

RFQ-2025-0606
Construction of Access Road & Associated Works
at Fire Brigade 11kV Primary Substation

BILL OF QUANTITIES

1. The bid price for the works represents the full cost to BPC for the performance and delivery of the works by the Contractor. The rates in these bills shall include supply of materials, labour costs to operate, temporary works or any other PPE and safety training costs deemed necessary to complete the works as stated.
2. The Contractor's bid price shall be in full compliance with Specification and Drawings, and all relevant HSE rules and regulations implemented by BPC and Government Authorities.
3. The Contractor is advised to visit the site to fully understand the scope of work prior to submitting the bid. No claims shall be entertained for incorrect and insufficient information at any point
4. The contractor has to note that the works are to be carried out in high security areas. Contractor must comply with all site security rules and requirement of relevant government authorities. The contractor shall allow for any costs associated with limited or restricted working hours imposed by the Client/authorities.
5. All quantities in these bills are provisional and shall be re-measured upon completion of the works.

<i>Item</i>	<i>Description</i>	<i>Unit</i>	<i>Qty.</i>	<i>Unit Rate BND</i>	<i>Amount BND</i>
A.	Preliminaries				
1.	Site Topographic Survey. Provision of Licensed Land Surveyor, complete with survey equipments, tools and support personnel to conduct Topographical Survey of the Fire Brigade 11kV Primary Substation vicinity. The scope shall include, but not limited to, the following: - verification of lot boundaries within the designated area. - Survey and pickup of all natural and manmade features, including but not limited to: ▪ Ground level contours at 1 m intervals ▪ Roads, pavements, and access routes ▪ Buildings, structures, and perimeter fences ▪ Rivers, streams, and drainage channels ▪ Drainage features including invert levels, manholes, and sump pits ▪ Visible utilities and markers (e.g., electrical, water, and telecommunication services) - Preparation and submission of topographical survey plans at 1:1000 scale, showing bearings and coordinates referenced to the Borneo RSO projection system. - Submission of two (2) printed copies of the certified topographical plan in A1 size, signed and endorsed by the Licensed Surveyor and one (1) digital copy in AutoCAD 2020 or later format, including all relevant coordinate and level data.	hectare	0.5		
2.	Construction Drawings. Prepare and submit construction drawings for BPC's approval covering the proposed access road construction. The work shall include, but not be limited to, the following: ▪ Preparation of detailed construction drawings based on approved design concepts and site survey data. ▪ Endorsement by a Qualified Person (Civil/Structural) in accordance with relevant authorities' requirements. ▪ Submission of drawings in both AutoCAD (2020 or later) softcopy and hard copy formats, and shall include all necessary revisions arising from site conditions or review comments until final approval.	lot	1		

Item	Description	Unit	Qty.	Unit Rate BND	Amount BND
B.	Construction of Access Road				
1.	<i>Site Clearing.</i> Clearing and grubbing of the proposed access road alignment, including cutting, removal, and proper disposal of all vegetation such as shrubs, trees, bamboos, grass, and undergrowth within the construction limits. The work shall include uprooting of stumps, removal of roots and organic materials, and disposal of cleared vegetation to an approved location. The area shall be left clean and free from vegetation, ready for subsequent earthworks.	lot	1		
2.	<i>Surface Preparation Works</i> - Preparation of sub grade - Preparation of base course. - placing of form work <i>Refer to attached Civil Works Specifications</i>	lot	1		
3.	<i>Maintenance Access Road.</i> Ref. Dwg. PJ199/L/4 Construct concreted pavement and access road consisting of minimum 150mm thick layer of compacted hardcore, 200mm thick reinforced concrete slab with 2 layers of BRC A10 and 450 x 150mm perimeter and intermediate beam. Concrete surface to be trowelled smooth finish. <i>Note:</i> <i>Contraction joints shall be constructed so that slabs are no more than 4500mm in any dimension.</i>	sq.m.	180		
4.	<i>Perimeter Drain.</i> Ref. Dwg. PJ199/L/4 Construct R.C. U-drain nominally 300mm wide x 300mm deep; 125mm thk. Grade 25 concrete with a layer of BRC A8; extending from the substation building perimeter to existing main road drain.	m	22		
5.	<i>Slotted Drain.</i> Ref. Dwg. PJ199/L/4 Construct 450mm wide slotted drain over existing roadside drain.	m	5		
TOTAL					

Completion Time: months from Purchase Order Date (inclusive of time for submission of RAMS for approval and attendance to Safety Induction Course)

(Signature and Company Stamp)

Date: _____

Name :

Position :

Company Name :

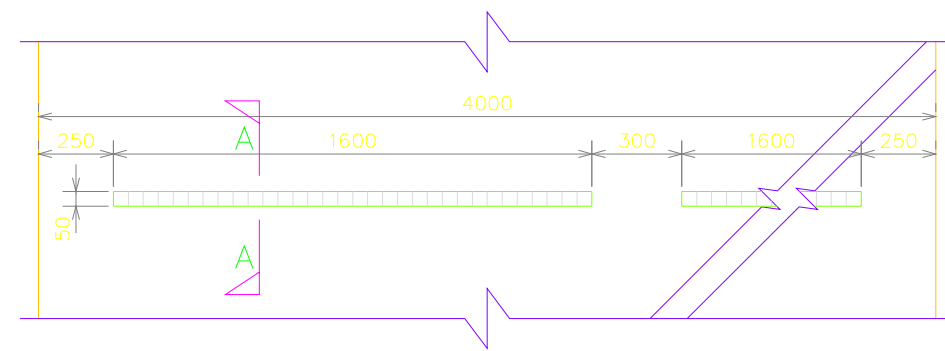
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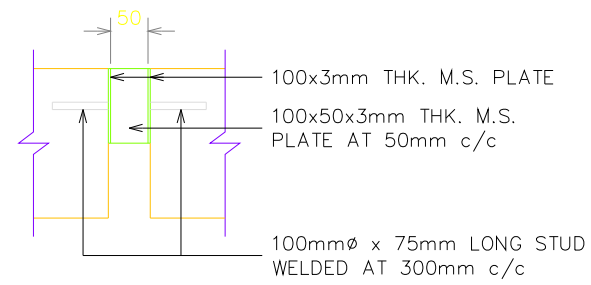
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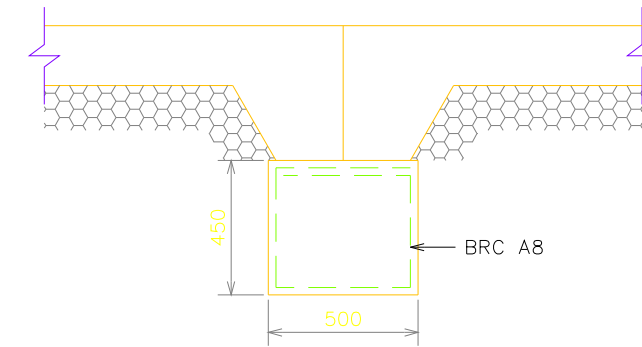
CONSTRUCTION OF ACCESS ROAD
AT FIRE BRIGADE 11KV PRIMARY SUBSTATION



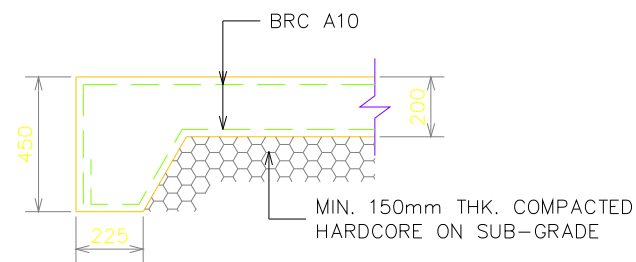
SLOTTED DRAIN DETAIL



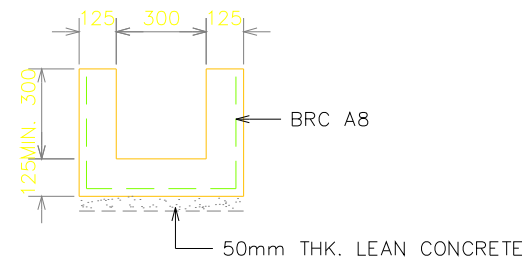
SECTION A-A



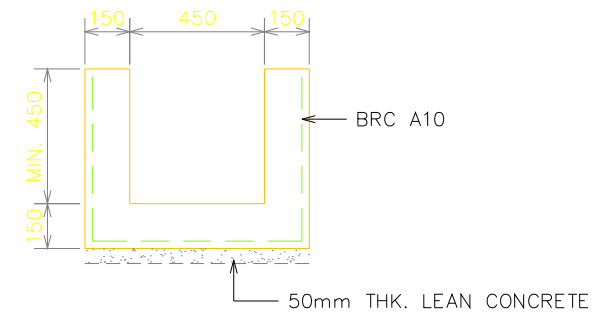
CONSTRUCTION JOINT DETAIL



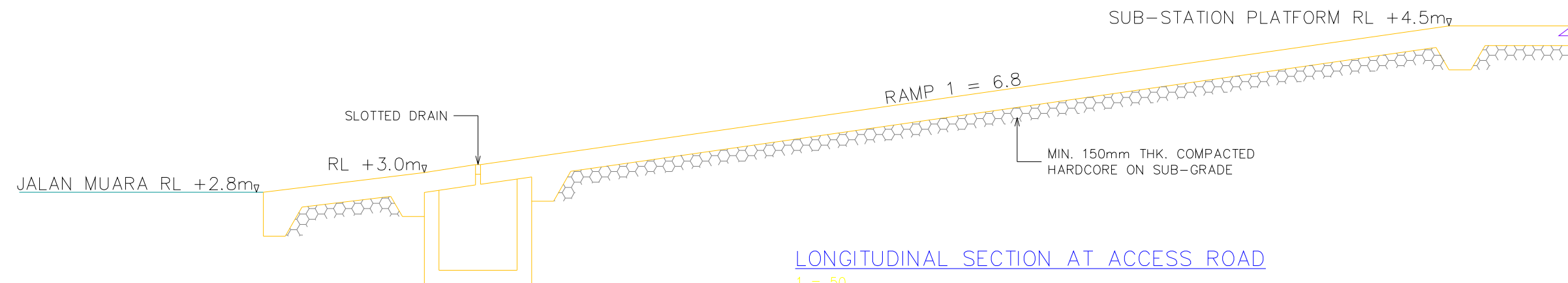
TYPICAL CONCRETED PAVEMENT DETAIL



TYPICAL 300mm WIDE DRAIN



TYPICAL 450mm WIDE DRAIN



LONGITUDINAL SECTION AT ACCESS ROAD

$$1 = 50$$

OVE ARUP dan RAKAN-RAKAN BRUNEI SPG. 748, KG. TASEK BERKAYU, JALAN TUTONG, B.S.B. BF1520, P. O. BOX 892, B.S.B. BS8671 TEL: 2653290	TITLE		PAVEMENT DETAILS	
	REV.	DATE	DESCRIPTION	
			DRAWN BY	DATE
		DLS	DECEMBER 2012	REV.
		SCALE	DRAWING NO.	
		1 = 10, 25, 50	PJ199/L/4	

TECHNICAL SPECIFICATIONS INDEX

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1 NOTES

- 1.1 This Technical Specifications is to be read in conjunction with all other parts of these Contract Documents.
- 1.2 This Technical Specifications is a standard document and where items of materials and workmanship are not specified herein, the Contractor is referred to the Drawings and to the Bills of Quantities for details and for locations of finishes. Specifications clauses that are not applicable to this Contract should be disregarded.
- 1.3 Where there are no details of a particular finishing material or other material or standard of workmanship, this shall be taken as being in accordance with the manufacturer's recommendations and accepted practice for good quality workmanship.
- 1.4 Finishes materials, methods of construction and details of workmanship, where shown in the Drawings, supersede details contained in this Technical Specifications.
- 1.5 The description of Materials, Workmanship and General Clauses shall apply to the whole of the Works regardless of the trade headings under which they have been described and shall be read in conjunction with the Drawings.
- 1.6 In the following descriptions of materials, the letters B.S. refer to the British Standards as published by the British Standards Institution, London. The letters C.P. refer to the British Standard Code of Practice issued by the Council for Codes of Practice. The letters P.B.D. refer to Piawai Brunei Darussalam issued by the Ministry of Development, Negara Brunei Darussalam. The Piawai Brunei Darussalam in defining requirements of any Specifications items or works shall take priority over other reference documents. The latest amendment is implied in each case.
- 1.7 All materials incorporated in the permanent work and all workmanship employed in its construction shall be consistent with good practice and where applicable and unless stated otherwise in the Contract, shall comply with any relevant British Standard and British Standard Code of Practice and Piawai Brunei Darussalam as stated in Clause 2.3 of this Technical Specifications.
- 1.8 Where works are ordered to be performed by the Contractor but such works are not specified in this Technical Specifications, the Contractor must nevertheless carry them out with full diligence and expedience.
- 1.9 The Contractor's attention is drawn to the Conditions of Contract, and to the Bill No. 1 - Preliminaries and General Conditions. Any financial obligations thereby imposed shall be specifically priced within Bill No. 1 or otherwise allowed for among other unit rates.
- 1.10 The term "Superintending Officer" wherever used in the Bills of Quantities or Technical Specifications shall mean the Engineer.
- 1.11 Where manufacturer's items are so specified in this Technical Specifications or in the Drawings, this is to be read as "equal or approved equivalent".

2 GENERAL**2.1 SURVEY OF PROPERTIES, LANDS AND CROPS**

- 2.1.1 Where appropriate, the Engineer shall arrange for surveys to be carried out, in conjunction with the Contractor and owners or occupiers, of the condition of all properties, lands and crops which may be affected by the Works.
- 2.1.2 Before any work is commenced, the Contractor shall confirm in writing to the Engineer that the relevant survey is a true and accurate record of the condition of all properties, lands and crops inspected.

2.2 SITE FENCING

- 2.2.1 As soon as the Contractor is given possession of any part of the site, he shall erect site fencing of the type and at the locations shown in the Contract. The Contractor shall regularly inspect and maintain all such fencing, any defects being made good without delay. Access shall be provided in temporary site fencing as necessary for the use of occupiers of adjacent lands. Temporary site fencing shall remain in position until either it is replaced by permanent fencing or the Works are completed on that part of the site.

2.3 LEVELS AND REFERENCE POINTS

- 2.3.1 The Contractor shall supply to the Engineer details of the value and location of the temporary benchmarks and reference points which he proposes to use.
- 2.3.2 The Contractor shall satisfy himself that the existing ground levels as indicated in the Contract are correct. Should the Contractor wish to dispute any levels, he shall submit to the Engineer a schedule of the positions of the levels considered to be in error and a set of revised levels. The existing ground relevant to the disputed levels shall not be disturbed before the Engineer's decision as to the correct levels is given.

2.4 AREA OF SITE, ADDITIONAL AND MAINTENANCE AREAS

- 2.4.1 The site as defined in the Contract will be made available to the Contractor free of charge for the purpose of the Contract. The site includes the "works areas" and "borrow areas", if any, indicated in the Drawings and includes such other areas of roads, footpaths and lands which, in the opinion of the Engineer, are necessary for the execution of the Works. The Contractor shall confine his constructional operations within the site, or such other areas of land as may be negotiated, and shall instruct his workers not to trespass.
- 2.4.2 The Contractor may apply to the Engineer in writing for an additional area to be included in the site. If, in the opinion of the Engineer, such an additional area is required to meet special circumstances which have arisen due to a change in the extent or nature of the Works then if a suitable area is available, the Engineer will arrange for the area to be allocated to the Contractor free of charge. Other than in accordance with the provisions of this sub-clause, the Contractor will make his own arrangement for any additional area he requires.
- 2.4.3 The area so indicated in the Drawings shall be made available to the Contractor free of charge for the duration of the period of purposes in connection with the Contract. No plant, equipment or stores other than those specifically required for maintenance purposes shall be stored in the area.

2.5 TEMPORARY ACCOMMODATION FOR THE ENGINEER

- 2.5.1 Where required, the Contractor shall provide, erect, service and subsequently dismantle temporary accommodation for the use of the Engineer and his staff on a site chosen by the Engineer.
- 2.5.2 The layout, together with a list of furnishings, is detailed in the Contract.

2.6 TEMPORARY SITE LABORATORY

- 2.6.1 Where required, the Contractor shall provide, erect, service and subsequently dismantle temporary site laboratory.
- 2.6.2 The layout, furnishings and services required are detailed in the Contract. Staff shall be provided by the Contractor and shall be subject to direction and approval by the Engineer.

2.6.3 As a minimum, the site laboratory shall be equipped to perform the following tests:-

- a) Determine Liquid Limit & Plastic Limits of cohesive soil.
- b) Determine moisture content of soil.
- c) Determine particle size distribution by sieve analysis.
- d) Determine specific gravity of soil sample.
- e) Determine the dry density / moisture content relationship using 2.25kg or 4.5kg rammer.
- f) Determine laboratory CBR value.
- g) Determine in-situ CBR value.
- h) Determine in-situ density by sand replacement method.
- i) Prepare and cure 150mm concrete test cubes.

2.6.4 All testing shall be conducted and reported in accordance with the relevant section of B.S. 1377 or with other suitable standards. In addition, the laboratory shall have the capabilities to perform any tests listed in Section 6 failing which the Contractor shall include in his tender for such tests to be carried out at a central laboratory as required.

2.7 CONTRACTOR'S TEMPORARY ACCOMMODATION

2.7.1 The Contractor shall provide and maintain all necessary sheds and stores and remove the same from the site on completion of the Works. No structure shall be erected by the Contractor within the site without the Engineer's written consent; such consent will not relieve the Contractor of the responsibility of siting temporary structures clear of the Works. A copy of the plan showing the extent and position of all offices, stores, sheds, etc. shall be prepared by the Contractor and retained for inspection in the site office.

2.7.2 No temporary accommodation for workers shall be erected by the Contractor within the site without the Engineer's written consent. The Contractor shall provide proper sanitary facilities for his personnel and shall ensure that these, together with all other temporary accommodation, are approved by the Engineer and kept in a clean and sanitary condition.

2.8 EMERGENCY ARRANGEMENTS

2.8.1 The Contractor shall maintain arrangements whereby he can quickly call out labour outside normal working hours to carry out any work needed for an emergency associated with the Works. The Engineer shall be provided at all times with a list of addresses and telephone numbers of the Contractor's staff who are currently responsible for organising emergency work.

2.8.2 The Contractor shall acquaint himself and his workers with any relevant local arrangements which are in existence for dealing with emergencies.

2.9 ASSISTANCE TO ENGINEER

2.9.1 The Contractor shall provide all labour, survey instruments, staging, ladders, wire ropes and other equipment, information and assistance required by the Engineer and his staff for inspecting, measuring and for the supervision of the Works.

2.10 SAFETY PRECAUTIONS AND FIRST AID

2.10.1 The Contractor shall be responsible for the safety of all persons engaged in the execution of the Works and shall take such safety precautions as are generally accepted as good civil engineering practice, including the provision of first aid equipment and personnel trained in its use.

2.10.2 When working in drains and sewers, adequate safety equipment shall be provided and maintained to the satisfaction of the Engineer. The Contractor's attention is drawn to the minimum requirements contained in the publication "Safety Precautions in Sewers, Drains and Other Enclosed Spaces", part reproduced as in the Appendices to the Preambles.

2.10.3 When work is being carried out over water, adequate life saving equipment shall be provided and maintained, all to the satisfaction of the Engineer.

2.10.4 The Contractor shall nominate a senior member of the site staff as Safety Officer. This person shall make a safety inspection once a fortnight with the Engineer.

2.11 PROGRESS PHOTOGRAPHS

- 2.11.1 Where required by the Contract, the Contractor shall provide record progress photographs taken as and when directed by the Engineer and in any case at intervals of not more than one month. The photographs shall be sufficient in number and location to record the exact progress of the Works. Two copies of each not less than 3R size shall be provided plus additional copies on request. The Contractor shall supply approved albums to accommodate the photographs, which will become the property of the Employer.

2.12 SUPPLY OF WATER

- 2.12.1 The Contractor shall arrange for an adequate supply of fresh water at the site, including provision of any storage tanks, so that sufficient fresh water is always available for the execution of the Works.

2.13 INTERFERENCE WITH ACCESS TO PROPERTIES

- 2.13.1 Before interfering with access to any property, the Contractor shall provide satisfactory alternative arrangements. The Contractor shall notify the Engineer and the relevant occupiers in writing 14 days in advance of any such interference.

2.14 PROCEDURE FOR COMPLAINTS AND CLAIMS FOR DAMAGE

- 2.14.1 Details of all claims or warnings of intended claims which the Contractor may receive in respect of matters against which he is required by the Contract to indemnify the Employer shall be notified without delay to the Engineer, who shall likewise pass to the Contractor any such claims or warnings which may be submitted directly to the Engineer or Employer.
- 2.14.2 A similar exchange of information shall also be made in relation to all complaints which may be received.
- 2.14.3 The Contractor shall notify the Engineer in writing immediately following any damage or injury arising out of execution of the Works.

2.15 PROTECTION AGAINST DAMAGE

- 2.15.1 The Contractor shall take all necessary precautions to avoid causing any damage to roads, lands, properties, trees and other features, and during the currency of the Contract shall deal promptly with any complaints by owners or occupiers.
- 2.15.2 Where any portion of the Works is close to, across, or under any existing apparatus of public utilities or other parties, the Contractor shall temporarily support and work round, under or adjacent to all apparatus in a manner designed to avoid damage, leakage or danger and to ensure uninterrupted operation.
- 2.15.3 Should any leakages or damage be discovered, the Contractor shall at once notify the Engineer and the Statutory Authority owner concerned, and the Contractor shall afford every facility for the repair or replacement of the apparatus affected.

2.16 PROTECTION OF WORKS FROM WEATHER

- 2.16.1 The Contractor shall carefully protect from damage by rain, heat or inclement weather all work which may be adversely affected thereby.

2.17 WORKS AFFECTING WATERCOURSES

- 2.17.1 The Contractor shall notify the Engineer in writing 14 days in advance of his intention to start any part of the Works affecting a watercourse.
- 2.17.2 The Contractor shall be responsible for maintaining watercourses within the site in effective working condition at all times.
- 2.17.3 The Contractor shall take all practicable measures, which shall be to the prior approval of the Engineer, to prevent the deposition of silt or other material in and the pollution of any existing watercourses, lake, reservoir or catchment area, arising from his operations.

2.18 REMOVAL OF TREES, PIPES, CABLES, ETC.

- 2.18.1 If any trees, utility services or other obstructions are required to be removed during the progress of the Works and are not otherwise specifically catered for in the Contract, the Contractor shall draw the Engineer's attention to them and the Engineer shall arrange for their removal by the Contractor or otherwise.

2.19 CLEANLINESS OF SITE

- 2.19.1 The Contractor shall remove all rubbish, debris, cement bags, disused formwork, etc. as they accumulate on the site, at least once weekly, and clean the area by sweeping and flushing with water as necessary so that the site is kept constantly clean and tidy during the progress of the Contract.
- 2.19.2 The Contractor shall be responsible for ensuring that no earth, debris or rock is deposited on public or private rights of way as a result of the Works, including any deposits arising from the movement of plant and vehicles.
- 2.19.3 The Contractor shall clean all vehicles and plant before they leave the site to ensure that no earth, mud, debris, etc. is deposited by them on roads.
- 2.19.4 The Contractor shall provide all facilities and labour required for complying with this Clause.

2.20 RESTRICTIONS ON USE OF ROADWAYS

- 2.20.1 The Contractor shall not make use of public or private rights of way for depositing or storing plant or materials, other than such plant, materials and tools as shall from time to time be required for immediate use on the several sections of the Works. Plant, materials and temporary works shall be placed in such a way as to cause minimum interference with the use of any right of way by the public and the Contractor shall maintain those parts of the right of way not temporarily occupied by the Works in a clean, passable and safe state at all times.

2.21 TRAFFIC ARRANGEMENTS

- 2.21.1 Before any work in or affecting the use of any roadway is commenced, the Contractor's proposed method of working shall be agreed with and confirmed in writing to the Engineer, the Roads Department and the Police.
- 2.21.2 Throughout the execution and maintenance of the Works, the Contractor shall co-operate with the aforementioned Authorities concerning works in, or access to the roadway. The Contractor shall inform the Engineer of any requirements of, or arrangements made with the Authorities.

2.22 TEMPORARY DIVERSION OF TRAFFIC

- 2.22.1 The Contractor shall construct and maintain diversion ways wherever the Works will interfere with existing roads, footways or other ways over which there is a public or private right of way.
- 2.22.2 The standard of construction and lighting shall be suitable in all respects for the class or classes of traffic using the existing way and the width of the diversion shall be not less than that of the existing way unless described otherwise in the Contract.
- 2.22.3 Diversion ways must be constructed in advance of any interference with the existing ways and shall be maintained to provide adequately for the traffic flows.

2.23 TRAFFIC CONTROL, WATCHING AND LIGHTING

- 2.23.1 The Contractor shall comply in all respects with all local Road Traffic Regulations concerning the lighting and guarding of road works.

2.24 LOCATION OF UTILITY SERVICES

- 2.24.1 For the information of the Contractor, details and extent of existing services and installations and future services and installations likely to be carried out by the public utilities Authorities are shown in the Drawings. These have been prepared from information provided by the Authorities but neither the Employer nor his representatives accept any responsibility whatsoever for the accuracy of the Drawings or for the

information contained thereon and the Contractor shall make such further enquiries and investigation as are required for his own information.

2.25 CARE OF UTILITY SERVICES

- 2.25.1 The Contractor shall exercise the greatest care during the progress of Works to avoid damage to or interference with any utility services within the vicinity of the site and shall be responsible for any such damage caused by him or his agents directly or arising indirectly from anything done or omitted to be done. The Contractor shall carry out all temporary works necessary to adequately support and protect such services.
- 2.25.2 Where alterations to services are necessitated by the Works, no adjacent work will be commenced until the alterations have been made.
- 2.25.3 If, in the Engineer's opinion, damage may be caused by the operation of mechanical plant over or adjacent to any utility services, the Contractor shall be required to excavate by hand in their vicinity. The rates in the Contract shall include for such hand excavation.
- 2.25.4 Before excavations are carried out near utility services by means of mechanical plant, the Contractor shall carry out full and adequate preliminary investigations to locate utility services by means of hand-dug trial holes. Should any cables, ducts and/or cover tiles be exposed, the respective utility undertakers should be contacted to determine if all the services had been located. The ducts and cover tiles should only be removed directly by the Authorities concerned.
- 2.25.5 The cost of all investigations arising from the requirements of this Clause shall be borne by the Contractor.
- 2.25.6 The Contractor shall confirm with the Engineer that the layouts for all services have been approved by the relevant public utilities Authorities. Materials shall not be ordered prior to this approval.

2.26 PUBLIC UTILITIES - WORKS AND PROGRESS

- 2.26.1 Public utilities Authorities may be carrying out certain works within the site and the Contractor's attention is drawn to the Contract which makes provision for this.
- 2.26.2 In the preparation of the programme of work to be submitted as required by the Contract, the Contractor shall be responsible for arranging, co-ordinating and agreeing with the Authorities a programme for their works. The Contractor shall make full allowance for time and provision of facilities and working space for the Authorities in the preparation of his programme.
- 2.26.3 The Contractor shall be responsible for maintaining close liaison with the Authorities during the progress of the work and no claims for extra costs or delays incurred by the failure of Authorities to comply with the agreed programme of works will be considered unless, in the opinion of the Engineer, the Contractor has taken all reasonable steps to cause the Authorities to proceed with their work in accordance with the agreed programme.

2.27 NOISE CONTROL ON WORKS SITES

- 2.27.1 All audible works and ancillary operations shall be carried out only between 8:00 a.m. and 5:00 p.m. on official work days and at no other time except where the written approval of the Engineer has been obtained.
- 2.27.2 The best practicable means shall be employed at all times to reduce noise to minimum.
- 2.27.3 All plant and machinery in use shall be properly silenced and maintained and operated in accordance with the manufacturer's instructions and recommendations.
- 2.27.4 The noise level outside the nearest occupied room shall not be caused by the Contractor to exceed an Leq (12 hours) value of 75 dB(A) during the working hours specified in Clause 2.27.1 above.
- 2.27.5 Where it is necessary to operate plant intermittently or continuously outside the working hours specified in Clause 2.27.1 above, or in such other circumstances as the Engineer may consider necessary, the noise produced by such operations shall not exceed the pre-existing background noise level outside the nearest occupied room. The Contractor should take particular regard of this requirement as it may affect inter alia his plant and methods of operating dewatering equipment, pumps, etc.

- 2.27.6 The provisions of this Clause shall not be applicable in the case of emergency work necessary for the saving of life or property or for the safety of the Works.

2.28 MATERIALS SUPPLIED BY THE EMPLOYER

- 2.28.1 Any material supplied by the Employer shall be delivered to the Contractor either at ship, Employer's stores or quarries on presentation of a requisition signed by the Engineer. The Contractor must satisfy himself at the time of taking delivery that all stores stated in the requisition are handed over to him and that each article is in good condition. No claim for compensation after they have been removed from the ship or stores can be entertained. The Contractor shall remove the whole of the articles to the Works and house them to the satisfaction of the Engineer in a proper store until such time as they are required for use in the Works.
- 2.28.2 The Contractor shall be held responsible for all stores issued to him by the Engineer and shall make good any damage or losses to the same, the value of such damage or loss being assessed by the Engineer and deducted from the Engineer's certificates for payment to the Contractor.
- 2.28.3 Where materials supplied by the Employer are delivered in crates or containers, the Contractor shall dispose of such crates or containers as directed by the Engineer.

2.29 PREVENTION OF MOSQUITO BREEDING ON BUILDING AND CONSTRUCTION SITES

- 2.29.1 The Contractor shall provide, throughout the period of the Contract, a central collection point on the site, to the approval of the Engineer, at which all empty cans, oil drums, packings and other receptacles capable of holding water shall be deposited and he shall, at his own cost, provide for the regular collection and removal of such articles from the site.
- 2.29.2 The Contractor shall, at his own cost, treat any standing water on the site with an approved oil at least once a week.
- 2.29.3 All items on site, including constructional plant capable of retaining water shall be so stored, covered or treated as to prevent water collecting in them and the Contractor shall allow for the cost of so doing.
- 2.29.4 The Contractor shall, at his own cost, obtain and display prominently upon all structures or temporary huts on site, posters in the appropriate languages, drawing attention to the dangers of allowing the breeding of mosquitoes. These posters shall be removed on completion of the Works.

2.30 WORKS IN THE DRY

- 2.30.1 All works shall be carried out in the dry, unless authorised otherwise by the Engineer. The Contractor shall arrange for the rapid dispersal of water which enters the Works from any source and when practicable the water shall be discharged into the permanent drainage system. Adequate means for trapping silt shall be provided before discharging into the permanent systems.
- 2.30.2 The Contractor shall provide where necessary temporary water courses, ditches, drains, pumping, well pointing or other means of maintaining the Works free of water.

2.31 ADVERTISING ON WORKS SITE

- 2.31.2 No advertising notice boards of any kind are to be erected on the site without the prior consent of the Engineer in writing. The proposed advertising board design shall be submitted to the Engineer for approval well in advance of the intended erection.

2.32 SIGNBOARDS

- 2.32.1 Where required by the Contract, the Contractor shall provide, erect, maintain and dismantle signboards to the satisfaction of the Engineer. The signboards shall be of a suitable material and shall be in accordance with the Drawings in respect of the lettering, characters and diagrammatic or perspective views shown thereon.

2.33 ENGINEER'S VEHICULAR TRANSPORT

- 2.33.1 Where required by the Contract, the Contractor shall provide and keep available at all times vehicular transport required for the use of the Engineer's staff.

- 2.33.2 The Contract rates for the vehicular transport shall include for all costs of providing, running and upkeep of the transport including depreciation, taxes, insurances, fuel, oils, lubricants, repairs, maintenance, cleaning and the service of competent drivers approved by the Engineer.
- 2.33.3 The vehicle(s) shall revert to the Contractor on the expiry of the Period of Maintenance as defined in the Contract or at such date as the Engineer may advise the Contractor in writing. The Contractor shall make available alternative transport during the periods when the vehicle(s) so provided are under repair or maintenance or cannot be used for any reason.

3 MATERIALS**3.1 GENERAL**

3.1.1 All materials used in the Works shall be of the quality, grade and dimensions stated in the Contract.

3.2 APPROVED

3.2.1 Wherever the word 'approved' or 'approval' appears in this Section, it shall refer to approval by the Engineer.

3.3 BRITISH STANDARDS

3.3.1 Unless specified otherwise, all materials shall be in accordance with the relevant British Standards (B.S.) or Code of Practice (C.P.).

3.3.2 A list of such Standards is provided in the Appendices to this Technical Specifications but omission of any B.S. from this list shall not limit the generality of the Clause.

3.3.3 The editions of the B.S. and C.P. that shall apply to the Contract shall be those listed in the British Standards Catalogue current 42 days prior to the date for return of Tenders unless required otherwise in the Contract.

3.3.4 Should alternative requirements be provided by a B.S. and no one alternative be specified elsewhere in the Contract, then before proceeding to execute the Works or to order materials, the Contractor shall give notice requesting further specification of such matter.

3.4 SUBMISSIONS OF SAMPLES AND TEST CERTIFICATES

3.4.1 As soon as possible after the Contract has been awarded and if so required by the Engineer, the Contractor shall submit to the Engineer a list of the suppliers from whom he proposes to purchase the materials for the execution of the Works.

3.4.2 The information regarding the names of the suppliers may be submitted at different times, as may be convenient, but no source of supply shall be changed without the Engineer's prior approval.

3.4.3 If required by the Engineer, the Contractor shall submit to the Engineer test certificates furnished by the supplier or manufacturer of any material or article indicating compliance with the requirements of the Contract.

3.5 INVOICES

3.5.1 The Contractor shall produce all delivery notes and the like for any materials if required by the Engineer.

3.6 STORAGE OF MATERIALS

3.6.1 Materials and components shall be stored in such a manner as to preserve their quality and condition to the standards required by the Contract.

3.6.2 The quantity of materials and components stored on the site shall be consistent with that necessary for efficient working.

3.7 HANDLING OF MATERIALS

3.7.1 Materials and components shall be handled in such a manner as to avoid any damage or contamination, and in accordance with all applicable recommendations by the manufacturers.

3.8 IMPORTED TOPSOIL

3.8.1 Imported topsoil shall be approved material capable of supporting plant growth and containing no deleterious matter. It shall be of light or medium texture, having a pH value of between 6.0 and 7.5. Imported topsoil shall not contain stones greater than 50mm in size, nor have a total stone content exceeding 10% by weight.

3.9 IMPORTED TURF

- 3.9.1 All turfs shall be cut 300mm wide and at least 300mm long. They shall consist of healthy dense indigenous carpet grass firmly rooted into at least 50mm of topsoil. The turf shall be free from Mimosa, Lallang and any other objectionable plants and should be preferably laid on the day it is cut. Turf which cannot be laid within three days of cutting may, at the discretion of the Engineer, be classified as topsoil.

3.10 GRASS SEED

- 3.10.1 Grass seed shall be an approved tested blend of named varieties and certificates of purify and germination shall be provided.

3.11 FERTILIZER

- 3.11.1 Fertilizer shall consist of a compound containing not less than 10% nitrogen, 15% phosphoric acid, and 10% potash

3.12 RUBBLE GENERALLY

- 3.12.1 Rubble shall consist of broken stone of a durable nature, hard, clean and free from dust, clay, organic or other deleterious matter, and from elongated or brittle pieces. The individual stones shall be of the size and shape as specified in the Contract

3.13 BUILDING DEBRIS

- 3.13.1 Building debris shall consist of recovered materials from the demolition of buildings such as broken brick of concrete, plaster, mortar, rubble and the like, and shall be free from steel, timber and other organic and deleterious material.

3.14 HARDCORE

Hardcore shall consist of recovered stone, broken brick or concrete, free from general building debris and organic or other deleterious matter.

3.15 WATER

- 3.15.1 Water for the Works is to be taken from:-

- a) public supplies of potable water; and/or
- b) any other source, as approved for one or more purposes after such treatment and such test as the Engineer may require; if for mixing of cement in any form, the Contractor must arrange with the Engineer, five weeks in advance of such use, for testing of the water to B.S. 3148.

3.16 FABRIC MEMBRANES

- 3.16.1 Fabric membranes shall be as described in the Contract and shall be used strictly according to the manufacturer's instructions.

3.17 STEEL SHEET PILES

- 3.17.1 Steel from which steel sheet piles are rolled shall comply with the relevant requirements of B.S. 4360.
- 3.17.2 Sheet piles shall be straight, true to section, and free from seams, flaws, cracks, laminations and other injurious defects.
- 3.17.3 Maximum rolling margins shall be 4% above and 2.5% below the calculated masses, and 75mm over and 50mm under the required lengths.
- 3.17.4 Before being driven, permanent steel sheet piles shall be wire-brushed to remove loose rust and dirt, and be coated with black tar-based paint complying with B.S. 1070, Type B.

3.18 TIMBER GENERALLY

- 3.18.1 Timber generally shall be of mature growth, properly seasoned and sawn square. Timber shall be free from wood warp holes, large loose or dead knots, splits or other defects which will reduce its strength. Pin holes and worm holes shall be permitted to a slight extent in a small number of pieces provided that there is no active infestation of the material.

3.19 QUARRY SPALLS

- 3.19.1 Quarry spalls shall comprise sound hard granite resulting from quarry operations, obtained from an approved source, and shall be free from vegetable matter, earth or other impurity.
- 3.19.2 The maximum size shall be 225mm and the grading shall be such that not more than 10% shall be less than 100mm.
- 3.19.3 Where second grade material is required, granitic material unsuitable for use in concrete work may be used, but the foregoing size requirements shall still apply.

3.20 AGGREGATES FOR BITUMINOUS MIXTURES

- 3.20.1 Coarse aggregates for bituminous mixtures shall consist of clean, hard, durable crushed rock to B.S. 4987, angular but not flaky and substantially free of material passing a 3.35mm B.S. sieve.
- 3.20.2 Fine aggregate shall consist of crushed rock as above or of clean sand to B.S. 4987 substantially all of which shall pass a 3.35mm B.S. sieve. If sand is used, the total content of silt, loam and clay shall not exceed 3% by weight of the fine aggregate determined by the sedimentation method of B.S. 812.
- 3.20.3 The filler shall consist of crushed rock as above, hydrated lime or Portland cement, and at least 75% of it shall pass a 75µm B.S. sieve.

3.21 AGGREGATES FOR SURFACE DRESSING

- 3.22 Aggregates for surface dressing shall consist of clean, hard, durable crushed rock and shall be to B.S. 63.

3.22 COMPOSITION OF BITUMINOUS MIXTURES

- 3.22.1 The compositions of various bituminous mixtures are shown in Table 8.8 - 8.12 of Section 8.

3.23 DOWEL BARS IN CARRIAGEWAYS

- 3.23.1 Dowel bars in carriageways shall consist of plain mild steel bars to B.S. 4449 and shall be free from oil, paint, dirt and loose rust. They shall be straight, free from burred edges or other irregularities and shall have their sliding ends sawn, not sheared, unless approved otherwise by the Engineer.

3.24 JOINTING MATERIALS FOR CONCRETE CARRIAGEWAYS

- 3.24.1 The materials for filling, priming and sealing of joints in concrete roads and similar paving shall, for each location, be obtained from a single manufacturer, shall be used strictly in accordance with that manufacturer's instructions and shall be of grades suited to the climatic conditions of Brunei.
- 3.24.2 Joint fillers shall be preformed to the dimensions described in the Contract and shall be of a proprietary brand, purpose-made for the appropriate location in the Works. They shall be installed in accordance with the manufacturer's instructions.
- 3.24.3 Joint sealers shall consist of hot or cold poured compounds or of a preformed neoprene compression strip. Hot poured compounds shall be to B.S. 2499.

3.25 PRECAST CONCRETE KERBS, EDGINGS, QUADRANTS AND FLAGS

- 3.25.1 Precast concrete units shall comply with B.S. 7263 and shall be cast to the dimensions described in the Contract in Grade G30 concrete with maximum aggregate size of 20mm.

- 3.25.2 Precast concrete kerbs, edgings and quadrants shall be cast to the dimensions of the appropriate B.S. 7263 Figure. They shall be cast in new steel moulds which are appropriately curved where necessary, maintained free of damage and provided with effective grout seals.
- 3.25.3 A high quality of road kerb will be required and before commencing production of kerbs, the Contractor shall submit two samples of the precast kerb to the Engineer for his approval.
- 3.25.4 No kerbs shall be painted either before or after laying without the written consent of the Engineer
- 3.26 GRANITE KERB.S.
- 3.26.1 Granite kerbs shall be made from hard, clean durable stone worked straight or circular, square with the top front and top back edges parallel. They shall be to the dimensions required by the Contract and shall normally have a minimum length of 600mm. Ends shall be chisel dressed neatly and accurately square to form a close butt joint. The top and front faces shall be fine punched on exposed areas. The back face shall be dressed to a depth of 75mm with a 25mm chisel-drafted margin to form a joint with the footway paving. The back below the dressing may be left rough.
- 3.27 PRECAST CONCRETE FLAGS
- 3.28 Precast concrete flags shall be hydraulically pressed and shall comply with the relevant requirements of B.S. 7263. Unless described otherwise in the Contract, flags shall be 50mm thick.
- 3.29 PAINT FOR ROAD MARKING
- 3.29.1 Paint for road marking shall be made by an approved manufacturer specifically for road marking under the traffic and climatic conditions prevailing in Brunei. It shall be suitable for applying by brush or mechanical means to cement concrete or bituminous pavement to give a chemically stable film of uniform thickness. The drying time shall not exceed 30 minutes and the paint shall contain not less than 8% titanium dioxide plus zinc oxide and not more than 70% basic pigment, barium sulphate and calcium carbonate. It shall be white or yellow as described in the Contract. Yellow paint shall be standard colour B.S. 381C No. 356.
- 3.29.2 The paint shall be supplied fresh and ready for use in sealed containers, which shall be stored in accordance with the manufacturer's instructions. Unless agreed otherwise by the Engineer, the paint shall be applied without the use of thinners or other additives.
- 3.29.3 Where required by the Contract, the paint shall be suitable for the incorporation of "ballotini" (glass spheres) for reflective purposes. The ballotini shall comply with the general requirements for ballotini in B.S. 3262 : Part 1 but shall pass a 850µm B.S. sieve and not more than 5% shall pass a 150µm B.S. sieve.
- 3.30 PAINTS AND OTHER PROTECTIVE COATINGS
- 3.30.1 All paints shall be obtained from suppliers approved by the Engineer. Unless agreed otherwise by the Engineer, all paints forming part of any one painting system shall be obtained from the same source. Paint shall be supplied in the manufacturer's sealed containers of not more than 5 litres capacity and shall be used in strict rotation. Unless agreed otherwise by the Engineer, samples of paint of not less than 2 litres shall be submitted to the Engineer for approval.
- 3.30.2 The containers shall be clearly labelled with the following information:-
- a) Name of manufacturer.
 - b) Brand name and specification type.
 - c) Primer, undercoat or finish coat.
 - d) Interior or exterior use.
 - e) Colour.
 - f) Method of application (brush, spray or roller).
 - g) Batch number and date of manufacture.
- 3.31 PERMANENT FENCING
- 3.31.1 Permanent fencing shall comply with the relevant requirements of the appropriate part of B.S. 1722.

3.32 CEMENT

- 3.32.1 The various types of cements shall comply with P.B.D. 6 : Part 1, Section 3.2.
- 3.32.2 For other types of cement not listed in the preceding clause, the Contractor shall inform the Engineer 7 days in advance of usage with all qualifying conditions for the use of such cements.

3.33 AGGREGATES FOR CONCRETE

- 3.33.1 The various types of aggregates shall comply with P.B.D. 6 : Part 1, Section 3.3.

3.34 BONDING AGENTS

- 3.34.1 Bonding agents shall be of the epoxy resin adhesive compound type and shall be strictly according to the manufacturer's instructions.

3.35 NON-SLIP AGGREGATE

- 3.35.1 Non-slip aggregate shall be a non-metallic aggregate possessing a high abrasion resistance index and of approved colour and shall be applied to clean, dry concrete surfaces treated with the appropriate bonding agent. After a natural curing period of 24 hours, surplus aggregate is to be removed by brushing or other means approved by the Engineer.

3.36 CONCRETE CURING COMPOUND

- 3.36.1 Concrete curing compound shall be an approved proprietary brand and used strictly according to the manufacturer's instructions.

3.37 COVER BLOCKS AND SPACERS

- 3.37.1 Concrete cover blocks shall be manufactured with a 10mm maximum aggregate size or produced to the same specification as the surrounding concrete. Wire cast in the block for the purpose of tying it to the reinforcement shall comply with Clause 3.47.6.
- 3.37.2 Spacers shall be of rustproof material and shall not produce staining, or otherwise be detrimental to the concrete or steel.

3.38 RELEASE AGENTS

- 3.38.1 Release agents effective for the prevention of adhesion of concrete to the face of moulds and shutters shall be an approved proprietary brand and used strictly according to the manufacturer's instructions.

3.39 EPOXY RESINS

- 3.39.1 Epoxy resins are used as adhesives and as additives to produce particular concrete characteristics. All resins shall be an approved proprietary brand and used strictly according to the manufacturer's instructions.

3.40 FIXING FOR METALWORK

- 3.40.1 Rag and indented bolts shall comply with the relevant requirements of B.S. 1494 : Part 2 and shall be hot dip galvanised in accordance with B.S. 729. Steel for rag and indented bolts shall be in accordance with Clause 6.4.1 of B.S. 1494 : Part 2.
- 3.40.2 Mild and high tensile steel proprietary fixings shall be protected by hot dip galvanising in accordance with B.S. 729, or electroplated to Class 'A' of B.S. 1706.

3.41 EXTRACTABLE DUCT-FORMERS

- 3.41.1 Extractable duct-formers shall have the appropriate diameter and shall be an approved proprietary brand and used strictly according to the manufacturer's instructions.

3.42 MORTAR

- 3.42.1 Mortar for brickwork and pipework shall be mixed in the proportions 1 part cement to 3 parts sand by volume.
- 3.42.2 The sand shall be natural sand or crushed natural stone or a combination of both to B.S. 1200.
- 3.42.3 Mortar shall be mixed thoroughly either by hand or mechanically until its colour and consistency are uniform. The constituent materials shall be accurately gauged, allowance being made for bulking of sand. Mortar shall be made in small quantities only as and when required. Mortar which has begun to set or which has been mixed for a period of more than one hour shall be discarded.

3.43 DRY PACK MORTAR

- 3.43.1 Dry pack shall be a stiff cement mortar composed of Portland Cement and fine aggregate which shall be thoroughly mixed with water to obtain a strength when vibrated in standard cylinders of not less than 30 N/mm² at 28 days. The mix shall have a minimum water content compatible with achieving a consistency suitable for ramming into place using caulking tools, all to the approval of the Engineer.

