REPUBLIC OF KENYA

MINISTRY OF TRANSPORT AND COMMUNICATIONS

STANDARD SPECIFICATION

FOR

ROAD AND BRIDGE CONSTRUCTION

CHIEF ENGINEER
(ROADS & AERODROMES)
MINISTRY OF TRANSPORT AND
COMMUNICATIONS
P.O. BOX 52692
NAIROBI

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1986

SECTION 1 - GENERAL

SECTION 9 - PASSAGE OF TRAFFIC

SECTION 10 - GRAVEL WEARING COURSE

SECTION 11 - SHOULDERS TO PAVEMENT

SECTION 17 - CONCRETE WORKS

SECTION 1 –
GENERAL

101 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.

102 EXTENT OF CONTRACT

The extent of the Contract is defined in the Special Specification.

103 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.

104 PROGRAMME

In accordance with Clause 14 of the Conditions of Contract Parts I and II, the Contractor shall submit a fully detailed and time related programme showing the order of procedure and method in which he proposes to carry out the Works. The Contractor shall supply together with his programme an expenditure chart superimposed on it showing his monthly anticipated expenditure.

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 Clause 43 of the Conditions of Contract.

105 ORDER OF WORK

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.

106 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 d'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 his responsibilities under the Contract.

107 CERTIFICATE OF COMPLETION

The minimum length of road for which a Certificate of Completion will be issued under Clause 48 of the Conditions of Contract shall be specified in the Special Specification.

In addition to the above, a Certificate of Completion will not be issued for a section road unless it can conveniently be opened to the public without the necessity to construct additional detour roads and all works within the section are complete with the exception of the following which may be completed during the Period of Maintenance.

(a) Surface dressing to accesses and junctions.

(b) Reinstatement of borrow pits and quarries.

(c) Grouted stone pitching. (except where specified in side drains)

(d) Reinstatement of deviations.

(e) Erection of informatory signs.

(f) Erection of kilometre marker posts.

108 METHOD OF CONSTRUCTION

The Contractor shall submit to the Engineer not later than 28 days from the date of award of the Contract a general description of his 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 7.00 a.m to 5.00 p.m on weekdays with Saturdays and Sundays set aside for rest. If the Contractor wishes to execute permanent Works outside these hours, he 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.

109 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 he may deem necessary for its inspection and checking.

The Contractor shall give the Engineer not less than 1 full working days notice in writing of his intention to set out or give levels for any part of the Works in order that arrangements may be made for checking.

110 UNITS OF MEASUREMENT, ABBREVIATIONS AND TERMINOLOGY

(a) Units of measurement

Symbols for units of measurement conform to the SI system as set out in BS 5775 (IS0 31/1.) Examples are given below.

Where reference is made in the documents to imperial units, the equivalent metric units shall be substituted.

μ	micron = m x 10^{-6}
mm	millimetre
m	metre
km	kilometre
n mile	nautical mile
mm^2	square millimetre

m^2	square metre
km^2	square kilometre
ha	hectare
m^3	cubic metre
l	litre
rad	radian
^oC	degrees Celsius
kg	kilogram
g	gram = kg x 10^{-3}
mg	milligram = kg x 10^{-6}
mg/l	milligrams per litre
t	tonne = kg x 10^3
kg/m^3	kilogram per cubic metre
t/m^3	tonnes per cubic metre
N	newton
N/m^2	newton per square metre

b) Abbreviations

The following abbreviations are used:

ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ALD	Average Least Dimension
BA	Bitumen Affinity
CBR	California Bearing Ratio
CR	Crushing Ratio
FI	Flakiness Index
LAA	Los Angeles Abrasion Value
LL	Liquid Limit
LS	Linear Shrinkage
MC	Moisture Content
MDD	Maximum Dry Density
OMC	Optimum Moisture Content
PI	Plasticity Index
PL	Plastic Limit
PM	Plasticity Modulus (PI x % passing 0.425mm sieve)
SE	Sand Equivalent
SG	Specific Gravity
SI	International Standard Units of Measurements
SSS	Sodium Sulphate Soundness Test, loss on 5 cycles
STV	Standard Tar Viscosity
TS	Tensile Strength
UC	Uniformity Coefficient
UCS	Unconfined Compressive Strength
VIM	Voids in Mix
VMA	Voids in Mineral Aggregates
OPC	Ordinary Portland Cement
no.	Number (units) as in 6 no.
No.	Number (order) as in No 6.
w/c	Water cement (ratio)
wt	Weight
	Percent

dia	Diameter
hr	Hour
min	Minute
sec	Second

(c) Terminology

The most important terms related to the cross-section and pavement are shown in Figure 1-1 and Figure 1-2:

111 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 Branch MOTC	Materials Branch of the Kenya Ministry of Transport and Communications
BS	British Standard
BSCP or CP	British Standard Code of Practice
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society of Testing and Materials
ISO	International Organisation for Standardization

The Contractor shall supply and maintain in his office on the Site at least one complete set of all National Specifications referred to in this Specification and all other approved Specifications. This set shall be made available for use by the Engineer.

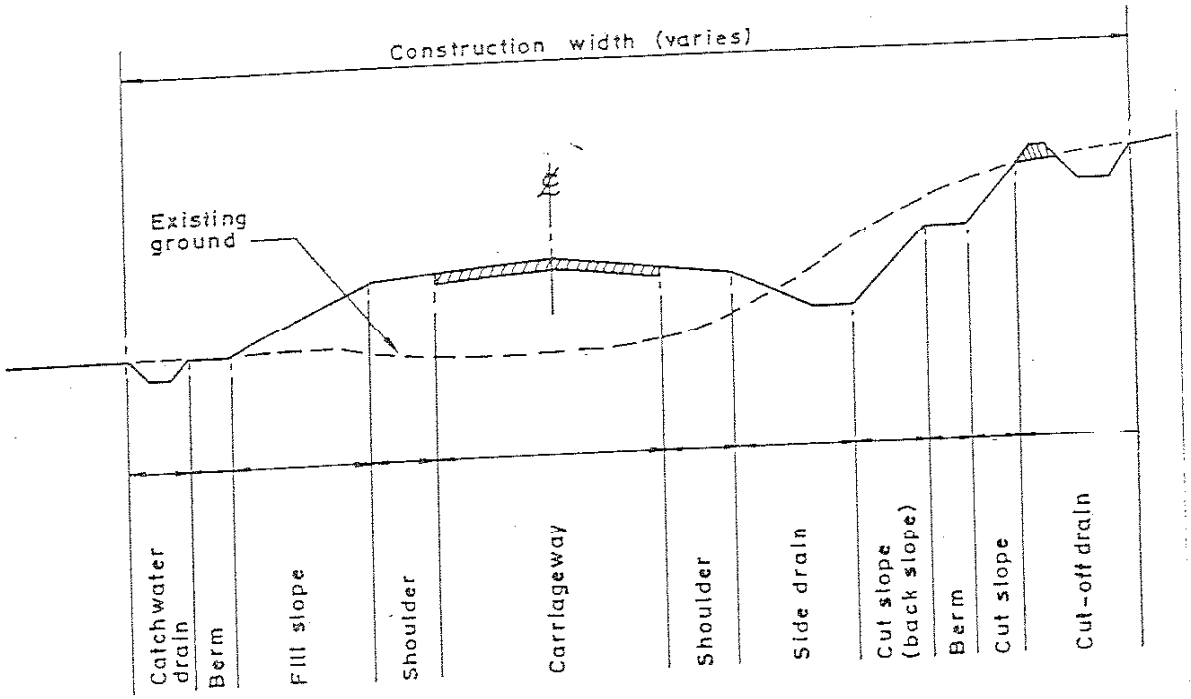

FIGURE 1-1

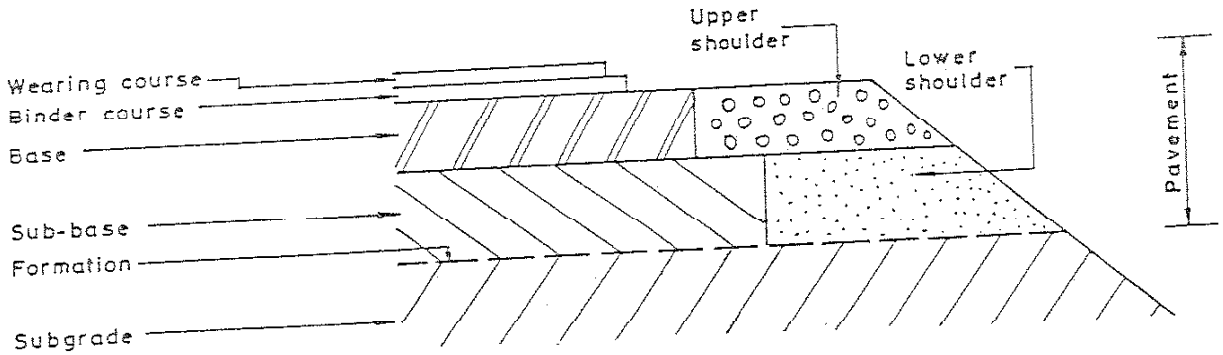

FIGURE 1-2

112 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 Clause 31 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 him, his employees or his sub-contractors.

113 TRANSPORT OF WORKMEN

The Contractor shall include in his 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.

114 TEMPORARY WORKS

After the Contract is placed and before work commences the Contractor shall submit to the Engineer drawings showing the general arrangement of his Temporary Works with diagrams and descriptions showing how he proposes to execute such Temporary Works and how they fit into his programme for the Permanent Works, all to be subject to adjustment and approval by the Engineer. 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 his liability.

115 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, he 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 his 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 acquainting himself with and 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 his sub contractors for the purpose of or in connection with the Works.

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

116 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 he 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 his own expense cut drains and ditches and carry out any other measures necessary to effectively drain the original ground and/or shall so programme his 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 his 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 Period of Maintenance, 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 Contractors failure to take the necessary precautions shall be made good at the Contractor's expense.

117 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 his employees including those of his sub-contractors and of all other persons on the Site. His 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 his 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;

(j) reporting details of any accident to the Engineer and the Kenya Police if appropriate as soon as possible after its occurrence.

(k) compliance with The Factories Act (Cap 514) and in particular the Factories (Building Operations and Works of Engineering Construction) Rules 1984.

118 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 his 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 his 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.

119 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 his 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.

120 PROTECTION OF EXISTING WORKS AND SERVICES

The Contractor shall acquaint himself with 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 co-ordinating 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.

121 DIVERSION OF SERVICES

The Contractor shall be responsible for arranging in liason 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.

122 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 Transport and Communications will give him no special privileges in this respect.

123 LIAISON WITH GOVERNMENT AND POLICE OFFICIALS

The Contractor shall consult with officials of the Police and Government in 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.

124 PROVISION OF LAND

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 his own camps, offices, houses, temporary works or any other purpose.

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 his 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 Commissioner of Lands. The Contractor's obligations are set out in detail in Clause 603 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.

125 WATER SUPPLY

The Contractor shall provide a clean, sufficient and continuous supply of fresh water, both for construction of the Works and for all houses, offices, laboratories and workshops. He shall undertake all arrangements including pipelines and meters for connecting to local water mains and the provision of pumps, storage tanks or water conveyance where necessary, payment for all fees and water charges and the satisfactory removal of all such arrangements and provisions on completion of the Works.

The water shall be clear of suspended solids and free from any matter in quantities considered by the Engineer to be deleterious to the work. Water supplied to all the offices, laboratories and houses shall be wholesome and potable to the satisfaction of the Medical Officer in the Area.

126 MATERIALS AND MANUFACTURED ARTICLES

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 he 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.

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.

127 INFORMATION FROM EXPLORATORY BORING AND TEST PITS.

The Materials Report, which forms part of the Contract Documents, contains information on exploratory borings, test pits and other investigations which have been made by the Engineer on the site of the Works. The Engineer will be responsible for the suitability of the borrow pits provided by him and shown on the Drawings. The Contractor will be solely responsible for any conclusions he may reach from the Materials Report at all locations other than the borrow pits provided by the Engineer.

The Engineer reserves the right to adjust foundation levels and other levels for construction below ground level, in the light of information that becomes available as general excavation proceeds upon the Site.

The Contractor's attention is drawn to his obligation with regard to the inspection and examination of the Site as detailed in Clause 11 of the Conditions of Contract.

128 STORAGE OF MATERIALS AND MANUFACTURED ARTICLES

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 may be affected.

129 TEST CERTIFICATES

When instructed by the Engineer, the Contractor shall submit to him 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.

130 PROGRESS PHOTOGRAPHS

36 number colour negatives showing the progress of the Works shall be taken every month by the Contractor from positions to be selected by the Engineer. The Contractor shall supply proof prints from each negative from which the Engineer shall select negatives from which the Contractor shall produce 2 sets of progress photographs. Each set shall comprise 10 number, 200 x 150 mm colour prints, which together with all the negatives shall be handed over to the Engineer. Each proof and photograph shall be marked with the number of the negative and a statement shall be submitted giving the location, date when taken and a brief description or title. The Contractor shall supply one album with each set of photographs.

On completion of the Contract, the ownership of the office furniture and laboratory and survey equipment shall revert to the Employer. Unless otherwise stated the ownership of all houses, offices, and laboratories shall revert to the Contractor.

135 MAINTENANCE OF THE ENGINEER'S STAFF HOUSES, OFFICES, LABORATORIES, FURNITURE AND EQUIPMENT

The Contractor shall keep all buildings, accesses, services and facilities provided by him, for the use of the Engineer and his staff, in a well maintained, clean and fully habitable condition, 24 hours per day until the expiry of the Period of Maintenance.

The Contractor shall also provide constant electricity, water and an adequate refuse collection service for all houses, offices and laboratories.

The Contractor shall also maintain all furniture and equipment provided by him and/or the Employer in a reasonable state of repair and useable condition and shall replace promptly any item which becomes unserviceable or is lost.

136 REMOVAL OF CAMPS

Unless otherwise instructed, upon completion of the Contract and, after receiving approval in writing from the Engineer, the Contractor shall take down and remove all structures forming part of his own camp and that of the Engineer, and shall arrange for the disconnection of the water supply, remove all drains and culverts, backfill trenches, fill in all latrine pits, soakaways and other sewage disposal excavations, with the exception of items and services which are required to revert to the ownership of the Employer and shall restore the Site, as far as practicable, to its original condition and leave it in a neat and tidy condition.

The Contractor shall carry out similar reinstatement in the event that he relocates his camp and that of the Engineer.

137 ATTENDANCE UPON THE ENGINEER AND HIS STAFF

In the Engineer's offices and laboratories the Contractor shall provide a continuous supply of soap, towels and toilet paper, coffee, tea, sugar and milk, and cleaning equipment, and shall keep the offices and laboratories in a well maintained, clean and habitable condition.

The Contractor shall provide all tools, protective clothing, wooden pegs, iron pins and pickets, water, cement and aggregate for concreting and all assistance as may be required by the Engineer and his staff for setting out, measuring and checking the Works.

The Contractor shall provide, pay, including all overtime, and house such junior staff as are listed in the Special Specification.

The Contractor shall provide adequate security by day and by night for the Engineer's offices, laboratory, vehicles and houses, and for the Engineer's staff. This shall include the provision of suitable gates and fencing and the full-time attendance of permanent watchmen.

138 PROVISION OF VEHICLES

The Contractor shall, if so required in the Special Specification, supply new vehicles and maintain them for the exclusive use of the Engineer and his staff, for any purpose whatsoever authorised by the Engineer.

A description of the number and types of vehicles to be provided is given in the Special Specification.

Unless otherwise specified, the vehicles shall be owned by the Contractor and be licenced and comprehensively insured by the Contractor for use within Kenya by any licenced driver authorised by the Engineer together with authorised passengers and the carriage of goods and samples. The Contractor shall pay all tolls, provide fuel, oil, maintenance including replacing defective parts, tyres and the like whenever required, in conformity with the vehicle manufacturer's recommendations or as may be necessary. The vehicles shall be fueled, oiled and maintained as aforementioned until released by the Engineer. The vehicles on being released shall revert to the Contractor. Each vehicle shall be fitted with a fire extinguisher, first aid kit, tow hook and rope, tool kit, spare wheel, wheel wrench, jack and handle and seat belts all of which shall be maintained in working order or replaced by the Contractor as necessary.

The Contractor shall provide a similar replacement for any vehicle out of service for more than twenty four hours, and shall replace any vehicle by a similar new vehicle after it has completed 150,000 km.

The Contractor shall provide, pay including all overtime and night allowances, and house competent and licensed drivers approved by the Engineer for each of the vehicles indicated in the Special Specification. Sufficient drivers shall be available at night and at weekends whenever required by the Engineer.

139 MISCELLANEOUS ACCOUNTS

The Contractor may be instructed by the Engineer to purchase and supply to the Engineer, or pay for miscellaneous items including but not limited to stationery, stores, equipment, office consumables , computer charges and hotel accommodation. The Contractor shall submit a miscellaneous account including receipts of all such items purchased or paid for.

140 PAYMENT OF OVERTIME FOR ENGINEER'S JUNIOR STAFF

The Contractor may be instructed by the Engineer to make payment for overtime worked by the Engineer's junior staff. The Contractor shall

be reimbursed for such payments in accordance with the relevant items of Clause 141 of this Specification except when any overtime worked by the Engineer's junior staff is incurred by the need for the Engineer to inspect work which, owing to earlier default by the Contractor, has resulted in such work being performed outside normal working hours as defined in Clause 108 of this Specification then the full cost of such overtime shall be at the Contractor's expense.

141 MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made for the cost of complying with the requirements of Clauses 101 to 120 inclusive, Clause 122, Clause 123, Clause 125 to Clause 129 inclusive and Clause 137 of this Specification and the Contractor shall be deemed to have allowed elsewhere in his rates and price for all such costs.

(a) Item : Preliminary Item

Unit : Lump Sum

Measurement and payment of the Preliminary Item shall be made in accordance with the requirements of Clause 60(1) of the Conditions of Contract, Part II.

(b) Item : Engineer's senior staff houses

Unit : no. of each type

Engineer's senior staff houses shall be measured by the number instructed to be built.

The rate for the Engineer's senior staff houses shall include for the cost of providing each house, furniture, equipment, water, electricity and gas in accordance with the Special Specification and complying with the requirements of Clauses 117, 124, 125, 132, 133, 134, 135, 136 and 137 of this Specification.

Payment for the Engineer's senior staff houses shall be made in instalments in accordance with the following conditions:-

(i) The Contractor will be paid 50% of the amount due when the buildings are accepted by the Engineer fully furnished and equipped.

(ii) 30% of the amount due will be paid in equal monthly instalments from the date the Engineer accepts the buildings over the remainder of the Contract Period excluding the Period of Maintenance. This payment shall be deemed to cover maintenance of buildings, furniture, equipment and services and the Engineer may withhold or reduce any instalments if the Contractor fails in his maintenance obligations.

(iii) 20% of the amount due will be paid when the buildings have been removed, if required, and the site cleared at the end of the Period of Maintenance or earlier if the Engineer has no further requirement for the houses.

(iv) Each instalment will be subject to the deduction of retention money.

(c) Item : Engineer's junior staff houses

Unit : no. of each type

Engineer's junior staff houses shall be measured by the type and number instructed to be built.

The rate for the Engineer's junior staff houses shall include for the cost of providing each house, furniture, equipment, electricity and water in accordance with the Special Specification and complying with the requirements of Clauses 117, 124, 125, 132, 133, 134, 135, 136 and 137 of this Specification.

Payment for the Engineer's junior staff houses shall be made in instalments in accordance with Clause 141(b) of the Specification.

(d) Item : Engineer's office

Unit : no.

Engineer's office shall be measured by the number instructed to be built.

The rate for the Engineer's office shall include for the cost of providing the office, electricity, water, telephone charges and heating in accordance with the Special Specification and complying with the requirements of Clauses 117, 124, 125, 132, 133, 134, 135, 136 and 137 of this Specification.

Payments for the Engineer's office shall be made in instalments in accordance with Clause 141(b) of this Specification.

(e) Item : Engineer's laboratory

Unit : no.

Engineer's laboratory shall be measured by the number instructed to be built.

The rate for the Engineer's laboratory shall include for the cost of providing the laboratory, electricity, water, gas and heating in accordance with the Special Specification and complying with the requirements of Clauses 117, 124, 125, 132, 133, 134, 135, 136 and 137 of this Specification.

Payment for the Engineer's laboratory shall be made in instalments in accordance with Clause 141(b) of this Specification.

(f) Item : Furniture and equipment for the Engineer's office and laboratory

Unit : Prime Cost Sum
: plus % for Contractor's overheads and profit

Reimbursement for the purchase of furniture and equipment for the Engineer's office and laboratories shall be on a Prime Cost basis plus a percentage for overheads and profit. The Prime Cost shall be the cost of the item ordered, less any discount, in Nairobi. The percentage entered for overheads and profit shall be deemed to cover all other costs including transport from Nairobi to the Engineer's office or laboratory (permanent or mobile) and maintenance thereof. The Contractor shall be required to produce quotations and invoices if so required and shall produce receipts of payments for all goods supplied.

(g) Item : Vehicles for the Engineer

Unit : V. month for each type of vehicle

Provision of vehicles for the Engineer shall be measured by the Vehicle month (V.month) for each month, or part thereof, that the vehicle is provided for the Engineer.

The rate shall include for the cost of complying with the requirements of Clause 138 of this Specification.

Additional payment will be made under Clause 141(h) of this Specification for each kilometre travelled.

(h) Item : Kilometre travelled by vehicles for the Engineer

Unit : km for each type of vehicle

Payment will be made for each kilometre travelled by the vehicles for the Engineer.

The rate for each kilometre travelled shall include for the cost of complying with the requirements of Clause 138 of this Specification.

(i) Item : Removal and alteration to existing services

Unit : Prime Cost Sum
: plus % for Contractor's overheads and profit.

Reimbursement for the removal of or alterations to existing services which are affected by the Works shall be on a Prime Cost basis plus a percentage for overheads and profit. This percentage shall be deemed to include for all costs incurred in

liaising with the appropriate bodies and for programming and co-ordinating work to enable any removal or alteration to the service to be carried out and complying with the requirements of Clause 120 and 121 of this Specification.

(j) Item : Land acquisition

Unit : Prime Cost Sum

: plus % for Contractor's overheads and profit

Reimbursement for the acquisition of land required for the Works shall be on a Prime Cost basis plus a percentage for overheads and profits. This percentage shall be deemed to include for all costs in providing the information of owner, land registration numbers, local details, maps and plans, initially providing the money for the purchase of the land, setting out and complying with clause 124 of this Specification.

(k) Item : Miscellaneous accounts

Unit : Prime Cost Sum
: plus % for Contractor's overheads and profit

The Contractor, on provision of receipts, will be reimbursed on a Prime Cost basis for miscellaneous accounts plus a percentage for overheads and profit. This percentage shall be deemed to include for all costs in providing the items in the miscellaneous account including purchase, transport to Site and complying with the requirements of Clause 139 of this Specification

(l) Item : Payment of overtime for the Engineer's junior staff

Unit : Prime Cost Sum
: plus % for Contractor's overheads and profit.

Reimbursement for the payment of the Engineer's junior staff overtime shall be on a Prime Cost basis plus a percentage for overheads and profit. This percentage shall be deemed to include for all costs of complying with Clause 140 of this Specification.

(m) Item : Progress photographs

Unit : no. of sets

Progress photographs shall be measured by the number of sets instructed.

The rate shall include for the cost of complying with Clause 130 of this Specification.

(n) Item : Signboards.

Unit : no.

Signboards shall be measured by the number instructed.

The rate for signboards shall include for the cost of complying with Clause 131 of this Specification.

SECTION 2

MATERIALS AND TESTING OF MATERIALS

201 SCOPE OF SECTION

This Section covers the tests and methods of testing which are required for the selection and control of the quality of materials and for control of workmanship, trials and construction control testing.

202 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. 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. In appropriate circumstances, tests may be carried out at the place of manufacture.

203 ACCEPTANCE STANDARDS OF MATERIALS

All materials used in or upon the Works shall comply with this Specification and the Special Specification and shall be acceptable to the Engineer. Where so specified, the material shall comply with the national specification named or with an alternative national specification in accordance with Section 1 of this Specification.

Similarly, where a material has been specified by manufacturer's trade name, the product of another manufacturer will be acceptable provided it is in all respects of equivalent or higher quality and provided that the Engineer's approval has been obtained.

Samples of all materials proposed to be used shall be submitted to the Engineer and shall, where required, be tested prior to the material being delivered in bulk upon the Works.

204 SIEVES

ISO sieves shall be used for all tests. The standard sieve series, based on ISO 565, shall be as follows:

75 - 63 - 50 - 37.5 - 28 - 20 - 14 - 10 - 6.3 - 5 - 4
2 - 1 - 0.6 - 0.5 - 0.425 - 0.300 - 0.150 - 0.075 mm

The Engineer may require the use of additional ISO sieves.

In various standard test procedures quoted in this Section, American or British sieves shall be replaced by the nearest ISO sieves, eg.

19.0 mm shall be replaced by 20 mm
9.5 mm shall be replaced by 10 mm
4.75 mm shall be replaced by 5 mm

2.36 mm shall be replaced by 2 mm
1.18 mm shall be replaced by 1 mm

205 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, except that:

(i) The mass (in g) of a sample required for sieve analysis is about 400 D, 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 2-1.

It is further specified that:

(i) Sieve analysis (BS 1377 - Test 7 (A) - wet sieving) shall be carried out using ISO sieves, as indicated in Clause 204.

(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.

TABLE 2-1: TEST PROCEDURES APPLICABLE TO DISTURBED SAMPLES OF SOILS AND GRAVELS.

Determination of	Test Procedure
Moisture Content	BS 1377 - Test 1 (A), Oven-drying method
Liquid Limit	BS 1377 - Test 2 (A), Cone penetrometer or Test 2 (B), Casagrande
Plastic Limit	BS 1377 - Test 3
Plasticity Index	BS 1377 - Test 4
Linear Shrinkage	BS 1377 - Test 5
Specific Gravity of Particles	BS 1377 - Test 6
Particle size Distribution	BS 1377 - Test 7 (A), Wet sieving
	BS 1377 - Test 7 (D), Hydrometer.
Organic Matter Content	BS 1377 - Test 8
Total Sulphate Content	BS 1377 - Test 9
pH Value	BS 1377 - Test 11(A), Electometric method.
Density-Moisture Content relationship	AASHTO T99 - Method A (Materials with not less than 90% passing a 5 mm sieve)
(2.5 kg rammer)	AASHTO T99 - Method D (Materials with less than 90% passing 5 mm sieve)
Density-Moisture Content relationship	AASHTO T180 - Method A (Materials with not less than 90% passing 5 mm sieve)
(4.5 kg rammer)	AASHTO T180 - Method D (Materials with less than 90% passing 5 mm sieve)
Density-Moisture Content relationship (Vibrating Hammer)	BS 1377 - Test 14
California Bearing Ratio	AASHTO T193
Sand Equivalent	AASHTO T176 - Mechanical shaker or manual shaker method
Field Dry Density	BS 1377 - Test 15
	AASHTO T238 - Method E (Moisture determination in accordance with BS 1377 Test 1(A))

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 2-1 and Clause 226 of this Specification.

206 STONE, AGGREGATE, SAND AND FILLER

a) Sampling and preparation of samples

Sampling shall be carried out and the samples prepared in accordance with BS 812.

b) Standard methods of testing

Tests on stone, aggregate, sand and filler shall be performed in accordance with the standard methods given in Table 2-2.

(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.

TABLE 2-2: TEST PROCEDURES APPLICABLE TO STONE, AGGREGATE SANDS AND FILLERS.

Determination of	Test Procedure
Particle Size Distribution	BS 812,
Clay, Silt and dust in aggregate	BS 812
Flakiness Index	BS 812
Relative density-water absorption	BS 812
Bulk density, Voids and Bulking	BS 812
Moisture Content	BS 812 - Standard method (oven - drying)
Aggregate Crushing Value	BS 812
Soluble Chloride Content	BS 812
Organic impurities in sands	AASHTO T21
Los Angeles Abrasion	AASHTO T96 (ASTM C 131) (coarse aggregate)
	ASTM C 535 (Large size coarse aggregate)
Sodium Sulphate Soundness	AASHTO T104 (ASTM C 88) (5 cycles)
Sand Equivalent	AASHTO T176 - Mechanical shaker or manual shaker method.

(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.

Apparatus required:

Plastic buckets.

Spring balance capable of reading to 5 kg with an accuracy of $\pm$ 10 g.

Plastic drinking cups or similar containers.

Whatman No. 90 filter papers 125 mm diameter.

Quantab chloride titrators Type 1175 (supplied by Miles Laboratories Ltd., Stoke Court, Stoke Poges, Slough, Bucks, England)

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.

Calculation:

If the % NaCl is X, the amount of Cl ion by weight of aggregate is given by:

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.

207 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 02-21. The main requirements are summarized in Table 2-3.

Other types of cement shall comply with the specification named.

208 LIME

Building limes shall be sampled and tested in accordance with and shall comply with all requirements of BS 890.

Lime for treatment of road materials shall be Hydrated Calcium Lime or Quicklime and, unless otherwise specified, shall comply with the following requirements:

Fineness	Hydrated lime	Quicklime
Residue on 0.2 mm sieve - Maximum	1%	10%
Residue on 0.075 mm sieve - Maximum	10%	50%
Chemical requirements		
Free lime content - Minimum	50%	80%
Hydrated lime content - Maximum	-	5%

209 CEMENT OR LIME TREATED MATERIALS

(a) Samples and sampling

Sampling of cement or lime treated materials shall be carried out as specified or as instructed by the Engineer.

TABLE 2-3

SUMMARY OF THE CHEMICAL AND PHYSICAL REQUIREMENTS OF KS 02-21
PORTLAND CEMENT
(ORDINARY AND RAPID-HARDENING)

CHEMICAL COMPOSITION

1. Lime Saturation Factor:

$$L.S.F. = \frac{(CaO) - 0.7\ (SO_3)}{2.8\ (SiO_2) + 1.2\ (Al_2O_3) + 0.65\ (FeSO_3)}$$

The L.S.F. should not be greater than 1.02 and not less than 0.66.

2. Insoluble Residue: The weight of insoluble residue shall not exceed 3%. If a pozzolana is added then the weight of insoluble residue shall not exceed (3 + 0.67P)% where P is the percentage by mass of pozzolana.

3. Magnesium Oxide: The weight of magnesium oxide in the cement shall not exceed 5%

4. Sulphuric Anhydride: The content of total sulphur in the cement, expressed as SO_3, shall not exceed 3.5%.

5. Loss on Ignition: The total loss on ignition at 900° - 1000°C shall not exceed 5%.

6. Pozzolana: Not more than 15% by mass of pozzolana shall be added.

PHYSICAL REQUIREMENTS

	ORDINARY	RAPID HARDENING
1. SPECIFIC SURFACE		
Minimum Specific Surface (m^2/kg)	225	325
2. COMPRESSIVE STRENGTH		
Minimum average compressive strength of 3 mortar cubes(N/mm^2)		
at 3 days	17.5	23.0
at 7 days	26.5	31.0
at 28 days	38.0	46.0
3. SETTING TIMES		
Minimum initial setting time (min)	45	45
Maximum final setting time (hours)	10	10
4. SOUNDNESS		
Maximum expansion (mm)		
Unaerated cement	10	10
Aerated cement	5	5

Samples shall be prepared for testing as indicated in Clause 1.5.3 of BS 1924, except that:

Samples containing particles larger than 20 mm shall be prepared for compaction and CBR tests as indicated in Clause 205 (a) (ii). (The fraction coarser than 20 mm shall be rejected but replaced by an equal weight of 5/20 mm material).

(b) Standard methods of testing

The tests on cement or lime treated materials shall be performed in accordance with the standard methods given in Table 2 - 1 and Table 2 - 4.

It is further specified that:

(i) Compaction tests: when cement is used, compaction must start within one hour and be complete within two hours after the start of mixing operations.

(ii) Determination of the Unconfined Compression Strength (UCS): the specimens shall be statically compacted to a predetermined density.

(iii) Determination of the CBR: the specimens shall be dynamically compacted with a 4.5 kg rammer, the number of blows being governed by the relative compaction chosen (Dynamic Compaction - Method 1). If it is required to soak the specimen, the mould shall be immersed in water to allow free access of water to top and bottom of the specimen. During soaking, the water level in the mould and the soaking tank shall be maintained approximately 25 mm above the top of the specimen.

(iv) Curing and soaking temperature: during the curing and soaking periods, the specimens shall be kept at a temperature of 27°C ± 2°C.

210 CONCRETE

Sampling and testing on concrete shall be carried out in accordance with BS 1881:

Part 1	Methods of sampling fresh concrete
Part 2	Methods of testing fresh concrete
Part 3	Methods of making and curing test specimens
Part 4	Methods of testing concrete for strength
Part 5	Methods of testing hardened concrete for other than strength.

It is further specified that the test specimens shall be cured at a temperature of 27°C ± 2°C.

Water to be used in concrete shall be tested as specified in BS 3148.

TABLE 2-4 : ADDITIONAL TEST PROCEDURES APPLICABLE TO CEMENT AND LIME TREATED MATERIALS

Determination of	Test Procedure
Moisture Content	BS 1924 - Test 1 (A), Oven-drying method
Density-Moisture Content relationship (2.5 kg rammer)	AASHTO T99 - Method A (Materials with not less than 90% passing 5 mm sieve) AASHTO T99 - Method D (Materials with less than 90% passing 5 mm sieve)
Density-Moisture Content relationship (4.5 kg rammer)	AASHTO T180 - Method A (Materials with not less than 90% passing 5 mm sieve) AASHTO T180 - Method D (Materials with less than 90% passing 5 mm sieve)
Density-Moisture Content relationship (Vibrating Hamner)	BS 1924 - Test 5
Unconfined Compressive Strength (UCS)	BS 1924 - Test 10 (Fine and medium grained materials) BS 1924 - Test 11 (Medium and coarse grained materials)
Effect of immersion on U.C.S.	BS 1924 - Test 12
California Bearing Ratio	BS 1924 - Test 13 Dynamic compaction - Method 1 Soaking as AASHTO T193
Cement Content	BS 1924 - Test 14
Lime Content	BS 1924 - Test 15
Field Dry Density	BS 1924 - Test 6 or test 7
	AASHTO T238 - Method B (Moisture determination in accordance with BS 1924 Test 1 (A))

211 BITUMINOUS BINDERS

(a) Samples and sampling

Sampling of straight-run and cut-back bitumens 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 that where a delivery is made in drums or barrels, the number of samples shall be as indicated in AASHTO Sampling Method T40 para 11.1.

(b) Standard methods of testing

(i) Straight-run bitumen

Tests on straight-run bitumen shall be carried out in accordance with the following test procedures:

Penetration	AASHTO T49 (ASTM D 5)
Softening point (Ring and Ball)	AASHTO T53 (ASTM D 2398)
Flash and fire points (Cleveland open cup)	AASHTO T48 (ASTM D 92)
Loss on heating	AASHTO T47 (ASTM D 6)
Ductility	AASHTO T51 (ASTM D 113)
Water	AASHTO T55 (ASTM D 95)
Thin film oven test	AASHTO T179 (ASTM D 1754)
Solubility in organic solvents	AASHTO T44 (ASTM D 2042)
Specific gravity	AASHTO T228 (ASTM D 70)

(ii) Cut-back bitumen

Tests on cut-back bitumen shall be carried out in accordance with the following test procedures:

Kinematic viscosity	AASHTO T201 (ASTM D 2170)
Flash point (Tag open cup)(RC-MC)	AASHTO T79 (ASTM D 1310)
Flash point (Cleveland open cup) (SC)	AASHTO T48 (ASTM D 92)
Distillation	AASHTO T78 (ASTM D 402)
Water	AASHTO T55 (ASTM D 95)
Specific gravity	AASHTO T228 (ASTM D 3142) (ASTM D 243)
Asphalt residue of 100 pen (SC)	
Tests on residue from distillation	
Penetration	AASHTO T49 (ASTM D 5)
Ductility	AASHTO T51 (ASTM D 113)
Solubility	AASHTO T44 (ASTM D 2042)
STV viscosity	BS 3235

(iii) Bitumen emulsion

Tests on bitumen emulsion shall be carried out in accordance with BS 434 test procedures:

Residue on 0.710 mm sieve
Residue on 0.150 mm sieve
Stability to mixing with coarse aggregate
Stability to mixing with cement
Binder content
Engler viscosity
Redwood II viscosity
Storage stability (short period)
Storage stability (long period)
Particle charge

(c) Requirements

(i) 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.

(ii) Straight-run bitumen

Straight-run bitumens shall comply with all the requirements given in Table 2-5.

(iii) 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 following requirements:

STV Viscosity at 40°C (10mm 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 (250°-100g-5s)	80 - 200 10-1mm
Specific gravity at 15°C	0.92 - 1.04

TABLE 2-5 : SPECIFICATION FOR STRAIGHT RUN BITUMEN

Penetration Grade	20/30	40/50	60/70	80/100	180/200
Peretration at 25° (100g-5 s) 0.1mm	20 - 30	40 - 50	60 - 70	80 - 100	130 - 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

Slow curing cut-backs shall comply with all the requirements of AASHTO Standard Specification M 141 (ASTM D 2026).

(iv) Bitumen emulsion

Bitumen emulsions shall comply with all the requirements of BS 434.

212 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 following test procedures:

Moisture and volatile distillates	AASHTO T110 (ASTM D 1461)
Quantitative extraction of bitumen	AASHTO T164 (ASTM D 2172)
Specific gravity of compacted mixture	AASHTO T166 (ASTM D 1188 and D 2726)
Recovery of bitumen from solution	AASHTO T170 (ASTM D 1856)
Coating and stripping	AASHTO T182 (ASTM D 1664)
Degree of particle coating	AASHTO T195 (ASTM D 2489)
Coating and stripping (with adhesion agent)	(ASTM D 2727)
Maximum specific gravity	AASHTO T209 (ASTM D 2041)
Degree of pavement compaction	AASHTO T230
Marshall stability	AASHTO T245 (ASTM D 1559)
Hubbard-Field stability	(ASTM D 1138)

213 REINFORCING STEEL

Hot-rolled steel bars for the reinforcement of concrete shall comply with BS 4449

Cold-worked steel bars for the reinforcement of concrete shall comply with BS 4461

Steel fabric for the reinforcement of concrete, shall comply with BS 4483

214 PRESTRESSING STEEL

Steel wire for prestressed concrete shall comply with BS 2691. Steel strands for prestressed concrete shall comply with BS 3617 (seven wire strand) or BS 4757 (nineteen-wire strand)

Hot-rolled and hot-rolled and processed high tensile alloy steel bars for the prestressing of concrete shall comply with BS 4486.

217 PAINTS FOR STRUCTURES

(a) Paint for structural steelwork

(i) Red lead priming paint

Lead based priming paints shall comply with B.S. 2523. 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.

(ii) Bituminous aluminium paint

Bituminous aluminium paint shall be of a type approved by the Engineer.

(iii) Other paints

All other paints used in the Works shall be subject to approval by the Engineer.

