, the health, safety and welfare at work of their employees including those of sub-contractors and of all other persons on the Site. The Contractor shall comply with the Factories and other Places of Work Act, the Public Health Act, the Work injury benefits Act, the Employment Act and other Statutory Regulations, rules and byelaws regarding occupational health, safety and gender. In this respect the Contractor shall liaise with the relevant local Government agencies.

The Contractor's responsibilities shall, inter alia, include the requirements specified in the following SUBCLAUSES (a) to (i):

a. Safe Constructional Plant, Equipment And Methods Of Work

Provision and maintenance of constructional plant, equipment and systems of work that are lighted, safe and without risks to health. This shall include maintaining equipment, engines, and related electrical installations in good working order; maintaining a clean and tidy work space; providing guards and rails, signals and lighting; providing work site rules, safe working procedures and allocating appropriate places to carry out the work.

b. Safe Handling, Storage, Transport And Disposal

Execution of suitable arrangements for ensuring safety and absence of risk to health in connection with the use, handling, storage, transport and disposal of articles and substances.

Transportation of any material by the Contractor shall be in suitable vehicles which when loaded does not cause spillage and all loads shall be suitably secured. Any vehicle that does not comply with this requirement or any of the local traffic regulations and laws shall be removed from the Site.

The Contractor must ensure that all stores are located such as to reduce risks to the workers on site. Arrangements for the safe use, handling, storage, transport and disposal of articles and substance are to be made before work commences to the satisfaction of the Engineer.

c. Protective Clothing, Equipment etc.

Provision of protective clothing and equipment, first aid stations with such personnel and equipment as are necessary and such information, instruction, training and supervision as are necessary to ensure the health and safety at work of all persons employed on the Works all in accordance with the Laws of Kenya. The Contractor shall provide, at their own expense, protective clothing and safety equipment to all staff and labour engaged on the Works to the satisfaction of the Engineer. Provision shall also be made for supply of such clothing and equipment for official visitors to the site.

Such clothing and equipment shall include, at a minimum:

- i. High visibility vest for workers directing traffic;
- ii. Protective boots and gloves for the workforce undertaking concrete mixing work;
- iii. Protective boots, gloves and masks for the workforce performing bituminous pavement works;
- iv. Protective footwear, gloves, goggles, and dust mask for the workforce undertaking screening, crushing or grinding;

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- v. Protective footwear and hard hats for the workforce engaged in bridge construction and in all locations subject to rock fall;
- vi. Ear protectors and dust mask for the workforce engaged in rock drilling or in using vibrating equipment such as rollers and compactors.

If the Contractor fails to provide such clothing and equipment the Employer shall be entitled to provide the same and recover the costs from the Contractor.

d. Safety Officer

The Contractor shall designate a qualified Safety Officer (Accident Prevention Officer) from one of their senior staff who has specific knowledge of safety regulations, experience of safety precautions on similar works and who shall advise on all matters affecting the safety of the workforce and on measures to be taken to promote such safety.

The Safety Officer shall work full time directly on the project at the construction site. The Safety Officer might have other obligations in relation to similar topics, e.g. environment, social and/or medical aspects including HIV/AIDS prevention, as long as at least 50% of their time is devoted to Occupational Health and Safety.

The Safety Officer shall have specific training in the Contractor's safety and health management system and procedures, practice, etc. and before commencement of the Works, the Safety Officer shall receive training in (or receive a refresher course in) industrial first aid (or the equivalent).

The Safety Officer shall routinely provide workers with training in safe work practices and general awareness of potential danger situations to avoid injuries. Trained first aid personnel, transport for sick or injured workers, and an industrial first aid kit shall be available at each site at all times. The Contractor shall establish emergency evacuation procedures to enable a rapid response to accidents.

e. Safety Training And Awareness

All employees shall be given training on how to ensure their own personal safety and on ways to reduce the accident risk on those sites where large, mobile heavy vehicles and equipment or equipment with moving parts are in use. The Safety Officer shall provide training in safe work practices and general awareness of potential danger situations to avoid injuries. In addition, all employees handling dangerous/toxic materials shall be trained in how to handle dangerous/toxic materials.

All the Contractor's personnel shall, before starting to work, have an induction course on safety and health at the site. The information and training shall be on the site and have duration of at least two hours. It shall be conducted in English and, if necessary, also in a relevant local language to ensure that all personnel can understand the information and instructions. The Site Manager shall take part in at least the first part of the training. He shall present the Contractor's safety policy and goal, the responsibilities and roles in relation to safety and health of all individuals, and the more specific responsibilities and roles of key staff (Site Manager, Safety Officer, superintendents, foremen, and others).