3.44 EPOXY MORTAR

- 3.44.1 Epoxy mortar shall comprise not more than 6.5 parts by weight of a suitable fine aggregate to one part by weight of approved epoxy resin. Concrete surfaces which are to receive epoxy mortar shall be hammered to remove all laitance immediately prior to covering with an epoxy resin tack coat. The mortar shall then be laid and cured, all in accordance with the manufacturer's instructions.

3.45 LIME MORTAR

- 3.45.1 Hydraulic lime slaked on site is to be mixed to a mortar by the addition of the necessary sand and water. Sand covering the slaking heap and then mixed in must be measured as aggregate. The mix should be used within four hours. Hydrated hydraulic lime mortar should be prepared the same way as cement mortar.

3.46 SAND

- 3.46.1 Sand for mortar, plaster, screeds, rendering, etc. shall comply with the relevant sections of B.S. 1198, 1199 and 1200.
- 3.46.2 Sand for concrete shall comply with Clause 3.33. Marine dredged sand shall not be used for concrete without the Engineer's prior written approval.

3.47 REINFORCEMENT FOR CONCRETE

- 3.47.1 Steel reinforcement shall be to B.S. 4449, B.S. 4461 or B.S. 4483 as specified, or an equivalent approved by the Engineer.
- 3.47.2 All steel reinforcement shall be free from scale, oil, paint, dirt, loose rust or any other matter which may tend to destroy the bond between the concrete and the reinforcement of which may prove harmful in any other manner.
- 3.47.3 In the case of deformed bars, the results of bond tests shall be furnished to the Engineer when required.
- 3.47.4 Steel reinforcement shall be obtained from an approved supplier and a mill test certificate showing the place of origin and specification test results shall be produced when required.
- 3.47.5 The Engineer may select samples to be tested and the Contractor shall have no claim for steel mutilated in obtaining these samples. The test procedure shall comply with the Engineer's requirements.
- 3.47.6 Tying wire for steel reinforcement shall be 1.6mm diameter annealed soft iron wire.

3.48 VOID-FORMERS

- 3.48.1 Void-formers shall be accurately formed to the required dimensions. They are to be of expanded polystyrene or of other materials at the discretion of the Engineer.

3.49 WATERPROOF MEMBRANE

- 3.49.1 Waterproof membrane shall be as described in the Contract and shall be used strictly according to the manufacturer's instructions.

3.50 WATERPROOF SEALANT

- 3.50.1 Waterproof sealant shall be as described in the Contract and shall be used strictly according to the manufacturer's instructions.

3.51 WATERPROOF UNDERLAYS

- 3.51.1 Waterproof sealant shall be as described in the Contract and shall be used strictly according to the manufacturer's instructions.
- 3.51.2 Alternatively if not stated in the preceding clause, waterproof underlays shall consist of either waterproof paper to B.S. 1521 Class B, or polythene sheeting 0.08mm minimum thickness to B.S. 3012 or B.S. 4646.

3.52 CLAY PIPES AND FITTINGS

- 3.52.1 Clay pipes and pipeline fittings for sewers shall comply with the relevant requirements of B.S. 65 and shall be of 'British Standard Extra Strength' quality. Pipes and Fittings shall have spigot and socket joints.
- 3.52.2 Short pipes shall be provided on all v.c. sewers at manhole connections to ensure that there are two joints just outside the structure. For each pipe entry, there will be a 600mm long spigot and socket short pipe together with cut length (either spigot ended or socket ended) built into the wall of the manhole.

3.53 CONCRETE CYLINDRICAL PIPES AND FITTINGS

- 3.53.1 Concrete cylindrical pipes and fittings shall comply with the relevant requirements of B.S. 5911 : Part 1. Pipes and fittings with sizes or strengths outside the ranges covered by B.S. 5911 : Part 1 shall comply with the requirements of that Standard where applicable.
- 3.53.2 All pipes and fittings shall have gasket-type flexible joints of spigot and socket, or rebated, form unless described otherwise in the Contract.
- 3.53.3 Pipes having a nominal bore greater than 600mm shall be reinforced concrete pipes as defined in Clause 3.3 of B.S. 5911 : Part 1.

3.54 GLASS-FIBRE-REINFORCED PLASTIC (GRP) PIPES AND FITTINGS

- 3.54.1 Glass-fibre-reinforced plastic pipes, joints and fittings shall comply with the relevant requirements of B.S. 5480 : Parts 1 and 2.

3.55 IRON PIPES AND FITTINGS

- 3.55.1 Grey and ductile iron pipes, fittings and joints shall comply with the relevant requirements of B.S. 4662 Class 3 and B.S. 4772 Class K9 respectively, except that a hot applied bitumen based coating of Type 1, Grade D to B.S. 4147 shall be substituted for hot applied coal tar solution complying with B.S. 4164 as the material specified for dipping.
- 3.55.2 Cement mortar lining for iron pipes shall comply with B.S. 4772 and be sulphate-resisting cement.
- 3.55.3 Polyurethane lined ductile iron pipes shall be suitable for sewerage and shall comply with Class K9 to ISO 2531 or B.S. 4772.
- 3.55.4 Ductile iron pipes laid in trench are to be polythene wrapped in accordance with manufacturer's instructions.
- 3.55.5 Push-in joint, flanged joint and bolted gland joint shall comply with B.S. 8010.
- 3.55.6 Nylon coated couplings from an approved proprietary brand shall be used where indicated as a sleeve coupling to plain-ended pipes.

- 3.55.7 Nylon-coated flanged coupling from an approved proprietary brand shall be used where indicated to join plain ended to flanged ended pipe.

3.56 POLYETHYLENE PIPE

- 3.56.1 Polyethylene pipe for service connections shall comply with the relevant requirements of B.S. 6572 or B.S. 6730.
- 3.56.2 Polyethylene pipe and fittings for gas service shall be approved medium density polyethylene pipe manufactured specifically for gas services and shall be in accordance with International Standards Organisation ISO/DP 4437 and British Gas Standards BCC/PS/PL2 : Parts 1 and 2, laid and jointed strictly according to the manufacturer's instructions.
- 3.56.3 Pipes and fittings shall be manufactured from the very same resin and shall be obtained from the same approved manufacturer.
- 3.56.4 Laying installation and jointing of gas and service pipes shall be carried out by approved personnel experienced in this type of Work.

3.57 PRESTRESSED CONCRETE PIPES AND FITTINGS

- 3.57.1 Prestressed concrete pressure pipes and fittings shall comply with the relevant requirements of B.S. 5178.
- 3.57.2 Unless steam cured, no pipes or fittings shall leave the place of manufacture until they have been allowed to cure and mature under suitable conditions for a total period of not less than 28 days.

3.58 STEEL PIPES AND FITTINGS

- 3.58.1 Steel pipes, fittings and joints shall comply with the relevant requirements of B.S. 534 and B.S. 3601.
- 3.58.2 Pipes for cutting shall be clearly identified and used only as directed.

3.59 UNPLASTICISED PVC PIPES AND FITTINGS

- 3.59.1 Unplasticised PVC pressure pipes shall comply with the relevant requirements of B.S. 3505.
- 3.59.2 Joints and fittings for pressure pipes in accordance with B.S. 3505 shall comply with the relevant requirements of B.S. 4346 : Part 1 and 2 for solvent welded and mechanical joints respectively.
- 3.59.3 Unplasticised PVC pipes, joins and fittings for gravity sewers shall comply with the relevant requirements of B.S. 5481.
- 3.59.4 Solvent cements for solvent welded joints to unplasticised PVC pipes shall comply with the requirements of B.S. 4346 : Part 3.

3.60 PIPES FOR LAND DRAINAGE AND TEMPORARY DRAINS

- 3.60.1 Pipes, joints and fittings for land drainage and temporary drains shall comply with the relevant requirements of the appropriate British Standard, as set out below:-

Type	B.S.
British Standard surface water clay pipes and fittings	65
Concrete porous pipes	5911 : Part 114
Clayware field drain pipes	1196
Unreinforced concrete tubes and fittings	5911 : Part 100
Plastics pipes for use as light duty sub-soil drains	4962

3.61 CABLE DUCTS

- 3.61.1 Cable ducts shall be formed using unplasticised PVC pipes to B.S. 5481 or as described in the Contract.

3.62 GASKETS FOR FLANGED JOINTS

- 3.62.1 Gaskets for flanged pipe joints shall be of the inside-bolt-circle type. The dimensions of gaskets shall comply with B.S. 4865 : Part 1. Gaskets shall be manufactured from material complying with the requirements of B.S. 2494 for Type 1 rings.

3.63 JOINT RINGS AND LUBRICANTS

- 3.63.1 Rubber joint rings for water mains and drainage purposes shall be Types 1 and 2 respectively, complying with the relevant requirements of B.S. 2494, and shall be obtained from the pipe manufacturer.
- 3.63.2 Joint lubricants for sliding joints shall have no deleterious effects on either the joint rings or pipes, and be unaffected by the liquid to be conveyed. Lubricants to be used for jointing water mains shall not impart to water taste, colour, or any effect known to be injurious to health, and shall be resistant to bacterial growth.

3.64 ELECTRODES FOR WELDING

- 3.64.1 Electrodes for welding shall be compatible with the grade of steel to be welded.
- 3.64.2 Electrodes for the manual metal-arc welding of mild and medium tensile steel shall comply with relevant requirements of B.S. 639.
- 3.64.3 Electrodes wires and fluxes for the submerged arc welding of carbon steel and medium tensile steel shall comply with the relevant requirements of B.S. 4165.

3.65 NUTS, SCREWS, WASHERS AND BOLTS

- 3.65.1 Nuts, screws, washers and bolts shall comply with the relevant requirements of the appropriate British Standard as set out below:-

Type	B.S.
Black hexagon bolts, screws and nuts	4190
Metal washers for general purposes	4320
High strength friction grip bolts, nuts and washers	4395
Black cup and countersunk head bolts and screws with nuts	4395

- 3.65.2 Bolting for pipes and fittings shall comply with the relevant requirements of B.S. 4504 : Part 1, except that spheroidal or nodular graphite iron bolts for use with ductile iron pipes and fittings shall be manufactured from metal complying with the requirements of B.S. 2789 for Grade 500/7.
- 3.65.3 Bolt lengths shall be sufficient to ensure that nuts are full-threaded when tightened in their final position.

3.66 PIPE BEDDING AND FILL MATERIAL

- 3.66.1 Granular bedding Type 'A' for pipes and backfilling material for land drains and temporary drains shall consist of free-draining, hard, clean, chemically stable gravel or crushed stone, graded in accordance with the following table:-

B.S. sieve size	Percentage passing by weight			
	Type 'A' 40	Type 'A' 20	Type 'A' 14	Type 'A' 10
63mm	100	-	-	-
37.5mm	85-100	85-100	-	-
20mm	0-25	85-100	100	-
14mm	-	-	85-100	100
10mm	0-5	0-25	0-50	85-100
5mm	-	0-5	0-10	0-25
2.36mm	-	-	-	-

- 3.66.2 Type 'A' bedding material shall have a compaction fraction value not exceeding 0.2 when determined in accordance with Clause 12.19.

3.66.3 Selected fill Type 'B' shall consist of uniform, readily compatible material, free from tree roots, vegetable matter, building rubbish and frozen soil, and excluding clay lumps retained on a 75mm sieve and stones larger than the maximum size permitted in any adjacent Type 'A' bedding material.

3.66.4 Pipe bedding and fill material to concrete pipes shall not contain more than 0.3% sulphate, expressed as sulphur trioxide.

3.66.5 Sand for bedding pipes shall comply with the requirements of B.S. 882, Table 5 for Grading C.

3.67 COMPRESSIBLE FILLER AND PACKING FOR PIPELINES

3.67.1 Compressible filler for interrupting concrete protection to pipelines shall consist of bitumen-impregnated insulating board to B.S. 1142 : Part 3 or other equally compressible material. The thickness of compressible filler shall be as follows:-

Nominal bore of pipe (mm)	Thickness of compressible filler (mm)
Less than 450	18
450-1200	36
Exceeding 1200	54

3.67.2 Compressible packing for use between pipes and precast concrete setting blocks shall consist of two layers of bitumen damp-proof sheeting complying with B.S. 743, Type G.

3.68 PRECAST CONCRETE SETTING BLOCKS FOR PIPES

3.68.1 Precast setting blocks for pipes shall have rectangular faces, with sufficient plan area to prevent punching of the blinding concrete or formation and to provide an adequate seating for the pipes. They shall be manufactured from Grade G20 concrete using the same type of cement as in the adjacent concrete bed, and be cast in an approved mould. Blocks shall not be used until they have achieved a cube strength of 13.5MPa.

3.69 CLAY PUDDLE

3.69.1 Clay puddle shall be impervious to water, and be free from sand, grit, stones and other deleterious matter.

3.69.2 The clay on being dug shall be exposed to the air for at least 24 hours and thereafter shall be worked with water into a consistency suitable for punning. A roll of clay 300mm long and 40mm in diameter shall support its own weight when suspended from one end.

3.70 GULLIES

3.70.1 Precast concrete gullies shall comply with the relevant requirements of B.S. 5911 : Part 2.

3.70.2 Clay gullies shall comply with the relevant requirements of B.S. 65.

3.71 GULLY COVERS, GRATINGS AND FRAMES

3.71.1 Gully covers, gratings and frames shall comply with the relevant requirements of B.S. 497.

3.72 HYDRANTS

3.72.1 Hydrants shall be pillar type complying with the relevant requirements of B.S. 750.

3.73 VALVE PRESSURE RATINGS

3.73.1 Valve pressure ratings shall be as described in the Contract and all flanges shall comply with the appropriate sections of B.S. 4504.

3.74 VALVES

3.74.1 Waterworks valves shall be an approved proprietary brand double flanged ductile iron wedge gate valves complying with B.S. 5163.

- 3.74.2 Valves shall be fitted with either a handwheel or cap for key operation with extension spindle or headstock as required.

3.75 WATER METERS

- 3.75.1 Water meters shall be as described in the Contract.

3.76 SURFACE BOXES

- 3.76.1 Cast iron surface boxes shall comply with the relevant requirements of B.S. 750 and B.S. 5834.

3.77 STOPCOCKS

- 3.77.1 Stopcocks for underground service connections shall comply with the relevant requirements of 5433.

3.78 FERRULES

- 3.78.1 Ferrules for connections to water mains shall be gunmetal swivel pattern with isolating plug (for under-pressure connection if required) as described in the Contract. Outlets shall be suitable for connecting to the flexible length of service pipe.

3.79 BRICKS

- 3.79.1 Clay bricks, concrete bricks and calcium silicate bricks shall comply with relevant requirements of B.S. 3921, B.S. 6073 and B.S. 187 respectively.

- 3.79.2 Bricks to be used for manholes and chambers shall be solid type (P.B.D. 20 minimum 2nd grade).

- 3.79.3 The shapes and dimensions of special bricks shall comply with the relevant requirements of B.S. 4729.

3.80 PRECAST CONCRETE MANHOLES

- 3.80.1 Precast concrete manhole units shall comply with the relevant requirements of B.S. 5911 : Part 1. Units of a type and size outside the ranges covered by B.S. 5911 shall comply with the requirements of that Standard where applicable.

- 3.80.2 Joints between chamber units shall be of ogee or rebated type. Units which bed onto bases, or onto which cover slabs sit, shall be manufactured with an appropriate plain end.

- 3.80.3 Where step irons are required, they shall be of the precast concrete manhole pattern, fixed into the units at the manufacturer's plant.

- 3.80.4 All chamber cover slabs which have been subjected to the load test in accordance with Clause 29 of B.S. 5911 : Part 1, shall be suitably marked, and certificates of compliance shall be supplied.

- 3.80.5 Chamber cover slabs shall have a minimum clear opening of 600mm.

3.81 MANHOLES COVERS AND FRAMES

- 3.81.1 Manhole covers and frames shall comply with the relevant requirements of B.S. 497 and have a minimum clear opening of 600mm.

- 3.81.2 Manholes within the highway or areas designed to carry traffic shall be heavy-duty cast iron covers of double triangular non-rocking pattern with a clear opening 600mm x 600mm to B.S. 497 : 1976 Ref. MA-60 (Class A 11.5 tonne loading) set flush with the existing road surface. The frame shall be bedded on no more than four nor less than two courses of engineering brick on a bed of Class M1 mortar to allow for future level adjustments.

- 3.81.3 Manholes within verges, grassed areas or other locations not normally subject to traffic loads shall ductile iron of the circular pattern also having a clear opening of 600mm diameter to B.S. 497 : 1976 Ref. MB2-604 (Class B 5.0 tonne loading). A single seal between the cover and frame shall be provided. The frame shall be cast into a plinth of Grade G20 concrete 150mm above the surrounding ground level.

3.81.4 In the case of head manholes of gravity sewers from rising mains, the manhole covers shall be provided with bolts or a locking device in stainless steel, and the manhole shall be ventilated with a stack as shown in the Drawings.

3.81.5 All manhole covers and frames shall be finished in black bituminous paint.

3.82 MANHOLES STEP IRONS

3.82.1 Step irons for manholes and other chambers shall comply with the relevant requirements of B.S. 1247.

3.83 GABIONS AND RENO MATTRESSES

3.83.1 Gabions and Reno mattresses shall be constructed using prefabricated units of plastic coated galvanised steel wire mesh. Unit, mesh and wire sizes shall be as described in the Contract. The fill shall be hard, durable stone of 125mm - 200mm for gabions and 75mm to two-thirds mattress thickness for Reno mattress construction.

3.84 COMPRESSIBLE FILLERS FOR WATER-RETAINING CONCRETE STRUCTURES

3.84.1 Compressible fillers for water retaining structures shall be approved bitumen impregnated cork. In other structures, compressible fillers shall be approved bitumen impregnated board.

3.85 TIMBER

3.85.1 All timber shall be well seasoned, sound and free from sapwood, large or loose knots, waney edges, white ants, borers or other defects.

3.85.2 Unless described otherwise in the Contract, all hardwood shall be selected Kapur Bukit, except that timber used structurally shall comply at least with Grade SC5 in accordance with Table 9 of B.S. 5268 : Part 2.

3.85.3 All work shall be left with a sawn surface except where necessary to be wrot.

3.85.4 The preferred dimensions of sawn and re-sawn sections shall comply with B.S. 4471 for softwoods and B.S. 5450 for hardwood.

3.85.5 All timber shall be equal to samples approved by the Engineer. The samples are to remain in the office of the Engineer during the currency of the Contract.

3.85.6 All carcassing timbers, concealed timbers and timbers which are to be painted are to be treated before being brought to the site. The preferred treatment is by pressure impregnation with a non-bleaching wood preservative.

3.85.7 Timber shall receive an approved preservative treatment and protective treatment from termite attack in accordance with the recommendations made in Overseas Building Notes No. 170 "Termites and Tropical Building" dated October 1976. The approval of the Engineer shall be obtained to the type of treatment.

3.85.8 Where pressure treated timber is not available, treatment shall be carried out on site in the presence and to the approval of the Engineer, in the following manner. The preservative solution shall be 'Solignum' or similar approved equivalent:-

- a) The Contractor shall allow for providing all necessary baths and tanks for the complete immersion of all timbers and they shall be immersed before framing up.
- b) The strength of solution and period of immersion, etc., shall be carried out strictly in accordance with the manufacturer's instructions. After thorough immersion, the timber shall be withdrawn and stacked to dry before being used.

3.85.9 All faces, ends and edges of timber cut and exposed on site shall receive immediate thorough application of the preservative by brush.

3.85.10 Timber which is to have an applied finish shall be treated against termite attack with a preservative which permits the finish to be applied.

4 DEMOLITIONS AND ALTERATIONS**4.1 APPLICATION**

- 4.1.1 This section applies to all repairs, maintenance work, alterations and additions, and other works affecting existing buildings or works. The other sections of this Technical Specification apply also to such works where appropriate.

4.2 DEMOLITION GENERALLY

- 4.2.1 The Contractor shall be held to have understood fully all matters concerning the Works to be carried out under the Contract. Any queries should be settled with the Engineer prior to the submission of the Tender. No consideration shall be given to any queries raised by the Contractor indicating lack of comprehension of work to be done after the acceptance of the Tender.
- 4.2.2 Prior to demolition, the Contractor shall ensure that all existing services have been turned off and adequate precautions shall be given to protect any services (not for demolition) that may traverse the site.
- 4.2.3 All debris and rubbish resulting from the demolition shall be cleared and removed from the site. The Contractor shall thoroughly clean up all rubbish and debris at the conclusion of the job.
- 4.2.4 The work shall be carried out in such sequence and manner as the Engineer shall approve. The Engineer shall be at liberty to stop the demolition works at any time should it be expedient to do so for any cause whatsoever. The Contractor is to liaise with the Authority concerned as the place may be occupied continuously.
- 4.2.5 The Contractor shall be held solely responsible for the safety of the public and adjoining properties and he shall provide all necessary and adequate dust sheet and shoots, walking boards, etc. as may be required. The Contractor must use adequate equipment, take all safety precautions and make every effort to prevent nuisance in carrying out the demolitions and to indemnify the Government from any liabilities arising out of claims by a third party against any damage, loss or injury, which may occur to any property or to any person due to the execution of the works and/or caused by his servants or agents. He shall take all precautions and make every effort to prevent nuisance and he is to allow in his Tender for all contingencies that may be necessitated by the execution of the Works.
- 4.2.6 Demolish existing building and structures on the sites of the buildings and other works or as otherwise required or specified. Demolition is to be carried out with due care and in an approved manner. Where required to be demolished, existing building and structures are to be completely pulled down to the level of the adjacent ground or paving, or to the underside of the lowest floor or paving, whichever is the lower. All floors and pavings, including beams, steps, etc. are to be hacked up. Any foundation or walling below the above level met with during excavation or required to be grubbed up will be the subject of additional payment unless specified otherwise.
- 4.2.7 When carrying out demolition against adjoining property, the Contractor shall leave adequate support and protection at each stage, and shall not proceed until inspection have been made by the Engineer and further instruction given to the Contractor.

4.3 SHORING AND STRUTTING

- 4.3.1 Provide and maintain all shoring and strutting necessary to ensure the safety of the existing and the adjoining premises, sewers, drains or other services, alter and adapt as necessary, clear away when no longer required and made good any damage. The Contractor is responsible that any timbers used for shoring and strutting are sound, of adequate strength for the pressures to be sustained, and that they are properly braced, secured and maintained.

4.4 EXISTING BUILDINGS AND CONTENTS

- 4.4.1 The Contractor is to cover up and protect as necessary the existing buildings or works and their contents, and is to make good any damage caused by the work. A sufficient quantity of dust sheets is to be provided and used, particularly during decorations. Floors, walls and furniture are to be covered up as necessary to protect them from drips, splashes, dust and dirt, and to protect floors from footmarks.

4.4.2 Furniture, fittings, furnishing and all other contents of existing buildings are to be carefully moved and stored as necessary, and replaced on completion to the satisfaction of the Engineer.

4.4.3 Where existing building or works are exposed to the weather by alterations, the Contractor is to provide and maintain all necessary temporary coverings to prevent damage. Where existing building or works are opened up by alterations so as to permit access from outside, the Contractor is to provide and maintain all necessary temporary barriers, temporarily block up all openings, and/or provide all necessary watching and security measures to prevent loss or damage by theft or similar cause.

4.5 OCCUPIED AND EXISTING PREMISES

4.5.1 Work in occupied premises is to be carried out after getting permission from the occupants or the Engineer and shall in such a manner as to permit continued use of the premises with as little as possible inconvenience to the occupants. All rubbish and debris is to be cleared away from time to time as it arises, and the whole of the working areas are to be left clean and tidy on completion of each day's work.

4.5.2 Existing premises are not to be used for storage, canteen, sanitary or other purposes unless so specified or permitted by the Engineer.

4.6 DISPOSAL AND RE-USE OF MATERIALS

4.6.1 The whole of the materials from the demolitions shall become the property of the Contractor, except where otherwise specified, and shall be cleared away from the site as the works proceeds and any credit value separately stated.

4.6.2 A condition is hereby imposed on the Contractor that he must first obtain the Engineer's permission prior to retaining or removing any materials salvaged from the demolition works. The Engineer reserves the right to acquire any salvaged materials that are removed without his approval. It will be deemed that in pricing the works, the Contractor has examined and valued each item of demolition in detail and as the result of such examinations has allowed in his price for all implications, conditions and matters affecting the Works.

4.6.3 Materials specified to be re-used shall be protected from damage, cleaned and overhauled.

4.7 DIMENSION

4.7.1 Whenever the dimensions are described as "approximate", they are given for guidance only and the Contractor shall verify the actual size from the site before submitting his Tender, as no claim for extra payment will be entertained later.

4.8 DEFINITIONS

The following words or expressions shall have the meanings hereunder assigned to them:-

4.8.1	Demolish	Disconnect all services, demolish and remove debris from site.
4.8.2	Shore Up	Shoring including erecting, cutting holes in the structure, maintaining, clearing away and making good all work disturbed.
4.8.3	Overhaul	Clean, renew parts and all incidentals and leave in working order.
4.8.4	Set Side	Setting aside for re-use including handling, cleaning, temporarily casing up, covering, protecting and the like and moving within the site and if required removal from and return to site.
4.8.5	Make good	Making good to match existing. Making good work and through, around into, over, and up to new items, openings and the like and the proper joining to existing.
4.8.6	Make good structure	Making good structure and cutting, toothing and bonding, pinning up, levelling and preparing, filling and facing up.
4.8.7	Make good finishing	Making good finishing (including dubbing out) to ceilings and soffits, walls and floors and making good skirting, architraves and joinery.

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| 4.8.8 | Making good decorations | Making good as previously decorations fined all decorations to ceilings and soffits, walls, floors, skirtings, architraves and joinery including preparing, trimming and bringing forward to the full number of existing coats and matching in texture and colour. |
| 4.8.9 | Cut opening | Cutting opening including quoining up jambs, forming recessed reveals, cutting, toothing and bonding, levelling and preparing bottom of openings, openings, cutting and pinning lintels and the like and pinning up over. |
| 4.8.10 | Blocking up openings | Blocking up openings including, openings cuttings, toothing and bonding, pinning up and levelling and preparing bottom of openings. |
| 4.8.11 | Take out door frame | Taking off door, taking out and frame, lining, architraves and all associated joinery, taking out threshold and any steps, taking out pelmet and curtain rails, taking up floor springs, preparing opening to receive new work. |
| 4.8.12 | Take out window and frame | Taking out window, taking out frame, lining, and architraves, and shutters all associated joinery, taking out internal and external sills, frame taking out pelmet and curtain rails, preparing opening to receive new work. |
| 4.8.13 | Take out sanitary fitting | Take out sanitary fittings complete with brackets, bearers, backboards , drainers and the like, disconnecting wastes and services, stopping off pipes out of sight and making good. |
| 4.8.14 | Overhaul and repair door and frame | Piecing out repairing damaged portions of doors frame and lining, repairing and re-fixing architraves including renewing as necessary, re-fixing frame and lining, hacking out defective putties and re-puttying, hacking out broken glass and glazing, raking out and re-pointing frames, overhauling, oiling and adjusting shooting ironmongery shooting, easing and adjusting door, taking out door and shooting bottom to clear new finish and re-hanging. |
| 4.8.15 | Overhaul and repair | Piecing out and repairing damaged portions of window frame window and lining, repairing and re-fixing architraves including renewing as necessary, re-fixing and lining, hacking out defective putties and re-puttying, hacking out broken glass and re-glazing, raking out and re-pointing frames, oiling and adjusting ironmongery, easing and adjusting window. |

4.9 MAKING GOOD

- 4.9.1 All making good shall be executed with materials and workmanship to match in every respect the surrounding work and shall be properly bonded thereto. Otherwise, all new work shall be executed with materials and workmanship as hereafter describe.

4.10 BENCHMARKS

- 4.10.1 Any benchmarks found on buildings to be demolished shall be reported to the Engineer and under no circumstances shall they be removed or destroyed without his instruction.

4.11 DISCONNECTION OF SERVICES

- 4.11.1 Before demolition is commenced, the Contractor shall arrange with the public utilities Authorities for the proper disconnection of their mains and removal of their fixtures or fittings, and shall pay all charges in connection therewith.

4.12 TREE FELLING

- 4.12.1 No trees shall be felled or removed without the specific instructions of the Engineer.

4.13 DEFECTS DISCLOSURE

- 4.13.1 Any defects discovered in the existing buildings or structures, including decayed or infested woodwork and cracked walls or floors, are to be brought to the attention of the Engineer before any work is carried out.

4.14 WATER AND ELECTRICITY

4.14.1 Electricity and water pipes services to existing premises may be used by Contractor for the Works, provided that the permission of the relevant Authorities is obtained and provided that the occupants is reimbursed by the Contractor for any excess cost due to such use. Where not separately metered, such excess cost shall be arrived at by comparison of current charges with those of the two proceeding months.

4.14.2 Stored rainwater at existing premises may be used by the Contractor for the Works only with the permission of the occupants or in the case of unoccupied premises, of the Engineer.

4.15 WEATHER PROTECTION

4.15.1 The Contractor's attention is drawn to the requirement that adequate measures should be taken to protect the buildings and the contents therein from the ingress of water and other weather elements. Any claims, losses, complaints or legal actions whatsoever arising from and in connection with the Works shall be sole responsibility of the Contractor and he shall indemnify the Government or the occupants in full.

4.16 PREPARATION OF EXISTING SURFACES TO RECEIVE WATERPROOFING SYSTEM

4.16.1 The Contractor shall carry out a thorough examination of the existing roof slabs and the conditions of the existing finishings. The Contractor shall thoroughly scrap-off and repair any visible cracks in the exposed slab, chase the existing crack lines to 25mm x 38mm deep and wash clean, apply 3 layers epoxy-cement mortar each 19mm thick with base finish trowelled smooth.

4.16.2 All stains, fungus and other biological growth on any surface to be plastered and receive new roofing system shall be removed and cleaned with the aid of approved chemicals if necessary, before repair works or other works are carried out.

4.16.3 If necessary, repair and clean out existing rainwater outlets of all dirt, fungal growth, etc. and supply and install new balloon gratings to all roof outlets if they are badly corroded or ingrained with dirt or biological growth.

4.17 APPLICATION OF WATERPROOFING MEMBRANE

4.17.1 The proposed waterproofing system shall be executed in strict accordance with the specifications and the manufacturer's recommendations and to the complete satisfaction of the Engineer. The areas to be covered shall as specified in the Drawings, which includes dressing over sides and top of kerbs, upstand beams etc. Skirting shall be dressed up to 300mm high. Columns and other pipe projection shall be dressed up a minimum 300mm high by means of a collar formed monolithic with the application of the waterproofing system.

4.17.2 The unit rates quoted for waterproofing shall be the total price inclusive of any periodic maintenance and or renewal of any top coast sealing to ensure a waterproof free from any leaks for a period of ten years (10) commencing from date of practical completion of the Contract.

4.18 PROOF OF LICENSED APPLICATOR

4.18.1 The Contractor shall be required to produce documentary proof that he is a licensed applicator approved by the manufacturer of the waterproofing system quoted.

4.19 COMPLETE SYSTEM

4.19.1 The waterproofing system proposed by the Contractor is deemed to be a complete system to achieve watertightness and adherence to the manufacturer's specifications and instructions. The rates are deemed to include any protection slab, screeding or other incidental items not specified in the Bills of Quantities but required by the proposed system and the Contractor is to state so in their Tender. All provisional items must be priced according to the prevailing market rates and shall be re-measured upon completion of the Works.

4.20 COMPLETION OF WORKS

4.20.1 On completion of the Works, the Contractor shall clean and clear all surplus materials, rubbish and debris etc. from site to the entire satisfaction of the Engineer.

5 GROUND INVESTIGATION**5.1 TEMPORARY WORKS**

- 5.1.1 Any temporary works necessary for the provision of stable working platforms for or access to borehole locations shall be provided by the Contractor.

5.2 POSITIONS OF BOREHOLES AND TRIAL PITS

- 5.2.1 The numbers and approximate positions of boreholes and/or trial pits are as given in the Contract. The positions, numbers and depths of boreholes and trial pits are provisional at the tender stage and may be subject to revision as the work proceeds.
- 5.2.2 The precise location of each borehole and trial pit shall be determined by the Contractor within a radius of 2m on plan at ground level from the positions indicated in the Drawings or by the Engineer.
- 5.2.3 The Contractor shall take all necessary precautions to ensure that each borehole and trial pit is located clear of existing underground and above ground services, equipment, property and the like, whether the property of the public utilities, statutory authorities or privately owned. Any change in the numbers and positions of the boreholes and trial pits during the course of the Works shall not relieve the Contractor of his responsibilities in this respect.

5.3 STARTING PITS

- 5.3.1 In the vicinity of underground services, the Contractor shall carefully excavate a starting pit at the location of each borehole to such a depth as he may consider necessary to ensure that it is clear of all underground services, equipment, property and the like.

5.4 REPORTING TO ENGINEER

- 5.4.1 The Contractor shall report progress of the work to the Engineer, from time to time, in order to obtain his instructions regarding the final depths to which the boreholes shall be constructed.

5.5 OB.S.TRUCTIONS

- 5.5.1 If obstructions are encountered below ground level, the Contractor shall immediately inform the Engineer.
- 5.5.2 The Engineer will decide whether the obstruction shall be overcome, or whether the borehole shall be terminated.

5.6 DELAYS

- 5.6.1 In the event of any delays occurring which are beyond the control of the Contractor, he shall immediately inform the Engineer.

5.7 STANDARDS

- 5.7.1 The sinking of boreholes, obtaining and testing of samples shall be carried out in accordance with B.S. 5930 "Site Investigations" and B.S. 1377 "Methods of Test for Soils for Civil Engineering Purposes" or in accordance with any other standards or code of practice as directed or approved by the Engineer.

5.8 SUPERVISION

- 5.8.1 The Contractor shall provide continuous supervision of the boring and excavation of trial pits, by an experienced and competent supervisor fully conversant with the requirements of this Technical Specifications. The Contractor shall also supply all the necessary personnel required properly to carry out the field tests as specified and to give accurate and reliable descriptions of soil and rock samples. The standard of supervision shall be of a very high order and each boring crew shall have a competent and experienced rig or machine operator.
- 5.8.2 The Engineer will, should he not be satisfied with the standard qualifications or experience of the Contractor's site supervision staff, order their removal from the site and suspension of Works pending their replacement by suitable persons. Any standing time thus incurred by the Contractor shall be his liability.

5.9 DAILY BORING AND DRILLING RECORDS SHEETS

- 5.9.1 The Contractor shall submit to the Engineer each day a copy of the foreman's daily boring and/or drilling record sheets containing the following information in respect of each boreholes:-
- a) Site.
 - b) Number of borehole.
 - c) Date.
 - d) Depth of borehole at end of day.
 - e) Depth of borehole for which casing was used, with diameter of such casing, and depth of uncased borehole.
 - f) Method of boring.
 - g) Depths at which water encountered, depth to standing water at start and end of day's boring and depth to standing water on completion of borehole.
 - h) Description of each stratum encountered.
 - i) Depth below ground level of each change of stratum.
 - j) Depth and details of all undisturbed and disturbed samples taken and results of any in-situ tests carried out.
 - k) Whether water was introduced into borehole to assist boring.
 - l) Weather conditions.
 - m) Details of any delays occurring which were beyond the Contractor's control.
 - n) Any other relevant information.

5.10 LEVELS

- 5.10.1 The Contractor shall provide the Engineer with the ground level at the top of each borehole or trial pit referenced to Brunei State Datum 1988 (B.S.D88) and shall state in his report the value and precise location of the datum benchmark used for taking these levels.

5.11 PRELIMINARY BOREHOLE LOG SHEETS

- 5.11.1 The Contractor shall submit to the Engineer on completion of the site work a copy of the preliminary borehole log sheets for each borehole giving an engineering description of the strata encountered together with a list of all samples obtained.

5.12 LABORATORY TESTING

- 5.12.1 On receipt of the Contractor's preliminary borehole log sheets, the Engineer will instruct the Contractor on the laboratory tests to be carried out.

5.13 BACKFILLING AND CLEANING SITE

- 5.13.1 The Contractor shall backfill all boreholes with material arising therefrom to within 3 metres of ground level and shall fill the top 3 metres of the borehole with sand or as required in the Contract.
- 5.13.2 The Contractor shall backfill all trial pits with material arising therefrom, and shall compact it in compliance with Section 6 "Earthworks"

5.14 REPORT ON SITE INVESTIGATION

- 5.14.1 The Contractor shall submit to the Engineer the requisite number of copies of a factual report giving full details of all the information obtained in the site investigation.

5.15 METHODS OF EXPLORATION

- 5.15.1 The Engineer may require exploration to be carried out by all or any of the following methods:-
- a) Percussion boring with shell, auger or clay cutter, with or without sampling and in either cased or uncased holes.
 - b) Hand auger boring with or without sampling.
 - c) Probing in soft soils with small diameter rods and a probe head of approximately 25mm diameter.

- d) Rotary drilling through soil or rock either from the bottom of a percussion boring or from original ground level and either with or without core recovery.
- e) The excavation of inspection pits.
- f) The excavation of trial pits.
- g) Penetration vane tests.

5.16 SHELL AND AUGER BOREHOLES

5.16.1 Diameter of boreholes and sampling in general:-

- a) The Contractor shall ensure that at ground level the diameter of the borehole is of sufficient size to enable reductions to be made such that at no time during boring is the borehole less than 150mm diameter.
- b) Sampling shall be carried out in accordance with the clauses below except that in the first 2.0m from ground level, sampling shall be carried out at intervals of not more than 300mm.

5.16.2 Disturbed samples of soils for identification:-

- a) The Contractor shall take a sample of approximately 450gm in weight of each stratum immediately it is encountered, but at intervals not exceeding 1.5m.
- b) Each sample shall be sealed in a separate airtight container which shall be clearly labelled with the borehole number and depth from which the sample was taken.

5.16.3 Disturbed samples of soils for testing:-

- a) The Contractor shall take samples weighing not less than 13kg at each stratum of non-cohesive soils, and from cohesive soils when instructed by the Engineer.
- b) Each sample shall be sealed in a separate airtight container which shall be clearly labelled with the borehole number and depth from which the sample was taken.

5.16.4 Undisturbed samples of soils for testing:-

- a) The Contractor shall take undisturbed cores of approximately 100mm diameter from cohesive soils as described in the B.S. 5930. The cores are to be taken immediately at level where cohesive stratum is first encountered and if the stratum exceeds 1.5m thickness, samples shall be taken at intervals of 1.5m or such other intervals as may be directed by the Engineer.
- b) The samples shall be immediately sealed in their tubes with wax and sent to the testing laboratory.

5.16.5 If directed by the Engineer, the Contractor shall take a sample (approximately half litre) of ground water each time it is met in the boring and shall send the samples to the testing laboratory.

5.16.6 The Contractor shall carry out a standard or cone penetration test immediately when a non-cohesive stratum is encountered and shall repeat the test at intervals of 1.5m throughout the stratum, or at intervals as directed by the Engineer.

5.16.7 If rock is encountered, it shall be proven by chiselling to the depth required by the Engineer.

5.16.8 The Contractor shall not terminate a borehole without the approval of the Engineer.

5.16.9 Permanent water level observation wells:-

- a) The Contractor shall insert into the open borehole to the depth required by the Engineer a rigid pipe having a minimum internal diameter of 19mm, the bottom 3m of which shall be perforated for at least 5% of its surface area. All joints in the pipe shall be screwed, glued and sealed. The top of the pipe shall conform to the detail given in the Drawings.

- b) The annular space between the pipe and the perimeter of the borehole shall be backfilled with gravel having maximum size of 10mm up to a level required by the Engineer.
- c) The Contractor shall provide a bentonite/cement seal around the pipe at the top of the filter material, to prevent the entry of surface water.
- d) The installation shall be protected at ground level by a valve box cover of the type shown in the Drawings. The valve box shall be set in concrete, its top at least 25mm above the surrounding ground, and left in a safe and secure condition.
- e) After installation, and daily thereafter during the period of the site work, the Contractor shall take and record the level of the water in the well by means of a dip meter.

5.17 HAND SOIL PROBING

- 5.17.1 The probe shall consist of a 12mm diameter by 6m long straight bar.
- 5.17.2 The probe shall be inserted vertically into the ground until refusal or until 6m depth of penetration is reached. The depth of refusal shall be recorded to the nearest 50mm.
- 5.17.3 If refusal occurs at a level not compatible with the general profile of the soft deposit, e.g. on a buried obstruction, log, etc., the Contractor shall repeat the test at his own cost until a compatible result is obtained.
- 5.17.4 The probe tests shall be carried out at the locations indicated by the Engineer and at each location the surface level of the ground relative to datum shall be taken.

5.18 TRIAL PITS

5.18.1 Hand excavated trial pits:-

- a) Trial pits shall be approximately 2m x 1.5m on plan and shall be excavated in positions and to depths necessary to expose the foundations of adjoining buildings or to explore upper strata, as directed by the Engineer.
- b) The Contractor shall provide all shuttering necessary to safely support the sides of the trial pits, and pumps and pumping necessary to keep the excavations free from water.
- c) The Contractor shall notify the Engineer when the trial pits excavations have been completed to his requirements and shall keep the pits covered until they have been inspected by the Engineer. The Contractor shall ensure that all necessary pumping facilities are available on the site at the time of the Engineer's inspection, and provide means of access to the pits. The Contractor shall have men, tools and equipment available to carry out further excavation if required by the Engineer during or subsequent to his inspection.

5.18.2 Machine excavated trial pits:-

- a) The Engineer will be present during the excavation of the trial pits.
- b) The minimum width of the pits shall be 600mm and they shall be excavated to the depths required by the Engineer. The maximum excavation depth is stated in the Contract.

5.19 LABORATORY SOIL TESTING

- 5.19.1 The Engineer shall decide in consultation with the Contractor what testing shall be carried out and shall provide the Contractor with a schedule of tests.
- 5.19.2 All storing, preparation and testing of samples shall be in accordance with the relevant British Standards Specifications or with other standards as directed or approved by the Engineer.
- 5.19.3 The information submitted by the Contractor for each test shall be in accordance with Clause 3.23 and B.S. 1377, or with other standards as directed or approved by the Engineer.

5.19.4 The concentration of sulphur trioxide in a sample soil should be determined using the gravimetric method outlined by Bowley, MJ (BRE Current Paper 2/79 and a 2:1 water extract).

5.20 INFORMATION REQUIRED FROM LABORATORY SOIL TESTING

5.20.1 In addition to the information required by B.S. 1377, the following information shall be submitted with all soil tests referred to in this Technical Specifications and items in the Contract Documents. Where no additional information is required, the test has been omitted from this Clause:-

ITEM	TEST	ADDITIONAL INFORMATION TO BE SUBMITTED
1	<u>GENERAL</u>	1. All results shall be reported in S.I. units. 2. Exploratory hole number and sample number. 3. Depth of test or sample.
2	<u>IN-SITU TESTING</u>	
2.1	In-situ shear strength by the Vane Test, Test No. 18	1. Dimensions of and the constant K for the vane. 2. Maximum reading of torque scale in degrees. 3. Vane shear strength reported to the nearest 1% of the measured value. 4. Time taken to reach maximum torque.
2.2	Penetration resistance using a split barrel or solid sampler, Test No. 19	1. Number of blows for first 150mm. 2. Number of blows for each successive 75mm penetration, or penetration produced by 50 blows.
3	<u>LABORATORY TESTING</u>	
3.1	Liquid Limit, Plastic Limit and Plasticity Index determination, Tests No. 2A, 3 and 4	1. Natural moisture content %. 2. % of material passing the 425µm sieve to the nearest 1%.
3.2	Particle size distribution, Test No. 7A	1. Results are to be plotted as tables for the aggregation of several tests.
3.3	Dry density/moisture content relation (2.5 kg. hammer), Test No. 12.	1. A graph relating moisture content % to dry density with at least 2 determinations with MC % greater than the optimum MC %.
3.4	Dry density/moisture content relation (4.5 kg. hammer), Test No. 13	1. As Item 3.3.
3.5	All strength tests.	1. Initial moisture content %. 2. Initial dimensions. 3. Initial dry density kg/m³. 4. Rate of strain % minute. Based on the rate of drive of the machine ignoring stiffness of the measuring system. 5. Description of extruded sample if this is found to vary from the previous description.
3.6	Unconfined compressive strength test, Test No. 20	1. Estimated cohesive strength kN/m².
3.7	Undrained quick triaxial compressive strength test on a set of 3 or more specimen, Test No. 21	1. Mohs circle stress diagrams only required if the minimum and maximum values of the principle stress differences vary by more than 10%. 2. The type of specimen failure, plastic, brittle or compound.

3.8	Determination of the one-dimensional consolidation properties, Test No. 17	1. Initial and final moisture content %. 2. Initial dimension mm and mm². 3. Specific gravity (either measured or assumed). 4. Initial and final voids ratio. 5. A graph of voids ratio and coefficient of consolidation both against pressure kN/m² to a semi-logarithmic scale.
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5.21 PIEZOMETER AND METHOD OF INSTALLATION (SEE FIGURE 5.1)

5.21.1 Piezometers and extension tubes:-

- a) Piezometers shall be Casagrande piezometers and shall consist of 51mm diameter by 255mm long porous element retained between rigid PVC end fittings. The porous element shall have a pore diameter of 60µm and a permeability of 3×10^{-2} cm/s. The top of the piezometer shall have a coupling to receive a 19mm diameter extension tube.
- b) The extension tubes required to connect the piezometer to the surface shall be 19mm bore rigid PVC tubes in 3.0m lengths. Joints between extension tubes shall be made using screwed sleeve couplings and an approved adhesive which shall be applied according to the manufacturer's instructions.
- c) The piezometer and extension tubes shall be purchased from an approved manufacturer.

5.21.2 Dipmeter:-

- a) The dipmeter consists of an electrode and coaxial cable mounted on a winding reel which contains an electrical relay and vibrator, and a 9 volt battery.
- b) The dipmeter shall be purchased from an approved manufacturer.

5.21.3 Where directed by the Engineer, piezometers shall be installed in boreholes terminated in overburden by the following procedures:-

- a) The bottom of the borehole shall be cleaned of any loose material and a measured quantity of coarse sand sufficient to fill the bottom 1m shall be poured into the borehole. When the sand has settled, the borehole casing shall be withdrawn by 0.60m. The piezometer and the required length of extension tubes shall be assembled and lowered into the borehole, until the piezometer comes to rest on the settled sand. The depth of which the piezometer comes to rest shall be recorded. A measured quantity of coarse sand shall be poured into the borehole to surround the piezometer and fill the hole to approximately 0.30m above the top of the piezometer. When the sand has settled, the casing shall be withdrawn a further 0.60m.

A further measured quantity of coarse sand shall be added to fill the borehole a further 0.60m thus locating the piezometer in the centre of a 2.50m column of sand. The final surface level of the settled sand shall be measured by a tamper lowered into the borehole.