(b) Paint for road signs

Road signs, posts and fittings shall be prepared, treated and painted in accordance with the requirements of BS 873, Parts 2,6 and 7.

218 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 reflectorized unless otherwise specified.

The paint shall be of a type approved by the Engineer, and if not on the current approved list, samples shall be submitted to the Engineer at least 6 months prior to its proposed use.

(b) Colour

(i) 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.

(ii) Yellow

The colour of yellow markings shall be to BS Colour No. 08E51 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) Reflectorization

(i) Non-reflectorized

Paint specified to be non-reflectorized shall have minimum reflective brightness values, as compared to magnesium oxide (MgO) of, for white 80% and for yellow (using a yellow filter of 5800°A) 65%.

(ii) Internal reflectorization

Internally reflectorized paint shall be specifically manufactured for this purpose and shall contain ballotini beads to BS 6088. The ballotini shall be reasonably spherical and free from flaws, and of a size suitable for this method of reflectorization, subject to a maximum size of 0.5 mm.

(iii) Surface reflectorization

Surface reflectorization of the paint shall be by application of ballotini beads to BS 6088 to the wet paint film. The ballotini shall be reasonably spherical and free from flaws and of a size suitable for this method of reflectorization, subject to a maximum nominal size of 0.8 mm.

219 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 BS 3262: Part 1.

The material shall be of a type approved by the Engineer, and if not on the current approved list, samples shall be submitted to the Engineer at least 6 months prior to the proposed use.

(b) Colour

(i) White

The colour of white markings shall be BS Colour No 00E55 of BS 4800.

(ii) Yellow

The colour of yellow markings shall be to BS Colour No. 08E51 of BS 4800.

(c) Composition

The thermoplastic material shall consist of light coloured aggregate, pigment and extender bound together with resin plasticized with oil as necessary, in approximately the following proportions:

Aggregate, including ballotini:	60%
Pigment and extender:	20%
Binder:	20%

The maximum size of the aggregate shall be 2 mm.

The softening point of the binder shall be 45° - 50°C.

(d) Reflectorization

Reflectorization shall be by ballotini beads to BS 6088, which shall make up approximately 20% 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 reflectorization, subject to a maximum size of 2 mm.

220 REFLECTIVE MATERIALS ON ROAD SIGNS

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.

The reflective material shall comply with the following specifications:

(a) 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 2-6. 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.

(b) 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 of Transport and Communications, Materials Branch. After cleaning, the CIL values of the reflective surface shall then be not less than 80% of the values given in Table 2-6, and the colours shall still conform to the specified requirements.

(c) 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.

TABLE 2-6: CIL FOR REFLECTIVE SIGNS

ANGLE OF		MINIMUM CIL VALUE Candelas per hex per m^2				
DIVERGENCE +	INCIDENCE ++	WHITE	YELLOW	RED	GREEN	BLUE
0.2°	5° 30° 40°	70 30 12	50 22 10	14.5 6.0 2.7	9.0 3.5 1.5	4.0 1.7 0.7
0.33°	5° 30° 40°	50 24 9	35 10 6	10.0 4.0 1.8	7.0 3.0 1.2	3.0 1.0 0.4
0.5°	5° 30° 40°	30 15 7	25 13 5	7.5 3.0 1.4	4.5 2.2 1.1	2.0 0.8 0.3
2°	5° 30° 40°	4 2 1.5	5 2.5 1.3	1.0 0.5 0.3	1.0 0.4 0.2	0.6 0.1 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.

(d) 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 2-6.

(e) 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 2-6.

(f) 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 overcoating in accordance with the manufacturer's recommendations.

221 COLOURS FOR ROAD SIGNS

Standard colours to be used for signs, posts and fittings shall be as described in the relevant BS as follows:

Red	BS 381C No. 537
Blue	BS 4800 No 18 E 53
Yellow	BS 381C No. 355
Green for primary route signs	BS 4800 No. 14 C 39
Grey for posts, fittings and backs of signs	BS 4800 No. 10 A 11
Cream	BS 381C No. 352
White	BS 873 Part 1 - Clause 1-3.2
Black	BS 873 Part 1 - Clause 1-3.3

222 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.

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223 GALVANIZED COATINGS

Galvanized coatings on iron and steel shall comply with the following standards as appropriate:-

Galvanized coatings on corrugated sheets	BS 3083
Galvanized coatings on iron and steel	BS 729
Galvanized coatings on steel sheet and strip	BS 2989
Galvanized coatings on wire	BS 443

224 TRIALS TO CONFIRM COMPLIANCE WITH SPECIFICATIONS

(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 Section 16 of this Specification.

For mixed materials the composition which meets the specified requirements and is accepted by the Engineer shall then be used in the site trials carried out in accordance with Clause 224(b) to establish that all specified requirements of the completed pavement course can be achieved.

The laboratory trials on mixed materials shall be undertaken, and the Contractor's proposals based thereon submitted to the Engineer, at least two weeks before the Contractor proposes to use the mixed material in the site trials in accordance with Clause 224(b).

(b) Site trials

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 his 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 this Specification. Any areas which do not comply with this Specification shall be removed and a new trial shall be laid.

The Contractor shall allow in his programme for conducting site trials and for carrying out the appropriate tests on them. 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 pressures, 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.

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

226 FREQUENCY OF TESTING

If a nuclear method is used for determining the wet density, 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 three readings taken at positions rotated by 90° will be used. A check/comparison test using the sand replacement method will be carried out at a 10 test interval.

Initial calibration of the nuclear density testing equipment will be done by carrying out at least fifty tests in parallel with the sand replacement method for each different material encountered. The check tests will be used to update the initial calibration of the nuclear density testing equipment.

(i) Original ground

The AASHTO T99 MDD and OMC shall be determined for each new material encountered, and at intervals of at least once per 1000 m^2 of each layer of compacted ground but at a maximum interval of 50 m along the alignment.

(ii) Bulk earthworks

The AASHTO T99 MDD and OMC shall be determined for each new material encountered, and at intervals of at least once per 150 m^3 of compacted material placed. The field dry density shall be determined at least once per 150 m^3 of compacted material placed or at least three tests per section, whichever is the more frequent.

(iii) Upper 300mm of earthworks

The AASHTO T99 MDD and OMC shall be determined for each new material encountered, and at intervals of at least once per 500 m^2 of each layer of compacted subgrade .

The field dry density shall be determined at least once per 250 m^2 of each layer of compacted subgrade but with a minimum of three tests per section.

The soaked CBR of material in the upper 300 mm of earthworks shall be determined at least once per 500 m^2 of each layer.

(iv) Backfill/fill to culverts and structures (including excavated surface to receive culvert or structure)

The AASHTO T99 MDD and OMC shall be determined for each new material encountered.

The field dry density shall be determined at least twice per 10 m^3 of material placed and compacted but with a minimum of two tests per section.

(v) Gravel wearing course

The AASHTO T180 MDD and OMC shall be determined for each new material encountered and at intervals of at least once per 400 m^2 of each layer of compacted material.

The field dry density shall be determined at least once per 200 m^2 of each layer of compacted material but with a minimum of three tests per section.

The soaked CBR and Plasticity Index of material used for gravel wearing course shall be determined on opening up each new source of material and at least once per 150 m^3 of compacted material taken from that source. The grading of the material shall be determined at least once per 300 m^3 of compacted material.

(vi) Natural materials in subbase and base

The AASHTO T180 MDD and OMC shall be determined for each new source of subbase or base course material used and at intervals of at least once per 400 m^2 of each layer of compacted subbase or base course laid.

The field dry density shall be determined at least once per 200 m^2 of each layer of compacted subbase or base but with a minimum of three tests per section.

The soaked CBR and Plasticity Index of gravel used for subbase or base shall be determined on opening up each new source of gravel and at least once per 75 m^3 of compacted gravel taken from that source.

The ACV and LAA of a gravel used for base and subbase shall be determined on opening up each new source of gravel and whenever the Engineer considers that its quality may have altered. The grading and Plasticity Modulus shall be determined at least as often as the CBR.

(vii) Crushed stone subbase and base

The MDD (Vibrating Hammer Method) and the Specific Gravity of the graded crushed stone shall be determined at least once per 400 m^2 of each layer of compacted subbase or base course laid.

The field dry density shall be determined at least once per 200 m^2 of each layer of compacted subbase or base but with a minimum of three tests per section.

The LAA, ACV, SSS and CR shall be determined on opening up and crushing material from each new source for subbase or base and whenever the Engineer considers that the material has altered.

The grading, PI and FI of crushed material for subbase or base shall be determined at least once per 500 m^3 of material produced.

(viii) Cement or lime treated materials in subgrade, subbase and base

The AASHTO T99 MDD and OMC shall be determined for each new treated material used for subgrade and at intervals of at least once per 400 m^2 of each layer of compacted subgrade.

The AASHTO T180 MDD and OMC shall be determined for each new treated material used for subbase or base and at intervals of at least once per 400 m^2 of each layer of compacted treated subbase or base layer.

The field dry density shall be determined at least once per 200 m^2 of each layer of compacted treated subgrade, subbase or base course, but with a minimum of three tests per section.

The following properties shall be determined on opening up of each new source, and when in the opinion of the Engineer the nature of the material has changed, and once per 300 m^3 of subbase or base laid and compacted:-

Grading
Atterberg Limits
CBR or UCS as indicated in the Special Specification.

(ix) Bituminous surface treatments and surface dressing

(a) Aggregates, sand, gravel

The properties listed below, as appropriate to the type of surface treatment specified, shall be determined on opening up of each new source and when the Engineer considers that the properties may have altered:-

FI
LAA
ACV
SSS
PI
Sand Equivalent
ALD (Average Least Dimension)

The properties listed below, as appropriate to the type of surface treatment specified, shall be determined twice daily when surfacing dressing or slurry seal work is in progress:-

FI
Grading
Angularity
Cleanliness

PI
Deleterious Matter
Spread Rate (Tray Test)
Sand Equivalent

(b) Binder

Compliance with Clause 211 of this Specification shall be determined at least once per 20,000 litres delivered to Site.

Binder spray rate shall be determined once per section sprayed. The rate of application of slurry seal shall be determined once per load of slurry applied.

(x) Bituminous mixes

(a) Aggregates

The aggregate properties listed below, as appropriate to the type of mix specified, shall be determined on opening up of each new source of aggregate, and whenever the Engineer considers that the aggregate properties may have altered:-

Grading
LAA
ACV
SSS
FI
CR
Sand Equivalent
Uniformity Coefficient
Atterberg Limits
Soluble Salts and Deleterious Matter
Real and apparent Specific Gravity and Absorption in the mixed aggregate
Voids

The grading of cold feed mixed aggregates shall be determined at least once per day during mixing.

(b) Mineral filler

The grading and bulk density in toluene shall be determined once per 100 tonnes of filler used, and when the source of filler is changed.

(c) Bituminous mixture (from the mixing plant)

The properties of the bituminous mixture, as appropriate to the type of mix specified shall be determined every 4 hours or part thereof of mixing time on samples taken from the mixing plant:-

Bitumen Content
Grading
Marshall Stability
Flow
Voids
Absorbed Water

(d) Bituminous mixture (on cores from the compacted layer)

The properties of the bituminous mixture, as appropriate to the type of mix specified, shall be determined at least once for every 1000 m^2 of mix laid from core samples cut from the compacted layer:-

Bitumen Content
Grading
Density
Voids

227 MEASUREMENT AND PAYMENT

No separate measurement and payment will be made for testing of materials, trials and construction control testing and the Contractor shall be deemed to have allowed in his rates and prices for the cost of complying with the requirements of Section 2 of this Specification.

SECTION 3

SETTING OUT AND TOLERANCES

301 SETTING OUT

(a) 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 satisfy himself as to 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, he 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 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 of the Engineer, he shall be liable for the full cost of its replacement and a fine under the Survey Ordinance, 1951, or any subsequent amendment.

(b) Detailed setting out

In addition to the requirements of Clause 301(a) the Contractor shall set out the line and level of the Works at intervals of not more that 25 m or such lesser intervals as are required to construct the Works to the tolerances specified in Clause 302 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 of 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 kms 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.

302 TOLERANCES

(a) Horizontal alignments

Horizontal alignments shall be determined from the centreline of the pavement surface as shown on or calculated from the Drawings. The centreline of the pavement surface as constructed, and all other parallel alignments, shall be correct within a tolerance of $\pm$ 13 mm therefrom.

(b) Thickness of pavement layers

The average thickness of any pavement layer measured at five points in any length of 100 m shall not be less than 100% nor more than 120% of the thickness specified or ordered by the Engineer. In addition the thickness of any pavement layer measured at any point shall not be less than 98% nor more than 125% of the thickness specified or ordered by the Engineer.

(c) 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 3 - 1.

For checking compliance with Table 3 - 1 measurements of surface levels will be taken at points to be selected by the Engineer at 12.5m centres longitudinally and at 2 m centres transversely. At junctions, the grid point spacings shall be determined by the Engineer.

(d) 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 parallel to or at right angles to the centreline of the road. The maximum allowable deviation of the surface below the straightedge shall be as given in Table 3 - 1.

In addition the longitudinal slope or transverse crossfall shall not deviate from that shown on the Drawings by more than the tolerances shown in Table 3 - 1.

(e) Shoulders

Shoulders shall be constructed to the same thickness, level and surface regularity requirements as for the adjacent pavement layers.

Table 3-1

LAYER	LEVEL mm	STRAIGHT EDGE mm	SLOPE OR CROSSFALL %
Bituminous Wearing Course	±10	6	± 0.25
Bituminous Binder Course	±10	6	± 0.25
Base	±10	6	± 0.25
Subbase	±15	10	± 0.50
Gravel Wearing Course	±15	15	± 0.50
Formation	+ 0 -50	20	± 0.50

(f) 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.

(g) 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 Drawings or more than that shown on the Drawings plus 0.25 m.

(h) 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.

(i) Construction control testing

Unless otherwise directed values given in this Specification are minimum values and the workmanship will only be considered as satisfactory if all tests, taken at the frequency specified in Section 2 of this Specification are at least equal to that specified in the relevant section.

303 RECTIFICATION OF EARTHWORKS AND PAVEMENT LAYERS OUTSIDE PERMITTED TOLERANCES

Where any tolerances in Clause 302 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.

(a) Earthworks

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 in 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 the requirements of Section 5 of this Specification.

Where the width of a cutting is less than, 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 than, 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 Section 5 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 (AASHTO T99) 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) The 300 mm layer below formation level

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 12.5m 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.

(c) Base and subbase

Where these consist of unbound (i.e. natural or graded stone) material the full depth of the material shall be removed from the pavement and replaced to specification. The area treated shall be at least 30 m long and 3 m wide or such area to the determined by the Engineer as necessary to obtain compliance with this Specification.

Where the courses consist of cement or lime treated 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.

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 subbase materials 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, a length of at least 50m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

(d) Wearing course

These shall have the full depth of the layer 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, a length of at least 50m 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.

304 MEASUREMENT AND PAYMENT

The Contractor shall be deemed to have allowed in his general rates and prices for the cost of complying with the requirements of Clauses 301, 302 and 303 of this Specification.

Notwithstanding the provisions of Clauses 302 and 303 of this Specification, measurement and payment for earthworks and pavement works shall be made on the basis of the net cross-section ordered by the Engineer and no additional payment shall be made in respect of variation within or without the specified tolerances.

SECTION 4

SITE CLEARANCE AND TOPSOIL STRIPPING

401 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 6 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 450mm at a point 600mm 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 Period of Maintenance. 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 95% MDD (AASHTO T99) up to the existing ground level or up to the formation level if the area is in cut.

402 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 5 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 6 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.

403 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 6 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 Period of Maintenance .

404 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.

405 MEASUREMENT AND PAYMENT

(a) Item : Site clearance

Unit : ha

Site clearance shall be measured by the hectare calculated as the plan area instructed by the Engineer to be cleared.

The rate for site clearance shall include for the cost of complying with the requirements of Clauses 401 and 404 of this Specification.

(b) Item : Removal of topsoil

Unit : m^3

Removal of topsoil shall be measured by the cubic metre calculated as the product of the plan area measured from cross-sections taken prior to site clearance and the vertical depth of topsoil instructed to be removed.

The rate for removal of topsoil shall include for the cost of all hauls as necessary and compliance with the requirements of Clauses 402 and 404 of this Specification.

(c) Item : Allow for the removal of structures and obstructions

Unit : Provisional Sum

Payment will be made on a daywork basis where the Engineer orders the removal of structures and obstructions.

501 SCOPE OF SECTION

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 rockfill to swamps and topsoiling and grassing.

502 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 Clause 509 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.

503 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 material which cannot be ripped to an average depth of rip greater than 300mm by a track type crawler tractor complying with the following:

(i) in good order complete with all equipment and accessories as supplied;

(ii) rated 300 BHP flywheel power or over;

(iii) with an operating weight of not less than 37.2 tonnes;

(iv) equipped with a hydraulically operated single tine ripper compatible with the tractor used; and

(v) operated by a qualified operator in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer.

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 m^3 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 506 of this Specification.

504 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.

505 CONSTRUCTION OF 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 his method of working, take suitable fill material obtained from cuttings to spoil provided he substitutes 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.

Soft material for use in the 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 8% 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.

Where materials of differing quality are available for placing in embankments the Engineer may instruct that certain materials should be excluded from the upper 300mm 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 14 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 150mm compacted depth unless, as a result of site compaction trials, the Contractor has satisfied the Engineer that his 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 508.

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

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.

506 SWAMPS

Areas that are to be classified as swamps will be identified and the treatment thereof specified in the Special Specification. 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 114 of this Specification.

507 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 proofroll each layer in accordance with Clause 512 of this Specification.

Where instructed by the Engineer the Contractor shall place a filter fabric ('Terram' or similar approved) 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 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.

508 COMPACTION OF EARTHWORKS

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 T99). 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: 95% MDD (AASHTO T99)

(ii) The 300 mm below formation in embankments: 100% MDD (AASHTO T99)

(iii) The 300 mm below formation in cuttings under the carriageway and shoulders : 100% MDD (AASHTO T99).

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 224 of this Specification. The 300 mm below formation in both fill areas and in cuttings shall be completed in two 150 mm compacted layers.

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 2 of this Specification the Contractor shall submit to the Engineer his proposals 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.

509 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.

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.

The mass haul diagram will be drawn 'in fill' on the basis that $1m^3$ of material obtained from cuttings will on being compacted into the embankments produce $0.8m^3$ 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 Clause 505 of this Specification.

510 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.

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 hours notice of his intention to commence spoiling operations at a particular location.

511 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 510 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 6 of this Specification.

512 PROOFROLLING

All subgrade and embankment layers, cuttings, benches and original ground shall be proofrolled with a loaded scraper or truck with a minimum axle load of 8 tonnes. Proofrolling 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 proofrolling shall be at the Contractor's expense.

513 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 subbase 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.

514 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:-

(a) Grassing

(b) 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 his 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.

515 SIDE DRAINS

Side drains are considered as cuttings in accordance with Clause 501 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 Section 8 of this Specification.

516 TREATED MATERIALS

Lime or cement treatment if required by the Special Specification or Drawings shall be carried out on subgrade materials that comply with the requirements of Section 5 and shall be treated in accordance with Section 14 of this Specification.

517 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 25m 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 4 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 4 of this Specification.

(iii) The construction of access road, per km, in accordance with Section 9 of this Specification.

(iv) Removal to topsoil and/or overburden, as "Spoil", from the borrow area per cubic metre in accordance with Section 5 of this Specification.

Excavation to spoil of unsuitable material (as defined in Clause 510 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 Clause 509 of this Specification.

Material shall be classified as either hard or soft in accordance with Clause 503 of this Specification.

(a) Item : Fill in soft material

Unit : 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 Clauses 502, 504, 505, 508, 509, 511, 512 and 513 of this Specification.

(b) Item : Fill in hard material

Unit : 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 Clauses 502, 504, 505, 508, 509, 512 and 513.

(c) Item : Spoil in soft material

Unit : 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 topsoiling spoil areas in accordance with Section 6 of this Specification, and complying with the requirements of Clauses 502, 504, 510, 511 and 513 of this Specification.

(d) Item : Spoil in hard material

Unit : 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 6 of this Specification, and complying with the requirements of Clauses 502, 504, 509, 510, 513 of this Specification.

(e) Item : Overhaul

Unit : m^3km

Overhaul shall be measured by the unit m^3km calculated as the product of 'Overhaul Earthworks' in cubic metres and 'Overhaul Distance' in kilometres all as shown on Figure 5-1.

The distance between the centres of volume of cut and fill shall be measured along the centreline of the new road. Should the Contractor elect to haul by a different route no additional measurement or payment will be made.

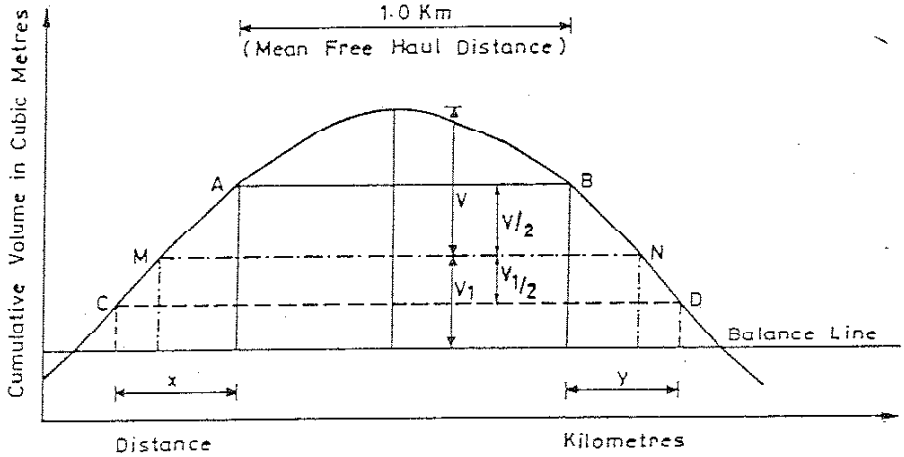

FIGURE 5-1

Diagram showing method of computation of freehaul 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 = Vl

6) Overhaul Distance = CD - 1.0

7) Overhaul = Vl (CD - 1.0)m^3km

Cut and fill volumes 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 utilization 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.

(f) Item : Compaction of existing ground

Unit : 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 Clauses 502, 504, 508, and 512 of this Specification.

(g) Item : Compaction of the 300mm below formation level in cutting to 100% MDD (AASHTO T99)

Unit : 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 Clauses 502, 503, 504, 508, 510, 511, 512 and 513 of this Specification.

(h) Item : Extra over (a) for compaction of top 300mm to 100% MDD(AASHTO T99)

Unit : m^3

The rate for extra over Clause 517(a) 'Fill in soft material" for compaction of the 300 mm below formation level in 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 Clauses 502, 503, 504, 505, 508, 511, 512 and 513 of this Specification.

(i) Item : Excavation in swamps

Unit : 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 area, trimming shaping and topsoiling of spoil areas in accordance with Section 6 of this Specification, all additional excavation required to achieve the instructed area and depth, excavating underwater, a free haul of 1.0km and complying with the requirements of Clauses 506 and 507 of this Specification. Overhaul will be measured in accordance with Clause 517(e) of this Specification.

(j) Item : Rockfill

Unit : tonne

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 507 of this Specification.

(k) Item : Filter fabric under, over or around rockfill

Unit : m^2 of each weight of fabric specified

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 included 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 506 and 507 of this Specification.

(l) Item : Topsoiling

Unit : m^2 for each situation

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 514 of this Specification.

(m) Item : Grassing

Unit : m^2 for each situation

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 514 of this Specification.

601 GENERAL

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 subbases, 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 602 (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 he elect to use them.

The sources of natural materials such as fill material for the construction of embankments, and gravel for subbase, base, surfacing and shoulders shall be designated as borrow pits and are defined in Clause 602 (b). 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 materials, 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.

602 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.

603 PROVISION OF LAND

The Employer 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 Section 1 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 them, in the opinion of the Engineer:

(a) is less than 3 km from the next quarry, borrow pit, spoil or stockpile area;

(b) will have a detrimental effect on the environment;

(c) will incur relatively high land acquisition costs or would be very difficult to acquire;

(d) is in or near an urban centre;

(e) will require an access road which is excessively long;

(f) has excessively thick layers of overburden;

(g) covers too large an area;

(h) would constitute a danger to the public;

(i) is an excessive distance from the location the material is to be used or removed from; or

(j) a source of suitable material is closer at hand.

The Contractor shall inform the Engineer in writing not later than 90 days after the Engineer's order to commence work (Clause 41 of the Conditions of Contract) 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 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 his 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 himself 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 603 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 124 of this Specification.

604 ENTRY UPON LAND

The Contractor shall, before entering upon any land provided by the Employer, satisfy himself 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.

605 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 his 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 his own expense stockproof fencing and gates 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 20 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.

606 ACCESS ROADS AND TRAFFIC CONTROL

The Contractor shall comply with the provisions of Section 9 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.

607 SITE CLEARANCE AND REMOVAL OF TOPSOIL AND OVERBURDEN

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 4 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 4 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 5 of this Specification.

608 MIXING, SELECTING 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.

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.

609 MATERIAL UTILIZATION

Where the Contractor uses a borrow pit, instructed by the Engineer for use in earthworks or under 'Method B' of Section 10, 11 and 12 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 Sections 10, 11 or 12 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 Sections 10, 11, or 12 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 Sections 10, 11, or 12 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.

610 MEASUREMENT AND PAYMENT

Reimbursement for land acquisition shall be made in accordance with the provisions of Section 1 of this Specification.

No separate measurement and payment will be made in respect of this Section 6 of this Specification. The Contractor shall be deemed to have allowed elsewhere in his rates and prices for the cost of complying with all the requirement of this Section 6, including all site clearance, overburden and topsoil removal, access roads to quarries, borrow pits, spoil areas and stockpile areas and reinstatement including landscaping and spreading topsoil.

Where the Engineer has instructed that overburden or topsoil is used in the Works measurement and payment will be in accordance with the relevant Sections of this Specification.

701 SCOPE OF SECTION

This section covers all excavation and filling operations to bridges, box culverts, retaining walls and other major structures.

702 CLASSIFICATION OF EXCAVATION

(a) Hard material is material which can be excavated only after blasting with explosives or barring and wedging or the use of a mechanical breaker fitted with a rock point in good condition and operated correctly. Boulders of more than $0.20m^3$ occuring in soft material shall be classified as hard material.

(b) Soft material is all material other than hard material.

703 EXCAVATION OF FOUNDATIONS FOR STRUCTURES

The excavation of foundations for structures and any associated drainage works shall be kept to the minimum. The sides of the excavation shall be kept vertical and shall be properly timbered or sheet piled, shored and strutted as necessary to prevent subsidence or slipping of the surrounding soil.

All excavated surfaces, in material other than hard material, on which foundations for structures are to be placed shall be compacted to 95% MDD (AASHTO T99) immediately before foundations are constructed.

Excavated surfaces in hard material shall be further excavated to achieve a minimum thickness of 50mm of blinding concrete.

Where a combination of hard and soft materials exist in the excavated surfaces then, dependant on the proportions of existing materials, the Contractor will either, remove a minimum of 300 mm of soft material below underside of foundation and replace it with lean concrete to the top of blinding level or remove a minimum of 300mm of hard material below the underside of blinding concrete and replace it with soft material compacted to 95% MDD (AASHTO T99).

The Engineer's approval of any excavation shall be obtained prior to any construction thereon.

704 EXCAVATIONS TO BE KEPT DRY

All excavations shall be kept dry and the Contractor shall take all necessary measures to maintain excavations free from water.

Where required by the Engineer, the sumps from which pumps operate shall be constructed outside the area of the foundation base. Excessive pumping from the excavation which is liable to cause settlement, disturbance, or washing out of fines from the adjacent ground will not be permitted.

Where, in the opinion of the Engineer, the foundation has become soft and additional excavation is required due solely to the Contractor's method of working, the resulting backfill shall be with approved material or concrete as instructed by the Engineer. All such backfill shall be at the Contractor's expense.

705 FOUNDATIONS AND ABUTMENTS CAST AGAINST IN-SITU MATERIAL

Where shown on the Drawings or instructed by the Engineer that a foundation and/or abutment shall be cast against the in-situ material, the excavations shall be neatly excavated to the shape required. Should any over-excavation occur the space between the foundation and/or abutment and the in-situ material shall be backfilled with Class 15/20 concrete or with the same grade of concrete as the foundation and/or abutment and shall be placed in advance of the concrete for the foundation and/or abutment. All such backfill shall be at the Contractor's expense.

706 SURPLUS EXCAVATED AND BACKFILLING MATERIALS

Surplus excavated material shall be taken to spoil areas or may be used in adjacent earthworks if suitable.

The Engineer's approval must be obtained to the Contractor's proposed material for backfilling and filling behind and around a structure.

707 BACKFILLING OF EXCAVATIONS AND FILLING FOR STRUCTURES

No filling around a structure or backfill in a trench or excavation shall commence, neither shall a structure be loaded, without the approval of the Engineer.

The sequence of filling and backfilling behind and around a structure and the maximum difference in height at any time between fill levels shall as directed by the Engineer.

All filling and backfilling shall be with selected materials approved by the Engineer, brought up in horizontal layers not exceeding 150 mm compacted thickness. Each layer shall be thoroughly mixed, watered or dried as necessary, and compacted to a minimum dry density of 95% MDD (AASHTO T99).

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. The

interface between selected granular material to this Section of the Specification and the adjacent earthworks to Section 5 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.

708 PROTECTION OF STRUCTURES

The Contractor shall furnish, construct and maintain all necessary cofferdams, cribs, channels, flumes and other diversion and protection works and shall furnish, install, maintain and operate all necessary pumping and other equipment for the exclusion or removal of water from various parts of the Works.

Drawings for cofferdams and other proposed temporary installations shall be submitted to the Engineer before commencement of the work. The Contractor shall avoid any measures in the proposed installations which will cause flooding or endanger the safety of persons or property upstream or downstream of the site.

All such structures shall be removed on completion of the works unless otherwise instructed by the Engineer.

709 EXCAVATIONS FOR RIVER TRAINING AND NEW WATERCOURSES

Excavations carried out in the diversion, enlargement, deepening or straightening of streams and rivers or in the formation of new watercourses shall be performed as shown on the Drawings or as instructed by the Engineer, and may include site clearance, trimming of slopes, grading of beds and disposal of the excavated materials.

Where water courses have to be diverted, the original channels shall be cleared of all vegetable growth and soft deposits and carefully filled in with approved materials, deposited and compacted as instructed by the Engineer.

710 STONE PITCHING

Where shown on the Drawings or directed by the Engineer the Contractor shall excavate for, trim to line and level, provide and lay stone pitching.

Stone pitching shall be formed of hard stone, roughly dressed square. The least dimension of any stone shall not be less than 200 mm, and the volume not less than 0.01 m^3. No rounded boulders shall be used.

The stones shall be set on edge and securely bedded with the largest dimensions at right angles to the flow of water, fitted closely together so as to leave only a minimum of voids between the stones

which shall be filled in with suitably shaped and tightly wedged spalls. The top of the pitching shall be finished flush with the adjacent material.

Where grout is specified, a 1:4 cement : sand mortar shall be rammed into the wetted interstices and smoothed off flush with the pitched face.

711 GABIONS

Where shown on the Drawings or directed by the Engineer the Contractor shall excavate for, trim to line and level, provide and erect gabions including providing selected rock, crushed if necessary, packed and compacted inside the gabions.

Gabions shall include gabion mattresses and gabion boxes and for the purposes of construction and method of measurement and payment no distinction shall be made between them.

Gabions shall be "Maccaferri" boxes and/or "Reno" mattresses both with diaphragms at 1 metre centres, or similar approved. The maximum mesh size shall be 100 mm x 120 mm for boxes and 60 mm x 80 mm for mattresses. The wire used for the construction of gabions shall unless otherwise instructed by the Engineer comply with the requirements of Table 7 - 1.

TABLE 7 - 1

		Diameter (mm)	Galvanising (g/m^2)
Mesh	Box	3.4	275
	Mattress	2.7	260
Binder	Box	2.2	240
	Mattress	2.2	240
Selvedge	Box	3.9	290
	Mattress	3.4	275

All wire shall be to BS 1052 having a tensile strength of not less than $40 kg/mm^2$

Galvanizing shall comply with the requirements of BS 443.

Gabions shall be constructed to the shapes and dimensions as shown on the Drawings or given in the Special Specification or as directed by the Engineer. Gabions, as constructed shall be within a tolerance of $\pm$ 5% on the height or width instructed and $\pm$ 3% on the length instructed.

The alignment of the gabion shall be correct within a tolerance of 100mm of the instructed alignment and the level of any course of gabion shall be correct to within a tolerance of 50mm of the instructed level. In addition adjacent gabions shall not vary by more than 25mm in line and/or level from each other.

The surface upon which gabions are to be laid shall be compacted to a minimum dry density of 95% MDD (AASHTO T99) and trimmed to the specified level or shape.

Joints in gabions shall be stitched together with 600mm minimum lengths of binder wire, with at least one stitch per 50mm, and each end of the wire shall be fixed with at least two turns upon itself.

Adjacent gabions shall be stitched together with binder wire along all touching edges.

Gabion boxes shall be laid with broken bond throughout to avoid continuous joints both horizontally and vertically. Pre-tensioning of gabions shall be subject to the approval of the Engineer.

Gabions shall be handpacked with broken rock of 150 mm minimum dimension and 300mm maximum dimension. The sides shall be packed first in the form of a wall, using the largest pieces, with the majority placed as headers with broken joints to present a neat outside face. The interior of the gabion shall be hand packed with smaller pieces and the top layers shall be finished off with larger pieces. The whole interior and top layers shall be packed tight and hammered into place.

Where instructed by the Engineer the Contractor shall place filter fabric ('Terram' or similar approved) behind gabion faces in contact with existing or backfilled ground. The Contractor shall ensure that the filter fabric is not damaged during the construction or backfilling around the gabion works and any damaged or torn fabric shall be replaced at the Contractor's expense. The filter fabric shall be installed in accordance with the manufacturer's instructions and the filter fabric shall not be left exposed to sunlight for more than 3 weeks.

At the back face and ends of completed gabion work or where shown on the Drawings or instructed by the Engineer the existing soil shall be backfilled, thoroughly compacted against the sides of the gabions and finished flush with the top surface of the gabion.

On completion of gabion construction the exposed joints shall be painted with a thick bitumen to the approval of the Engineer to discourage vandalism.

712 RIP-RAP

Stone for rip-rap shall consist of well shaped hard dense durable rock. At least 50 per cent of the pieces shall have a volume greater that $0.03m^3$ and not more than 5 per cent shall have a volume of less

than $0.01m^3$. Where instructed by the Engineer or shown on the Drawings the stones shall be laid with close joints from the bottom of the slope of embankment, or existing gound upward, the larger of the stones being laid at the bottom. The surface shall be hand packed, carefully bedded and tightly wedged with suitable spalls to form an even surface. Alternatively the Engineer may direct that the stones are dumped from above and that the rip-rap is roughly dressed to the dimensions shown on the Drawings or instructed by the Engineer.

713 MEASUREMENT AND PAYMENT

(a) Item : Excavate for structures in soft material

Unit : m^3

Excavate for structures in soft material shall be measured by the cubic metre, calculated as the product of the net plan area of the foundation to be excavated and the average depth of the excavation. No allowance will be made for working space. The average depth shall be calculated as the difference between the original ground level as agreed between the Engineer and the Contractor or the formation level, whichever is the lower, and the required level.

The rate for excavate for structures in soft material shall include for the cost of excavation to any depth, compaction at the foundation level of the excavation, backfilling with the excavated material or removing the excavated material to spoil if it is unsuitable or surplus to requirements, and complying with the requirements of Clauses 702, 703, 704, 705, 706, 707 and 708 of this Specification.

(b) Item : River training in soft material

Unit : m^3

River training in soft material shall be measured by the cubic metre, calculated as the product of the average end areas measured at intervals of not greater than 10m along the centreline of the area to be excavated and the length of the excavation. The end areas shall be calculated from existing ground levels or existing river or stream profiles taken prior to commencement of excavation and the cross-section shown on the Drawings or instructed by the Engineer.

The rate for river training in soft material shall include for the cost of excavation to any depth and to any bed width, disposal of the excavated material to spoil and compliance with the requirements of Clauses 702, 704, 708 and 709 of this Specification.

(c) Item : Backfill to existing channels in soft material

Unit : m^3

Backfill in soft material to existing channels shall be measured in accordance with Clause 713 (b) of this Specification.

The rate for backfill in soft material to existing channels shall include for excavating the material to be used for backfill, clearing vegetation from the channel, transporting, depositing and compacting the material in the existing channel all hauls as necessary and complying with Clause 709 of this Specification.

(d) Item : Extra over (a) and (b) for excavation in hard material

Unit : m^3

Hard material encountered in any excavation covered by Clause 713 (a) and (b) of this Specification shall be measured by the cubic metre, calculated as the product of the average end areas measured at intervals agreed with the Engineer along the centreline of the excavation and the length over which hard material is encountered. The end areas shall be calculated from levels taken on top of the hard material prior to excavation and levels taken after excavation of the hard material or to the levels instructed whichever is the higher.

The rate for extra over Clause 713(a) and (b) for excavation in hard material shall include for the cost of excavation to any depth and compliance with the requirements of Clauses 702, 703, 704, 705, 706, 707, 708 and 709 of this Specification.

(e) Item : Porous filter material

Unit : m^3

Porous filter material shall be measured by the cubic metre, calculated as the plan area instructed to be backfilled with porous filter material and the average depth of porous filter material instructed to be placed.

The rate for porous filter material shall include for the cost of providing the material, backfilling at any depth, all hauls as necessary and complying with the requirements of Clause 707 of this Specification.

(f) Item : Selected granular fill material

Unit : m^3

Selected granular fill material shall be measured by the cubic metre, calculated as the plan area instructed to be backfilled

with selected granular fill material and the average depth of selected granular fill material instructed.

The rate for selected granular fill material shall include for the cost of providing the material, backfilling at any depth, all hauls as necessary and complying with Clauses 702, 703, 704, 705, 706, 707 and 708 of this Specification.

(g) Item : Stone pitching

Unit : m^2

Stone pitching shall be measured by the square metre calculated as the net area, measured on the slope, instructed by the Engineer.

The rate for stone pitching shall include for the cost of excavating, trimming to line and level, providing and laying the stone and of complying with the requirements of Clause 710 of this Specification.

(h) Item : Extra over (g) for grout

Unit : m^2

Grouting of the stone pitching covered by Clause 713 (g) of this Specification shall be measured by the square metre of stone pitching instructed by the Engineer to be grouted.

The extra over rate for grouting of stone pitching shall include for providing the sand, cement, mortar, wetting of the stone to be grouted, ramming the grout into the interstices and smoothing off flush with the pitched face and complying with Clause 710 of this Specification.