The topics of the course can be, but are not limited to:

- i. Contractor's safety policy and goal.
- ii. Contractor's code of conduct.
- iii. Organisation of safety and health work and the responsibilities and roles of the Site Manager, the superintendents/supervisors/foremen, the Safety Officer and of each individual worker.
- iv. Mandatory use of personal protective equipment on the Site.
- v. Specification of the type of equipment, where and when to use it and how it shall be used, stored, cleaned and maintained correct.

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- vi. Placement and content of first aid equipment.
- vii. Use of fire extinguishers.
- viii. How to use the equipment and information on who are specially trained in first aid and how to contact them.
- ix. How to transport an injured person to a medical doctor or to the hospital.
- x. Safety rules for the site, e.g. in relation to the use of different equipment, tools, vehicles, fuel, oil, chemicals, explosives and abrasives.
- xi. Cleaning, housekeeping and maintenance of the site, including vehicles, equipment, tools, workshops, houses etc.
- xii. If work permits are required for specific tasks.
- xiii. Manual handling, transport, storage and disposal of equipment, goods, etc. in a safe way preventing accidents and too heavy burdens.
- xiv. How to ensure that equipment, goods, etc. will not be an obstacle imposing a risk to other persons due to inadequate placement and protection of it.
- xv. Welfare facilities and access to drinking water and water in case of skin burns on the site when handling asphalt.
- xvi. Procedure for specific instruction when working with new work function, machinery, tool, chemicals, etc.
- xvii. The use of safety signs and protective barriers.
- xviii. Safe use of fuel, oil, chemicals, explosives.
- xix. Prevention of dust generation and exposure.
- xx. Road safety aspects, sign posting and principles and measures for minimising the risk of traffic accidents.
- xxi. HIV/AIDS prevention (only an introduction, more information shall be provided within one month of the employment on the Site).
- xxii. Consequences of breach of discipline and not complying with rules.

Different induction courses can be held for different types of workers ensuring the correct weight on relevant topics, e.g. vehicle operators, workers in the quarry, workers in the asphalt plant, work shop workers.

A Safety Booklet written in English and Swahili shall spell out the most important aspects of occupational safety and health. The Safety Booklet may take its starting point in the Contractor's general description of safety and health, but it shall be very specific for contract works. The safety booklet shall be handed to all staff at the introduction course and used as training material. More training material might be relevant to use at the induction course.

f. Safe Access

The Contractor shall provide and maintain access to all places on the Site in a condition that is safe and without risk of injury.

g. Sanitation

The Contractor shall provide adequate waterborne sanitation; and refuse collection and disposal, complying with the Laws of Kenya and all local Bye-laws, to the satisfaction of the Engineer, for all houses, offices, workshops and laboratories erected on the camp site or sites.

h. Latrines and Other Sanitary Arrangements

The Contractor shall provide an adequate number of suitable latrines and other sanitary

arrangements at sites where work is in progress to the satisfaction of the Engineer and the Medical Officer in the area.

i. Control Of Harmful Insects and Other Dangerous or Poisonous Animals

The Contractor shall execute appropriate measures in consultation with the Public Health Authority to control within the Site, including the camp sites, mosquitoes, flies, snakes and pests including the application of suitable chemicals to breeding areas. Insect repellents and mosquito nets, preferably pre-treated, shall be supplied in areas of high malaria risk.

j. Reporting of Accidents and Incidents

The Contractor shall report details of any accident or incident to the Engineer and the Kenya Police, if appropriate, as soon as possible after its occurrence.

An updated accidents and incident register should be maintained on site.

k. Incident Root Cause Analysis (RCA) and Corrective Action Plan (CAP)

The Contractor shall carry out Root Cause Analysis after every accident and incident and develop a Corrective Action Plan.

l. Contagious Diseases

The Contractor shall manage the risk of spreading contagious diseases (e.g. cholera, tuberculosis) through awareness raising programmes, especially when workers come from outside the locality. The Contractor shall manage the risk of harassment and sexual assaults, especially for the female workers. The Safety Officer or Health Services shall inform the workers and the community about the danger of communicable diseases included those transmitted by insects, water, faecal / oral and sexual contact. Prophylaxis shall be provided to all workers free of charge if recommended by the Public Health Authority.