- b) The column of sand shall be sealed with bentonite/cement grout to ground level. The bentonite content of the grout shall be not less than 5% of the weight of cement. The grout shall have a low water solid ratio to produce a pumpable mix.
- c) The extension tube shall be extended to 0.50m above ground level. A 2m length of transparent extension tube shall be added using a removable watertight coupling and the piezometer installation shall be tested by carrying out a falling head permeability test, as described in Clause 5.19 above.
- d) The 0.50m length of extension tube left projecting above the ground shall be protected by a 1.30m length of 100mm diameter rigid PVC pipe, set 1m into the ground. The pipe shall be provided with a 100mm diameter PVC end cap 0.30m long. A plastic label giving the reference number of the piezometer, its depth below ground level and whether it is located in rock or overburden shall be securely fixed to the inside of the cap.

5.22 DEEP BENCHMARKS AND METHOD OF INSTALLATION (SEE FIGURE 5.2)

- 5.22.1 The boreholes required for deep benchmarks shall be of sufficient depth to penetrate 1m into the sedimentary bedrock underlying the alluvial strata.
- 5.22.2 The bottom of the borehole shall be cleared of any loose material. The 40mm mild steel bar and the 75mm PVC pipe shall be assembled and lowered into the borehole until the bar and the pipe rests on the base of the borehole. The depth at which the bar comes to rest shall be recorded. The PVC outer tube shall be withdrawn 750mm.
- 5.22.3 1m of cement grout shall be tremied into the base of the borehole and the casing withdrawn 1.5 m. The middle section of the borehole shall be backfilled with sand and the casing withdrawn.
- 5.22.4 The 100mm diameter PVC protection tube shall be grouted into the top section of the borehole and the annulus between the bar and the PVC tube filled with oil.
- 5.22.5 The level of the top of the bar and the grid coordinates relative to B.S.D88 shall be recorded.
- 5.22.6 A plastic label giving the data obtained in Clause 5.22.5 shall be fixed to the inside of the locking cap to the 100mm PVC tube.
- 5.22.7 A robust timber fence approximately 2m square and 1.5m high shall be provided to protect the installation.

5.23 SETTLEMENT GAUGE AND METHOD OF INSTALLATION (SEE FIGURE 5.3)

- 5.23.1 The boreholes required for settlement gauges shall be to the depth instructed by the Engineer.
- 5.23.2 The bottom of the borehole shall be cleared of any loose materials and keeping the hole full water the drilling tools withdrawn slowly from the borehole.
- 5.23.3 The 20mm diameter mild steel bar and base plate shall be assembled and lowered to the base of the hole and lightly bedded. The depth at which the base plate is bedded shall be recorded. 1m of sand backfill shall be placed in the base of the borehole and the casing withdrawn 1m.
- 5.23.4 The 40mm diameter PVC tube shall be assembled and lowered over the mild steel bar until it comes to rest on the sand backfill. The middle section of the borehole shall be backfilled with sand and the casing withdrawn.
- 5.23.5 The 100mm diameter PVC protection tube shall be grouted into the top section of the borehole.
- 5.23.6 A plastic label giving the reference number, depth of the base plate and stratum number shall be fixed to the inside of the locking cap to the PVC tube.
- 5.23.7 A robust timber fence approximately 5m x 10m x 0.5m high shall be provided to protect the instrument cluster.

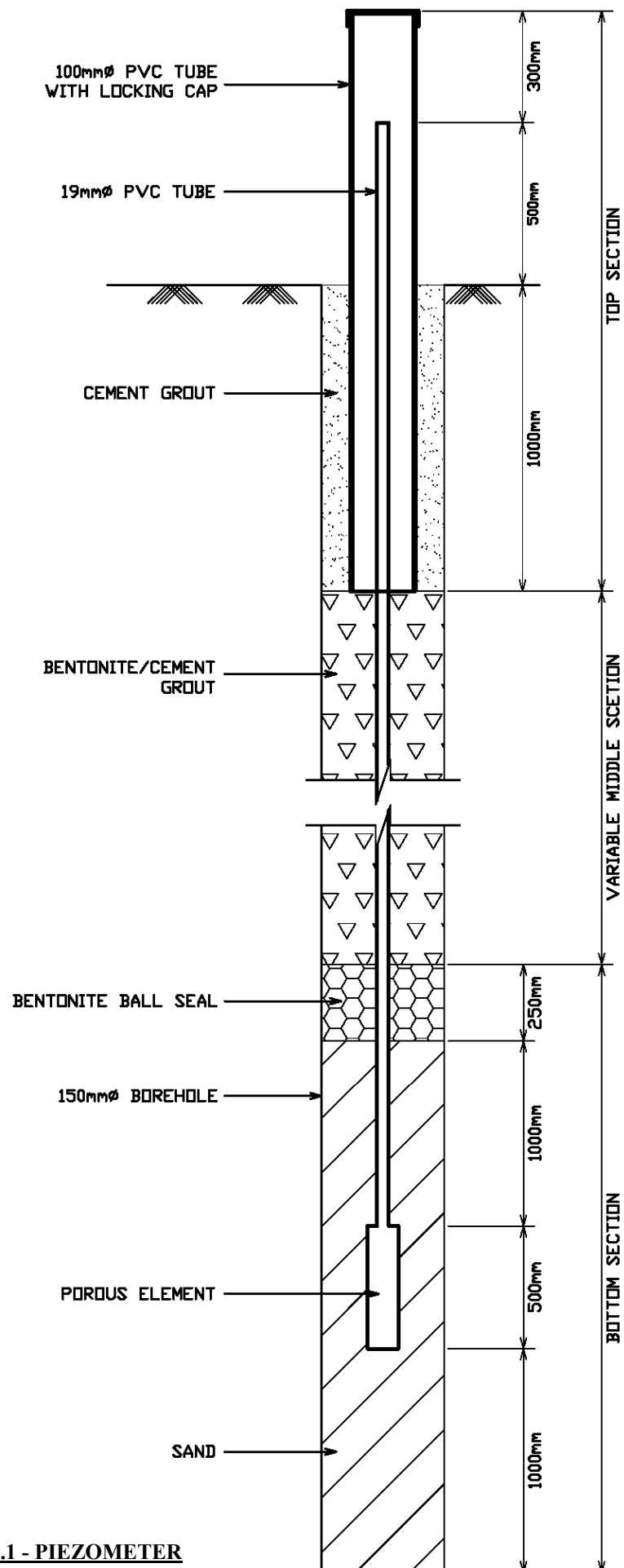
5.24 SURFACE MONUMENTS AND ROAD PINS

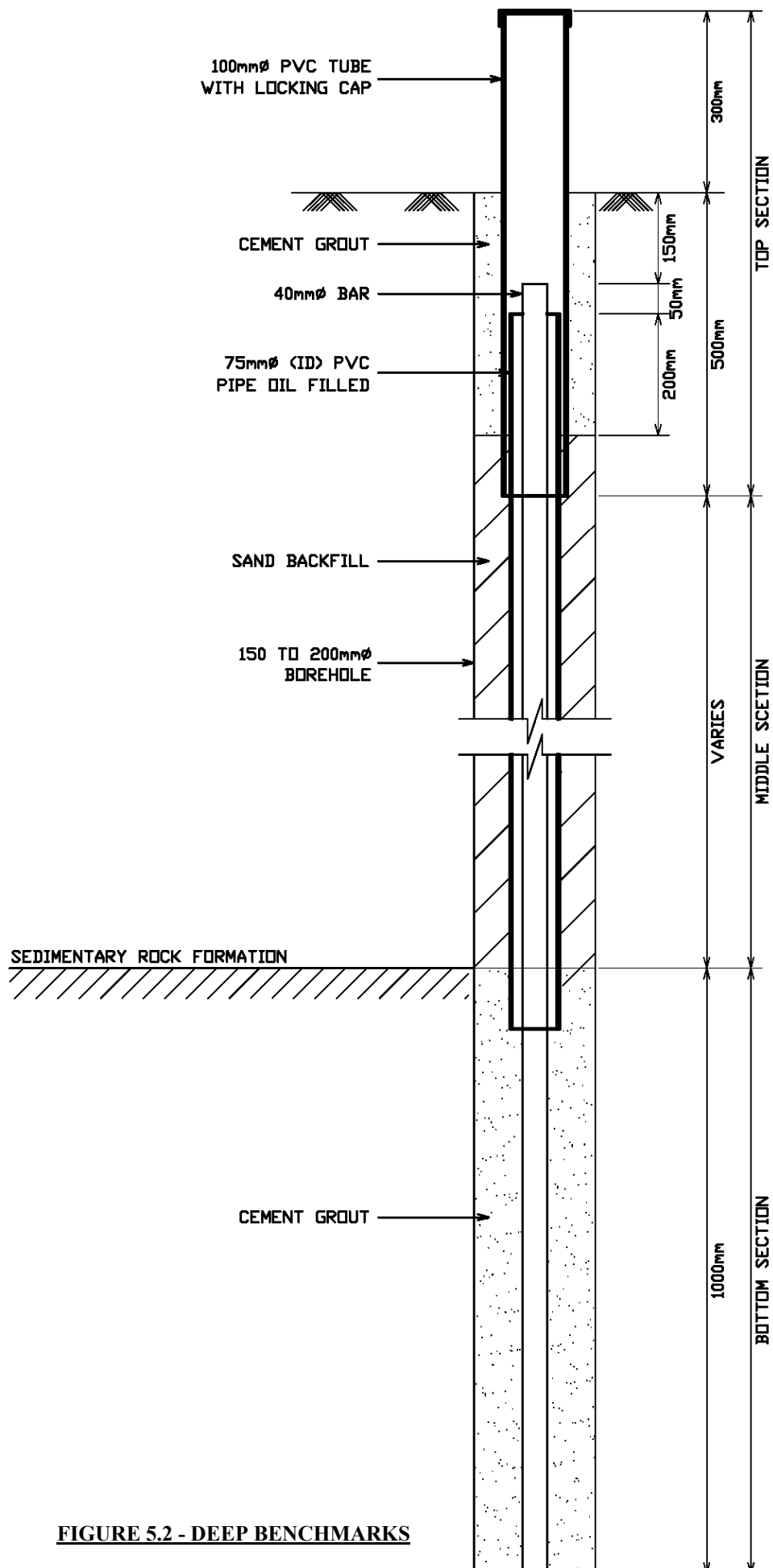
- 5.24.1 Surface Monuments shall consists of concrete cylinders 150mm in diameter and 500mm long placed in the ground with the top surface projecting 25mm above ground level. A stake shall be placed immediately adjacent to the movement for identification and location.
- 5.24.2 Road Pins shall be 50mm long steel pins suitable for penetration into concrete and complete with a 25mm washer. They shall be sunk or shot into the surface of the roadway and marked with a number and a circle of road marking point.

5.25 FIELD PERMEABILITY TESTS

- 5.25.1 Where directed by the Engineer, permeability tests shall be carried out in open boreholes during boring and coring operations either by the constant head method or where applicable by the rising head method, or the falling head method.

- a) Constant Head Method : The borehole shall be cleaned out at the prescribed depth under an induced head. The water level in the casing shall be maintained at a prescribed level by adding or extracting water for 60 minutes. The total quantity of water so added/extracted shall be recorded in litres at 10 minute intervals.
 - b) Rising Head Method : The borehole shall be cleaned out at the prescribed depth under an induced head. After the hole has been cleaned, the induced head shall be allowed to fall to the natural water table level and remain steady. The prescribed level and the time taken to regain the steady water table level shall be recorded. Three consecutive tests shall be made.
 - c) Falling Head Method : The natural water table level shall be measured. The borehole shall be cleaned out at the prescribed depth under an induced head. After the borehole has been cleaned, the induced head shall be allowed to fall to the natural water table level and remain steady. The water level in the borehole shall be raised by adding water to a prescribed level and the time taken to regain the steady water level shall be recorded. Three consecutive tests shall be made.
- 5.25.2 The permeability of the strata in which a piezometer has been installed shall be determined by filling the transparent 19mm extension tube with water to a prescribed level above ground level and the rate at which the level falls shall be recorded. Three consecutive tests shall be made.
- 5.26 SOAKAWAY TESTS
- 5.26.1 The following procedure shall be followed for permeability (soakaway) tests, in boreholes above the water table:-
- a) The borehole shall be sunk to a depth of 1m.
 - b) Provided the soil will support itself in the sides of the borehole, the casing should be withdrawn 300mm. If not, the borehole should remain cased to the bottom.
 - c) Water should be poured into the borehole to a depth of 300mm (measured from the bottom of the borehole) and an observation made of the time required for it to soak away.
 - d) Where practicable, the test should be repeated twice to get an average time.
 - e) On completion of the tests, the hole should be bored a further 1m and a further group of tests made.
 - f) The test should be repeated at 3m depth and 4m depth. If, however, the water table is encountered above 4m depth, the last test should be made with the borehole extending to the top of the water table.
- 5.27 PUMPING OUT TESTS
- 5.27.1 Pumping out tests will be required at selected borehole positions, in order to determine the permeability of the ground stratum. These tests shall be carried out by the Contractor under the direction of the Engineer.
- 5.27.2 The Contractor shall supply and set up at the borehole position a suction pump in good working order capable of extracting up to 25 litre/sec (20,000 Imperial gallons/hour), together with all necessary equipment to ensure its efficient operation, to include one 6m length suction header pipe and ten 6m lengths of delivery hose. The pump shall be provided with a gate head valve in order to vary the rate of flow. The rate of flow shall be measured by an approved flowmeter incorporated in the systems, or by other means to be approved by the Engineer
- 5.27.2 The Contractor shall provide suitable uPVC lining, perforated along part of its length to be approved by the Engineer. The diameter of the lining shall be compatible with the temporary steel casing through which it will be placed, and should permit water abstraction up to the maximum rating of the suction pump
- 5.27.3 The uPVC lining shall be installed to a depth to be decided on site by the Engineer but generally not exceeding 6m. The Contractor shall allow for backfilling the exploratory borehole to this depth and include for a one metre layer of punned bentonite balls to achieve a watertight seal. After installing the uPVC lining, the Contractor shall take all due care in extracting the temporary steel casing not to damage or move the lining.

**FIGURE 5.1 - PIEZOMETER**

**FIGURE 5.2 - DEEP BENCHMARKS**

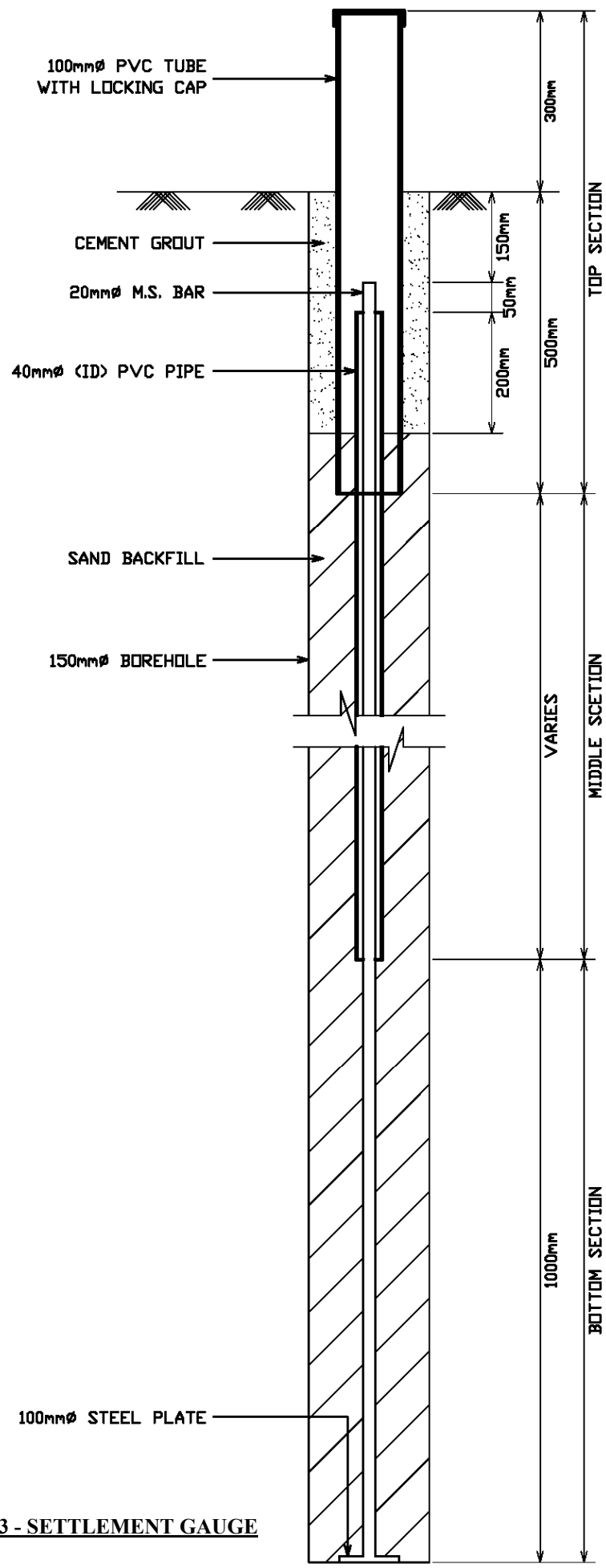


FIGURE 5.3 - SETTLEMENT GAUGE

6 EARTHWORKS**6.1 DEFINITION AND CLASSIFICATION OF EARTHWORKS MATERIALS**

The following definitions of earthworks materials shall apply to this and other clauses of the Technical Specifications in which reference is made to the defined materials:-

- 6.1.1 "Top Soil" shall mean the top layer of soil that can support vegetation. It shall include all turf which has been cut too long to be acceptable for turfing.
- 6.1.2 "Suitable material" shall comprise all that which is acceptable in accordance with the Contract for use in the Works and which is capable of being compacted in the manner specified in Clause 6.20 to form a stable fill.
- 6.1.3 "Sand" for use in the earthworks shall be free of silts, clay, shale and organic and unsuitable material, and shall be capable of being compacted in the manner specified in Clause 6.20 to form a stable fill.
- 6.1.4 "Unsuitable material" shall mean other than suitable material and shall include:-
- a) material from swamps.
 - b) peat, logs, stumps and perishable material.
 - c) material susceptible to spontaneous combustion.
 - d) clay of Liquid Limit exceeding 80 and/or Plasticity Index exceeding 55.
 - e) materials having an in-situ moisture content greater than the maximum permitted for such materials in the Contract, unless permitted otherwise by the Engineer.
- 6.1.5 "Rock" shall mean hard material whose geological nature is to be regarded as such and individual boulders exceeding 0.2m³ in size or other masses of hard material which necessitate the use of blasting or (if agreed by the Engineer) approved pneumatic tools for their removal.
- 6.1.6 "Rock fill" shall consist of hard material of suitable size and grading for deposition and compaction as given in Clauses 6.19 and 6.20 and may comprise rock as defined in this Clause, broken stone, hard brick, concrete or other comparable hard inert material.
- 6.1.7 "Cohesive soil" includes clays with up to 20% of gravel and having moisture content not less than the value of the Plastic Limit (determined in accordance with B.S. 1377, Test No. 3) minus 4.
- 6.1.8 "Well-graded granular and dry cohesive soils" or "granular material" includes clays containing more than 20% of gravel and/or having a moisture content less than the value of the Plastic Limit (determined in accordance with B.S. 1377, Test No. 3) minus 4, well-graded sands and gravels with a uniformity coefficient exceeding 10.
- 6.1.9 "Uniformly-graded material" includes sands and gravels with a uniformity coefficient of 10 or less, and all silts. Any soil containing 80% or more of material in the particle size range of 0.06 - 0.002mm will be regarded as silt for this purpose.

6.2 GENERAL SITE CLEARANCE

- 6.2.1 The Contractor shall demolish, break up and remove walls and superficial obstructions to the depths shown in the Contract on the site in the way of or affected otherwise by the Works. He shall clear each part of the site at the time period and to the extent required or approved by the Engineer.
- 6.2.2 Prior to commencing any site clearance, the Contractor shall mark out by means of a cut trace (rentis) the boundaries of trees and vegetation which are to be retained protected and left undisturbed and agree such boundaries with the Engineer. Clearance works shall commence only with the approval of the Engineer.
- 6.2.3 The Contractor shall clear the whole area within the boundary lines, as shown in the Drawings, of all trees, shrubs, bushes, lallang, vegetation, rubbish, other debris, grub stumps and roots of all trees etc., and dispose off by burning or removing from the site to a pit to be provided by the Contractor at his own cost.
- 6.2.4 The Contractor shall exercise such care and attention as is necessary to ensure that the clearing operation is confined within the boundaries as shown in the Drawings and that no damage is caused to any property or vegetation outside the boundary.

6.3 DEMOLITION OF BUILDINGS AND STRUCTURES

- 6.3.1 Where the Contractor is required to demolish buildings and structures, he shall demolish only those parts which are scheduled for removal in the Drawings or which he is directed to remove by the Engineer. Any damage beyond that so required shall be made good by the Contractor at his own cost. During demolition, the Contractor shall take every precaution to protect all existing works from damage and to ensure the safety of his workers and the public.

6.4 EXISTING TREES, ETC.

- 6.4.1 Where shown in the Drawings to be removed or directed by the Engineer, trees shall be uprooted or cut down as near to ground level as possible. All felled timber shall be removed from the site or burnt.
- 6.4.2 Stumps and tree roots shall, unless directed otherwise by the Engineer, be grubbed up and removed from the site or burnt.

6.5 FILLING DISUSED UNDERGROUND STRUCTURES AND CHAMBERS

- 6.5.1 Disused underground structures and chambers shall be filled and compacted as directed by the Engineer.

6.6 TAKE UP OR DOWN, RE-USE, TAKE TO STORE

- 6.6.1 Various items, when appropriately listed shall be taken up, or taken down, transported to store, re-used, or disposed of, all to the satisfaction of the Engineer.

6.7 EARTHWORKS GENERALLY

- 6.7.1 The Contractor shall carry out all earthworks in such a manner as to prevent erosion or slips, shall limit working faces to safe slopes and height, and shall ensure that all surfaces have at all times sufficient gradients to enable them to shed water without causing erosion and to prevent ponding.
- 6.7.2 The Contractor shall provide and maintain all necessary temporary access roads and temporary drainage and shall divert and re-instate permanent drainage systems. The proposed alignments and levels of temporary access roads shall be submitted to the Engineer for approval prior to their construction. All temporary roads shall be provided with drainage ditches over their full length.

6.8 EXCAVATION GENERALLY

- 6.8.1 The whole of the excavation shown in the Drawings or specified by the Engineer shall be carried out to such lines, levels and dimensions and slopes shown, or as may be ordered by the Engineer in writing from time to time, and faces shall be neatly trimmed. If required by the Engineer, the Contractor shall replace any excess excavation at his own cost and with such material as directed.
- 6.8.2 Unless provided otherwise for in the Contract, excavated material surplus to the requirements of the Works shall become the property of the Contractor and shall be removed from the site.
- 6.8.3 No excavated suitable material other than surplus to requirements of the Contract shall be removed from the site except on the direction or with the permission of the Engineer. If the Contractor is permitted to remove suitable material from the site to suit his operational procedure, then he shall make good at his own cost any consequent deficit or filling arising therefrom.
- 6.8.4 If any suitable material excavated from within the site is, with the permission of the Engineer, taken by the Contractor for purposes other than the forming of embankments general filling areas and other areas of fill, sufficient suitable filling material to occupy, after full compaction, a volume corresponding to that which the excavated material occupies shall, unless directed otherwise by the Engineer, be provided by the Contractor from his own resources.
- 6.8.5 Where the excavation reveals a combination of suitable and unsuitable materials, the Contractor shall, unless agreed otherwise by the Engineer, carry out the excavation in such a manner that the suitable materials are excavated separately for use in the Works without contamination by the unsuitable materials.
- 6.8.6 The Contractor shall dispose of excavated materials in such a manner and at such time as provided for in the Contract.

6.9 BULK EXCAVATION GENERALLY

6.9.1 In bulk excavation, provided that the mean of the excavated area is to the required design level, a spot tolerance of 100mm over or under the design profiles may be permitted unless required otherwise by the Contract.

6.9.2 In the case of cut slopes, the tolerance shall not exceed 50mm measured at right angles to the batter. The tolerance is for workmanship purposes only. Trimming to formation surfaces shall be carried out in accordance with Clause 6.24.

6.10 EXCAVATION OF CUTTINGS

6.10.1 Hauling of material from cuttings or borrow pits to the embankments or other areas of fill shall proceed only when sufficient compaction plant is operating at the place of deposition to ensure compliance with the requirements of Clause 6.19.

6.10.2 Any excess depth excavated below the formation profile tolerance specified in Clause 6.9 shall be made good by backfilling with suitable material of similar characteristics to that removed, and compacted in accordance with Clause 6.20.

6.10.3 Construction traffic shall not use any road formation at the bottom of a cutting unless the cutting is in rock or the Contractor maintains the level of the bottom surface at least 300mm above formation level. Any damage to the subgrade arising from such use of the surface shall be made good by the Contractor at his own cost, with material having the same characteristics as the material which has been damaged.

6.11 BENCHING

6.11.1 Where an embankment or other filling is to be formed on sloping ground, this surface shall be benched in steps or trenched, as shown in the Drawings, if so directed by the Engineer. Where the surface requires to be benched or trenched, this shall include any necessary underdraining of the affected part of the site.

6.11.2 The benching or trenches shall be kept free of water in accordance with Clause 6.25

6.12 EXCAVATION BELOW EMBANKMENTS AND BELOW FORMATION LEVEL IN CUTTING

6.12.1 Where any material below the natural ground level under embankments or below formation level in cuttings is required to be excavated, it shall be removed to such depth and over such areas as are shown in the Drawings or as the Engineer shall direct and disposed of in a manner depending on its nature and condition at the time. The resultant excavation shall be backfilled with suitable material as defined in Clause 6.1, deposited and compacted as specified for the forming of the embankments. Nevertheless where in these circumstances such backfill has to be deposited below standing water, the Contractor shall use only an approved granular material of maximum size not greater than 40mm and which on analysis by sieving complies with the requirements of Table 6.1. Such material may be deposited below water without the associated use of compaction plant.

Table 6.1 - Free Draining Material

B.S. sieve size	Percentage passing by weight
10mm	up to 100
5mm	not more than 85
600µm	not more than 45
75µm	not more than 5

6.12.2 If after the removal of material as specified in Clause 6.12.1 above the Contractor allows the material so exposed to reach a condition where compaction of backfilling is impracticable, he shall make good at his own cost either by additional excavation and filling in the manner specified in this Clause, or by waiting until the condition of the exposed material is fit to receive the approved backfill.

6.13 EXCAVATION OF FOUNDATION PITS AND TRENCHES

6.13.1 The sides of pits and trenches shall be adequately supported at all times. Alternatively, except where the Contract expressly requires otherwise, they may be suitably battered.

- 6.13.2 Trenches and pits shall be kept free of water in accordance with Clause 6.25.
- 6.13.3 Trenches and pits shall be no wider than is necessary for the works to be carried out efficiently.
- 6.13.4 The bottom of all excavations shall be levelled carefully and stepped or benched horizontally as shown in the Drawings. Any pockets of soft material or loose rock in the bottom of pits and trenches shall be removed and the resulting cavities and any large fissures filled with Grade G10 concrete. After placing any blinding concrete required by the Contract, no trimming of the side faces shall be carried out for 24 hours.
- 6.13.5 All excavated materials from such excavations not required for re-filling shall be disposed in accordance with the requirements of the Contract.
- 6.13.6 The Contractor shall make good with suitable material as defined in Clause 6.1 or concrete as directed by the Engineer:-
- a) Any excavation greater than the net volume required for the Works as described in the Contract.
 - b) Any additional excavation at or below the bottom of foundations to remove material which the Contractor allows to become unsuitable.
- 6.13.7 No greater length of trench shall be opened at any one time than has been approved by the Engineer. All surplus spoil shall be removed immediately on excavation, and stacked spoil for filling shall be kept tidy at all times.
- 6.14 FILLING OF FOUNDATIONS PITS AND TRENCHES AND REMOVAL OF SUPPORTS
- 6.14.1 Unless detailed otherwise in the Drawings or directed by the Engineer, all filling for this purpose shall consist of suitable material as defined in Clause 6.2 deposited and compacted by approved plant in accordance with Clause 6.20. Timber shuttering and other excavation supports shall be carefully removed as the filling proceeds except where they are required by the Contract to be left in position, but the removal of such supports will not relieve the Contractor of his responsibilities for the stability of the works.
- 6.15 RE-USE OF PEAT
- 6.15.1 Where required by the Contract, clean peat from the excavations containing no logs, stumps or perishable materials shall be stockpiled in designated storage areas for drying out and treatment, to produce a topsoil substitute for use on the site.
- 6.16 RECORD SURVEY
- 6.16.1 Surveys shall be made of areas of excavation and filling before any work is carried out under the Contract and after all excavation and filling work has been completed. When plans or sections prepared from the above surveys have been agreed between the Engineer and the Contractor as truly representing the original ground levels and the final levels as required by the Contract, the same shall be signed and become record surveys for the assessment of earthwork quantities.
- 6.17 PREPARATION OF FILL AREAS
- 6.17.1 Unless required otherwise by the Contract, the natural ground over which filling is to be placed shall be cleared of all loose boulders, grass, productive soil, bushes, trees, roots and other vegetation. No filling material shall be placed until all watercourses have been diverted or underdrained. No filling material shall be placed on sloping ground until benching or trenching as described in Clause 6.11 has been completed.
- 6.18 SUPPLY OF FILLING MATERIALS
- 6.18.1 All filling material shall be obtained from excavation on site, approved borrow areas or from other sources approved by the Engineer.
- 6.19 FORMING OF EMBANKMENTS AND OTHER AREAS OF FILL
- 6.19.1 Embankments and other areas of fill shall be formed of material defined as "sand" in Clause 6.1. Additionally, when approved by the Engineer, material wetter than the appropriate limit provided by the Contract under inclusion Clause 6.1.4(e) may be incorporated.

- 6.19.2 All earthworks material placed in or below embankments, below formation level in cuttings or elsewhere in the Works shall be deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used. Embankments shall be built up evenly over the full width and shall be maintained at all times with a sufficient camber and a surface sufficiently even to enable surface water to drain readily from them. During the construction of embankments, the Contractor shall control and direct constructional traffic uniformly over their full width. The slope faces of embankments or other fill areas shall be formed by overfilling and cutting back to the desired profile to a tolerance not exceeding $\pm 50\text{mm}$ measured at right angles to the batter. The tolerance is for workmanship purposes only. Damage to compacted layers by constructional traffic shall be made good by the Contractor.
- 6.19.3 Compaction of embankments shall be undertaken to the requirements of Clause 6.20.
- 6.19.4 If the material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the requirements of the Contract, the Contractor shall either:-
- a) make good by removing the material off the embankment either to tip or elsewhere until it is in a suitable physical condition for re-use, and replacing it with suitable material; or
 - b) make good the material by mechanical or chemical means to improve its stability; or
 - c) cease work on the material until its physical condition is again such that it can be compacted as described in the Contract.
- 6.19.5 Isolated boulders each within the range 0.015m^3 to 0.10m^3 in size may be incorporated in embankments not of rock fill at the discretion of the Engineer, provided that the specified compaction requirements are met and no stone exceeding 0.015m^3 shall be placed less than 2m below formation level of carriageways or hard shoulders.
- 6.19.6 Works on embankments and/or cuttings in areas required for the construction of structures shall not be carried out until the Engineer agrees that construction of such structures is sufficiently advanced that there is no risk of interference or damage to them.
- 6.19.7 In carrying embankments up to or over culverts or pipe drains, and where required in the Contract up to or over bridges, the Contractor shall bring the embankments up equally on both sides. Where special forms of compaction adjacent to structures are described in the Contract, filling may proceed over widths less than the full width of the embankment and in steps not exceeding the depth of one layer above the adjoining area of fill.
- 6.19.8 If the Contractor wishes to continue to use the surface of embankments for constructional traffic before trimming to formation level, he shall bring up and maintain the areas to be used to a level not less than 150mm above formation level whereupon constructional traffic will be allowed to use the surface so formed but any damage to the subgrade caused by the use of such surface shall be made good by the Contractor at his own cost.
- 6.19.9 In areas of shallow filling where after removal of topsoil the ground level is within 300mm of formation level, constructional traffic shall not use the surface unless the Contractor brings up and maintains the surface level at least 300mm above formation level. Any damage to the subgrade arising from such use shall be made good by the Contractor at his own cost with material having the same characteristics as the damaged material.

6.20 COMPACTION

Compaction shall be carried out to the following requirements:-

- 6.20.1 All materials shall be compacted as soon as practicable after deposition. Compaction shall be undertaken to the requirements of this Clause and Table 6.2 by approved plant, except where the Engineer directs or permits a departure from the requirements of the Table.
- 6.20.2 Variation from the methods given in Table 6.2, or the use of plant not included therein, will be permitted only if the Contractor demonstrates at site trials that a state of compaction is achieved by the alternative method equivalent to that obtained using the approved methods. The procedure to be adopted for these site trials shall be agreed with and approved by the Engineer.
- 6.20.3 Earth moving plant shall not be accepted as compaction equipment under this Clause.

- 6.20.4 The fill shall be so compacted as to conform to the finished levels shown in the Drawings. The Contractor shall make such allowances as may be necessary for the settlement of fill and foundations during construction. If the Works settle in whole or in part (during construction) below the finished levels shown in the Drawings, the levels shall be made good by the Contractor at his own cost.
- 6.20.5 Fill shall be placed in continuous layers which are approximately horizontal in accordance with Table 6.2. The difference in elevation at any two points on the unfinished surface of the fill shall not generally exceed 1m and any difference in elevation between adjacent points shall be such as to give slopes not in excess of 1 in 20. Before placing any layer, the surface of the underlying layer shall be moistened and/or worked with a scarifier or other suitable equipment if such moistening or working is necessary to ensure that there is a satisfactory bond between the two layers. Furthermore, before placing a new layer any material in underlying layers shall be removed or re-worked, if:-
- a) it has been compacted outside the limits of moisture content specified herein, or
 - b) it has received less compaction than specified herein, or
 - c) it has been cracked by drying, softened by wetting, or damaged by any other cause.

The cost of such removal, reworking or moistening shall be deemed to have been included in the rates entered in the Contract.

- 6.20.6 At the time of compaction of the fill, each portion of the fill shall have moisture content within $\pm 4\%$ (as a percentage of dry weight) above the Proctor optimum moisture content, or within such other 8% range related to the Proctor optimum as the Engineer may allow. The Contractor shall carry out such compaction tests from time to time as may be necessary to determine the Proctor optimum moisture content of the fill material, and such routine moisture content tests as may be necessary to determine the actual moisture content of the fill as placed, so as to ensure and to satisfy the Engineer that this requirement is met. All tests shall be carried out in accordance with B.S. 1377 "Methods of Test for Soil Classification and Compaction" and the Contractor shall maintain clear and accurate records of the results, duly authorised by a competent representative of the Contractor, to the Engineer.

If it is necessary to add water, this may be added on the fill, but only by means of a uniform controlled spray. If it is necessary to dry the material, all necessary work such as ripping, aeration with rotary cultivators, harrowing, etc., shall be done before transporting the material to the embankment.

- 6.20.7 The fill shall be compacted in such a manner that the mean percentage compaction of the fill at any time defined by the ratio Field Dry Density : Laboratory Dry Density, shall be not less than 95% where:-
- a) Field Dry Density = Average of results of tests to determine field dry density.
 - b) Laboratory Dry Density = Average of results of laboratory tests to determine Proctor maximum dry density of the same fill materials.
 - c) The Proctor maximum dry density shall be determined using the Modified Test (4.5 kg. Rammer) in accordance with the requirements of B.S. 1377.
 - d) Within the 500mm depth range below outfall canal, culvert structure, or road formation levels, the mean percentage compaction shall be 100.
 - e) During the course of compaction works, the Contractor will be required to test at a frequency to be determined by the Engineer, but this will be at a rate of not less than that defined in Clause 12.3.
- 6.20.8 Material which has been compacted to a dry density less than that required by these Clauses shall be removed or compacted until the required dry density is achieved.
- 6.20.9 Holes in the fill formed by the removal of samples for tests shall be filled and consolidated in perfect homogeneity with the surrounding fill.
- 6.20.10 The Contractor shall include for the costs of such tests, removal and further compaction in his rates.

- 6.20.11 The Contractor shall carry out compaction trials using the intended compaction plant on each type of fill to be compacted, in advance of the actual use of the fill to determine the number of passes of the plant, the speed of the plant and any layer thickness restriction required to obtain at least the percentage of relative compaction or density already specified. Provided the material in the trial is compacted to the required density, the trial material may form part of the permanent fill. The Contractor shall give the Engineer at least 24 hours written notice of his intention to carry out a compaction trial. The site of the trial shall be clearly marked and levels taken to determine the thickness of the layers before and after compaction. All test results obtained from the trial fill areas shall be submitted to the Engineer.
- 6.20.12 Without prejudice to the provisions of the Conditions of Contract and in order that the Engineer may make proper provision for the supervision of compaction in the permanent processes during periods of overtime, apply in writing to the Engineer for permission to do so. If compaction is carried out during periods of overtime without such permission, the Engineer will carry out field density tests to determine the state of compaction achieved. The results of these tests will be compared with the results of similar tests made on the work known to have been carried out in accordance with Table 6.2 under supervision. If the state of compaction is thereby shown to be inadequate, the Contractor shall at his own cost carry out such further work as the Engineer may decide is required to comply with the terms of the Contract.
- 6.20.13 When materials of widely divergent characteristics are used in embankments and fill areas, they shall be spread and compacted in separate clearly defined areas in such a manner to comply with the requirements of Table 6.2. If more than one class or material is being used in such a way that it is not practicable to define the areas in which each class occurs, compaction plant shall be operated as if only the material which requires the greatest compactive effort is being compacted.

6.21 FILLING - RESTRICTION

- 6.21.1 End tipping will not normally be permitted.
- 6.21.2 At the end of each day, the surface shall be left with no area that can retain water and, if necessary, ditches shall be cut to ensure that this object is attained.
- 6.21.3 When the state of the weather is such that, in the opinion of the Engineer, it would adversely affect the placing of specially compacted fill, all such work shall be stopped.
- 6.21.4 All filling material, whether placed and/or compacted, or awaiting placing and/or compaction which in the opinion of the Engineer does not comply with the specifications or has been damaged by weather or in any other way, shall be removed and replaced at the Contractor's own cost.

6.22 DEFINITIONS AND REQUIREMENTS ASSOCIATED WITH TABLE 6.2

- 6.22.1 The depth of compacted layer is the height by which an embankment is raised by each successive compacted layer.
- 6.22.2 For items marked *, the rollers shall be towed by track-laying tractors. Self-propelled rollers are unsuitable.
- 6.22.3 Where combinations of different types of categories of plant are used, the compaction requirements shall be:-
- a) the depth of layer shall be that for the type of plant requiring the least depth of layer; and
 - b) the number of passes shall be that for the type of plant requiring the greatest number of passes.

However, where the Contractor uses a lighter type of plant to provide some preliminary compaction only to assist the use of heavier plant, this shall be disregarded in assessing the above requirements.

Table 6.2 - Compaction Requirements

Type of compaction plant	Category	Cohesive soil		Well-graded granular and dry cohesive soils		Uniformly-graded materials	
		Max. depth of compacted layer (mm)	Min. no. of passes	Max. depth of compacted layer (mm)	Min. no. of passes	Max. depth of compacted layer (mm)	Min. no. of passes
Smooth wheel roller	Force per 100mm width (kN)						
	2.1 - 2.6	125	8	125	10	125	10*
	2.7 - 5.2	125	6	125	8	125	8*
	more than 5.2	150	4	150	8	Unsuitable	
Grid roller	Force per 100mm width (kN)						
	2.6 - 5.2	150	10	Unsuitable		150	10*
	5.3 - 7.8	150	8	125	12	Unsuitable	
	more than 7.8	150	4	150	12	Unsuitable	
Pneumatic roller	Wheel load (tonnes)						
	1 - 1.5	125	6	Unsuitable		150	10*
	1.5 - 2	150	5	Unsuitable		Unsuitable	
	2 - 2.5	175	4	125	12	Unsuitable	
	2.5 - 4	225	4	125	10	Unsuitable	
	4 - 6	300	4	125	10	Unsuitable	
	6 - 8	350	4	150	8	Unsuitable	
	8 - 12	400	4	150	8	Unsuitable	
	more than 12	450	4	175	6	Unsuitable	
Vibratory roller	Force per 100mm width (kN)						
	0.25 - 0.45	Unsuitable		75	16	150	16
	0.46 - 0.70	Unsuitable		75	12	150	12
	0.71 - 1.25	100	12	125	12	150	6
	1.26 - 1.75	125	8	150	8	200	10*
	1.76 - 2.30	150	4	150	4	225	12*
	2.31 - 2.80	175	4	175	4	250	10*
	2.81 - 3.50	200	4	200	4	275	8*
	3.51 - 4.20	225	4	225	4	300	8*
	4.21 - 4.90	250	4	250	4	300	8*
Vibration plate compactor	Static pressure under base plate (kN/m ²)						
	8.6 - 10.3	Unsuitable		Unsuitable		75	6
	10.3 - 12.1	Unsuitable		75	10	100	6
	12.1 - 13.8	Unsuitable		75	6	150	6
	13.8 - 17.2	100	6	125	6	150	4
	17.2 - 20.7	150	6	150	5	200	4
	more than 20.7	200	6	200	5	250	4
Vibrotamper	Mass (kg)						
	50 - 65	100	3	100	3	150	3
	65 - 75	125	3	125	3	200	3
	more than 75	200	3	150	3	225	3
Power rammer	Mass (kg)						
	100	150	4	150	6	Unsuitable	
	more than 100	275	8	275	12	Unsuitable	

6.23 SETTLEMENT GAUGES

- 6.23.1 Settlement gauges shall be constructed according to the details shown in the Drawings and be placed at locations and levels agreed with the Engineer. The gauges shall be placed at the commencement of earth filling, supported and extended as necessary and protected during the course of the earth filling. The Contractor shall allow in his rates for localised compaction around these gauges by hand or using mechanical wackers, and for recording the levels on a weekly basis.
- 6.23.2 Settlement monitoring locations shall be referenced by incised plastic markers and protected by 4 nos. 100mm x 100mm timber posts with crosspieces spaced 1m from the monitoring point.

6.24 PREPARATION AND SURFACE TREATMENT OF FORMATION SURFACES

- 6.24.1 Preparation and surface treatment of formation surfaces for drainage channels, culvert structures, road carriageways, etc. shall be carried out only after completion of any specified subgrade drainage and, unless agreed otherwise by the Engineer, immediately prior to laying the blinding or the sub-base or road base where no sub-base is required. The sequence of operations shall be as follows:-
- a) All formation surfaces shall, after reinstatement of any soft areas, be well cleaned and freed from mud and slurry.
 - b) The surface shall be compacted by 4 passes of a smooth-wheeled roller having a load per 100mm width of roll of 2.35 - 6.1kN.
 - c) The formation shall be regulated and trimmed.
 - d) The trimmed formation shall be rolled by 1 pass of a smooth-wheeled roller having a load per 100mm width of roll not less than 2.1kN or a vibratory roller having a static load per 100mm width or vibratory roll or not less than 0.7kN or a vibratory plate compactor having a static pressure under the base plate of not less than 13.8kN/m².
- 6.24.2 Where the completed formation is not immediately covered with blinding or sub-base material, it shall be protected by a membrane of 500 gauge impermeable plastic sheeting with 300mm laps set to prohibit ingress of moisture or by sealing. If the Contractor allows the moisture content of accepted compacted material to reach a value above the maximum permitted for the material under the Contract for compaction the Contractor shall allow the material to revert to an acceptable moisture content and if directed by the Engineer, make good at his own cost the surface by re-compaction before laying the sub-base or road base.

6.25 EARTHWORKS TO BE KEPT FREE OF WATER

- 6.25.1 All works shall be carried out in the dry unless authorised otherwise by the Engineer. The Contractor shall arrange for the rapid dispersal of water, shed on to the earthworks or compacted formation during construction, or which enters the earthworks from any source, and when practicable the water shall be discharged into the permanent outfall for the pipe drainage system. Adequate means for trapping silt shall be provided on temporary systems discharging into permanent drainage systems. The arrangements shall be made in respect of all earthworks including excavations whether for pipe trenches, foundations or cuttings.
- 6.25.2 The Contractor shall provide where necessary temporary watercourses, ditches, drains, pumping or other means of maintaining the earth works free from water. Such provision shall include carrying out the work of forming the cuttings and embankments in such a manner that their surfaces have at all times a sufficient minimum crossfall and where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

6.26 SOILING AND TURFING

- 6.26.1 Where turfing is to be carried out, a 100mm thick layer of approved topsoil shall be spread and compacted on the surfaces to be turfed.
- 6.26.2 Turfs shall be neatly laid and well-bonded and shall be laid diagonally across side slopes. The joints between turfs shall be well-flushed up with mould, the whole watered when necessary and beaten down to produce a uniform surface.

6.26.3 Newly turfed areas on slopes of cuttings and embankments shall when required, be pegged down as described in the Contract.

6.26.4 During the period of the Contract, except where directed otherwise, the Contractor shall keep all turfed and soiled areas watered as necessary and prevent the material being disturbed in any way.

6.27 WATERCOURSES

6.27.1 Excavations carried out in the diversion, enlargement, deepening or straightening of watercourses shall include the operations of any necessary trimming of slopes, grading of beds, disposal of excavated materials, pumping, timbering works and materials necessary for dealing with the flow of water.

6.27.2 The beds and sloping sides of watercourses shall, where shown in the Drawings, be protected against the action of water by rubble paving to form a flat or curved surface as indicated. The protection shall consist of large smooth faced stones or of mass or pre-cast concrete. Stones for rubble paving shall be roughly dressed square. No stone shall be less than 250mm in depth or 0.03mm³ in volume and no rounded boulders shall be used.

6.27.3 Where stone protection is required in the beds of watercourses, the stones shall be set on edge and securely bedded, breaking bond, with the longest dimensions at right angles to the flow of water and 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 Contractor shall ensure that the paving stones or concrete, especially at the ends, will not be undermined or damaged by the action of water during construction.

6.27.4 Where stone protection is described in the Contract on the sloping sides of watercourses, the stones of the size and shape as described above shall be set in a similar manner to that required for paving in the bed but in addition shall be bedded on a 75mm layer of gravel.

6.28 FILLING EXISTING WATERCOURSES

6.28.1 Where watercourses have to be diverted from the sites of embankments or other works, the original channels shall be cleared of all vegetable growths and soft deposits, and carefully filled in with suitable materials deposited and compacted as specified in Clauses 6.19 and 6.20.

6.29 VEHICLE CHECKS

6.29.1 The Engineer may require checks to be made on vehicles carrying materials to and from the works. In such cases, the Contractor shall take particular care to ensure that all vehicles are filled and emptied as required and that all vehicles pass the required checkpoints.