(i) Item : Excavate for gabions in soft material

Unit : m^3

Excavate for gabions in soft material shall be measured by the cubic metre, calculated as the product of the net plan area of the gabion to be excavated and the average depth of the excavation. No allowance will be made for working space. The average depth shall be calculated as the difference between the original ground level as agreed between the Engineer and the Contractor or the formation level or drain profile which ever is the lower, and the required level.

The rate for excavate for gabions in soft material shall include for the cost of excavation to any depth, compaction of the surfaces to receive the gabions, backfilling with the excavated material or removing the excavated material to spoil if surplus to requirements, and complying with the requirements of Clauses 702, 703, 704, 706, 707, 708 and 711 of this Specification.

(j) Item : Extra over (i) for excavation in hard material

Unit : m^3

Hard material encountered in any excavation covered by Clause 713 (i) of this Specification shall be measured by the cubic metre, calculated as the product of the average end areas measured at intervals agreed with the Engineer along the centreline of the excavation and the length over which the hard material is encountered. The end areas shall be calculated from levels taken on top of the hard material prior to excavation and levels taken after excavation of the hard material or to the levels instructed whichever is the higher.

The rate for extra over Clause 713 (i) of this Specification for excavation in hard material shall be extra over that for excavating in soft material and shall include for the cost of excavation to any depth and compliance with the requirements of Clauses 702, 703, 704, 706, 707, 708 and 711 of this Specification.

(k) Item : Gabion mesh

Unit : m^2

Gabion mesh shall be measured by the square metre calculated as the net area of material required to construct the gabions, including diaphragms.

The rate for gabion mesh shall include for the cost of providing and fixing the mesh and the cost of complying with requirements of Clause 711 of this Specification.

(l) Item : Rockfill to gabions

Unit : m^3

Rockfill to gabions shall be measured by the cubic metre calculated as the volume of the gabions instructed to be placed.

The rate for rockfill to gabions shall include for the cost of providing, hauling and placing the rock and the cost of complying with the requirements of Clause 711 of this Specification.

(m) Item : Filter fabric under and/or behind gabions

Unit : m^2 of each weight of fabric specified

The filter fabric placed under and/or behind gabions 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 the requirements of Clause 711 of this Specification.

(n) Item : Dumped rip-rap

Unit : m^3

Rip-rap shall be measured by the cubic metre calculated from the dimensions given on the Drawings or instructed by the Engineer.

The rate for dumped rip-rap shall include for the cost of providing, dumping and roughly dressing the rip-rap and complying with the requirements of Clause 712 of this Specification.

(o) Item : Close jointed rip-rap

Unit : m^3

Close jointed rip-rap shall be measured as the volume of close jointed rip-rap instructed to be placed.

The rate for close jointed rip-rap shall include for the cost of providing, dumping and close jointing the rip-rap and complying with the requirements of Clause 712 of this Specification.

801 SCOPE OF SECTION

This section covers the following:-

(a) The provision and installation of circular concrete pipe culverts, nestable and multiplate corrugated metal pipe culverts and arches and half round channels.

(b) The construction of minor structures including culvert inlet and outlet structures, scour checks, catchpits, cascades and the like.

(c) The construction of drainage protection works including rip-rap, stone pitching and gabions.

(d) The excavation and/or fill and all work associated with the construction of:-

- trenches to receive culverts
- inlets drains
- outfall drains
- mitre drains
- cut-off drains
- subsoil drains
- catchwater drains
- minor structures
- scour checks
- erosion protection works
- guiding dams.

Side drains are covered in Section 5 of this Specification.

Concrete box culverts are covered in Sections 7 and 17 of this Specification.

802 ORDER OF WORKS

(a) The Drawings give a guide only to the location and size of each culvert. Precise details of length, skew and invert levels will be issued to the Contractor from time to time as construction proceeds. The Contractor should allow in his programme a period of 30 days between submission of cross-sections in accordance with Section 3 of this Specification and the issue of precise culvert details.

(b) All culverts and drainage works shall be carefully programmed and the Contractor shall normally allow in his programme (submitted under Clause 14 of the Conditions of Contract) for the completion of all pipe culverts and drainage works prior to the construction of embankments over or beside them.

(c) Where the Contractor considers that drainage conditions are such that it is not necessary to construct a pipe culvert ahead of

the embankment, the Engineer may consent to its installation after construction of the embankment on the following conditions:

(i) that the Contractor will be responsible for any damage or delays to the culvert or to the embankment earthworks; and

(ii) that the construction of the culvert shall follow immediately upon the substantial completion of the embankment earthworks.

(d) Where culverts are to be constructed under a road formation in cutting, excavation and backfill shall be carried out after the bulk earthworks are complete but before the processing of the 300mm layer below formation level in cuttings. The Engineer may consent to the excavation for these culverts being carried out before the earthworks are completed but payment for the excavation of the trench will only be made for the volume excavated below formation level.

803 CLASSIFICATION OF EXCAVATION

All excavation for culverts and drainage works shall be classified as follows:-

(a) Hard material is material which can be excavated only after blasting with explosives or barring and wedging or the use of a mechanical breaker fitted with a rock point in good condition and operated correctly. Boulders of more than 0.20 m3 occurring in soft material shall be classified as hard material.

(b) Soft material is all material other than hard material.

804 EXCAVATION FOR CULVERTS AND DRAINAGE WORKS

The Contractor shall carry out all excavations for culverts and drainage works to the lines, levels, inclinations, and dimensions shown on the Drawings or instructed by the Engineer.

Should excavations be effected to a greater depth or width than is necessary, then the Contractor shall at his own expense backfill the excess excavation with approved materials, compacted to the density of the adjacent ground, to the correct levels and dimensions all to the approval of the Engineer.

The Contractor shall carefully set aside the various suitable materials encountered so that they may be reused for backfilling. If excavated materials are unsuitable the Contractor may spoil the material only after approval by the Engineer.

All excavations shall be kept clean and free from water, and the Contractor shall dig diversion channels, erect cofferdams or otherwise de-water the excavation.

Where, in the opinion of the Engineer, the surface of the excavation has become soft or unsuitable due to the Contractor's method of working, the Contractor shall at his own expense remove and replace the unsuitable material with non-structural concrete as specified in Section 17 of this Specification or other approved material as instructed by the Engineer.

The final excavated surface in soft material on which culverts or structures are to be constructed shall be compacted to a dry density of at least 95% MDD (AASHTO T99) to a depth of 150 mm. All particles larger than 20 mm shall be removed prior to compaction.

For culverts which are to be constructed approximately on the existing ground after the removal of topsoil, the Contractor shall level the existing ground by excavating and/or filling in layers. He shall then compact the ground for 150 mm below invert or underside of bedding material to a dry density of 95% MDD (AASHTO T99) such that the foundation for the culvert or bedding is true to grade and of uniform density over the whole length of the culvert.

The Engineer's approval to the final excavated surface shall be obtained prior to the installation of culverts or the construction of structures.

The sides of pits, trenches and other excavations shall, where required, be adequately timbered and supported, and all such excavations shall be of sufficient size to enable the pipes and concrete to be laid accurately, and proper refilling and compaction to be carried out.

Where instructed by the Engineer, shoring and supporting timber shall be left in trenches or other excavations.

Where ground conditions are such that a satisfactory foundation cannot be achieved the Contractor shall, if instructed by the Engineer, remove the unsuitable material either until a suitable material is encountered or to the depth and width instructed by the Engineer. The Contractor shall backfill the resultant excavation with approved material to a dry density of 95% MDD (AASHTO T99). Approved material may include rockfill as specified in Clause 507 of this Specification and/or selected backfill material in accordance Clause 812 of this Specification.

805 EXCAVATION IN HARD MATERIAL

(a) For concrete pipe culverts

Where hard material is encountered in trenches for concrete pipe culverts, it shall be excavated so that no hard material protrudes within 50 mm of the underside of the pipe barrel. A regulating layer of non-structural concrete of minimum thickness 50 mm shall be placed and compacted on the excavated hard

material surface, the top of which shall be at the level of the underside of the pipe barrel. The maximum thickness of regulating layer shall be 150 mm. Where both soft and hard material are encountered in the trench either the soft material shall be removed to a depth of 300 mm or to such depth as instructed by the Engineer, or if directed by the Engineer the hard material shall be removed to a depth of 300 mm or to such depth as instructed by Engineer and backfilled to 95% MDD (AASHTO T99) with similar material to that in the remainder of the trench invert.

(b) For metal pipe culverts

Where hard material is encountered in trenches for corrugated metal pipe culverts, it shall be excavated to a depth of 150 mm below the invert level of the culvert and replaced with 150 mm of sand or other approved material to provide a firm but flexible bed for the culvert. Where both soft and hard material are encountered in the trench the hard material shall be removed to a depth of 300mm or to such depth as instructed by the Engineer and backfilled to 95% MDD (AASHTO T99) with similar material to that in the remainder of the trench invert.

(c) For minor structures

In accordance with the relevant sections of Clause 703 of this Specification.

806 WATER IN EXCAVATION

The Contractor shall at his own expense make good any damage caused by prolonged and/or excessive pumping and shall take all precautions necessary for the safety of adjoining structures and buildings by shoring or otherwise, during the time that excavations are open.

807 CONCRETE PIPES

Concrete pipes shall be manufactured and tested in accordance with Section 2 of this Specification.

808 CORRUGATED METAL PIPES AND ARCHES

Corrugated metal pipes and arches shall comply with Section 2 of this Specification.

809 BEDDING AND LAYING OF PIPE CULVERTS

Pipe culverts shall normally be bedded directly on in-situ soft material. Where the in-situ material is unsuitable the invert shall be excavated and backfilled as specified in Clause 804 and Clause 805 of this Specification.

(a) Bedding and laying of concrete pipe culverts on in-situ or imported soft material or imported granular material.

The bottom of the excavation shall be compacted to 95% MDD (AASHTO T99) and shaped to the lower part of the pipe such that the barrel of the culvert rests on it over a width of at least one third of its diameter, and throughout the length of barrel.

Voids shall be formed under the joints and sockets so that adequate space is provided under the pipe to form the joint. When the joint has been formed the void shall be packed hard with bedding material. The underside of the barrel shall be packed hard with selected fill material with a maximum particle size of 20 mm, at a suitable moisture content, and rammed solid.

(b) Bedding and laying of concrete pipes on a concrete bed

Where pipes are laid on a concrete bed the pipes shall be bedded on 1:3 cement:sand mortar at least 50 mm thick, 150 mm wide and extending the full length of the barrel.

After the joints have been formed, concrete Class 15/20 shall be packed hard under the barrel and sockets of the culvert and extending upwards on each side of the pipe to the height shown on the Drawings.

(c) Bedding and laying of metal culverts

All pipes shall be laid, bedded and jointed in accordance with the manufacturer's recommendations.

Where shown on the Drawings the excavation shall be trimmed to the contour of the base of the culvert and a bed of fine granular material not less than 75 mm thick shall be placed, compacted and shaped to enable the culvert to be bedded.

Unless otherwise directed, all pipes shall be painted prior to assembly both inside and out with one coat of purpose made bituminous paint, approved by the Engineer. During assembly both areas of pipe sections in contact shall be painted with a second coat of purpose made bituminous paint immediately prior to fixing.

After assembly all pipes shall be painted over the exposed area outside with a further coat of purpose made bituminous paint, and all pipes of 1.2 m diameter and over shall also be painted internally.

Pipe laying shall be started at the inlet end with the separate sections firmly jointed together and with outside laps of circumferential joints pointing upstream. With the permission of the Engineer pipes may be assembled out of the trench and

lowered in, in which case particular care shall be taken to ensure the barrels are properly bedded along the whole length. Outside laps of longitudinal joints shall point downwards.

Multiple installations shall be laid with centrelines parallel. Unless otherwise instructed or shown on the Drawings, the clear distance between barrels of adjacent pipes shall be at least equal to one half the diameter of the pipes.

Where instructed by the Engineer the gradeline shall be cambered to allow for future settlement.

810 JOINTING CONCRETE PIPES

(a) Rigid joints

When laying rigid jointed concrete pipes with integral sockets, before entering a pipe spigot into its socket, both spigot and socket shall be clean and free from mud, oil, grease or other deleterious matter. A gasket of tarred hemp yarn, cut to length so that it forms a butt joint at the crown of the pipe, shall be wrapped round the spigot which shall then be fully entered into the socket and the gasket caulked up hard into the joint. The joint shall then be filled completely with a plastic mortar composed of one part of cement to two parts of sand and finished off with a fillet at an angle of 45°.

Rigid jointed sleeves used to join two spigots shall be jointed in the same manner as integral sockets.

If the Drawings require ogee jointed pipes to be laid with a mortar joint, the joint shall be made at the time of laying. Mortar as described above shall be applied to the lower semi-circumference of the socket and to the upper semi-circumference of the spigot and the pipe shall be drawn hard into the socket. The outside of the joint shall be pointed up with a fillet of 1:2 cement:sand mortar, 75 mm wide and 25 mm thick, all the way round and central over the joint.

All pipes shall be saturated with water before jointing and shall be scraped, cleaned inside and the joint flushed up with 1:2 cement: sand mortar.

All joints shall be protected from the wind, sun and rain by a covering approved by the Engineer, and shall be kept constantly damp for a period of at least three days.

The pipes shall not be disturbed in any way for at least 48 hours after jointing.

(b) Flexible joints

Flexible joints between concrete pipes having integral sockets may be formed by a shaped rubber gasket fitted within the socket or by a rubber ring of circular cross section (O-ring) placed on the pipe spigot. The type of flexible joint to be used shall be subject to the approval of the Engineer.

Before any joint is made all parts of the joint shall be clean and free from mud, oil, grease or other deleterious matter.

Fixed gaskets shall be lubricated strictly in accordance with the manufacturer's recommendations. O-ring gaskets shall not be lubricated. Components of flexible joints from different manufacturers shall not be used together.

The spigot of the pipe to be laid shall be entered into the socket of the previous pipe with the two pipes in line, and a firm steady pressure exerted on the end of the pipe being laid. If necessary a jack anchored round the collar of the previous pipe shall be used to pull in pipes. The spigot shall be pulled hard into the socket and then eased back the distance recommended by the manufacturer to provide flexibility in the joint.

After jointing, the position of O-rings shall be tested with a feeler to ensure that they are correctly positioned. If any ring shows a significant departure from a line following a pipe circumference, the joint shall be broken and remade using a new ring.

Where plain ended pipes are connected by a sleeve incorporating flexible joints, the joints shall be made as described for pipes with integral sockets. The joint between the first pipe and the sleeve shall be completed before the second pipe is inserted into the sleeve.

The annular space inside the socket of each pipe or sleeve but outside the gasket shall be filled with puddled clay, uncaulked yarn or other suitable material approved by the Engineer to prevent the entry of stones.

(c) Pipe ends

Unless otherwise specified pipe ends shall be left square.

811 CONCRETE BEDS, SURROUNDS AND HAUNCHES

The floor of the trench shall be thoroughly cleaned trimmed and compacted before any bed, surround or haunch is placed and shall be subject to approval by the Engineer before concreting is commenced.

All concrete for beds, surrounds and haunches shall be Class 15/20 complying with Section 17 of this Specification formed to the dimensions shown on the Drawings or instructed by the Engineer.

Unless otherwise instructed by the Engineer, 150 mm of concrete surround shall be provided to concrete pipes in the following circumstances:

(a) concrete pipes up to and including 600 mm diameter with less than 0.60 m cover or more than 3.0 m of cover;

(b) concrete pipes over 600 mm diameter and not exceeding 900 mm diameter with less than 1.0 m of cover or more than 3.0 m of cover; and

(c) concrete pipes over 900 mm diameter, at any depth.

812 BACKFILL

Backfill for concrete and metal pipes and minor drainage structures shall be obtained from the material excavated in forming the excavation and in the event of there being insufficient excavated material or the culvert is laid close to or above existing ground then selected backfill shall be obtained from borrow pits. All backfill whether from excavated material or borrow pits shall have a CBR of at least 5 measured after 4 day soak on laboratory mix compacted to 95% MDD (AASHTO T99), a Plasticity Index of less than 35%, a maximum particle size of 20 mm and shall be compacted to a dry density of 95% MDD (AASHTO T99).

For pipe culverts which have been placed and where no concrete haunch or surround is called for, selected fill material, consisting of the finest available from the excavation shall be placed in layers not exceeding 150 mm loose thickness and water shall be uniformly mixed in or the material dried out, such that the moisture content at the time of compaction shall be between 75% and 105% of the Optimum Moisture Content (AASHTO T99) and thoroughly compacted along the remainder of the underside of the barrel of the pipe and in the joint holes. Similar selected material shall then be laid in layers, not exceeding 150 mm loose thickness, mixed, dried or watered as necessary and compacted, and brought up uniformly on both sides of the pipe up to a height of not less than 300 mm over the crown.

The remainder of the trench shall then be backfilled with the best selected material available, placed in layers not exceeding 150 mm loose thickness, mixed, watered or dried as necessary, and compacted.

All backfilling material shall be compacted to a minimum dry density of 95% of MDD (AASHTO T99).

Timbering and sheeting left in for the purposes of supporting the excavation shall be eased up 150 mm at a time in step with the backfill layer and compaction of the backfill shall be achieved under and behind such timber and sheeting.

For pipe culverts which have been constructed close to, above or where the culvert protrudes above the existing ground the backfilling under the flanks and alongside and over the culverts shall be placed and compacted in layers not exceeding 150 mm after compaction to a density of at least the density required for the material in adjoining layers of fill. The width of backfilling along the flanks of the culvert shall be at least (2+1.5h)metres from each side of the culvert (Where 'h' is the height from the underside of the layer being compacted to the crown of the pipe in metres). All existing ground under this backfill shall be compacted to 95% MDD (AASHTO T99) to a depth of 150 mm.

The material used for filling alongside the culvert above existing ground shall be the same material as will be used for the adjacent fill and no additional payment will be made other than that provided for the fill in Section 5 of this Specification.

Backfilling shall be carried out simultaneously and equally on both sides of the culvert to avoid unequal lateral forces.

In all cases there shall be cover of at least 600 mm over the crown of the culvert before construction equipment is driven over it unless other protective measures approved by the Engineer have been provided.

Where instructed by the Engineer that the acidity of the material used for backfilling shall be neutralised, the Contractor shall add 5% of lime by weight, or such other quantity as the Engineer may instruct, to the fill material throughout the width and depth instructed by the Engineer. The lime shall be evenly spread over the surface of each layer of fill material and shall be mixed in with rakes and the moisture content adjusted as necessary before it is compacted.

813 HALF ROUND CONCRETE CHANNELS

600 mm diameter half round concrete channels shall comply with Section 2 of this Specification except that they will not be subject to a load test. Where a channel is cast in pipe moulds, every care shall be taken to see that the battens separating the two halves are rigidly secured to the mould, the edges of the channel are parallel to the axis of the barrel, and each channel is of identical shape.

The excavation to receive the half round concrete channels shall be compacted to 95% MDD (AASHTO T99) to a depth of 150 mm and shaped as shown on the Drawings before the channel is laid. The invert of the trench shall be accurately excavated to line and level and shaped so that the barrel of the channel rests on a width of one third of its diameter and throughout the length of the barrel.

After the channel is laid selected fill material shall be placed, watered if necessary, and compacted against the sides of the channel for the remainder of the height so that the channel is rigidly held in position before the next length is laid. Joints shall be made by placing a thick covering of 1:3 cement mortar on the joint face of the section already installed before driving the next channel section hard up against it. The excess mortar squeezed out of the joint shall be neatly trowelled off to a smooth invert.

All channel ends shall be soaked with water for one hour before jointing and all joints shall be protected from the wind, sun and rain by a covering acceptable to the Engineer and shall be kept constantly damp for a period of at least 3 days after forming.

814 SUBSOIL DRAINS

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.

Trenches for subsoil drains shall be not less than 0.5 m wide or the outside diameter of the pipe plus 0.3m whichever is the greater. Concrete pipes shall comply with Section 2 of this Specification and shall be laid with joints open by 10 mm.

The filling in subsoil drains shall be clean hard crushed rock or gravel, and, in soils where fines are not liable to migrate, the grading shall be in accordance with BS 882 for 37.5 mm maximum size graded aggregate or as otherwise instructed by the Engineer.

Where more than one size of stone is required in a trench, the different sizes shall be kept separate by temporary metal or plywood baffles which shall be removed when the filling is complete, or by other suitable means acceptable to the Engineer.

Where permeable filter membranes are instructed they shall be 'Terram' or similar approved material. Transverse joints shall be lapped by at least 0.5m with the upstream material laid on top. Longitudinal joints shall be stitched together. 'Terram' or similar approved material shall not be left exposed to sunlight for more than 3 weeks, and shall be installed in accordance with the manufacturer's instructions.

815 PROTECTION WORK

Where shown on the Drawings or instructed by the Engineer the Contractor shall provide and place protection works.

Protection work in connection with drainage channels, culvert inlets and outlets and river training will consist generally of stone pitching, gabions or rip-rap in accordance with Section 7 of this Specification.

816 MINOR DRAINAGE STRUCTURES

Minor drainage structures shall include culvert inlet and outlet structures, catchpits, cascades, spillways and the like. Typical details are shown on the Drawings but working details will be issued by the Engineer from time to time during the Contract.

Concrete for minor drainage structures shall be Class 20/20 in accordance with Section 17 of this Specification unless otherwise shown on the Drawings. The surface finish shall be UF1 for unformed surfaces and Class F1 for formed surfaces.

Unless otherwise specified or shown on the Drawings concrete shall be reinforced in the back and front faces of all walls and the top and bottom of all slabs with 10 mm diameter high yield deformed bars placed at 200 mm centres both horizontally and vertically to form a mesh. The reinforcement shall be fixed in accordance with, and shall comply with, the requirements of Section 17 of this Specification.

817 MITRE DRAINS, CUT-OFF DRAINS, CATCHWATER DRAINS, SIDE DRAINS, CULVERT OUTFALL DRAINS AND EARTH DAMS

Mitre drains, cut-off drains, catchwater drains, culvert outfall drains and earth dams shall be formed at the locations and to the lines and levels shown on the Drawings or as instructed by the Engineer.

Where shown on the Drawings or instructed by the Engineer the Contractor shall construct earth dams in side drains, cut-off drains, catchwater drains, mitre and outfall drains to prevent the flow overshooting the drainage works or to direct flows into culvert inlets. Similar earth structures may also be used as erosion checks.

Earth dams shall be formed in selected fill material compacted to a minimum dry density of 95% MDD (AASHTO T99). Where stone pitching and/or gabions are instructed they shall be in accordance with Section 7 of this Specification. Where topsoiling and grassing is instructed it shall be in accordance with Section 5 of this Specification.

818 SCOUR CHECKS

The Contractor shall excavate in the invert of side drains, cut-off drains, catchwater drains, outfall drains and mitre drains for scour checks to be located as shown on the Drawings or directed by the Engineer. The width and depth of the scour check will be determined by the drain and scour check dimensions and shall be as directed by the Engineer.

Concrete for scour checks shall be Class 20/20 which shall comply with the requirements of Section 17 of this Specification or if shown on the Drawings or directed by the Engineer scour checks shall be gabions in accordance with Section 7 of this Specification. Formwork shall be provided and placed for all concrete required above the existing drain profile and shall comply with the requirements of Section 17 of this Specification. Unless otherwise specified or shown on the Drawings concrete for scour checks shall be reinforced in the back and front faces with 10 mm diameter high yield deformed bars placed at 200 mm centres both horizontally and vertically to form a mesh. The reinforcement shall be fixed in accordance with, and shall comply with, the requirements of Section 17 of this Specification.

Where the overflow section of a scour check is above the invert level of the drain the void upstream of the scour check shall be backfilled to the level of the overflow section. The upper 50 mm of the backfill shall be topsoil and shall be planted with grass and such topsoiling and grassing shall comply with the requirements of Section 5 of this Specification.

819 CLEANING AND MAINTENANCE

The Contractor shall be responsible for maintaining the existing and new drainage system during construction of culverts and all other drainage works such that water is passed along and across the Works without damage to the Works and all cofferdams, diversions, pumping, temporary drainage works or other works necessary shall be provided and maintained at the Contractor's expense. Any damage to the Works caused by the Contractor's failure to make adequate provision for drainage of the Works shall be repaired at the Contractor's expense.

Before any drainage channel, culvert or other drainage structure is brought into use, the Contractor shall ensure that such channel or structure is free from all silt and extraneous material and the removal and disposal of all such material shall be at the Contractor's expense.

Notwithstanding Clause 48 of the Conditions of Contract, the Contractor shall be responsible for maintaining all drainage structures, culverts, channels and drains free of silt and extraneous material at his own expense until the issue of the Maintenance Certificate in accordance with Clause 62 of the Conditions of Contract and any damage to the Works caused by his failure to maintain the drainage system shall be repaired at the Contractor's expense.

820 MEASUREMENT AND PAYMENT

(a) Item : Excavate for culverts and subsoil drains in soft material

Unit : m^3

Excavation for culverts and subsoil drains shall be measured by the cubic metre, calculated as the product of the width of the excavation and the sectional area of the excavation measured along its length and these shall be determined from (1) and (2) below:-

(1) Width of excavations

(i) The width of excavation, W, to install a culvert 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 = 0.3 m for concrete pipes surrounded in concrete
A = 0.6 m for concrete pipes of 600 mm nominal diameter or less not surrounded in concrete
A = 0.9 m for concrete pipes of 750 mm nominal diameter or greater not surrounded in concrete.
A = 0.9 m for corrugated metal pipes.

(ii) The width of trenches for subsoil drains shall be as shown on the Drawings or as instructed or measured by the Engineer, whichever is the lesser.

(2) Sectional area of excavations

The sectional area of the excavation, measured in square metres, shall be calculated as the product of the average depth of the excavation and the length of subsoil drain or culvert which is to be constructed. The average depth shall be measured from the instructed final profile and the average depth as calculated from the following:-

(i) Where a trench excavation is carried out in and through a previously constructed road embankment, the depth of the trench shall be measured from the underside of the pipe or the concrete surround, haunch or bed, to formation level, or to a point one metre above the top of the pipe culvert, whichever is the lesser.

(ii) Where a trench excavation is carried out ahead of road embankment construction, the depth of the trench shall be measured from ground level existing at the time of excavation to the underside of the pipe or the concrete surround, haunch or bed.

(iii) Where a trench excavation is required under a road cutting, its depth shall be measured from formation level to the underside of the pipe or concrete surround, haunch or bed.

(iv) The depths of excavation measured in (2) (i) to (2) (iii) above, refer to excavation in soft material; where the excavation is in hard material the underside of the excavation shall be in accordance with Clause 805 of this Specification.

Where a satisfactory invert cannot be achieved the depth and width of the excavation shall be in accordance with Clause 804 of this Specification.

The rate for excavation of culverts and subsoil drains in soft material shall include for the cost of excavation to any depth, compaction of the invert of the excavation, backfilling with the excavated material or removing the excavated material to spoil if it is unsuitable or surplus to requirements, and complying with the requirements of Clauses 802, 803, 804, 806, 809, 812, 814 and 819 of this Specification.

(b) Item : Excavate for minor drainage structures

Unit : m^3

Excavation for minor drainage structures shall be measured by the cubic metre, calculated as the product of the plan area of the minor drainage structure and the average depth of the excavation. The average depth of the excavation shall be measured from the instructed final profile irrespective of whether the Contractor has completed earthworks or not prior to the excavation of the minor drainage structure, to the invert level on the underside of the concrete apron or bed.

The rate for excavation for minor drainage structures in soft material shall include for the cost of excavation to any depth, compaction of the invert of the excavation, backfilling with the excavated material or removing the excavated material to spoil if it is unsuitable or surplus to requirements, and complying with the requirements of Clauses 802, 803, 804, 806, 812, 816 and 819 of this Specification.

(c) Item : Excavate for inlet, outfall, mitre and catchwater drains in soft material

Unit : m^3

Excavation for inlet, outfall, mitre and catchwater drains shall be measured by the cubic metre, calculated as the product of the average end areas measured at intervals of not greater than 10 m along the centreline of the drain and the length of the drain. The end areas shall be calculated from existing ground levels or existing drain profiles taken prior to commencement of excavation and the cross-section and longitudinal profile of the drain as shown on the Drawings or instructed by the Engineer.

The rate for excavation for inlet, outfall, mitre and catchwater drains shall include for the cost of excavation to any depth, excavation for bed widths not greater than 2.5 m wide, disposal of the excavated material to spoil and compliance with the requirements of Clauses 802, 803, 804, 806, 817 and 819 of this Specification. Where the instructed bed width for an inlet, outfall, mitre or catchwater drain is greater than 2.5 m then the excavation shall be measured and paid for under Clause 820 (d) : Channel excavation in soft material.

(d) Item : Channel excavation in soft material

Unit : m^3

When the instructed bed width for an inlet, outfall, mitre or catchwater drain is greater than 2.5 m it shall be classified as channel excavation which shall be measured by the cubic metre calculated as for Clause 820 (c) of this Specification.

The rate for channel excavation in soft material shall include for the cost of excavation to any depth, disposal of the excavated material to spoil and compliance with the requirements of Clauses 802, 803, 804, 806, 817 and 819 of this Specification.

(e) Item : Excavate for cut-off drains in soft material

Unit : m^3

Excavation for cut-off drains shall be measured by the cubic metre, calculated as the product of the average end areas measured at intervals of not greater than 10 m along the centreline of the drain and the length of the drain. The end areas shall be calculated from existing ground levels or existing drain profiles taken prior to commencement of excavation and the cross-section and longitudinal profile of the drain as shown on the Drawings or instructed by the Engineer.

The rate for excavation for cut-off drains in soft material shall include for the cost of excavation to any depth, forming and compacting the berm on the lower side of the drain and for compliance with the requirements of Clauses 802, 803, 804, 806, 817 and 819 of this Specification.

(f) Item : Extra over (a) to (e) for excavation in hard material.

Unit : m^3

Hard material encountered in any excavation covered by Clause 820 (a) to (e) shall be measured by the cubic metre, calculated as the product of the average end areas measured at intervals agreed with the Engineer along the centreline of the excavation and the length over which hard material is encountered. The end areas shall be calculated from levels taken on top of the hard material prior to excavation and levels taken after excavation of the hard material.

The rate for extra over Clause 820 (a) to (e) for excavation in hard material shall be extra over for excavating in soft material and shall include for the cost of excavation to any depth and compliance with the requirements of Clauses 802, 803, 804, 805, 806, 817 and 819 of this Specification.

(g) Item : Selected backfill material

Unit : m^3

Selected backfill material shall be measured by the cubic metre, calculated as the product of the average end area (excluding any pipe or concrete surround) and the length of selected backfill material instructed to be placed.

The rate for selected backfill material shall include for the cost of providing the material, backfilling at any depth, all hauls as necessary and complying with the requirements of Clauses 809, 812 and 814 of this Specification.

(h) Item : Crushed rock backfill in subsoil drains

Unit : m^3

Crushed rock backfill in subsoil drains shall be measured by the cubic metre, calculated as the product of the average end area and the length of the subsoil drain. The end area shall be calculated as the product of the depth of crushed rock backfill instructed and the width of the excavation calculated in accordance with Clause 820 (a) of this Specification less the end area of the pipes.

The rate for crushed rock backfill shall include for the cost of providing the material, backfilling at any depth, all hauls as necessary and complying with the requirements of Clause 814 of this Specification.

(i) Item : Rockfill below culverts

Unit : m^3

Rockfill below culverts shall be measured by the cubic metre calculated as the plan area and average depth of rockfill instructed.

The rate for rockfill below culverts shall include for the cost of providing and placing the material, all hauls as necessary and complying with the requirements of Clauses 507 and 804 of this Specification. The filter fabric will be measured and paid for separately.

(j) Item : Provide, lay and joint pipes

Unit : m of each type, diameter and gauge

Provide, lay and joint pipes shall be measured by the metre calculated as the instructed length measured along the centreline of the culvert or subsoil drain.

The rate for provide, lay and joint pipes shall include for the cost of providing the pipes and complying with the requirements of Clause 807, 808, 809, 810, 814 and 819 of this Specification.

(k) Item : Concrete Class 15/20 to beds, surrounds and haunches

Unit : m^3

Concrete Class 15/20 to beds, surrounds and haunches shall be measured by the cubic metre calculated as the product of the end area and the instructed length of bed, surround or haunch. The end area shall be as shown on the Drawings or directed by the Engineer and shall exclude the area of the pipe.

The rate for concrete Class 15/20 to beds, surrounds and haunches shall include for the cost of providing and placing the concrete and complying with the requirements of Clauses, 805, 809, 811, and 819 of this Specification.

(l) Item : Concrete Class 20/20 to minor drainage structures

Unit : m^3

Concrete Class 20/20 to minor drainage structures shall be measured by the cubic metre calculated from the dimensions given on the Drawings or instructed by the Engineer.

The rate for concrete Class 20/20 to minor drainage structures shall include for the cost of providing and placing the concrete, reinforcement and shuttering and complying with the requirements of Clauses 816 and 819 of this Specification.

(m) Item : Earth dams

Unit : m^3

Earth dams shall be measured by the cubic metre calculated from the dimensions shown on the Drawings or directed by the Engineer.

The rate for earth dams shall include for the cost of providing the fill material, placing and compacting, all hauls as necessary and complying with the requirements of Clause 817 of this Specification.

(n) Item : Concrete scour checks

Unit : m^3

Scour checks shall be measured by the cubic metre calculated from the dimensions of the scour check shown on the Drawings or directed by the Engineer.

The rate for scour checks shall include for the cost of providing and placing the concrete, reinforcement and shuttering and complying with the requirements of Clause 818 of this Specification.

Measurement and payment for gabion scour checks will be made in accordance with Section 7 of this Specification.

(o) Item : Filter fabric to rockfill and subsoil drains

Unit : m^2 of each weight of fabric specified.

The filter fabric placed under, around or over rockfill and subsoil drains shall be measured as the net area of filter fabric instructed.

The rate for filter fabric shall include for 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 complying with the requirements of Clauses 804 and 814 of this Specification.

(p) Item : Lime to backfill
PROVISIONAL

Unit : tonne

Lime to backfill shall be measured by the tonne calculated as the product of the rate of addition instructed and the volume instructed to be treated with lime.

The rate for lime to backfill shall include for the cost of providing, transporting, spreading and mixing the lime at the rate of spread instructed by the Engineer and for complying with the requirements of Clause 812 of this Specification.

(q) Item : Half round concrete channels

Unit : m

Provide and lay half round concrete channels shall be measured by the metre calculated as the instructed length measured along the centreline of the channel.

The rate for half round concrete channels shall include for the cost of excavation in any material, preparation of the bed, providing and laying the half round concrete channel, backfilling with selected material and complying with the requirements of Clauses 802, 804, 806 812, 813 and 819 of this Specification.

901 SCOPE OF THE SECTION

(a) Where public traffic using an existing road is affected by construction of the new road and, where shown on the Drawings or instructed by the Engineer to do so, the Contractor shall carry out one or more of the following:-

(i) Effect improvements to and maintain existing roads.

(ii) Construct and maintain deviations.

(iii) Pass traffic through or over the Works.

(b) The Contractor shall provide and maintain temporary signs, barriers, lights etc. along deviations and existing roads adjacent to the Works in order to ensure the safe passage of traffic during the Contract.

(c) The Contractor shall provide adequate notice of the implementation of deviations etc. and shall ensure efficient and safe passage of traffic at all times.

(d) The Contractor shall be required to provide and maintain all access and haul roads to ensure access to all parts of the Site for his plant, labour and materials.

(e) The Contractor shall be required to protect the Works and adjacent public roads from the effects of his own construction traffic.

902 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:-

(a) Site clearance and removal of topsoil from the shoulders and verges.

(b) Scarifying, re-shaping, widening and watering and compacting the top 150mm of the existing road to 95% MDD (AASHTO T99) compaction.

(c) Laying gravel wearing course.

(d) Cutting, re-shaping and deepening where necessary, side drains and mitre drains, including clearing and maintaining existing protection works.

(e) Clearing and maintaining culverts and cutting or deepening outfall drains.

(f) Clearing and maintaining existing watercourses and protection works.

(g) Repair of potholes in bitumen roads.

(h) Re-sealing of bitumen roads.

(i) Providing erecting and maintaining temporary traffic signs, barriers lights etc.

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

903 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 Clause 902 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 Part D of Section 16 of this Specification.

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

904 CONSTRUCTION OF DEVIATIONS

(a) General

Where shown on the Drawings or instructed by the Engineer the Contractor shall construct and maintain deviations.

The length of a deviation shall be the shortest practicable route having regard to gradient and obstructions and the detailed alignment shall be agreed between the Engineer and the Contractor.

The Contractor shall give at least one months notice in writing of his intention to commence construction of any deviation along any section of the Works and such notice shall include details of locations of any deviation, cross-overs, one-way traffic operations, restricted widths, culverts, drainage, drifts, bridges, gradients in excess of 7.0%, earthworks, signs, barriers, lights, traffic lights, and methods of operation

of the entire system. Upon approval of such notice in writing from the Engineer the Contractor shall become responsible for the passage of traffic including maintenance of the deviation and the project road in that section.

Should the Contractor propose, and the Engineer approve, that a deviation be located other than as shown on the Drawings then the Contractor shall be responsible for all land acquisition, payment for land acquisition, negotiation with landowners and appropriate Authorities, diversion of services including telephone lines, power lines, water pipes etc, all at the Contractor's expense, and the construction, operation and maintenance of the deviation in accordance with this Specification.

Where telephone poles, power poles or other services are outside but close to the edge of a deviation the Contractor will be responsible for protection of such poles or services and for negotiation with the relevant Authority or owner with respect to the type of protection and the method of removing or replacing stay wires, propping of poles etc.

Where services cross the deviation the Contractor shall protect such services and shall negotiate with the relevant Authority or owner as to the method of protection and shall comply with all the requirements of such Authorities or owners. Where services are required to be moved, diversion of such services shall be in accordance with Clause 121 of this Specification.

Land required for deviations shall be acquired in accordance with Clause 124 of this Specification except where the Contractor has proposed and alternative route for the deviation.

(b) Geometry

Deviation shall be constructed to the cross-section shown on the Drawings.

Single-lane traffic operation shall not be permitted unless in the opinion of the Engineer, it is impracticable to provide a two-lane deviation. A single-lane carriageway shall not be less than 4.0m wide with traffic control and passing bays provided at approximately 250 metre intervals.

The gradient of any deviation shall not exceed 7%, except with the approval of the Engineer, and any change of gradient shall be formed to a smooth vertical curve with a length of not less than 60 m. Where gradients in excess of 7.0% are encountered on any deviation the Contractor shall ensure the safe and convenient passage of traffic and if necessary shall seal the deviation with a double seal surface dressing or other approved seal and shall maintain such seal whilst the deviation is in use.

(c) Construction

Site clearance and earthworks shall be carried out in accordance with Sections 4 and 5 of this Specification except in respect of measurement and payment which shall be in accordance with Clause 912 of this Specification.

Gravel wearing course shall be constructed in accordance with Section 10 of this Specification. The thickness of gravel wearing course shall be as shown on the Drawings or instructed by the Engineer.