The Contractor shall comply with Government regulations in case of epidemic outbreaks.

m. Occupational Health Hazards

The Contractor shall reduce occupational health hazards, such as:

- i. Physical hazards (continuous noise and vibrations, prolonged stay in high temperatures).
- ii. Chemical hazards (exposure to fumes, chemicals and dust including solvents, paints, exhaust gases and possible carcinogens such as bitumen).
- iii. Mechanical hazards (unguarded or exposed moving objects and other dangers from the use and operation of machines).
- iv. Risk of accidents with hand tools (slips, falls, eye injuries) heavy Items (the accidental dropping of heavy Items) and vehicles.
- v. Thermal hazards (heat stroke from long hours working in direct sunlight and burns due to contact with hot Items (e.g. heated bitumen or the burner).
- vi. Electrical, fire or explosion hazards.
- vii. Ergonomic risk factors (personal injuries associated with poor working postures, heavy lifting, repetitive work, repetitive hand arm vibrations, manual transport).
- viii. Sanitation hazards (including contaminated drinking water, poor food practices, improper waste disposal, unhygienic toilet and washing facilities, contact with solid and/or biological waste).

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The means of reducing the occupational health hazards shall include:

1. Using vibration-reduced and sound-reduced equipment.
2. Providing shade at stationary work places and at welfare facilities.
3. Having only trained and experienced persons use dangerous chemicals and operate the machines.
4. Providing safety awareness training for all workers.
5. Providing easily movable equipment to reduce risk of injury associated with heavy lifting or strenuous work.
6. Varying job functions (to avoid excessive repetitive motions).
7. Providing on the Site, throughout working hours, adequate and easily accessible supplies of safe drinking water (including water supply to the Engineer's offices and laboratories), access to washing facilities (because of chemical and biological hazards), proper eating places and waste disposal facilities. The water for drinking and cooking purposes shall be filtered, boiled or treated as necessary for human consumption. All water sources used shall be approved by the Engineer. The Contractor's attention is drawn to the fact that no separate payment will be made for the provision of water and the Contractor shall include in their rates and lump sum items for the provision of all water required in and for the Works.
8. Provide adequate signing, fencing and guards to ensure that unauthorised persons shall be kept off the Site. This is especially relevant for the dangerous parts of the Site, e.g. the quarry, the asphalt plant, the storage areas for oil, fuel, chemicals, machines, the car park, the work shop, near deep holes, bridges, villages and power lines.
9. The Contractor shall keep the site free from all unnecessary obstructions, and shall store or dispose any equipment or surplus of materials. The Contractor shall clear away and remove from the site any wreckage, rubbish and temporary works which are no longer required.
10. The Contractor is responsible for providing safe passage around and through the work site for all kinds of traffic, including non-motorised traffic and pedestrians. Traffic signs, traffic control signals and barriers shall be used for direction and control of traffic and to inform drivers of the importance to slow down and drive carefully. The signs shall be reflectorised or adequately illuminated at night in a manner approved by the Engineer. The goal is to minimise road accidents in general, including accidents involving pedestrians and persons living, working and playing next to the construction site.
11. Vehicles shall at all times be maintained in accordance with original manufacturer's specifications and service manual. This will ensure low noise generation, low emission of diesel particulate emission and that the vehicle will not result in accidents due to inadequate maintenance. Special inspection and maintenance is required for brakes, steering wheel, light, horn, tyres, oil and water. Seat belts shall be installed and used. All heavy vehicles shall have reverse warning signal. The operators shall be instructed in avoiding spillage, not overturning or overloading and not to drive at too fast speed. Operators shall be protected against the sun and a cabin shall protect against injuries if the vehicle is tipping around.
12. All accidents shall be recorded and analysed by the Contractor in order to prevent similar accidents in the future. The Contractor shall notify the Engineer immediately any accident occurs, at the latest within 24 hours. Fatal accidents should also be reported to the police. Accident records shall be submitted to the authorities according to regulations, but also sent to the Engineer.
13. Special precautions shall be taken when working close to overhead power lines. All drivers and operators of vehicles working or passing close to the power lines shall be given site specific safety instructions. Signs and barriers shall also be placed adequately to warn of danger, prevent personnel approaching danger areas and lower risk of occurrence of accidents.
14. The Contractor shall comply with statutory regulations with respect to use of explosives.