7 PILING**7.1 GENERAL**

- 7.1.1 All aspects of piling shall conform to B.S. 8004 "Code of practice for foundations". The recommendations contained in B.S. 8004 are to be complied with unless required otherwise in the Contract.
- 7.1.2 In addition to submitting the records required by this Section, the Contractor shall report immediately to the Engineer any circumstance which indicates that the ground conditions differ from his interpretation of the site investigation records so as to affect materially the bearing capacity of the pile.
- 7.1.3 Where piles have not been positioned or driven within the limits described in the Contract, no method of forcible correction shall be permitted. The Engineer may require piles so positioned to be withdrawn and re-driven, or take such other action as he considers may be necessary, without any cost to the Employer,
- 7.1.4 The Contractor shall provide a competent English speaking Foreman resident on the site throughout the period of the piling work, who shall be in charge of the work on behalf of the Contractor.
- 7.1.5 The Contractor shall establish and locate all lines, levels and be responsible for the correct positions of all piles. The setting out of the pile shall be carried out by a Licensed Surveyor. The Contractor shall submit two copies of setting out plan signed by the Licensed Surveyor and submit for approval before the commencement of the work. The Contractor shall provide methods and means, acceptable to the Engineer for checking the setting out of each pile. All the necessary equipment, tools, labour and any assistance as may be required by the Engineer for carrying out such checking shall be provided by the Contractor. The acceptance of the final position of each pile shall not relieve the Contractor of his responsibility of all necessary remedial works, be it temporary or permanent, ordered by the Engineer as a result of inaccuracy in the positions or piles installed. After the works have been completed, 3 further sets of plans showing the actual positions, inclinations and eccentricities of the piles at their cut-off levels shall be submitted to the Engineer, duly endorsed by the Licensed Surveyor.
- 7.1.6 No idling time or period will be entertained and the Contractor shall allow for this in his Tender.

7.2 WORKING LOAD

- 7.2.1 The designed working load of piles, whether considered singly or as a group, shall be the assessed ultimate bearing capacity divided by a factor which shall not be less than 2. The working load of piles shall be stated in the Drawings.
- 7.2.2 Should the Contractor not agree with the Engineer's instructions concerning installation criteria and/or maximum safe loads for the working piles, he shall notify the Engineer immediately. In the event of no such notification being received by the Engineer, the Contractor will be deemed to agree with the Engineer's decisions and accept responsibility for the load carrying capacity of the piles.
- 7.2.3 The Contractor shall ensure that the piles shall be capable of safely supporting the maximum working loads shown in the Drawings. Should failure of the piles cause any defects or damage to the Works, then all necessary remedial measures as determined by the Engineer shall be implemented without any cost to the Employer.

7.3 TRIAL PILES

- 7.3.1 Where required and before commencing piling works, the Contractor shall provide and drive trial piles in accordance with details agreed with the Engineer.
- 7.3.2 If ordered by the Engineer, trial piles shall be lengthened and re-driven as directed.
- 7.3.3 Within 24 hours of the completion of driving, the Contractor shall submit to the Engineer a record of the pile driving.

7.4 PROPOSED METHOD TO BE APPROVED

- 7.4.1 Prior to the commencement of piling operations, the Contractor shall submit to the Engineer for his approval, details of the proposed method of forming or driving piles together with such information on the equipment to be used as the Engineer may require.

7.5 PILE RECORDS

- 7.5.1 A record of all piles driven or installed shall be kept by the Contractor and a copy of the record of work done each day shall be given to the Engineer within 24 hours.
- 7.5.2 Temporary compression records shall be taken for every pile driven, unless and until the Engineer directs otherwise.
- 7.5.3 On completion of the piling operations, the Contractor shall deliver to the Engineer a drawing recording the final depths of all piles relative to site datum, and details of any tests carried out to the Engineer's instructions.

7.6 BAKAU PILES

- 7.6.1 Bakau piles shall not be less than 100mm in outside diameter anywhere along their lengths. They shall be straight and circular, and of uniform section and supplied in 6m lengths. All branch joints shall be trimmed off to the general outline of the pile. Bark adhering firmly shall be left on the pile, or debarked otherwise. The driving head shall be chamfered off at its edges to minimise splitting during driving, and the lower end shall be pointed. The piles shall be stored on the site constantly in a wet condition.
- 7.6.2 The piles shall be driven using a 0.5 tonne hammer with maximum free fall of 1.2m. The Contractor shall provide a piling rig capable of handling a 9m pile length. No other methods of driving such as the use of excavator, etc shall be allowed.
- 7.6.3 A suitable steel helmet shall be used to protect the head of the pile from damage during driving. Where extension to a pile is necessary, the joint shall be formed by means of a heavy grade galvanised iron pipe 500mm long and of 110mm internal diameter securely spiked to both sections of the pile. After driving has been completed, the tops of the piles shall be cut off to a uniform level.
- 7.6.4 When each pile is being driven, the Contractor shall provide suitable means of measuring the pile set under each blow of the hammer. The cost of the measuring device and of taking and recording all readings during driving shall be deemed to have been included in the Contract.
- 7.6.5 All piles which are broomed, split or otherwise damaged during handling or driving shall be repaired or withdrawn and replaced as directed by the Engineer, at the Contractor's own cost.
- 7.6.6 After driving, no pile shall be more than 50mm off its true position on plan at cut-off level. Vertical piles shall not be out of plumb by more than 1 in 75.

7.7 TIMBER PILES

- 7.7.1 Piles shall be square "Tanapiles" or equivalent approved timber pile which has been treated by tanalising or equivalent preservative process, and shall conform to P.B.D. 8 and P.B.D. 11. Piles shall be incised as recommended by "Tanapile". Preservative shall be continuous and of uniform penetration to a depth of 25mm when tested in accordance with Clause G3 or G4 of B.S. 4072. Minimum retention of preservative in the outer 25mm of pile surface shall not be less than 16kg/m³ when tested in accordance with B.S. 4072 : Appendix D. Samples of piles shall be tested, certified and approved by the Engineer prior to start of production piling.
- 7.7.2 Although the estimated driving length for tender purposes is shown on the documents, the minimum length and/or set to which the piles are to be installed will be stated in writing by the Engineer following completion of tests on the trial pile(s), where such tests are required, but subject to a minimum length below cut-off level of 3m.
- 7.7.3 The piles shall be stored and handled so that they are not subjected to excessive stresses or damage.
- 7.7.4 Piles shall be pitched accurately in the positions shown on drawings. They should be suitably constrained to maintain their correct position by means of guides and no pile which has been wrongly aligned shall be forcibly brought back to the correct alignment.
- 7.7.5 During driving, the heads of all piles shall be protected with a helmet of cast or mild steel fitting closely around the pile, a packing of coiled hemp rope, or plywood, 25mm thick, covering the head of the pile, and

shall be contained within the helmet to separate the helmet from the head of the pile. This type of helmet or modifications shall be approved by the Engineer prior to driving the first pile.

- 7.7.6 A hammer energy of between 1,000 and 1,500kg/m should be employed for driving the piles. In the case of drop hammers, the minimum hammer weight should be 1 tonne properly regulated to achieve a constant drop height. The method and driving energy used for non-working pile(s) and working piles shall be the same.
- 7.7.7 Driving shall be continuous and no stoppage during driving of a complete pile length shall be permitted other than for the addition of a pile extension section. Driving records for the full length of the pile should be submitted to the Engineer each day. When a significant change of driving characteristics is noted, the Contractor shall inform the Engineer immediately. Three consecutive sets shall be taken for each pile.
- 7.7.8 The sets and temporary compression for each pile shall be measured as detailed in B.S. 8004. Each set shall be measured for 10 blows of the hammer.
- 7.7.9 Where it is necessary to extend the piles during driving, an additional length of pile shall be supplied and connected using prefabricated joints. These joints shall be formed by using a mild steel welded box joint 500mm long, 5mm thick and of suitable section. The joints will be dipped in bituminous paint before use, driven to a tight fit with the pile hammer and spiked to both sections of the pile. Sections of piles shall be coaxial and straight.
- 7.7.10 All piles which are broomed, split or otherwise damaged during handling or driving shall be repaired or withdrawn and replaced as directed by the Engineer, at the Contractor's own cost.
- 7.7.11 After driving, no pile shall be more than 50mm off its true position on plan at cut-off level. Vertical piles shall not be out of plumb by more than 1 in 75.
- 7.7.12 The Contractor shall adopt adequate measures to prevent and/or overcome any detrimental effects of ground heave in the piles, and shall record any movement of piles due to subsequent pile driving. The sequence of piling shall be such that piles already driven shall not be damaged.
- 7.7.13 Jetting of piles shall not be undertaken without the previous written agreement of the Engineer, and if used shall not impair the bearing capacity of any pile nor the stability of the surrounding ground.
- 7.7.14 The levels to which piles are to be cut-off shall be as shown in the Drawings. All cut-offs and bored holes shall be treated as follows:-
- a) The cut-heads or bored holes shall be given two flood coats of a 20% (m/v) solution of the preservatives specified in Clause 23 of SS 72 or Clause 12 of B.S. 4072 allowing each application to soak thoroughly into the cut or bored surface.
 - b) Immediately after the preservative solution has dried the pile head shall be heavily coated with a bituminous compound which conforms to B.S. 3416 "Black Bituminous Coating Solutions", for the whole depth that the pile is to be encased in the pile cap.

7.8 CONCRETE PILES

- 7.8.1 All concreting work shall conform to the requirements in Section 9 of this Technical Specifications.
- 7.8.2 Piles shall not be lifted otherwise than by slinging from approved lifting holes or points. For each section, lifting points shall be clearly marked.
- 7.8.3 Before the commencement of driving, each pile (or the driving tube) and the leaders or guides of the pile frame shall be checked for correct rake or plumb and such rake or plumb shall be maintained. At no time during the driving operation shall the centre of the monkey or hydraulic ram be more than 40mm off the centre of the pile being driven.
- 7.8.4 During driving, the heads of piles shall be protected by a helmet and dolly of approved design. The packing of the helmet and the dolly shall be renewed as often as necessary, or as directed by the Engineer to prevent damage to the pile.
- 7.8.5 Driving of a pile shall continue without interruption until the pile has reached the specified or approved set, except that the Engineer may permit the suspension of driving if he is satisfied that the rate of penetration

prior to the cessation of driving will be substantially re-established on its resumption or if the Engineer is satisfied that the suspension of driving is beyond the control of the Contractor.

- 7.8.6 When piles are driven below the leads of the pile frame, extension leads shall be lifted. A follower shall not be used except on approval by the Engineer.
- 7.8.7 All piling shall be carried out in the presence of the Engineer or his representative. Checking and measurement of plumb, alignment, rake, set and temporary compression shall be made as and when directed by the Engineer and in his or his representative's presence.
- 7.8.9 Piles shall not be installed unnecessarily beyond the depths required for them to develop the required load carrying capacity. The Contractor shall state sound and acceptable basis for determining the penetration required of all the piles. No payment shall be made for the extra penetration or board length which the Contractor cannot technically justify.
- 7.8.10 The Contractor shall cover up and protect the works from the weather and suspend all operations which in the opinion of the Engineer would be detrimental to the works.
- 7.8.11 Piles shall be maintained in their correct positions by means of guys or guides or other approved methods but no piles which has been deflected from its course during driving or wrongly aligned shall be brought forcibly back to the correct alignment. During driving, any pile deviating beyond the limits specified in Clause 7.8.16 of this Technical Specifications should be replaced or supplemented by one or more additional piles at the discretion of the Engineer.
- 7.8.12 At the commencement of work in a new area or zone, sets shall be taken at appropriate intervals during the last 3m of the driving to establish the driving characteristics of the piles.
- 7.8.13 When final set is being measured, the following requirements shall be met:-
- a) The exposed part of the pile should be in good conditions without damage or distortion;
 - b) The dolly and packing, if any, shall be in sound conditions;
 - c) The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angle to the pile and hammer axis; and
 - d) The hammer shall be in good conditions and shall perform correctly according to manufacturer's specification.
- 7.8.14 The machine used for the installation of piles shall be of such type and capacity as to meet approval of the Engineer. The selection of hammer shall in general be in accordance with B.S. 8004. It shall be the responsibility of the Contractor to provide a hammer of sufficient capacity and to control the drop of the ram so as to ensure that no piles are damaged during driving.
- 7.8.15 Each pile shall be clearly marked in paint with its number and its overall length. In addition, each pile shall be marked at intervals of 500mm to enable determination of pile penetration. Where necessary, the intervals may be reduced to 250mm as directed by the Engineer.
- 7.8.16 Any single piles in the line carrying a structural load in isolation and deviating more than 50mm laterally from its correct location, or more than 1 in 50 from its correct inclination shall be rejected and replaced when ordered by the Engineer. Positional tolerance of the centre of gravity of the group of pile may be increased to 70mm. Alternatively, at the sole discretion of the Engineer, the pile caps shall be constructed to modified design, to be proposed by the Contractor which takes into account the variation in the pile position of alignment. The cost of such replacement or any extra cost in modification required to the pile cap shall be borne by the Contractor. The Contractor shall have to propose for approval and execute any remedial work, at his own cost, to correct the failure on his part to meet the tolerance permitted. For rake pile, the piling rig shall be set and maintained to attain the specified rake. The maximum permissible deviation of the finished pile from the specified is 1 in 25.
- 7.8.17 The Contractor shall inspect adjoining properties frequently and shall inform the Engineer immediately when any crack, failure or damage is observed.

- 7.8.18 Any piles cracked, deformed, twisted or otherwise damaged in anyway or not installed within the specified tolerance shall be rejected at the discretion of the Engineer, and replaced or supplemented by substitute piles by the Contractor at his own cost. In addition, the Contractor shall bear the extra costs occasioned by such rejection due to increase size of pile caps, strengthening of tie beams, etc.
- 7.8.19 Observations and measurements shall be made at the site during the process of driving piles, by any suitable method so chosen by the Engineer to determine whether a pile has risen as a result of driving adjacent piles. The Contractor shall provide the necessary tools, instrument, and other assistance required by the Engineer to make these measurements.
- 7.8.20 Any pile which has risen by more than 5mm shall be re-driven to the original depth or resistance, unless tests have shown this to be unnecessary. Such tests shall be conducted at the Contractor's own cost under the direction of the Engineer. If the system uses sections which are inadequately designed against driving stresses, the pile shall be jacked down to its original position. The Contractor shall not be entitled to payment for re-driving or jacking down risen piles.
- 7.8.21 The Contractor's proposed sequence of installation of piles in a group or in close proximity shall be approved by the Engineer prior to implementation. The Engineer reserves the right to order changes to the approved sequences of piling if, based on work completed, he considers it necessary to do so. The Contractor shall not be entitled to claim extra payment for additional plant movements, etc. resulting from such an order.

7.9 STEEL PILING

- 7.9.1 The whole of the steelwork and testing shall comply with the relevant clauses of the following standards:-
- a) P.B.D. 10 "Welding - Factors to be considered to ensure quality in welded structures"
 - b) B.S. 4 "Specification for hot-rolled sections"
 - c) B.S. 639 "Specification for covered carbon and carbon manganese steel electrodes for manual metal-arc welding"
 - d) B.S. 648 "Schedule of weights of building materials"
 - e) B.S. 4360 "Specification for weldable structural steels"
 - f) B.S. 4848 "Hot-rolled structural steel sections"
 - g) B.S. 5135 "Specification for arc welding of carbon and carbon manganese steels"
 - h) B.S. 5950 "Structural use of steelwork in building"
- 7.9.2 Sizes of steel sections shall be as shown in the Drawings. All steel piles shall be well and cleanly rolled to the dimensions, sections, and weights specified. They shall be sound and free from cracks, surface flaws, laminations and other defects and shall be finished in a good workman-like manner, straight and free from twists.
- 7.9.3 All steel piles shall be stored and handled so that members are not subjected to excessive stresses or damage. Piles shall be stored clear off the ground on timber or other suitable bearers. Any damage to the steel piles on the site due to inadequate precautions shall be made good to the satisfaction of the Engineer at the Contractor's own cost.
- 7.9.4 H-Section piles shall be supplied in 12m lengths, together with certificates of testing and origin. Steel pipe bearing piles shall be supplied in 9m lengths, together with certificates of testing and origin.
- 7.9.5 For welding of any particular type of joint, welders shall give evidence acceptable to the Engineer of having satisfactorily completed appropriate tests as described in B.S. 5950.
- a) Welding shall be electric arc welding.
 - b) Welding procedures shall be approved in accordance with B.S.EN 288 : Part 3 and shall be carried out in accordance with the requirements of P.B.D. 10.
 - c) The surface to be welded shall be free from scale, grease, paint, rust or other matter. After every run of weld, slag shall be chipped out and surfaces thoroughly wire-brushed.
 - d) The piles shall be accurately located and adjusted during welding to ensure that the straightness of the completed pile shall not deviate more than 3mm along a 3m straight edge or by more than 1 in 1000 overall.
 - e) Welding shall not be carried out in adverse weather conditions as determined by the Engineer.

- 7.9.6 In the event of any material proving defective, such material shall be rejected notwithstanding any previous certificate of satisfactory testing. Defective material shall be removed from the site immediately on being condemned. For used B.S.P pipe piles, all pipes with corrosion scale of more than 1.5mm shall be rejected.
- 7.9.7 Manufacturer's mill test certificates for all structural steel shall be supplied to the Engineer when requested. The certificates shall state the process of manufacture and shall include a test sheet signed by the manufacturer giving the results of the mechanical test applied to the steel purchased and its chemical composition. Should the Engineer require structural steel to be tested, samples shall be taken for testing at an independent testing station in accordance with B.S. 4360. All costs in this connection shall be borne by the Contractor. Should the results of either test be unsatisfactory, the whole consignment of steel which the sample represents shall be rejected and shall be replaced by other materials of proper quality at the Contractor's own cost.
- 7.9.8 If proper resistance to driving is not attained at the contemplated level of cut-off, the driving shall be continued and an additional length of pile required shall be supplied and joined in such a way as to develop the full strength of the section of the pile. The method of jointing shall be as detailed in the Drawings.
- 7.9.9 Piles shall be pitched accurately in the positions shown in the Drawings. They should be suitably constrained to maintain their correct positions by means of guys or guides and no pile which has been wrongly aligned, shall be forcibly brought back to correct alignment. The first driven length of every pile shall be a full supplied length without joints. The use of lengths less than full supplied length for the first portion of the pile will not be permitted without prior approval of the Engineer. If such approval is given, the cost of any joints will be at the Contractor's own cost.
- 7.9.10 Driving shall be continuous and no stoppages shall occur during driving of a complete pile length (other than for extension of a pile). The pile head shall be protected properly by a well-packed pile helmet.
- 7.9.11 On the Engineer's instructions, The Contractor shall extract, re-pitch and re-drive any pile which deviates from its correct position beyond the specified tolerance stated in Clause 7.9.16.
- 7.9.12 Piles are to be driven to a minimum resistance of 2 times the safe carrying capacity of the pile for each size of pile as calculated by the Hiley Formula.
- 7.9.13 The sets and temporary compression for each pile must be agreed and approved by the Engineer. The temporary compression shall be obtained by site measurement. The Contractor is required to determine the set of the piles based on the plant type used. The proposed set is to be submitted for the approval of the Engineer.
- 7.9.14 For the purpose of determining the levels at which piles shall be cut off, the cut-off level shall be as shown in the Drawings. The Contractor shall be fully responsible for finishing the piles at the specified cut-off levels and shall obtain written permission for cutting off the piles from the Engineer. Where piles cannot be (or at the instruction of the Engineer, are not) driven to the full length supplied, the Contractor shall cut these piles at the cut-off as defined. The cut-off lengths may be re-used if approved by the Engineer.
- 7.9.15 The Contractor must provide sufficient approved diesel hammer piling machine to complete the whole piling works within the stipulated contract period, and all other necessary equipment and competent operatives for the piling works. The piling machines shall be easily mobile, either self-propelled on tracks or of the independent type attached to a crane which is self-propelled.
- 7.9.16 No driven pile shall deviate from the vertical or raking position greater than 50mm for the full length of the pile, nor more than 50mm out of position on plan. Piles deviating from correct position or plumb by more than this tolerance will be liable to rejection (at the Engineer's absolute discretion) in which case the piles concerned shall be extracted and removed from site and replacement piles (complying in all respects with the requirements of this Technical Specifications) driven in substitution thereof, all at the Contractor's own cost. If necessary, the Contractor will drive 2 piles in replacement of the rejected pile at no extra charge. Piles deviating from correct position or plumb shall under no circumstances be rectified by pulling, pushing or forcibly brought back to correct alignment.

- 7.9.17 If buried tree trunks or obstructions of any kind to pile driving are encountered, the Contractor shall submit to the Engineer for approval details of the method he proposes to adopt for overcoming the problems. Notwithstanding such approval, the Contractor shall remain solely responsible for ensuring that the piles are driven to true position and set. The Contractor shall bear all costs involved in removing these obstructions. In order to avoid buried obstructions, the Contractor is advised to excavate for the pile caps prior to the piling work.
- 7.9.18 Any piles cracked, broken or otherwise damaged in handling or driving, not truly driven or installed or which are unduly out of position or twisted, shall be removed and a new pile or piles shall be substituted by the Contractor at his own cost, even if piles of bigger capacity are required.
- 7.9.18 Any piles cracked, broken or otherwise damaged in handling or driving, not truly driven or installed or which are unduly out of position or twisted, shall be removed and a new pile or piles shall be substituted by the Contractor at his own cost, even if piles of bigger capacity are required.
- 7.9.19 Immediately after a pile has been completely driven, a record shall be made of the reduced level of the pile head and further checks as directed by the Engineer shall be made on the level of the head after the driving of adjacent piles. Should any pile heave upwards, it shall be re-driven to its original level or until its specified set is again obtained, as directed by the Engineer, all at the Contractor's own cost. Alternatively, the pile may be load tested to show that the pile complies with the load settlement clause.
- 7.9.20 During execution of the Works, the Contractor shall exercise all precautions for the avoidance of such vibrations as will be likely to cause movement in the sub-soil below existing neighbouring drains and service pipe. Any damage caused by vibrations arising from the execution of the Works shall be made good at the Contractor's own cost and to the satisfaction of the Engineer and the relevant Authorities.

7.10 STEEL SHEET PILES

- 7.10.1 The steel sheet piling shall be of the type and lengths detailed in the Drawings, including any corner, junction or other special piles required. The steel from which the piles are rolled shall be mild steel complying with B.S. 4360 Grade 43A or 43A1. The maximum rolling margins shall be 4% above and 2.5% below the calculated weights. The Contractor shall be responsible for providing all works test certificates, analyses and mill test certificates as required.
- 7.10.2 The piles shall be in one length throughout, straight and true to section. Piles which, in the opinion of the Engineer, are defective in any way shall be rejected and replaced by the Contractor.
- 7.10.3 Where piles have to be stored, they shall be placed on sufficient supports on firm ground to avoid damage by excessive bending. Piles shall be lifted when pitching only by use of suitable fittings attached through lifting holes.
- 7.10.4 The steel sheet piling shall be driven vertical on the lines and to the dimensions shown in the Drawings. It shall be pitched in panels and driven with a hammer suspended from a crane.
- 7.10.5 During driving, the steel sheet piling shall be held in position by substantial temporary waling at two levels. The lower waling shall be as low as possible, either at ground level or just above low water level, and the upper ones usually at a height equal to about one-third or one-half the pile length. The guide waling shall be securely supported by a substantial trestle spiked to the ground or adequately weighted, or by temporary piles.
- 7.10.6 When pitching the piles, a check shall be kept and adjustments made as required to ensure that the correct spacing is maintained. To achieve this, the width of individual pairs of piles can be varied slightly by "opening" or "closing" them.
- 7.10.7 The sheet piling shall be driven in pairs and the hammer shall be equipped with a suitable wide anvil or driving head for the particular section of piling in accordance with the manufacturer's recommendations. In commencing the pile driving, a pair of piles shall be placed between the guide waling and carefully plumbed so that it shall be driven truly vertical.
- 7.10.8 This first pair shall be driven to half its final penetration. About 6 to 12 further pairs of piles to form a panel shall then be pitched and secured between the waling in their correct line and spacing, and the last pair of piles in the panel shall be driven to half penetration. Thereafter, the remaining piles in the panel shall be driven to full penetration, starting with the pair next to the last pair pitched and working back towards the

first pair. The last pair pitched shall be left upstanding and treated as the first pair of the following panel of piles.

- 7.10.9 If driving is hard, it shall be carried out in several stages in which each pair of piles in turn is driven down only a few metres and the process repeated over the whole panel until the required penetration is obtained. If one pair of piles reaches refusal at part penetration due for example to striking an obstruction, driving on it shall not be continued but the adjoining piles shall first be driven down and the installation of the troublesome pair then completed if possible.
- 7.10.10 If the Contractor wishes to adopt any special method of driving the piles, he will first submit details and obtain the approval and consent of the Engineer.
- 7.10.11 After driving, no pile shall be more than 50mm off its true position on plan. Vertical piles shall not be out of plumb by more than 1 in 75.

7.11 PRESTRESSED SPUN CONCRETE PILES

- 7.11.1 Piles shall be manufactured to comply with the requirements of B.S. 8004 and B.S. 8110 : Part 1.
- 7.11.2 Materials shall be as follows:-
- a) Cement shall be ordinary Portland cement conforming to B.S. 12.
 - b) Aggregates shall be clean granite that is durable and strong. Soundness and the maximum amount of dust, clay, organic matter or other deleterious substances in the aggregates shall conform to the requirements of B.S. 882. Grading shall be consistent with the grading used in the approved mix designs. Aggregates shall be uniformly graded. The maximum size of coarse aggregate shall not exceed 20mm, or 40% the thickness of the pile.
 - c) Fine aggregates shall be clean river sand and NOT sea or beach sand.
 - d) Water used in mixing concrete shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials or other substances that be deleterious to concrete or steel and shall conform to the requirements of B.S. 3148.
 - e) Admixtures when ordered or permitted to be used shall meet the requirements of B.S. 5075.
 - f) Wires of prestressed concrete shall conform to (JIS) G 3109 for pretensioned construction. Spiral reinforcement shall be cold drawn conforming to B.S. 4461. Deformed reinforcing bars shall conform to B.S. 4449.
 - g) Joints shall consist to steel plates meeting the requirements of B.S. 4360, Grade 43A as applicable.
 - h) Cast-in-place concrete used in capping the piles shall be Grade G30 concrete.
- 7.11.3 Piles shall be manufactured by the centrifugal casting process. Metal forms shall be used and they shall be well-braced and stiffened against deformations caused by the hydrostatic pressure of the wet concrete while spinning. The metal forms shall have smooth joints and inside surfaces. The forms shall be accessible for adequate cleaning.
- 7.11.4 The portions of the forms which form the end surfaces of the pile sections must be a true plane perpendicular to the axis of the section within the following tolerances. Maximum allowable deviation for abutting end surfaces 1.5mm; for pile head end surfaces 5mm; and for pile tip end surfaces 25mm.
- 7.11.5 The concrete mix shall provide the most uniform possible distribution of aggregates across the wall of the pile sections. Fine and coarse aggregates shall have as nearly as possible the same specific gravity. The water ratio by weight shall not exceed 0.35. The concrete shall be Grade G60 (in conformance to B.S. 5400 : Part 7) and have a minimum compressive strength of 60MPa in 28 days. The wall thickness of the spun pile shall be within tolerances of -3mm and +9mm.
- 7.11.6 Pretension reinforcing wires shall be centred in the pile wall. The transfer of prestress shall be accordance with B.S. 8004. The spiral reinforcement shall be outside the longitudinal reinforcement and shall have the

minimum cover as required in the Codes. The spiral cage shall be securely held in position during the casting and spinning operation.

- 7.11.7 The piles may be initially steam cured. Steam shall not be applied until 60 minutes have elapsed following casting. The section may then be steam cured between 55°C and 70°C. Steam shall be so introduced that the temperature in the curing chamber is raised uniformly. After the section has been steam cured for a minimum of 3 hours, the forms may, if the concrete has reached sufficient strength to sustain all handling stresses, be removed from the section. The piles shall not be taken out of the curing chamber until the temperature in the curing chamber has been gradually reduced to that prevailing temperature outside. The curing shall be carried out by such a method that may not affect adversely the quality of the product.
- 7.11.8 The method of handling of the pile sections shall be such that no damage to the concrete will occur. However, the minimum prestress in the concrete after all losses shall be adequate to resist stresses induced by handling. The main body of the prestressed concrete pile shall, when subjected to the bending test, not develop crack of width more than 0.05mm under a bending moment as specified.
- 7.11.9 The bending strength test shall be performed by supporting the pile section at points located 0.2L from its ends (where L is the length of the pile section). The vertical load shall be applied at the centre of the span. Two piles from each lot shall be so tested. If one of the two does not meet the test criteria, four other pile sections shall be further sampled and tested. If all four satisfy the test, then all piles in the lot will be accepted, otherwise all piles in that lot shall be rejected.
- 7.11.10 Both ends of each length of pile are to be provided with a steel end plate. The ends of the PC tendons shall be fixed to the steel end plate such that the full prestressing force is transmitted over to the steel end plate. The ends of the PC tendons shall be flushed with the top of the steel end plate. The end surface of the steel end plate shall be in plane which is at right angles to the longitudinal axis of the pile.
- 7.11.11 The barrel of the steel casing welded to the end plate shall be flushed with the barrel of the concrete shaft of the pile, with a chamfer to accommodate the required depth of welding when two lengths of pile are jointed.
- 7.11.12 The bending strength of a joint between lengths of pile shall be equal or more than the bending strength of the concrete shaft. When two lengths of piles are jointed, the end plates must bear over their complete areas. Shims for packing will not be accepted. The two end plates are then welded along their entire periphery with weld size as specified.
- 7.11.13 All welding shall be carried out in accordance with the requirement of B.S. 5135. Welders shall be qualified in accordance with the requirements of AWS Code D 1.1. Only welders who pass the qualifying tests for the type of weld specified shall be employed on the Works.
- 7.11.14 Fillet welds between the end plates of the joints shall be tested using magnetic particle or dye penetrant test methods. Copies of these test records and reports shall be furnished to the Engineer. Where such examination reveals defects in the welds, the joints shall either be rejected or repaired. If repeat tests show the weld to be still defective, the joint shall be rejected. The defective weld shall be removed and replaced with a fresh weld and re-examined. For the purpose of this Clause, cracks, leaks, laminations, lack of complete fusion, undercutting or reduction in wall thickness adjacent to the weld shall constitute a defect.
- 7.11.15 Pile driving:-
- Pile hammers shall be of size and type able to deliver consistently an effective dynamic energy suitable to the piles to be driven and the material into which they are to be driven. Hammers shall be provided with proper driving helmets suited for the piles. Any indication of collapse of hoses, stripping of hose lining or any erratic action of the hammer shall be cause for immediate shutdown until the problem has been corrected.
 - Pile hammers shall be operated at the full rated efficiency any capacity and in the manner specified by the manufacturer, except as directed otherwise by the Engineer, or noted herein below in Clause 7.11.15(d).
 - When a steam or air hammer is used for driving any type of piles, both the volume and pressure of steam or air recommended by the manufacturer of the hammer shall be maintained at all times to ensure full energy of the driving. Before pile driving is started, the Contractor shall provide written certification to the Engineer that the pile hammer, compressors and valves have been inspected and found to be in good working condition.

- d) When the pile is set in a pre-jetted or pre-drilled hole or when the point of a prestressed concrete pile is passing through soft soil so that there is little or no resistance to penetration of the pile, there is a possibility that longitudinal tensile stresses may be set up in the pile shaft by the elastic shock waves travelling up and down the pile. For such driving conditions, the length of stroke of the hammer shall be reduced. Failure of the piles due to longitudinal tensile stresses caused by excessive driving shall be the Contractor's responsibility.
 - e) The heads of all prestressed concrete cylinder piles shall be protected with a soft wood cushion block at least 18cm thick to effectively and uniformly distribute hammer blow energy. The block shall be composed of layers of 20mm hi-grade marine plywood or approved equal, and of such dimensions as to completely cover the concrete cross-section of the pile. The cushion block shall be inspected periodically during driving and no driving shall be done with a block that has been unduly worn and compressed with use. Cushion blocks must be replaced when compressed to half their original thickness, when badly worn or when burning.
 - f) The piles shall be driven to the driving resistance or tip elevation as determined by the Engineer from pile load tests. The maximum allowable variation at the butt end of the pile shall be 150mm in any direction from the location shown in the Drawings or as direction by the Engineer. Any variation beyond these limits shall be allowed or rejected at the sole discretion of the Engineer.
- 7.11.16 Top of foundation piles shall be embedded in the concrete footing of pile cap, a minimum depth of 75mm (measured at centreline of pile). When the top elevation of a pile is below the elevation of the bottom of the cap, the pile shall, if approved by the Engineer, be built up from the butt of the pile to the elevation of the bottom of the cap by an approved method. The cuts shall be made accurately in clean, straight lines; care shall be exercised to avoid damaging the remaining pile and to ensure full bearing between the footings (or caps) and piles.
- 7.11.17 The inside of the pile shall be roughened (by sand blasting or bush hammering) in order to improve the bonding strength between the cast-in-place concrete cap and the precast concrete pile. The cast-in-place concrete cap shall not be poured until the inside of the precast pile has been inspected by the Engineer and his approval is obtained.
- 7.11.18 Any length of pile surplus to that required for incorporation in the substructure shall be cut off and removed.
- 7.12 STATIC LOAD TESTING OF PILES
- 7.12.1 This Clause addresses the testing of a pile by the controlled application of an axial load. It covers vertical and raking piles tested in compression (i.e. subjected to loads or forces in a direction such as would cause the piles to penetrate further into the ground) and vertical or raking piles tested in tension (i.e. subjected to forces in a direction such as would cause the piles to be extracted from the ground).
- 7.12.2 The design and full details of the proposed load application system shall be satisfactory for the required test. When required, these details shall be submitted to the Engineer prior to the commencement of testing.
- 7.12.3 Definitions:-
- a) *Allowable pile capacity* : a load which is not less than the specified working load and which takes into account the pile's ultimate bearing capacity, the materials from which the pile is made, the required factor of safety, settlement, pile spacing, downdrag, the overall bearing capacity of the ground beneath the piles and any other relevant factors. The allowable pile capacity indicates the ability of a pile to meet the specified loading requirements.
 - b) *Compression pile* : a pile which is designed to resist an axial force such as would cause it to penetrate further into the ground.
 - c) *Constant rate of penetration (CRP) test* : a test in which the pile is made to penetrate the soil from its position as installed at a constant controlled speed, while the force applied at the top of the pile to maintain the rate of penetration is continuously measured. The purpose of the test is to derive the ultimate bearing capacity of a pile and not its load settlement characteristics.
 - d) *Constant rate of uplift (CRU) test* : the same in principle as the CRP test, but the pile is subject to uplift rather than compression. The purpose of the test is to determine the 'pull-out' capacity of a pile.

- e) *Design verification load (DVL)* : a load which will be substituted for the specified working load for the purpose of a test and which may be applied to an isolated or singly loaded pile at the time of testing in the given conditions of the site. This load will be particular to each preliminary or other test pile and should take into account the maximum specified working load for a pile of the same dimensions and materials, allowances for soil-induced forces such as downdrag (which may act in reverse under the temporary loading conditions), any other particular conditions of the test such as variation of pile head casting level.
 - f) *Kentledge* : dead load used in a loading test.
 - g) *Maintained load test* : a loading test in which each increment of load is held constant either for a defined period of time or until the rate of movement (settlement or uplift) falls to a specified value.
 - h) *Proof load* : a load applied to a selected working pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed the design verification load plus 50% of the specified working load.
 - i) *Raking pile* : a pile installed at an inclination to the vertical.
 - j) *Reaction system* : the arrangement of kentledge, piles, anchors or rafts that provides a resistance against which the pile is tested.
 - k) *Specified working load (SWL)* : the specified load on the head of a pile as shown in the Drawings or in provided schedules.
 - l) *Tension pile* : a pile which is designed to resist an axial force such as would cause it to be extracted from the ground.
 - m) *Test pile* : any pile to which a test is, or is to be, applied.
 - n) *Ultimate bearing capacity* : the load at which the resistance of the soil becomes fully mobilized.
 - o) *Working pile* : one of the piles forming the foundation of a structure.
- 7.12.4 The Contractor shall give the Engineer at least 48 hours' notice of the commencement of construction of any preliminary pile which is to be test-loaded.
- 7.12.5 Each preliminary test pile shall be constructed in a manner similar to that to be used for the construction of the working piles, and by the use of similar equipment and materials. Any variation will be permitted only with prior approval. Extra reinforcement and concrete of increased strength will be permitted in the shafts of preliminary piles at the discretion of the Engineer.
- 7.12.6 For each preliminary pile which is to be tested, a detailed record of the conditions experienced during boring, or of the progress during driving, shall be made and submitted to the Engineer daily, not later than noon on the next working day. Where the Engineer requires soil samples to be taken or in-situ tests to be made, the Contractor shall present the results without delay.
- 7.12.7 Four test cubes shall be made from the concrete used in the preliminary test pile and from the concrete used for building up a working pile. If a concrete pile is extended or capped for the purpose of testing, a further four cubes shall be made from the corresponding batch of concrete. The cubes shall be made and tested in accordance with B.S. 1881. The pile test shall not be started until the strength of the cubes taken from the pile exceeds twice the average direct stress in any pile section under the maximum required test load, and the strength of the cubes taken from the cap exceeds twice the average stress at any point in the cap under the same load. Variation of procedure will be permitted only if approved by the Engineer.
- 7.12.8 If a test is required on a working pile, the Contractor shall cut down or otherwise prepare the pile for testing as required by the Engineer.
- 7.12.9 The cut-off level for a preliminary test pile shall be approved by the Engineer. Where the cut-off level of working piles is below the ground level at the time of pile installation and where it is required to carry out a proof test from that installation level, either allowance shall be made in the determination of the design verification load for friction which may be developed between the cut-off level and the existing ground level,

or the pile may be sleeved appropriately or protected otherwise to reduce substantially or eliminate friction which develops over the extended length.

- 7.12.10 The setting-up of pile testing equipment shall be carried out under competent supervision and the equipment shall be checked to ensure that the setting-up is satisfactory before the commencement of load application. All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.
- 7.12.11 Design, erection and dismantling of the pile test reaction system and the application of load shall be carried out according to the requirements of the various applicable statutory regulations concerned with lifting and handling heavy equipment and shall safeguard operatives and others who may from time to time be in the vicinity of a test from all avoidable hazards.
- 7.12.12 Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structure in such a manner that there will not be differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it becoming unstable because of deflection of the supports or for any other reason.
- 7.12.13 The weight of kentledge for each test shall be greater than the maximum test load for that test, and if the weight is estimated from the density and volume of the constituent materials an adequate factor of safety against error shall be allowed. Additional kentledge required shall be determined taking into account the accuracy of positioning of the centre of gravity of the stack.
- 7.12.14 Where tension piles, reaction piles or ground anchorages are required to provide the necessary load reaction, they shall be so designed that they will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. Such piles (which unless approved will not be working piles) or anchorages shall be placed in the specified positions, and bars, tendons or links shall be aligned to give a stable reaction in the direction required. Any welding employed to extend or to fix anchorages to a reaction frame shall be carried out so that the full strength of the system is adequate and unimpaired.
- 7.12.15 In all cases, the Contractor shall ensure that when the hydraulic jack and load-measuring device are mounted on the pile head, the whole system will be stable up to the maximum load to be applied. If in the course of carrying out a test any unforeseen occurrence should take place, further loading shall not be applied until a proper engineering assessment of the condition has been made and steps have been taken to rectify any fault. Reading of gauges should, however, be continued where possible and if it is safe to do so.
- 7.12.16 Where an inadequacy in any part of the system might constitute a hazard, means shall be provided to enable the test to be controlled from a position clear of the kentledge stack or test frame. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a pressure of 1.5 times the maximum pressure used in the test without leaking.
- 7.12.17 The maximum test load expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.
- 7.12.18 For a pile that is tested in compression, the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment. Any pile cap shall be concentric with the test pile; the joint between the cap and the pile shall have a strength equivalent to that of the pile. Sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that, at the maximum expected settlement, load is not transmitted to the ground by the cap.
- 7.12.19 For a pile that is tested in tension, means shall be provided for transmitting the test load axially without inducing moment in the pile. The connection between the pile and the loading equipment shall be constructed in such a manner as to provide a strength equal to the maximum load which is to be applied to the pile during the test, with an appropriate factor of safety on the structural design.
- 7.12.20 Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorages. Kentledge shall not be used for tests on raking piles except where the test arrangement has been specifically designed for such use and has been approved by the Engineer. Where kentledge is to be used, it shall be

supported on cribwork and positioned so that the centre of gravity of the load is as close as possible to the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack.

- 7.12.21 Tension tests may be carried out using compression piles, rafts or grillage constructed on the ground to provide the necessary reaction. In all cases, the resultant force of the reaction system shall be coaxial with the test pile. Where inclined piles or reactions are proposed, full details shall be submitted for approval prior to the commencement of testing.
- 7.12.22 Working piles shall not be used as reaction piles without approval. Where working piles are used as reaction piles, their movement shall be measured and recorded to within an accuracy of 0.5mm.
- 7.12.23 Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3m. The centre-to-centre spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2m, whichever is the greatest, except in the case of piles of 300mm diameter (or equivalent) or less, in which case the latter dimension may be reduced to 1.5m. Where a pile to be tested has an enlarged base, the same criterion shall apply with regard to the pile shaft, with the additional requirement that no surface of a reaction pile shall be closer to the base of the test pile than one half of the enlarged base diameter.
- 7.12.24 Where ground anchorages are used to provide a test reaction for loading in compression, no section of fixed anchor length transferring load to the ground shall be closer to the test pile than three times the diameter of the test pile. Where the pile to be tested has an enlarged base, the same criterion shall apply with regard to the pile shaft, with the additional requirement that no section of the fixed anchor transferring load to the ground shall be closer to the pile base than a distance equal to the base diameter.
- 7.12.25 The reaction frame support system shall be adequate to transmit the maximum test load in a safe manner without excessive movement or influence on the test pile. Calculations shall be provided to the Engineer when required to justify the design of the reaction system.
- 7.12.26 The method employed in the installation of the reaction system shall be such as to prevent damage to any test pile or working pile.
- 7.12.27 The equipment used for applying load shall consist of a hydraulic ram or jack. The jack shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. Detailed proposals to use more than one ram or jack will be subject to approval by the Engineer. The complete system shall be capable of safely transferring the maximum load required for the test. The length of stroke of a ram shall be sufficient to cater for deflection of the reaction system under load plus a deflection of the pile head up to 15% of the pile shaft diameter unless otherwise specified or agreed prior to commencement of test loading.
- 7.12.28 A load measuring device shall be used and in addition a calibrated pressure gauge included in the hydraulic system. Readings of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used; the pressure gauge readings are required as a check for gross error.
- 7.12.29 The load measuring device may consist of a load measuring column, pressure cell or other appropriate system. A spherical seating of appropriate size shall be used to avoid eccentric loading. Care shall be taken to avoid any risk of buckling of the load application and measuring system. Load measuring and application devices shall be short in axial length in order to secure stability. The Contractor shall ensure that axial loading is maintained. The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together. Certificates of calibration shall be supplied to the Engineer.
- 7.12.30 The loading equipment shall enable the load to be increased or decreased smoothly or to be held constant at any required value.
- 7.12.31 In a maintained load test, movement of the pile head shall be measured by one of the methods in clauses 7.12.33, 7.12.34, 7.12.35 and 7.12.36 in the case of vertical piles, or by one of the methods in clauses 7.12.33, 7.12.35 and 7.12.36 in the case of the raking piles, as required.

- 7.12.32 In a CRP or a CRU test, the method in Clause 7.12.33 shall be used. Check levelling of the reference frame or the pile head shall not be required. The dial gauge shall be graduated in divisions of 0.02mm or less.
- 7.12.33 An independent reference beam or beams shall be set up to enable measurement of the movement of the pile to be made to the required accuracy through dial gauges. The supports for a beam shall be founded in such a manner and at such a distance from the test pile and reaction system that movements of the ground do not cause movement of the reference beam or beams which will affect the accuracy of the test. The supports of the beam or beams shall be at least three test pile diameters or 2m from the centre of the test pile, whichever distance is the greater. Check observations of any movements of the reference beam or beams shall be made and a check shall be made of the movement of the pile head relative to a remote reference datum at suitable intervals during the progress of the test. The measurement of pile movement shall be made by four dial gauges rigidly mounted on the reference beam or beams, bearing on prepared flat surfaces fixed to the pile cap or head and normal to the pile axis. Alternatively, the gauges may be fixed to the pile and bear on prepared surfaces on the reference beam or beams. The dial gauges shall be placed equidistant from the pile axis and from each other. The dial gauges shall enable readings to be made to an accuracy of at least 0.02mm and have a stroke travel of at least 25mm. Machined spacer blocks may be used to extend the range of reading. Equivalent electrical displacement measuring devices may be substituted.
- 7.12.34 An optical levelling method by reference to a remote datum may be used. Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5mm. A scale attached to the pile or pile cap may be used instead of a levelling staff. At least two reliable independent datum points shall be established. Each datum point shall be so situated as to permit a single setting-up position of the level for all readings. No datum point shall be located where it can be affected by the test loading or other operations on the site.
- 7.12.35 Two parallel reference wires, one on either side of the pile, shall be held under constant tension at right angles to the test pile axis between supports formed as in the method in clause 7.12.33. The wires shall be positioned against scales fixed to the test pile head in an axial direction and the movements of the scales relative to the wires shall be determined. Check observations of any movements of the supports of the wires shall be made and a check shall be made on the movement of the pile head at approved time intervals. Readings shall be taken to within an accuracy of 0.5mm.
- 7.12.36 The Contractor may submit for approval any other method of measuring the movement of the test pile head.
- 7.12.37 Throughout the test period all equipment for measuring load and movement shall be protected from adverse effects of sun, wind and precipitation.
- 7.12.38 Construction activity and persons who are not involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measuring apparatus. Full records shall be kept of any intermittent unavoidable activity and its effects.
- 7.12.39 The Contractor shall give the Engineer at least 24 hours' notice of the commencement of the test. No load shall be applied to the test pile before the commencement of the specified test procedure.
- 7.12.40 The maximum load which shall be applied in a proof load test shall normally be the sum of the design verification load (DVL) plus 50% of the specified working load (SWL). The loading and unloading shall be carried out in stages as shown Table 7.1. Following each application of an increment of load, the load shall be maintained at the specified value for not less than the period shown in Table 7.1 and until the rate of settlement is less than 0.25mm/h and slowing down. The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the points. For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load, at not more than 5 minute intervals up to 15 minutes, at approximately 15 minute intervals up to 11 hour, at 30 minute intervals between 1 hour and 4 hours, and 1 hour intervals between 4 hours and 12 hours after the application of the increment of load. Where the methods of measuring pile head movement given in Clauses 7.12.34 and 7.12.35 are used, the time periods for which loads must be held constant to achieve the specified rates of settlement shall be extended as necessary to take into account the lower levels of accuracy available from these methods and to allow correct assessment of the settlement rate.
- 7.12.41 The procedure to be adopted for carrying out preliminary load tests on compression piles shall be in accordance with either the extended proof load test procedure Clause 7.12.42 or the constant rate of penetration testing procedure Clause 7.12.43. A normal proof load test will constitute the first stage of such a preliminary test unless otherwise specified.