(d) Drainage and drifts

Temporary ditches, culverts, drifts and bridges of adequate size and strength shall be constructed for the deviation where necessary.

The length of a drift shall be such that there is less than 150mm of water over it, except in flood.

The edge of a drift shall be defined with posts or other markers acceptable to the Engineer and a gauge installed to indicate the maximum depth of water over the road. The minimum width of drift shall be 3.5m.

Existing bridges shall be checked by the Contractor and if found inadequate to pass the traffic, and at other locations where a drift would not be practicable, the Contractor shall construct temporary bridges of adequate size and strength to pass the traffic.

(e) Reinstatement of deviation

Prior to the commencement of construction of any deviation or the use of land provided for the deviations the Contractor shall supply one 125 mm by 175 mm colour print of each of a series of photographs taken at a maximum of 500 m intervals along the line of the deviation and the Contractor shall not commence construction of any deviation until the prints have been agreed with the Engineer as being a true record of the condition of the land prior to construction including land usage, fences, existing roads and tracks, drainage and any other features.

The Contractor shall reinstate the deviation to a condition similar to the condition prevailing prior to the commencement of construction of the deviation. The colour prints provided by the Contractor may be used by the Engineer to confirm that the reinstatement is satisfactory. Where the deviation is on private land the Contractor may obtain a written statement, signed by the landowners, requesting that the deviation be left unreinstated in lieu of reinstating the deviation. Where the deviation is within the road reserve or on other land owned by

the Government of Kenya the Contractor shall reinstate the deviation to a condition similar to the condition prevailing prior to the commencement of construction of the deviation.

905 MAINTENANCE OF DEVIATIONS

The Contractor shall maintain the deviations constructed under Clause 904 of this Specification to the standard existing at the time of opening to traffic, from the date of opening until the adjacent section of new road is opened to public traffic.

Maintenance shall include watering, full width grading and dragging as necessary, keeping clear watercourses and culverts, cutting grass, minor repairs to culverts drifts and bridges, and rendering assistance to public traffic.

906 PASSAGE OF TRAFFIC THROUGH THE WORKS

Where shown on the Drawings or instructed by the Engineer that traffic is to be passed through or across the Works the Contractor shall so order his work in half widths or in short lengths, so as to pass traffic over or across his work.

The frequency and duration of delays to traffic while being passed through or across the Works, shall be kept to a minimum and shall not exceed 30 minutes without the prior agreement of the Engineer and should normally be less than 5 minutes. Any method of working, which requires a road closure in excess of 30 minutes shall require 48 hours prior notice to, and the 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.

907 SIGNS, BARRIERS AND LIGHTS

The Contractor shall provide, erect and maintain temporary signs, barriers, lights, traffic lights etc. along existing roads scheduled in the Special Specification and along deviations constructed in accordance with Clause 904 of this Specification.

The number, type and siting of these signs etc. shall be in accordance with the Drawings and this Specification, or as directed by the Engineer.

The construction of all warning signs, prohibitory signs, mandatory signs and priority signs used for temporary signing shall comply with the requirements of the latest edition of the "Manual for Traffic Signs in Kenya", Part II.

Direction signs, advance direction signs and confirmatory signs may be manufactured as fixed short life signs.

Sign plates for fixed short life signs shall be manufactured from hardboard plywood or chipboard or other material that is approved by the Engineer. The sign shall be constructed so as not to deteriorate during the estimated time the sign will be in use, and shall be to the satisfaction of the Engineer. The face of the sign shall be sealed with a wood filler, or otherwise treated to provide a satisfactory appearance. The sign shall be supported on one or more posts made of wood. The support shall be strong enough to withstand the loading that is estimated will be placed on the sign. The fixing of fixed short life signs may be achieved by nailing, screwing or glueing the sign plate to its supports, to the satisfaction of the Engineer.

Where one-way traffic operation is necessary the Contractor shall provide, maintain and operate traffic lights. The use of "Stop" and "Go" boards provided, maintained and operated by the Contractor shall be permitted between 0630 hours and 1830 hours in lieu of traffic lights. Traffic lights shall be used at all other hours. The use of flags in lieu of either "Stop" and "Go" boards or traffic lights will not be permitted.

Where the distance between the edge of a road or deviation and the permanent Works is less than 10 m, continuous fences and barriers shall be erected. Such fences and barriers shall be painted red and white in alternate sections. Where pedestrians must use the line of the road or deviation for access, similar fences and barriers shall be provided to separate pedestrians and traffic.

Barriers, other hazards and entrances to detours and deviations and one-way operations shall be illuminated thoughout the night by red lamps or amber flashing lights provided by the Contractor and supported at a height of between 0.7m and 1.35m above the road, and maintained burning bright.

In addition to the signs detailed on the Drawings the Contractor shall provide, erect and maintain on deviations and existing roads the temporary traffic signs detailed in Table 9-1 whose reference numbers refer to the "Manual for Traffic Signs in Kenya" Part II.

908 DIVERSION OF ACCESS ON TO NEW CONSTRUCTION

Where as a result of the Works, an existing public or private road is to be permanently closed, or diverted, or temporarily diverted or re-opened to traffic, the Contractor shall give the Engineer at least one month's notice of his requirements or intentions. Depending on the length of road and amount of work involved, the Engineer may negotiate with the appropriate Authority or owner regarding the method, order and times of carrying out the work and issue instructions to the Contractor accordingly. Where the amount of work involved is small, the Engineer may instruct the Contractor to make his own arrangements. In all cases, the Contractor shall obtain the Engineer's instructions and no road shall be interfered with in any way until the appropriate Authority's or owner's consent to the work has been obtained.

TABLE 9-1 TEMPORARY TRAFFIC SIGNS

Reference	Description	Location
W1/W2	Sharp bend ahead	100 m each side of all bends having a radius of less than 160 m.
W3/W4	Sharp bends ahead	100m each side of all series of bends having radii of less than 160 m.
W5/W6	Steep hill ahead	100 m each side of all gradients exceeding 7.0%.
W7	Road narrows ahead	100 m each side of locations where the deviation reduces from normal width to restricted width.
W13A	Severe dip ahead	100 m each side of hazard.
W138B	River-bed crossing	100 m each side of all drifts.
W22	Roadworks ahead	100 m each side of roadworks.
W23	Traffic lights ahead	200 m each side of lights.
W25	Two-way traffic ahead	100 m before and at 250 m intervals within the two-way section.
W26	Hazard ahead	100 m each side of hazard.
W27	Road junction ahead	100 m before all junctions where traffic is required to yield or stop.
W36	Dangerous change in direction of road	At dangerous locations.
W38	Hazard demarcation	At hazards.
R1/R2	Stop/Give Way	At junctions where traffic is required to yield or stop.
M3	Turn at next junction	As required.
A6	"Deviation Ahead"	As required.
A6	"Heavy Plant Turning"	As required.
A4	200 m	As required.
A4	100 m	As required.

909 ASSISTANCE TO PUBLIC

The Contractor shall render such assistance to the public as shall be necessary to allow safe and convenient passage of traffic at all times.

910 ACCESS ROADS

(a) Access to the Site

The Contractor shall be responsible for providing and maintaining at his own expense access to all parts of the Site for his plant, labour and materials and local public traffic where no alternative access is available. Where there is no deviation or existing road providing access to or along the new alignment, the Contractor must construct and maintain his own access and haul roads as required, all at his own expense. All such accesses shall be available for the use of the Employer.

(b) Public highways

Where the Contractor proposes to use an existing public highway as an access to a borrow area, or as a haulage road for the construction of any work under the Contract, such as is likely to cause a subsequent claim for "extraordinary traffic", the Contractor shall give the Engineer at least one month's notice of his intention to use such a road. The Engineer may call for a joint inspection of the road by the appropriate Highway Authority, the Contractor and the Engineer, to agree upon a statement of the actual condition of the road prior to use by the Contractor and to determine the extent of any remedial work required.

Where, in the opinion of the Engineer, the existing highway is inadequate to withstand the volume and weight of the Contractor's traffic, the Engineer may instruct the Contractor:

(i) to improve the road;

(ii) to construct a temporary road in lieu; or

(iii) to use an alternative route.

(c) Private roads

Where the Contractor proposes to use a private road as an access road to the Works, a quarry or a borrow pit it shall be entirely his responsibility to comply with any conditions laid down by the owner, and the Employer will be in no way responsible for any claim arising from such arrangements.

(d) New roads

Access roads to stockpile and spoil areas, quarries and borrow pits shall be constructed on the line agreed or instructed by the Engineer. The access road shall follow the shortest practicable route between the stockpile or spoil area, quarry or borrow pit and the nearest point to it on the new alignment. The access road shall be drained with ditches and culverts of adequate size and strength and existing watercourses shall be maintained in proper working order.

The siting of the junction of an access road with the existing road shall be to the satisfaction of the Engineer and the Contractor shall comply with the Engineer's instructions, particularly regarding clearance of obstructions to provide adequate sight lines, temporary drainage or culverts and the provision of signs and traffic control.

(e) Reinstatement

The Contractor shall be required to reinstate all access roads in accordance with Clause 904 (e) of this Specification.

(f) Administration

The Contractor shall be wholly responsible for all administrative and financial arrangements for the construction of access roads and for all costs arising out of them, such as negotiations with the owner and occupier for the use of the land, and paying rent and/or compensation.

911 CONTRACTOR'S CONSTRUCTION TRAFFIC

(a) Use of new road or road under construction

The Contractor will not be permitted to use completed sections of the road or deviation or any completed pavement or surfacing layer for hauling earthworks, pavement or other materials with earthwork plant or vehicles having axle loads exceeding the legal limit. Furthermore, the use of completed sections of the road or completed pavement layers will be restricted if, in the opinion of the Engineer, damage to structures, subgrade, the formation, pavement or surfacing could ensue.

Any damage to the completed formation or to a completed pavement layer caused by any of the Contractor's vehicles, whether with legal axle loading or otherwise, shall be repaired as instructed by the Engineer and at the Contractor's expense.

In addition the Contractor will not be permitted to operate vehicles having axle loads exceeding the legal limit on any public road in Kenya.

The Contractor shall allow the Engineer to carry out check axle weighings on his vehicles and shall observe any instructions given by the Engineer with regard to reduced loadings should this prove necessary.

(b) Use of deviations and existing road

If, in the opinion of the Engineer, additional work is required on deviations and existing roads, solely as a result of the requirements or effects of the Contractor's construction traffic, the cost of all such additional work shall be borne by the Contractor.

912 MEASUREMENT AND PAYMENT

(a) Item : Improve existing road

Unit : km

Improve existing road shall be measured by the kilometre to the nearest 0.1 km along the centreline of the existing road. Measurement and payment will only be made for lengths of road over which improvements have been carried out in accordance with the Engineer's instructions.

The rate for improve existing road shall include for the cost of complying with all the requirements of Clause 902 of this Specification with the exception of gravel wearing course which shall be measured and paid for separately.

(b) Item : Construct deviation

Unit : km

Construct deviation shall be measured to the nearest 0.1 km along the centreline of the deviation. Measurement and payment will only be made for lengths of deviation instructed by the Engineer and constructed to his approval.

The rate for construct deviation shall include for the cost of complying with all the requirements of Clause 904 of this Specification with the exception of gravel wearing course which shall be measured and paid for separately.

(c) Item : Provide signs and barriers

Unit : km

Provide signs and barriers shall be measured to the nearest 0.1 km along the centreline of the project road as defined in the Special Specification.

Measurement and payment will only be made when the Contractor has submitted, and the Engineer approved, his proposals for the passage of traffic in accordance with Clause 904 of this Specification and when the Contractor has installed the necessary signs and barriers etc. along deviations and existing roads, all to the Engineer's satisfaction.

The rate for provide signs and barriers shall include for the cost of complying with the requirements of Clause 907 of this Specification.

(d) Item : Maintain the passage of traffic

Unit : Lump Sum

Maintenance of deviations and existing roads, maintenance of signs, barriers, lights, traffic lights, stop-go boards, etc., the passing of traffic through or across the Works and compliance with all the provisions of Section 9 of this Specification for which no separate payment is expressly stated shall be paid for by the Lump Sum stated in the Special Specification.

Payment of the Lump Sum will be by equal monthly instalments over the period of the Contract excluding the Period of Maintenance.

The conditions attached to the payment of the instalments are:-

(i) That the total sum of instalments paid shall not exceed the Lump Sum.

(ii) If, in any month, the Engineer is not satisfied that the Contractor has fully complied with all the provisions of Section 9 of this Specification, he shall withhold the whole of the instalment due and if the Contractor fails to comply with the Engineer's instructions within 14 days of the instalment becoming due the Contractor shall forfeit such instalment.

The Engineer, having given 14 days notice to the Contractor and in the event of the Contractor's subsequent default, may deduct from any payments due to the Contractor, in addition to withholding any instalments due, all reasonable expenses incurred by the Employer, including the costs of employing another Contractor to carry out the works instructed, necessitated by the failure of the Contractor to comply properly with the provisions included in Section 9 of this Specification.

(iii) That the instalment will be subject to the deduction of retention money.

The Contractor shall be deemed to have allowed elsewhere in his rates and prices for any difference between the Lump Sum stated and the actual cost of maintaining the passage of traffic.

(e) Item : Gravel wearing course

Unit : m^3

Where the Engineer instructs gravel wearing course to be laid on existing roads or deviations, measurement and payment shall be in accordance with Clause 1011(a) of Section 10 of this Specification.

(f) Item : Overhaul of gravel wearing course

Unit : m^3 km

Overhaul of gravel wearing course shall be measured and paid for in accordance with Clause 1011(b) of Section 10 of this Specification.

(g) Item : Access roads

Unit : km

Access roads shall be measured by the kilometre to the nearest 0.1 km, from the boundary of the borrow pit along the centreline of the access road to the edge of the new road reserve or to the edge of the carriageway when it connects to an existing road. Only access roads on an alignment approved by the Engineer will be measured.

Only access roads to earthwork borrow pits and borrow pits measured in accordance with 'method B' of Sections 10 and 12 of this Specification shall be measured and paid for.

Where the Contractor uses an existing public or private road as an access road to an earthwork borrow pit or a borrow pit measured in accordance with 'method B' of Section 10 and 12 of this Specification, measurement and payment shall be made as though the Contractor had constructed a new access road.

The rate for access roads shall include for the cost of site clearance, topsoil strip, earthworks, drainage, gravel wearing course, maintenance, reinstatement and for complying with the requirements of Clause 910 of this Specification.

(h) Item : Reinstatement of deviations

Unit : Lump Sum

Reinstatement of deviations shall be paid for by the Lump Sum stated in the Special Specification.

Payment of the Lump Sum shall be made when all the deviations along the entire project road have been reinstated in accordance with the requirements of Clause 904 of this Specification.

The Contractor shall be deemed to have allowed elsewhere in his rates and prices for any difference between the Lump Sum stated and the actual cost of reinstating deviations.

SECTION 10

GRAVEL WEARING COURSE

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.

1003 MATERIAL REQUIREMENTS

The grading of the gravel after placing and compaction shall be a smooth curve within and approximately parallel to the following envelope:-

Sieve (mm)	% by weight passing	
	Class 1	Class 2
37.5	-	100
28	100	85 - 100
20	95 - 100	85 - 100
14	80 - 100	65 - 100
10	65 - 100	55 - 100
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

The material shall have a minimum CBR of 20 at 95% MDD (AASHTO T180) and 4 days soak.

The plasticity requirements and the class of material shall be specified in the Special Specification.

1004 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 his 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.

1005 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 all at his own expense. The Engineer may require the formation to be proofrolled by a loaded truck, scraper or other approved means prior to dumping of the wearing course material. The cost of all such proofrolling shall be at the Contractor's expense.

1006 SETTING OUT

The gravel wearing course shall be set out in accordance with Section 3 of this Specification.

1007 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 1003 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 TI80). 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 (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.

1008 PROOFROLLING

The Contractor shall proofroll the completed layers in accordance with Clause 1205 of this Specification.

1009 TOLERANCES

The gravel wearing course shall be constructed to the tolerances specified in Section 3 of this Specification.

1010 MAINTENANCE

The wearing surface shall be maintained by the Contractor in its finished condition and shall be watered, graded, dragged, reshaped, or recompacted 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.

1011 MEASUREMENT AND PAYMENT

(a) Item : Gravel wearing course

Unit : m^3 of each type in each method of measurement.

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 1.5km measured from the centre of volume of the source of material and dumping the material.

(vi) Complying with the requirements of Section 2, 6 and 10 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 4 of this Specification.

(ii) Removal of topsoil (if instructed by the Engineer to be stockpiled separately) from the borrow area per m^3 in accordance with Section 4 of this Specification.

(iii) Length of access road, per km, in accordance with Section 9 of this Specification.

(iv) Removal of top soil and/or overburden , as "Spoil", from the borrow area per cubic metre in accordance with Section 5 of this Specification.

(b) Item : Overhaul

Unit : m^3 km

The unit of overhaul will be the m^3 km. The overhaul quantity shall be measured as the product of the overhaul length and the quantity of material overhauled measured in accordance with Clause 1011(a) of this Specification.

The rates for providing and laying gravel wearing course shall include for the cost of a free haul of 1.5km measured from the centre of volume of the source of the material.

The overhaul length shall be the length from a point 1.5km from the centre of volume of the source of material to the centre of volume of the total overhauled material. It shall be measured to the nearest 0.1 km along the shortest practicable route from the source of the material to the nearest point on the new alignment and then along the new alignment to the centre of volume of the overhauled material.

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

SECTION 11

SHOULDERS TO PAVEMENT

Where topsoil and grassing is shown on the Drawings or instructed by the Engineer, 50 mm of humus or topsoil shall be spread on the completed shoulder and lightly rolled. Sprigs of approved indigenous 'runner' type grass as directed shall be planted and kept watered until growth is established. Topsoiling and grassing shall be in accordance with the requirements of Clause 514 of this Specification.

1106 MEASUREMENT AND PAYMENT

Where shoulders are constructed in the same material as the adjacent pavement layers no separate items will be included in the Bill of Quantities for shoulder construction and the measurement and payment will be in accordance with the relevant Clauses in Sections 10, 12, 13, 14 and 16 of this Specification.

Where shoulder construction differs from that of adjacent pavement layers the method of measurement and payment will be in accordance with the relevant clauses relating to the type of material shown on the Drawings or instructed by the Engineer for shoulder construction but itemised in this Section 11 of this Specification. The rate for shoulder construction shall include for the costs of complying with Clauses 1101, 1102, 1103 and 1104 of this Specification.

1101 DEFINITIONS

The term "shoulder" means that part of the road construction above formation level, between the edge of the pavement and the side ditch or embankment slopes. It is illustrated in Fig 1-2 in Section 1 of this Specification and is divided into "upper shoulder" and "lower shoulder".

1102 MATERIAL FOR CONSTRUCTION OF SHOULDERS

Material for construction of shoulders shall be as shown on the Drawings or instructed by the Engineer. It may consist of:-

(a) Gravel wearing course or natural material in accordance with Sections 10 and 12 of this Specification.

(b) Graded crushed stone in accordance with Section 13 of this Specification.

(c) Cement or lime treated material or lean concrete in accordance with Section 14 and 14A of this Specification.

(d) A bituminous mix in accordance with Section 16 of this Specification.

(e) A combination of (a) to (d) above.

1103 CONSTRUCTION OF SHOULDERS

Shoulders shall be construed concurrently with, or subsequent to, construction of the adjacent pavement layers. Shoulders shall not be constructed ahead of adjacent pavement layers and the Contractor shall ensure that the method of construction is such that at no time is water prevented from draining off any of the pavement layers. The method of laying and compacting shoulder material and the compaction requirements will be in accordance with the relevant sections of Clauses 1204 and 1205 of this Specification.

1104 SETTING OUT AND TOLERANCES

Shoulders shall be set out and constructed to the tolerances given in Section 3 of this Specification.

1105 SURFACE TREATMENT OF SHOULDERS

Surface treatment of shoulders shall be as shown on the Drawings or instructed by the Engineer.

Bituminous surface treatments shall be in accordance with Section 15 of this Specification.

SECTION 12

NATURAL MATERIAL SUB-BASE AND BASE

1201 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 subbase 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 satisfy himself as to 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 6 of this Specification in respect of borrow pits.

1202 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.

1203 MATERIAL REQUIREMENTS

(a) Subbase

The grading and material requirements after placing and compaction shall conform to the following requirements:-

Gravels:

- maximum size	max 63mm
- Plasticity Index	max 15%

Sands, silty and clayey sands:

- % passing 2mm sieve	max 95%
- % passing 0.075 mm sieve	min 10 - max 30%
- Plasticity Index	min 5 - max 12%

All materials

- Uniformity Coefficient	min 5%
- Plasticity Modulus	max 250%
- CBR at 95% MDD (AASHTO T180) and 4 day soak	min 30%

(b) Base

The grading of the material after placing and compaction shall be a smooth curve within and approximately parallel to the following envelope:-

Sieve Size	Percentage by weight passing
50	100
37.5	95 - 100
28	80 - 100
20	60 - 100
10	35 - 90
5	20 - 75
2	12 - 50
1	10 - 40
0.425	7 - 33
0.075	4 - 20

The material requirements after placing and compaction shall comply with the following limits:-

- Los Angeles Abrasion	max 50%
- Aggregate Crushing Value	max 35%
- Plasticity Index	max 15%
- Plasticity Modulus	max 250%
- CBR at 95% MDD (AASHTO T180) and 4 day soak	min 80%

(c) Natural material for cement or lime improved subbase

The material to be treated shall conform to the following requirement:-

Gravels:

- maximum size	10 - 50mm
- % passing 0,075mm sieve	max 40%

Sands, silty and clayey sands:

- maximum size	0.5 - 10mm
- % passing 0.075mm sieve	max 50%

All materials:

- Plasticity Index	max 30%
- Plasticity Modulus	max 2500
- Organic matter	max 2%

Additional requirements for lime treated materials:

- % passing 0.425mm sieve	min 15%
- Plasticity Index	min 10%

After treatment the material shall have a CBR of at least 60% measured after 7 day cure and 7 day soak on the site mix compacted to at least 95% MDD (AASHTO T180) and the treated material shall have a Plasticity Index between 5 and 12% and a Plasticity Modulus less than 250.

(d) Natural material for cement or lime improved base

The materials to be treated shall conform to the following requirements:-

Gravels:

- maximum size	10 - 50mm
- % passing 0.075mm sieve	5 - 35%

Sands, silty and clayey sands:

- maximum size	1 - 10mm
- % passing 0.075mm sieve	max 40%
- Uniformity Coefficient	min 5

All materials:

- Plasticity Index	max 25%
- Plasticity Modulus	max 2000
- Organic matter	max 1%
- CBR at 95% MDD (AASHTO T180) and 4 day soak	min 20%

Additional requirements for lime treated materials:

- % passing 0.425mm sieve	min 15%
- Plasticity Index	min 10%

After treatment the material shall have a CBR of at least 160% measured after 7 day cure and 7 day soak on the site mix compacted to at least 95% MDD (AASHTO T180) and the treated material shall have a Plasticity Index less than 6% and a Plasticity Modulus less than 250.

(e) Natural materials for cement stabilized base

The material to be treated shall conform to the following requirements.

Gravels and coarse clayey sands:

- maximum size	2 - 40mm
- % passing 0.075mm sieve	max 35%
- Uniformity Coefficient	min 10
- Plasticity Index	max 25%
- Plasticity Modulus	
Mix-in-place method	max 1500
Stationary plant method	max 700
- CBR at 95% MDD (AASHTO T180) and 4 day soak	min 30%

After treatment the material shall have a UCS of at least 1800 kN/m^2 measured after 7 day cure and 7 day soak on the site mix compacted at 95% MDD (AASHTO T180) and the treated material shall have a Plasticity Index of less than 6% and a Plasticity Modulus of less than 250.

1204 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 1203. 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 (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 3 of this Specification or such other action as the Engineer may instruct or agree.

1205 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.

1206 SETTING OUT AND TOLERANCES

The layer shall be set out and constructed to the appropriate tolerances specified in Section 3 of this Specification.

1207 DRAINAGE OF SUBGRADE, SUBBASE AND BASE LAYERS

The subgrade, subbase 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 Section 1 and Section 11 of this Specification shall apply.

Should water accumulate on any part of the subgrade, subbase 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.

1208 TREATED MATERIALS

Lime or cement treatment, if required by the Special Specification or Drawings, shall be carried out in accordance with Section 14 of this Specification.

1209 MEASUREMENT AND PAYMENT

(a) Item : Natural material for subbase or base

Unit : m^3 of each type in each method of measurement

Natural material for subbase or base 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 natural material for subbase or base 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, 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 compacting.

(iv) Spreading, providing and admixing of fines if necessary, rolling, making good defective areas and maintenance of the surface.

(v) Loading, hauling a freehaul of 1.5km measured from the centre of volume of the source of material and dumping the material.

(vi) Complying with the requirements of Section 2, 6 and 12 of this Specification.

The rates for natural material for subbase and base 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 4 of this Specification.

(ii) Removal of topsoil (if instructed by the Engineer to be stockpiled separately) from the borrow area per m^3 in accordance with Section 4 of this Specification.

(iii) Length of access road, per km, in accordance with Section 9 of this Specification.

(iv) Removal of topsoil and/or overburden, as "Spoil", from the borrow area per cubic metre in accordance with Section 5 of this Specification.

(b) Item : Overhaul

Unit : m^3 km

The unit of overhaul will be the m^3km. The overhaul quantity shall be measured as the product of the overhaul length and the quantity of material overhauled measured in accordance with Clause 1209(a) of this Specification.

The overhaul length shall be the length from a point 1.5km from the centre of volume of the source of material to the centre of volume of the total overhauled material. It shall be measured to the nearest 0.1 km along the shortest practicable route from the source of the material to the nearest point on the new alignment and then along the new alignment to the centre of volume of the overhauled material.

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

SECTION 13

GRADED CRUSHED STONE SUBBASE AND BASE

1301 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 Clause 1303 (c) below.

The class and nominal size of the graded crushed stone to be provided will be specified in the Special Specification.

1302 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 6 of this Specification.

1303 MATERIAL REQUIREMENTS

The material shall comply with the following requirements:-

(a) It shall consist of crushed stone, free from clay, organic or other deleterious matter.

(b) It shall comply with the following physical requirements:-

(i) Stone Classes A, B and C.

	Base			Subbase		
Stone Class	A	B	C	A	B	C
LAA Max.	30	40	45	40	45	50
ACV Max.	25	30	32	30	32	35
SSS Max.	12	12	12	20	20	20
FI Max.	25	30	30	35	35	35
CR Min.	100	80	60	30	30	-

(ii) Stone Class D

Base

CBR at 95% MDD (AASHTO T180) and 4 days soak	min 80%
Los Angeles Abrasion	max 50%
Aggregate Crushing Value	max 35%
Plasticity Index	max 15%

Subbase

The plasticity of the material will be specified in the Special Specification.

CBR at 95% MDD (AASHTO T180) and 4 days soak	min 30%

(c) It shall comply with the following gradings:

(i) Stone Classes A, B and C.

The grading of the material, after processing, placing and compaction in the pavement shall be a smooth curve within, and approximately parallel to, one of the following envelopes. The class and nominal size shall be specified in the Special Specification:

Sieve Size (mm)	Percentage by weight passing			
	Base		Subbase	
	0/30	0/40	0/40	0/60
75	-	-	-	100
63	-	-	-	95 - 100
50	-	100	100	85 - 100
37.5	100	90 - 100	90 - 100	75 - 95
28	90 - 100	75 - 95	75 - 95	60 - 87
20	65 - 95	60 - 90	60 - 90	50 - 80
10	40 - 70	40 - 75	35 - 75	30 - 67
6.3	30 - 55	30 - 63	25 - 63	23 - 58
2	20 - 40	20 - 45	15 - 45	13 - 40
1	15 - 32		8 - 35	7 - 32
0.425	10 - 24	15 - 31	4 - 23	4 - 20
0.075	4 - 10	5 - 15	0 - 12	0 - 10

Cleanliness and plasticity: Material passing the 0.425 mm sieve shall be non-plastic.

(ii) Stone Class D

Base

Sieve (mm)	% by weight passing
50	100
37.5	90 - 100
28	80 - 100
20	60 - 100
10	35 - 90
5	20 - 75
2	12 - 50
1	10 - 40
0.425	7 - 33
0.075	4 - 20

Subbase

Maximum particle size to be 2/3 layer thickness or 80 mm whichever is the lesser
Uniformity Coefficient min 5

(d) The grading and physical requirements of the material for use in treated material in accordance with Section 14 of this Specification shall be specified in the Special Specification.

1304 CRUSHING, SCREENING AND MIXING

Unless otherwise instructed, cruching 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:-

(i) The Contractor shall be responsible for all costs associated with the provision and mixing in of the material, including land acquisition.

(ii) 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.

(iii) Only material passing the 6.3mm sieve may be added. The percentage to be added shall be agreed with the Engineer and in any case shall not exceed 15% by weight of the mixture.

(iv) The minimum crushing ratios specified in Clause 1303 of this Specification shall be maintained.

1305 TRANSPORTING GRADED CRUSHED STONE

Graded crushed stone shall be transported damp and in such a way that no segregation occurs.

1306 LAYING AND COMPACTING GRADED CRUSHED SUBBASE 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 subbase 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 sections of Clause 1204 of this Specification shall apply.

All rolling shall be longitudinal and shall commence at the outer edges of the pavement and progress towards the centre, except that on superelevated 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.

Subbase: average dry density not less than 96% MDD with no result less than 94% MDD.

In addition to the above, the dry densities to be achieved as a percentage of the specific gravity of the stone shall be:

Base: average dry density not less than 85% of the specific gravity with no result less than 82% of the specific gravity (Oven - dry value).

Subbase: average dry density not less than 82% of the specific gravity with no result less than 80% of the specific gravity (Oven - dry value).

On completion of the compaction the surface shall be well closed, mechanically stable, free from visible 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 3 of this Specification or such other action as the Engineer may instruct or agree.

1307 PROOFROLLING

The Contractor shall proofroll completed layers in accordance with Clause 1205 of this Specification.

1308 SETTING OUT AND TOLERANCES

Graded crushed stone subbase and base shall be set out and constructed to the tolerances given in Section 3 of this Specification.

1309 TREATED MATERIALS

Lime or cement treatment, if required by the Special Specification or Drawings, shall be carried out in accordance with Section 14 of this Specification.

1310 MEASUREMENT AND PAYMENT

(a) Item : Graded crushed stone for base or subbase

Unit : m^3 of each nominal size of each class

Graded crushed stone shall be measured by the cubic metre for each of the nominal sizes in each class of material calculated as the product of the compacted sectional area instructed to be laid and the length instructed.

The rate for graded crushed stone shall include for the cost of mixing, hauling, spreading and compacting the material and complying with the requirements of Sections 2, 6 and 13 of this Specification.

No overhaul will be paid.

SECTION 14

CEMENT AND LIME TREATED MATERIALS

1401 SCOPE OF SECTION

This section deals with the addition and mixing in of cement or lime, hereinafter described as the "stabilizer", to the upper layers of earthworks as described in Section 5, natural materials as described in Section 12, and crushed materials as described in Section 13, of this Specification.

Following the addition and mixing in of the stabilizer the material is referred to as "treated material". Treated material may either be lime on cement improved material, or cement stabilized material.

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, subbase layer or base layer.

1402 SOURCES OF MATERIALS

In accordance with Sections 5, 12 and 13 of this Specification.

1403 MATERIAL REQUIREMENTS

(a) Natural materials

In accordance with Sections 5, 12 and 13 of this Specification.

(b) Cement and lime

(i) Cement

Unless otherwise specified cement shall be ordinary Portland cement complying with the requirements of Section 2 of this Specification.

(ii) Lime

Lime shall be hydrated calcium lime or quicklime and shall comply with the requirements of Section 2 of this Specification.

(iii) Storage and handling

The requirements of Section 17 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.

1404 AMOUNT OF STABILIZER 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 Section 2 of this Specification.

1405 MIX-IN-PLACE METHOD OF CONSTRUCTION

The mix-in-place method may be used for the addition and mixing in of stabilizer.

(a) Mixing equipment

The equipment for pulverizing the material and mixing in the stabilizer shall be purpose - built equipment, capable of pulverizing the materials and mixing in the stabilizer 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 multipass machines and shall only be acceptable if, during the site trials carried out in accordance with Section 2 of this Specification, it can produce material to the specified requirements.

If single-pass equipment is used for plastic soils, the degree of pulverization 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 stabilizer 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 stabilizer shall be adjusted to within the range of 70% to 85% of the Optimum Moisture Content (AASHTO TI80).

(c) Spreading the stabilizer

After the layer to be treated has been prepared to the satisfaction of the Engineer, the stablizer shall be uniformly spread over the width to be worked at the specified rate. If a spreader is used to spread the stabilizer 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 stabilizer 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 stabilizer, when so spread, before it has been mixed into the material to be treated.

(d) Mixing and watering

Immediately after the stabilizer 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.

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 stabilizer. 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 stabilizer 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 stabilizer and finished off in accordance with this Clause.

Throughout the process of mixing in the stabilizer 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.

1406 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 stabilizer 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 stabilizer 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 stabilizer 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 3 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.

1407 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. 1½ hours in hot tropical/equatorial Climate.

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.

(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 subbase 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 (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 3 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 3 of this Specification or such other action as the Engineer may instruct or agree.

1408 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 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 stabilizer 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.

1409 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 0.1mm. 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 500mm 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.

(ii) Completely covering the treated material with a layer of damp uncompacted gravel or soil material of minimum thickness 100mm. This material, which may be that forming the next layer, shall be kept continuously damp.

(iii) Spraying the layer with A3 anionic emulsion at a rate of 1.5 l/m^2 to be applied in accordance with Parts A and B of Section 15 of this Specification. This method shall not be permitted where the following layer is to be a bituminous mix in accordance with Section 16 of this Specification.

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 Parts A and B of Section 15 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.

1410 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.

1411 TOLERANCES

(a) Geometric tolerances

The treated upper earthworks, subbase and base shall be constructed within the tolerances specified in Section 3 of this Specification.

(b) Amount of stabilizer

(i) Mix-in-place method of construction.

The average amount of stabilizer, measured before mixing, over a length of 100 m, shall not be less than the amount ordered.

The average amount of stabilizer 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 stabilizer, 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 stablizer 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 stabilizer measured after mixing shall at no point be less than 90% or more than 110% of the amount ordered.

(iii) Determination of stabilizer 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.

1412 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 5, 11, 12 and 13, as appropriate, of this Specification.

For the additional work of providing and mixing-in the stabilizer and curing the treated materials the Contractor will be paid as follows:-

(a) Item : Stabilizer

Unit : Tonne of each type of stabilizer

The provision of the stabilizer shall be measured by the tonne calculated as the specified weight of stabilizer added to the material.

The rate for stabilizer shall include for the cost of provision, storage, handling, transport and spreading of the stabilizer at any point on the Works and complying with the requirements of Clauses 1401, 1403, 1404, 1405, 1406, 1408 and 1411 of this Specification.

(b) Item : Mix-in stabilizer

Unit : m^3

Mixing stabilizer 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 for mixing shall include for the cost of complying with the requirements of Section 14 of this Specification.

(c) Item : Curing treated material

Unit : 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 Parts A and B of Section 15 of this Specification.

SECTION 14A

LEAN CONCRETE

14A/01 SCOPE OF SECTION

This section deals with the addition and mixing in of cement to graded aggregate, and the transporting, laying and compaction of the mix, hereinafter referred to as "lean concrete" for base or subbase.

14A/02 SOURCE OF MATERIALS

The Contractor shall be responsible for locating and developing suitable sources of material for lean concrete. 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 6 of this Specification.

14A/03 MATERIALS REQUIREMENTS

(i) Aggregates

(a) Grading

Sieve Size (mm)	% passing (by weight)
37.5	100
28	90 - 100
20	65 - 95
10	40 - 70
5	30 - 55
2	18 - 40
1	13 - 32
0.425	10 - 24
0.075	0 - 6

(b) Combined aggregate

Sodium Sulphate Soundness : Max 12%
Fines (passing 0.425mm) : shall be non-plastic
Sand-equivalent : Min 30%
Organic matter : Max 0.3% (by weight)

(c) Aggregate retained on a 2mm sieve

CR : Min 80%
FI : Max 25%
LAA : Max 35%
ACV : Max 28%

(ii) Cement

(a) Cement

Unless otherwise specified cement shall be ordinary Portland cement complying with Section 2 of this Specification.

(b) Storage and handling

The requirements of Section 17 of this Specification shall apply to the storage and handling of cement.

(c) Water shall comply with Section 17 of this Specification.

14A/04 MIX REQUIREMENTS

(i) Proportions

The ratio of cement to aggregate by weight (including any absorbed moisture but excluding free water in the aggregate) shall be such as to produce average crushing strengths to the requirements of this Section.

The amount of cement to be added shall be determined by the Engineer following laboratory trials, and site trials carried out by the Contractor in accordance with Section 2 of this Specification.

The water content of the mixed concrete shall be such as to ensure that the specified degree of compaction can be achieved under all normal working conditions.

(ii) Crushing strength

The essential strength requirement for the material is that the average 28-day strengths of groups of three cubes shall be such that not more than one such average strength in any consecutive five such averages is less than 10 N/mm^2. If, however, the overall average of any consecutive five groups of three cubes (i.e. fifteen cube strengths) falls below 12 N/mm^2 at 28 days, or if the average range of five consecutive groups exceeds 20N/mm^2 the Engineer may require the use of different materials, mix proportions, plant or methods notwithstanding any approval which may have been previously given to such materials, mix proportions, plant or methods.

The initial rate of testing shall comply with the requirements of Section 17 of this Specification until the Engineer is satisfied that the specified material is being consistently produced.

Further, in order to ensure a high probability that at an early stage the above requirements will be met, the average 7-day strengths of groups of three cubes shall be not less than 7 N/mm^2 and if more than one of the 7-day average strengths of groups of three cubes in any consecutive five such averages fall below 9 N/mm^2 the cement content shall be increased to such a value as may be approved by the Engineer and the making of cubes shall be continued at the same rate as at the start of the work until the results show that a satisfactory material is being consistently produced.

14A/05 METHOD OF CONSTRUCTION

(i) Site trials

The Contractor shall carry out site trials in accordance with Section 2 of this Specification at least one month before he intends commencing full scale construction of any lean concrete layer. Should the trial show that the specified strength and compaction requirements cannot be achieved the Contractor shall amend the mix proportions or the laying and compaction techniques in order to achieve the required result.

(ii) Mixing, transporting and laying

Lean concrete shall be mixed, transported and laid in accordance with Section 14 of this Specification (stationary plant method of construction).

(iii) Compaction

Immediately after laying, the mix shall be compacted by vibratory and smooth wheel rollers to 96% of the target dry density. Compaction shall be completed within 2 hours of the cement being added to the aggregates at the batching plant.

The target dry density shall be determined daily as follows:-

From three separate batches of the mix, two 150mm test cubes shall be prepared in accordance with BS 1881 except that the cubes shall be compacted to refusal in three layers using a vibrating hammer as described in BS 1377, Test 14, but with a square flat plate head with an area of between 10,000 and 15,000mm^2. As soon as the cubes can be handled without damage, their density and moisture content shall be determined in accordance with BS 1881. The average dry density of the six cubes shall be the target dry density.