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The Contractor shall not use or bring onto the site explosives of any kind without the prior consent in writing of the Engineer. The explosives shall be stored in a manner and quantities acceptable to the Engineer in magazines provided by the Contractor at suitable positions. The Contractor shall be responsible for the prevention of unauthorised issue or improper use of explosives brought on the site, and shall employ only experienced and responsible men to handle explosives for the purpose of the works. Police shall be employed as required.

Blasting procedures shall be approved by the Engineer. The shots shall be properly loaded, tamped and where necessary the Contractor shall use heavy blasting nets. Blasting shall be restricted to such periods as the Engineer may agree. If in the opinion of the Engineer, blasting would be dangerous to persons or property, or to any finished work, or is being carried out in a reckless manner, he may prohibit it and require excavation by other means. Use of explosives by the Contractor in large blasts as in seams, drifts, shafts, pits or large holes is prohibited unless authorised in writing by the Engineer.

15. Internal quarry roads shall be kept free of obstacles and spillage shall be removed. The crusher and other very noisy equipment shall be placed at a location such that other site personnel will be exposed to as low a noise level as possible. If necessary noise levels shall be limited by the construction of shields or embankments. Persons working at the crusher must either be in a separate cabin (noise insulated) or wear noise and breathing protection. Personnel working at noise levels above 90 dB(A) shall wear hearing protection. If dust cannot be controlled, the persons shall wear filter masks.

Operators of dozers, dumpers and other heavy vehicles shall be suitably experienced and shall have received special instruction on safety procedures for quarry operations.

16. The Contractor shall take every precaution to avoid fire and health hazards at the asphalt plant. He shall always ensure that:
 - i. Bitumen is heated only to the temperature required for the particular application,
 - ii. Hot bitumen never comes in contact with water,
 - iii. Suitable protective clothing and gloves, safety glasses and masks are used when handling hot bitumen,
 - iv. Dust is reduced to a minimum.
17. The Contractor shall by daily inspections monitor :
 - i. The use of specified personal protective equipment,
 - ii. The cleanliness of the working area which is to be kept tidy with no unnecessary obstacles.
 - iii. Dust generation and exposure and appropriate watering if required.
 - iv. The presence of any new workers on the site, or plans to hire in the near future, and therefore need for induction courses
 - v. The position and adequacy of signing, barriers and fencing.

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18. The Contractor (Safety Officer) shall, at least on a monthly basis, monitor all site activities including quarry and asphalt plant operations and prepare a report on their findings. The report shall be submitted to the Engineer and include:
- i. Number and type of accidents, and preventive measures implemented to minimise future similar accidents.
 - ii. Number of workers who have attended (and not attended) an induction course.
 - iii. Number of workers who have received special training because they started on a new work function, and the total number of workers who should have received such training.
 - iv. Number of workers who have participated in the HIV/AIDS awareness training.
 - v. Stock of personal protective equipment and quantities issued.
 - vi. Maintenance of the vehicles: tyres, brakes, light, steering wheel, oil, water.
 - vii. Condition of first aid equipment in place with quantities and requirements for replenishment.
 - viii. The change in number of workers and their work functions.

9204 HIV/AIDS and STI Prevention

The Contractor's Management Plan for HIV/AIDS and STI shall include details of the measures he proposes to adopt to combat the spread of HIV/AIDS and sexually transmitted Infections (STI) between their staff, labour and the local community. The plan shall also outline workplace policies and programmes for employees living with HIV/AIDS, information and awareness campaigns and effective screening and counselling policies for STI and HIV/AIDS cases of project staff. In any case, the Contractor shall comply with the HIV and AIDS Prevention and Control Act (2006) which prohibits discrimination of persons living with HIV and AIDS.

The Contractor will work closely with Kenya National Syndemic Diseases Control Council and MoH to put in place non-discriminatory workplace measures to protect the employees living with HIV/AIDS and to ensure that they are treated and counselled. Prevention measures will also be established to protect others against any risk of illness and injury, which can result in HIV/AIDS infection and transmission.

The Contractor shall advise all site staff and labour of the danger and impacts of STI's in general and HIV/AIDS in particular. To this end, the Contractor shall conduct information, education and consultation (IEC) campaigns at least every other month, targeting the aforementioned site staff, labour, and the immediate local communities. The Safety Officer or another of the Contractor's staff may carry out the awareness training if qualified; otherwise a person from outside (e.g. from Hospital) may be hired to carry out the awareness training.