Table 7.1 - Proof Load Test Sequencing (CRP Method)

Load	Minimum time of holding load
25% DVL	30 minutes
50% DVL	30 minutes
75% DVL	30 minutes
100% DVL	1 hour
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour
100% DVL	6 hours
100% DVL + 25% SWL	1 hour
100% DVL + 50% SWL	6 hour
100% DVL + 25% SWL	10 minutes
100% DVL	10 minutes
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour

- 7.12.42 Where verification of the required minimum factor of safety is called for, the loading procedure may be carried out as a continuation of the proof load testing procedure given in Clause 7.12.40. Following the completion of the proof load test, the load shall be restored in two stages (DVL, DVL + 50% SWL), and shall subsequently be increased in stages of 25% of the specified working load or other specified amount until the maximum specified load for the test is reached. Following each application of an increment of load, the load shall be maintained at the specified value for not less than 30 minutes and until the rate of settlement is slowing down and is less than 0.25mm/h or other approved rate appropriate to the stage of loading and its proximity to a failure condition. The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the points. Reduction of load at the end of the test shall be gradual as required by clause 7.12.40 and the final recovery of the pile head shall be recorded. Permissible settlement at the load corresponding to the required minimum factor of safety called for in the design will not normally be specified. The mobilization of ultimate load for compression piles normally involves settlements of at least 10% of the pile base diameter in clay and more in granular soils. The settlement of piles bearing on rock requires special consideration, and failure of pile materials may precede failure of the rock.
- 7.12.43 Where it is required to determine the ultimate load of a preliminary compression pile, and particularly where piles are largely embedded in and bearing on clay soils, the CRP testing procedure will normally be specified. The rate of movement of the pile head shall be maintained constant in so far as is practicable and shall be approximately 0.01mm/s for piles in predominantly cohesive soils and 0.02mm/s for piles in predominantly cohesionless soils. Readings of loads, penetration and time shall be made simultaneously at regular intervals; the interval chosen shall be such that a curve of load versus penetration can be plotted without ambiguity. Loading shall be continued until one of the following results is obtained:-
- the maximum required test load as specified.
 - a constant or reducing load has been recorded for an interval of penetration of 10mm.
 - a total movement of the pile base equal to 10% of the base diameter, or any other greater value of movement specified, has been reached.
- The load shall then be reduced in five approximately equal stages to zero load, penetration and load at each stage and at zero load being recorded.
- 7.12.44 The testing of piles designed to carry load in tension shall follow the same procedure as specified in Clauses 7.12.40 and 7.12.41. In testing by the constant rate of uplift method, overall movements of the pilehead will normally be less than those expected in a constant rate of penetration test. The rate of movement of the pile head shall be maintained at approximately 0.005mm/s in so far as is practicable.
- 7.12.45 Working load test using maintained load test procedure shall be carried out on non-working test piles or working piles selected by the Engineer. The test load of a working load test shall be two times the safe

carrying capacity of the pile or as specified in the Drawings or directed by the Engineer. The Contractor shall supply everything necessary for the performance of the tests. Pile caps for load tests, if used, shall be designed and constructed by the Contractor to the approval of the Engineer. The cost of such pile caps shall be deemed to have been included in the cost for load testing. The test loads shall be applied to the pile or group of piles by kentledge placed on a platform bearing on the piles or pile cap. The Contractor shall arrange and pay for the weighing of representative samples of the kentledge if so ordered by the Engineer. The test load shall be applied in stages as shown in Table 7.2 in not less than 4 equal increments for any load test. The number of increments may be increased depending on the value of the full test load. The minimum time interval between each increment of load shall be 3 hours from the completion of the previous loading. No more than two load increments shall be allowed per day. When the loading has been completed the full test load shall remain in place for a minimum period of 72 hours after equilibrium is reached. Equilibrium shall mean a rate of settlement not exceeding 0.5mm per 24 hours. The test load shall be removed in not less than 4 decrements with intervals of not less than 3 hours. The final rebound shall be recorded 24 hours after the entire test load has been removed.

Table 7.2 - Working Load Test Sequencing (Standard Maintained Load Test Method)

Load	Minimum time of holding load
25% SWL	3 hours
50% SWL	3 hours
75% SWL	3 hours
100% SWL	3 hours
75% SWL	3 hours
50% SWL	3 hours
25% SWL	3 hours
0	3 hours
25% SWL	3 hours
50% SWL	3 hours
75% SWL	3 hours
100% SWL	3 hours
125% SWL	3 hours
150% SWL	3 hours
175% SWL	3 hours
200% SWL	72 hours
175% SWL	3 hours
150% SWL	3 hours
125% SWL	3 hours
100% SWL	3 hours
75% SWL	3 hours
50% SWL	3 hours
25% SWL	3 hours
0	24 hours

7.12.46 Alternatively, subject to approval by the Engineer, the load test shall be applied in stages as shown in Table 7.3

7.12.47 During the progress of a test, all records taken shall be available for inspection by the Engineer. Results shall be submitted as:-

- a) a preliminary copy of the test records to the Engineer, unless directed otherwise, within 24 hours of the completion of the test, which shall show:-
 - i) Maintained Load Test; for each stage of loading, the period for which the load was held, the load and the maximum pile movement at the end of the stage.
 - ii) CRP or CRU Load Test; the maximum load reached and a graph of load against penetration or load against uplift.
- b) the completed schedule of recorded data as prescribed in Clause 7.12.48 within 10 days of the completion of the test, or as directed by the Engineer.

Table 7.3 - Working Load Test Sequencing (Quick Maintained Load Test Method)

Load	Minimum time of holding load
25% SWL	30 minutes
50% SWL	30 minutes
75% SWL	30 minutes
100% SWL	1 hour
75% SWL	30 minutes
50% SWL	30 minutes
25% SWL	30 minutes
0	1 hour
25% SWL	30 minutes
50% SWL	30 minutes
75% SWL	30 minutes
100% SWL	30 minutes
125% SWL	30 minutes
150% SWL	30 minutes
175% SWL	30 minutes
200% SWL	24 hours
175% SWL	30 minutes
150% SWL	30 minutes
125% SWL	30 minutes
100% SWL	30 minutes
75% SWL	30 minutes
50% SWL	30 minutes
25% SWL	30 minutes
0	1 hour

7.12.48 The Contractor shall provide information about the test pile in accordance with the following schedule where applicable:-

a) General : Site location; contract identification; proposed structure; main contractor; piling contractor; Engineer; Client/Employer; date and time of test.

b) Pile details :

All types of piles : Identification (number and location); specified working load (SWL); design verification load (DVL); commencing surface level at pile position; head level at which test load was applied; type of pile; vertical or raking, compression or tension; shape and size of cross-section of pile, and position of any change in cross-section; shoe or base details; head details; length in ground; level of toe; dimensions of any permanent casing;

Concrete piles : Concrete mix/grade; aggregate type and source; cement type and cement replacement and type where used; admixtures; slump; cube test results for pile and cap; date of casting of precast pile; reinforcement;

Steel piles : Steel quality; coating; filling or core materials - type and quality.

c) Installation details :

All piles : Dates and times of boring, driving and concreting of test pile; difficulties and delays encountered; date and time of casting concrete pile cap;

Bored piles : Type of equipment used and method of boring; temporary casing - diameter, type and length; full log of pile borehole; method of placing concrete; volume of concrete placed;

Driven preformed and driven cast-in-place piles : Method of support of hammer and pile; driven length of pile or temporary casing at final set; hammer type, and size or weight; dolly and packing, type and condition; driving log (depth, hammer drop, blows per 250mm, interruptions or breaks in driving); final set in penetration (mm) per 10 blows; re-drive check, time interval and set in penetration (mm) per 10 blows or other agreed amount; at final set and at re-drive set - for a drop hammer or for a single acting hammer the length of the drop or stroke, - for a diesel hammer the length of the stroke and the blows per minute, - for a double acting hammer the operating pressure and

the number of blows per minute; condition of pile head or temporary casing after driving; use of a follower; use of pre-boring; use of jetting; lengthening; method of placing concrete.

- d) Test procedure : Mass of kentledge; tension pile, ground anchorage or compression pile details; plan of test arrangement showing position and distances of kentledge supports, rafts, tension or compression piles or ground anchorages, and supports to pile movement reference system; jack capacity; method of load measurement; method(s) of penetration or uplift measurement.
 - e) Test results : In tabular form; In graphical form, load plotted against pile head movement; ambient temperature records during test.
- 7.12.49 On completion of a test and subject to the approval of the Engineer, all measuring equipment and load application devices shall be dismantled and checked. All other test equipment, including kentledge, beams and supporting structures shall be removed from the test pile location. Measuring and other demountable equipment shall be stored in a safe manner so that it is available for further tests, or removed from the site as approved by the Engineer. Temporary tension piles and ground anchorages shall be cut-off below ground level, and discarded materials removed from the site. The ground shall be made good to the original commencing surface level.
- 7.12.50 Unless specified otherwise, the head of each preliminary test pile shall be cut-off below ground level, discarded material shall be removed from the site and the ground made good to the original commencing surface level.
- 7.12.51 On completion of a test on a proof load pile, the test pile cap shall be prepared as specified and left in a state ready for incorporation into the Works. Any resulting discarded materials shall be removed from the site.
- 7.13 FAILURE OF WORKING LOAD TEST
- 7.13.1 A pile or pile group shall be deemed to have failed the working load test if any one of the following observations is recorded:-
- a) The maximum settlement under full test load (200% SWL) exceeds 20mm.
 - b) The permanent or residual settlement after removal of the test load exceeds 5mm for working load less than or equal 100 tonnes, or 0.05mm per tonne of working load for piles with working loads greater than 100 tonnes but less than or equal to 250 tonnes, or maximum of 13mm for piles with working loads exceeding 250 tonnes.
 - c) The test could not be completed due to instability of the kentledge.
 - d) The pile is found to have cracked, crumbled, distorted from its original shape, deflected from its original position or the like.
- 7.13.2 Any piles or pile groups which fail under working load test shall be replaced by one or more piles to be installed as directed by the Engineer. If, in the opinion of the Engineer, it is impracticable or inadvisable to install substitute piles in place of a failed pile, the Contractor shall not be paid in respect of the pile which has failed.
- 7.13.3 For each working load test which has failed, the Contractor shall at his own cost carry out two more working load tests. The piles for these tests shall be selected by the Engineer.
- 7.13.4 Piling work for a block containing up to 100 piles shall be deemed to be rejected if 3 working load tests therein have failed. The acceptance criteria for working load test in a piling contract containing more than 100 piles shall be on the basis of one failed test for every 30 piles.

8 ROAD WORKS**8.1 HORIZONTAL ALIGNMENTS**

- 8.1.1 Horizontal alignments shall be determined from one edge of the carriageway pavement surface as shown in the Drawings. The edge of the carriageway as constructed and all other parallel alignments shall be correct within a tolerance of $\pm 12\text{mm}$ therefrom.

8.2 ACCURACY OF FINISHED CARRIAGEWAY LEVELS

- 8.2.1 Finished surfaces at each stage of road hardstanding and footpath construction shall not vary from the levels shown in the Drawings by more than the deviation shown in Table 8.1. In addition, neither the base course nor the wearing course shall deviate by more than the amounts shown in the table when tested with a 3m straight edge.
- 8.2.2 Notwithstanding the tolerances and deviations permitted, the thicknesses of the base course, wearing course and overall construction shall not be reduced by more than the amounts shown in the table.

Table 8.1 - Levels Accuracy

Layer	Roads and Hardstandings	Footpaths
Permissible Variation in Levels (mm)		
Formation	+10, -25	+10, -25
Base	+10, -15	+10, -15
Base Course	± 7	± 13
Wearing Course	± 7	± 7
Maximum Deviation Under 3m Straight Edge (mm)		
Base Course	5	13
Wearing Course	5	7
Maximum Reduction in Thickness (mm)		
Overall	15	15
Base Course	7	10
Wearing Course	7	5

8.3 ROAD FORMATIONS

- 8.3.1 The road formation shall be the surface obtained after completion of any earthworks. Preparation and surface of formations shall be carried out after reinstatement of any excavations for services and immediately prior to laying the sub-base, or road base where no sub-base is required. Formations shall be clean, free from mud and slurry and properly shaped and compacted to an even and uniform surface.
- 8.3.2 Unsuitable material below the formation levels shown in the Drawings shall be removed to such depths and over such areas as directed by the Engineer and replaced by fill material unless otherwise directed by the Engineer.
- 8.3.3 Following excavation to the levels shown in the Drawings or as directed by the Engineer, the Contractor shall protect the surface exposed against damage at all times.
- 8.3.4 The formation, whether in excavation or filling shall be compacted to the approval of the Engineer and in accordance with the requirements of this Technical Specifications using an 8 to 10 tonnes roller or such other plant as may be appropriate.
- 8.3.5 The formation shall be tested using In-situ CBR, Dutch Cone Penetrometer or Field Density tests at the direction of the Engineer. The Contractor shall include for any such testing required by the Engineer in the Bills of Quantities. The frequency of any such tests, if required, will be not less than three tests per 1600m^2 of formation.
- 8.3.6 All services or other structures laid in trenches or constructed otherwise across roads, hardstandings or other paved areas shall be completed and backfilled to the Engineer's approval prior to construction of the road base.

8.4 USE OF CONSTRUCTION SURFACES BY TRAFFIC

- 8.4.1 The use by construction and other traffic of prepared formation or subgrade and areas of fill prior to preparation of the formation shall not be permitted unless prior written agreement of the Engineer has been obtained.
- 8.4.2 Where damage occurs to the prepared formation subgrade or areas of fill, such damage shall be made good by the Contractor at his own cost by removing the damaged material and replacing with an acceptable material having the same characteristics as the material which has been damaged.
- 8.4.3 Construction and other traffic moving over roads under construction or completed roads shall be suitable in relation to the thickness of the courses in transverse so that damage is not caused to the subgrade or the material already constructed. Any damage to roads under construction or completed roads from whatever cause arising shall be made good by the Contractor at his own cost by removing the damaged layers to their full depth over the area as directed by the Engineer and replacing with new material in accordance with this Technical Specifications.
- 8.4.4 The wheels and tracks of plant moving over the various courses shall be kept clean and free from deleterious materials.

8.5 TRANSPORTING BITUMINOUS MATERIAL

- 8.5.1 Bituminous material shall be transported in clean vehicles and shall be covered over when in transit or waiting tipping. The use of dust, coated dust, oil or water on the interior of the vehicles to facilitate discharge of the mixed materials is permissible but the amount shall be kept to a minimum and any excess shall be removed by tipping or brushing.

8.6 LAYING BITUMINOUS MATERIAL

- 8.6.1 The material shall be laid in accordance with the recommendations in the appropriate British Standard to which the material has been made or in accordance with B.S. 594 where there is no British Standard for the material.
- 8.6.2 When a mechanical spreader laying bituminous material approaches a joint at a structure it shall be taken out of use as soon as there is a danger of the material being laid fouling the joint.
- 8.6.3 Hand raking of wearing course material which has been laid by a paver and the addition of such material by manual spreading to the paved area for adjustment of level will be permitted only in the following circumstances:-
- a) at the edges of the layers of material and at gullies and manholes.
 - b) at the approaches to joints at structures.
 - c) where directed otherwise by the Engineer.
- 8.6.4 Manual laying of any bituminous material will be permitted only in the following circumstances:-
- a) for laying regulating courses of irregular shape and varying thickness.
 - b) in confined spaces where it is impracticable for a paver to operate.
 - c) for footways.
 - d) at approaches to joints at structures,
 - e) where directed otherwise by the Engineer.
- 8.6.5 A bituminous pavement course shall be laid in one or more layers so that the compacted thickness of each layer shall not exceed 100mm. The material shall be compacted in accordance with B.S. 594 "Hot-rolled asphalt for roads and other paved areas" or B.S. 4987 "Coated macadam (asphalt concrete) for roads and other paved areas", depending on the type of material.
- 8.6.6 Joints shall be made in accordance with B.S. 594 or B.S. 4987 depending on the type of material. All preparatory works shall be carried out in accordance with B.S. 594 or B.S. 4987 whichever is appropriate.

8.6 PROTECTION OF FORMATION

- 8.6.1 Where the completed formation is not immediately covered with a sub-base or road base material, it shall be protected by polythene sheeting laid with 300mm laps adequately secured from being blown off the surface, or by spraying with bitumen emulsion at the rate of 0.7 to 1.0 litre/m².
- 8.6.2 If a granular sub-base is not to be covered immediately with a road base material, it shall be protected by spraying with bitumen emulsion or by covering with an approved impermeable plastic sheeting laid with 300mm laps adequately secured from being blown off the surface.
- 8.6.3 Basecourse material shall not remain uncovered by either the wearing course or surface treatment whichever is specified in the Contract for more than three consecutive days after being laid. The Engineer may extend this period by the minimum amount of time necessary if compliance herewith is impracticable because of weather conditions or for any other reasons such as awaiting the test results.

8.7 SUB-BASE AND ROAD BASE

- 8.7.1 Unless described otherwise in the Contract, sub-bases and road bases shall be constructed using one or other of the materials specified in Clauses 8.8 - 8.12. Any substitution of one material for another within the specification groups shall be agreed with the Engineer. The Contractor may also substitute for the specified material in a sub-base any of the road base materials or in a road base course any of the materials specified for the courses of pavement to be superimposed on it without additional cost to the Employer.
- 8.7.2 Transport vehicles carrying plant mixed sub-base or road base material shall have a capacity suited to the output of the mixing plant and the site conditions and be capable of discharging cleanly. Material when mixed shall be removed at once from the mixer transported directly to the point where it is to be laid and protected from the weather both during transit from the mixer to the laying site and whilst awaiting tipping.
- 8.7.3 All material shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. Road base material shall be spread using mechanical equipment which levels off the material to an even depth. The material shall be spread so that after compaction, the total thickness is as specified in the Contract. The sub-base material under unreinforced concrete pavements with warping joints shall, when laid and compacted, provide a smooth, close textured surface. For cement treated materials, the Contractor shall so organise the work that longitudinal joints against hardened material are avoided as far as possible. Before work proceeds against a longitudinal joint of such material the edge compacted earlier, shall, if it has been exposed for more than one hour be cut back vertically to produce a face of the specified thickness of layer and of properly compacted material.
- 8.7.4 Except for lean concrete and dry bound macadam, which shall be compacted in the manner specified in Clauses 8.10 and 8.12 respectively, compaction shall be carried out by the method specified in Table 8.2. Compaction shall be completed as soon as possible after the material has been spread. The surface of any layer of material shall on completion of compaction be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose material.
- 8.7.5 Any layer of cement-treated material not covered within 2 hours either by another layer of such material or by another pavement course, shall immediately on completion of compaction, be cured for a period which shall be not less than 7 days unless the Engineer agrees otherwise.

8.8 GRANULAR SUB-BASE MATERIAL

- 8.8.1 Granular sub-base material shall be natural sands, gravels, crushed rock or crushed concrete. The material shall be well-graded and lie within the limits shown in Table 8.3.
- 8.8.2 Natural sands and gravels shall only be permitted in Type 2 material in Table 8.3.
- 8.8.3 The particle size shall be determined by B.S. 1377, Test No. 7A. The material passing a 425µm B.S. sieve, when tested in accordance with B.S. 1377, shall be non-plastic for Type 1, and have a Plasticity Index of less than 6 for Type 2.

TABLE 8.2 - Compaction Requirements For Granular And Soil-Cement Materials

Type of compaction plant	Category	No. of passes for		
		Not greater than 100mm layer	Not greater than 150mm layer	Not greater than 225mm layer
Smooth wheel roller	Force per 100mm width (kN)			
	2.1 - 2.6	Unsuitable	Unsuitable	Unsuitable
	2.7 - 5.2	16	Unsuitable	Unsuitable
	more than 5.2	8	16	Unsuitable
Pneumatic roller	Wheel load (tonnes)			
	4 - 6	12	Unsuitable	Unsuitable
	6 - 8	12	Unsuitable	Unsuitable
	8 - 12	10	16	Unsuitable
	more than 12	8	12	Unsuitable
Vibratory roller	Force per 100mm width (kN)			
	0.70 - 1.25	16	Unsuitable	Unsuitable
	1.26 - 1.75	6	16	Unsuitable
	1.76 - 2.30	4	6	10
	2.31 - 2.80	3	5	9
	2.81 - 3.50	3	5	8
	3.51 - 4.20	2	4	7
	4.21 - 4.90	2	4	6
Vibration plate compactor	Static pressure under base plate (kN/m ²)			
	13.8 - 17.2	8	Unsuitable	Unsuitable
	17.2 - 20.7	5	8	Unsuitable
	more than 20.7	3	6	10
Vibrotamper	Mass (kg)			
	50 - 65	4	8	Unsuitable
	65 - 75	3	6	10
	more than 75	2	4	6
Power rammer or dropping weight compactor	Mass (kg)			
	100 - 500	5	8	Unsuitable
	more than 500	5	8	12

Table 8.3 - Granular Sub-base Material Grading

B.S. sieve size	Percentage passing by weight	
	Type 1	Type 2
75mm	100	100
37.5mm	85 - 100	85 - 100
10mm	40 - 70	45 - 100
5mm	25 - 45	25 - 85
600µm	8 - 22	8 - 45
75µm	0 - 10	0 - 10

8.9 SOIL-CEMENT SUB-BASE MATERIAL

- 8.9.1 The material used for stabilisation shall be soil, a washed or processed granular material, crushed rock or any combination of those provided that the sulphate content shall not exceed 1% except for cohesive materials when the limit shall be 0.25%, determined in accordance with B.S. 1377.

- 8.9.2 The material shall be well-graded with a Coefficient of Uniformity of not less than 5, capable of producing a well closed surface finish to the compacted layer and have a grading finer than the limit shown in Table 8.4.
- 8.9.3 If the material passing the 425µm B.S. sieve is plastic, it shall have a Liquid Limit less than 45% and a Plastic Limit less than 20% determined in accordance with B.S. 1377.

Table 8.4 - Soil-Cement Sub-base Material Grading

B.S. sieve size	Percentage passing by weight
50mm	100
37.5mm	95
20mm	45
10mm	35
5mm	25
600µm	8
300µm	5
75µm	0

- 8.9.4 The material used for stabilisation shall be mixed with sufficient cement to provide a crushing strength to the requirements stated in this clause.
- 8.9.5 The moisture content of the mixed cement stabilised material shall be not less than the optimum as determined by the Vibrating Hammer Method Test of B.S. 1924 nor more than 2% above the optimum as determined by this test or such higher value as may be agreed by the Engineer on the basis of the preliminary trial.
- 8.9.6 The thickness of layer to be stabilised shall be not less than 75mm when compacted. If the compacted thickness does not exceed 200mm and provided the plant meets the requirements specified, the material may be constructed in one layer using either stationary plant or mix-in-place for the mixing process. If the course to be stabilised exceeds 200mm in thickness when compacted, it shall be constructed in two or more layers each within the range 75mm - 200mm in compacted thickness.
- 8.9.7 If stationary plant is used for soil stabilisation, it shall be of the power driven paddle or pan type and may be of the batch or continuous type.
- 8.9.8 If batch mixers are used, the appropriate measured amounts of material and cement shall first be placed in the mixer, water then being added as necessary to bring the moisture content of the resulting mixture within the range specified. Special care shall be taken with batch type paddle mixers to ensure that the cement is spread uniformly in the loading skip so that it is fed evenly along the mixing trough, and that the cement in both paddle and pan mixers 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 uniformity required and for not less than 1 minute unless a shorter minimum period is permitted by the Engineer after satisfactory preliminary trials.
- 8.9.9 If continuous mixing is used the paddles, baffles and rate of feed of materials shall be adjusted to give a uniformly mixed material.
- 8.9.10 When hard non-plastic soil is encountered in-situ, the Engineer may approve the use of scarifier ahead of the mixer but with plastic soils, no prior scarification will be permitted unless the soil is subsequently re-compacted before processing with the single-pass mixer.
- 8.9.11 At least 10 days before the main work of stabilisation is scheduled, the Contractor shall construct an area of stabilised material of 400m² - 800m² as a preliminary trial at a location to be approved by the Engineer. For the trial, the Contractor shall use the materials, mix proportions, mixing, laying, compaction plant and construction procedure that he proposes to use for the main work.
- 8.9.12 The preliminary trial is to test the efficiency of mixing, spreading and compaction plant and the suitability of the methods and organisation proposed by the Contractor. The results of the dry density measurements made in the stabilised trial area will be used to confirm the moisture content and minimum stage of compaction to be attained in the main stabilisation work.
- 8.9.13 The average crushing strength at an age of 7 days for each batch of 5 test specimens of the mixed material to be stabilised, made and tested in accordance with Section 12 shall be not less than 2.8N/mm² for cylindrical

specimens having a height/diameter ratio of 2 : 1 or 3.5N/mm² for cubical specimens. If an area of stabilised layer represented by the 5 test specimens has an average strength less than the specified minimum values, the area shall be replaced with acceptable stabilised material

8.10 LEAN CONCRETE BASE MATERIAL

- 8.10.1 Aggregate for lean concrete for roads shall consist of coarse or fine aggregate batched separately, or an all-in aggregate, having a maximum nominal size not exceeding 40mm nor less than 20mm. Aggregate quality and cleanliness shall comply with the relevant requirements of Clause 3.33 and the overall grading of the aggregate shall be within the limits shown in the following table:-

Table 8.5 - Lean Concrete Aggregate Grading

B.S. sieve size	Percentage passing by weight	
	Nominal max. size 40mm	Nominal max. size 20mm
75mm	100	-
37.5mm	95 - 100	100
20mm	45 - 80	80 - 100
5mm	30 - 40	35 - 45
600µm	8 - 30	10 - 35
75µm	0 - 6	0 - 6

- 8.10.2 The particle size shall be determined by B.S. 1377, Test No. 7A.
- 8.10.3 The ratio of cement to aggregate by weight shall be sufficient to produce a 28 day characteristic strength of 7MPa (max).
- 8.10.4 The materials shall be mixed in accordance with the relevant requirements of B.S. 5328.
- 8.10.5 The lean concrete shall be transported, laid and cured in accordance with the requirements of Clauses 8.72, 8.73, and 8.75.
- 8.10.6 Compacting shall be carried out by means of a vibrating roller which applies a static load of more than 1.76kN/100mm width of vibrating roll or by a vibratory compactor with a static pressure under the base plate of more than 20.7kN/m². Where required by the Engineer, the vibrating roller shall be operated both longitudinally and transversely and the surface finished by rolling without vibration. Compaction shall be continued until the surface is closed and the density of the compacted base meets the requirements for density in this Clause. The maximum period of time between mixing of the materials and completion of any given material shall be 2 hours.

8.11 WET-MIX MACADAM

- 8.11.1 The coarse and fine aggregate shall consist of crushed rock in accordance with Section 3. The aggregate shall have the grading shown in Table 8.6.

Table 8.6 - Wet-mix Macadam Aggregate Grading

B.S. sieve size	Percentage passing by weight
50mm	100
37.5mm	95 - 100
20mm	60 - 80
10mm	40 - 60
5mm	25 - 40
2.36mm	15 - 30
600µm	8 - 22
75µm	0 - 8

- 8.11.2 The particle size shall be determined in accordance with the requirements of B.S. 1377.
- 8.11.3 The moisture content of the wet-mix macadam shall be the optimum $\pm 0.5\%$ as determined in accordance with the Vibrating Hammer Method Test in B.S. 1377.
- 8.11.4 Wet-mix macadam shall be laid and compacted in layers in accordance with Clauses 8.73 and 8.74.

8.12 DRY MIX ROAD BASE

8.12.1 Dry mix road base shall consist of crushed rock in accordance with Section 3 and the aggregate shall have the grading shown in Table 8.6.

8.12.2 It shall be placed in layers not exceeding 100mm thickness and compacted in accordance with Table 8.2 up to the specified thickness of road base.

8.13 MAINTENANCE OF SURFACE OF ROADBASE

8.13.1 On completion of the roadbase and until any surfacing is laid on it, the finished surface shall be maintained free from potholes, ruts and undulations, irregularities, depressions, loose material or other defects.

8.14 SCARIFYING

8.14.1 Where an appropriate item is included in the Bills of Quantities, scarifying shall be completed to the satisfaction of the Engineer.

8.15 FLEXIBLE SURFACING

8.15.1 Base course and wearing course shall be constructed using any of the materials described in the appropriate group of Table 8.7. The surfacing group and the required thickness for each course for each category of road shall be described in the Contract.

8.16 REGULATING COURSE

Regulating course material shall be made and laid in accordance with the requirements for one or other of the base course or road base materials in this Technical Specifications as described in the Contract.

Table 8.7 - Flexible Surfacing Materials

Type of road permitted	Materials
District and Local Roads	<u>Wearing course</u> Rolled asphalt to Clause 8.18 Asphaltic concrete to Clause 8.22 <u>Base course</u> Rolled asphalt to Clause 8.17 Asphaltic concrete to Clause 8.22 Dense bitumen macadam to Clause 8.19
Collector and Access Roads	<u>Wearing course</u> Cold asphalt to Clause 8.21 Dense bitumen macadam to Clause 8.19 <u>Base course</u> Bitumen macadam to Clause 8.20 <u>Single course alternative</u> Rolled asphalt to Clause 8.17 Dense bitumen macadam to Clause 8.19

Table 8.8 - Bitumen Macadam Mixtures

B.S. sieve size	Base course	Base course or wearing course	Wearing course
	40mm nominal size	20mm nominal size	10mm nominal size
	Percentage passing by weight (as a percentage of the total aggregate excluding binder)		
50mm	100	-	-
37.5mm	90 - 100	-	-
28mm	50 - 80	100	-
20mm	-	90 - 100	-
14mm	10 - 30	50 - 80	100
10mm	-	-	85 - 100
6.3mm	-	15 - 35	30 - 60
3.35mm	0 - 10	-	-
2.36mm	-	9 - 19	9 - 19
75µm	-	2 - 6	2 - 6

Temperature (°C)		
Task	60-70 pen bitumen	80-100 pen bitumen
Mixing	150 - 170	140 - 150
Delivery to site	min. 100	min. 90
Rolling	min. 85	min. 75

Table 8.9 - Dense Bitumen Macadam Mixtures

B.S. sieve size	Base course	Base course or wearing course	Wearing course
	40mm nominal size	20mm nominal size	10mm nominal size
	Percentage passing by weight (as a percentage of the total aggregate excluding binder)		
50mm	100	-	-
37.5mm	90 - 100	100	-
20mm	62 - 84	95 - 100	100
10mm	49 - 67	55 - 75	95 - 100
5mm	37 - 55	35 - 53	41 - 63
2.36mm	27 - 43	25 - 40	25 - 40
1.18mm	-	15 - 30	15 - 30
300µm	7 - 21	-	-
75µm	2 - 8	3 - 6	4 - 8
Binder	Grade	Straight-run bitumen of 60-70 or 80-100 pen at 25°C	
	Content	As percentage of total weight including binder	
		3.5 - 4.5	4.4 - 5.4
			4.6 - 5.6

Temperature (°C)		
Task	60-70 pen bitumen	80-100 pen bitumen
Mixing	150 - 165	140 - 160
Delivery to site	min. 100	min. 90
Rolling	min. 85	min. 75

Table 8.10 - Asphaltic Concrete Mixtures

B.S. sieve size		Base course	Base course or wearing course	Wearing course
		40mm nominal size	20mm nominal size	10mm nominal size
		Percentage passing by weight (as a percentage of the total aggregate excluding binder)		
50mm		100	-	-
37.5mm		90 - 100	-	-
28mm		75 - 90	-	-
20mm		-	100	-
14mm		55 - 75	80 - 100	100
10mm		-	-	87 - 100
5mm		36 - 56	54 - 72	62 - 80
2.36mm		28 - 44	42 - 58	44 - 60
1.18mm		20 - 34	34 - 48	36 - 50
600µm		15 - 27	26 - 38	28 - 40
300µm		10 - 20	18 - 28	20 - 30
150µm		5 - 13	12 - 20	12 - 20
75µm		2 - 6	6 - 12	6 - 12
Binder	Grade	Straight-run bitumen of 60-70 or 80-100 pen at 25°C		
	Content	As percentage of total weight including binder		
		4.5 - 6.0	6.0 - 7.5	6.5 - 8.0

Temperature (°C)		
Task	60-70 pen bitumen	80-100 pen bitumen
Mixing	150 - 165	140 - 160
Delivery to site	min. 120	min. 110
Rolling	min. 100	min. 90

Table 8.11 - Rolled Asphalt Base Course Mixtures

B.S. sieve size		Course thickness (mm)		
		44 - 57	57 - 70	70 - 75
		Percentage passing by weight		
Aggregate	50mm	-	-	100
	37.5mm	100	100	85 - 100
	28mm	85 - 100	60 - 100	40 - 100
	20mm	40 - 100	40 - 100	0 - 40
	14mm	0 - 40	0 - 40	-
	6.3mm	0 - 10	0 - 10	0 - 10
Filler and binder	5mm	100	100	100
	2.36mm	75 - 100	75 - 100	75 - 100
	1.18mm	35 - 100	35 - 100	35 - 100
	210µm	5 - 60	5 - 60	5 - 60
	75µm	0 - 15	0 - 15	0 - 15
Rolled asphalt	300µm	100	100	100
	210µm	98 - 100	98 - 100	98 - 100
	75µm	85 - 100	85 - 100	85 - 100
Coarse aggregate content (as percentage of total aggregate by weight)		55 - 70	60 - 75	65 - 75
Composition of mixture (percentage of total mixture by weight)		Coarse aggregate retained on 2.36mm B.S. sieve	Aggregate passing 2.36mm B.S. sieve	Straight-run bitumen of 60-70 pen at 25°C
		55	38.0 - 39.0	6.0 - 7.0
		60	33.4 - 34.4	5.6 - 6.6
		65	28.8 - 29.8	5.2 - 6.2
		70	24.1 - 25.1	4.9 - 5.9
		75	19.5 - 20.5	4.5 - 5.5

Table 8.11 - Rolled Asphalt Base Course Mixtures (Cont'd)

Temperature (°C)			
Layer	Mixing	Delivery to site	Rolling
Aggregate	150 - 205	-	-
Filler and binder	150 - 175	-	-
Rolled asphalt	-	120 - 160	min. 80

Table 8.12 - Rolled Asphalt Wearing Course Mixtures

B.S. sieve size		Course thickness (mm)			
		25	32	37.5	44
		Percentage passing by weight			
Aggregate	28mm	-		100	
	20mm	100		85 - 100	
	14mm	85 - 100		0 - 100	
	10mm	0 - 100		0 - 60	
	6.3mm	0 - 60		-	
	2.36mm	0 - 5		0 - 5	
Filler and binder	5mm	100		100	
	2.36mm	95 - 100		95 - 100	
	600µm	15 - 60		15 - 60	
	210µm	15 - 60		15 - 60	
	75µm	0 - 3		0 - 3	
Rolled asphalt	300µm	100		100	
	210µm	98 - 100		98 - 100	
	75µm	85 - 100		85 - 100	
Coarse aggregate content (as percentage of total aggregate by weight)		0 - 25	15 - 30	30 - 45	35 - 50
Composition of mixture (percentage of total mixture by weight)		Coarse aggregate retained on 2.36mm B.S. sieve	Aggregate passing 2.36mm and retained on 75µm B.S. sieve	Aggregate passing 75µm B.S. sieve	Straight-run bitumen of 60-70 pen at 25°C
		0	75.2 - 78.2	12.0 - 14.0	9.8 - 10.8
		15	63.4 - 66.4	10.0 - 12.0	8.6 - 9.6
		20	59.5 - 62.5	9.3 - 11.3	8.2 - 9.2
		25	55.6 - 58.6	8.6 - 10.6	7.8 - 8.8
		30	51.7 - 54.7	7.9 - 9.9	7.4 - 8.4
		35	47.9 - 50.8	7.2 - 9.2	7.0 - 8.0
		40	44.0 - 47.0	6.4 - 8.4	6.6 - 7.6
		45	40.0 - 43.0	5.8 - 7.8	6.2 - 7.2
		50	36.1 - 39.1	5.1 - 7.1	5.8 - 6.8

Temperature (°C)			
Layer	Mixing	Delivery to site	Rolling
Aggregate	150 - 205	-	-
Filler and binder	150 - 175	-	-
Rolled asphalt	-	135 - 175	min. 90

8.17 ROLLED ASPHALT BASE COURSE

- 8.17.1 Rolled asphalt base course shall be made in accordance with B.S. 594, and laid and compacted in accordance with Clause 8.6 above.
- 8.17.2 The coarse aggregate shall comply with B.S. 594, Table 2, 65% coarse aggregate of a nominal size as specified.
- 8.17.3 The fine aggregate shall comply with B.S. 594, Table 3 for base course mixtures.

8.17.4 The asphaltic cement shall comply with B.S. 594, Table 1, Column 1.

8.17.5 The composition of the freshly mixed material shall comply with B.S. 594, Table 7, 65% coarse aggregate content.

8.17.6 The temperature of the material shall comply with B.S. 594, Clause 1.6.

8.17.7 The mixing of the material shall comply with B.S. 594, Clause 1.6.

8.18 ROLLED ASPHALT WEARING COURSE

8.18.1 Rolled asphalt wearing course shall be made in accordance with B.S. 594, and laid and compacted in accordance with Clause 8.6 above.

8.18.2 The coarse aggregate shall comply with B.S. 594, Table 2, 55% coarse aggregate content of 220mm nominal size and shall have a polished stone value (PSV) of not less than 62.

8.18.3 The fine aggregate shall comply with B.S. 594, Table 3, for wearing course mixtures and shall have a PSV of not less than 62.

8.18.4 The asphaltic cement shall comply with B.S. 594, Table 1, Column 1.

8.18.5 The composition of the freshly mixed material shall comply with B.S. 594, Table 4, Schedule 1A, 55% coarse aggregate content.

8.18.6 The temperature of the material shall comply with B.S. 594 Clause 1.6.

8.18.7 The mixing of the material shall comply with B.S. 594 Clause 1.6.

8.19 DENSE BITUMEN MACADAM

8.19 Dense bitumen macadam shall be made in accordance with the general requirements of B.S. 4987 and shall be laid and compacted in accordance with Clause 8.6 above. The binder shall be petroleum bitumen complying with B.S. 3690 and of the grade specified.

8.20 BITUMEN MACADAM

8.20.1 Open textured macadam shall be made in accordance with the general requirements of B.S. 4987 and shall be laid and compacted in accordance with Clause 8.6 above.

8.21 COLD ASPHALT

8.21.1 Cold asphalt shall be made in accordance with the general requirements of B.S. 4987 and shall be laid and compacted in accordance with Clause 8.6 above.

8.22 ASPHALTIC CONCRETE

8.22.1 Asphaltic concrete shall be made in accordance with the following and laid and compacted in accordance with Clause 8.6 above.

8.22.2 The aggregate shall consist of hard clean durable crushed rock. Content for new works shall be 30% by weight. Content for resurfacing shall be as described in the Contract.

8.22.3 Filler shall be crushed stone, Portland cement, hydrated lime or other material approved by the Engineer and at least 65% of it shall pass a 75µm B.S. sieve.

8.22.4 The binder shall be petroleum bitumen complying with B.S. 3690. The penetration of the bitumen shall be as in this Technical Specifications.

8.22.5 Freshly mixed material shall comply with Table 8.10 above.

8.22.6 The aggregate shall be surface-dry and shall be mixed at an appropriate temperature so that the temperature of the mixed material as delivered to the laying site is within the appropriate range given in Table 8.10 and at the time of rolling, not less than the appropriate temperature also in Table 8.10.

8.22.7 The material, comprising asphaltic concrete including filler, shall be weighed or measured into a mechanical mixer, and thoroughly mixed in such a manner that all particles of the aggregate are completely and uniformly coated.

8.23 TACK COAT

8.23.1 Before laying the base course, the surface of the road base shall be cleared of surplus stone fines and in the case of wet mix, the emulsion checked for intactness before placing the tack coat or wearing course. Unless otherwise directed by the Engineer, a tack coat shall be applied and it shall be in accordance with B.S. 594.

8.24 BITUMINOUS GRIT

8.24.1 The surface of newly compacted bitumen macadam should be blinded mechanically or by hand with bituminous grit as specified in B.S. 4987, Clause 2.3.7 and the rate of spread shall be sufficient to seal the interstices.

8.25 REINSTATEMENT

8.25.1 Reinstatement of flexible surfacing over foundation pits and trenches and the like, shall be completed to the satisfaction of the Engineer.

8.26 SURFACE DRESSING

8.26.1 Where directed by the Engineer, completed roads and hardstandings shall be protected by the application of surface dressing.

8.26.2 If with the written approval of the Engineer, the Contractor delays laying the wearing course until the works are otherwise completed or to suit his construction method or programme, then the Contractor shall at his own cost protect the base course by the application of a surface dressing.

8.26.3 Immediately before commencement of work, the road surface shall be thoroughly cleared of all loose material, dirt or other deleterious matter to the satisfaction of the Engineer.

8.26.4 The binder shall be applied at a temperature of approximately 160°C and the rate of spread shall be in the range 1.2 to 1.8 litre/m². The binder shall be sprayed uniformly onto the road surface and the application should be carried out by a mechanical distributor fitted with suitable speed and pressure indicators. Both temperature and rate of spread may be varied to suit the conditions of application as directed by the Engineer.

8.26.5 Chipping shall be carried out uniformly by a mechanical spreader, which shall follow closely behind the sprayer at a rate of 9 to 12 kg/m². Any thinly chipped areas should immediately be chipped by hand and any surplus chipping accidentally spilled should be removed.

8.26.6 Rolling shall be carried out to the approval of the Engineer using a rubber tyred roller. If, with the Engineers approval, a steel tyred roller is used, this shall not exceed 8 tonnes in weight.

8.26.7 Where directed by the Engineer, excess chipping shall be removed by sweeping before traffic is permitted to use the road or hardstanding. Further sweeping shall be carried out as directed by the Engineer to remove chipping loosened by traffic.

8.27 CONCRETE CARRIAGEWAYS

8.27.1 Materials for concrete carriageway slabs shall comply with the requirements of Section 3.

8.27.2 Once the appropriate grading, including the grading zone of the fine aggregate has been determined and approved, it shall be varied only with the permission of the Engineer. Minor fluctuations in the grading will be allowed.

8.27.3 Coarse aggregate shall be of nominal sizes between 10mm and 40mm as required by the Contract. It shall not exceed 20mm in concrete placed above the reinforcement mesh.

- 8.27.4 The weight of cement incorporated in each cubic metre of fully compacted concrete shall not be less than 300kg.
- 8.27.5 The ratio of free water to cement for surface-dry aggregate shall be determined by strength requirements but shall in no case exceed 0.55 by weight.

8.28 CONCRETE MIX AND WORKABILITY

- 8.28.1 The grade of concrete is denoted in the Contract by the characteristic strength. To achieve this, the materials shall be proportioned to comply with Section 9 and Table 9.1 together with Clause 8.27 above.
- 8.28.2 Trial mixes, where required by the Engineer, shall be made in accordance with relevant clauses in Section 9.
- 8.28.3 The concrete shall be of suitable workability for full compaction (without under flow) to be obtained with the plant used. The compacting factor shall be determined in accordance with B.S. 1881. When its optimum value has been determined and approved by the Engineer for the mix and plant being used, that value shall be maintained within a tolerance of ± 0.03 .
- 8.28.4 Alternatively, the slump test in accordance with B.S. 1881 shall be used when the average slump of the concrete so determined is equal to or greater than 40mm. In this case, the slump shall be maintained within a tolerance of ± 10 mm from the optimum approved by the Engineer.

8.29 WATERPROOF MEMBRANE

- 8.29.1 An underlay as specified in Section 3 shall be used to provide a waterproof membranes where described in the Contract. Where an overlap of underlay material is necessary this shall be at least 150mm. Water shall not be allowed to pond on the membrane which shall be completely waterproof when the concrete is laid.

8.30 STEEL REINFORCEMENT

- 8.30.1 Reinforcement for carriageways shall be steel fabric or deformed bars, both as specified in Section 3. The quantity and distributions shall be modified as approved by the Engineer to suit manholes and surface boxes, junctions or slabs of abnormal width or length.
- 8.30.2 The reinforcement shall be so placed that after compaction of the concrete, its cover below the finished surface of the slab is 60 ± 10 mm in slabs not less than 150mm thick, and 50 ± 10 mm in slabs less than 150mm thick, and it terminates at least 40mm and not more than 80mm from the edges of the slab and all joints in the concrete, or as detailed in the Contract. Reinforcement shall be positioned above dowel bars and tie bars irrespective of the tolerances on position.
- 8.30.3 At transverse joints between mats of steel fabric reinforcement, the first transverse wire of one mat shall lie within the last complete mesh of the previous mat and the overlap shall be not less than 450mm. No overlap will be needed longitudinally between mats.

8.31 JOINTS

- 8.31.1 Joints shall be formed as detailed in the Contract. The sealing grooves, whether wet formed or cut after concreting, shall be within a tolerance of ± 10 mm from the true line along the length of the joint. Joint assemblies, filler boards or crack inducing fillets positioned before concreting shall be within a tolerance of ± 3 mm from the true line of the joint.
- 8.31.2 Proprietary joint crack inducers, fillers and sealers shall be stored, handled and installed strictly in accordance with the manufacturer's instructions.

8.32 FORMS

- 8.32.1 All side forms shall be set to line and secured by using not less than three pins for each 3m of length and having one pin fixed at each side of every joint. Form sections shall be tightly joined together by a locked joint free from play or movement in any direction. The joints between form sections shall be made without discontinuity in the top surface. Forms shall be cleaned and oiled immediately before each use.
- 8.32.2 Side forms shall be removed not less than 4 hours after the completion of the construction of the concrete road slab. The concrete and any projecting tie rods shall not be damaged in any way during the removal of

the forms. If the removal of forms results in any damage to the concrete, the period of 4 hours shall be increased to that which is necessary to eliminate the damage.

8.33 DELIVERY AND STORAGE OF MATERIALS

- 8.33.1 Cement and aggregates shall be delivered and stored in compliance with relevant clauses in Section 9.

8.34 READY-MIXED CONCRETE

- 8.34.1 Ready-mixed concrete as defined in B.S. 5328 batched off the site, may be used only with the agreement of the Engineer and shall comply with relevant clauses in Section 9. The quality and strength of concrete shall be determined by site tests. Test results from the supplier shall not be accepted as proof of the quality and strength of the concrete agreed by the Engineer.