The density of the compacted base shall be determined for each 500m^2 laid. The Contractor shall provide a portable coring rig capable of cutting acceptable cores of minimum diameter 150mm

and to a depth of at least 250mm. The density and moisture content of each core shall be measured in accordance with BS 1881.

Following the determination of the density each core shall be crushed and the minimum equivalent cube strength shall be 7 N/mm^2 at 7 days calculated in accordance with BS 1881.

The compacted thickness shall not exceed 250mm.

(iv) Finishing

The surface finish after compaction 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 3 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 3 of this Specification or such other action as the Engineer may instruct or agree.

(v) Joints

At the end of each day's work the lean concrete shall be compacted against a securely fixed vertical temporary stop-end and if compaction is being done with a vibratory roller this shall be used transversely close to the stop-end. In addition, the material in the corners adjacent to the stop-end shall be compacted by means of a small power-operated compactor. When the stop-end is removed any poorly compacted material adjacent to it shall be removed and a
1 : 1 cement:sand grout shall be applied to the exposed face to a thickness of 5 - 10mm before proceeding with the laying of further adjoining lean concrete. Such fresh lean concrete shall be thoroughly compacted against the joint and where a vibratory roller is employed this shall be used transversely close to the joint again using the small power-operated compactor in the corners of the new work. None of the compacting equipment shall be allowed to bear directly on the hardened or partially hardened lean concrete previously laid.

Where the full width of the layer cannot be placed by one pass of the paver, work shall be arranged so that at longitudinal joints a free edge of spread material is not exposed for more than one hour after mixing before placing the adjacent layer. Where a free edge is exposed for more than one hour after mixing, it shall be cut back to expose fully compacted material before laying the adjacent layer.

(vi) Curing

Curing and the period of curing shall be in accordance with the Special Specification.

14A/06 TRAFFIC

Traffic or equipment, other than that actually engaged in the various treatment processes, shall not run over the layer being processed or compacted.

No traffic or equipment will be allowed on a treated layer earlier than that period specified in the Special Specification after completion of compaction, and subsequently only that traffic necessary for construction of the next layer will be permitted on the treated layer.

14A/07 SETTING OUT AND TOLERANCES

Lean concrete base and subbase shall be set out and constructed to the tolerances given in Section 3 of this Specification.

14A/08 MEASUREMENT AND PAYMENT

(a) Item : Lean concrete for base or subbase

Unit : m^3

Lean concrete shall be paid by the cubic metre calculated as the compacted sectional area instructed to be laid and the length instructed.

The rate for lean concrete for base or subbase shall include for the cost of providing mixing hauling spreading and compacting the material and complying with the requirements of Section 14A of this Specification.

No overhaul will be paid.

(b) Item : Curing lean concrete

Unit : as specified in the Special Specification

The unit and method of measure shall be as specified in the Special Specification.

The rate shall include for complying with Section 14A of this Specification and with the Special Specification.

SECTION 15

BITUMINOUS SURFACE TREATMENTS AND SURFACE DRESSINGS

1501 SCOPE OF SECTION

This Section covers the application of different bituminous binders and aggregates to any kind of road surface and is divided into the following parts:

PART A	General
PART B	Prime Coat and Tack Coat
PART C	Surface Dressing
PART D	Sand Seal
PART E	Gravel Seal
PART F	Emulsion Slurry Seal

PART A - GENERAL

1501A SCOPE OF PART A

Part A comprises all the general requirements for bituminous binder and aggregate common to Parts B to F inclusive.

1502A BITUMINOUS BINDER SPECIFICATIONS

All bituminous binders shall comply with the relevant requirements set out in Section 2 of this Specification.

1503A 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 1504A 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.

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.

1504A 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 the following table:-

Binder	Temperatures (°C)*			
	Minimum	Spraying		Maximum
	Pumping	Slot-jets	Atomising jets	Heating
Cut-back RC 30	10	35 - 45	-	50
" RC 70	25	55 - 65	-	70
" RC 250	45	80 - 90	-	90
" RC 800	60	100 - 115	-	120
" RC 3000	80	125 - 135	-	135
Cut-back MC 30	10	35 - 45	50 - 60	65
" MC 70	25	55 - 65	70 - 85	85
" MC 250	45	80 - 90	90 - 110	110
" MC 800	60	100 - 115	120 - 135	135
" MC 3000	80	125 - 135	135 - 150	150
" 800/1400 (France)	90	135 - 145	145 - 160	160
Bitumen 400/500	95	140 - 150	160 - 170	170
" 280/320	100	150 - 160	160 - 170	170
" 180/200	105	155 - 165	160 - 170	170
" 80/100	115	160 - 170	160 - 170	170
Emulsion Kl-70	15	75 - 85	75 - 85	95
" **Kl-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 Kl-60 shall be in accordance with the manufacturer's recommendations.

For slot-jets the viscosity for spraying shall be 70 to 100 centistokes and for atomizing 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).

1505A 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.

1506A CONSTRUCTION LIMITATIONS

No bituminous construction work will be permitted in adverse weather conditions (rain, wind etc.,) 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.

1507A SAFETY PRECAUTIONS

The Contractor shall take every precaution to avoid fire or health hazards. He shall always ensure that:

(a) bitumen is heated only to the temperature required for the particular application;

(b) hot bitumen never comes in contact with water;

(c) suitable protective clothing and gloves are used when handling hot bitumen; and

(d) 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.

1508A MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made for complying with the requirements of Clauses 1501A to 1507A inclusive of this Specification and the Contractor shall be deemed to have allowed in his rates in Parts B to F inclusive of Section 15 of this Specification for the costs of complying with the requirements of Part A of Section 15 of this Specification.

PART B - PRIME COAT AND TACK COAT

1501B 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.

A tack coat shall mean a light application of bituminous binder to a bituminous or concrete surface.

1502B 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 binder shall be a penetration grade bitumen applied hot immediately prior to laying the bituminous mixture layer or alternatively a rapid curing cut-back or medium curing cut-back applied at sufficient time before laying the bituminous mixture to allow the evaporation of the cutter (solvent); or a quick-breaking emulsion or slow-setting emulsion diluted with water, 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.

1503B 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.

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.

1504B SPRAYING OF PRIME COAT AND TACK COAT

As soon as possible after the surface to be sprayed has been prepared as specified in Clause 1503B 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 handspraying 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 handspray , 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.

1505B 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.

1506B TOLERANCES

The rate of application of bituminous binder across the width of each spray run shall not vary by more than ± 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.

1507B MEASUREMENT AND PAYMENT

(a) Item : Prime coat or tack coat

Unit : l (litre) 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 1502B, 1503B, 1504B, 1505B and 1506B of this Specification.

PART C - SURFACE DRESSING

1501C 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.

1502C MATERIALS FOR SURFACE DRESSING

(a) Binder

The binder will generally be a suitable cationic quick-breaking emulsion such as K1-60 or K1-70, a medium-curing cut-back MC 3000 or a penetration/cut back mixture blended to the approval of the Engineer. 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 following requirements, for the appropriate class as specified in the Special Specification.

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

Sieve Size (mm)	Percentage by weight passing — Nominal Sizes			
	14/20	10/14	6/10	3/6
28	100	-	-	-
20	85-100	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

1503C 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.

1504C 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 Clause 1502C(b). This may require washing the chippings to meet the cleanliness requirements.

The Contractor shall comply with Section 6 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.

1505C 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.

1506C 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 him 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 antidrip 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 $\pm$ 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/mm^2.

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.

1507C 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.

1508C 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.

1509C 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 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.

1510C 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 $\pm$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 $\pm$10% of the rate ordered.

1511C MEASUREMENT AND PAYMENT

(a) Item : Seal coat

Unit : l (litre) for 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 Parts A and C of Section 15 of this Specification.

(b) Item : Chippings

Unit : 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 Parts A and C of Section 15 of this Specification.

(c) Item : Precoated chippings

Unit : as specified in the Special Specification

The method of measurement for precoated chippings shall be as specified in the Special Specification.

The rate for precoated chippings shall include for the cost of complying with Parts A and C of Section 15 of this Specification and with the relevant sections of the Special Specification.

PART D - SAND SEAL

1501D DEFINITION

A sand seal means an application of bituminous binder covered with aggregate as specified below.

1502D MATERIAL FOR SAND SEAL

(a) Binder

The binder shall be a medium-curing cut-back MC800 or MC3000 or K1-60 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 follows:

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
0.150	0 - 8
0.075	0 - 5

1503D 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.

1504D CONSTRUCTION

The surface to be covered shall be prepared in accordance with Clause 1507C.

The binder shall be uniformly sprayed at the specified rate. The fine aggregate shall be uniformly spread and rolled, all in accordance with Clause 1508C, except that the fine aggregate shall be spread in excess of that required to cover the binder.

1505D 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 1509C 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.

1506D TOLERANCES

Sand seal shall be constructed within the same width tolerance as given in Clause 1510C 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.

1507D MEASUREMENT AND PAYMENT

(a) Item : Seal coat

Unit : l (litre) for each type of bituminous binder

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 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 Parts A and D of Section 15 of this Specification.

(b) Item : Aggregate

Unit : 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 Parts A and D of Section 15 of this Specification.

PART E - GRAVEL SEAL

1501E DEFINITION

A gravel seal means an application of bituminous binder covered with graded granular material.

1502E MATERIAL FOR GRAVEL SEAL

(a) Binder

The binder shall be a medium curing cut-back MC800 or MC3000 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 602 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 6 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 following envelope:-

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.

1503E RATE OF APPLICATION OF BINDER AND 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.

1504E CONSTRUCTION

The surface to be covered shall be prepared in accordance with Clause 1507C.

The binder shall be uniformly sprayed and the aggregate shall be uniformly spread and rolled in accordance with Clause 1508C.

1505E AFTERCARE AND TRAFFIC CONTROL

The road shall be opened to traffic when so instructed by the Engineer. The traffic speed shall be restricted as per Clause 1509C for as long as the Engineer may require.

1506E TOLERANCES

Gravel seal shall be constructed within the width tolerance given in Clause 1510C.

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.

1507E MEASUREMENT AND PAYMENT

(a) Item : Seal coat

Unit : l (litre) 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 bitumdnous binder at any instructed application rate and complying with the requirements of Parts A and E of Section 15 of this Specification.

(b) Item : Aggregate

Unit : 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 Parts A and E of Section 15 of this Specification.

PART F - EMULSION SLURRY SEAL

1501F 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.

1502F MATERIALS FOR SLURRY SEAL

(a) Emulsion

The emulsion shall be either an anionic emulsion A4 (slow setting or rapid-setting) or a slow-acting cationic emulsion K3 unless otherwise instructed by the Engineer.

(b) Aggregate

The aggregate shall be free of 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 specified in the Special Specification:-

Sieve Size (mm)	Percentage 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
0.150	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 2 of this Specification.

1503F 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.

Water shall be added in sufficient 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.

1504F RATE OF APPLICATION OF SLURRY MIXTURE

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.

1505F CONSTRUCTION

Where a slurry seal is to be applied to a surface dressing the surface dressing shall be trafficked for a period of least two weeks prior to the application of the slurry.

The surface to be covered shall be prepared in accordance with Clause 1507C.

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 6 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.

1506F 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.

1507F TOLERANCES

Slurry seal shall be constructed within the same width tolerances given in Clause 1510C.

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 be not less than the rate ordered.

1508F MEASUREMENT AND PAYMENT

(a) Item : Slurry seal

Unit : m^3 of dry aggregate 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 metres/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 Part A and F of Section 15 of this Specification and with the relevant Clauses of the Special Specification.

(b) Item : Variation in emulsion content

Unit : l (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.

(c) Item : Variation in cement or lime content

Unit : 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.

SECTION 16

BITUMINOUS MIX BASES, BINDER COURSES AND WEARING COURSES

1601 SCOPE OF SECTION

This section covers different types of bituminous mixes for Base and Surfacing (Wearing and Binder Courses) and is divided into the following Parts:-

PART A	General
PART B	Asphalt Concrete for Surfacing
PART C	Dense Bitumen Macadam for Base
PART D	Cold Asphalt for Surfacing, Base, Levelling courses and Patching

PART A - GENERAL

1601A SCOPE OF PART A

Part A comprises all the general requirements for bituminous mixes which apply to Parts B to D inclusive.

1602A REQUIREMENTS FROM OTHER SECTIONS

The following Sections of this Specification apply to Parts B to D of this Section and shall be read in conjunction therewith:-

Section 2 Materials and Testing of Materials

Section 3 Setting Out and Tolerances

Section 6 Quarries, Borrow Pits, Stockpile and Spoil Areas

Section 15 Bituminous Surface Treatments and Surface Dressing

1603A CONSTRUCTION PLANT

(a) General

The Contractor shall submit to the Engineer in accordance with Section 1 of this Specification, full details of the construction plant he proposes to use and the procedures he proposes to adopt for carrying out the permanent Works.

The Engineer shall have access at all times to construction plant for the purposes of inspection. The Contractor shall carry out regular calibration checks in the presence of the Engineer and shall correct forthwith any faults which are found.

All construction plant used in the mixing, laying and compacting of bituminous mixes shall be of adequate rated capacity, in good working condition, and shall be acceptable to the Engineer. Obsolete or worn-out plant will not be allowed on the work.

(b) Mixing plant

Bituminous materials shall be mixed in a plant complying with ASTM Designation D995 and shall be located on the Site unless otherwise agreed by the Engineer. It shall be equipped with at least three bins for the storage of heated aggregates and a separate bin for filler. All bins shall be covered to prevent the ingress of moisture.

The plant may be either the batch-mix type or the continuous-mix type and shall be capable of regulating the composition of the mixture to within the tolerances specified in Clause 1614A of this Specification.

The bitumen tank shall be capable of maintaining its contents at the specified temperature within a tolerance of plus or minus 5°C and shall be equipped with a thermostat to prevent the temperature rising above 180°C and a fixed thermometer easily read from outside the tank. Any bitumen which has been heated above 180°C or has suffered carbonisation from prolonged heating shall be removed from the plant and disposed of.

(c) Laying plant

Bituminous materials shall be laid by a self propelled spreader finisher equipped with a hopper, delivery augers and a heated adjustable vibrating screed. It shall be capable of laying bituminous materials with no segregation, dragging, burning or other defects and within the specified level and surface regularity tolerances. Delivery augers shall terminate not more than 200mm from the edge plates.

(d) Compaction plant

The Contractor shall provide sufficient rollers of adequate size and weight to achieve the specified compaction. Prior to commencing the laying of bituminous mixes in the permanent Works the Contractor shall carry out site trials in accordance with Section 2 of this Specification to demonstrate the adequacy of his plant and to determine the optimum method of use and sequence of operation of the rollers.

1604A PREPARATION OF SURFACE

Immediately before placing the bituminous mix in the pavement, the existing surface shall be cleaned of all loose material and foreign matter with mechanical brooms or by other approved methods. The debris shall be deposited well clear of the surface to be covered.

Any defect of the surface shall be made good and no bituminous mix shall be laid until the surface has been approved by the Engineer.

If instructed by the Engineer a tack coat shall be applied in accordance with Section 15 of this Specification. If the Engineer considers a tack coat is required prior to laying the bituminous mix or between layers of the bituminous mix, due solely to the Contractors method of working, then such tack coat shall be at the Contractor's expense.

1605A DESIGN AND WORKING MIXES

At least two months prior to commencing work using a bituminous mix, the Contractor shall, having demonstrated that he can produce aggregates meeting the grading requirements of the Specification, submit samples of each constituent of the mix to the Engineer.

The Engineer will then carry out laboratory tests in order to decide upon the proportions of each constituent of the initial design mix or mixes to be used for site trials to be carried out in accordance with Clause 1606A of this Specification.

Should the Engineer conclude from the site trials that the mix proportions or aggregate gradings are to be changed, the Contractor shall submit further samples of the constituents and carry out further site trials all as directed by the Engineer.

The Engineer may instruct the alteration of the composition of the minus 75 micron fraction of the aggregates by the addition or substitution of mineral filler. The Engineer may also instruct the alteration of all or part of the minus 6.3mm fraction of the aggregates by the addition or substitution of a natural sand.

The Contractor shall make the necessary adjustments to his plant to enable the revised mix to be produced.

Following laboratory and site trials the Engineer will determine the proportions of the working mix and the Contractor shall maintain this composition within the tolerances given in Clause 1614A.

Should any changes occur in the nature or source of the constituent materials, the Contractor shall advise the Engineer accordingly. The procedure set out above shall be followed in establishing the new mix design.

1606A SITE TRIALS

Full scale laying and compaction site trials shall be carried out by the Contractor on all asphalt pavement materials proposed for the Works using the construction 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, at a location approved by the Engineer.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of his mixing and compaction equipment to provide and compact the material to the specified voids content and to confirm that the other specified requirements of the completed asphalt pavement layer can be achieved.

Each trial area shall be at least 100 metres long and to the full construction width and depth for the material. It may form part of the Works provided it complies with this Specification. Any areas which do not comply with this Specification shall be removed.

The Contractor shall allow in his programme for conducting site trials and for carrying out the appropriate tests on them. The trial on any 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 the following data shall be recorded for each level of compactive effort at each site trial:-

(i) The composition and grading of the material including the bitumen content and type and grade of bitumen used.

(ii) The moisture content of aggregate in the asphalt plant hot bins.

(iii) The temperature of the bitumen and aggregate immediately prior to entering the mixer, the temperature of the mix on discharge from the mixer and the temperature of the mix on commencement of laying, on commencement of compaction and on completion of compaction. The temperature of the mixture is to be measured in accordance with BS 598, Part 3, Appendix A.

(iv) The type, size, mass, width of roll, number of wheels, wheel load, tyre pressures, frequency of vibration and the number of passes of the compaction equipment, as appropriate for the type of roller.

(v) The target voids and other target properties of the mix together with the results of the laboratory tests on the mix.

(iv) The density and voids achieved.

(v) The compacted thickness of the layer.

(vi) 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 then 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.

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/or 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.

1607A MIXING OF AGGREGATES AND BITUMEN

The bitumen shall be heated so that it can be distributed uniformly and care shall be taken not to overheat it. The temperature shall never exceed 170°C for 80/100 or 60/70 bitumen.

The aggregates shall be dried and heated so that they are mixed at the following temperatures:

125 - 165°C when 80/100 bitumen is used
130 - 170°C when 60/70 bitumen is used.

The dried aggregates shall be combined in the mixer in the amount of each fraction instructed by the Engineer and the bitumen shall then be introduced into the mixer in the amount specified. The materials shall then be mixed until a complete and uniform coating of the aggregate is obtained.

The mixing time shall be the shortest required to obtain a uniform mix and thorough coating. The wet mixing time shall be determined by the Contractor and agreed by the Engineer for each plant and for each type of aggregate used. It shall normally not exceed 60 seconds.

1608A TRANSPORTING THE MIXTURE

The bituminous mix shall be kept free of contamination and segregation during transportation. Each load shall be covered with canvas or similar covering to protect it from the weather and dust.

1609A LAYING THE MIXTURE

Immediately after the surface has been prepared and approved, the mixture shall be spread to line and level by the laying plant without segregation and dragging.

The mixture shall be placed in widths of one traffic lane at a time, unless otherwise agreed by the Engineer. The compacted thickness of any layer shall be at least 2.5 times the maximum size of the aggregate for wearing course and at least 2 times for binder course. The minimum thickness shall be 25mm.

Only on areas where irregularities or unavoidable obstacles make the use of mechanical laying impracticable, may the mixture be spread and compacted by hand.

1610A COMPACTION

Immediately after the bituminous mixture has been spread, it shall be thoroughly and uniformly compacted by rolling.

The layer shall be rolled when the mixture is in such a condition that rolling does not cause undue displacement or shoving.

The number, weight and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The sequence of rolling operations shall be as agreed with the Engineer and proved during site trials.

Initial rolling with a steel tandem or three-wheeled roller shall follow the laying plant as closely as possible. The rollers shall be operated with the drive roll nearest the laying plant, at a slow and uniform speed (not exceeding 5km/h).

Rolling shall normally commence from the outer edge and proceed longitudinally parallel to the centreline, each trip overlapping one half of the roller width. On superelevated curves, rolling shall begin at the low side and progress to the high side. Where laying is carried out in lanes care must be taken to prevent water entrapment.

Intermediate rolling with a pneumatic tyred or vibratory roller shall follow immediately. Final rolling with a steel wheeled roller shall be used to eliminate marks from previous rolling.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept lightly moistened with water.

In areas too small for the roller, a vibrating plate compactor or a hand tamper shall be used to achieve the specified compaction.

1611A FINISHING, JOINTS AND EDGES

Any mixture that becomes loose and broken, mixed with dirt or foreign matter or is in any way defective, shall be removed and replaced with fresh hot mixture, which shall be compacted to conform with the surrounding area.

Spreading of the mixture shall be as continuous as possible. Transverse joints shall be formed by cutting neatly in a straight line across the previous run to expose the full depth of the course. The vertical face so formed shall be painted lightly with hot 80/100 penetration grade bitumen just before the additional mixture is placed against it.

Longitudinal joints shall be rolled directly behind the paving operation. The first lane shall be placed true to line and level and have an approximately vertical face. The mixture placed in the abutting lane shall then be tightly crowded against the face of the previously placed lane. The paver shall be positioned to spread material overlapping the joint face by 20 - 30 mm. Before rolling, the excess mixture shall be raked off and discarded.

When the abutting lane is not placed in the same day, or the joint is destroyed by traffic, the edge of the lane shall be cut back as necessary, trimmed to line and painted lightly with hot 80/100 penetration grade bitumen just before the abutting lane is placed.

Any fresh mixture spread accidentally on the existing work at a joint shall be carefully removed by brooming it back on to uncompacted work, so as to avoid formation of irregularities at the joint. The finish at joints shall comply with the surface requirements and shall present the same uniformity of finish, texture and density as other sections of the work.

The edges of the course shall be rolled concurrently with or immediately after the longitudinal joint. In rolling the edges, roller wheels shall extend 50 to 100mm beyond the edge.

1612A SAMPLING AND TESTING OF BITUMINOUS MIXTURES

The sampling of bituminous mixtures shall be carried out in accordance with AASHTO T168 (ASTM Designation D979).

1613A QUALITY CONTROL TESTING

During mixing and laying of bituminous mixtures, control tests on the constituents and on the mixed material shall be carried out in accordance with Clause 1612A and Section 2 of this Specification.

If the results of any tests show that any of the constituent materials fail to comply with this Specification, the Contractor shall carry out whatever changes may be necessary to the materials or the source of supply to ensure compliance.

If the results of more than one test in ten on the mixed material show that the material fails to comply with this Specification, laying shall forthwith cease until the reason for the failure has been found and corrected. The Contractor shall remove any faulty material laid and replace it with material complying with this Specification all at his own expense.

1614A TOLERANCES

Surfacing courses and base shall be constructed within the geometric tolerances specified in Section 3 of this Specification.

The Contractor shall maintain the composition of the mixture as determined from the laboratory and site trials within the following tolerances, per single test:-

Bitumen Content:	± 0.3% (by total weight of total mix)
Passing 10mm sieve and larger sieves:	± 6% (by total weight of dry aggregate including mineral filler)
Passing sieves between 10mm and 1.0mm sieves:	± 4% (by total weight of dry aggregate including mineral filler)

Passing sieves between 1.0mm and 0.075mm sieve:	± 3%	(by total weight of dry aggregate including mineral filler)
Passing 0.075mm sieve:	± 2%	(by total weight of dry aggregate including mineral filler)

The average amount of bitumen in any length of any layer, calculated as the product of the bitumen contents obtained from single tests and the weight of mixture represented by each test, shall not be less than the amount ordered.

The average amount of bitumen for each day's production calculated from the checked weights of mixes shall not be less than the amount ordered.

The final average overall width of the upper surface of a bituminous mix layer measured at six equidistant points over a length of 100m shall be at least equal to the width specified. At no point shall the distance between the centreline of the road and the edge of the upper surface of a bituminous mix layer be narrower than that specified by more than 13mm.

1615A MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made for complying with the requirements of Clauses 1601A to 1614A inclusive and the Contractor shall be deemed to have allowed in his rates in Parts B, C and D of Section 16 of this Specification for the costs of complying with the requirements of Part A of Section 16 of this Specification.

PART B ASPHALT CONCRETE FOR SURFACING

1601B DEFINITION

Asphalt concrete means a thoroughly controlled, hot-mixed, hot-laid, plant mixture of well graded dried aggregate and penetration grade bitumen, which, when compacted, forms a dense material.

A distinction is drawn between asphalt concrete Type I (High Stability) and asphalt concrete Type II (Flexible). The asphalt concrete type will be specified in the Special Specification.

1602B MATERIALS FOR ASPHALT CONCRETE

(a) Penetration grade bitumen

Bitumen shall be 80/100 penetration grade. For asphalt concrete laid at altitudes in excess of 2,500 metres bitumen 180/200 penetration grade shall be used.

(b) Aggregate

Coarse aggregate (retained on a 6.3mm sieve) shall consist of crushed stone free from clay, silt, organic matter and other deleterious substances. The aggregate class will be specified in the Special Specification and it shall comply with the following requirements:-

Coarse Aggregate (retained on a 6.3 mm sieve)				
Aggregate	Class	a	b	c
LAA	Max	30	35	40
ACV	Max	25	28	30
SSS	Max	12	12	12
FI	Max	20	20	25

For asphalt concrete Type I, the coarse aggregate shall be entirely crushed. For asphalt concrete Type II, the Crushing Ratio of the coarse aggregate shall be as specified in the Special Specification or as instructed by the Engineer, but shall in no case be less than 60%.

Fine aggregate (passing a 6.3 mm sieve) shall be free from clay, silt, organic and other deleterious matter and shall be non-plastic. Unless otherwise specified in the Special Specification it shall consist of entirely crushed rock produced

from stone having a Los Angeles Abrasion of not more than 40. The Sand Equivalent of the fine aggregate shall be not less than 40, and the SSS not more than 12.

(c) Mineral filler

Mineral filler shall consist of finely ground particles of limestone, hydrated lime, Ordinary Portland cement or other non-plastic mineral matter as specified in the Special Specification. It shall be thoroughly dry and free from lumps. At least 75% (by weight) shall pass a 0.075mm sieve and 100% shall pass a 0.425mm sieve. It shall have a bulk density in toluene measured in accordance with BS 812 of between 0.5 and 0.9 g/ml.

TABLE 16B-1

GRADING REQUIREMENTS FOR ASPHALT CONCRETE

Sieve Size (mm)	Percentage by weight passing							
	Type I						Type II	
	Wearing Course			Binder Course			Wearing Course	
	0/14	0/10	0/6	0/20	0/14	0/10	0/14	0/10
28	-	-	-	100	-	-	-	-
20	100	-	-	90-100	100	-	100	-
14	90-100	100	-	75-95	90-100	100	90-100	100
10	70-90	90-100	100	60-82	70-90	90-100	70-95	90-100
6.3	55-75	60-82	90-100	47-68	52-75	60-82	55-85	62-90
4	45-63	47-67	75-95	37-57	40-60	45-65	46-75	50-80
2	33-48	33-50	50-70	25-43	30-45	30-47	35-60	35-65
1	23-38	23-38	33-50	18-32	20-35	20-35	25-45	25-50
0.425	14-25	14-25	20-33	11-22	12-24	12-24	14-32	14-33
0.300	12-22	12-22	16-28	9-17	10-20	10-20	11-27	11-27
0.150	8-16	8-16	10-20	5-12	6-14	6-14	6-17	6-17
0.075	5-10	5-10	6-12	3-7	4-8	4-8	3-8	3-8

1603B GRADING REQUIREMENTS

The grading of the mixture of coarse and fine aggregate shall be within and approximately parallel to one of the grading envelopes given in Table 16B-1, as specified in the Special Specification.

1604B REQUIREMENTS FOR ASPHALT CONCRETE

The mixture shall comply with the requirements given in Table 16B-2 as specified in the Special Specification.

The proportion, by weight of total mixture, of bitumen shall be stated in the Special Specification. This shall be termed the nominal binder content. The binder content of the working mix will be instructed by the Engineer following laboratory and site trials.

TABLE 16B-2
REQUIREMENTS FOR ASPHALT CONCRETE

Asphalt Concrete	Type I (Wearing Course)	Type I (Binder Course)	Type II (Wearing Course)
Marshall Stability 50 blows (N)	Min 9 000	Min 7 000	4 000 - 9 000
Flow Value (mm)	2 - 4	2 - 4	3 - 5
Voids in total mix (%)	3 - 5	3 - 7	3 - 5

1605B MIXING AND LAYING ASPHALT CONCRETE

The temperature of the bitumen when mixed with the aggregate shall be between 120°C and 140°C when 80/100 or 180/200 bitumen is used.

The minimum temperature of the mixture at the commencement of compaction shall be 125°C when 80/100 or 180/200 bitumen is used. The minimum temperature at completion of compaction shall be 80°C when 80/100 or 180/200 bitumen is used.

The minimum thickness of the compacted layer shall be 25mm when 0/10 and smaller aggregate is used and 50mm when 0/20 aggregate is used.

1606B COMPACTION

Rolling shall be continued until the voids measured in the completed layer are within the appropriate ranges tabulated in Table 16B-2 above.

1607B MEASUREMENT AND PAYMENT

(a) Item : Asphalt concrete

Unit : m^3 of each type, binder and nominal size for each layer

Asphalt concrete shall be measured by the cubic metre compacted on the road 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 rate for asphalt concrete shall include for the cost of providing, transporting, laying and compacting the mix with the nominal binder content and complying with the requirements of Parts A and B of Section 16 of this Specification.

(b) Item : Variation in binder content

Unit : l(litre)

Measurement of variation of binder content shall be by the litre calculated as the product of the difference, corrected to 15.6°C, between the nominal binder content and the binder content instructed by the Engineer, and the weight of compacted mix to which the variation applies, calculated from the volume determined in accordance with Clause 1607B (a) of this Specification.

Adjustment of compensation to the Contractor shall be as follows:-

(i) as a payment to the Contractor where the binder content is increased above the nominal rate specified, but only where such increase has been instructed in writing by the Engineer.

(ii) as a refund to the Employer where the binder content is reduced below the nominal rate specified. The binder content may only be reduced if the Engineer so instructs.

(c) Item : Mineral filler

Unit : tonne of each type

The rate per cubic metre for asphalt concrete shall include for providing any mineral filler necessary to achieve the specified gradings.

The Engineer may require the addition or substitution of mineral filler to modify a grading curve which already meets the specified requirements and in this case measurement and payment shall be made for the mineral filler so added or substituted.

1607B MEASUREMENT AND PAYMENT

(a) Item : Asphalt concrete

Unit : m^3 of each type, binder and nominal size for each layer

Asphalt concrete shall be measured by the cubic metre compacted on the road 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 rate for asphalt concrete shall include for the cost of providing, transporting, laying and compacting the mix with the nominal binder content and complying with the requirements of Parts A and B of Section 16 of this Specification.

(b) Item : Variation in binder content

Unit : l(litre)

Measurement of variation of binder content shall be by the litre calculated as the product of the difference, corrected to 15.6°C, between the nominal binder content and the binder content instructed by the Engineer, and the weight of compacted mix to which the variation applies, calculated from the volume determined in accordance with Clause 1607B (a) of this Specification.

Adjustment of compensation to the Contractor shall be as follows:-

(i) as a payment to the Contractor where the binder content is increased above the nominal rate specified, but only where such increase has been instructed in writing by the Engineer.

(ii) as a refund to the Employer where the binder content is reduced below the nominal rate specified. The binder content may only be reduced if the Engineer so instructs.

(c) Item : Mineral filler

Unit : tonne of each type

The rate per cubic metre for asphalt concrete shall include for providing any mineral filler necessary to achieve the specified gradings.

The Engineer may require the addition or substitution of mineral filler to modify a grading curve which already meets the specified requirements and in this case measurement and payment shall be made for the mineral filler so added or substituted.

Measurement shall be by the tonne of mineral filler added or substituted at the Engineer's instruction.

The rate for additional or substituted mineral filler shall include for the cost of the following:-

(i) Provision, haulage and storage of mineral filler.

(ii) Batching and mixing of mineral filler.

(iii) Removal from the graded aggregates of part or all of the minus 75 micron fraction if required by the Engineer.

(d) Item : Sand

Unit : tonne from each source

The rate per cubic metre for asphalt concrete shall include for providing aggregates to the specified gradings.

The Engineer may instruct the alteration of all or part of the minus 6.3mm fraction by the addition or substitution of natural sand in which case measurement and payment shall be made for sand so added or substituted.

Measurement shall be by the tonne of sand added or substituted at the Engineer's instructions.

The rate for sand shall include for the cost of the following:-

(i) Provision, haulage and storage of sand.

(ii) Batching and mixing of sand.

(iii) Removal from the graded aggregates of part or all of the minus 6.3mm fraction if required by the Engineer.

PART C DENSE BITUMEN MACADAM FOR BASE

1601C DEFINITION

Dense bitumen macadam means a hot-mixed, hot-laid plant mixture of well graded aggregate and penetration grade bitumen.

1602C MATERIAL REQUIREMENTS

(a) Penetration grade bitumen

Bitumen shall be either 60/70 or 80/100 penetration grade, as specified in the Special Specification or as instructed by the Engineer.

(b) Aggregate

Coarse aggregate (retained on a 6.3 mm sieve) shall consist of crushed stone produced from rock or boulders, the minimum size of which are at least 4 times the maximum size of the final crushed stone. The coarse aggregate shall be free from clay, silt, organic matter and other deleterious substances and shall comply with the following requirements:-

LAA	Max 35
ACV	Max 28
SSS	Max 12
FI	Max 25

The Crushing Ratio shall not be less than 100%.

Fine aggregate (passing a 6.3 mm sieve) shall be free from clay, silt, organic and other deleterious matter. Unless otherwise specified in the Special Specification it shall consist either of entirely crushed rock produced from stone having a Los Angeles Abrasion of not more than 40. The Sand Equivalent of the fine aggregate shall be not less than 40 and the SSS not more than 12.

(c) Mineral filler

Mineral filler shall consist of finely ground particles of limestone, hydrated lime, ordinary Portland cement or other non-plastic mineral matter as specified in the Special Specification. It shall be thoroughly dry and free from lumps. At least 75% (by weight) shall pass a 0.075mm sieve and 100% shall pass a 0.425mm sieve. It shall have a bulk density in toluene measured in accordance with BS 812 between 0.5 and 0.9 g/ml.

1603C GRADING REQUIREMENTS FOR DENSE BITUMEN MACADAM

The grading of the mixture of coarse and fine aggregate shall be within and approximately parallel to one of the following grading envelopes, as specified in the Special Specification:-

Sieve Size (mm)	% by weight passing	
	0/40	0/30
50	100	-
37.5	95-100	100
28	70-94	90-100
20	-	71-95
14	56-76	58-82
6.3	44-60	44-60
2	25-40	26-40
1	20-33	20-33
0.300	7-21	7-21
0.150	4-15	-
0.075	2-8	2-8

1604C REQUIREMENTS FOR DENSE BITUMEN MACADAM

The mixture shall comply with the appropriate requirements given in Table 16C-1 as stated in the Special Specification.

The proportion, by weight of total mix, of bitumen shall be stated in the Special Specification. This shall be termed the nominal binder content. The binder content of the working mix will be instructed by the Engineer following laboratory and site trials.

TABLE 16C-1: REQUIREMENTS FOR DENSE BITUMEN MACADAM

	0/40	0/30
Marshall Stability (50blows)N	min 5000	min 5000
Flow Value (mm)	2 - 5	2 - 4
Voids in total mix (%)	4 - 10	4 - 10
Loss of Stability after soaking (ASTM 1075) as % of unsoaked value	max 35%	max 35%

1605C MIXING AND LAYING DENSE BITUMEN MACADAM

The temperature of the freshly mixed dense bitumen macadam shall be between 130°C and 150°C. The minimum temperature at laying and commencement of compaction shall be 120°C and at completion of compaction shall be not less than 90°C.

The requirements regarding laying specified in Clause 1609A shall be modified as follows:

Laying plant capable of spreading the mixture over the full carriageway width shall be used as much as possible, otherwise the longitudinal joint shall be compacted before the temperature of the existing lane has dropped to 70°C where 80/100 bitumen is used and to 80°C where 60/70 bitumen is used. This temperature limitation requires the use of at least two mechanical pavers working in echelon.

The minimum thickness of the compacted layer shall be 60mm when 0/30 aggregate is used and 75mm when 0/40mm is used. No compacted layer shall exceed 100mm thickness when 0/30mm aggregate is used and 125mm when 0/40mm is used.

1606C COMPACTION

Rolling shall be continued until the voids measured in the completed layer are within the appropriate specified range given in Table 16C-1.

1607C SEALING OF DENSE BITUMEN MACADAM BASE

Bitumen macadam base course shall be sealed by applying the wearing course or surface dressing specified within two weeks of completing any section of base course. If the Contractor is unable to comply with this clause he shall apply a temporary single seal surface dressing at his own expense within the two weeks.

1608C MEASUREMENT AND PAYMENT

(a) Item : Dense bitumen macadam

Unit : m^3 of each type, binder and nominal size for each layer

Dense bitumen macadam shall be measured by the cubic metre compacted on the road 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 rate for dense bitumen macadam shall include for the cost of providing, transporting, laying and compacting the mix with the nominal binder content and complying with the requirements of Parts A and C of Section 16 of this Specification.

(b) Item : Variation in binder content

Unit : l(litre)

Measurement of variation of binder content shall be by the litre calculated as the product of the difference, corrected to 15.6°C, between the nominal binder content and the binder content instructed by the Engineer, and the weight of compacted mix to which the variation applies, calculated from the volume determined in accordance with Clause 1608C(a) of this Specification.

Adjustment of compensation to the Contractor shall be as follows:-

(i) As a payment to the Contractor where the binder content is increased above nominal rate specified, but only where such increase has been instructed in writing by the Engineer.

(ii) As a refund to the Employer where the binder content is reduced below the nominal rate specified. The binder content may only be reduced if the Engineer so instructs.

(c) Item : Mineral filler

Unit : tonne of each type

The rate per cubic metre for dense bitumen macadam shall include for providing any mineral filler necessary to achieve the specified gradings.

The Engineer may require the addition or substitution of mineral filler to modify a grading curve which already meets the specified requirements and payment shall be made for the mineral filler so added or substituted.

Measurement shall be by the tonne of mineral filler added or substituted at the Engineer's instruction.

The rate for additional or substituted mineral filler shall include for the cost of the following:-

(i) Provision, haulage and storage of mineral filler.

(ii) Batching and mixing of mineral filler.

(iii) Removal from the graded aggregates of part or all of the minus 75 micron fraction if required by the Engineer.

(a) Item : Sand

Unit : tonne from each source

The rate per cubic metre for dense bitumen macadam shall include for providing aggregates to the specified gradings.