The Contractor shall throughout the Contract provide, maintain, and operate at least one STI and HIV/AIDS clinic on each site or make alternative arrangements with an existing suitably qualified and equipped local clinic. Each clinic shall be suitably staffed and equipped for the screening, diagnosis and counselling of STI and HIV/AIDS cases of the project staff and labour. The Contractor shall pay the clinic to provide free treatment for general STI cases for their workers, whereas the HIV/AIDS cases shall be referred to the National Syndemic Diseases Control Council coordinated by the Ministry of Health (MoH).

The Contractor shall throughout the Contract liaise with MoH and designated local representatives to report progress and coordinate the STI and HIV/AIDS alleviation measures on Site with the MoH national programmes.

The Contractor shall also make available 100 condoms per year for each member of the above mentioned site staff and labour.

All of the above provisions shall be provided free of charge for the workers.

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9205 Gender

The Contractor's Management Plan for Gender shall include description of recruitment policy and procedures, awareness raising meetings, gender sensitive working conditions and facilities to be provided at the workplace, and participatory gender sensitive monitoring of site conditions.

The Contractor shall throughout the contract period liaise with both government and non-government organisations at all levels dealing with gender and social development issues. The local leaders and Community Development Officers shall be contacted to advise and mobilise communities during the recruitment process.

The Contractor shall ensure that recruitment procedures and working conditions and facilities are gender sensitive and in particular that:

1. Announcement notices of equal employment opportunities are posted in visible and popular places in the local communities and that such notices also reach women and youth leaders.
2. Both men and women are represented in any information and consultative meetings held at the site and that gender and social issues are raised and analysed.
3. Equal payment is made to men and women for similar work and that payment of wages is made to the workers and not to representatives.
4. Flexible working hours are introduced to the fullest extent possible to take account of multiple roles of women and cultural norms.
5. Separate toilet and accommodation facilities are provided for women, including sanitary facilities and shades for children of working mothers.
6. The contractor shall adhere to all laws on Sexual and Gender based violence (SGBV) including: the Sexual Offences Act 2006 (SOA), The Protection Against Domestic Violence Act 2015 (PADV), The Prohibition of Female Genital Mutilation Act 2011, and Counter-Trafficking in Persons Act 2011 through:
 - i. Adhering to the National Guidelines on the Management of Sexual Violence (2014) namely:
 - The National Policy for Prevention and Response to Gender Based Violence (2014)
 - The National Guidelines on the Management of Sexual Violence (2014), and;
 - The National Monitoring and Evaluation Framework towards the Prevention of and Response to Sexual and Gender Based Violence in Kenya (2016)
 - ii. Awareness creation and education on the root causes of violence and creation of safe spaces and forums to discuss gender-based violence.
 - iii. Use of appropriate non-discriminatory language.
 - iv. Stop sexual harassment.
 - v. Prepare and submit a comprehensive GBV action plan.
 - vi. Work with relevant GBV government, NGOs and community agencies to create awareness and address GBV
 - vii. Ensuring all workers sign a GBV code of conduct

The Contractor shall submit monthly reports of labour attendance, disaggregated by gender, and the Contractor shall use gender compliance monitoring and evaluation forms to assess and report how gender concerns are addressed in recruitment, promotion, payment, provision of gender sensitive facilities, on-the-job training, etc.

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9206 Labour And Working Conditions

The Contractor shall develop and implement written labour management procedures applicable to each project. These procedures will set out the way in which project workers will be managed, in accordance with the requirements of national law and International Best Practices.

Project workers shall be provided with information and documentation that is clear and understandable regarding their terms and conditions of employment. The information and documentation shall set out their rights under national labour and employment law (which will include any applicable collective agreements), including their rights related to hours of work, wages, overtime, compensation, and benefits.

The Contractor shall promote the fair treatment, non-discrimination, and equal opportunity of project workers; protect project workers, including vulnerable workers such as women, persons with disabilities, children and migrant workers, contracted workers, community workers, and primary supply workers, as appropriate; don't use of all forms of forced labour and child labour; support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law; and provide project workers with accessible means to raise workplace concerns.