8.35 TRANSPORT, PLACING AND COMPACTION

- 8.35.1 The mixed material shall be covered during transit and while awaiting tipping to prevent wetting by rain or evaporation of moisture. It shall be transported and placed so that segregation or loss of the constituent materials is reduced to the minimum.
- 8.35.2 Concrete shall be placed either continuously or in alternate bays as the Engineer shall direct. It shall be deposited in the forms as near to its final position as possible and shall be initially well compacted by means of internal vibrators. It shall be struck off at such a level that the surface level after all air voids have been removed by compaction is above that of the side forms. The concrete shall then be compacted by a steel-shod hardwood vibratory compacting beam not less than 75mm wide x 225mm deep, the beam being lifted and moved forward by increments not exceeding the beam width. When compacting layers of concrete exceeding 200mm in depth by such a beam, sufficient additional internal vibration shall be provided over the whole width of the slab as to produce full compaction. After every 1.5m length of slab has been compacted, the vibratory beam shall be taken back 1.5m and then drawn slowly forward whilst vibrating over the compacted surface to provide a smooth finish.
- 8.35.3 The surface shall then be regulated by at least two passes of a scraping straight-edge with blade length not less than 1.80m. If the surface is torn extensively by the straight-edge, owing to irregularities in the surface, a further pass of the vibratory beam shall be made followed by a further pass of the scraping straight-edge.
- 8.35.4 When reinforced concrete is to be laid, the concrete shall be spread in two layers. The first layer shall be spread and struck off at such a level that after compaction it will support the reinforcement in the compacted concrete slab at the depth below the finished surface specified in the Contract. The reinforcement shall then be placed in position and the slab completed as rapidly as possible.

8.36 SURFACE FINISH OF CONCRETE CARRIAGEWAYS

- 8.36.1 After the final pass of the finishing beam, the completion of joints, and before the application of the curing membrane, the surface of concrete carriageways to be used as running surfaces shall be brushed in a direction at right angles to the centre line of the carriageways with a wire broom not less than 450mm wide. The wire tufts of the broom used shall initially be 100mm long of 32 gauge tape wire. The broom shall contain two rows of tufts, at 20mm centres and tufts shall be at 10mm centres and offset to the centre of gap between tufts in the other row. The tufts shall average 14 wires each. Brooms shall be replaced when the shortest tufts wear down to 90mm long.
- 8.36.2 The texture depth shall be determined by the "sand patch" test described in Section 12, not less than 2 days and not more than 7 days after finishing the concrete.
- 8.36.3 The average texture depth for each set of 10 tests shall not be less than 0.75mm and not more than one test of each set shall show a texture depth of less than 0.65mm. Where the texture depth requirement is not achieved, the Contractor shall make good the deficiencies in texture depth across the full lane width on lengths directed by the Engineer, by a means approved by the Engineer.

8.37 CURING

- 8.37.1 The exposed surfaces of concrete carriageways shall be cured immediately after the brush treatment specified by treating with an approved curing compound as specified in Section 3. It shall be mechanically sprayed on to the surface and sides of slabs at the rate recommended by the manufacturer using a fine spray. Any groove over a joint shall be protected from entry of curing compound.
- 8.37.2 Alternatively, and when approved by the Engineer, curing may be achieved by covering with approved impermeable plastic sheeting adequately secured from being blown off the surface, with joints overlapped at least 300mm and set to prohibit the ingress of moisture.

8.38 PRECAST CONCRETE KERBS, EDGINGS AND QUADRANTS

- 8.38.1 Precast concrete kerbs, edgings and quadrants shall comply with Section 3 and shall be laid and bedded in a layer of mortar not less than 12mm thick complying with Section 3, either on the concrete carriageway or a concrete foundation or haunch constructed as described in the Contract. They shall be backed with Grade G10 concrete complying with Section 9.
- 8.38.2 Where kerbs are laid on concrete carriageways, joints with filler complying with Section 3 shall be provided between kerbs coincident with the carriageway expansion joints.
- 8.38.3 For radii of 12m or less, kerbs of appropriate radius shall be used.
- 8.38.4 Any unit of kerb, edging and quadrant deviating more than 3mm from line and level at either end shall be made good by lifting and relaying.

8.39 FOOTWAYS PRE-CAST CONCRETE FLAGS

- 8.39.1 Precast concrete flags shall comply with Section 3 and be laid on sub-base material compacted to the required thickness. The sub-base material shall comply with this Section, if suitable for bedding, or with B.S. 882, Table 5, Limits C, M or F.
- 8.39.2 Flags shall be laid to the required cross-falls and bedded using five parts of lime mortar complying with Section 3 not less than 150mm diameter for each slab. The flags shall be laid to a 150mm or 300mm bond as described in the Contract with joints at right angles to the kerb.
- 8.39.3 On circular work where the radius is 12m or less, all flags shall be radially cut on both edges to the required line.

8.40 FOOTWAYS FLEXIBLE SURFACING

- 8.40.1 Flexible surfacing shall comply with either B.S. 4987 or B.S. 1447, or shall be of a material complying with one of the clauses in this Technical Specifications for base course or wearing course.
- 8.40.2 The flexible surfacing shall be laid to the levels and cross-falls described in the Contract on a sub-base compacted to the thickness required and of a material complying with this Section or other approved material.

8.41 FOOTWAYS IN-SITU CONCRETE

- 8.41.1 Concrete shall comply with the quality specified for concrete carriageways in this Section.
- 8.41.2 The concrete surface shall be laid to the levels and cross-falls described in the Contract on a sub-base compacted to the thickness required and of a material complying with this Section or other approved material.
- 8.41.3 The concrete shall be laid in bays of the dimensions required by the Contract but not exceeding 10m² in area and shall have a surface finish as specified in the Contract.
- 8.41.4 Expansion joints shall be formed in the concrete footway at spacings and such widths as specified in the Contract.

8.42 PERMANENT TRAFFIC SIGNS

- 8.42.1 Permanent traffic signs shall be as described in the Contract and shall comply with the requirements of B.S. 873, P.B.D. GD 17 and all Land Transport Department and Police Authority regulations.
- 8.42.2 Traffic signs shall be erected with stainless steel fittings or approved non-corrosive fittings on posts made from rectangular or tubular steel, reinforced or prestressed concrete or timber all as described in the Contract.
- 8.42.3 Should any conflict or inconsistency become apparent between standards in Clause 8.42.1, the Engineer shall be consulted before any work is commenced and shall decide which requirement shall take precedence.

8.43 MATERIALS FOR SIGN PLATES

- 8.43.1 The backing plates of permanent traffic signs shall be manufactured from 3mm sheet aluminium to B.S. 1470. The plates shall show no sign of twisting, warping or buckling and their surfaces shall be free from blemishes and other defects. All holes shall be of the size and in the locations shown in the Drawings and shall be drilled prior to painting or the application of reflective sheeting.

8.44 PAINT AND STOVED FINISHES

- 8.44.1 Before painting, the surface of the sign shall be thoroughly cleaned, pre-treated by anodizing or by using an etching primer or by an equivalent approved process, and primed with a paint pigmented with chromates or chromes (excluding lead chromes).
- 8.44.2 At least one undercoat and at least one finishing coat of paint shall be applied and stoved. A thickness of 0.0313 to 0.0375mm of enamel is recommended over 0.025mm of primer. Surface shall be of uniform thickness, smooth and free from defects, with an egg-shell flat finish.
- 8.44.3 Legends, symbols and borders of signs shall have clean-cut and sharp edges. On signs where light colours are applied over dark, at least two coats light colour shall be applied.
- 8.44.4 The reverse sides of all signs shall be finished black by the same method.
- 8.44.5 Paint shall comply with the requirements of Section 3.

8.45 WIDE ANGLE FLAT SURFACE REFLECTIVE SHEETING

- 8.45.1 Where required by the Contract, traffic signs shall be surfaced with wide angle, flat surface reflective sheeting which shall be of proprietary brand approved by the Engineer. Application of the sheeting, including the addition of a clean coating finish, shall be undertaken strictly in accordance with the manufacturer's instructions.
- 8.45.2 Whole sheets shall be used for individual signs and the rates in the Contract shall allow for all cutting to waste.

8.46 PLASTIC FILMS

- 8.46.1 Plastic film shall be of an approved proprietary brand.

8.47 COLOUR OF THE FINISHES

- 8.47.1 The colour of the finished coating shall be homogeneous and uniform.
- 8.47.2 The colours will be as follows: -
- a) Red complying with B.S. 381C No 537.
 - b) Yellow complying with B.S. 381C No 335
 - c) Blue complying with B.S. 381C No 109
 - d) Green complying with B.S. 381C No 225
 - e) Black and white complying with relevant clauses of B.S. 873 : Part 6.

8.48 DELIVERY AND STORAGE OF FINISHED SIGNS

- 8.48.1 All signs shall be slip sheeted and packed in such a manner as to ensure their arrival at the location of installation in an undamaged condition. Signs shall be kept in a perfectly dry store.

8.49 ROAD MARKINGS

- 8.49.1 Road markings shall be white or yellow continuous or intermittent lines, letters or figures laid to the dimensions and consisting of one of the following materials all as described in the Contract:-
- a) Thermoplastic material in accordance with B.S. 3262 : Part 1 or Part 2. The laid thickness of material complying with B.S. 3262 : Part 1 shall not exceed 6mm.
 - b) Paint for road markings complying with Section 3 applied at a covering rate not lighter than that recommended by the manufacturer and approved by the Engineer.
- 8.49.2 Where the lines are to be reflectorised, the relevant clauses of B.S. 3262 : Part 1 shall apply in the case of thermoplastic. For paint lines, the reflecting medium "ballotini" shall comply with Section 3 and shall be applied at a rate not less than 0.55kg/m^2 .

8.50 ROAD MARKING APPLICATION

- 8.50.1 Road marking paint shall comply with the requirements of Section 3 and shall be applied only on a surface which is clean and dry. The lines shall be laid to a regular alignment.
- 8.50.2 Where the road marking is to be laid at the junction between a carriageway and a paved hardshoulder or the carriageway of slip road and marginal strip shall be prepared and marked in accordance with Clause 8.49.
- 8.50.3 The Engineer shall assess the wear of the paint under traffic conditions and such wear shall not exceed 50% within a period of 15 weeks after the date of application to flexible road surfaces, and 12 weeks after the date of application to concrete road slabs.
- 8.50.4 Where the paint fails to meet the required standard of resistance to wear, the Contractor shall re-paint the markings at his own cost.
- 8.50.5 Road markings shall be set out by the Contractor in accordance with the Drawings and any incorrect marking shall be removed by him at his own cost.

8.51 MARGINAL STRIPS

- 8.51.1 Marginal strips shall be laid to the widths and in the positions described in the Contract.
- 8.51.2 The carriageway shall be prepared for receiving white road markings in the following manner:-
- a) On a concrete carriageway, the transverse texturing of the carriageway shall be carried across the width of the marginal strip, which shall be free, by wired brushing or other approved means, from all traces of the curing compound before the marking is applied.
 - b) On a flexible carriageway where chipping are applied to the wearing course, they shall be omitted from the marginal strip if the road marking is to consist of a surface dressing with white aggregate. If the road marking is to consist of white paint, chipping shall be provided to the marginal strip suitable for obtaining a rugous surface for painting.
- 8.51.3 The finish to be applied to marginal strips shall be reflectorised or unreflectorised paint or white surface dressing as described in the Contract.
- 8.51.4 White paint shall comply with Section 3 and be applied in accordance with Clause 8.47.
- 8.51.5 The surface dressing shall be in compliance with Section 8.36 but subject to the following particular requirements: -
- a) The binder shall be road tar to Grade A50 of B.S. 76 applied at the rate of $1.36 - 1.83 \text{ litre/m}^2$.

- b) The chipping shall be approved calcined flint or other approved equivalent white aggregate of 6.3mm or 10mm nominal size otherwise complying with B.S. 63 and as described in the Contract. They shall be applied at a rate of 6.15 - 6.75kg/m² and rolled with a roller of 2.5 tonnes nominal weight.
- 8.51.6 Traffic shall not be permitted to run over surface dressed marginal strips within one hour of laying nor over painted markings until dry.
- 8.52 REMOVAL OF CARRIAGEWAY MARKINGS
- 8.52.1 When ordered by the Engineer, carriageway markings shall be removed completely to the satisfaction of the Engineer by utilizing suitable paint-removers, blow lamps or other means. The use of black paint for the obliteration of markings will not be permitted. The method of paint removal will be such that the road surface shall not be damaged.
- 8.53 ROAD STUDS AND PLATES
- 8.53.1 Road studs and plates shall comply with the requirements of B.S. 873 : Part 4 and shall be installed to the satisfaction of the Engineer.
- 8.54 UNTENSIONED CORRUGATED BEAM SAFETY FENCE
- 8.54.1 Beams shall be of corrugated mild steel galvanised section not less than 300mm deep with traffic face centre trough at least 75mm deep. The deflection of the section, when freely supported over a 3m span with road face uppermost and central point load of 1000kg, should not exceed 40mm. Adjacent beams shall be joined by lap joints using bolts, nuts and washers to B.S. 970 : 080M40 (Normalised).
- 8.54.2 Posts shall be of approved hardwood 150mm x 150mm cross-section with 200mm blocking out piece 360mm high x 150mm wide. Spacing shall be not greater than 3.2m unless otherwise required in the Contract. Post and blocking out pieces shall be drilled 20mm diameter for beam fixing bolts. Timber to timber joints shall be fitted with 50mm O.D. double-sided toothed plate washer.
- 8.54.3 End beams shall be sloped down 10° to the horizontal to terminate 150mm above ground level. The junction between the horizontal and sloping beam shall be a butt weld with a tensile strength of not less than 330kN.
- 8.55 STREET LIGHTING
- 8.55.1 Street lights shall be located as shown in the Contract.
- 8.55.2 The Contractor shall satisfy himself as to the correctness of all connections before any of the equipment is put into operation and shall give reasonable notice to the Engineer and obtain his agreement before connection is made to the mains supply. The execution of all work shall be carried out by approved sub-contractors registered with the Department of Electrical Services. Only workers who have had experience in the erection of street lighting or similar columns shall be employed on the work of erection.
- 8.55.3 The earthing of the installation shall comply with the recommendations contained in the current issue of the I.E.E. Regulations for the Electrical Equipment of Building and B.S. 7430. The Contractor shall ensure that throughout the installation, all metallic parts of the whole of the equipment including the lantern, columns, cut-outs, and control gear, etc., other than current carrying conductors, are bonded to form a continuous path to the armouring on the incoming cables. Particular note is made that separate earth wires shall be installed between the lanterns at the top of the masts or columns and the incoming cable armouring in the base compartments.
- 8.55.4 The Contractor shall give not less than 3 days notice to the Engineer of the intention to carry out the tests specified in the Contract. Two copies of all test certificates shall be supplied as soon as possible after completion of the tests to the Engineer for his approval. Information is to be given on each test certificate sufficient to identify the material or equipment to which the certificate refers.
- 8.55.5 The following tests shall be carried out in order to determine whether the materials and apparatus comply with the Technical Specifications:-
- a) Insulation resistance tests for vulcanised rubber and polyvinylchloride insulated cables, as detailed in the current I.E.E. Regulations for the Electrical Equipment of Building and at the test voltage of 500 volts.

- b) A continuity test of each cable armouring between the point at which the earthing connection is made to the feeder pillar or distribution board and the most distant point of the run.
- c) The resistance of any length of earth return path comprising cable armouring, connecting boxes and fittings shall not exceed the resistance of a similar length of continuous cable armour.
- d) The Contractor shall carry out on completion of the installations, running tests to enable him to produce and send certificates to the Engineer guaranteeing that the installations are working satisfactorily.
- e) Tests shall be carried out to show that all switches have been placed in the phase or non-earthed conductor.

Tests (a), (b), (c) and (e) are to be carried out before the current is switched on, and test (d) is to be carried out before the installation is handed over to the Employer.

- 8.55.6 Contractor shall supply all ladders, tools, cranes and other plant necessary for the execution of the Contract, and remove these when the works are completed.

8.56 LANTERNS AND LAMPS

- 8.56.1 All lanterns shall comply with B.S. 4533.
- 8.56.2 All lumen outputs quoted will be minimum values applying to the lower hemisphere of lanterns, when fitted with the lantern manufacturer's recommended lamp of the nominal output specified for each lantern type, after 3000 hours of lamp life.
- 8.56.3 Lanterns shall be correctly orientated with the roadway in accordance with the recommendations of B.S. 5489 and mounting instructions issued by the manufacturer of the lantern.
- 8.56.4 Lantern and lamps shall be thoroughly cleaned after erection and again immediately before the road is opened to the public.

8.57 CONTROL GEAR

- 8.57.1 Power factor capacitors shall provide an overall power factor of not less than 0.85 lagging for each type of lantern.
- 8.57.2 Chokes and auto transformers shall be of the resin-filled type and shall be silent in operation. They shall be clearly marked with a circuit diagram and a schedule of connections.

8.58 PHOTOCONTROL UNITS FOR ROADS

- 8.58.1 These units shall have an inherent time delay to prevent false operation by extraneous agencies.
- 8.58.2 The design of the unit is to be such that adjustments can only be effectively carried out at a suitable equipped work bend, and the assembly is to be so enclosed as to be effectively tamper-proof on site.
- 8.58.3 In the event of a fault, the unit is to revert to fail-safe mode, i.e. the controlled lamp is to be switch on.
- 8.58.4 Photocontrol units are to be fitted with a "plug and twist" connector to mate with the sockets provided on the distribution pillars. Sealing rings are to be provided to prevent dirt and moisture from getting into photocontrol unit. Fixing to the pillar shall be by means of four screws.
- 8.58.5 Photocontrol units are required to switch on at 45 lux and have a switch off/switch ON differential of 1.5 - 2.0. The setting is to be within 10%. The setting must not be sensitive to the temperature changes likely to occur on site.
- 8.58.6 The photocontrol units will switch a whole feeder circuit through a suitably rated contactor.

8.59 LIGHTING COLUMNS

- 8.59.1 Columns shall be hot dip galvanised steel columns to B.S. 5649 or aluminium except where superseded or amended by the ensuing clauses.
- 8.59.2 Sections of butt welded tube shall not be employed in the manufacture of these columns. If columns involving longitudinal welding are offered then such welding shall be machine welding to B.S. 5135.
- 8.59.3 All columns shall be provided with metal door. Each door shall be provided with a tamper-proof locking device, and all locking devices shall be identical for each type of column. The centreline door openings shall be at right angles to the line of the bracket arms. Doors shall be designed to effectively prevent ingress of dirt and moisture. All door openings shall be smooth and free from irregularities and burrs.
- 8.59.4 Base boards should be non-hygroscopic and made of 20mm thick hardwood or marine plywood.
- 8.59.5 Each column shall be provided with a tapped stud and set screw to be used as an earthing terminal, and this is to be so positioned as to be easily accessible from the door opening. The screw, washers and nut are to be made of non-corrodible material.
- 8.59.6 The columns shall be completely waterproof when installed.
- 8.59.7 24 keys for each type of lock shall be provided and handed over to the Engineer immediately after commissioning.
- 8.59.8 Each column shall be provided with a spigot at least 100mm long to accommodate the fixing of the bracket arm. Where lanterns with remote control gear are required, the base compartment shall be large enough to receive this control gear, and the layout of the control gear on the base board is to be approved by the Engineer.
- 8.59.9 Bracket arms for columns shall be tubular in cross section, the size and cross sectional area being calculated for the longest arm (or span in the case of double arm columns) and heaviest lantern specified for each type. Webs shall not be used for stiffening purposes.
- 8.59.10 The securing arrangements of all brackets arms to columns shall be positive to ensure that the arms cannot rotate when fixed.
- 8.59.11 Columns and bracket arms shall be designed to carry that load or system of loads comprising:-
- The distributed wind loads on the projected area of the column, lanterns and bracket arms calculated at the rate shown in Table 8.13

Table 8.13

Description of column or part of column	Rate of wind loading	
	kN/m ²	lb/ft ²
Columns and bracket arms:		
of circular cross-section	0.72	15.0
of octagonal cross-section	0.90	19.0
of hexagonal cross-section	1.00	21.0
of square cross-section	1.34	28.0
Lanterns	0.72	15.0

- The loads due to the weight of the columns and bracket arms.
 - The loads due to the weight of the lanterns plus an allowance of 25% for impact.
 - Other applied loads.
- 8.59.12 The utmost importance is attached to ensuring that columns and arms are structurally sound. To this end the Contractor is required to submit information as follows unless columns to be supplied are as specified in the Contract: -

- a) Two copies of all working drawings and calculation sheets prepared by or on behalf of the Contractor shall be submitted to the Engineer for his approval but this approval shall in no way relieve the Contractor of his responsibilities for the work under the Contract. The working drawings shall be fully dimensioned and shall show complete details of all connections including weld geometry and welding procedures.
 - b) The calculations of structural adequacy are required for each type of column, when fitted with the heaviest type of lantern (or lanterns in the case of double arm columns) specified for use with that type of column, and with the longest outreach (double outreach in the case of the double arm columns) to be used for that type of column.
 - c) Full details of all assumptions made in these calculations in respect of the strength of welds.
- 8.59.13 The Contractor shall erect all columns and lanterns. Columns shall be handled with extreme care during transport and erection. Padded slings, etc., shall be used exclusively, and the types of sling to be used will be required to be approved by the Engineer.
- 8.59.14 Where lighting columns are to be erected in concrete foundations, the Contractor shall insert the root of the column into the prepared hole and shall adjust it into a vertical position by means of three wedges driven between the column and the sleeve lining the hole in the concrete. The space between the column and the lining shall be filled with washed sand well rammed down. After the sand has been compacted, the wedges shall be removed and further sand inserted and compacted.
- 8.59.15 Care shall be taken in erecting each column to ensure that the cable entry at the base is in the correct position. The entry shall be temporarily plugged to ensure that it is maintained free from concrete during the back-filling process.
- 8.59.16 To avoid confusion, each column on this Contract has been given a unique number. For subsequent maintenance purposes, however, the columns will be required to have the different numbers. The appropriate Contract number shall be stencilled on the base of each column, or otherwise marked as approved by the Engineer. Before any section of lighting is opened to traffic, however, each column shall be labelled with its appropriate service number, which will be issued later. These markings shall be by means of reflective plates, each digit being approximately 50mm high.
- 8.59.17 For each lighting column, the Contractor shall supply an insulated street lighting cut-out. Each cut-out shall be complete with an H.R.C. fuse, rating of which shall be suitable for the type of lamps and control gear to be employed. The cut-out shall be of the type that allows the looping in and out of cables, thereby avoiding the need for T-joints for feeding each column. The Contractor shall provide all ancillary equipment required to accommodate the cut-out within the columns. Mechanical connections of wires shall be by pressure plate. The use of screw faces bearing directly on to a wire, whether solid or stranded, is not acceptable.
- 8.59.18 The Contractor shall wire the columns internally complete to ancillary gear and lantern. An insulated wire connection shall be used to connect earth to each lantern earthing terminal. Vulcanised rubber insulated and braided cables shall comply with B.S. 6007 for 600 volts (to earth) cable. Polyvinyl-chloride insulated cables shall comply with B.S. 6004 and B.S. 6500. Conductor size shall not be less than 2.5mm². Where cables pass over sharp edges, for example at the arm entry, provision shall be made for protection of the insulation by grommets or other means approved by the Engineer.
- 8.59.19 Except where stated otherwise in the Drawings, copper core underground cables are to be used throughout. Copper cables shall be PVC insulated, steel wire armoured PVC sheathed overall, 600/1000V grade to B.S. 6346.
- 8.59.19 The Contractor shall carry out the whole of the excavation necessary for the installation of the cables with the exception of those areas where they pass under roads where ducts will be installed, or are in central reserves where ducts will be provided. The positions of such ducts are clearly marked in the Drawings. The Contractor shall locate and swab through the ducts and draw the cables through the ducts. Cables generally shall be laid at a minimum depth of 600mm below ground level. Trenches shall be provided with a 75mm deep bed of sand free from stones or sharp materials and a further 75mm of sand is to be placed over the cables when laid. Excavated material shall then be reinstated and well-compacted. The finished level shall be substantially the same as that of the surrounding level. All surplus excavated material shall be removed from the site. The routes of cables are shown in the Drawings and the Contractor shall follow these routes. The Contractor shall terminate all cables in distribution pillars on fuse-link type terminations. Drums of

cable shall be tested before leaving the manufacturer's plant and manufacturer's test certificates shall be supplied by the Contractor to the Engineer prior to the cables being installed.

- 8.59.20 Cable joint locations shall be permanently marked to the satisfaction of the Engineer and recorded in the as-built drawings. All cables laid in trench shall be marked by plastic strip. The strip is required to be manufactured from yellow self-coloured polythene 150mm wide by 0.1mm thick printed boldly in black "CAUTION STREET LIGHTING CABLE BELOW" or standards by the electrical utility authorities. The strip is to be continuous and wording shall occur at least at 1m intervals, and shall occupy at least 75% of the available length. The strip is to be laid at a depth of 150mm below the surface and immediately above the cables.
- 8.59.21 The supply to the lighting columns and bollards shall be derived from surface mounted weatherproof feeder pillars, the positions of which are shown on the relevant Drawings. The base for each feeder pillar shall be formed by the Contractor. These shall be of glass fibre construction and fitted with doors swinging through an angle of 180°. They shall be completely weatherproof, with adequate ventilation and the joint of the door shall be recessed on to a flat seating. Distribution pillars shall have a full size backboard of 10mm weatherproof plywood. The entry for cables shall be at the root of the pillar. Pillars shall be supplied in priming paint and the painting shall be finished using two coats of good quality gloss paint on site to the same colour as the adjacent columns. The pillars shall be fitted with recessed carriage type locks, all locks being identical in pattern. Twelve keys shall be provided and handed to the Engineer at the end of the Contract, and a receipt obtained. The feeder pillars shall be designated in accordance with the reference numbers or letters used in the Drawings. All feeder pillars shall be provided with a substantial circuit chart fixed by screws to the inside of the front cover. The function of each circuit shall be clearly printed on the chart and under the respective circuit number. Spare ways shall not be printed "SPARE" but left blank. The numbers of each column on each circuit and phase shall also be shown. The negotiations and complete installation of electricity supplies connected to the pillars by the electrical utility authorities will be arranged by the Engineer and paid for by the Employer. The Contractor shall be responsible for liaison with the Engineer to ensure that supplies are available when required. The pillars shall have enough space for the future installation of KWH meters (at least 300mm wide x 400mm high x 200mm deep).
- 8.59.22 The photo-electric cell controlled contactors shall comply with B.S. 775 and shall be rated in accordance with "uninterrupted duty", utilisation category AC4. The contactor coils shall be rated at 240V, 50 Hz.
- 8.59.23 After all tests have been carried out to the satisfaction of the Engineer, the complete system shall be commissioned at a time as agreed by the Engineer. This commissioning may require a return to site after the main Works have been finished.
- 8.59.24 Within six weeks of the completion of the work the Contractor shall provide as-built drawings of the Works. The drawings shall be in black indian ink on transparent linen with three sets of prints and shall include all plant, cable runs, duct crossings and depths at crossings, column locations, joint locations, and all information necessary for maintenance purposes, and the columns shall be re-labelled to show their service numbers. It is necessary that the Contractor should produce accurate records. The Contractor is required to make a daily record of all works done and to make modifications to diagrams etc., immediately the work to which such recording or modification pertains. The Engineer will require to know that accurate records are being kept and if not satisfied that this is being done, a satisfactory physical check of plant will be made against the Contractors records, any additional work necessary to meet this requirement being paid for by the Contractor.

9 CONCRETE WORKS**9.1 FORMWORK**

9.1.1 Falsework is any temporary structure used to support a permanent structure during its erection and until it becomes self-supporting.

9.1.2 Formwork is that timber or other material which forms the mould against which the concrete is cast, and which gives the shape, form and surface finish to the concrete.

9.2 CONSTRUCTION OF FORMWORK

9.2.1 Formwork shall be sufficiently rigid and tight to prevent loss of mortar matrix from the concrete and to maintain the correct position, shape and dimensions of the finished work. Formwork shall be so constructed as to be removable from the cast concrete without shock or damage.

9.2.2 The formwork shall be capable of producing a consistent quality of surface as required in the Contract.

9.2.3 Where holes are required in formwork to accommodate projecting reinforcement, fixing devices or other built-in items, approved proprietary materials shall be used to prevent loss of mortar matrix.

9.2.4 Formwork shall give access for the preparation of joint surfaces before the concrete has hardened.

9.3 FORMWORK CLASSES OF FINISH

9.3.1 Type A finish for surfaces next to earth, to receive further treatment or of no visual merit. This finish is obtained by the use of moulds or properly designed formwork of closely-jointed sawn boards. The surface shall be free from substantial voids, honeycombing or other large blemishes.

9.3.2 Type B finish for surfaces required for serviceability and structural soundness. This finish is obtained from formwork designed to produce a hard smooth surface with true, clean arrises. Only very minor surface blemishes will be permitted and there shall be no staining or discolouration. Fins and other projections shall be removed and the surface made good.

9.3.3 Type C finish for surfaces to good quality concrete, required for serviceability, structural soundness and appearance. The formwork shall be steel lined to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall make good any imperfections in the resulting finish as required by the Engineer. Internal ties and embedded metal parts will be allowed only with the Engineer's approval.

9.3.4 The tolerances permitted for the finishes are as follows:-

	Type A (mm)	Type B (mm)	Type C (mm)
Departure from alignment and grade	+50 , -12	±12	±4
Variations in cross-sectional dimensions	+12 , -6	+6 , -3	+4 , -2
Abrupt	±12	±3	±2
Deviation under 3m straight-edge	±12	±6	±3

9.4 PREPARATION OF FORMWORK BEFORE CONCRETING

9.4.1 The interiors of all formwork shall be thoroughly cleaned out before any concrete is placed. The faces of the formwork in contact with the concrete shall be clean and treated with a suitable release agent where applicable.

9.4.2 Where a concrete surface is to be permanently exposed, only one release agent shall be used throughout the entire area. Release agents shall be applied evenly, and contact with reinforcement and other embedded items is strictly prohibited. Where the concrete surface is to receive an applied finish, care shall be taken to ensure the compatibility of the release agent with the finish.

9.5 REMOVAL OF FORMWORK

9.5.1 Formwork shall be removed without shock to or disturbance of the concrete.

- 9.5.2 Formwork to vertical surface or sloping formwork not supporting concrete in flexure shall not be removed until, as may be relevant, the following criteria are met:-
- A minimum period shall have elapsed since the concrete was placed equivalent to 8 hours at 20° C for unsealed plywood forms or 6 hours at 20°C for impermeable forms.
 - The concrete strength shall be sufficient to meet any wind loading likely to arise upon the concrete at the time when the formwork is removed.
- 9.5.3 Formwork supporting concrete in flexure shall not be removed until the concrete strength (as confirmed by tests on cubes cured under representative conditions) has reached 10MPa or twice the stress to which the concrete will then be subjected, whichever is the greater.
- 9.5.4 In the absence of cube test results or any formal procedure agreed in writing with the Engineer, the periods before striking given in the following table shall be used:-

Sides of beams, walls, columns and piles	after 24 hours
Soffits of slabs (props left under)	3 days
External forms of circular culverts	24 hours
Internal forms of circular culverts	7 days

The periods stated above are based on the use of ordinary Portland cement and may be change if other types of cement are used, subject to the Engineer's agreement.

- 9.5.5 Formwork shall be constructed so that the side formwork can be removed without disturbing the soffit formwork and, if props are to be left in place when the soffit formwork are removed, these props shall not be disturbed during striking.
- 9.5.6 Notice shall be given to the Engineer of the intention to strike formwork.

9.6 SLOPING FORMWORK

Top formwork shall be provided to slopes 30° or more from the horizontal.

9.7 CONCRETE SURFACE CLASSES OF FINISH

- 9.7.1 Type 1 finish for surfaces to receive further treatment, or of no visual merit. The concrete shall be levelled and screeded to produce a uniform plain or ridged surface as required. No further work shall be applied to the surface unless it is a first stage for a Type 2 finish.
- 9.7.2 Type 2 finish for surfaces required for serviceability, structural soundness and appearance. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, the surface to a Type 1 finish (plain) shall be steel-trowelled under firm pressure to produce a dense, smooth, uniform surface free from trowel marks.
- 9.7.3 Where the type of finish is not given, it shall be Type 1 (plain).
- 9.7.4 The tolerances permitted for the finishes are as follows:-

	Type 1 (mm)	Type 2 (mm)
Departure from alignment and grade	±12	±4
Abrupt	±12	±3
Deviation under 3m straight-edge	±12	±4

9.8 FORMWORK TIE BOLTS

- 9.8.1 Tie bolts or other devices to be built into concrete shall be approved by the Engineer.
- 9.8.2 Only tie bolts which avoid embedding any metal parts permanently within 50mm of the concrete surface will be permitted. Voids remaining after the removal of all or part of each tie bolt shall be filled flush with the surrounding concrete using an approved proprietary non-shrink grout. In the case of water retaining structures, the Contractor shall ensure that the measures adopted will not impair the watertightness of the structure.

9.9 BUILT-IN ITEMS

- 9.9.1 Where pipes, sleeves, water bars or other items are built into concrete, they shall be rigidly secured in position to prevent movement and shall be free from external coatings which might adversely affect the bond. The Contractor shall take precautions to prevent the formation of air pockets, voids or other defects whilst the concrete is being placed.

9.10 VOIDS

- 9.10.1 Where permanent voids are to be formed in the concrete, the void formers shall be maintained rigidly in position. When required, the Contractor shall submit to the Engineer for his approval details of the measures he proposes to take to ensure accurate formation of the voids.

9.11 FIXINGS AND INSERTS IN CONCRETE

- 9.11.1 Submit details of all fixings to be permanently built into the concrete where these are not shown.
- 9.11.2 If any supports for formwork are to be left permanently embedded in the concrete, submit details and obtain the Engineer's agreement.
- 9.11.3 Where conduit, pipes, cables or the like are to be cast in structural members, they may be wired to the reinforcement but not placed within the cover, except at entry and exit points to the member.
- 9.11.4 Provide all templates necessary to accurately locate all bolts and other fixings in position and projection as shown in the Drawings.
- 9.11.5 Following casting in of bolts and other fixings, check their location and projection for accuracy and notify all inaccuracies. Do not modify the steelwork or fixings, bend bolts, or use excessive washers to accommodate errors in projections of bolts or fixings without the Engineer's agreement.
- 9.11.6 Do not use explosive to insert fixings into structural concrete without submitting details of their sizes and positions, and obtain the Engineer's agreement. Do not use them where rusting is possible, and install them in accordance with the manufacturer's instructions.
- 9.11.7 Cast holding down bolts in tapered timber boxes to the dimensions shown in the Drawings. Alternatively, use acceptable polystyrene or expanded metal boxes. Ensure that the projecting ends of the bolts have freedom for horizontal movement within the hole formed by the box. The projecting ends of bolts must be well greased and wrapped, and this protection must remain undisturbed until steelwork erection commences.
- 9.11.8 Where inserts are cast into concrete for subsequent attachment of a fixing, they must be of suitably shaped insert material.

9.12 REINFORCEMENT

- 9.12.1 Steel reinforcement shall be stored in clean conditions. It shall be clean and free from loose rust and loose mill scale at the time of fixing in position and subsequent concreting.

9.13 BENDING OF REINFORCEMENT

- 9.13.1 Reinforcement shall be bent to the dimensions given in the bar schedules if provided in the Drawings.
- 9.13.2 All reinforcement shall be bent cold and in accordance with B.S. 4466.
- 9.13.3 Cold worked and hot-rolled high yield bars shall not be straight-ended or bent again once having been bent. Where it is necessary to bend mild steel reinforcement already cast in the concrete, the internal radius of bend shall be not less than twice the diameter of the bar.

9.14 PLACING OF REINFORCEMENT

- 9.14.1 Reinforcement shall be placed and maintained in the position shown in the Contract. Unless permitted by the Engineer, all intersecting bars shall be tied together and the ends of the tying wire shall be turned into the main body of the concrete. Stainless steel wire 1.2mm diameter shall be used for members having exposed soffits. Soft annealed iron wire 1.6mm diameter shall be used elsewhere.

- 9.14.2 No splices shall be made in the reinforcement except where described in the Contract or where approved by the Engineer.

9.15 COVER BLOCKS

- 9.15.1 Concrete cover blocks required for ensuring that the reinforcement is correctly positioned, shall be as small as possible consistent with their purpose, of a shape acceptable to the Engineer, and designed so that they will not overturn when the concrete is placed. They shall be made of concrete in accordance with Clause 3.37.
- 9.15.2 Other types of cover blocks or spacers may be used at the discretion of the Engineer.

9.16 WELDING OF REINFORCEMENT

- 9.16.1 Reinforcement in structures shall not be welded except where permitted in the Contract. All welding procedures shall be subject to the prior approval of the Engineer in writing.

9.17 CONCRETE

- 9.17.1 Concrete mix design, materials, and workmanship shall all comply with the requirements of B.S. 8110. Designed mixes may only be used with the approval of the Engineer.
- 9.17.2 The grade of concrete is denoted by the characteristic strength. The characteristic strength of a particular grade of concrete is the ultimate strength for the purposes of design below which only 5% of test results are expected to fail.
- 9.17.3 The subscript C in the concrete designation means that a minimum cement content and a maximum water/cement ratio is specified in the Contract. The subscript S in the concrete designation means that sulphate resisting cement is to be used.
- 9.17.4 The cement content of any mix shall not exceed 550kg/m³ of concrete and the water cement ratio shall not exceed that required to produce a concrete with the workability and compaction specified.
- 9.17.5 Rapid hardening cement shall not be used.
- 9.17.6 The drying shrinkage of concrete of the specified crushing strength manufactured from aggregates and tested in accordance with the provisions of B.S. 1881 : Part 5, shall not exceed 0.045%.

9.18 PRESCRIBED MIXES

- 9.18.1 The mix proportions given by the Engineer in Table 9.1 will under normal control conditions produce a concrete which has a characteristic strength at 28 days at least equal to the grade of concrete.
- 9.18.2 When the characteristic strength cannot be obtained, the Engineer may agree variations in the mix proportions with the Contractor.
- 9.18.3 The weights given in the Table 9.1 are based on the use of crushed stone fines conforming to grading limits M in B.S. 882.
- 9.18.4 If sand is used instead of crushed stone fines, the weight of the coarse aggregate should be increased by not more than 10kg without altering the weight of the crushed stone fines.
- 9.18.5 The weight of the fine aggregate should be decreased by at least 10kg if its grading is within the limits of grading limits F of B.S. 882, and increased by at least 10kg if its grading is within the limits of grading limits C of B.S. 882. The weight of the coarse aggregate should be increased or decreased respectively by the same amount so that the total weight of the aggregate remains the same.

9.19 TRIAL MIXES

- 9.19.1 Where Standard Mixes are to be used, trial mixes and preliminary testing will not normally be required but the Engineer may require them if he deems it necessary.

9.20 PROCEDURE FOR TRIAL MIXES

- 9.20.1 Where trial mixes are required, three separate batches of concrete shall be made using materials typical of the proposed source of supply and where practicable, under full-scale production conditions.
- 9.20.2 The workability of each of the trial batches shall be determined and three cubes made from each batch for test at 28 days.
- 9.20.3 The trial mix proportions shall be approved if the average compressive strength of the nine cubes tested at 28 days exceeds the characteristic strength by 10N/mm^2 for Grade G20 concrete and over, or 5N/mm^2 for Grade G15 concrete or lower.
- 9.20.4 Additional sets of cubes from each batch may be required for tests at an earlier age.
- 9.20.5 Where required, two further trial mix batches shall be made with cement and typical surface dry aggregates to show that any stated maximum free water/cement ratio is not exceeded. The proposed mix proportions shall not be accepted unless both batches have the correct cement content and a free water/cement ratio below the maximum specified value for the intended degree of workability. For this purpose, existing test reports may be used instead of trial mixers, if the Engineer is satisfied that the materials to be incorporated in the concrete are likely to be similar to those used in the tests.

9.21 "NO-FINES" CONCRETE

- 9.21.1 "No-fines" concrete shall be composed of ordinary Portland cement and 10mm - 20mm chipping. The chipping shall be free of dust. The mix proportions shall be 1 part of cement to 10 parts of aggregate by weight and the water/cement ratio shall be maintained at 0.45 by weight. The "no-fines" concrete is made by coating each stone with a layer of mortar, but with no surplus mortar left. "No-fines" concrete shall be placed with the minimum of punning. No traffic will be allowed on the finished work, and the surface shall be kept clean. Before placing any other class of concrete on top, a layer of approved high quality waterproof building paper or roofing felt shall be laid and well lapped, to ensure that no mortar from the overlain concrete penetrates to the "no-fines" concrete.

9.22 DELIVERY AND STORAGE OF MATERIALS

- 9.22.1 Cement shall be stored in a dry weatherproof shed with a raised wooden floor or in a silo and shall be delivered in quantities sufficient to ensure that there is no suspension or interruption of the work of concreting at any time. If stored in sheds, each consignment shall be kept separate and distinct and used in the order in which it was delivered. Any cement which has become injuriously affected by damp or other causes shall be removed at once from the site.
- 9.22.2 The Contractor may be required to forward to the Engineer a sample for testing from each cement delivery and no cement shall be used from that batch until approved by the Engineer.
- 9.22.3 Coarse aggregate, unless otherwise agreed by the Engineer, shall be delivered to the site in separate sizes (2 sizes when the maximum size is 20mm and 3 sizes when the maximum size is 40mm or more).
- 9.22.4 All aggregates brought to the site shall be kept free from contact with deleterious matter and in the case of aggregates passing a 5mm B.S. sieve, they shall be deposited on the site of mixing for not less than 8 hours before use. Aggregate of different sizes shall be stored in different hoppers or different stockpiles which shall be separated from each other.
- 9.22.5 Aggregates shall be stored on specially prepared well-drained concrete floors, divided into compartments as necessary. Alternatively, the Contractor may make such other arrangements for the storage of aggregates as may be approved by the Engineer.
- 9.22.6 Any aggregates whose properties are proven to be at variance with the requirements of B.S. 8S2 must be removed from site at the Contractor's own cost.

9.23 MIXING CONCRETE

- 9.23.1 The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in B.S. 1305 and checked against accurate weights and volumes when required by the Engineer.

- 9.23.2 The weights of cement and each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of $\pm 2\%$ of the respective weights per batch as agreed by the Engineer. The weight of the fine and coarse aggregates shall be adjusted to allow for the free water contained in them. The water to be added to the mix shall be reduced by the quantity of free water contained in the fine and coarse aggregates which shall be determined by the Contractor by a method approved by the Engineer immediately before mixing begins, and further as the Engineer requires.
- 9.23.3 Concrete shall be mixed in a power-driven batch type mixer approved by the Engineer. The batch capacity, method of loading, mixing time and speed of operation shall be as recommended by the mixer manufacturer's instructions but mixing shall not be carried out for a period greater than one hour.
- 9.23.4 Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.
- 9.23.5 The Contractor shall ensure that the constituent materials of the concrete are sufficiently cool to prevent the concrete from stiffening in the interval between its discharge from the mixer and compaction in its final position.
- 9.24 READY-MIXED CONCRETE
- 9.24.1 Ready-mixed concrete shall conform to P.B.D. 6 or B.S. 5328, and all requirements of the Contract. The quality and strength of cements shall be determined by site tests. No test results supplied by the ready-mix supplier shall be accepted as proof of the quality and strength of the concrete.
- 9.24.2 The concrete shall be carried in purpose-made agitators operating continuously or in truck mixers. The concrete shall be compacted and in its final position within two hours of the introduction of water to the cement and aggregates or the cement to the mix, whichever period is the longer. The time of such introduction shall be recorded on the Delivery Order together with the weight of the constituents of each mix.
- 9.24.3 When truck mixed concrete is used, water shall be added under supervision either at the site or at the central batching plant as agreed by the Engineer but in no circumstances shall water be added in transit.
- 9.24.4 Unless agreed otherwise by the Engineer, truck mixer units and their mixing and discharge performance shall comply with the requirements of B.S. 4251. Mixing shall continue for the number and at the rate of revolutions recommended in accordance with B.S. 4251 or, in the absence of the manufacturer's instructions, mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.
- 9.24.5 Prior to any ready mixed concrete being ordered, the Contractor shall submit to the Engineer details of the supplier and shall arrange for the Engineer to inspect the supplier's plant any time during working hours without prior notification.
- 9.24.6 Truck-mixer units shall be maintained and operated strictly in accordance with the manufacturer's instructions.
- 9.25 SAMPLING CONCRETE
- 9.25.1 Sampling shall be carried out in accordance with the requirements given in B.S. 1881 : Part 1. A single batch sampling procedure shall be adopted and the number, frequency and location of batches to be sampled shall be decided by the Engineer.
- 9.26 TRANSPORT AND PLACING
- 9.26.1 The method of transporting and placing concrete shall be to the approval of the Engineer. Concrete shall be so transported and placed that contamination, segregation or loss of the constituent materials does not occur.
- 9.26.2 All formwork and reinforcement installed in structural elements shall be clean and free from standing water immediately before the placing of the concrete.
- 9.26.3 Concrete shall not be placed in any part of the structure until the Engineer's approval has been obtained.

- 9.26.4 If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Engineer. Concreting shall then proceed continuously over the area between construction joints. Fresh concrete shall not be placed against in-situ concrete which has been in position for more than 30 minutes unless a construction joint is formed. When in-situ concrete has been in place for 4 hours, no further concrete shall be placed against it for a further 20 hours.
- 9.26.5 Concrete shall be compacted in its final position within 30 minutes of discharge from the mixer unless carried in purpose-made agitators, operating continuously, when the time shall be within 2 hours of the introduction of cement to the mix and within 30 minutes of discharge from the agitator.
- 9.26.6 Except where agreed otherwise by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 450mm where internal vibrators are used or 150mm in all other cases.
- 9.26.7 Unless agreed otherwise by the Engineer, concrete shall not be dropped into place from a height exceeding 2m. When trunking or chutes are used, they shall be kept clean and used in such a way as to avoid segregation. In general, trunking or chutes shall not be more than 20° off the vertical.
- 9.26.8 No concrete shall be placed in flowing water.
- 9.26.9 Concrete placed underwater shall be conforming to recommendations in B.S. 8004.

9.27 COMPACTION

- 9.27.1 All concrete shall be compacted to produce a dense homogeneous mass. Unless agreed otherwise by the Engineer, it shall be compacted with the assistance of vibrators. Sufficient vibrators in serviceable condition shall be on site so that spare equipment is always available in the event of breakdown.
- 9.27.2 Internal vibrators shall be capable of producing not less than 10,000 cycles per minute and external vibrators not less than 3,000 cycles per minute.
- 9.27.3 Vibration shall not be applied by way of the reinforcement. Where vibrators of the immersion type are used, contact with reinforcement and all inserts shall be avoided.
- 9.27.4 Concrete shall not be subjected to vibration between 4 and 24 hours after compaction.

9.28 CONSTRUCTION JOINTS

- 9.28.1 The position and detail of any construction joints not described in the Drawings shall be subject to the approval of the Engineer, and shall be so arranged as to minimise the possibility of the occurrence of shrinkage cracks.
- 9.28.2 The upper surface of lifts of concrete walls and columns shall be horizontal and the formwork shall be cleaned of adhering concrete before the next lift is placed. The concrete placed immediately above a horizontal construction joint shall contain only two-thirds the normal quantity of coarse aggregate, shall not be the first batch through the mixer and shall be thoroughly compacted and worked against the existing concrete.
- 9.28.3 In the case of vertical surfaces, joints shall not be so dry that water can be absorbed from the fresh concrete.
- 9.28.4 Where sections of the work are carried out in lifts, the reinforcement projecting above the lift being cast shall be adequately supported so as to prevent movement of the bars during the casting and setting of the concrete.
- 9.28.5 Wherever possible, laitance and all loose material shall be removed before initial set and no further roughening shall then be required. Where this is not possible, it shall be removed by mechanical means provided the concrete has been in position for more than 24 hours. The roughened surface shall then be washed with clean water.
- 9.28.6 Cast slabs in either alternate bay or random bay construction, but restrict the area of concrete cast in a single pour to the following:-
- a) Where all sides are unrestrained, the maximum area must not exceed 100m² and the greatest overall length must not exceed 12m.