The Engineer may instruct the alteration of all or part of the minus 6.3mm fraction by the addition or substitution of natural sand in which case measurement and payment shall be made for sand so added or substituted.

Measurement shall be by the tonne of sand added or substituted at the Engineer's instruction.

The rate for sand shall include for the cost of the following:-

(i) Provision, haulage and storage of sand:-

(ii) Batching and mixing of sand.

(iii) Removal from the graded aggregates of part or all of the minus 6.3mm fraction if required by the Engineer.

PART D COLD ASPHALT FOR SURFACING, BASE, LEVELLING AND PATCHING

1601D DEFINITION

Cold asphalt means a hot or cold-mixed, cold-laid plant mixture of graded aggregate and bituminous binder.

1602D MATERIALS FOR COLD ASPHALT

(a) Bituminous binder

For cold-asphalt to be used immediately, the bituminous binder shall be a medium-curing cut-back MC 250, MC 800 or MC 3000 or an anionic emulsion A2 or A3, or a cationic emulsion K2 or K3, as specified in the Special Specification or as instructed by the Engineer.

For cold-asphalt to be stockpiled, the bituminous binder shall be a medium-curing cut-back MC 250 or MC 800 or a slow-curing cut-back SC 250 or SC 800 or a slow-setting emulsion A3 or K3, as specified in the Special Specification or as instructed by the Engineer.

(b) Aggregates

Coarse aggregate (retained on a 6.3 mm sieve) shall consist of crushed stone produced from rock or boulders the minimum size of which are at least 4 times the maximum size of the final crushed stone. The coarse aggregate shall be free from clay, silt, organic matter and other deleterious substances. The aggregate class will be specified in the Special Specification and shall comply with the following requirements as appropriate:-

Coarse Aggregate (greater than 6.3 mm)				
Aggregate Class		a	b	c
LAA	Max	30	35	40
ACV	Max	25	28	30
SSS	Max	12	12	12
FI	Max	20	25	25

The fine aggregate (passing a 6.3mm sieve) shall be free from clay, silt, organic and other deleterious matter. Unless otherwise specified in the Special Specification it shall consist of entirely crushed rock produced from stone having a Los Angeles Abrasion of not more than 40. The Sand Equivalent of the fine aggregate shall be not less than 40 and the SSS not more than 12.

(c) Mineral filler

The mineral filler shall consist of finely ground particles of limestone, hydrated lime, Ordinary Portland cement or other non-plastic mineral matter as specified in the Special Specification. It shall be thoroughly dry and free from lumps. At least 75% (by weight) shall pass a 0.075mm sieve and 100% shall pass a 0.425mm sieve. It shall have a bulk density in toluene measured in accordance with BS 812 between 0.5 and 0.9 g/ml.

1603D GRADING REQUIREMENTS FOR COLD ASPHALT

The mixture of aggregates shall be within and approximately parallel to the grading envelope specified in the Special Specification or as instructed by the Engineer.

1604D REQUIREMENTS FOR COLD ASPHALT

The density and stability of the cold asphalt shall be as specified in the Special Specification or as instructed by the Engineer.

The proportion, by weight of total mix, of bitumen shall be stated in the Special Specification. This shall be termed the nominal binder content. The binder content of the working mix will be instructed by the Engineer following laboratory and site trials.

1605D MIXING AND LAYING COLD ASPHALT

When bitumen emulsion is used as the binder, heating and drying of aggregates are not required. Heating of the binder shall be in accordance with the manufacturer's recommendations. The moisture content of the mixture shall be adjusted in the mixing plant to permit optimum compaction. The aggregate shall have a moisture content in the range 3% - 5% at the time the emulsion is added.

When cut-back bitumen is used as the binder the requirements of Clause 1607A shall apply but with the following temperature limitations:-

Cut back	Mixing	Heating (Max)
MC and SC 250	55-80°C	100°C
MC and SC 800	70-100°C	125°C
MC 3000	90-120°C	140°C

The aggregates shall be dried and heated so that they are mixed at the following temperatures.

60 - 90°C when MC or SC 250 is used
75 - 115°C when MC or SC 800 is used
90 - 130°C when MC 3000 is used.

Cold asphalt may be placed at ambient temperature and may be laid by grader, provided the Contractor can demonstrate in the site trials that he can achieve the geometric tolerances for the base with this method.

1606D COMPACTION

The average density of the 100mm cores cut from the cold asphalt should not be less than 98% of the average density obtained from Marshall specimens (50 blows) made during laboratory trials on the mixture used for site trials. No individual density shall be below 95% of the average of the laboratory specimens.

1607D MEASUREMENT AND PAYMENT

(a) Item : Cold Asphalt

Unit : m^3 of each type, binder and nominal size for each layer

Cold asphalt shall be measured by the cubic metre compacted on the road 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 rate for cold asphalt shall include for the cost of providing, transporting, laying and compacting the mix with the nominal binder content and complying with the requirements of Parts A and D of Section 16 of this Specification.

(b) Item : Variation in binder content

Unit : l(litre)

Measurement of the variation of binder content shall be by the litre calculated as the product of the difference, corrected to 15.6°C, between the nominal binder content and the binder content instructed by the Engineer, and the weight of compacted mix to which the variation applies, calculated from the volume determined in accordance with Clause 1607D (a) of this Specification.

Adjustment of compensation to the Contractor shall be as follows:-

(i) As a payment to the Contractor where the binder content is increased above the nominal rate specified, but only where such increase has been instructed in writing by the Engineer.

(ii) As a refund to the Employer where the binder content is reduced below the nominal rate specified. The binder content may only be reduced if the Engineer so instructs.

(c) Item : Mineral filler

Unit : tonne of each type

The rate per cubic metre for cold asphalt includes for providing any mineral filler necessary to achieve the specified grading.

The Engineer may require the addition or substitution of mineral filler to modify a grading curve which already meets the specified requirements and in this case measurement and payment shall be made for the mineral filler so added or substituted.

Measurement shall be by the tonne of mineral filler added or substituted at the Engineer's instructions.

The rate for additional or substituted mineral filler shall include for the cost of the following:-

(i) Provision, haulage and storage of mineral filler.

(ii) Batching and mixing of mineral filler.

(iii) Removal from the graded aggregates of part or all of the minus 75 micron fraction if required by the Engineer.

(d) Item : Sand

Unit : tonne from each source

The rate per cubic metre for cold asphalt shall include for providing aggregates to the specified gradings.

The Engineer may instruct the alteration of all or part of the minus 6.3mm fraction by the addition or substitution of natural sand in which case the measurement and payment shall be made for sand so added or substituted.

Measurement shall be by the tonne of sand added or substituted at the Engineer's instruction.

The rate for sand shall include for the cost of the the following:-

(i) Provision, haulage and storage of sand.

(ii) Batching and mixing of sand.

(iii) Removal from the graded aggregates of part or all of the minus 6.3mm fraction if required by the Engineer.

SECTION 17
CONCRETE WORKS

1701 SCOPE OF SECTION

This section covers the materials, design of mixes, mixing, transport, placing, compaction and curing of concrete and mortar required in the Works. It also covers formwork and reinforcement for concrete.

1702 DEFINITIONS

Structural concrete is any class of concrete which is used in reinforced, prestressed or unreinforced concrete construction, which is subject to stress.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling voids, blinding foundations and similar purposes where it is not subjected to significant stress.

A formed surface is a face which has been cast against formwork.

An unformed surface is a horizontal or nearly horizontal surface produced by screeding or trowelling to the level and finish required.

A pour refers to the operation of placing concrete into any mould, bay or formwork, etc, and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

1703 MATERIALS FOR CONCRETE

(a) General

The Contractor shall submit to the Engineer full details of all materials which he proposes to use for making concrete. No concrete shall be placed in the works until the Engineer has approved the materials of which it is composed. Approved materials shall not thereafter be altered or substituted by other materials without the consent of the Engineer.

(b) Cement

Cement shall comply with the following Kenya Standards:-

KS02-21	for ordinary Portland cement
KS02-21	for rapid hardening Portland cement plus all special conditions to its use stipulated by the manufacturer

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 an 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. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on Site to ensure that his anticipated programme or work is not interrupted due to lack of cement.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

All cement for any one structure shall be from the same source.

All cement used in the Works shall be tested by the manufacturer or the Contractor in a laboratory acceptable to the Engineer. The tests to be performed shall be those set out in Section 2 of this Specification and the Contractor shall supply two copies of each certificate to the Engineer.

Each set of tests carried out by the manufacturer or Contractor shall relate to not more than one day's output of each cement plant, and shall be made on samples taken from cement which is subsequently delivered to the Site. Alternatively, subject to the agreement of the Engineer, the frequency of testing shall be one set of tests for every 200 tonnes of cement delivered to Site from each cement plant.

Cement which is stored on Site for longer than one month shall be retested in the laboratory of the Materials Branch of the Ministry of Transport and Communications or at the Kenya Bureau of Standards at the rate of one set of tests as shown in Section 2 of this Specification for every 200 tonnes, and at monthly intervals thereafter.

Cement which does not comply with the Specification shall not be used in Works and it shall be disposed of by the Contractor.

The Contractor shall keep full records 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.

(c) Fine aggregate

Fine aggregate shall be clean hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with BS 882. All the material shall pass through a 5 mm BS sieve and the grading shall be in accordance with Zones 1, 2 or 3 of BS 882. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source. Fine aggregate for mortar only shall comply with BS 1200.

The fine aggregate shall not contain iron pyrites or iron oxides. It shall not contain mica, shale, coal or other laminar, soft or porous materials or organic matter unless the Contractor can show by comparative tests, on finished concrete as set out in BS 1881, that the presence of such materials does not adversely affect the properties of the concrete.

Other properties shall be as set out below:

Content passing a 75 micron BS sieve shall not exceed 3 per cent for natural or crushed gravel sand or 15 per cent for crushed rock sand.

Chlorides soluble in a 10 per cent solution by weight of nitric acid shall not exceed 0.05 per cent by weight expressed as chloride ion when tested as set out in BS 812, subject also to the further restriction given in the note on total chloride content in Sub-Clause 1703 (d).

Sulphates soluble in a 10 per cent solution by weight of hydrochloric acid shall not exceed 0.4 per cent by weight expressed as SO_3, when tested as set out in BS 1377, subject also to the further restriction given in the note on total sulphate content in Sub-Clause 1703 (d).

Soundness: After five cycles of the test in AASHTO T104 the aggregate shall not show a weight loss of more than 10 per cent.

Organic impurities: If the test described in Section 2 of this Standard Specification shows that more than a trace of organic impurities is present, the fine aggregate shall not be used in the Works unless the Contractor can show by tests on finished concrete as set out in BS 1881 that the presence of organic impurities does not adversely affect the properties of the concrete.

(d) Coarse aggregate

Coarse aggregate shall be clean hard and durable crushed rock, crushed gravel or natural gravel complying with the requirements of BS 882. The material shall not contain any iron pyrites, iron oxides, flaky or laminated material, hollow shells, coal or other soft or porous material, or organic matter unless the Contractor can show by comparative tests on finished concrete as set out in BS 1881 that the presence of such materials does not adversely affect the properties of the concrete. The pieces shall be angular rounded or irregular as defined in BS 812 Part I.

Coarse aggregate shall be supplied in the nominal sizes called for in the Contract and shall be graded in accordance with BS 882 for each nominal size.

Other properties shall be as set out below:-

The proportion of clay, silt and other impurities passing a 75 micron BS sieve shall be not more than one per cent by weight.

The content of hollow and flat shells shall not be such as will adversely affect the concrete quality when tested as set out in BS 1881. The total shell content of aggregate shall not be more than the following:

40 mm nominal size and above	2% of dry weight
20 mm nominal size	5% of dry weight
10 mm nominal size	15% of dry weight

Chlorides soluble in a 10 per cent solution by weight of nitric acid shall not exceed 0.03 per cent by weight, expressed as chloride ion when tested as set out in BS 812 but subject also to the further restriction under the note on total chloride content hereunder. Sulphates soluble in a 10 per cent solution by weight of hydrochloric acid shall not exceed 0.4 per cent by weight expressed as SO_3 when tested as set out in BS 1377 subject also to the further restriction given in the note on total sulphate content hereunder.

Soundness: After 5 cycles of the test in AASHTO T104, the aggregate shall not show a weight loss of more than 12 per cent.

When tested in accordance with test C289 of the American Society for Testing and Materials, the aggregate shall be non-reactive.

Flakiness Index when tested in accordance with BS 812 shall be as set out hereunder:-

For 40 mm stone and above, not more than 40
For 20 mm stone and below, not more than 35

If the Flakiness Index of the coarse aggregate varies by more than five units from the average value of the aggregate used in the approved trial mix, then a new set of trial mixes shall be carried out if the workability of the mixes has been adversely affected by such variation.

Impact value: Not more than 45 per cent when tested in accordance with BS 812.

Ten per cent fines value: Not less than 50kN when tested in accordance with BS 812.

Shrinkage: When mixed with other ingredients in the approved proportions for concrete and tested as set out in BS 1881, the shrinkage factor shall not exceed 0.05 per cent.

Organic impurities: If the test described in Section 2 of this Specification shows that more than a trace of organic impurities is present, the aggregate shall not be used in the Works unless the Contractor can show by tests on finished concrete as set out in BS 1881 that the presence of organic impurities does not adversely affect the properties of the concrete.

Water absorption: The aggregate shall not have a water absorption of more than 2.5 per cent when tested as set out in BS 812.

Aggregate Crushing Value (ACV): Not more than 35%.

Los Angeles Abrasion (LAA): Not more than 50%.

NOTE: Total chloride and sulphate content:-

The total chloride content, expressed as chloride ion, arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits, expressed as a percentage of the weight of cement in the mix:-

For prestressed concrete, steam cured concrete or concrete containing sulphate resisting or supersulphated cement: 0.05 per cent.

For any other reinforced concrete: 0.3 per cent in 95 per cent of all test results provided no result is more than 0.5 per cent.

The total sulphate content expressed as SO_3 of all the ingredients in a mix including cement, water and admixtures shall not exceed 0.4 per cent by weight of the aggregate or 4.0 per cent of the weight of cement in the mix, whichever is the lesser.

(e) Testing aggregates

(i) Acceptance testing

the Contractor shall deliver to the Engineer samples containing not less than 50 kg of any aggregate which he proposes to use in the Works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labelled to show its origin and shall be accompanied by all the information called for in BS 882.

Tests to determine compliance of the aggregates with the requirements of Sub-Clause 1703 (c) and (d) shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Engineer and acceptance of the material shall be based on such tests.

A material shall be accepted if not less than three consecutive sets of test results show compliance with the Specification.

(ii) Compliance testing

The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period that concrete is being produced for the Works. The tests set out below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to Site provided that no set of tests shall represent more than 250 tonnes of fine aggregate nor more than 500 tonnes of coarse aggregate, and provided also that the aggregates are of uniform quality. If the aggregate from any source is variable, the frequency of testing shall be increased as instructed by the Engineer.

Grading	BS 812
Silt and clay contents	BS 812
Moisture content	BS 812
Check on organic impurities	Section 2 of this Specification

In addition to the above routine tests, the Contractor shall carry out the following tests at the frequencies stated:

Moisture content; As frequently as may be required in order to control the water content of the concrete as required by the Specification.

Chloride content: as frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

The Contractor shall take account of the fact that when the chloride content is variable it may be necessary to test every load in order to prevent excessive amounts of chloride contaminating the concrete. For this purpose the Contractor shall use the rapid field test described in Section 2 of this Specification (the Quantab test). In the event of disagreement regarding the results of the field test, the chloride content of the aggregate shall be determined in the laboratory as described in BS 812 (the Volhard test).

(f) Delivery and storage of aggregates

Aggregates shall be delivered to Site in clean and suitable vehicles. Different types or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that contamination of the aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregates shall be arranged so that as far as possible rapid drying out in hot weather is prevented in order to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged so that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

(g) Water for concrete and mortar

Seawater or brackish water containing more than 1000 ppm chloride ion or 2000 ppm sulphate ion shall not be used for mixing or curing concrete.

Water shall be clean and free from harmful matter and shall comply with the requirements of BS 3148.

The Contractor shall carry out tests in accordance with BS 3148 to establish compliance with the Specification.

(h) Admixtures

(i) General

The use of the admixtures in concrete may be required under the Contract to promote special properties in the finished

concrete or may be proposed by the Contractor to assist him in compliance with the Specification.

In all cases the Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he proposes to add it to the mix. The information provided shall include:-

(a) The typical dosage, the method of dosing and the detrimental effects of an excess or deficiency in the dosage.

(b) The chemical names of the main active ingredients in the admixture.

(c) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture.

(d) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so, the extent to which it does so.

(e) Details of previous uses of the admixture in Kenya.

The chloride ion content of any admixture shall not exceed 2 per cent by weight of the admixture nor 0.03 per cent by weight of the cement in the mix.

Admixtures shall not be mixed together without the consent of the Engineer.

Calcium chloride or admixtures containing calcium chloride shall not be used in prestressed concrete.

(ii) Workability agents

Workability agents shall comply with BS 5075 and shall not have any adverse affect on the properties of the concrete.

1704 THE DESIGN OF CONCRETE MIXES

(a) Classes of concrete

The classes of structural concrete to be used in the Works shall be those shown on the Drawings and designated in Table 17-1, in which the class designation includes two figures. The first figure is the nominal strength at 28 days expressed in N/mm^2 and the second figure is the maximum nominal size of aggregate in the mix expressed in millimetres.

TABLE 17-1 Concrete Classes and Strengths

Class of Concrete	Nominal Strength N/mm^2	Maximum Nominal size of aggregate mm	Maximum water/cement ratio		Trial mixes Target Mean Strength (Clause 1704(c)) N/mm^2	Early works test cubes (Clause 1704 (d))	
			A	B		Any one cube N/mm^2	Average of any group of 4 cubes N/mm^2
10/75	10	75	0.60	0.55	13.5	8.5	13.3
15/75	15	75	0.60	0.50	21.5	12.8	20.0
15/40	15	40	0.60	0.50	21.5	12.8	20.0
15/20	15	20	0.57	0.50	21.5	12.8	20.0
20/40	20	40	0.55	0.48	31.5	17.0	27.5
20/20	20	20	0.53	0.48	31.5	17.0	27.5
20/10	20	10	0.50	0.48	31.5	17.0	27.5
25/40	25	40	0.52	0.46	36.5	21.3	32.5
25/20	25	20	0.50	0.46	36.5	21.3	32.5
25/10	25	10	0.48	0.46	36.5	21.3	32.5
30/40	30	40	0.50	0.45	41.5	25.5	37.5
30/20	30	20	0.48	0.45	41.5	25.5	37.5
30/10	30	10	0.47	0.45	41.5	25.5	37.5
40/20	40	20	0.46	0.43	51.5	34.0	47.5
40/10	40	10	0.45	0.43	51.5	34.0	47.5

NOTE: Under water/cement ratio, column A applies to moderate and intermediate exposure, and column B applies to severe exposure. See NOTE after Table 17-2.

(b) Design of proposed mixes

The contractor shall design all the concrete mixes called for on the Drawings, making use of the ingredients which have been approved by the Engineer for use in the Works and in compliance with the following requirements:-

(i) The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 micron size.

(ii) The cement content shall be such as to achieve the strengths called for in Table 17-1 but in any case not less than the minimum necessary for impermeability and durability shown in Table 17-2.

(iii) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.

(iv) The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than that shown in Table 17-1 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.

(v) The drying shrinkage determined in accordance with BS 1881 shall not be greater than 0.05 per cent.

Table 17-2 Minimum Cement Content

Class of Concrete	Minimum Cement Content - Kg/m^3 of Compacted concrete		
	Moderate Exposure	Intermediate Exposure	Severe Exposure
10/75; 15/75	200	220	270
15/40, 20/40, 25/40, 30/40	240	270	290
15/20, 20/20, 25/20, 30/20	260	300	330
40/20	300	320	330
20/10, 25/10, 30/10	300	340	390
40/10	310	340	390

NOTE: the minimum cement contents shown in the above table are required in order to achieve impermeability and durability. In order to meet the strength requirements in the Specification higher contents may be required.

The categories applicable to the Works are based broadly on the factors listed hereunder:

Moderate exposure	Surface sheltered from severe rain; buried concrete, concrete continuously under water
Intermediate exposure	Surface exposed to driving rain; alternate wetting and drying; traffic; corrosive fumes; heavy condensation
Severe exposure	Surface exposed to sea water, moorland water having a pH of 4.5 or less, groundwater containing sulphates.

(c) Trial mixes

At least six weeks before commencing placement of concrete in the Permanent Works trial mixes shall be prepared for each class of concrete specified.

For each mix of concrete for which the Contractor has proposed a design, he shall prepare three separate batches of concrete using the materials which have been approved for use in the Works and the mixing plant which he proposes to use for the Works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the following action taken, all in accordance with BS 1881:-

(i) The slump of the concrete shall be determined.

(ii) Six test cubes shall be cast from each batch. In the case of concrete having a maximum aggregate size of 40 mm or less, 150 mm cubes shall be used. In the case of concrete containing 75 mm or larger aggregate, 200 mm cubes shall be used and in addition any pieces of aggregate retained on a 53 mm BS sieve shall be removed from the mixed concrete before casting the cubes.

(iii) Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.

(iv) The density of all the cubes shall be determined before the strength tests are carried out.

Subject to the agreement of the Engineer, the compacting factor apparatus may be used in place of a slump cone. In this case the correlation between slump and compacting factor shall be established during preparation of the trail mixes.

The average strength of the nine cubes tested at 28 days shall be not less than the target mean strength shown in Table 17-1.

The Contractor shall also carry out tests to determine the drying shrinkage of the concrete unless otherwise directed by the Engineer.

Based on the results of the tests on the trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, the proposed proportions of each mix and the results of the tests on the trial mixes.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the Works without the written consent of the Engineer.

(d) Quality control of concrete production

(i) Sampling

For each class of concrete in production at each plant for use in the Works, samples of concrete shall be taken at the point of mixing or of deposition as instructed by the Engineer, all in accordance with the sampling procedures described in BS 1881 and with the further requirements set out below.

Six 150 mm or 200 mm cubes as appropriate shall be made from each sample and shall be cured and tested all in accordance with BS 1881, two at seven days and the other four at 28 days.

Each sample shall be taken from one batch selected at random and at intervals such that each sample represents not more than $20m^3$ of concrete unless the Engineer agrees to sampling at less frequent intervals.

Until compliance with the Specification has been established the frequency of sampling shall be three times that stated above or such lower frequency as may be instructed by the Engineer.

(ii) Testing

(a) The slump or compacting factor of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the frequency instructed by the Engineer.

The slump of the concrete in any batch shall not differ from the value established by the trial mixes by more than 25 mm or one third of the value, whichever is the greater.

The variation in value of the compacting factor, if used in place of a slump value, shall be within the following limits:

For value of 0.9 or more	± 0.03
For value of between 0.8 and 0.9	± 0.04
For values of 0.8 or less	± 0.05

(b) The water/cement ratio as estimated from the results of (a) above, determined by samples from any batch shall not vary by more than five per cent from the value established during the trial mixes.

(c) The air content of air entrained concrete in any batch shall be within 1.5 units of the required value and the average value of four consecutive measurements shall be within 1.0 unit of the required value, expressed as a percentage of the volume of freshly mixed concrete.

(d) Until such time as sufficient test results are available to apply the method of control described in (e) below, the compressive strength of the concrete at 28 days shall be such that no single result is less than the value shown in Table 17-1 under the heading early works test cubes' and also that the average value of any four consecutive results is not less than the value shown in Table 17-1 under the same heading.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Engineer.

(e) When test cube results are available for at least 20 consecutive batches of any class of concrete mixed in any one plant, the average of any four consecutive results at 28 days shall exceed the nominal strength by not less than half the current margin (see below) and each individual result shall not be less than 85 per cent of the nominal strength.

The current margin shall be defined as 1.64 times the standard deviation of cube tests on at least 20 separate consecutive batches produced from one plant over a period exceeding five days but not exceeding six months or on at least 50 separate consecutive batches produced from one plant over a period not exceeding 12 months. If both figures are available, the smaller shall be taken.

The current margin shall in any case not be less than the figure given below:-

	Minimum Current Margin for		
	10N/mm^2	15N/mm^2	20N/mm2 and above
After 20 batches	3.3	5	7.5
After 50 batches	1.7	2.5	3.8

(e) Failure to comply with requirements

If any one test cube result in a group of four consecutive results is less than 85 per cent of the nominal strength but the average of the group of which it is part satisfies the strength requirement, then only the batch from which the failed cube was taken shall be deemed not to comply with the Specification.

If more than one cube result in a group of four consecutive results is less than 85 per cent of the nominal strength or if the average strength of the group fails to satisfy the strength requirement then all the batches between those represented by the first and last cubes in the group shall be deemed not to comply with the Specification, and the Contractor shall immediately adjust the mix design subject to the agreement of the Engineer to restore compliance with the Specification. After adjustment of the mix design the Contractor will again be required to comply with sub-Clauses 1704 (b) and 1704 (c) of this Section of this Specification.

The Contractor shall take necessary action to remedy concrete which does not comply with this Specification. Such action may include but is not necessarily confined to the following:-

(i) Increasing the frequency of sampling until control is again established.

(ii) Cutting test cores from the concrete and testing in accordance with BS 1881.

(iii) Carrying out strengthening or other remedial work to the concrete where possible or appropriate.

(iv) Carrying out non-destructive testing such as load tests on beams.

(v) Removing the concrete.

1705 MIXING CONCRETE

Before any plant for batching, mixing, transporting, placing, compacting and finishing concrete is ordered or delivered to Site, the Contractor shall submit to the Engineer full details including drawings of all the plant which he proposes to use and the arrangements he proposes to make.

Concrete for the Works shall be batched and mixed in one or more central plants unless the Engineer agrees to some other arrangement. If the Contractor proposes to use ready mixed concrete he shall submit to the Engineer for his approval full details and test results of the concrete mixes. The Engineer may approve the use of ready mixed concrete provided that:

(a) the proposed mixes, the material to be used and the method of storage and mixing comply with the requirements of the Specification; and

(b) adequate control is exercised during mixing.

Approval to the use of ready mixed concrete may be withdrawn if the Engineer is not satisfied with the control of the materials being used and control during mixing.

Batching and mixing plants shall be modern efficient equipment complying with the requirements of BS 1305 and capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixes shall comply with the requirements of BS 4251 and shall only be used with the prior agreement of the Engineer. If the plant proposed by the Contractor does not fall within the scope of BS 1305, it shall have been tested in accordance with BS 3963 and shall have a mixing performance within the limits of Table 6 of BS 1305.

All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt removed.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in BS 1305 and checked against accurate weights and volumes when required by the Engineer.

The weights of cement and of each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of plus or minus two per cent of the respective weights per batch agreed by the Engineer.

The Contractor shall provide standard test weights at least equivalent to the maximum working load used on the most heavily loaded scale and other auxiliary equipment required for checking the satisfactory operation of each scale or other measuring device. Tests shall be made by the Contractor at least once a week or at intervals to be determined by the Engineer and shall be carried out in his presence. For the purpose of carrying out these tests, there shall be easy access for personnel to the weigh hoppers. The Contractor shall furnish the Engineer with copies of the complete results of all check tests and shall make any adjustments, repairs or replacements necessary to ensure satisfactory performance.

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at least one minute after all the water has been added to the drum or pan.

The blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

Mixers shall be fitted with an automatic recorder registering the number of batches discharged.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer immediately before mixing begins each day and thereafter at least once per hour during concreting and for each delivery of aggregates during concreting. When the correct quantity of water, determined as set out in the Specification, has been added to the mix, no further water shall be added, either during mixing or subsequently.

After mixing for the required time, each batch shall be discharged completely from the mixer before any materials for the succeeding batch are introduced.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed and thereafter the first batch of concrete through the mixers shall contain only

half the normal quantity of coarse aggregate. This batch shall be mixed for one minute longer than the time applicable to a normal batch.

Mixers shall be cleaned out before changing to another type of cement.

1706 HAND MIXED CONCRETE

Concrete for structural purposes shall not be mixed by hand. Where non-structural concrete is required, hand mixing may be carried out subject to the agreement of the Engineer.

The mixing shall be done on a hard impermeable surface. The materials shall be turned over not less than three times dry, water shall then be sprayed on and the materials again turned over not less than three times in a wet condition and worked together until a mixture of uniform consistency is obtained.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.5 cubic metre shall be mixed at one time. During windy weather efficient precautions shall be taken to prevent cement from being blown away during the process of gauging and mixing.

1707 TRANSPORT OF CONCRETE

The concrete shall be discharged from the mixer and transported to the Works by means which shall prevent adulteration, segregation or loss of ingredients, and which shall ensure that the concrete is of the required workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall not exceed 25 mm.

The time elapsing between mixing and placing a batch of concrete shall be as short as practicable and in any case not longer than will permit completion of placing and compaction before the onset of initial set. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the Works.

1708 PLACING OF CONCRETE

(a) Consent for placing

Concrete shall not be placed in any part of the Works until the Engineer's consent has been given in writing, and the Contractor shall give the Engineer at least 1 full working days notice of his intention to place concrete.

If concrete placing is not commenced within 24 hours of the Engineer's consent the Contractor shall again request consent as specified above.

(b) Preparation of surface to receive concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 7 of this Specification.

Existing concrete surfaces shall be prepared as set out in Clause 1717. Before deposition of further concrete they shall be clean, hard and sound and shall be wet but without any freestanding water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump, or be removed by other suitable methods which will prevent washing away the freshly deposited concrete or any of its constituents. Any underdrains constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Engineer.

Unless otherwise instructed by the Engineer surfaces against which concrete is to be placed shall receive a prior coating of mortar mixed in the proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete. The mortar shall be well worked into all parts of the excavated surface and shall be not less than 5 mm thick.

If any fissures have been cleaned out as described in Section 7 of this Specification they shall be filled with mortar or with concrete as instructed by the Engineer.

The amount of mortar placed at any one time shall be limited so that it does not dry out or set before being covered with concrete.

(c) Placing procedures

The concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items, or formwork. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 500 mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the layers shall not be thinner than four times the maximum nominal size of aggregate.

Layers shall not be placed so that they form feather edges nor shall they be placed on a previous layer which has taken its initial set. In order to comply with this requirement, a layer may be started before completion of the preceding layer.

All the concrete in a single bay or pour shall be placed as a continuous operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely full of compacted concrete with no segregation or honeycombing. It shall also be carefully worked round and between waterstops, reinforcement, embedded steelwork and similar items which protrude above the surface of the completed pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has partially hardened during transit shall be used in the Works and the transport of concrete from the mixer to the point of placing shall be such that this requirement can be complied with.

Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In drying weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

When concrete is discharged above its place of final deposition, segregation shall be prevented by the use of chutes, downpipes, trunking, baffles or other appropriate devices.

Forms for walls, columns and other thin sections of significant height shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will prevent segregation and accumulations of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

When it is necessary to place concrete under water the Contractor shall submit to the Engineer his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies which are kept continously full with concrete up to a level above the water and which shall have the discharging bottom fitted with a trapdoor and immersed in the concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

If the level of concrete in a tremie pipe is allowed to fall to such an extent that water enters the pipe, the latter shall be removed from the pour and filled with concrete before being again lowered into the placing position. During and after

concreting under water, pumping or de-watering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

(d) Interruptions to placing

If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete already placed in accordance with Clause 1709. All work on the concrete shall be completed while it is still plastic and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all times during concrete placing.

Before concreting is resumed after such an interruption the Contractor shall cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.

(e) Dimensions of pours

Unless otherwise agreed by the Engineer, pours shall not be more than two metres high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except in the circumstances described in Sub-clause 1708 (d).

The Contractor shall plan the dimensions and sequence of pours in such a way that cracking of the concrete does not take place due to thermal or shrinkage stresses.

(f) Placing sequence

The Contractor shall arrange that as far as possible the intervals between placing successive lifts of concrete in one section of the Works are of equal duration. This duration shall normally be not less than three or more than seven days under temperate weather conditions unless otherwise agreed by the Engineer.

Where required by the Engineer to limit the opening of construction joints due to shrinkage, concrete shall not be placed against adjacent concrete which is less than 21 days old.

When the Drawings call for contraction gaps in concrete, these shall be of the widths and in the locations shown on the Drawings and they shall not be filled until the full time interval shown on the Drawings has elapsed.

1709 COMPACTION OF CONCRETE

The concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded items, without displacing them. Particular care shall be taken at arrises and other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Engineer agrees another method.

Immersion vibrators shall operate at a frequency of between 7000 and 10 000 cycles per minute. The Contractor shall ensure that vibrators are operated at pressures and voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, stand-by vibrators shall be available for instant use at each place where concrete is being placed.

Where the concrete contains aggregate with a nominal size of 75 mm or more, vibrators with a diameter of 100 mm or more shall be used.

Vibration shall be continued at each point until the concrete ceases to contract, a thin layer of mortar has appeared on the surface and air bubbles have ceased to appear. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

Vibration shall not be applied by way of reinforcement nor shall vibrators be allowed to touch reinforcement or other embedded items. The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective.

1710 CURING OF CONCRETE

(a) General

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperature differentials within the concrete sufficient to cause cracking. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but in any case for at least seven days or until the concrete is covered by later construction whichever is the shorter period.

The above objectives are dealt with in sub-clauses 1710 (b) and (c) but nothing shall prevent both objectives being achieved by a single method where circumstances permit.

The curing process shall commence as soon as the concrete is hard enough to resist damage from the process, and in the case of large areas or continuous pours, shall commence on the completed section of the pour before the rest of the pour is finished.

Details of the Contractor's proposals for curing concrete shall be submitted to the Engineer before the placing of concrete commences in the Works.

(b) Loss of moisture

Exposed concrete surfaces shall be closely covered with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Joints in the sheeting shall be lapped by at least 300 mm.

If for some reason it is not possible to use impermeable sheeting, the Contractor shall keep the exposed surfaces continuously wet by means of a water spray or by covering with a water absorbent material which is kept wet, unless this method conflicts with sub-clause 1710 (c).

Water used for curing shall be of the same quality as that used for mixing as stated in sub-clause 1703 (g).

Formed surfaces may be cured by retaining the formwork in place for the required curing period.

If the use of the foregoing methods is inappropriate, surfaces which will not have further concrete bonded to them and which are not to receive an application of a finish may be cured by the application of a curing compound having an efficiency index of at least 90 per cent. Curing compounds shall contain a fugitive dye to enable the extent of the spread to be seen easily.

Curing compound used on surfaces exposed to the sky shall contain sufficient finely divided flake aluminium in suspension to produce a complete coverage of the surface with a metallic finish when applied at the rate recommended by the manufacturer.

Curing compounds shall become stable and impervious to the evaporation of water from the concrete surface within 60 minutes of application. The material shall not react chemically with the concrete and shall not crack, peel or disintegrate within three weeks after application.

If instructed by the Engineer, the Contractor shall, in addition to the curing provisions set out above provide a suitable form of shading to prevent the direct rays of the sun reaching the concrete surfaces for at least the first four days of the curing period.

(c) Limitation of temperature differentials

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances including the following:

(i) limiting concrete temperatures at placing as set out in sub-clause 1712 (b);

(ii) use of low heat cement, subject to the agreement of the Engineer;

(iii) insulation of exposed concrete surfaces by insulating blankets. Such blankets shall have an insulation value at least equivalent to 50 mm of dry mineral wool;

(iv) leaving formwork in place during the curing period. Steel forms shall be suitably insulated on the outside;

(v) preventing rapid dissipation of heat from surfaces by shielding from wind;

(vi) avoiding the use of water sprays when such use would cause rapid cooling of the surface.

1711 PROTECTION OF FRESH CONCRETE

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes.

No traffic shall be allowed on any concrete surface until such time as it is hard enough to resist damage by such traffic.

Concrete placed in the Works shall not be subjected to any loading until it has attained at least its nominal strength as defined in Clause 1704.

If the Contractor desires to impose loads on newly-placed concrete, he shall make at least three test cubes and cure them in the same conditions as the concrete they represent. These cubes shall be tested singly at suitable intervals in order to estimate the time at which the nominal strength is reached.

1712 CONCRETING IN HOT WEATHER

(a) General

The Contractor shall prevent damage to concrete arising from exposure to extreme temperatures, and shall maintain in good working order all plant and equipment required for this purpose.

In the event that conditions become such that even with the use of the equipment the requirements cannot be met, concrete placing shall immediately cease until such time as the requirements can again be met.

(b) Concrete placing in hot weather

During hot weather the Contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the Works does not exceed 30°C and that the concrete does not lose any moisture during transporting and placing.

Such measures may include but are not necessarily limited to the following:-

(i) Shielding aggregates from direct sunshine.

(ii) Use of a mist water spray on aggregates.

(iii) Sun shields on mixing plants and transporting equipment.

(iv) Cooling the mixing water. If ice is used for this purpose it should preferably be in flake form. Lump ice shall not be allowed to enter the tank supplying the mixer drum.

(v) Covering skips closely with polythene sheet so that the latter is in contact with the concrete.

Areas in which concrete is to be placed shall be shielded from direct sunshine and rock or concrete surfaces shall be thoroughly wetted to reduce absorption of water from the concrete placed on or against them.

After concrete in any part of an area has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

1713 FINISHES ON UNFORMED SURFACES

Horizontal or nearly horizontal surfaces which are not cast against formwork shall be finished to the class shown on the Drawings and defined hereunder.

UF 1 finish

All surfaces on which no higher class of finish is called for on the Drawings or instructed by the Engineer shall be given a UF 1 finish.

The concrete shall be levelled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

UF 2 finish

This is a floated finish for roof or floor slabs and other surfaces where a hard trowelled surface is not required.

The surface shall first be treated as a Class UF 1 finish and after the concrete has hardened sufficiently, it shall be floated by hand or machine sufficient only to produce a uniform surface free from screed marks.

UF 3 finish

This is a hard trowelled surface for use where weather resistance or appearance is important, or which is subject to high velocity water flow.

The surface shall be floated as for a UF 2 finish but to the tolerance stated below. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel-trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

Table 17-3 Surface Tolerances

Class of Finish	Tolerance in mm. See notes		
	A	B	C
UF 1	Not applicable	10	+ 20 or - 10
UF 2	Nil	10	+ 20 or - 10
UF 3	Nil	5	+ 12.5 or - 7.5

Notes:

1. Col A is the maximum allowable value of any sudden change of level in the surface.

2. Col B is the maximum allowable value of any gradual irregularity of the surface, as indicated by the gap between the surface and a three metre long straight edge or correctly shaped template placed on the surface.

3. Col C is the maximum allowable value of the difference in level or position between a three metre long straight edge or correctly shaped template placed on the surface and the specified level or position of that surface.

Where dimensional tolerances are given on the Drawings or in this Special Specification they shall take precedence over those given in Table 17-3.

1714 MORTAR

This clause covers mortar for use ahead of concrete placing, and other uses not covered elsewhere in the Specification.

Mortar shall be composed of fine aggregate complying with sub-Clause 1703 (c) and ordinary Portland cement complying with KS02-21. The mix proportions shall be as stated on the Drawings or elsewhere in this Specification or if not stated shall be one part of cement to two parts of fine aggregate by weight.