9207 Measurement And Payment

Item		Unit
92.01	HIV/AIDS And STI Prevention And Counselling	
(a)	Information, Education And Consultation Campaigns Including Regular Distribution Of Condoms To The Workforce	Monthly
(b)	Provide, Maintain And Operate Sti And Hiv/Aids Clinic Or Make Alternative Arrangements With Existing Local Clinic	Monthly

The tendered rates per month for SUBITEMS 92.01(a) and (b) represent full compensation for these parts of the Contractor's obligations, which are mainly a function of time. The tendered sum will be paid monthly, pro rata for parts of a month, from the date of commencement of Works until the completion of the Works or demobilisation of the local workforce, whichever comes first.

Item		Unit
92.02	Gender	
(a)	Gender Sensitisation And Awareness Raising Meetings/ Workshops	Number
(b)	Gender Management Plan And Gender Sensitive Monitoring And Reporting	Month

The tendered rate per number of meetings/workshops for SUBITEM 92.02(a) represents full compensation for production and distribution of awareness raising material and conducting the meetings/workshops, including provision of the venue and making all arrangements. The tendered sum will be paid upon submission to the Engineer of an acceptable meeting/workshop report.

The tendered rate per month for SUBITEM 92.02(b) represents full compensation for this part of the Contractor's obligations, which is mainly a function of time. The tendered sum will be paid monthly, pro rata for parts of a month, from the date of commencement of Works until the completion of the Works or demobilisation of the local workforce, whichever comes first.

Except as provided in ITEMS 92.01 and 92.02 above and entered into the Bill of Quantities no separate payment will be made for any work included in this section. The costs of complying with these requirements, in particular all the OHS requirements shall be included in the Contractor's rates for other Items of work.

SECTION 9300 Road Safety Awareness

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9301 Scope

This specification sets out the Contractor's obligations with regard to on-site road safety campaign which is to be conducted during the construction period. The aim of this road safety campaign is to achieve safe road use in the project area.

The Contractor shall conduct a road safety campaign in order to increase the awareness of the dangers of the road among the communities living alongside the project road and the general Construction workers.

9302 General

The Road Safety Awareness Campaign and Training shall be executed by a specialist Sub-contractor on behalf of the Contractor.

9303 Road Safety Awareness Campaign

At the commencement of the works, the Contractor will, subject to the Engineer's approval, subcontract the Road Safety Awareness Campaign activities to a registered organisation with proven experience in the provision of Road Safety awareness and training activities. The Contractor, through the sub-contractor, shall implement a road safety campaign amongst their workers for the duration of the contract.

The sub-contractor will be required to implement the road safety awareness campaign, whose activities may consist of at least the following:-

- a. Identify stakeholders affected by the road. These may include drivers and operators of public transport and commercial firms including matatu, bus and commercial vehicles drivers, and boda-boda riders; local institutions such as schools, county/national government officials and the general public in local market centres.
- b. Carry out baseline study on road safety awareness amongst stakeholders, existing road safety knowledge attitudes and practices.
- c. Formulate and implement a structured road safety awareness education stakeholders campaign for stakeholder focus groups.
- d. Training of peer educators recruited from the stakeholder groups.
- e. Provide and disseminate road safety information, flyers and brochures, display road safety posters at strategic locations including institutions and markets and in all buildings under the control of the Contractor (offices, workshops, eating houses, guest houses, vehicles etc.).
- f. Carry out a structured awareness and training campaign for Contractor's staff. Carry out driver refresher courses for all drivers of vehicles and construction plant operators employed by the Contractor, including drivers assigned to the Resident Engineer. Emphasis should be placed on awareness creation and enforcement of road safety precautions including wearing safety belts, observance national speed limits, and use of speed limiting / recording devices, basic first aid skills kits and defensive driving

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- g. Promotional events such as sports and video presentations to highlight road safety issues. Supply promotional material bearing road safety messages such as t-shirts, caps, umbrellas, bumper stickers, key rings etc.
- h. Provision of reflective jackets and/or helmets to boda-boda riders bearing road safety messages
- i. Compile monthly and quarterly reports on road safety campaign activities for submission to the Contractor and Resident Engineer.

9304 Road Safety Training

a. General

The objective of the road safety campaign is to reduce the risk of exposure to road accidents in the area of the road. The target groups will be the public alongside the road, especially the children in schools and the chiefs of the village, but also local labourers and their supervisors to be employed by the Contractors. The wider community will benefit indirectly through their normal day-to-day interaction with the target groups.