- b) Where any one or more sides will be restrained by reinforcement projecting from adjoining concrete, the maximum area must not exceed 75m² and the greatest overall length must not exceed 10m.

9.28.7 Walls shall be cast in alternate panel or random panel construction but restrict the length of panel cast in a single pour to the following: -

- a) The maximum length between two stop ends shall not exceed 7.5m.
- b) The maximum length where one or more ends will be restrained by reinforcement projecting from adjoining concrete shall not exceed 5m.

9.28.8 Do not cast concrete against work previously constructed until the latter is at least 36 hours old.

9.29 CURING

9.29.1 Immediately after compaction and for 7 days thereafter, concrete shall be protected against harmful effects of weather, including rain, running water and drying out. The protection shall be applied by using one of the following methods:-

- a) Except in the case of surfaces to which concrete subsequently has to be laid, the concrete shall be cured by application of an approved liquid curing membrane. Application shall be by a low-pressure spray at the rate recommended by the manufacturer. On the horizontal surfaces, the membrane shall be applied immediately after placing the concrete, and on vertical surfaces immediately after removing the formwork.
- b) After thoroughly wetting, the concrete shall be covered with a layer of approved waterproof paper or plastic membrane kept in contact with the concrete for at least 7 days.
- c) The concrete shall be completely covered with a layer of hessian, sacking, canvas or similar absorbent material or a layer of fine aggregate kept constantly wet.

9.30 EARLY LOADING

9.30.1 Concrete shall at no time be subjected to loading, including its own weight, which will induce a compressive stress in it exceeding one-third of its compressive strength at the time of loading or of the specified 28-days strength.

9.30.2 For the purpose of this clause, the assessment of the strength of concrete and the stresses produced by the loads shall be subject to the agreement of the Engineer.

9.31 ADMIXTURES

9.31.1 Unless approved by the Engineer, neither admixtures nor cements containing additives shall be used. If their use is approved or specified in the Contract, they shall be used strictly in accordance with the manufacturer's instructions.

9.32 CONCRETE FOR ANCILLARY PURPOSES

9.32.1 Where concrete is used for ancillary purposes, it shall be either Grade G7, G10 or G15 as specified in the Contract. The Engineer may vary this, as required elsewhere in the Contract.

9.33 WATERTIGHT CONSTRUCTION

Where watertight construction is specified the following criteria shall be met:

- 9.33.1 The water content of the concrete mix shall be kept to a minimum by using a plasticiser after receiving the Engineer's written approval.
- 9.33.2 An accurate dispenser shall be provided at the concrete mixer to control accurately the quantity of plasticiser used.
- 9.33.3 Rapid hardening cement shall not be used.

9.33.4 Determine construction joint positions as follows: -

- a) For unrestrained slabs, restrict the maximum area to 40m² and the longest side to 8m.
- b) For slabs restrained by reinforcement projecting from concrete already cast, restrict the maximum area to 30m² and longest side to 7m.
- c) For unrestrained walls, restrict the length to 8m.
- d) For restrained walls, restrict the length to 5m.

9.33.5 Details of construction joint locations and sequences of construction shall be submitted to the Engineer for approval at least 14 days before casting begins.

9.33.6 A PVC or rubber water bar shall be provided at all joints as required by the Contract.

9.33.7 One of the following shall be provided at all construction joints:-

- a) 150mm minimum width PVC or rubber water bar with special factory-made junction pieces at all intersections, so that water bars are not lapped or crossed. Restrict site jointing to butt ends welded to the manufacturer's recommendations. Securely fix the water bar without perforating it so that it cannot move during concreting.
- b) Proprietary metal water bars jointed and fixed to the manufacturer's recommendations.

9.33.8 Starter plinths to walls shall be cast integrally with the concrete slab and at least 75mm high.

9.33.9 Fixings embedded in or passing through the concrete must not impair its watertightness and must be specifically for use in watertight construction. All pipe lengths passing through concrete walls and slabs shall be cast integrally with the concrete section and include puddle flanges, etc. No box-outs will be permitted without the Engineer's prior approval.

9.33.10 Cutting or drilling shall not be permitted on watertight construction.

9.33.11 All leaks or signs of water appearing during the construction and maintenance periods shall be made good after receiving written approval from the Engineer.

Table 9.1 - Prescribed mixes for ordinary structural concrete

Grade	Max. aggregate size (mm)	40			20			10		
	Workability	Low	Med	High	Low	Med	High	Low	Med	High
	Slump (mm)	25 - 50	50 - 100	100 - 175	13 - 25	25 - 50	50 - 125	0 - 6	6 - 25	25 - 50
	Compacting factor	0.82 - 0.88	0.88 - 0.94	0.94 - 0.97	0.82 - 0.88	0.88 - 0.94	0.94 - 0.97	0.80 - 0.86	0.86 - 0.92	0.92 - 0.97
7	Cement (kg)	160	180	200	190	210	230			
	Total aggregate (kg)	2000	1950	1850	1950	1900	1800			
	Fine aggregate (%)	30 - 45	30 - 45	30 - 45	30 - 45	35 - 50	35 - 50			
10	Cement (kg)	190	210	230	220	240	260			
	Total aggregate (kg)	1950	1900	1850	1900	1850	1800			
	Fine aggregate (%)	30 - 45	30 - 45	30 - 45	30 - 45	35 - 50	35 - 50			
15	Cement (kg)	230	250	270	250	280	310			
	Total aggregate (kg)	1900	1850	1800	1850	1800	1750			
	Fine aggregate (%)	30 - 45	30 - 45	30 - 45	30 - 45	35 - 50	35 - 50			
20	Cement (kg)	280	300	320	290	320	350	320	360	410
	Total aggregate (kg)	1900	1850	1750	1850	1800	1750	1850	1750	1650
	Fine aggregate (%)	30 - 35	30 - 35	30 - 40	30 - 40	30 - 40	35 - 45	35 - 45	40 - 50	45 - 55
25	Cement (kg)	320	340	360	330	360	390	360	400	410
	Total aggregate (kg)	1850	1800	1750	1800	1750	1700	1800	1700	1600
	Fine aggregate (%)	30 - 35	30 - 35	30 - 40	30 - 40	30 - 40	35 - 45	35 - 45	40 - 50	45 - 55
30	Cement (kg)	350	370	390	370	400	430	420	460	510
	Total aggregate (kg)	1800	1750	1700	1750	1700	1650	1750	1650	1550
	Fine aggregate (%)	30 - 35	30 - 35	30 - 40	30 - 40	30 - 40	35 - 45	35 - 45	40 - 50	45 - 55

10 PIPELINES AND CHANNELS**10.1 TYPES OF PIPE**

- 10.1.1 Except as permitted below, the Contractor shall construct the pipelines using the designs of pipe, bedding, haunching and surround all as shown in the Contract. However, the Contractor may provide a different design of pipe supported in the same manner or differently, subject to written approval indicating that the Engineer is satisfied that all other requirements of this Technical Specifications will be met, that the strength of the proposed pipe and any different form of support is equally effective as that shown in the Contract, and that the pipe will not be injuriously affected by either the adjacent ground or the fluid to be carried.

10.2 EXCAVATION

- 10.2.1 The Contractor shall exercise such care and attention as is necessary to ensure that all excavation of pipe trenches is to the correct setting out of line and levels. The Contractor shall carry out his operations in such a manner as to avoid damage to, or deterioration of, the final surfaces of excavations.
- 10.2.2 If the Contractor encounters ground in the final surface which he considers unsuitable, or if the final surface is damaged or allowed to deteriorate, the Engineer shall be promptly informed.
- 10.2.3 The sides of excavations shall be adequately supported at all times, and, except where required by or permitted under the Contract, shall not be battered.
- 10.2.4 No excavated material suitable for re-use in the Works shall be removed from the site except on the direction or with the permission, of the Engineer.
- 10.2.5 Trenches for pipes carrying water under pressure shall, except where otherwise required by the Contract, be excavated to a sufficient depth to ensure a minimum cover of 900mm to the top of pipes after completion of backfilling.

10.3 PIPE LAYING

- 10.3.1 Where pipes are to be bedded directly on the trench bottom, the formation shall be trimmed and levelled to provide even bedding of the pipeline, and shall be free from all extraneous matter that may damage the pipe or pipe coating. Joint pocket shall be provided at each joint to facilitate proper jointing of pipes.
- 10.3.2 Where pipes are to be laid directly on the trench bottom, on granular or sand bed, joint holes shall be formed in the formation or bedding material to ensure that each pipe is uniformly supported throughout the length of its barrel, and to enable the joint to be made. On no account are pipes to be propped on bricks, pegs, etc to adjust line and level prior to backfill.
- 10.3.3 Pipes shall only be laid on setting blocks where a concrete bed or cradle is used.
- 10.3.4 No protective cap, disc, or other appliance on the end of a pipe or fitting shall be removed permanently until the pipe or fitting that it protects is about to be jointed. Pipes and fittings, including any lining or sheating, shall be examined for damage and the joint surfaces and components shall be cleaned immediately before laying.
- 10.3.5 Suitable measures shall be taken to prevent soil or other material from entering pipes, and to anchor each pipe to prevent flotation or other movement before the Works are complete.

10.4 GRANULAR BEDDING

- 10.4.1 Granular bedding for pipes shall be constructed by spreading and compacting granular bedding material over the full width of the pipe trench. After the pipes have been laid, additional granular material shall, if required, be placed and compacted equally on each side of the pipes and, where practicable, this shall be done in sequence with the removal of the trench supports.

10.5 CONCRETE PROTECTION TO PIPES

- 10.5.1 Pipes to be bedded on or cradled with concrete shall be supported on precast concrete setting blocks, the top face of each block being covered with compressible packing in accordance with Clause 3.67

10.5.2 Concrete provided as a protection to pipes shall be placed to the required depth in one operation. Concrete protection shall be interrupted over its full cross section at each flexible joint by a shaped former of compressible filler in accordance with Clause 3.67

10.5.3 Rapid hardening cement shall not be used in concrete for the protection of UPVC pipes.

10.6 COMPLETION OF PIPE SURROUND

10.6.1 After completion of the relevant operations in Clauses 10.3 to 10.5, Type B fill material as described in Clause 3.66 shall, where required, be placed and compacted by hand over the full width of the trench, in layers not exceeding 150mm loose depth, to a minimum finished thickness of 300mm above the crown of the pipes, before mechanical compactor plant is used.

10.6.2 Subsequent backfill material shall be deposited in layers not exceeding 250mm loose depth and compacted in accordance with the requirement of Section 6 of this Technical Specifications. Where the excavations have been supported and the supports are to be removed, where practicable, these shall be withdrawn progressively as backfilling proceeds in such a manner as to minimise the danger of collapse and to ensure complete backfilling of the excavation. Any voids behind the trench supports shall be fully filled and compacted with backfill material.

10.7 REINSTATEMENT

10.7.1 On completion of work in unpaved land, the Contractor shall break up and cultivate the surface of all land affected, to a depth of at least 300mm, replacing top soil and restoring the land as closely as possible to its original condition.

10.7.2 For trenches in carriageway pavements, backfill material shall be brought up to formation level. The remaining reinstatement shall be undertaken to the widths and in the materials described in Contract.

10.8 THRUST BLOCKS

10.8.1 Before any internal pressure is applied to a pipeline, concrete thrust blocks shall be cast in contact with undisturbed ground and allowed to develop adequate strength.

10.9 PIPE JOINTING

10.9.1 Pipe jointing surfaces and components shall be kept clean and free from extraneous matter until the joints have been made or assembled. Care shall be taken to ensure that there is no ingress of grout or other extraneous material into the joint annulus after the joint has been made.

10.9.2 Proprietary joints shall be made in accordance with the manufacturer's instructions.

10.9.3 Where flexibly jointed pipes are laid to curves, the deflection at any joint as laid shall not exceed three quarters of the maximum deflection recommended by the manufacturer.

10.10 FLANGED JOINTS

10.10.1 Flanges shall be properly aligned before any bolts are tightened to the recommended torque. Bolt threads shall be treated with graphite paste and the nuts tightened evenly in diametrically opposite pairs.

10.10.2 Jointing compounds shall not be used when making flanged joints, except that to facilitate the making of vertical joints, gaskets may be secured temporarily to one flange face by a minimum quantity of clear rubber solution.

10.11 SOLVENT WELDED JOINTS

10.11.1 When solvent welded pipes are jointed outside the trench, they shall not be lowered into place until the period recommended by the manufacturer for complete setting of the joints has elapsed.

10.12 OGEE JOINTS

- 10.12.1 Ogee joints shall be so made that the required jointing material completely fills the joint cavity. Any surplus jointing material which is extruded inside the barrel shall be trimmed off and, where practicable, pointed on completion.

10.13 CEMENT MORTAR JOINTS

- 10.13.1 In making yarn and mortar joints for pipes or fittings, the spigot shall be entered into the socket of the last pipe laid until it bears on the back face of the socket, and it shall be entered in the socket. Two turns of tarred yarn shall then be caulked into the back of the socket with a proper caulking tool and cement-sand mortar shall be pressed into the joint to fill the socket completely and shall be leveled off at 45° from the outside edge of the socket.

10.14 WELDED JOINTS

- 10.14.1 Welded joints in carbon steel pipelines shall be made in accordance with the relevant requirements of B.S. 4515.

10.15 PROTECTION OF STEEL JOINTS

- 10.15.1 Joints on steel pipelines or joints having exposed mild steel components shall be cleaned, and all loose rust shall be removed.
- 10.15.2 They shall be protected as follows:-
- a) Internal protection, where pipes have a bituminous lining in which a gap has been left for the joint to be made. The lining shall be completed in accordance with the manufacturer's instructions, unless otherwise detailed in the Contract.
 - b) External protection shall be:-
 - i) protection shall comprise bitumen poured into a suitable mould in accordance with the manufacturer's instructions, unless otherwise detailed in the Contract, or
 - ii) protection shall comprise the application of approved mastic paste in sufficient quantity to cover all protruding edges, bolt heads and sharp edges of flanges, so as to give a smooth external profile, followed by wrapping with two separate layers of approved protective tape wound spirally with a half width overlap. The taping shall extend along 150mm of the barrel of the pipe on each side of the joint, or
 - iii) protection shall comprise painting the external surfaces as detailed in the Contract.

10.16 CUTTING PIPES

- 10.16.1 Pipes shall be cut by a method which provides a clean square profile, without splitting or fracturing the pipe wall, and which causes minimum damage to any protective coating. Where necessary, the cut ends of pipes shall be formed to the tapers and chamfers suitable for the type of joint to be used, and any protective coatings shall be made good, burrs and swarf shall be removed from the pipe bore.

10.17 CONNECTIONS TO EXISTING SEWERS

- 10.17.1 A pipe saddle must always be used when connecting pipe to existing sewers.
- 10.17.2 Pipe saddles for concrete or clay sewers shall be bedded in 1 : 3 cement-sand mortar and a cement mortar filler formed to give a cover of at least 50mm to the base of the saddle. Pipe saddles for asbestos cement sewer pipes shall be formed from asbestos cement and fixed with an epoxy resin adhesive. Pipe saddles for UPVC pipes shall be purpose made from UPVC and shall be fixed with an appropriate solvent cement.
- 10.17.3 The ends of connections and pipes not required for immediate use shall be closed with purpose made stoppers or discs. The position of all junctions shall be recorded by the Contractor by measurement from the manhole immediately downstream, and notified to the Engineer, before backfilling is carried out.

10.18 SEWERS AND MANHOLES TO BE ABANDONED

- 10.18.1 Where sewers are to be abandoned and filled by grouting, the lowest point of the abandoned length shall be suitably sealed, and the filling operation shall commence from this point and continue progressively so as to fill the voids completely.
- 10.18.2 The shafts of manholes on abandoned sewers shall be broken down to a level 1 metre below finished ground level, and the remaining void filled as detailed in the Contract.

10.19 CLEANSING OF PIPELINES

- 10.19.1 On completion of construction, and before any sterilisation, internal surfaces of pipelines shall be cleaned thoroughly in such a way as to remove all oil, grit and other deleterious matter.

10.20 SWABBING OF WATER MAINS

- 10.20.1 On completion of the hydraulic test on water mains as described in Section 12.24, a foam swab shall be passed through the mains for final cleansing. This process shall be repeated until the wash water runs clear.

10.21 STERILISATION OF WATER MAINS

- 10.21.1 After pressure testing, the pipeline shall be flushed with potable water at velocity of 1m/s until the wash water is clear. The disinfection shall be carried out as described below with sufficient samples taken along the section of the pipeline or whole pipeline in order to ensure that the pipeline is fully disinfected as evidenced by the laboratory test results of the samples.
- 10.21.2 The pipeline on the whole or by section shall be cleaned with the potable water first and filled with the clear water containing 50mg/l (ppm) of free chlorine. It shall be kept full for 24 hours and the samples to be taken at various points shall be tested for free residual chlorine of not less than 25mg/l (ppm). The process shall be repeated if the free residual chlorine is found to be less than 25mg/l (ppm). After the satisfactory disinfection, the pipeline shall be flushed again with the potable water until the free residual chlorine is not greater than 0.75mg/l (ppm). Thereafter, the pipeline shall be kept full with the potable water for 24 hours. The samples taken shall be bacteriologically tested. If the test results are negative the cleaning and disinfection operations shall be repeated until the results are satisfactory. The point of application of chlorine and the point of withdrawal shall be as directed by the Engineer. The Contractor shall dispose of the water used in the disinfection operations in such a manner without causing damage to properties, utilities, grass, flower beds, fish or similar growing or living things.
- 10.21.3 The Contractor shall supply the approved chemicals containing free chlorine of 50mg/l (ppm) acceptable for the use in the potable water supply.
- 10.21.4 The measurement of free chlorine, tests of samples for the residual free chlorine and bacteriological analysis shall be carried out by approved laboratories, with the prior notice of two weeks through the Engineer. The Contractor shall make all the arrangements, supply of labour and equipment and carry out the disinfection operations to the satisfaction of the Engineer.
- 10.21.5 The item appearing in the Bills of Quantities for sterilisation shall be adequately priced to cover all costs. This shall include repeated operations of disinfection and the supply of chemicals and other related items for the successful disinfection of both the pipeline by sections and the whole pipeline once the entire installation is completed. Only after satisfying the laboratory tests shall the pipeline be declared operational.
- 10.22 STORM WATER DRAINAGE CHANNELS**
- 10.22.1 On completion of the earthworks and prior to commencement of road works and other construction work, the Contractor shall construct the storm water drainage system comprising surface channels, culverts and outfall works.
- 10.22.2 Earth drains and roadside channels shall be formed accurately to line and level and turfed as shown in the Drawings.
- 10.22.3 Precast concrete drainage channels shall be constructed to the dimensions shown in the Drawings using steel forms to ensure a high standard of accuracy and Type C surface finish to the inside and to joint faces.

- 10.22.4 Excavation for the units shall be carried out as accurately as possible with backfill of compacted clay material being placed to the back of the channel section.
- 10.22.5 As soon as possible after installation of the channel sections, the ground on either side of the channel shall be formed to the required profiles and turfed as shown in the Drawings.
- 10.22.6 In-situ concrete drainage channels shall be constructed as shown in the Drawings and in accordance with Section 9 with Type C surface finish to the inside faces.
- 10.22.7 Backfilling, ground profiling and turfing shall be carried out to the relevant clauses in Section 6.
- 10.23 IN-SITU CONCRETE CULVERTS
- 10.23.1 Construction of large diameter in-situ concrete culverts shall be generally in accordance with Section 9.
- 10.23.2 Particular care shall be exercised in the construction and stability of the formwork and the inner face of the culvert shall be Type 2 finish as specified in Section 9.
- 10.24 SERVICE DUCTS
- 10.24.1 The installation of service ducts shall comply with the relevant clauses of this Technical Specifications.
- 10.25 GAS PIPELINES
- 10.25.1 The installation of gas pipelines shall comply with the relevant clauses of this Technical Specifications together with any special requirements contained in the pipe manufacturer's instructions.

11 MANHOLES AND CHAMBERS**11.1 GENERAL**

11.1.1 The standard of workmanship for manholes and chambers shall be in accordance with Section 16.4 of this Technical Specifications.

11.2 IN-SITU CONCRETE

11.2.1 Cast in situ manholes, chambers, etc. shall be constructed generally in accordance with Section 9 of this Technical Specifications. Step irons or ladders shall be built in as work proceeds where detailed in the Contract.

11.3 PRECAST CONCRETE

11.3.1 Precast units shall be set vertical, with step irons, ladders and slabs aligned correctly. Joints shall be made, as detailed in the Contract, so that the required jointing material completely fills the joint cavity. Any surplus jointing material which is extruded inside the chamber shall be trimmed off and joints shall be pointed on completion.

11.3.2 Where manholes are to have a concrete surround, the concrete shall be Grade G20 and the heights of each concrete lift shall not exceed 2m. Each construction joint in the surround shall break joint with that of the chamber or shaft ring by at least 150mm.

11.4 BRICKWORK

11.4.1 Bricks shall be set in mortar with all bed and vertical joints filled solid. Exposed work shall be flush jointed as the work proceeds. Class B engineering bricks shall be used. Alternatively, the moisture content of the bricks shall be adjusted so that excessive suction is not exerted on the mortar.

11.4.2 Brick courses shall break joint correctly with the bricks underneath. The courses shall be laid parallel with joints of uniform thickness and shall be kept straight or regularly curved as required, and all perpend shall be truly plumb. No four courses including four joints shall rise more than 40mm above such four courses laid dry, and vertical joints shall have a uniform thickness of 10mm. Bricks forming reveals, internal and external angles shall be selected for squareness and built plumb. Bricks with single frogs shall be laid frog upwards.

11.4.3 Brickwork shall rise uniformly. Corners and other advanced work shall be racked back and not raised above the general level more than one metre. No bats or broken bricks shall be incorporated in the work unless essential for bond specified on the Drawings.

11.5 INVERTS AND BENCHING

11.5.1 Manhole inverts and benchings shall be formed of the materials and slope detailed in the Contract and, where there is no change of diameter, the invert shall drop 25mm between the inlet and outgoing sewer.

11.5.2 Where a heavy duty lining is required, the invert and benching shall be formed in Grade G20 concrete with surface finish Type 1 or Type A, as required, and the sulphate resistant heavy duty concrete shall be applied as soon as practicable thereafter.

11.5.3 Where the finished surface is to be in situ concrete, the concrete shall be Grade G25 and the surface finish Type 2 or Type B, as required.

11.5.4 Where practicable, the pipeline may be laid through the manhole and the crown broken out to the half diameter, provided flexible joints are situated on each side, no further than 600mm from the inner face of the manhole wall.

11.6 WATERTIGHTNESS OF MANHOLES AND CHAMBERS

11.6.1 Manholes and chambers shall be substantially watertight, with no identifiable flow of water penetrating the Works.

11.7 SETTING MANHOLE COVERS AND FRAMES

- 11.7.1 Manhole frames in roads or vehicular access ways shall be set to the required level on at least two and not more than four courses of Class B engineering brickwork. The frames shall be set to level, bedded and haunched over the base and sides of the frame in 1 : 3, cement-sand mortar. Manhole covers in verges or grassed areas shall be set a minimum of 150mm above the surrounding finish levels.

11.8 LIFTING KEYS

- 11.8.1 The Contractor shall have available on site two keys for each type of cover used.

11.9 STEP IRONS AND LADDERS

- 11.9.1 Step irons for manholes and chambers shall comply with the relevant requirements of B.S. 1247. Ladders shall comply with Section 13.4 of this Technical Specifications.

12 TESTING**12.1 PROVISION OF TESTING EQUIPMENT**

- 12.1.1 All equipment necessary for the testing of materials and workmanship shall be regarded as constructional plant as defined in the Contract. It shall be delivered to the Engineer in accordance with the schedule of requirements of such equipment described in the Contract, and if he so requires, within 4 weeks of the order in writing from the Engineer to the Contractor to commence the works. All equipment shall be kept in good repair throughout the period of the Works.

12.2 ASSISTANCE IN SAMPLING

- 12.2.1 The Contractor shall supply all samples of materials for testing. He shall render such assistance as may from time to time be required by the Engineer in taking and packing them in containers, provided by the Contractor, and dispatching them for test.
- 12.2.2 In addition to the terms of Clause 2.6, the Contractor shall also be liable for the costs of any testing by approved specialist laboratories.

12.3 EARTHWORKS COMPACTION TESTS

- 12.3.1 Compaction tests shall be supervised by the Engineer's staff with such labour and assistance as may be required, provided and paid for by the Contractor.
- 12.3.2 The maximum dry density and optimum moisture content shall be determined in accordance with B.S. 1377 : 1975, Test No. 12. Each soil type shall be tested when first used and thereafter at the same time as every set of field density tests or wherever the Engineer may direct.
- 12.3.3 Records shall be kept identifying the soil type and location in the Works and showing the maximum dry density and optimum moisture content for each series of tests.
- 12.3.4 The in-situ field density and moisture content shall be determined in accordance with B.S. 1377 : 1975, Test No. 15 (which shall be the sand replacement method) to determine the degree of compaction achieved. Three determinations shall be made for every 400m² or part thereof in each layer of earthworks or whenever directed by the Engineer. Each layer shall be tested and approved before the next layer is placed.
- 12.3.5 Records shall be kept identifying the soil type and its location in the works and showing the following information for each series of tests:-
- a) Dry density of soil tested.
 - b) Moisture content.
 - c) Relative compaction achieved (%).
- 12.3.6 Moisture content determination in connection with B.S. compaction tests shall be carried out by means of a drying-oven. In order to expedite results, moisture contents for field density tests may be determined by use of a "Speedy" moisture tester which, however, shall not be used until it has been calibrated by an independent agency against moisture content tests carried out in a drying-oven. The Contractor shall submit a calibration chart to the Engineer for approval before the "Speedy" moisture tester is used.
- 12.4 TESTING GRANULAR SUB-BASE
- 12.4.1 Granular sub-bases shall be tested for bearing capacity by in-situ CBR tests. The frequency of the test shall be as required by the Engineer but shall be at a rate of not less than 3 times for every 1600m² of sub-base. The Engineer may waive the requirements for CBR tests if, in his opinion, adequate compaction has been obtained.
- 12.5 TESTING SOIL-CEMENT SUB-BASE
- 12.5.1 Soil-cement sub-base shall be tested as follows: -
- a) Samples of the mixed cement-stabilised material shall be taken from the site immediately prior to the compaction of the material. Five samples shall be taken at random times and spacings over each 800m² of completed layer or such other area as the Engineer decides. From each sample a cylindrical

or cubical test specimen as appropriate to the type of material shall be prepared, cured and tested using the procedure given in B.S. 1924. The specimens shall be compacted to a state of compaction within 30g/litre of the average density being achieved in the compacted stabilised layer. After preparation, the specimens shall be cured at constant moisture content within the range of curing temperatures given in B.S. 1924 for a period of 7 days. The specimens shall then be weighed, the dimensions checked and tested in unconfined compression. A representative portion of the crushed material from each specimen shall be retained for a moisture content determination in accordance with B.S. 1924 and the dry density of each test specimen shall then be determined using the weight, dimensions and moisture content of the material.

- b) The results of the five test specimens shall be averaged to give a representative figure for the area from which the samples were originally taken.
- c) To obtain a comparable average value for the state of compaction of the stabilised layer, five determinations of dry density shall be made at random over each 800m² of stabilised layer or such other area as the Engineer decides and the results averaged. The method to be used for determining the dry density shall be the sand replacement method according to B.S. 1377. The measurements shall be made at least 4 hours after the completion of the compaction work and preferably within a period of 24 hours.

12.6 TESTING LEAN CONCRETE ROAD BASE

12.6.1 Lean concrete road base shall be tested for strength and density.

12.6.2 The strength of lean concrete road base shall be determined by compression tests on test cubes. The cubes shall be of 150mm size and made in pairs at intervals, each pair being from a separate batch of concrete. One cube of each pair shall be tested at 7 days and the other at 28 days. At the start of the work and until such time as the Engineer may order a reduction in the number of cubes required, 3 pairs of cubes shall be made for each 800m² of base or part thereof laid each day. When the first 30 results of 7-days tests are available and provided that these meet the requirements in Section 8 and for so long as the Engineer is satisfied with the quality of the mix, he may reduce the number of cubes required to 3 pairs for each 1600m² or part thereof of base laid each day.

12.6.3 The making, curing and testing of all cubes shall be in accordance with the methods described in B.S. 1881, except that the cubes shall be compacted by means of an electric or pneumatic hammer. The hammer shall have a square or rectangular foot having an area between 0.01 and 0.015m² and sufficient pressure shall be used directly on each of the three layers of material filled into the mould to result in the material being compacted to refusal.

12.7 TESTING BITUMINOUS MATERIALS

12.7.1 Tests of bituminous mixtures and their component materials to measure all or any of the characteristics required by the Contract shall be carried out as required by the Engineer. The sampling and analysis of the mixtures shall be in accordance with B.S. 598.

12.7.2 Test shall be carried out on samples taken either before or after laying the mixture.

12.7.3 The density of flexible surfacing shall be determined from samples taken on the day following the laying of the mixture. A 100 or 150mm diameter core shall be cut from the paving or, if permitted by the Engineer, a 300mm square sample shall be cut and carefully trimmed to a 100mm square to give an undisturbed sample. The density as determined from the sample shall be not less than 95% of the laboratory Marshall density.

12.7.4 Sampling and testing shall be carried out as frequently as the Engineer may deem necessary to satisfy himself that the mixtures and materials comply with the requirements of the Contract.

12.8 TESTING STRENGTH AND SURFACE TEXTURE FOR CONCRETE CARRIAGEWAY

12.8.1 Concrete cubes of 150mm size shall be prepared, cured and tested all in accordance with B.S. 1881. When required, the specimens shall be sent to a testing laboratory approved by the Engineer. All specimens made in compliance with this Clause shall be made in the presence of the Engineer and their reference numbers shall be submitted to the Engineer in a weekly report.

12.8.2 Tests shall be carried out using approved compression testing machines. The machines shall not be used for test loads below one-fifth of the machines' appropriate scale (see B.S. 1610, Table 1 - Note 2 for the limits of accuracy).

12.8.3 The following apparatus shall be used for measurement of texture depth (sand patch test):-

- a) A metal cylinder 86mm internal depth and 19mm internal diameter.
- b) A flat wooden disc diameter 64mm with a hard rubber disc 1.5mm thick attached to one face, the reverse face being provided with a handle.
- c) Dry natural sand with a rounded particle shape and which will pass a 300µm B.S. sieve and be retained on a 150µm B.S. sieve.

12.8.4 Dry the surface to be measured and swept clean with a soft brush. Fill the cylinder with sand, tapping the base three times on the surface to ensure compaction, and strike off the sand level with the top of the cylinder. Pour the sand into a heap on the surface to be tested. Spread the sand over the surface, working the disc with its face kept flat, in a circular motion so that the sand is spread into a circular patch with the surface depressions filled with sand to the level of the peaks. Measure the diameter of the patch to the nearest 6mm. The texture depth is $31000/D^2$ mm where D is the diameter of the patch in mm.

12.9 SAMPLES OF MATERIALS FOR CONCRETE

12.9.1 The Contractor shall deliver samples of materials to be used in concrete to the Engineer's laboratory in sufficient time to allow for all tests to be carried out before the materials are required for use in the Works.

12.10 TESTING STRUCTURAL CONCRETE

12.10.1 The Engineer will nominate the structural concrete elements requiring test certificate direct from the laboratory and will decide which tests are to be carried out and their frequency.

12.10.2 The Contractor is to supply sufficient equipment to maintain adequate quality control over the supply of materials and production of concrete, including:-

- a) Maximum and minimum thermometer.
- b) 150mm x 150mm x 150mm test cube moulds, together with baseplate and rammer.
- c) One slump testing apparatus complete with baseplate and rammer.
- d) One thermostatically controlled curing tank.

12.10.3 Where details of materials are required, the Contractor is to submit them in sufficient time to receive a written reply before delivery of them to site.

12.11 TESTING CEMENT

12.11.1 The Contractor is to submit details of the cement manufacturer, and arrange for him to submit his test certificates to the Engineer at monthly intervals throughout the concreting period, if required.

12.11.2 The Contractor may be required to provide the soda equivalent content of the cement as determined by B.S. 196.

12.12 PRELIMINARY TESTING OF AGGREGATES

12.12.1 Details of the sources of aggregates and proposed suppliers are to be submitted together with copies of their latest quality control test results, prior to testing of samples and approval by the Engineer.

12.12.2 Submit small samples (each approximately 2kg in weight) of the aggregates and also forward to the laboratory a minimum of 300kg of the coarse aggregate and 200kg of the fine aggregate for testing and manufacture of preliminary concrete test cubes. Clearly label the samples with the name of the project, the Contractor, the name and address of the supplier and a description of the contents.

12.12.3 Arrange laboratory tests as follows to B.S. 812 on representative samples of all aggregates:-

- a) Grading tests on fine and coarse.
- b) Determination of loose and compacted bulk density.
- c) Clay, silt and fine dust content test and organic impurities test on fine aggregates.
- d) Determination of shell proportion and the chloride salt content of the aggregates where these are sea-dredged.

12.12.4 If instructed, submit wearing resistance details from the following:-

- a) B.S. 812 : No. 33, aggregate impact value.
- b) B.S. 812 : No. 35, 10% fine value.

12.12.5 If instructed, reactive silica content tests shall be according to B.S. 812 : Part 104.

12.13 WATER

12.13.1 Testing will not normally be required where the water to be used is from the mains supply. Otherwise, tests shall be according to B.S. 3148.

12.14 REINFORCEMENT

12.14.1 The contractor is to submit the following:-

- a) Manufacturer's name and address of rolling mill
- b) Full details of the reinforcement from this source.
- c) A written declaration stating that routine inspection and testing is being carried out in accordance with the British Standards, and that on the basis of these tests, the reinforcement supplied to site will comply with the B.S. requirements.

12.14.2 Use a covermeter or another acceptable method to check the position of reinforcement in all cantilevers at their roots, or any other positions required by the Engineer.

12.14.3 Carry out these checks in the presence of the Engineer, and before any soffit formwork or supports are in anyway disturbed

12.14.4 The covermeter used for the checks shall be calibrated for accuracy.

12.15 CONCRETE

12.15.1 Sample and test concrete according to B.S. 1881. Whenever concrete is sampled, the workability shall be ascertained by testing the slump and recording the result. For ready mixed concrete, test each delivery for initial acceptance and record the result.

12.15.2 The slump test will be accepted when it is within the limits given in B.S. 5328 for the workability chosen $\pm 25\text{mm}$ or plus(+) one-third of the nearer limit value, whichever is the greater, except that the $\pm 25\text{mm}$ tolerance shall be increased to $\pm 40\text{mm}$ for the initial acceptable test on a sample taken from the first part only of a load of concrete delivered to site ready mixed.

12.15.3 For testing of in-situ compressive strength, make a minimum of 6 test cubes of $150\text{mm} \times 150\text{mm} \times 150\text{mm}$ to represent not more than 10m^3 for columns and not more than 50m^3 for other structural elements from each grade (quality) of concrete placed during the day. All 6 cubes shall be made from the same batch of concrete and 3 of the 6 cubes shall be tested at 7 days and the remaining 3 at 28 days. Mark all cubes clearly and indelibly for identification and keep them damp, well-protected and in good condition. Deliver them to the laboratory with the following information for inclusion on the test certificate in addition to the information required by B.S. 1881:-

- a) Date of casting.
- b) Date of receipt of cube by laboratory.
- c) Mix and/or concrete grade (quality).
- d) Slump for the representative batch.
- e) Section of work represented by the cubes.

- 12.15.4 The compressive strength for concrete will be accepted when the resistance to crushing of each cube is not less than the specified works strength at either 7 or 28 days as appropriate.

12.16 UNSATISFACTORY TEST RESULTS

- 12.16.1 Any structural work represented by test results which do not comply with this Technical Specifications shall be regarded as unacceptable. However, immediate demolition may be deferred where the Engineer is requested to consider the results of further tests selected by him from the following:-
- a) Loading tests to a specification prepared by the Engineer, the procedures and standards of acceptance of which may be in excess of those laid down in B.S. 8110 or elsewhere.
 - b) Compressive strength tests on 150mm diameter cores cut from the work at positions determined by the Engineer.
 - c) Chemical analysis of samples cut from the work at positions determined by the Engineer.
- 12.16.2 The Contractor shall nominate and obtain acceptance of an accredited laboratory to carry out the tests.
- 12.16.3 The Engineer's interpretation of the results of tests carried out under this clause will be binding.
- 12.16.4 If a 7-days compressive strength test result is substandard, the further tests outlined in this clause may be delayed pending receipt of the relevant 28-days tests results. Should these 28-days results prove to be satisfactory, the 7-days test result will be discounted.
- 12.16.5 All costs and delays arising from the above will be the responsibility and liability of the Contractor, irrespective of the test results.

12.17 CORE TESTING

- 12.17.1 If the Engineer orders cores to be cut, they shall be drilled and tested in accordance with B.S. 1881.

12.18 REBOUND HAMMER TESTING

- 12.18.1 Where required by the Contract, the Contractor shall provide a rebound hammer (Schmidt hammer) for the purpose of non-destructive testing of in-situ or precast concrete. The hammer shall be used in accordance with the recommendations contained in B.S. 8110.

12.19 TESTING OF PIPE BEDDING MATERIAL

- 12.19.1 For testing pipe bedding material, a representative sample for about 40kg shall be heaped onto a clean surface and quartered to obtain approximately 10kg. The moisture content of the sample should not differ materially from that of the main body of material, at the time of use in the trench.
- 12.19.2 A 150mm internal diameter open-ended cylinder, 250mm high, shall be placed on a firm flat surface and loosely filled, without tamping, from the 10kg sample. Any surplus material shall be struck off level with the top of the cylinder. The area around the filled cylinder shall be cleared of all surplus material and the cylinder then lifted clear of its contents and placed alongside the material.
- 12.19.3 Approximately one-quarter of the material shall then be replaced into the cylinder and compacted by tamping vigorously with a 40mm diameter metal rammer weighing about one kg until no further compaction can be obtained. This operation shall then be repeated for each of the remaining quarters, tamping the final surface as level as possible.
- 12.19.4 The distance from the top of the cylinder to the surface of the final layer shall then be measured and this value, divided by the height of the cylinder, shall be taken as the Compaction Fraction.

12.20 PRECAUTIONS PRIOR TO TESTING PIPELINES

- 12.20.1 Before testing any pipeline, the Contractor shall ensure that it is anchored adequately and that thrusts from bends, branch outlets or from the pipeline ends are transmitted to solid ground or to a suitable temporary anchorage.

12.20.2 Open ends shall be stopped with plugs, caps or blank flanges properly jointed.

12.20.3 The Contractor shall notify the Engineer at least one working day beforehand of his intention to test a section of pipeline.

12.21 TESTING GRAVITY PIPELINES

12.21.1 Gravity pipelines laid in open cut shall be tested after they are jointed and before any concreting or backfilling is commenced, other than such as may be necessary for structural stability whilst under test.

12.21.2 The pipelines shall be tested by means of an air or water test or by a visual examination, in lengths determined by the course of construction, in accordance with a programme approved by the Engineer.

12.21.3 A further test shall be carried out after the backfilling is complete.

12.22 WATER TEST FOR GRAVITY PIPELINES

12.22.1 The test pressure for gravity pipelines shall be not less than 1.2m head of water above the pipe soffit at the highest point and not greater than 6m head at the lowest point of the section. Steeply-graded pipelines shall be tested in stages in cases where the maximum head, as stated above, would be exceeded if the whole section were tested in one length.

12.22.2 The pipeline shall be filled with water and a minimum period of two hours shall be allowed for absorption, after which water shall be added from a measuring vessel at intervals of 10 minutes and the quantity required to maintain the original water level noted. Unless otherwise specified, the length of pipeline shall be accepted if the quantity of water added over a 30 minute period is less than 0.5 litre per lineal metre per metre of nominal bore.

12.22.3 Notwithstanding the satisfactory completion of the above test, if there is any discernible leakage of water from any pipe or joint, the pipe shall be replaced and/or the joint re-made, as appropriate, and the test repeated until leakage is stopped.

12.23 AIR TEST FOR GRAVITY PIPELINES

12.23.1 Gravity pipelines to be air tested shall have air pumped in by suitable means until a pressure of 100mm head of water is indicated in a U-tube connected to the system. The pipeline shall be accepted if the air pressure remains above 75mm head of water after a period of 5 minutes without further pumping following a period for requisite stabilisation. Failure to pass the test shall not preclude acceptance of the pipeline if a successful water test, ordered by the Engineer, can subsequently be carried out in accordance with Clause 12.22

12.24 TESTING PRESSURE PIPELINES

12.24.1 Gauges used for testing pressure pipelines shall either be of the conventional circular type not less than 200mm diameter and calibrated in metres head of water, or shall have a digital indicator capable of reading increments of 0.1m head. Before any gauge is used, the Contractor shall arrange for it to be checked independently, and a dated certificate of its accuracy shall be provided.

12.24.2 Before testing, valves shall be checked and sealed, the sections of main filled with water and the air released. After having been filled, pipelines shall be left under operating pressure for the period specified in the Contract, so as to achieve conditions as stable as possible for testing.

12.24.3 The pressure in the pipeline shall then be raised steadily until the specified test pressure is reached in the lowest part of the section, and the pressure shall be maintained at this level, by pumping if necessary, for a period of one hour. The pump shall then be disconnected, and no further water shall be permitted to enter the pipeline for a further period of one hour. At the end of this period, the original pressure shall be restored by pumping, and the loss measured by drawing off water from the pipeline until the pressure as at the end of the test is again reached.

12.24.4 The permissible loss shall not exceed 2 litres per metre nominal bore per kilometre length per metre head (calculated as the average head applied to the section) per 24 hours. In addition to the tests on separate sections, the whole pipeline shall be tested on completion to the same pressure and by the same procedures as that outlined for individual sections.

- 12.24.5 The Contractor shall allow for venting and blanking off water supply service connections during pressure testing.
- 12.24.6 Test pressures for pressure pipelines shall be 1.5 times the maximum operating pressure at the lowest point of the main or the maximum operating pressure plus the maximum calculated surge pressure whichever is the greater.

12.25 TESTING WELDED JOINTS ON STEEL PIPELINES

- 12.25.1 For short sleeve welded joints on steel pipelines, a porosity test on individual joints shall be applied by raising the air pressure in the joint annulus to 40m head of water. This preliminary test shall be carried out before the trench is backfilled, and the joint shall be acceptable if there is no loss in the applied pressure over a period of one minute. A tapped hole for the test connection shall be provided at the socket end of each pipe and a sealing run of welding added at the face of the socket. Alternatively, an approved detachable clamp may be used. On completion of the pipeline, the hydraulic test described in Clause 12.24 shall be applied.

12.26 TESTING CONCRETE WATER-RETAINING STRUCTURES

- 12.26.1 After cleansing water-retaining structures, and as far as practicable before any earth or other filling is placed against the outside wall faces, the structure shall be filled with water at a rate approved by the Engineer. After allowing a period of 3 days or such other period as the Engineer may decide for absorption, the water level shall be recorded by a hook gauge with vernier attachment or by other approved means, and the water shall be allowed to stand for a period of 7 days, during which the total permissible drop, after allowing for evaporation and rainfall, shall not exceed 1/1,000 of the average water depth of the full tank.
- 12.26.2 Notwithstanding the satisfactory completion of the above test, any leakage visible on the outside faces of the structure shall be stopped. Any caulking or making good of cracks in the wall section shall where practicable, be carried out from the inside face.

13 METALWORK**13.1 GENERAL**

- 13.1.1 The Contractor shall design, supply and install all open mesh and chequer plate flooring and structural members necessary for the support of flooring, walkways, staircases, handrailing, ladders, etc. shown in the Drawings unless stated otherwise.
- 13.1.2 Flooring and walkway supports shall be independent of bearing supports to prevent the setting up of oscillations and noisy vibrations
- 13.1.3 All flooring, walkways, stairs and ladders shall be designed to support uniformly distributed loads of 5kN/m² except in machine areas when the load shall be 7.5kN/m² or as specified, or for a concentrated load of 5kN over any square of side 300mm whichever is the greater. These loadings shall be considered as a minimum requirement. If any item of plant demands larger loading, the loadings shall be increased accordingly.
- 13.1.4 The major dimensions of the structure shown in the Drawings are to be adhered to, but minor changes may be made to details with the approval of the Engineer. The Contractor shall be responsible for checking all leading dimensions.

13.2 FLOORING

- 13.2.1 Flooring shall be manufactured of approved structural aluminium type H30 for open mesh and type H30-TF for chequer plate as described in B.S. 1470 unless otherwise specified.
- 13.2.2 Open metal flooring shall be constructed in accordance with B.S. 4592.
- 13.2.3 The pattern, design thickness and finish shall be approved by the Engineer. The pattern of open type flooring shall match between adjacent panels. The upper surface of chequer plate flooring panels shall have an approved non-slip surface.
- 13.2.4 Panels shall be securely fixed to the supporting steelwork, but so arranged and sized that they can easily be removed by two men without the removal of adjacent panels or equipment. Panels shall not be heavier than 50kg.
- 13.2.5 The edges of all flooring, platforms etc. shall be finished with approved kerbs. The kerbing shall be provided by the flooring supplier and shall be fitted with fish tail lugs for building into the concrete work. The Contractor shall co-ordinate with the suppliers for the building in of the kerbs.

13.3 DUCT COVERS

- 13.3.1 Duct covers shall be aluminium or galvanised steel, cast iron (plain or perforated) or mild steel tray type recessed to receive floor finishings. Duct covers shall be provided with lifting key holes.

13.4 LADDERS

- 13.4.1 All ladders shall be to the approval of the Engineer. Fixed ladders shall be completed with safety hoops where detailed, fixed in such a manner that full rigidity is obtained when they are fixed, with the lowest hoop set 2.4m above the benching or platform levels. The dimensions of the ladders shall be as detailed. Fixed ladders shall have sufficient fixing brackets to render them fully rigid when fixed, and spacing between brackets shall not exceed 2m. Ladders shall be fixed using M12 cadmium plated bolts and suitable washers etc. or similar approved.
- 13.4.2 Ladders shall be of integral welded construction and shall comply with the requirements of B.S. 4211 for the spacing of stringers, rungs, safety hoops and hand holds unless detailed otherwise.
- 13.4.3 Where ladders extend above platform level, their height shall match the top line of the adjacent handrailing.
- 13.4.4 Aluminium alloy ladders shall be obtained from an approved manufacturer and shall be constructed of aluminium alloy. Rungs shall be of substantial section serrated tube to enable sure hand and foot holds.
- 13.4.5 Mild steel ladders shall be hot-dip galvanised after manufacture.