Small quantities of mortar may be hand mixed but for amounts over 0.5 m^3 a mechanical mixer shall be used.

The water content of the mortar shall be as low as possible consistent with the use for which it is required but in any case the water/cement ratio shall not be more than 0.5.

Mortar which is specified as 'dry pack' shall be mixed with sufficient water for the mix to become cohesive but not plastic when squeezed in the hand. Dry pack mortar shall be rammed into the cavity it is required to fill, using a hand rammer with sufficient force to ensure full compaction.

1715 CONCRETE FOR SECONDARY PURPOSES

(a) Non-structural concrete (NS concrete) shall be used only for non-structural purposes where shown on the Drawings.

NS concrete shall be composed of ordinary Portland cement complying with KS02-21 and aggregates complying with BS 882 including all-in aggregate within the grading limits of Table 3 of BS 882.

The weight of cement mixed with 0.3 m^3 metres of combined or all-in aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40 mm nominal.

The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand or by mechanical vibration.

(b) No Fines concrete (NF concrete) is intended for use where a porous concrete is required and shall only be used where shown on the Drawings or instructed by the Engineer.

The mix shall consist of ordinary Portland cement complying with KS02-21 and aggregate complying with BS 882. The aggregate size shall be 40.0 mm to 10.0 mm only. The weight of cement mixed with 0.3 m^3 metre of aggregate shall not be less than 50 kg. The quantity of water shall not exceed that required to produce a smooth cement paste which will coat evenly the whole of the aggregate.

1716 RECORDS OF CONCRETE PLACING

Records, in a form agreed by the Engineer, shall be kept by the Contractor of the details of every pour of concrete placed in the Works. These records shall include class of concrete, location of pour, date of pour, ambient temperature and concrete temperature at time of placing, moisture contents of aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, location of test cube sample points and details of any cores taken.

The Contractor shall supply to the Engineer four copies of these records each week covering work carried out the preceding week. In addition he shall supply to the Engineer monthly histograms of all 28

day cube strengths together with accummulative and monthly standard deviations and any other information which the Engineer may require concerning the concrete placed in the Works.

1717 CONSTRUCTION JOINTS

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the sections shall be deemed a construction joint.

Where construction joints are shown on the Drawings, the Contractor shall form such joints in those positions. The location of joints which the Contractor requires to make for the purpose of construction shall be subject to the agreement of the Engineer. Construction joints shall be in vertical or horizontal planes except in sloping slabs where they shall be normal to the exposed surface or elsewhere where the Drawings require a different arrangement.

Construction joints shall be so arranged as to reduce to a minimum the effects of shrinkage in the concrete after placing, and shall be placed in the most advantageous positions with regard to stresses in the structures and the desirability of staggering joints.

Feather edges of concrete at joints shall be avoided and any feather edges which may have formed where reinforcing bars project through a joint shall be cut back until sound concrete has been reached.

The intersections of horizontal or near horizontal joints and exposed faces of concrete shall appear as straight lines produced by use of a guide strip fixed to the formwork at the top of the concrete lift, or by other means acceptable to the Engineer.

Construction joints formed as free surfaces shall not exceed a slope of 20 per cent from the horizontal.

The surface of the fresh concrete in horizontal or near horizontal joints shall be thoroughly cleaned and roughened by means of high pressure water and air jets when the concrete is hard enough to withstand the treatment without the leaching of cement. The surface of vertical or near vertical joints shall be similarly treated if circumstances permit the removal of formwork at a suitable time.

Where concrete has become too hard for the above treatment to be successful, the surface whether formed or free is to be thoroughly scabbled by mechanical means or wet sand blasted and then washed with clean water. The indentations produced by scabbling shall be not less than 10 mm deep and shall not extend closer than 40 mm to a finished face.

If instructed by the Engineer the surface of the concrete shall be thoroughly brushed with a thin layer of mortar composed of one part of cement to two parts of sand by weight and complying with Clause 1714. all as set out in Sub-Clause 1708 (b) immediately prior to the

deposition of fresh concrete. The mortar shall be kept just ahead of the fresh concrete being placed and the fresh layer of concrete shall be thoroughly and systematically vibrated to full depth to ensure complete bond with the adjacent layer.

No mortar or concrete may be placed in position on or against a construction joint until the joint as been inspected and passed by the Engineer.

1718 EXPANSION AND CONTRACTION JOINTS

Expansion and contraction joints are discontinuities in concrete designed to allow for thermal or other movements in the concrete.

Expansion joints are formed with a gap between the concrete faces to permit subsequent expansion of the concrete. Contraction joints are formed to permit initial contraction of the concrete and may include provision for subsequent filling.

Expansion and contraction joints shall be formed in the positions and in accordance with the details shown on the Drawings or elsewhere in the Specifications.

1719 WATERSTOPS

All references to waterstops include groutstops.

Waterstops shall be of the material and form shown on the Drawings. No waterstop material shall be brought onto site until the Contractor has submitted full details of the materials he proposes to use, including samples, and these have been approved by the Engineer. All samples shall be of adequate length for testing.

Waterstops shall be made of material which are resistant to chlorides, sulphates, or other deleterious substances which may be present in the environment of the Works.

Rubber waterstops may be of natural of synthetic rubber and shall have an elongation at breaking stress of at least 500 per cent at 25°C and shall allow a joint movement of at least 50 mm.

Polyvinyl chloride (PVC) waterstops shall be extruded from an unfilled plasticised PVC polymer or copolymer which does not contain any reclaimed or scrap PVC. PVC waterstops shall have an elongation at breaking stress of at least 225 per cent at 25°C and shall allow a joint movement of at least 10 mm.

Low modulus waterstops shall be of rubber or PVC as described above but shall have an elongation of at least 200 per cent at 25°C under a tensile stress of 6 N/mm^2 and shall allow a joint movement of at least 50 mm.

Waterstops shall be supplied in lengths as long as possible consistent with ease of handling and construction requirements.

In rubber or plastic materials joints other than butt joints shall be supplied ready made by the manufacturer. Butt joints shall be made on site in accordance with the manufacturer's instructions and with equipment supplied for the purpose by the manufacturer.

Waterstop material shall be stored carefully on Site to avoid damage and contamination with oil, grease, or other pollutants. Rubber and plastic waterstops shall be stored in cool well ventilated places away from direct sunlight.

Rubber and plastic waterstops which are embedded in one side of a joint more than one month before the scheduled date of placing concrete on the other side, shall be protected from the sun.

Waterstops shall be firmly fixed in the formwork so that they cannot be displaced during concrete placing and shall be completely free of all dirt, grease, oil, etc before placing concrete. Where eyelets are provided these shall be fully wired to the reinforcement and be the only means whereby the waterstop is fixed. In no circumstances shall a waterstop be punctured with nails etc as a means of fixing.

Concrete shall be placed carefully round waterstops so as to avoid distortion or displacement and shall be fully compacted. Where waterstops lie in a horizontal or nearly horizontal plane the Contractor shall ensure that no voids are left on the underside of the waterstop.

Formwork round waterstops shall be carefully removed to avoid damage. If waterstops suffer any damage which cannot be properly repaired in situ the Engineer may require a section of concrete to be removed and the waterstop replaced.

1720 GROUTING OF POCKETS AND HOLES AND UNDERPINNING OF BASEPLATES

Pockets and holding-down bolt holes shall be thoroughly cleaned out using compressed air and water jet. Holes drilled by a diamond bit shall be roughened. The pockets and holes shall be filled with grout consisting of cement and clean fresh water mixed in proportion of two parts by weight of cement to one part by weight of water. The pouring of liquid grout shall cease as soon as each hole is filled and any excess grout on the surface of the concrete foundation shall be completely removed and the surface dried off before the next operation proceeds.

The space between the top surface of foundation concrete and the underside of baseplates shall be filled with a special mortar made up in the following proportions:-

Portland cement ..... 50 kg
Fine aggregate ..... 50 kg
An additive acceptable to the Engineer to counteract shrinkage in proportions recommended by the manufacturer.

The special mortar shall be mixed with the lowest water-cement ratio which will result in a consistency of mix of sufficient workability to enable maximum compaction to be achieved.

The special mortar shall then be well rammed in horizontally below the baseplate and from one edge only until it is extruded from the other three sides. The mortar which has extruded shall then be rammed back to ensure complete support without voids.

1721 FORMWORK FOR CONCRETE

Definitions

Formwork means the surface against which concrete is placed to form a face, together with all the immediate supports to retain it in position while concrete is placed.

Falsework means the structural elements supporting both the formwork and the concrete until the concrete becomes self supporting.

A formed face is one which has been cast against formwork.

An exposed face is one which will remain visible when construction has been completed.

1722 CONSTRUCTION OF FORMWORK AND FALSEWORK

Before construction begins, the Contractor shall submit to the Engineer drawings showing details of the proposed formwork and falsework.

Formwork and falsework shall be so constructed that they will support the loads imposed on them by the fresh concrete together with additional stresses imposed by vibrating equipment and by construction traffic, so that after the concrete has hardened the formed faces shall be in the positions shown on the Drawings within the tolerances set out in Clause 1726.

Ground supports shall be properly founded on footings designed to prevent settlement.

Joints in formwork for exposed faces shall, unless otherwise specified, be evenly spaced and horizontal or vertical and shall be continuous or form a regular pattern.

All joints in formwork including formwork for construction joints shall be tight against the escape of cement and fines. Where reinforcement projects through formwork, the form shall fit closely round the bars.

Formwork shall be so designed that it may be easily removed from the work without damage to the faces of the concrete. It shall also incorporate provisions for making minor adjustments in position, if

required, to ensure the correct location of concrete faces. Due allowance shall be made in the position of all formwork for movement and settlement under the weight of fresh concrete.

Where overhangs in formwork occur, means shall be provided to permit the escape of air and to ensure that the space is filled completely with fully compacted concrete.

Formwork shall be provided for concrete surfaces at slopes of 30° to the horizontal or steeper. Surfaces at slopes less than 20° may be formed by screeding. Surfaces at slopes between 20° and 30° shall generally be formed unless the Contractor can demonstrate to the satisfaction of the Engineer that such slopes can be screeded with the use of special screed boards to hold the concrete in place during vibration.

Horizontal or inclined formwork to the upper surface of concrete shall be adequately secured against uplift due to the pressure of fresh concrete. Formwork to voids within the body of the concrete shall also be tied down or otherwise secured against floating.

The internal and external angles on concrete surfaces shall be formed with fillets and chamfers of the sizes shown on the Drawings unless otherwise instructed by the Engineer.

Supports for formwork may be bolted to previously placed concrete provided the type of bolt used is acceptable to the Engineer. If metal ties through the concrete are used in conjunction with bolts, the metal left in shall not be closer than 50 mm to the face of the concrete.

Formwork shall not be re-used after it has suffered damage which is sufficient to impair the finished surfaces of the concrete.

Where circumstances prevent easy access within the form for cleaning and inspection, temporary openings for this purpose shall be provided through the formwork.

Shear keys shall be provided in all construction joints of the size and shape indicated on the Drawings.

Where precast concrete elements are specified for use as permanent formwork, or proposed by the Contractor and agreed by the Engineer, they shall comply with the requirements of the Specification. Such elements shall be set true to line and level within the tolerances prescribed for the appropriate class of finish in Clause 1726 and fixed so that they cannot move when concrete is placed against them.

1723 PREPARATION OF 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.

In order to avoid colour differences on adjacent concrete surfaces, only one type of release agent shall be used in any one section of the Works.

In cases where it is necessary to fix reinforcement before placing formwork, all surface preparation of formwork shall be carried out before it is placed into position. The Contractor shall not allow reinforcement or prestressing tendons to be contaminated with formwork release agent.

Before placing concrete all dirt, construction debris and other foreign matter shall be removed completely from within the placing area.

Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure that no movement occurs.

1724 REMOVAL OF FORMWORK

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand safely any stresses to which it may thereby be subjected.

The minimum periods which shall elapse between completion of placing concrete and removal of forms are given in Table 17-4 and apply to ambient temperatures higher than 10°C. At lower temperatures or if cement other than ordinary Portland are involved, the Engineer may instruct longer periods.

Alternatively, formwork may be removed when the concrete has attained the strength set out in Table 17-4, provided that the attained strength is determined by making test cubes and curing them under the same conditions as the concrete to which they refer.

Compliance with these requirements shall not relieve the Contractor of his obligation to delay removal of formwork until the removal can be completed without damage to the concrete.

Table 17-4 Minimum Periods for Formwork Removal

Position of Formwork	Minimum Period for Temps over 10°C	Strength to be Attained
Vertical or near vertical faces of mass concrete	24 hours	0.2 C
Vertical or near vertical faces of reinforced walls, beams and columns	48 hours	0.3 C
Underside of arches beams and slabs (formwork only)	4 days	0.5 C
Supports to underside of arches, beams and slabs	14 days	C
Arched linings in tunnels and underground works	24 hours	4 N/mm^2

NOTE: C is the nominal strength for the class of concrete used.

If the Contractor wishes to strip formwork from the underside of arches beams and slabs before the expiry of the period for supports set out above, it shall be designed so that it can be removed without disturbing the supports. The Contractor shall not remove supports temporarily for the purpose of stripping formwork and subsequently replace them.

As soon as the formwork has been removed, bolt holes in concrete faces other than construction joints which are not required for subsequent operations shall be completely filled with mortar sufficiently dry to prevent any slumping at the face. The mortar shall be mixed in the same proportions as the fine aggregate and cement in the surrounding concrete and with the same materials and shall be finished flush with the face of the concrete.

1725 SURFACE FINISHES

Classes of finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the Drawings and defined hereunder:-

(a) Class F1 finish

This finish is for surfaces against which backfill or further concrete will be placed. Formwork may be sawn boards, sheet

metal or any other suitable material which will prevent the loss of fine material from the concrete being placed.

(b) Class F2 finish

This finish is for surfaces which are permanently exposed to view but where the highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thicknessed tongued and grooved boards with square edges arranged in a uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets shall be such that there shall be no visible deflection under the pressure exerted by the concrete placed against them. Joints between boards or panels shall be horizontal and vertical unless otherwise directed. This finish shall be such as to require no general filling of surface pitting, but fins, surface discolouration and other minor defects shall be remedied by methods agreed by the Engineer.

(c) Class F3 finish

This finish is for surfaces which will be in contact with water flowing at high velocity, and for surfaces prominently exposed to view where good appearance is of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood complying with BS 1088 or equivalent material in large sheets. The sheets shall be arranged in an approved uniform pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features or changes in direction of the surface.

All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish. The Contractor shall ensure that the surface is protected from rust marks, spillages and stains of all kinds.

(d) Curved surfaces

For curved surfaces where F2 or F3 finishes are called for, the formwork face shall be built up of splines cut to make a tight surface which shall then be dressed to produce the required finish.

Alternatively single curvature surfaces may be faced with plastic or plywood linings attached to the backing with adhesive or with escutcheon pins driven flush. Linings shall not bulge, wrinkle or otherwise deform when subjected to temperature and moisture changes.

1726 TOLERANCES

All parts of formed concrete surfaces shall be in the positions shown on the Drawings within the tolerances set out in Table 17-5.

In cases where the Drawings call for tolerances other than those given in Table 17-5 the Drawings shall rule.

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 17-5 Tolerances

Class of finish	Tolerances in mm (See Note)		
	A	B	C
F1	10	10	+ 25 to - 10
F2	5	10	+ or - 15
F3	2	5	+ or - 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.

1727 REMEDIAL WORK TO DEFECTIVE SURFACES

If on stripping any formwork the concrete surface is found to be defective in any way, the Contractor shall make no attempt to remedy such defects prior to the Engineer's inspection and the receipt of any instructions which the Engineer may give.

Defective surfaces shall not be made good by plastering.

Areas of honeycombing which the Engineer agrees may be repaired shall be cut back to sound concrete or to 75 mm whichever is the greater distance. In the case of reinforced concrete the area shall be cut back to at least 25 mm clear distance behind the reinforcement or to 75 mm, whichever is the greater distance. The cavity shall have sides at right angles to the face of the concrete. After cleaning out with water and compressed air, a thin layer of cement grout shall be brushed on to the concrete surfaces in the cavity and it shall then be filled immediately with concrete of the same class as the main body but with aggregate larger than 20 mm nominal size removed. A form shall be used against the cavity, provided with a lip to enable concrete to be placed. The form shall be filled to a point above the top edge of the cavity.

After seven days the lip of concrete shall be broken off and the surface ground smooth.

Surface irregularities which are outside the limits of tolerance set out in Clause 1726 shall be ground down in the manner and to the extent instructed by the Engineer.

Defects other than those mentioned above shall be dealt with as instructed by the Engineer.

1728 REINFORCEMENT FOR CONCRETE

Reinforcement which shall comply with the following British Standards, covers plain and deformed bar reinforcement and steel fabric to be cast into concrete in any part of the Works but does not include prestressing tendons or any other embedded steel.

BS 4449 for hot rolled plain bar and high yield deformed bar
BS 4482 for hard drawn mild steel wire
BS 4461 for cold worked steel bar
BS 4483 for steel mesh fabric

All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit a test certificate from the manufacturer.

All reinforcement for use in the Works shall be tested for compliance with the appropriate British Standard in a laboratory acceptable to the Engineer and two copies of each test certificate shall be

supplied to the Engineer. The frequency of testing shall be as set out in the British Standard.

In addition to the testing requirements described above, the Contractor shall carry out additional tests as instructed by the Engineer.

Any reinforcement which does not comply with the Specification shall be removed from Site.

1729 STORAGE OF REINFORCEMENT

All reinforcement shall be delivered to Site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transported bent over double.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. All reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall either be removed from Site or may be tested for compliance with the appropriate British Standard in accordance with Clause 1728 of this Specification at the Contactor's expense.

1730 BENDING REINFORCEMENT

Unless otherwise shown on the drawings, bending and cutting shall comply with BS 4466.

The Contractor shall satisfy himself as to the accuracy of any bar bending schedules supplied and shall be responsible for cutting, bending, and fixing the reinforcement in accordance with the Drawings.

Bars shall be bent cold by the application of slow steady pressure. At temperatures below 5°C the rate of bending shall be reduced if necessary to prevent fracture of the steel.

After bending, bars shall be securely tied together in bundles or groups and legibly labelled as set out in BS 4466.

Reinforcement shall be thoroughly cleaned and all dirt, scale, loose rust, oil and other contaminants removed before it is placed in the Works.

1731 FIXING REINFORCEMENT

Reinforcement shall be securely fixed in position within a dimensional tolerance of 20 mm in any direction parallel to a concrete face and within a tolerance of 5 mm at right angles to a face, provided that the cover is not thereby decreased below the minimum shown on the Drawings, or if not shown shall be not less than 25mm or the diameter of the bar, whichever is the greater. Cover on distribution steel shall not be less than 15mm or the diameter of the bar whichever is the greater.

Unless otherwise agreed by the Engineer, all intersecting bars shall either be tied together with 1.6 mm diameter soft annealed iron wire and the ends of the wire turned into the body of the concrete, or shall be secured with a wire clip of a type agreed by the Engineer.

Spacer blocks shall be used for ensuring that the correct cover is maintained on the reinforcement. Blocks shall be as small as practicable and of a shape agreed by the Engineer. They shall be made of mortar mixed in the proportions of one part of cement to two parts of sand. Wires cast into the block for tying in to the reinforcement shall be 1.6 mm diameter soft annealed iron.

Alternatively another type of spacer block may be used subject to the Engineer's agreement.

Reinforcement shall be rigidly fixed so that no movement can occur during concrete placing. Any fixings made to the formwork shall not be within the space to be occupied by the concrete being currently placed.

No splices shall be made in the reinforcement except where shown on the Drawings or agreed by the Engineer. Splice lengths shall be as shown on the Drawings.

Reinforcement shall not be welded except where required by the Contract or agreed by the Engineer. If welding is employed, the procedures shall be as set out in BS 2640 for gas welding or BS 5135 for metal arc welding. Full strength butt welds shall only be used for steel complying with BS 4449, and if used on high yield deformed bars complying with BS 4449 the permissible stresses in the vicinity of the weld shall be reduced to those applicable to plain bars complying with that specification.

Mechanical splices shall not be used unless the Engineer agrees otherwise.

The Contractor shall ensure that reinforcement left exposed in the Works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for mild steel bars or six times the bar diameter for high yield bars. Such bends shall be carefully straightened before concrete placing continues, without leaving residual kinks or damaging the concrete round them. In no circumstances will heating and bending of high yield bars be permitted.

Bars complying with BS 4461 or other high tensile bars shall not be bent after placing in the Works.

Before concrete is placed in any section of the Works which includes reinforcement, the reinforcement shall be completely clean and free from all contamination including concrete which may have been deposited on it from previous operations.

1732 PRECAST CONCRETE

Precast concrete covers all precast units for use in the Works, whether instructed under the Contract or proposed by the Contractor, and includes prestressed units where applicable. Additional requirements for prestressed units are set out in Section 18 of this Specification.

1733 FORMWORK FOR PRECAST UNITS

Moulds for precast units shall comply with the general requirements of Clauses 1721 to 1729.

Moulds shall be so constructed that they do not suffer distortion or dimensional changes during use and are tight against loss of cement grout or fines from the concrete.

Moulds shall be set up on firm foundations so that no settlement occurs under the weight of the fresh concrete.

Moulds shall be constructed so that units may be removed from them without sustaining any damage.

Release agents used for demoulding shall not stain the concrete or affect its properties in any way.

1734 REINFORCEMENT FOR PRECAST UNITS

Reinforcement in precast units shall comply with the requirement of Clauses 1728 to 1731. When preformed cages are used the cages shall be made up on jigs to ensure dimensional accuracy and shall be carefully supported within the mould in such a way that they cannot move when concrete is placed. Reinforcement complying with BS 4449 may be tack welded where bars cross to provide rigidity in the cage but reinforcement complying with BS 4461 shall not be welded.

Cover to main reinforcement shall be as shown on the Drawings, or if not shown shall be not less than 25 mm or the diameter of the bar, whichever is the greater. Cover on distribution steel shall not be less than 15 mm or the diameter of the bar whichever is the greater.

Bars shall be spaced so that the minimum clear distance between them is the maximum nominal aggregate size plus five millimeters but in any case not less than the diamter of the bars.

Bars may be placed in pairs provided that there are no laps in the paired lengths.

1735 CASTING OF UNITS

Concrete for precast units shall comply with Clauses 1703 to 1709 using the class of concrete specified on the Drawings.

If lightweight aggregates are specified, they shall comply with BS 3797.

The area in which units are cast shall be adequately protected from the weather so that the process is not affected by rain, sun or drying winds.

1736 CURING PRECAST UNITS

Requirements for curing shall be generally as set out in Clause 1710.

The Contractor shall ensure that units do not suffer any loss of moisture or sudden changes of temperature for at least four days after casting. If a water spray is used for curing, the water shall be at a temperature within 5°C of the temperature of the unit being cured.

If the Contractor proposes curing at elevated temperatures, the method shall be subject to the agreement of the Engineer and shall include means whereby units are heated and subsequently cooled evenly without sudden changes of temperature.

1737 DIMENSIONAL TOLERANCES OF PRECAST UNITS

Units shall be accurately formed to the dimensions shown on the Drawings and within the tolerances set out in BSCP 110 unless closer tolerances are called for in the Special Specification or on the Drawings

1738 SURFACE FINISH OF PRECAST UNITS

The formed faces of precast units shall be finished to Class F3 as set out in Clause 1725 unless another class of finish is specified on the Drawings.

Free faces shall be finished to Class UF2 unless another class of finish is specified on the Drawings.

In cases where a special finish is requried a trial panel shall be constructed by the Contractor which after approval by the Engineer shall be kept available for inspection at the place of casting and production units shall thereafter match the approved pattern.

Those parts of the unit which are to be joined to other units or to in situ concrete shall be brushed with a stiff brush before the concrete has fully hardened. Alternatively, if the concrete has been allowed to harden, the surfaces shall be roughened by sand blasting or the use of a needle gun.

1739 HANDLING AND STORAGE OF PRECAST UNITS

Precast units shall be handled in a manner which will not cause damage of any kind and shall be stored on a hard impermeable base.

Prestressed units and large precast normally reinforced units shall be handled and stored so that no stresses shall be induced in excess of those which they will incur in their final positions in the Works unless they have been designed to resist such stresses.

Units shall be provided with adequate lifting holes or loops, placed in the locations shown on the Drawings or agreed by the Engineer and they shall be lifted only by such holes or loops. Where it is not possible to provide holes or loops, suitable sling positions shall be indicated in paint on the units.

Units shall be marked indelibly with the reference number and date of casting and shall be stacked on suitable packers which will not damage the concrete or stain the surfaces. Not more than two packers shall be placed under each unit and these shall be located either at the positions of the permanent support points or in positions such that the induced stresses in the unit will be a minimum.

1740 TESTING PRECAST UNITS

Precast units shall be capable of safely sustaining the loads which they have been designed to carry. The Contractor shall subject units selected by the Engineer to load tests simulating the working conditions. Details of such tests shall be agreed between the Engineer and the Contractor.

In the case of units subject to bending loads the test piece shall be supported at full span and a loading equivalent to 1.25 times the sum of the live and dead loads which were assumed in the design shall be maintained for one hour without the appearance of any signs of distress. The recovery one hour after the removal of load shall be not less than 75 per cent of the full load deflection.

If the unit fails to meet the above requirements, further tests shall be carried out on two more units. If either of these fail the whole batch of units will be rejected.

If the Engineer so requires, a test to destruction shall also be carried out which on units subject to bending shall be as follows:-

The units shall be supported at full span and a load applied in increments instructed by the Engineer up to 95 per cent of the designed ultimate load. This load shall be held for 15 minutes without failure of the unit. The deflection at the end of this period shall be not more than 1/40th of the span. The load shall then be further increased until failure occurs.

If the unit fails to sustain the required load for the prescribed period or if the deflection exceeds the specified amount, the Engineer may order two further tests, and if either of these fail, the batch of units which they represent may be rejected.

1741 MEASUREMENT AND PAYMENT

(a) Item : Concrete

Unit : m^3 of each class

Concrete shall be measured by the cubic metre of each class calculated from the dimensions given on the Drawings or instructed by the Engineer. No deduction shall be made in the measurement for:

(i) bolt holes, pockets, box outs and cast in components provided that the volume of each is less than 0.15 cubic metres;

(ii) mortar beds, fillets, drips, rebates, recesses, grooves, chamfers and the like of 100 mm total width or less;

(iii) reinforcement

The rate for concrete shall include for the cost of:-

(i) Provison and transport of cement aggregates and water.

(ii) admixtures and workability agents including submission of details unless specified.

(iii) batching, mixing, transporting, placing, compacting and curing.

(iv) class UPI finish.

(v) laying to sloping surfaces not exceeding 15° from the horizontal and to falls.

(vi) formwork to blinding concrete.

(vii) placing and compacting against excavated surfaces where required including any additional concrete to fill overbreak or working space.

(viii) complying with the requirements of Clauses 1701 to 1718 inclusive and Clause 1727 of this Specification.

(b) Item : Blinding concrete

Unit : m^3

Blinding concrete shall be measured by the cubic metre calculated as the product of the plan area of the foundation as shown on the Drawings and the instructed thickness. No deduction shall be made for openings provided that the area of each is less than 0.5 square metres. Blinding concrete over

hard material shall be measured as the volume used provided that the maximum thickness of 150mm allowed for overbreak is not exceeded.

The rate for blinding concrete shall include for all costs itemised in Clause 1741(a) of this Specification.

(c) Item : No fines concrete

Unit : m^3

No fines concrete shall be be measured by the cubic metre calculated from the dimensions given on the Drawings or instructed by the Engineer.

The rate for no fines concrete shall include for all costs stated in Clause 1741(a) of this Specification.

(d) Item : Unformed surface finishes

Unit : m^2 of each class of finish

Unformed surface finishes shall be measured by the square metre from the dimensions given on the Drawings or instructed by the Engineer.

The rate for concrete in Clause 1741 (a), (b) and (c) shall include for class UFI finish.

The rate for unformed surface finishes shall include for the cost of complying with Clause 1713 of this Specification.

(e) Item : Formwork for formed surface finishes

Unit : m^2 of formwork for each class of finish for each range of inclinations.

Except as stated below, formwork shall be measured by the square metre of formkwork actually in contact with the finished face of the concrete. No deduction shall be made in the measurement for openings, pipes, ducts and the like, provided that the area of each is less than 0.50 square metres. Unless otherwise stated, if the volume or area of concrete has not been deducted when measuring the concrete in accordance with Clauses 1741 (a), (b) and (c), formwork to form or box out the void shall not be measured.

Formwork less than 300 mm high to edges of slabs shall be measured by the linear metre in accordance with Clause 1741(f) of this Specification.

Inclined formwork shall be measured in accordance with the following classification:

(i) Horizontal; 85 to 90° inclination from vertical

(ii) Sloping; 10 to 85° inclination from vertical

(iii) Battered; 0 to 10° inclination from vertical

(iv) Vertical; 0°

(v) Sloping upper surfaces inclined at more than 15° from the horizontal.

Formwork required for blinding concrete, to form construction joints and shear keys for future concrete and other construction surfaces shall not be measured and the costs shall be included in the rates for other work.

Formwork to contraction and expansion joints shall be measured by the square metre on one face only. The rates shall include for the costs stated below and for forming recesses for sealant and channels for grout.

The rates for formwork shall inlude for the cost of submission of details, providing and transporting all materials for formwork and falsework, erection including provision of supports, fillets and chamfers 75 mm and less in width, bolts, ties, fixings, cutting to waste, drilling or notching the formwork for reinforcement where required, working around pipes, ducts, conduits and waterstops, temporary openings, cleaning, dressing, stripping, filling bolt holes and any remdial work and for complying with Clauses 1708, 1710, 1717,1718, 1719 and 1721 to 1727 inclusive of this Specificaiton.

(f) Item : Formwork to edges of slabs

Unit : m of each class of finish

Formwork less than 300 mm high to edges of slabs shall be measured by the linear metre.

The rate shall include for the costs stated in Clause 1741 (c) of this Specification.

(g) Item : Waterstops

Unit : m of each type

Waterstops shall be measured by the metre run of each type.

The rate for waterstops shall include for the provision installation, jointing, any sealants required at the face of the

concrete and for placing and compacting concrete around the water stop.

(h) Item : Mortar

Unit : m^2

Mortar used for bedding baseplates and the like shall be measured by the square metre as the area of the base plate at the specified nominal thickness of bedding.

Mortar used in filling bolts pockets and the like shall not be measured separately and the costs shall be included in the rates for the bolts.

The rates for mortar shall include for the cost of providing and placing the mortar and of complying with the requirements of Clauses 1714 and 1720 of this Specification.

(i) Item : Admixtures, workability and hardening agents

Unit : as specified in the Special Specification

Where required by the Special Specification admixtures, workability and hardening agents will be measured and paid for in accordance with the Special Specification.

(j) Item : Reinforcement

Unit : tonne of each type for each range of diameters.

Reinforcement shall be measured separately for each of the following ranges.

(i) of diameter equal to or less than 16 mm.

(ii) of diameter greater than 16 mm.

Steel fabric reinforcement shall be measured in accordance with Clause 1741 (k) of this Specification.

Steel plain and deformed bar reinforcement shall be measured by the tonne and shall be the calculated weight of the steel required including splice lengths shown on the Drawings. No allowance shall be made in the measurement for rolling margin or cutting waste. The densisty of steel shall be taken as 7850 kilogrammes per cubic metre.

The rates for reinforcement shall include for the cost of providing, cutting to length, splice lengths additional to those shown on the Drawings, laps, bending, hooking, waste incurred by cutting, cleaning, spacer blocks, provision and fixing of chairs or other types of supports, welding, fixing the reinforcement in

position including the provision of wire or other material for supporting and tying the reinforcement in place, bending reinforcement aside temporarily and straightening, placing and compacting concrete around reinforcement and for complying with the requirements of Clause 1728 to 1731 inclusive of this Specification.

(k) Item : Fabric reinforcement

Unit : m^2 of each type

Steel fabric reinforcement shall be measured by the square metre and shall be the calculated area excluding any allowance for laps.

The rate for steel fabric reinforcement shall included for the costs stated in Clause 1741 (j) of this Specification.

(l) Item : Precast Units

Unit : no. of each type

Precat units shall be measured by the number of each type instructed unless otherwise specified in the Special Specification.

The rate for precast units shall include for the cost of all the materials, forming, and placing units, complying with the requirements of Clauses 1732 to 1740 inclusive and with the relevant Clauses of the Special Specification.

No separate measurement or payment will be made for formwork reinforcement or prestressing tendons to precast units.

If the anchorage is fixed after the main body of the concrete has been placed, it shall be carefully bedded so that it is bearing evenly and is in intimate contact with the concrete.

1805 PRESTRESSING TENDONS

Tendons used in prestressed concrete shall comply with the British Standards indicated on the Drawings. The Standards include the following:

BS 5896 for high tensile steel wire

BS 4486 for high tensile alloy steel bars

BS 5896 for 7 wire steel strand

BS 4757 for 19 wire steel strand

Tendons shall be stored on site under cover and protected from the weather. The storage area shall have a hard impermeable floor. Tendons shall be stored either straight or in the coils in which they left the factory.

Tendons shall not be allowed to become affected by excessive rusting or by pitting of the surface by corrosion. If pitting is present the Contractor shall replace the affected tendons by new ones.

1806 INSTALLATION OF PRESTRESSING TENDONS

Prestressing steel shall be cut by rotating disc or blade cutters or by such method as is recommended by the manufacturer.

Before being installed, prestressing tendons shall be thoroughly cleaned of mill scale, mortar, oil, paint, dust, grease, or any other deleterious matter whatsoever.

The prestressing steel (or where the tendons are accommodated in ducts, the sheaths, ducting or formers) shall be accurately placed in the positions shown on the Drawings and shall be firmly secured in position. Wooden supports shall not be used nor shall the sheaths, ducting or formers be placed on previous layers of fresh concrete or be adjusted during the placing of concrete.

The prestressing steel, sheaths, ducting or formers shall be so placed and secured that twisting, kinking or excessive deformation during and subsequent to concreting is eliminated and the prestressing tendons when finally stressed shall conform accurately to the profiles shown on the Drawings. Ducts and formers shall not be placed with small radius bends which would induce excessive frictional restraint on the wires or strands.

Where many individual wires or strands are placed in a duct, adequate provision shall be made to keep the wires separated by means of suitable spacers of approved design, construction and spacing.

1807 JACKS FOR PRESTRESSING

Jacks for tensioning tendons shall be hydraulically operated and capable of providing a slow uniform increase of load. Each jack shall be equipped with an appropriate pressure gauge capable of indicating the hydraulic fluid pressure at all times during the stressing operation. A certified calibration chart showing the relationship between gauge readings and force on the ram for both ascending and descending ram movements shall be made available on the Site by the Contractor.

The Contractor shall maintain tensioning jacks in good working order and shall ensure true and accurate readings by regular testing, calibration and servicing.

1808 TENSIONING OPERATIONS

Prestressing force, whether partial or full, shall not be transferred to the concrete until cube crushing tests have indicated that the concrete has attained the strength specified on the Drawings.

Stressing of the tendons shall be carried out with due care by experienced workmen under competent supervision and adequate steps shall be taken to safeguard against injury.

Full and accurate records shall be kept of all stressing operations and two copies of the records, which shall include wedging-device slip measurements during anchoring, loads and extensions, shall be submitted to the Engineer on the day following each stressing operation. The accuracy of the measurement of cable extensions, shall be plus or minus two per cent. The Engineer may order the Contractor to cease any or all stressing operations where proper records are not being kept or where the operations are not being properly or safely carried out and the Contractor shall take immediate steps to ensure that the work is carried out to the satisfaction of the Engineer.

Where the required tensions or extensions are not obtained the tendons shall be re-tensioned as directed by the Engineer. If on re-stressing, the extensions are not achieved, the Engineer may at his discretion reject the tendons involved.

1809 POST-TENSIONING

When a post-tensioning system is employed, all cable ducts, excluding extractable formers shall be thoroughly flushed with water immediately after concreting and before the concrete has hardened.

Ducts produced by extractable formers shall be flushed out as soon as the concrete has hardened.

SECTION 18
PRESTRESSED CONCRETE WORKS

1801 SCOPE OF SECTION

This section covers the materials, equipment and methods required for carrying out prestressing operations on in-situ and precast concrete. The production of in-situ concrete and precast concrete units is covered by Section 17 of this Specification.

1802 GENERAL

Prestressed concrete work shall be carried out in accordance with the recommendations of BSCP 110, 'The Structural Use of Concrete, Part I, Design, Materials and Workmanship', except that where the requirements of the Code differ from this Specification, this Specification shall take precedence.

The Contractor shall submit to the Engineer full details of the plant he proposes to use for the installation of prestressing tendons, the materials he proposes to use and the arrangements he proposes to make. He shall also submit evidence of his competence to undertake the installation.

1803 DUCTING

All ducting shall be sufficiently strong to withstand without damage the stresses to which it may be subjected during handling and after being fixed in position. The ducting shall completely protect the wires or cables from contact with concrete and the Contractor shall ensure that the wires or cables are completely free in the duct before tensioning. Any ducting which has been damaged during transportation to the Site or which in the opinion of the Engineer is inadequate for its purpose shall not be used in the Works. Ducting shall be free from loose material, oil coatings, or other contaminants which may affect the bond with the concrete.

The stools, saddles or supports for the ducts shall be of rigid construction and of such form that they remain securely in position and maintain the correct profile of the cables until the concrete placed round them has hardened.

Vents shall be incorporated into each duct at high and low points, at each end and at intermediate points not more than five metres apart. Blocking of vents during concreting operations shall be prevented.

1804 ANCHORAGES

Anchorages shall be the correct type for the prestressing system used and shall be rigidly fixed true to alignment in the formwork so that they cannot move during concreting operations. The anchorages shall be provided with means for injecting grout into the ducts.

Where anchorage of the prestressing tendons is by friction grips or wedges and where no other slipping limitation is specified, the slip of each individual prestressing steel element, both during tensioning and after anchoring shall not exceed seven millimetres. Tendons failing to satisfy this limitation shall be re-stressed.

The sequence of stressing shall be as shown on the Drawings and shall be such that lateral eccentricity of stress on any member is reduced to a minimum.

After stressing and anchoring, no tendon shall be cut, bent or in any way deformed until the bonding grout or concrete is at least seven days old.

Where tendons are cut back, the exposed ends of the tendons and anchorages shall be heavily coated with an approved bituminous compound or epoxy resin to prevent corrosion of the prestressing steel.

1810 PRE-TENSIONING

Pre-tensioning tendons shall be either crimped or indented wire, ribbed or deformed alloy bar or strand complying with the requirements of Clause 1805 of this Specification.

The tendons shall be anchored in such a manner that during concreting they will not suffer any loss of tension whatsoever due to anchorage yield or deficiency or due to yielding of the prestressing beds. No variation in the tension of the tendons shall be made subsequent to the commencement of concreting until transfer of prestressing force to the concrete is authorised.