The Contractor will designate a qualified road safety expert with vast experience on Road safety issues, to be approved by the Engineer, who will work closely with the Client, MOR and other implementing agencies to support the road safety campaign activities. This will ensure maximum effectiveness and integration with construction activities.

b. Activities

Specific but not exclusive issues to be addressed by the Contractor are:

- i. Scheduling of appropriate timing and duration for the implementation of the road safety campaign as part the work plan.
- ii. Identification of suitable individuals for education from recruitment with the implementing organisation and from within the local communities.
- iii. Provision of suitable sites for communication activities.
- iv. Monitoring of the implementation of peer educator activities.
- v. Provision of support as necessary to the implementing organisation and local communities.

c. Inputs

An organisation experienced in the provision of road safety campaigns will be selected as a subcontractor to provide the above scope of activities on behalf of the main Contractor.

d. Reporting

The implementing organisation will produce the following reports to be submitted to the Contractor, the Engineer, and the Employer:

- i. Monthly progress reports which will include briefs for inclusion in site meetings, as well as all activities carried out during the month.
- ii. Quarterly reports summarising and detailing activities carried out, issues to be emphasised with suggested follow up, etc.
- iii. A review report of activities in the road construction sector,
- iv. A review report of existing IEC materials with recommendations for development of materials specifically for the road sector.
- v. A final report detailing the methodology and activities carried out under this project including lessons learnt, impact, liaison with the Contractor and other parties, etc.

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Environmental, Health, Safety & Social Aspects | 9300 |

e. Timing

Activities shall commence at the start of the construction period and continue throughout the Contract duration to ensure a sustained impact. Reporting and dissemination activities shall continue for three months after the project is completed to ensure integration into current practice.

f. Scope of Activities

Activities for road safety awareness will be broad-based targeting both individuals and groups. They may consist of:

- i. Information posters in public places both on and offsite (eating houses, bars, guest houses, etc.) and on contractor's vehicles,
- ii. Peer educators (reference people) drawn from the local labour, and from the local communities, and educated in road safety issues for discussions with colleagues or the local community members. In addition and most importantly, local schools should be included
- iii. Small focus group discussions and information covering key issues,
- iv. Theatre groups and video presentations,
- v. Promotional events (such as football matches) to encourage openness and discussion of road safety issues,
- vi. Promotional bill boards to raise awareness of the integration of construction and road safety activities,
- vii. Availability of promotional materials such as T-shirts, caps, bumper stickers, key rings, etc.

The scope of activities may be tailored as required to meet the perceived needs and priorities of the local communities and the workers, determined by participatory approaches to ensure they are appropriate, desired and have a public impact.

The scale and frequency of activities may also be adjusted to suit requirements of the target groups.

Education will cover:

- i. Preventive behaviours including safe road crossings, walking on shoulders and not on the road;
- ii. Referral to local information centres and services available;

Tasks to support the above activities will be to:

- i. Establish the status and focus of all current and planned road safety campaign activities in the area to ensure complementarity and determine potential involvement in project activities.
- ii. Carry out a brief review of regional activities combining road construction with road safety campaigns to determine options, best practice key issues, constraints, etc.
- iii. Review of Information, Education and Communication (IEC) materials available and their relevance to road construction, making recommendations for future development of IEC materials.
- iv. Provide education and training for site personnel, supervisors, local schools, community members, and peer educators for the scope of activities as above.
- v. Provide supervision for peer educators to ensure sustained quality of education. Incentives for their continual work may be small promotional items such as T-shirts, caps, etc.
- vi. Monitor activities regularly to assess their effectiveness and impact. This should include an initial, interim and final assessment of basic knowledge, attitude and practices (KAP) taking account of existing data sources and recognising the limitations due to the short time frame to show behaviour change. The KAP will be supported by qualitative information from focus group discussions.

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9305 Measurement And Payment

Item		Unit
93.01	Instituting A Road Safety Awareness Campaign	Month

The unit of measurement shall be the calendar month or part thereof, measured over the duration of the campaign. The tendered rate shall include full compensation for equipment, labour and material required for the provision of the service.

Item		Unit
93.02	Instituting Accident Prevention Campaign	Month

The unit of measurement shall be the calendar month or part thereof, measured over the duration of the campaign. The tendered rate shall include full compensation for equipment, labour and material required for the provision of the service.

Item		Unit
93.03	Road Safety Training:	
(a)	Instituting A Road Safety Training Program	Provisional Sum
(b)	Extra Over (A) Above	Percent (%)

The Contractor to be paid a percentage extra over Training Item for Compensation of management of the training process on any amount approved in training Item.

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