At the appropriate time the prestressing force shall be transferred to the concrete uniformly by means of slow de-tensioning. The tendons shall not be de-tensioned individually and the de-tensioning operation shall be applied to all the tendons simultaneously. Where a set of tendons passes through several units, the units shall be free to move longitudinally during de-tensioning.

The prestressing steel shall be cut off flush with the end of the member and the exposed ends of the prestressing steel and anchorages shall be heavily coated with an approved bituminous compound or with an epoxy resin to prevent corrosion of the prestressing steel.

1811 BONDING AND GROUTING

Post-tensioned tendons shall after stressing and anchoring be intimately bonded to the adjacent concrete by means of concrete or, in the case of internal cables, by colloidal cement grout.

The properties of grout, the equipment and the grouting procedure shall be as follows:-

(a) The grout shall be a colloidal mix of water and ordinary Portland cement in the ratio of between 0.40 to 1.00 and 0.45 to 1.00 by weight.

(b) Admixtures of an approved type may be authorised by the Engineer for incorporation in the grout if tests have shown that their use improves the properties of the grout, for example by increasing the workability, by reducing bleeding, by entraining air or by expanding grout.

Admixtures shall not contain chlorides or nitrates. When an expanding agent is used the total unrestrained expansion shall not exceed 10 per cent.

(c) The mixing equipment shall be of a type capable of producing grout of uniform consistency with fully dispersed cement particles and shall incorporate suitable sieves for retaining lumps or other solid ingredients. After water has been added to the mixer, the cement shall be added. Admixtures if used, shall be added during the latter half of the mixing time. High speed mixing shall be carried out continuously for between two and four minutes in a close clearance high speed centrifugal mixer.

Subsequent to mixing and prior to injection the grout shall be continuously agitated by slow machine mixing. Any grout that has been left standing for more than 30 minutes shall be discarded and the container thoroughly washed before further mixing is carried out.

(d) A positive displacement pump shall be used for injecting the grout, capable of developing a pressure of at least one N/mm^2. The pump shall be fitted with a pressure gauge and an effective control against build-up of excessive pressure. The pump suction intake shall be kept below the surface level of the grout at all times during grouting operations.

(e) All tendons shall be grouted in their ducts as soon as practicable after the stressing operation. Each duct shall be cleaned by blowing through compressed air, flushing with clean water and surplus water shall be removed by compressed air or other approved means. Openings at the anchorages other than grout injection nozzle openings shall be plugged with mortar or other suitable material. Subsequent to the hardening of the plugging material the nozzle of the injection pipe shall be firmly connected to the duct in such a way that air cannot be sucked in. Injection shall be commenced from one end only and its progress monitored by the appearance of grout at successive vent holes. When the consistency of the grout emerging from a vent is equal to that of the grout being injected, that vent shall be plugged.

Injection shall continue until grout of a consistency equal to that being injected appears at the far end of the duct. The injection nozzle shall then be withdrawn and all holes and vents plugged to prevent loss of grout.

As far as possible all ducts in any one member shall be grouted in immediate succession commencing with the lowest duct.

Grouting shall not be carried out when the air temperature is 2°C or lower.

The temperature of newly grouted cable ducts shall be prevented from falling below 2°C for a minimum period of seven days.

1812 CAMBER OF PRESTRESSED PRECAST BEAMS

Where the predicted camber due to stressing precast beams is indicated on the Drawings, the actual camber shall not exceed the stated figure by more than 50 per cent.

Where a number of similar units are to be placed side by side, the variation in camber between adjacent units shall not be more than 6.0 mm for units up to 4.5 metres in length, or more than 9.0 mm for longer units.

1813 REJECTION OF PRESTRESSED WORK

Any structural element in which the prestressing tendons, the anchorages, or any part whatsoever of the prestressed element has been damaged, or in which excessive loss of prestress has occurred or in which the grouting has not been satisfactorily carried out, or which is deficient in any other manner, will be rejected and the Contractor shall rectify the deficiency to the satisfaction of the Engineer, failing which the element shall be replaced by the Contractor.

1814 TRANSPORT AND STORAGE OF PRESTRESSED UNITS

Unless otherwise agreed, prestressed concrete units shall be transported in the same attitudes and under the same support conditions as they will have in the final structure.

All handling, transporting and storing of prestressed units shall be to the satisfaction of the Engineer, and the Contractor shall ensure that all methods of handling, transporting and storing prestressed units shall be such as to prevent over-stressing or any other damage.

1815 JOINTING PRECAST UNITS

Where a load bearing structure is to be formed by tensioning together a string of precast units, the joints between the units shall be formed as shown on the Drawings by one of the methods set out below so as to achieve a uniform transfer of stress across the joint.

(a) Joints shall be set between 20 and 30 mm wide and shall be packed solid with mortar mixed in the proportion of one part of cement to 1.5 parts of sand with water sufficient only to allow the mix to cohere when squeezed in the hand. The mortar shall be rammed thoroughly into the joint, using formwork to retain it where necessary.

(b) Where joints are shown on the Drawings as 75 mm or wider, they shall be filled with concrete of a class similar to that used in the units or as shown on the Drawings. The concrete shall be compacted by vibration and retained by formwork.

(c) Procedure when using resin adhesives for jointing will depend on the configuration of the joint and the type of adhesive to be used and will be subject to the Engineer's agreement.

Irrespective of the method of joint filling employed, the joint shall be completely filled with material having a uniform consistency. The joint faces shall be flat without any high spots which might cause local stress concentrations.

Ducts for tendons shall be truly aligned between units and the duct joints in the gap between units shall be carefully formed and impervious to the entry of grout from the joint filling operation.

1816 TESTING PRESTRESSED WORK

If instructed by the Engineer, load testing of structures containing prestressed units shall be carried out generally as set out in BSCP 110.

Precast units shall be tested in accordance with Section 17 of this Specification and in addition, where a test of the prestressing is required, the unit shall be subjected for a period of five minutes to a load which is calculated to result in a bending tensile stress in the bottom surface equal to one tenth of the nominal strength of the concrete. The prestressing shall be deemed to be effective if no cracking is observed during the test.

Details of all testing procedures shall be agreed between the Engineer and the Contractor before testing is commenced.

1817 MEASUREMENT AND PAYMENT

Prestressed concrete shall be measured in accordance with Clause 1741 of this Specification and tendons for prestressing shall be measured under this Section.

(a) Item : Prestressing tendons

Unit : no. of each type for each length

Prestressing tendons in in-situ concrete shall be measured by the number required of each type for each length. No separate measurement or payment will be made for prestressing tendons in precast concrete.

The rates for tendons shall include for the cost of complying with the requirements of Section 18 of this Specification.

(b) Item : Load test

Unit : no. for each type of unit

Load tests on prestressed units shall be by the number instructed to be carried out.

The rates for load tests on prestressed units shall include for the cost of provision of the unit, testing and complying with the requirements of Clause 1816 of this Specification. If any units fails to meet the requirements of the Specification the unit and the load test shall not be measured or paid for.

SECTION 18
PRESTRESSED CONCRETE WORKS

1801 SCOPE OF SECTION

This section covers the materials, equipment and methods required for carrying out prestressing operations on in-situ and precast concrete. The production of in-situ concrete and precast concrete units is covered by Section 17 of this Specification.

1802 GENERAL

Prestressed concrete work shall be carried out in accordance with the recommendations of BSCP 110, 'The Structural Use of Concrete, Part I, Design, Materials and Workmanship', except that where the requirements of the Code differ from this Specification, this Specification shall take precedence.

The Contractor shall submit to the Engineer full details of the plant he proposes to use for the installation of prestressing tendons, the materials he proposes to use and the arrangements he proposes to make. He shall also submit evidence of his competence to undertake the installation.

1803 DUCTING

All ducting shall be sufficiently strong to withstand without damage the stresses to which it may be subjected during handling and after being fixed in position. The ducting shall completely protect the wires or cables from contact with concrete and the Contractor shall ensure that the wires or cables are completely free in the duct before tensioning. Any ducting which has been damaged during transportation to the Site or which in the opinion of the Engineer is inadequate for its purpose shall not be used in the Works. Ducting shall be free from loose material, oil coatings, or other contaminants which may affect the bond with the concrete.

The stools, saddles or supports for the ducts shall be of rigid construction and of such form that they remain securely in position and maintain the correct profile of the cables until the concrete placed round them has hardened.

Vents shall be incorporated into each duct at high and low points, at each end and at intermediate points not more than five metres apart. Blocking of vents during concreting operations shall be prevented.

1804 ANCHORAGES

Anchorages shall be the correct type for the prestressing system used and shall be rigidly fixed true to alignment in the formwork so that they cannot move during concreting operations. The anchorages shall be provided with means for injecting grout into the ducts.

Where anchorage of the prestressing tendons is by friction grips or wedges and where no other slipping limitation is specified, the slip of each individual prestressing steel element, both during tensioning and after anchoring shall not exceed seven millimetres. Tendons failing to satisfy this limitation shall be re-stressed.

The sequence of stressing shall be as shown on the Drawings and shall be such that lateral eccentricity of stress on any member is reduced to a minimum.

After stressing and anchoring, no tendon shall be cut, bent or in any way deformed until the bonding grout or concrete is at least seven days old.

Where tendons are cut back, the exposed ends of the tendons and anchorages shall be heavily coated with an approved bituminous compound or epoxy resin to prevent corrosion of the prestressing steel.

1810 PRE-TENSIONING

Pre-tensioning tendons shall be either crimped or indented wire, ribbed or deformed alloy bar or strand complying with the requirements of Clause 1805 of this Specification.

The tendons shall be anchored in such a manner that during concreting they will not suffer any loss of tension whatsoever due to anchorage yield or deficiency or due to yielding of the prestressing beds. No variation in the tension of the tendons shall be made subsequent to the commencement of concreting until transfer of prestressing force to the concrete is authorised.

At the appropriate time the prestressing force shall be transferred to the concrete uniformly by means of slow de-tensioning. The tendons shall not be de-tensioned individually and the de-tensioning operation shall be applied to all the tendons simultaneously. Where a set of tendons passes through several units, the units shall be free to move longitudinally during de-tensioning.

The prestressing steel shall be cut off flush with the end of the member and the exposed ends of the prestressing steel and anchorages shall be heavily coated with an approved bituminous compound or with an epoxy resin to prevent corrosion of the prestressing steel.

1811 BONDING AND GROUTING

Post-tensioned tendons shall after stressing and anchoring be intimately bonded to the adjacent concrete by means of concrete or, in the case of internal cables, by colloidal cement grout.

The properties of grout, the equipment and the grouting procedure shall be as follows:-

(a) The grout shall be a colloidal mix of water and ordinary Portland cement in the ratio of between 0.40 to 1.00 and 0.45 to 1.00 by weight.

(b) Admixtures of an approved type may be authorised by the Engineer for incorporation in the grout if tests have shown that their use improves the properties of the grout, for example by increasing the workability, by reducing bleeding, by entraining air or by expanding grout.

Admixtures shall not contain chlorides or nitrates. When an expanding agent is used the total unrestrained expansion shall not exceed 10 per cent.

(c) The mixing equipment shall be of a type capable of producing grout of uniform consistency with fully dispersed cement particles and shall incorporate suitable sieves for retaining lumps or other solid ingredients. After water has been added to the mixer, the cement shall be added. Admixtures if used, shall be added during the latter half of the mixing time. High speed mixing shall be carried out continuously for between two and four minutes in a close clearance high speed centrifugal mixer.

Subsequent to mixing and prior to injection the grout shall be continuously agitated by slow machine mixing. Any grout that has been left standing for more than 30 minutes shall be discarded and the container thoroughly washed before further mixing is carried out.

(d) A positive displacement pump shall be used for injecting the grout, capable of developing a pressure of at least one N/mm^2. The pump shall be fitted with a pressure gauge and an effective control against build-up of excessive pressure. The pump suction intake shall be kept below the surface level of the grout at all times during grouting operations.

(e) All tendons shall be grouted in their ducts as soon as practicable after the stressing operation. Each duct shall be cleaned by blowing through compressed air, flushing with clean water and surplus water shall be removed by compressed air or other approved means. Openings at the anchorages other than grout injection nozzle openings shall be plugged with mortar or other suitable material. Subsequent to the hardening of the plugging material the nozzle of the injection pipe shall be firmly connected to the duct in such a way that air cannot be sucked in. Injection shall be commenced from one end only and its progress monitored by the appearance of grout at successive vent holes. When the consistency of the grout emerging from a vent is equal to that of the grout being injected, that vent shall be plugged.

Injection shall continue until grout of a consistency equal to that being injected appears at the far end of the duct. The injection nozzle shall then be withdrawn and all holes and vents plugged to prevent loss of grout.

As far as possible all ducts in any one member shall be grouted in immediate succession commencing with the lowest duct.

Grouting shall not be carried out when the air temperature is 2°C or lower.

The temperature of newly grouted cable ducts shall be prevented from falling below 2°C for a minimum period of seven days.

1812 CAMBER OF PRESTRESSED PRECAST BEAMS

Where the predicted camber due to stressing precast beams is indicated on the Drawings, the actual camber shall not exceed the stated figure by more than 50 per cent.

Where a number of similar units are to be placed side by side, the variation in camber between adjacent units shall not be more than 6.0 mm for units up to 4.5 metres in length, or more than 9.0 mm for longer units.

1813 REJECTION OF PRESTRESSED WORK

Any structural element in which the prestressing tendons, the anchorages, or any part whatsoever of the prestressed element has been damaged, or in which excessive loss of prestress has occurred or in which the grouting has not been satisfactorily carried out, or which is deficient in any other manner, will be rejected and the Contractor shall rectify the deficiency to the satisfaction of the Engineer, failing which the element shall be replaced by the Contractor.

1814 TRANSPORT AND STORAGE OF PRESTRESSED UNITS

Unless otherwise agreed, prestressed concrete units shall be transported in the same attitudes and under the same support conditions as they will have in the final structure.

All handling, transporting and storing of prestressed units shall be to the satisfaction of the Engineer, and the Contractor shall ensure that all methods of handling, transporting and storing prestressed units shall be such as to prevent over-stressing or any other damage.

1815 JOINTING PRECAST UNITS

Where a load bearing structure is to be formed by tensioning together a string of precast units, the joints between the units shall be formed as shown on the Drawings by one of the methods set out below so as to achieve a uniform transfer of stress across the joint.

(a) Joints shall be set between 20 and 30 mm wide and shall be packed solid with mortar mixed in the proportion of one part of cement to 1.5 parts of sand with water sufficient only to allow the mix to cohere when squeezed in the hand. The mortar shall be rammed thoroughly into the joint, using formwork to retain it where necessary.

(b) Where joints are shown on the Drawings as 75 mm or wider, they shall be filled with concrete of a class similar to that used in the units or as shown on the Drawings. The concrete shall be compacted by vibration and retained by formwork.

(c) Procedure when using resin adhesives for jointing will depend on the configuration of the joint and the type of adhesive to be used and will be subject to the Engineer's agreement.

Irrespective of the method of joint filling employed, the joint shall be completely filled with material having a uniform consistency. The joint faces shall be flat without any high spots which might cause local stress concentrations.

Ducts for tendons shall be truly aligned between units and the duct joints in the gap between units shall be carefully formed and impervious to the entry of grout from the joint filling operation.

1816 TESTING PRESTRESSED WORK

If instructed by the Engineer, load testing of structures containing prestressed units shall be carried out generally as set out in BSCP 110.

Precast units shall be tested in accordance with Section 17 of this Specification and in addition, where a test of the prestressing is required, the unit shall be subjected for a period of five minutes to a load which is calculated to result in a bending tensile stress in the bottom surface equal to one tenth of the nominal strength of the concrete. The prestressing shall be deemed to be effective if no cracking is observed during the test.

Details of all testing procedures shall be agreed between the Engineer and the Contractor before testing is commenced.

1817 MEASUREMENT AND PAYMENT

Prestressed concrete shall be measured in accordance with Clause 1741 of this Specification and tendons for prestressing shall be measured under this Section.

(a) Item : Prestressing tendons

Unit : no. of each type for each length

Prestressing tendons in in-situ concrete shall be measured by the number required of each type for each length. No separate measurement or payment will be made for prestressing tendons in precast concrete.

The rates for tendons shall include for the cost of complying with the requirements of Section 18 of this Specification.

(b) Item : Load test

Unit : no. for each type of unit

Load tests on prestressed units shall be by the number instructed to be carried out.

The rates for load tests on prestressed units shall include for the cost of provision of the unit, testing and complying with the requirements of Clause 1816 of this Specification. If any units fails to meet the requirements of the Specification the unit and the load test shall not be measured or paid for.

SECTION 20
ROAD FURNITURE

2001 ROAD RESERVE BOUNDARY POSTS

Where road reserve boundary posts are instructed by the Engineer, they shall be erected as early as possible after the commencement of the Contract, on the boundary of the Road Reserve at intervals of 250m or as otherwise instructed by the Engineer or shown on the Drawings, but not closer than 5 m to any reference point or peg.

Where required by the Special Specification, the Contractor shall immediately establish a reference point on top of each post co-ordinated to an accuracy of ±5mm. A schedule of the road reserve boundary posts together with their chainage, offset and co-ordinates shall be submitted to the Engineer before construction on adjacent sections of the Works, begins.

Road reserve boundary posts shall be constructed of concrete Class 20/20 reinforced with 10 mm diameter high yield deformed bars as shown on the Drawings. The top 0.7 m of the posts shall be painted with two coats of white lead paint and the location and offset of the post shall be painted onto the front face in black.

The Contractor shall excavate for the posts in any material, embed the posts in concrete Class 15/20 all round and under the butt and backfill the remaining excavation, all as shown on the Drawings.

The posts shall be maintained in position and kept in a clean and legible state until the issue of the Certificate of Completion.

2002 FENCING AND GATES

Where shown on the Drawings or directed by the Engineer the Contractor shall provide and erect fences and gates including excavation and backfilling and complying with the details shown on the Drawings.

All timber for fencing and gates shall be well seasoned hardwood to the approval of the Engineer. After all cutting and drilling is complete the timber shall be impregnated by the vacuum/pressure process with an approved preservative such as 'Tanalith' in accordance with BS 4072 or as specified in the Special Specification to achieve an anticipated average dry salt retention of 12kg/m3. Prior to delivery of materials to Site samples are to be submitted by the Contractor to the Engineer for testing to ensure that the correct treatment has been applied.

2003 EDGE MARKER POSTS

Edge marker posts shall be constructed and erected in accordance with the Drawings. They shall be set out at the outer edge of the shoulder with their tops at a constant height above the edge of the carriageway at such locations as the Engineer instructs. The Contractor shall excavate in any material, provide and place edge marker posts, backfill and remove surplus material to spoil.

Markers shall be erected and painted with two coats of an approved white paint before the road is opened to traffic and shall be kept clean until the issue of the Certificate of Completion.

2004 PERMANENT ROAD SIGNS

All permanent road signs shall comply with the requirements of the "Manual for Traffic Signs in Kenya", Part II.

Road signs shall be obtained from a manufacturer approved by the Engineer and before placing any order for the manufacture of the road signs, the Contractor shall submit to the Engineer two copies of the following information:-

(a) Name of the firm from which he proposes to obtain the signs together with place of manufacture or fabrication.

(b) A description of the items to be supplied with manufacturer's specification together with a description of quality, grade, weight and strength.

(c) Manufacturer's 'type' test certificates, or recent test results carried out on similar items.

(d) A sample sign, post and fittings which sample shall be stored on site for the Engineer.

All colours on the permanent road signs, with the exception of black and grey, shall be reflectorized, unless otherwise specified or instructed by the Engineer. The reflective sheeting shall comply with the requirements given in Section 2 of this Specification, and shall be applied by mechanical vacuum-heat application method to the approval of the Engineer. The sign plate shall be covered by clear lacquer of a make recommended by the manufacturer of the reflective material.

Permanent road signs shall comply with the requirements of BS 873 Parts 2, 6 and 7 in respect of quality including the pre-treatment, preparation and protective coatings for the frame, posts and fittings. Unless directed otherwise posts, frames, fittings and the backs of signs shall be painted with a finish coat of grey. Bolts and nuts shall be spot welded after erection to prevent theft, and a grey epoxy paint shall be applied to all areas so treated.

Finished sign plates (with sign face attached) shall be clearly and durably marked on the back, with the following information:-

(a) The number of the British Standard to which they have been manufactured.

(b) The name, trade mark or other means of identification of the manufacturer or vendor.

(c) The classification of any retro-reflective material used in the manufacture of the sign face.

(d) The month and year of assembly.

These markings shall be in characters legible at a normal reading distance such that the total area of the marking does not exceed 30 cm^2 and shall be sufficiently durable to last the expected life of the sign plate to which it is applied.

The manufacturer or vendor shall make available the following information:-

(a) Instructions on the assembly and erection of the sign.

(b) Details of any limitations in location or usage.

(c) Instructions on the operation and maintenance of the sign.

The Contractor shall excavate in any material for the foundation of the road signs, provide and place concrete Class 15/20, embeded all round and under the posts and backfill the remaining excavation all as shown on the Drawings or directed by the Engineer. Foundations for signs of areas over $5m^2$ shall not be covered up until they have been approved by the Engineer.

The Contractor shall cut back trees and vegetation to permit visibility and shall not permit material to be dumped so as to obscure the signs.

All signs shall be maintained in a clear and legible condition and shall be washed down when necessary.

2005 ROAD MARKING

(a) General

Road marking shall comply with the requirements of the "Manual for Traffic Signs in Kenya", Part I. Markings shall be white or yellow as instructed by the Engineer.

Paint and hot applied thermoplastic material shall comply with Section 2 of this Specification.

Ballotini beads shall be mixed with the paint before application or applied to the painted areas immediately after painting, as instructed by the Engineer.

Lines and letters shall be painted on the road as shown on the Drawings or as instructed by the Engineer. The setting out of lines shall be made by the Contractor. Words and symbols shall be set out by the Contractor, by means of stencils and shall be in accordance with drawings provided.

(b) Application

Prior to application of paints, the road surface to be marked shall be thoroughly cleaned of all loose material and shall be completely dry. Where instructed by the Engineer a tack coat shall be used to increase adhesion.

The application of paint shall preferably be done by a purpose-made machine, but the Engineer may accept brushing. All application instructions issued by the paint manufacturer shall be strictly adhered to. The application of hot-applied thermoplastic material shall be carried out by a purpose-made machine.

The spraying rate for cold paint will vary with the roughness of the surface, but shall be such as to give continuous coverage and a minimum dry film thickness of 0.125 mm. If specified in the Special Specification, reflectorized paint as detailed in Section 2 of this Specification shall be used.

Hot-applied thermoplastic materials shall have a minimum thickness of 3 mm and a maximum of 6 mm. Application shall be in accordance with the manufacturer's instructions.

(c) Traffic control

Warning signs shall be erected when painting is in progress and traffic shall not be allowed to pass over wet paint. Any painting disfigured by traffic, or any painting not complying with the Specification shall be effaced and repainted.

2006 GUARDRAILS

Dimensions and erection details for guardrails are shown on the Drawings.

(a) Materials

(i) Beams

Beams for guardrails shall be Class A with a Type 1 finish in accordance with AASHTO M180 and shall be obtained from a manufacturer approved by the Engineer.

(ii) Posts

Posts shall be constructed of concrete Class 20/15 reinforced with 16 mm diameter mild steel bars all as shown on the Drawings.

(iii) Blocks

Blocks shall be made from well seasoned red cedar free from loose knots and shakes other than surface splits not exceeding 3 mm depth.

(b) Erection

Guardrail shall be erected in accordance with the manufacturer's published instructions and the Drawings. Where there is any conflict the Drawings shall take precedence.

Approximate locations for guardrail are shown on the Drawings but precise details will be issued to the Contractor by the Engineer as construction proceeds but generally not before the completion of the earthworks in the particular section.

The Contractor shall excavate for the posts in any material and provide the guardrail with all posts, blocks, nuts, washers and shall repair galvanising, backfill around the posts and remove surplus material to spoil.

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 stop their removal.

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.

(c) Tolerances

Guardrail shall be erected at the instructed or detailed offsets and levels from the pavement centreline and shall be correct within a tolerance of ± 20 mm in line and level. In addition adjacent plates shall not vary in line or grade by more than 5 mm measured from a line extended from one plate to the end of the adjacent plate; where the guardrail is on a horizontal or vertical curve the calculated deflection shall be added to this tolerance.

(d) Additional guardrail

Where specified or instructed by Engineer the Contractor shall arrange for an additional length of guardrail including all posts, blocks, nuts, washers and bolts, to be stored at the Contractor's camp. This material shall become the property of the Employer who shall remove it from the Contractor's camp before the end of the Period of Maintenance.

The tree seedlings shall be obtained by the Contractor from the District Forest Officer of the Forest Department of the Ministry of Environment and Natural Resources closest to the Works or, if not available, from an alternative source approved by the Engineer.

The tree seedlings shall be of indigenous varieties recommended by the District Forest Officer and the method of transportation, handling, planting and caring for each tree seedling shall be as directed by the District Forest Officer.

The Contractor shall water daily each tree seedling for the first four weeks after planting. For a further 12 weeks the Contractor shall water each tree seedling as necessary to ensure that each becomes firmly established.

Should any tree be damaged, uprooted or die during the first 16 weeks after planting the Contractor shall immediately replace the tree with a new tree seedling and shall water and care for it as prescribed in this Clause 2010. Should the replacement tree be damaged, uprooted or die within the first 16 weeks after planting the same conditions shall apply and the Contractor shall continue to replace trees and water and care for them until the end of the Period of Maintenance.

Any protection works that the Contractor deems necessary to protect trees from damage, uprooting or death shall be provided at the Contractor's expense.

All trees instructed by the Engineer shall be planted by the Contractor prior to the issuing of a Completion Certificate for the whole Works or any part thereof.

2011 MEASUREMENT AND PAYMENT

Posts

The rates for road reserve boundary posts, fence posts, gates, edge marker posts and kilometre marker posts shall include for the costs of providing all materials and fittings, fabrication, transportation, excavation in any material, concrete foundations where specified, provision of transport, and compaction of selected backfill, disposal of surplus material, and complying with the requirements of Clauses 2001, 2002, 2003 and 2008 of this Specification as appropriate.

(a) Item : Road reserve boundary posts

Unit : no.

Road reserve boundary posts shall be measured by the number instructed.

(b) Item : Fencing

Unit : m

Fences shall be measured by the metre calculated as the length instructed to be erected.

(c) Item : Gates

Unit : no.

Gates shall be measured by the number instructed.

(d) Item : Edge marker posts

Unit : no.

Edge marker posts shall be measured by the number instructed.

(e) Item : Kilometre marker posts

Unit : no.

Kilometre marker posts shall be measured by the number instructed.

Permanent Road Signs

The rates for permanent road signs shall include for the costs of providing all materials including posts and fittings, fabrication, transportation, excavation in any material, installation, concrete foundations, selected backfill and disposal of surplus material and for complying with Clause 2004 of this Specification.

(f) Item : Warning signs

Unit : no. of each size

Warning signs shall be measured by the number of each size instructed.

(g) Item : Priority, prohibitory and mandatory signs

Unit : no. of each size

Priority, prohibitory and mandatory signs shall be measured by the number of each size instructed.

(h) Item : Standard informatory signs

Unit : no. of each size

Standard informatory signs shall be measured by the number of instructed.

(i) Item : Non-standard informatory signs

Unit : no. of each range of sizes.

Non-standard informatory signs shall be measured by the number of each size in each of the following ranges:-

(i) Less than $1m^2$.

(ii) Equal or more than $1m^2$ but less than $2m^2$.

(iii) Equal or more than $2m^2$ but less than $5m^2$.

(iv) Equal or more than $5m^2$.

(j) Item : Road marking in yellow or white paint

Unit : m^2

Road markings in yellow or white paint shall be measured in square metres calculated as the plan area instructed to be painted.

The rate for road marking in yellow or white paint shall include for the cost of setting out, providing paint and painting to any symbol or line of any width and of complying with the requirements of Clause 2005 of this Specification.

(k) Item : Guardrail

Unit : m

Guardrail shall be measured by the metre as the length of guardrail instructed.

The rate for guardrail shall include for the cost of provision and transport of all materials, excavation, concrete posts, erection, backfilling and complying with the requirements of Clause 2006 of this Specification.

(l) Item : Provide additional guardrail

Unit : m

Provide additional guardrail shall be measured by the metre as the length of guardrail instructed to be provided and stored by the Engineer for the use of the Employer.

The rate for provide additional guardrail shall include for the cost of provision transport and storage of all materials and complying with the requirements of Clause 2006 of this Specification.

(m) Item : Kerbs to radii equal to or more than 1.0 m

Unit : m of each range of radius

Kerbs shall be measured separately for each of the following ranges of radii:-

(i) Straight.
(ii) Radius 12m - 6m.
(iii) Radius 5m - 1m.

The rate for kerbs shall include for the cost of provision of all materials, excavation in any material, laying and jointing kerbs, concrete bedding and haunching, backfill, removal of surplus material and complying with the requirements of Clause 2007 of this Specification.

(n) Item : Quadrants of radius less than 1.0 m

Unit : no.

Quadrants of less than 1.0 m radius shall be measured by the number instructed.

The rate for quadrants shall include for the cost of provision of all materials, excavation in any material, laying and jointing quadrants, concrete bedding and haunching, backfill, removal of surplus material and complying with the requirements of Clause 2007 of this Specification.

(o) Item : Rumble strips

Unit : m

Rumble strips shall be measured by the metre of rumble strip instructed.

The rate for rumble strips shall include for the cost of provision and transport of all materials and complying with the requirements of Clause 2009 of this Specification.

(p) Item : Trees

Unit : no.

Trees shall be measured by the number instructed.

The rate for trees shall include for the cost of the provision and transport of seedling, excavation, provision and backfill with topsoil, watering and replacement of seedlings as necessary, and complying with the requirements of Clause 2010 of this Specification.

SECTION 21
MISCELLANEOUS BRIDGEWORKS

2101 WATERPROOFING TO STRUCTURES

Waterproofing shall be applied to all structural concrete surfaces in contact with fill material or cut soil surfaces and wherever detailed on the Drawings or instructed by the Engineer.

Prior to application the surface shall be clean and completely free from damp, moisture, dust, membrane curing compounds, projecting tying wire, nails and the like.

Waterproofing materials shall consist of either bitumen emulsion or cut-back bitumen or bitumen/rubber latex emulsion.

Bitumen emulsion shall comply with the requirements of BS 434, Type A160. Two coats shall be applied, the first coat at a minimum rate of 0.55 litres per square metre. The first coat shall be allowed to dry before the second coat is applied.

Cut-back bitumen shall be type MC30 as described in Section 2 of this Specification. Two coats shall be applied, the application rates being as described for bitumen emulsion. The first coat shall be allowed to dry before the second is applied.

Bitumen/rubber latex emulsion shall contain a minimum of 10% rubber. Two coats shall be applied, the application rates being as described for bitumen emulsion. The second coat shall be applied when the first coat is touch dry. Bitumen/rubber latex emulsion shall not be applied during wet weather and should rain occur and cause damage before the rubber has dried the membrane shall be repaired or replaced as approved by the Engineer at the Contractor's expense.

Where concrete is cast against existing ground the waterproofing membrane shall be single layer polythene sheet 0.75mm thick laid with minimum laps between sheets of 150 mm.

2102 BRIDGE BEARINGS

Bearings shall be manufactured and installed in accordance with the details shown on the Drawings or as described in the Special Specification.

The levels shown on the Drawings are the soffit levels of the beams or deck at the bearing locations. Bearings shall be accurately set in their correct positions and shall be maintained in position during beam installation and deck construction. Bearing surfaces of bearings shall be kept free from contamination and after the deck has been completed, each bearing and the area around it shall be left clean.

All bearings shall be indelibly marked with the appropriate Type Numbers and shall be supplied complete with dowels and dowel caps, nuts, bolts, adhesives, mortars and the like as required.

Should the Contractor wish to use an alternative system to that shown on the Drawings he shall provide the Engineer with full details and technical specifications of the alternative system and shall satisfy the Engineer with regard to the suitability of the alternative system. The Contractor shall obtain the written approval of the Engineer for any alternative or amended type of bearing or bearing system.

Bearings shall not be despatched to the Site until the tests described in the Special Specification have been satisfactorily completed and the certified results of such tests approved by the Engineer.

2103 MOVEMENT JOINTS AND SEALANTS

(a) General

The term "movement joint" includes all types of permanent joint or hinge throat which allow expansion, contraction, shrinkage or angular rotation to take place.

Movement joints shall be constructed in accordance with the Drawings and manufacturer's instructions.

The size of the gap shall be compatible with the mean structure temperature at the time of installation. This temperature shall be determined in accordance with arrangements agreed with the Engineer after which the Engineer will instruct the size of the gap.

The position of all bolts cast into concrete and holes drilled in plates shall be accurately determined from templates.

(b) Prevention of damage

During the placing and hardening of concrete or mortar under expansion joint components, relative movement shall be prevented between them and the supports to which they are being fixed.

When one half of the joint is being set, the other half shall be completely free from longitudinal restraint. In particular where strongbacks or templates are used to locate the two sides of a joint, they shall not be fixed simultaneously to both sides.

Screw threads shall be kept clean and free from rust. Ramps shall be provided and maintained to protect all expansion joints from vehicular loading. Vehicles shall cross the joints only by means of the ramps until the Engineer permits their removal.

(c) Epoxy mortar nosings

Epoxy mortar nosings shall be formed under the direction of a competent supervisor experienced in the use of the material. The work shall be carried out preferably in warm dry weather. The air temperature around the joints shall be not less than 10°C which shall be achieved artificially if necessary.

Concrete surfaces to which the nosings are applied shall be dry, sound and free from laitance. Before application of the priming coat, loose material and dust shall be removed by an air jet tested to ensure that no oil is carried over from the compressor.

Unless otherwise described in the Contract, surfacing shall be carried across the joint and then cut back to accommodate the nosing. The cutting shall be done with a diamond saw to give a clean edge throughout the depth of the material to be removed. Masking material provided to prevent surfacing materials adhering to the deck where nosings are to be formed shall be adequately located to prevent displacement by the paving machine.

A priming coat of unfilled epoxy resin composition shall be well worked in by brush to all surfaces with which the nosings will be permanently in contact at a uniform rate of not less than 300 g/m^2. The mortar shall then be applied as quickly as possible while the priming coat is still tacky.

The epoxy mortar shall be acceptable to the Materials Branch of the Ministry of Transport and Communications. Aggregate shall be either silica sand, calcined bauxite or other approved synthetic or natural aggregate of suitable grading. The particle size distribution shall be that which produces a mortar with adequate workability and minimum void volume. Aggregate shall be clean and completely dry.

Whichever type of aggregate is used, the epoxy mortar components shall be thoroughly mixed in a suitable mechanical mixer. The sequence, duration and temperature of mixing shall be in accordance with the manufacturer's instructions.

The mortar shall be placed in position within the time recommended by the manufacturer; it shall be well worked against the primed surfaces and trowelled flush with the adjacent road surface to form a dense mortar to the profiles described in the Drawings.

Epoxy mortar shall generally be compacted in courses of thickness not exceeding 50 mm. Where an underlying course is more than 1 hour old it shall, unless otherwise agreed by the Engineer, be primed with an unfilled epoxy resin priming coat before placing the next course.

Traffic shall not be permitted to run on the mortar until the Engineer's agreement has been obtained.

(d) Sealing

The sealant shall be as specified in the Special Specification or shown on the Drawings.

A poured sealant shall only be placed when the mean bridge temperature is between 10°C and 16°C, unless otherwise agreed in writing by the Engineer.

Joints shall be clean and dry before sealing.

2104 PIPE HANDRAIL TO BRIDGES

Pipe handrails shall be 50 mm galvanised steel piping supported on galvanised steel posts all made from material complying with and fabricated to, the requirements of Section 19 of this Specification and the Drawings.

The Contractor shall drill or form all holes, provide and fix bolts, galvanise posts and pipe rails, cut and bend railing at bridge ends, grout in bolts and pack under base plates with 25 mm cement/sand mortar and finish off, all in accordance with the Drawings.

2105 GUARDRAILS TO BRIDGES

Guardrails shall be Class A with a Type 1 finish in accordance with AASHTO M180 and shall be obtained from a manufacturer approved by the Engineer, and shall be attached to the same post as the handrail in accordance with the Drawings and the Contractor shall drill all holes and provide and fix bolts.

Guardrails shall be erected in accordance with the Drawings.

2106 SURFACING TO BRIDGES

Surfacing to bridges shall be in accordance with the Special Specification.

2107 Weepholes

Where shown on the Drawings or directed by the Engineer the Contractor shall cast weepholes into concrete walls. The Contractor shall provide and place plastic pipe of the diameter shown on the Drawings to form weepholes which shall be firmly held in position during the placing of the concrete and shall be cut flush with the face of the concrete. A 500mm x 500mm square of 'Terram' (of weight 280 g/m^2) or similar approved fabric shall be placed, central on the weephole between the concrete wall and the backfill material.

2108 MEASUREMENT AND PAYMENT

(a) Item : Waterproofing to structures

Unit : m^2

Waterproofing to structures shall be measured by the square metre computed as the area of the structural surface covered by one or more layers of waterproofing and no deduction shall be made in the measurement for the area occupied by gratings, or other openings, provided that the area of each is less than 1 square metre in extent.

The rate for waterproofing to structures shall include for the cost of providing and placing waterproofing materials and complying with the requirements of Clause 2101 of this Specification.

(b) Item : Bridge bearings

Unit : no. of each type

The rate for bridge bearings shall include for the cost of providing and installing the bridge bearing and complying with the requirements of Clause 2102 of this Specification.

(c) Item : Movement joints and sealants

Unit : as specified in the Special Specification

The rate for movement joints shall include for the cost of providing and installing the joints and sealant and all costs of complying with the requirements of the Special Specification.

(d) Item : Pipe handrail and guardrail to bridges

Unit : m

Handrail and guardrail to bridges shall be measured by the metre as the instructed length of handrail and guardrail to be erected.

The rate for handrail and guardrail to bridges shall include for the cost of providing and erecting handrail and guardrail, posts and fittings and complying with the requirements of Clause 2104 and Clause 2105 of this Specification.

(e) Item : Surfacing to bridges

Unit : as specified in the Special Specification

The rate for surfacing to bridges shall include for the costs of complying with the requirements of the Special Specification.

(f) Item : Weepholes

Unit : no. of each diameter

Weepholes shall be measured by the number instructed by the Engineer to be placed.

The rate for weepholes shall include for the cost of providing and casting the plastic pipe into the concrete, providing and placing the 'Terram' filter fabric and complying with the requirements of Clause 2107 of this Specification.

SECTION 22
DAYWORKS

2201 GENERAL

In accordance with Clause 52(4) of the Conditions of Contract the Engineer may instruct that additional or substituted work be executed on a daywork basis.

Provisional items are 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 his sub-contractors.

2202 MEASUREMENT AND PAYMENT

(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 soley 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 turnboys 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 his 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.