13.5 LADDERS SHIP TYPE

- 13.5.1 Step or ship type ladders shall be obtained from an approved manufacturer and be constructed of mild steel and be hot-dip galvanised after manufacture.
- 13.5.2 The angle of rake shall be set at between 65° and 75°.
- 13.5.3 The length of tread between stringers shall be 550mm, single line handrails shall be fixed on both sides of the step supported by standards bolted to the stringers.
- 13.5.4 Solid pattern treads of galvanised mild steel and approved non-slip surface shall be bolted to the stringers. The width of tread shall be 250mm and the tread rise shall be between 200mm and 230mm.
- 13.5.5 The angle of rake and the tread rise shall not vary in one set of steps. All nuts, bolts and washers shall be 12mm cadmium plated steel. Where directed, the entire steps shall be coated with abrasive resistant pitch epoxide.
- 13.5.6 Safety chains shall be fixed at the top of each set of ship ladders.

13.6 HANDRAILING AND STANDARDS

- 13.6.1 Handrailing shall be of an approved design and conform to the details shown on the drawings. Welded construction will not be accepted. The designed load shall be 360N/m.
- 13.6.2 Where aluminium alloy handrailing is detailed, it shall comprise double line handrails made from 43mm outside diameter 9 SWG tube. All joints are to be made conforming to standards and shall have a core piece to provide rigidity.
- 13.6.3 Handrails shall be curved to smooth radii at bends and corners and all joints, except for removable sections. The external finish shall be completely smooth, free of all blemishes and rough areas.
- 13.6.4 Where hot-dip galvanised mild steel tubular handrailing is detailed, it shall be 32mm nominal bore tube with 3.25mm walls.
- 13.6.5 Rails shall be at heights of 0.5m and 1.1m and generally shall be spaced less than 1500mm, base fixing shall accommodate 2 or 3 bolts as directed by the Engineer which shall be stainless steel with nuts and washers. Where removable lengths of handrails are detailed, half lap joints shall be used.

13.7 PVC GASKETS

- 13.7.1 To avoid electrolytic action where aluminium surfaces are in contact with concrete surfaces or with dissimilar metals, PVC gaskets are to be used to isolate the aluminium.

13.8 FINISHES

- 13.8.1 Aluminium members which are detailed as 'anodised' are to be anodised after fabrication to a minimum thickness of 25µm.
- 13.8.2 If structural supports for walkways or floors are supplied in mild steel, they shall be hot-dip galvanised after manufacture.
- 13.8.3 Where required, coatings of plastic shall be applied by the handrailing manufacturer or other approved firm before delivery to site. The design of the joints shall permit assembly on site without damage to the coating.

13.9 SAFETY CHAINS

- 13.9.1 Safety chains shall be 10mm diameter x 3 links per 100mm aluminium alloy or stainless steel complete with spring safety hooks and eyes fitted to the adjacent posts or walls.

13.10 FORGINGS AND CASTINGS

- 13.10.1 Forgings and castings shall be of clean metal free from non-metallic inclusions, stoppings, repairs, porosity, cracks, flaws, chilled spots or blowholes. They shall be clean and sharp with all changes of form or size

made gradually with comers well rounded and adequately filled inside and out. Machined surfaces shall be free from blemishes and all other surfaces shall be carefully fettled to remove foundry irregularities.

- 13.10.2 Finished castings shall be carefully prepared, rubbed down and painted in accordance with this Technical Specifications prior to dispatch.

13.11 FASTENINGS

- 13.11.1 Bolts, nuts and washers for demountable items which are normally submerged shall be of stainless steel.

13.12 GALVANISING

- 13.12.1 All steel and iron work of whatever kind described to be galvanised shall be thoroughly descaled in a solution of sulphuric acid and cleaned by pickling in a bath of warm (60°) phosphoric acid, sandblasting, or other approved method and immediately after is to be galvanised by a hot-dip process. The molten zinc in the galvanising bath shall contain not less than 98.5% of zinc by weight. All articles are to be immersed in the bath only for a time sufficient for them to attain the temperature of the bath and they are to be withdrawn at such a speed that a coating of 90µm thickness is achieved, or such other practicable maximum thickness for the article defined in B.S. 729 : Part 1. The galvanising is to be rubbed down in all cases after drilling, chipping, trimming, filling, fitting or bending is completed. Every article is to be covered evenly on all sides.

- 13.12.2 Galvanising on steelwork where required is to be carried out after fabrication and assembly. All light gauge metalwork is to be galvanised by the hot-dip process as specified in B.S. 3083 or B.S. 2989.

- 13.22.3 Contact between galvanised steel members and aluminium surfaces is to be prevented by means of a layer of an approved insulating material.

13.13 WELDING

- 13.13.1 In all cases where welds are liable to be highly stressed, the Contractor shall supply to the Engineer before fabrication commences, detailed drawings of all relevant welds and weld preparations proposed. No welding shall be carried out before the Engineer has signified in writing his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior written approval of the Engineer and the Contractor may be called on to make trial welds to demonstrate the soundness of the weld procedure and the competence of his workers.

- 13.13.2 Radiographic examination of highly stressed fusion welds may be ordered by the Engineer. Other mechanical and non-radiographic tests, if required, shall be carried out in the presence of the Engineer.

- 13.13.3 All parts to be welded shall be accurately prepared so that on assembly, they will fit closely together. After assembly, and before general welding is commenced, the parts are to be tack-welded with small fillet welds. The tack welding shall be strong enough to hold the parts together but small enough to be covered by the general welding.

- 13.13.4 All welded components shall be stress relieved prior to machining.

14 STRUCTURAL STEELWORKS**14.1 GENERAL**

14.1.1 The Contractor shall submit with his Tender the name of the firm he proposes to employ for the fabrication and erection of the structural steelworks.

14.1.2 All steel shall conform to the requirements of B.S. 4360.

14.2 STEEL GRADES AND SECTIONS

14.2.1 Members shall be fabricated from the grade of steel designated in the Contract.

14.2.2 Mild steel sections and plates not exceeding 20mm in thickness shall be manufactured from Grade 43A steel. Mild steel plates exceeding 20mm thickness shall be manufactured from Grade 43C steel.

14.2.3 Hollow sections shall be manufactured from Grade 43C steel.

14.2.4 Hot-rolled members shall be manufactured to the following standards:-

- a) Hot-rolled sections except equal and unequal angles shall comply with B.S. 4 : Part 1.
- b) Hot-rolled equal and unequal angles shall comply with B.S. 4848 : Part 4.
- c) Hot-rolled hollow sections shall comply with B.S. 4848 : Part 2.
- d) Steel plates shall comply with B.S. 4360.

14.3 ACCESSORIES

14.3.1 Connectors shall comply with the following standards:-

- a) Unified precision hexagonal bolts and nuts - normal series to B.S. 1768.
- b) Unified black hexagonal bolts and nuts - heavy series to B.S. 1769.
- c) Metal washers for general engineering purposes (unified) to B.S. 3410.
- d) ISO metric precision hexagonal bolts and nuts to B.S. 3692.
- e) ISO metric black hexagonal bolts and nuts to B.S. 4190.
- f) ISO metric metal washers for general engineering purposes to B.S. 4320.
- g) High strength friction grip bolts and associated nuts and washers to B.S. 4395 : Parts 1 and 2.

14.3.2 Load indicating washers for use with high strength friction grip bolts shall be "Coronet" or approved equal.

14.3.3 Rag and indented bolts and nuts shall comply with B.S. 1494 : Part 2.

14.3.4 Metal-arc welding electrodes shall comply with B.S. 639.

14.4 FABRICATION AND WORKMANSHIP

14.4.1 Except where specifically noted on the Drawings, the breakdown of components shall be at the discretion of the Contractor subject to the approval of the Engineer.

14.4.2 The Contractor shall be responsible for ascertaining size limitations for transport and storage and shall include in his Tender for all additional labour, materials and accessories necessitated thereby.

14.4.3 Prior to the preparation of full fabrication details, the Contractor shall submit to the Engineer for approval the following information:-

- a) Details of any materials, accessories, etc. which are not to the specified British Standards or are proposed to be obtained from a manufacturer other than specified.
- b) Basic details of any method of fabrication proposed as an alternative to that indicated in the Contract.
- c) Location and type of proposed site splices.
- d) Any other information for which approval is required in accordance with this Technical Specifications and which affects the preparation of fabrication details.

- 14.4.4 The Contractor shall obtain his own information, check dimensions and prepare his own working drawings for fabrication.
- 14.4.5 Duplicate copies of the working fabrication drawings shall be submitted to the Engineer for comment in advance of the commencement of fabrication accompanied by a marking plan indicating the location of all members. The written acceptance by the Engineer of all details shall be obtained prior to fabrication.
- 14.4.6 The Contractor shall allow the Engineer 10 working days to process the examination and comment upon the fabrication drawings. Submissions shall take place at reasonable intervals and a submission shall not exceed the number of drawings required for one section of the work.
- 14.4.7 The sequence of submission of sets of fabrication drawings shall be in accordance with the Contractor's programme requirements for delivery to site.
- 14.4.8 Examination by the Engineer of drawings or any other information submitted by the Contractor shall not relieve the Contractor of full responsibility for any discrepancies, errors, or omissions therein.
- 14.4.9 The Contractor shall at his own cost supply such reasonable number of additional copies of the fabrication drawings as are required by the Engineer and other interested parties.
- 14.4.10 All workmanship shall be in accordance with the best practice and shall comply with the requirements of B.S. 5950 : Part 2 and shall be to the satisfaction of the Engineer.

14.5 WELDING

- 14.5.1 Metal-arc welding shall be used and all welding shall comply with the requirements of B.S. 5135.
- 14.5.2 Fabrication drawings shall indicate full details of and preparations for full strength butt welds.
- 14.5.3 The Contractor shall provide the Engineer with such evidence as he may require relating to the strength, ductility and other properties of the weld metal and electrodes or any other information relating to welding procedures to be used.
- 14.5.4 The Contractor shall provide the Engineer with such evidence as he may require regarding the suitability of welders engaged on shop fabrication for the type of welding they are required to undertake.
- 14.5.5 Welders engaged on site welding shall be subject to the set out in B.S. 5950 : Part 2, Appendix A8 "Tests for the Approval of Welders". The test numbers shall be agreed with the Engineer according to the type of weld and welding position of the work to be carried out by a particular welder. Details of the tests shall be in accordance with B.S. 4872.
- 14.5.6 Completed welds shall be subject to non-destructive testing in accordance with the requirements of this Technical Specifications.

14.6 BLACK BOLTING

- 14.6.1 Bolts shall be of suitable grip length for the thickness connected to ensure that the threaded portion projects at least one thread through the nut. The projection shall not exceed 10mm.
- 14.6.2 Flat or tapered washers, as appropriate, shall be provided under all nuts and tapered washers provided under bolt heads where necessary to provide a satisfactory bearing.

14.7 HIGH STRENGTH FRICTION GRIP BOLTING

- 14.7.1 High strength friction grip (HSFG) bolts where specified in the Contract or approved by the Engineer shall comply with the requirements of B.S. 4395 : Parts 1 and 2.
- 14.7.2 Joints formed with HSFG bolts shall be in accordance with the requirements of B.S. 4604 : Parts 1 and 2 except that part turn or torque control methods of tightening shall not be used.
- 14.7.3 Tightening shall be controlled by the use of load indicating washers which shall be installed and used strictly in accordance with the manufacturer's instructions.

- 14.7.4 Joint interfaces shall be clean, dry, free from oil, dirt, loose rust, scale deleterious salts, windburn contamination and any other defects which would prevent the effective mating of the parts.
- 14.7.5 Final tightening of bolt assemblies shall be carried out in a staggered pattern. Where there are more than four bolts in a joint, tightening shall be carried out from the centre of the joint outwards.
- 14.7.6 Bolts which have been finally tightened and subsequently slackened shall be removed from the joint and discarded.
- 14.8 COMPLETION OF FABRICATED PARTS
- 14.8.1 All completed work shall be to the dimensions required, true to thickness throughout and free from lamination, twist and distortion.
- 14.8.2 In welded fabrication, any distortion remaining in the component after completion of welding operations shall be rectified.
- 14.8.3 Members fabricated for delivery piece-small or in sections shall be trial assembled at the fabrication plant before delivery. The Engineer reserves the right to inspect the assemblies but any such inspections carried out shall not relieve the Contractor of his responsibilities for the accuracy and adequacy of the work.
- 14.8.4 Each piece of steel member shall be distinctly marked with an identification in accordance with the marking plans. Additional marking shall be used as necessary to indicate the position and direction in which the piece is to be fixed.
- 14.9 INSPECTION OF WORKS
- 14.9.1 The Engineer shall have access to works where any part of the steelworks is being fabricated or tested at all times while the works is in progress and shall be given facilities, including manual assistance where necessary, to make such inspections and checks as he deems necessary.
- 14.9.2 Any work which, in the opinion of the Engineer does not comply with this Technical Specifications or the Drawings, shall be rectified or replaced by the Contractor at his own cost.
- 14.10 DELIVERY AND STORAGE
- 14.10.1 The Contractor shall make his own arrangements for the delivery of the fabricated steel member to the site at such times and in sequences and quantities as are required by his programme for the works.
- 14.10.2 The Contractor shall allow for adequately packing or bundling site bolts, small fittings and such other items of the steelworks as is necessary to ensure safe delivery in an undamaged condition.
- 14.10.3 The Contractor shall provide the Engineer with such copies of consignment lists as he may require to facilitate identification and inspection of material delivered to site.
- 14.10.4 Storage of steel members on site and at plant before delivery shall be carried out in a neat and orderly fashion to facilitate identification and inspection by the Engineer.
- 14.10.5 Components shall be stacked clear of the ground and members shall be adequately supported to prevent distortion.
- 14.10.6 Stacked members shall be separated by timber packers to prevent abrasion and scoring of the protective finishes.
- 14.10.7 Acceptable protection shall be provided to prevent the accumulation of dirt and moisture, deleterious salts and windburn contamination on exposed surfaces.
- 14.10.8 Any component which, in the opinion of the Engineer has sustained damage during delivery or storage or is defective for any other reason, shall be rectified or replaced at the Contractor's own cost.

14.11 ERECTION OF STEELWORKS

- 14.11.1 The Contractor shall be responsible for the suitability of all plant and equipment necessary for the erection of the steelworks.
- 14.11.2 The steelworks shall be handled and erected in such a manner that it is not subjected to distortion and excessive stresses.
- 14.11.3 The Contractor shall not use any equipment or method of handling which, in the opinion of the Engineer, may cause damage to the steelwork or permanent works.
- 14.11.4 The Contractor will be deemed to have examined the arrangement drawings prior to tendering and have ascertained and allowed for all erection conditions including limitation of erection on permanent reinforced concrete structures.
- 14.11.5 No erection loads shall be imposed on permanent concrete works until it has attained the specified 28 days strength. All permanent work shall be adequately protected as necessary from damage during erection of the steelworks.
- 14.11.6 The Contractor shall accurately position level and plumb all steelworks and place every part of the structure in accordance with the Drawings and the approved fabrication drawings and marking plans.
- 14.11.7 During erection, the Contractor shall ensure that the work is securely fixed at all stages.
- 14.11.8 Where necessary for stability and security, temporary bracing shall be provided to cater for all temporary conditions including erection conditions and the use of erection equipment.
- 14.11.9 All stanchion bases, beam and girder seatings and bearings shall be securely supported on steel levelling packs prior to final grouting.
- 14.11.10 No permanent welding, bolting or grouting up shall be carried out until correct position and alignment have been achieved.
- 14.11.11 All work carried out on site shall, where applicable, be subject to the requirements of Clause 14.4.
- 14.11.12 No modification of steelworks on site for any reason, shall be carried out without the prior agreement of the Engineer to the Contractor's specific proposals.
- 14.11.13 Any member which sustains damage during handling or erection shall be rectified or replaced at the Contractor's own cost.
- 14.11.14 After final positioning and alignment of the steelwork has been completed to the satisfaction of the Engineer, grouting shall be carried out in accordance with this Technical Specifications.
- 14.11.15 The Contractor shall erect the work true to line and level as shown on the Drawings having due regard to the accuracy required to accommodate subsequent components and finishes.

14.12 PROTECTIVE PRIMING AND PAINTING

- 14.12.1 The painting system shall be applied to all steelworks at plant before delivery. The paint system shall be as described in the Contract. Alternative material of different manufacture for individual coats shall not be introduced into the system.
- 14.12.2 The Contractor shall afford the manufacturer facilities for inspecting the work at any stage as required by the Engineer.
- 14.12.3 Site treatment shall include making good damaged areas, site welds, bolt projections, etc., in accordance with the shop treatment and appropriate to depth of any damage.
- 14.12.4 Surfaces shall be thoroughly degreased, cleaned and dried immediately prior to the application of each coat, and adequate curing time shall be allowed in accordance with the manufacture's instructions between coats and before handling and delivery.

14.13 STEELWORK PREPARATION

- 14.13.1 Prior to fabrication, all steel sections shall be thoroughly cleaned free of scale, rust, dirt, etc. by means of blasting to Second Quality Finish in accordance with B.S. 7079.
- 14.13.2 The surface profile produced shall have a rounded shape with a maximum depth of 100µm.
- 14.13.3 Immediately after blasting, all surfaces shall be vacuum cleaned, blown or dry brushed free of all abrasive particles and dust. Any surface defects revealed by blasting shall, provided that they are not detrimental to the strength of the member, be chipped off and ground smooth.

14.14 SITE TREATMENT

- 14.14.1 Subject to the Engineer's agreement to the Contractor's specific proposals, site treatment may be carried out at ground level or after erection.
- 14.14.2 All damaged areas of coatings shall be thoroughly cleaned free from grease, dirt, loose or chipped coating by wire brushing, degreasing and dusting down.
- 14.14.3 Site weld areas shall be thoroughly cleaned free from slag, weld spatter, flux and any other surface contamination by chipping and power wire brushing, degreasing and dusting down.
- 14.14.4 The coating shall then be built up to the full original minimum dry film thickness of 250µm or as specified in the manufacturer's instructions. Treatment shall be in accordance with shop coatings as appropriate to the depth of the damage. Coats shall extend 25mm over the edge of sound priming to provide an unbroken film overall.

14.15 MAKING GOOD AFTER ERECTION

- 14.15.1 The Contractor shall take suitable precautions to prevent damage to coatings during erection.
- 14.15.2 Any damage sustained to treatments which have been made good and finished prior to erection shall be further made good in accordance with this Technical Specifications.

14.16 PROTECTIVE COATINGS TO BOLTS AND OTHER COMPONENTS

- 14.16.1 Protective coatings specified shall be applied by the bolt/accessory manufacturer.
- 14.16.2 Coatings shall comply with the appropriate standards:-
- a) Sherardising to B.S. 729 : Part 2.
 - b) Electro-cadmium plating to B.S. 1706.
 - c) Galvanising to B.S. 729 : Part 1.
- 14.16.3 The schedule of coatings shall be as follows:-
- a) HSFG bolts, general or higher grades to B.S. 4395 : Parts 1 and 2 - Sherardising
 - b) Nuts for use with HSFG bolts – Electro-cadmium plating
 - c) Load indicating washers for use with HSFG bolts - Sherardising
 - d) Flat and tapered washers for use with HSFG bolts - Sherardising
 - e) Black bolts, nuts, flat and tapered washers, nuts to be threaded after galvanising - Spun - galvanising
 - f) Coatings to other components and accessories noted in the documents shall comply with the relevant B.S. specifications.

14.17 MILL TEST CERTIFICATE FOR STRUCTURAL STEEL

- 14.17.1 The Contractor shall provide the Engineer with the steel manufacturer's signed mill test certificates stating the process of manufacture and giving the results of each of the mechanical tests applicable to the particular steel sections supplied as set out in B.S. 4360.
- 14.17.2 Each certificate shall indicate the identification of the cast to which it applies which shall correspond with the marking of the sections manufactured from that cast and supplied for fabrication.

14.18 MANUFACTURER'S CERTIFICATE FOR ACCESSORIES AND MATERIALS

- 14.18.1 The Contractor shall also provide manufacturer's signed certificates signifying compliance of components, accessories and materials other than steel sections with the relevant B.S. specifications/

14.19 NON-DESTRUCTIVE TESTING OF WELDS

- 14.19.1 The Contractor shall allow for the cost of radiographic or other appropriate and approved non-destructive testing of completed welds to the following extent:-

	Shop welding	Site welding
Full strength butt weld	50%	100%
Fillet weld	10%	100%
All weld (visual examination)	100%	100%

- 14.19.2 The testing shall be carried out by an independent testing agency approved by the Engineer.
- 14.19.3 The approved testing agency shall submit records of the test including precise identification of the weld location together with a report on the quality of the welding.
- 14.19.4 Any one of the following imperfections, as revealed by the non-destructive testing, shall be sufficient cause for rejection:-
- Any type of crack or crack-like defect.
 - Lack of root or side fusion or incomplete root penetration exceeding 12mm in length or a total of such imperfections exceeding 25mm in any 300mm length of weld.
 - Inclusions, gas pockets, or piping exceeding 6mm in length or 2mm width, for thicknesses not exceeding 25mm or a length of a quarter of the thickness with a minimum of 12mm for thicknesses above 25mm.
 - Any group of inclusions, gas pockets or piping in alignment the total length of which exceeds the thickness over a length of 12 times the thickness, except when the distance between successive defects exceeds 6 times the length of the longest defect in the group.
 - Porosity, the total area of which when projected radially through the weld exceeds 2mm² in any 25mm x 25mm of projected weld area.
 - No individual gas pore (excluding piping) shall have a diameter larger than that specified for the appropriate thickness of material as follows:-

Material thickness	Maximum diameter of pore
Up to 6mm	0.8mm
Over 6mm up to and including 12mm	1mm
Over 12mm up to and including 25mm	2mm
Over 25mm	3mm

- 14.19.5 Rejected welds shall be cut out, remade and tested. Further testing carried out on remade welds shall be at the Contractor's own cost.

15 PAINING FOR GENERAL APPLICATION**15.1 GENERAL**

- 15.1.1 All materials required for the Works shall be delivered to the site of the Works, ready-mixed in the manufacturer's containers with the seals, etc. unbroken and shall be clearly marked with the manufacturer's name or trademark, a description of the contents and colour and the manufacturer's batch number. All materials shall be stored on the site of the Works, and the Contractor's attention is drawn to the dangers associated with certain paints when used in confined areas.
- 15.1.2 The whole of the paints, distempers, varnishes, cement paints, etc. used in the Works shall be suitable for use in tropical climates. Unless specified in the Contract, the names of the paint system shall be submitted at least 14 days before use for approval by the Engineer.
- 15.1.3 All materials for multiple coat work, e.g. priming, undercoat and finishing coat shall be obtained from the same manufacturer and shall be of those recommended by the manufacturer as suitable for using together and for the surfaces concerned.
- 15.1.4 Manufacturer's samples of all paints, varnishes, distempers, etc. shall be submitted, free of cost, in sealed containers to the Engineer for his approval before bulk deliveries are made and before any paint work or distempering is started.
- 15.1.5 During the execution of the Work, further samples of all or any of the materials shall be taken by the Engineer as he desires and the Contractor shall provide the containers with necessary seals and all samples at his own cost. The samples shall be taken from the sealed or open containers or from the workers' batch at the site as may be directed by the Engineer. Any work executed with material found on test not to fulfill the requirements of this Technical Specifications shall be burnt off or otherwise removed and the work re-done as directed by the Engineer at the Contractor's own cost.
- 15.1.6 All painting shall be carried out in accordance with the schedule in Table 15.1. The type of paint to be used is indicated by a reference letter in the key to the schedule and one coat of paint shall be applied for each reference letter.

15.2 PREPARATORY WORK

- 15.2.1 Concrete surfaces shall be free from curing compounds, form oils and releasing agents. Plastered surfaces shall be free from dust, efflorescence etc., and given a coat of an alkali resistant sealer before emulsioneing.
- 15.2.2 All iron or steel surfaces shall be thoroughly scraped and rubbed down by the use of mechanical or power tools or blast cleaned and shall be entirely free from rust, mill scale, etc., before applying the priming coat. Before commencement of painting iron and steel structural components, suitable protection such as tarpaulins, canvassing, etc., shall be erected to shield such components from the heat of the sun. Any paintwork showing subsequent "blistering" will not be accepted.
- 15.2.3 All knots in woodwork shall be treated to prevent bleeding. Large or loose knots shall be cut out and replaced with sound wood or cut back and the surface made good with stopper. Smaller knots shall be treated with two thin coats knotting. The knotting used shall be of approved make, free from resin and shall consist of 0.4kg of "Shellac" mixed with one litre of industrial methylated spirit or naphtha and shall be applied to cover all knots in painted timber or to such surfaces as may be directed by the Engineer.
- 15.2.4 All cracks, holes and other imperfections in woodwork, concrete, plaster and metalwork shall be scraped out, primed and made good with hard stopping, faced up and rubbed down to an even surface. The hard stopping shall be of approved make and made up on the job according to approved practice. Hard stopping for external woodwork shall be white lead paste with or without addition of red lead complying with B.S. 217 : Type 2 and tinted to match the colour of the undercoat. Hard stopping for internal woodwork shall be cellulose based filler or putty tinted to match the colour of the undercoat.

15.3 WORKMANSHIP GENERALLY

- 15.3.1 All brushes, tools, pots, kettles, etc. used in carrying out the work shall be clean and free from foreign matter and shall be thoroughly cleaned out before being used with a different type or class of material.

- 15.3.2 All metal fittings, fastenings and ironmongery shall be removed before the preparatory processes are commenced, cleaned and re-fixed in position on completion.
- 15.3.3 An ample supply of clean dust sheets to protect the work during its progress shall be at hand and all floors shall be covered up when executing any paintwork.
- 15.3.4 Floors must be washed over and every possible precaution taken to keep down dust prior to painting, varnishing, polishing, etc.
- 15.3.5 Paints of different types shall not be mixed together.
- 15.3.6 Undercoatings shall be tinted in different shades so as to be readily distinguishable and, where directed, the Contractor shall provide panels of paintwork, etc. showing the respective tints of each coat selected for the work. The undercoat shall be 'flat' in all cases.
- 15.3.7 All internal paintwork shall have a gloss finish unless described otherwise in the Contract and all external paintwork shall be of special quality suited for external use.
- 15.3.8 All surfaces shall be clean, dry and free from oil or grease. Paint shall not be applied to any surface upon which there is moisture or to any external surfaces during wet weather.
- 15.3.9 All materials shall be thoroughly stirred and mixed when the containers, etc. are opened and when the contents are transferred to the painter's kettles. Where necessary, the paints shall be strained to remove all skin, etc. before application. Under no circumstances will the addition of any thinners, gas oil or driers, of any kind, be permitted. Each coat of oil paint shall be lightly nibbed down with fine glass paper before the next coat is applied.
- 15.3.10 Under no circumstances shall any successive coat of paint be applied until the Engineer's permission has been obtained.
- 15.3.11 All backs of timber frames, etc. shall be treated with one coat of approved non-staining wood preservative before fixing.
- 15.4 PAINING WOODWORK
- 15.4.1 In addition to the priming coat, exposed surfaces of external and internal work shall have two undercoats and one finishing coat.
- 15.5 PAINING FERROUS METALWORK
- 15.5.1 Except where already painted at manufacturer's plant and unless described otherwise, all iron and steelworks shall be primed before fixing with one coat of selected primer. All painting to produce the specified finish shall be in accordance with the painting schedule.
- 15.5.2 For non-ferrous metals and zinc coated surfaces, apply one coat of etch primer or mordant solution to facilitate the adhesion of subsequent coatings.
- 15.5.3 Coated pipes shall be cleaned prior to painting. Eaves gutters and rainwater heads shall be painted inside and out.
- 15.6 PAINING EXPOSED PIPES
- 15.6.1 Unless described otherwise, all exposed surfaces of internal cold water pipes, cisterns, wastes, overflows, flush pipes, water waste preventers, etc. shall be finished in a similar colour to the background to which they are fixed. Identification bands shall be painted on all pipes as directed by the Engineer.
- 15.6.2 Where directed, gate valves, penstocks, mild steel ladders and supporting steelwork shall have an epoxy pitch finish with approved materials.
- 15.7 VARNISH
- 15.7.1 Varnish shall comply generally with B.S. 256. The materials shall be clear and transparent and when applied, shall, on drying, give a glossy coating free from runs and specks.

- 15.7.2 Varnished work found "tacky" 2 or 3 days after application shall be washed off with turpentine and re-varnished at the Contractor's own cost.

15.8 PAINTING PLASTERWORK

- 15.8.1 For exterior plastered surfaces, apply one coat of alkali resistant sealer followed by two coats emulsion.

- 15.8.2 For internal plastered wall, apply either 3 coats of epoxy gloss finish, or one coat of alkali resistant sealer followed by two coats of emulsion.

15.9 CLEANING UP

- 15.9.1 On completion and before handing over the Works, the Contractor shall touch up and make good all damaged or defective surfaces, clean all glass on both sides, scrub all floors and leave to the entire satisfaction of the Engineer.

Table 15.1 - Painting Schedules For General Application

Item	Finish required	Surface finish prior to painting			
		Bare	Alkyd zinc phosphate	Chlor rubber	Galvanised or zinc sprayed
Item to be installed below liquid	Coal tar epoxy	ABB	ABB (See Note 1)	ABB	DCBB
Machinery, plant, external	Chlor rubber	EFG	FG	FG	DCFG
Machinery, plant, etc., external and in pump chamber	Gloss	EPG	FG	FG	DCFG
Machinery, plant in building	Gloss	AFG	FG	FG	DCFG
Machinery, metalworks, etc	Epoxy	AJK	AJK (See Note 1)	AJK (See Note 1)	DCAJK
Structural steelwork	Gloss	AJLL	MJLL	MJLL	DCAJLL
Structural steelwork	Micaceous iron-oxide	AJJ	MJJ	MJJ	DCAJJ
Concrete/plastered walls internal	Emulsion	NPP			
Concrete/plastered walls internal	Epoxy	KKK (See Note 2)			
Plastered wall external	Synthetic satin	WXX			
Concrete/plastered ceiling	Emulsion	NPP			
Concrete floor	Epoxy	KKK			
Woodwork internal and external	Gloss	RTU			
Woodwork external	Clear varnish	SSS			
Insulation board/hardboard	Emulsion	NPP			
Suspended ceiling/expanded polystyrene	Emulsion	PP			
Metal rainwater downpipe and exposed gutter	Gloss	HTU			
Pipework external	Gloss	HTUU	TUU	FG	DCFG
Pipework internal	Epoxy	AJK	MJK	MJK	DCMJK
Gate valve and penstock	Epoxy	AJVV	AJVV (See Note 1)	AJVV (See Note 1)	DCAJVV
Mild steel ladder	Epoxy	AJKK	MJKK	MJKK	DCMKK

Note 1 : Alkyd zinc phosphate primer or chlorinated rubber shall be removed by blast cleaning.

Note 2 : Thin the first coat 25% for penetration.

Key

A	Epoxy zinc phosphate primer	B	Coal tar epoxy
C	Mordant solution	D	Thinner
E	Chlorinated rubber primer	F	Chlorinated rubber MIO intermediate
G	Chlorinated rubber finish	H	Alkyd zinc phosphate primer
J	Epoxy MIO	K	Epoxy gloss finish
L	Re-coatable acrylic polyurethane	M	Surface tolerant epoxy
N	Alkali resistant sealer coat	P	Emulsion conforming to SS 150
Q	Emulsion conforming to SS 345	R	Aluminium wood primer
S	Clear urethane varnish	T	Alkyd undercoat
U	Alkyd gloss	V	Glass flake epoxy
W	Synthetic satin primer	X	Synthetic satin finish

16 BUILDING WORKS**16.1 GENERAL**

- 16.1.1 The extent of work required under this section comprises the supplying and fixing of all building work specified herein or shown in the Drawings.
- 16.1.2 The Contractor shall submit samples and/or trade literature of all materials to the Engineer. Written approval shall be obtained from the Engineer before placing an order.

16.2 BASIC MATERIALS FOR BRICKWORK

- 16.2.1 All bricks shall be of local manufactured and of a standard size, new, hard, even shape, well burnt, machine-made pressed bricks with true arrises, run-of-kiln and shall give a clear ring when struck with a trowel or another brick. The Contractor shall obtain samples of the bricks he proposes to use and submit to the Engineer for his written approval. Samples for testing of quality shall be at the rate of 50 bricks for every consignment of 30,000 delivered to site and the selection and testing of these samples shall be as defined in B.S. 3921. All bricks and blocks shall be carefully loaded, unloaded and stacked to avoid damage and shall not be unloaded by tipping. No damaged bricks shall be used.
- 16.2.2 Common bricks shall have the minimum crushing strength of 20MPa and nominal size 224mm x 112mm x 75mm. Water absorption by weight shall not be more than 3% greater than that of the approved sample.
- 16.2.3 Testing shall be carried out in accordance with B.S. 3921 and the standard of acceptance shall be as laid down in B.S. 5628 : Part 3.
- 16.2.4 If the bricks under test fail to comply with the requirements, a second sample shall be tested. Should both samples fail to comply with both tests, the bricks shall be deemed as failed and the whole consignment may be rejected.
- 16.2.5 Bricklaying from a consignment shall not commence until samples have been tested and found satisfactory.
- 16.2.6 Cement shall be ordinary Portland cement complying with B.S. 12. Sand shall comply with the requirements of B.S. 1200 and shall be clean, sharp, fresh water river sand, free from all impurities and shall be washed and/or screened if required by the Engineer at the Contractor's own cost.
- 16.2.7 Semi-hydraulic and non-hydraulic limes shall comply with B.S. 890 : Part 1, Class B. Cement and hydrated lime shall be stored as described in Section 9.22
- 16.2.8 Quicklime, which shall be of fresh manufacture, shall be slaked immediately after delivery on site. The method of slaking shall be approved by the Engineer.

16.3 MORTAR

- 16.3.1 Mortar shall be carefully mixed in an approved mechanical batch mixer and prepared in small quantities as required. The ingredients shall be thoroughly churned for at least three minutes. Care should be taken to produce the mixture of the right consistency. No mortar which has commenced setting may be used or mixed with any other mortar.
- 16.3.2 Cement mortar for engineering brickwork and work below damp proof course shall be composed of one part of cement to three parts of sand and shall have mortar in the proportion of 50kg Portland cement to 0.11m³ of sand.
- 16.3.3 Mortar for walls above damp proof course shall be to the manufacturer's recommendations and to the approval of the Engineer. For increased workability, an approved plasticiser may be added in accordance with manufacturer's instructions.

16.4 WORKMANSHIP AND CONSTRUCTION

- 16.4.1 The standard of workmanship is of prime importance, and shall be in strict accordance with the recommendations of B.S. 8000 with the exceptions undernoted:-

- a) The method and sequence of construction shall be in accordance with the requirements of the Engineer.
 - b) All workmanship shall be properly supervised by a capable supervisor, and to uniformly consistent standard. Any workmanship not in accordance with standards herein specified will be totally rejected by the Engineer.
 - c) The Contractor shall prepare, at his own cost, sample panels of brickwork including corners as directed until the quality, pointing and finish required is obtained and approved by the Engineer after which all finishings executed shall conform to the respective samples.
- 16.4.2 Horizontal dimensions shall be set out with a steel tape supported throughout its length. Dimensions shall be checked from time to time as the work progresses. The height of every four courses including mortar joints shall not exceed 335mm.
- 16.4.3 Bricks shall be laid on a full and perfect bed of mortar of an average thickness not exceeding 10mm and a maximum thickness not exceeding 13mm. Frogs shall be filled. All vertical joints shall be thoroughly filled and free from voids. All joints shall be struck flush as the work proceeds or as otherwise directed, joints in work to be rendered or plastered shall be raked out to a depth of 10mm to provide a key.
- 16.4.4 Unless pointing is mentioned, external unrendered walls are to be with weathered joints and internal unrendered walls are to be with flush joints, as the work proceeds. All brickwork is to be executed in the bond shown or required by the Engineer. The courses shall be horizontal and alignment and perpend shall be kept.
- 16.4.5 The cutting of bricks shall be reduced to a minimum by the use of closers and standard specials, and by the skilful setting out of the brickwork so as to avoid irregular or broken bond, particularly at openings, in piers, and in infilling between joints. No part less than a half brick shall be used.
- 16.4.6 When two brick walls meet or intersect, the intersection shall be fully bonded. No block bonding will be allowed.
- 16.4.7 Quoins shall be formed with heads and stretchers in alternate courses, bond being established, if necessary, by placing a queen-closer next to a quoin header.
- 16.4.8 All brick walls are to be reinforced with "Exmet" expanded metal reinforcement, Gauge 22 or equal approved, at every fourth course, the bottom-most reinforcement being 150mm above floor level. All 76mm thick brick-on-edge walling shall be similarly reinforced every third course. Where the 112mm thick wall bonds with thicker walls, the reinforcement shall be carried into the thicker wall.
- 16.4.9 Where brickwork abuts against concrete columns, bonding ties shall be provided at 600mm centres vertically.
- 16.4.10 The top of brick and partition walls shall be wedged and pinned up in cement mortar (1 : 3) to the underside of concrete floors, roofs, beams, etc.
- 16.4.11 As far as is practicable, sleeves and chases shall be provided during the erection of the brickwork and not cut afterwards.
- 16.4.12 Brickwork shall rise evenly in lifts of not more than 1.5m per day, nor shall any portion of the work be carried up more than 1.5m above the general level except in the gable. All putting holes shall be carefully, properly and completely filled up on completion of walling work before any plastering work is commenced.
- 16.5 CONCRETE BLOCKS
- 16.5.1 Concrete blocks shall be purpose-made precast concrete blocks cast using Portland Cement and fine aggregate. All materials shall comply with Section 3. Additionally, the fine aggregate shall be from an approved source and free from ferruginous material. Blocks shall be uniform in shape and free from cracks. The Contractor shall provide temporary shading and wet hessian or other measures as directed to ensure satisfactory curing of the blocks.
- 16.6 PROTECTION OF BRICKWORK
- 16.6.1 Walls in the course of erection shall be protected from heavy rain with tarpaulins or suitable coverings.

16.6.2 Newly erected brickwork shall be protected against inclement weather to prevent the mortar being washed out of the joints by rain. The tops of the walls shall be covered with sacks, tarpaulins, or other suitable material, and the inner board or any working platform must be turned up on edge against the wall to prevent splashing of the brick face.

16.6.3 Finished surfaces and quoins are to be protected where necessary to avoid damage during the building operations.

16.7 DAMP-PROOF COURSE

16.7.1 Damp-proof courses in all walls at ground level shall conform in all respects to B.S. 743 and shall consist of two layers of approved 2-ply self-finished bituminous felt, weighing 3.8kg/m^2 placed over the full thickness of the walls. The damp-proof course shall be stepped where shown in the Drawings or as directed by the Engineer.

16.7.2 Joints in damp-proof courses shall be lapped not less than 150mm. Cold bitumen rubber compound shall be spread brushed and punched into joint and interstices in 3 coats on to clean dust-free surfaces. All surfaces on which a damp-proof material is to be bedded shall be carefully flushed up with cement-sand mortar to form an even bed.

16.8 FIXING OF DOOR AND WINDOW FRAMES

16.8.1 Steel or aluminium windows shall be fixed in the positions indicated in the Drawings. Windows shall be fixed by screwing to approved patent fixings or with lugs cut and pinned or built into brickwork.

16.8.2 Windows fixed to brick or concrete reveals shall be packed with cement-sand mortar and neatly pointed in mastic externally and in cement-sand mortar internally where walls are not plastered. Openings for doors, etc., shall be properly marked out and left unbuilt until the timber frames have been fixed in position.

16.8.3 All timber frames shall be built in as the work proceeds and the backs of same coated with approved wood preservative before fixing. All timber frames shall be bedded in cement-sand mortar. All timber frames shall be carefully fixed and stayed in position and shall be anchored into walls with wrought iron holdfast size 32mm x 3mm x 230mm long, turned up one end, fixed to-frame with two screws and swallow-tailed and built into wall at approximately 600mm centres.

16.9 SURFACE HARDENERS

16.9.1 Concrete surface hardeners shall be as described in the Contract and laid strictly according to the manufacturer's recommendations.

16.10 PAVING AND SCREEDS

16.10.1 Prior to paving, all surfaces shall be thoroughly cleaned and free from dust. Concrete surfaces shall be roughened to form a key, joints in brickwork shall be raked out and free from loose mortar and concealed wiring or pipework chased in and fixed.

16.10.2 All paving or tiling not done in accordance with approved samples provided by the Contractor at his own cost, shall be hacked off and re-laid to the satisfaction of the Engineer at no extra cost to the Contract.

16.11 SCREEDS

16.11.1 The screeds shall be composed of one part of ordinary cement to three parts of sand. The materials shall be thoroughly and efficiently mixed and the amount of water added shall be the minimum necessary to give sufficient plasticity for laying and compacting.

16.11.2 The area of screeded bay laid in one operation shall not be greater than 14m^2 . The position of joints in the sub-floor and the screeded bed shall coincide. The surface of the concrete sub-floor shall be roughened to provide a good mechanical key.

16.11.3 The surface of the concrete sub-floor shall be thoroughly cleaned and well wetted with a cement slurry and the screeded bed shall be laid not less than 20mm thick, true to level or to the necessary falls before the cement slurry sets.

16.11.4 For skirting, a bed similar to a screeded bed and not less than 10mm thick shall be applied to the wall to form a base. The proportion of the mix for skirtings shall be similar to that for adjacent floorings and the mix laid 6mm thick.

16.11.5 Laid screeds shall be protected from wear or their damage until the laying of the floor finish begins. No floor finish shall be laid unless a reliable moisture test shows the screed is sufficiently dry to receive the covering. Defective screeding shall be made good at the Contractor's own cost.

16.12 CEMENT PAVING

16.12.1 Cement paving is, where possible, to be laid whilst the concrete is green, i.e. within 24 hours of laying the concrete. The Contractor is to ensure that the surface of the concrete is quite clean before he applies the cement paving.

16.12.2 Paving is to be laid in bays not exceeding 6m in either dimension or 18.5m². If the concrete floor has been laid in bays, the joints of the screed or paving must occur exactly above the joints of the floor. The intermediate bays are not to be laid less than 3 days after the first bays have been completed. The skirtings and risers shall be the heights and thickness shown in the Drawings, or as directed by the Engineer. Junction with paving at bottom shall be coved and paving at top shall have a rounded edge. All vertical angles shall be coved and vertical external angles shall be rounded.

16.12.3 Waterproofing agents to cement paving shall be from an approved manufacture and added to the mix strictly according with the manufacturer's instructions.

16.13 GRANOLITHIC PAVING

16.13.1 Granolithic paving shall compose two parts of Portland cement, one part clean washed sand and five parts granite chipping to pass 6mm mesh and be retained on 3mm minimum mesh washed free from dust.

16.13.2 The concrete floor shall be brushed with a stiff broom before it has hardened to remove laitance and give a roughened surface.

16.13.3 Alternatively, the surface shall be thoroughly hacked if so directed by the Engineer at the Contractor's own cost.

16.13.4 Paving shall be laid in alternate bays and to pattern as directed by the Engineer. The intermediate bays shall be laid not earlier than 3 days after the first bays have been completed.

16.13.5 The water content of the mix shall be only the absolute minimum required to give a workable mix.

16.13.6 The paving shall be thoroughly rammed and compacted within 45 minutes of laying and the surface trowelling shall be delayed until the paving has stiffened sufficiently to prevent laitance being brought to the surface by the trowel.

16.13.7 The paving shall be kept damp and free of heavy traffic for a minimum period of 7 days and shall be covered with a 25mm layer of wet sand during this period.

16.14 MOSAIC TILES

16.14.1 Mosaic tiles shall be approved vitreous clay tiles 19mm x 19mm x 5mm thick with mineral and colouring pigment fused into the clay at high temperature.

16.14.2 Tiles shall be of approved colours and pattern, mounted on suitably sized paper backings and laid on a prepared cement screed, and when dry, the paper is to be washed off. Liquid cement grout composed of one part of coloured cement to three parts of sand shall be run into the joints of the tiles.

16.14.3 When the grout is set, all surplus grout shall be cleaned off and the whole surface covered with a thin protective layer of sand or sawdust as directed.

16.14.4 Floor surfaces shall be laid to falls except staircase landings and corridors.

16.14.5 Mosaic tiles skirting shall be formed back to the floor surfaces for the width of one tile, bedded and jointed in cement-sand mortar and including any necessary dubbing out.

- 16.14.6 All nosings to steps in mosaic shall be 150mm x 75mm x 19mm vitreous non-slip nosing tiles of approved colour bedded and pointed as described for mosaic tiles.

16.15 CERAMIC FLOOR TILES

- 16.15.1 Ceramic floor tiles shall be as described in the Drawings. Tiles shall generally be of size 240 x 115 x 11mm.

- 16.15.2 Matching cove tiles of minimum height 100mm and internal and external corner coving tiles, shall be included.

16.16 QUARRY TILES

- 16.16.1 Quarry tiles and fittings shall be 150mm x 150mm x 10mm non-slip and semi-glazed red quarry tiles and to comply with the requirements of B.S. 6431. The quarry tiles shall be obtained from a source to be approved by the Engineer and they shall be of approved colours, patterns and texture.

16.17 LAYING OF CERAMIC AND QUARRY TILES

- 16.17.1 The concrete floor to which screeds are to be applied shall be free of major irregularities and completely dried out.

- 16.17.2 The semi dry mix screed shall be laid in one thickness, to a minimum of 25mm and a maximum of 65mm. One part cement to four parts sand, by volume, shall be mixed with water to a crumbly consistency.

- 16.17.3 Cement based adhesive shall be spread on the screed.

- 16.17.4 Tiles shall be firmly tapped into the slurry mix and brought to a true and level surface and 3mm joints shall be left between tiles for grouting up. Where tiling is applied direct to concrete surfaces, the laitance must be completely removed from the concrete and tiles fixed using a proprietary cement based adhesive.

- 16.17.5 At door openings where surface finishes change from one material to another, 25mm deep x 3mm thick brass dividing strips shall be built into the tile finish.

- 16.17.6 The depth of movement joints shall extend from the tile surface to the bottom of the bedding screed.

- 16.17.7 A movement joint shall be taken around the perimeter of the floor between coving tile and first row of floor tiles and around all plinths, large pipes and floor obstructions. In addition, intermediate movement joints shall be arranged at 3.5m to 4m intervals, measured in two directions at right angles and laid out to form a suitable pattern within each floor area.

- 16.17.8 All perimeter movement joints shall be 12mm wide and all intermediate movement joints 6mm wide.

- 16.17.9 Movement joints shall either be 'filled' with preformed resin bonded cork strips, as work proceeds, or by partly filling with polyethylene foam filler strip topped up to surface level by 10mm depth of silicon mastic. The work shall be finished neatly and flush with the floor surface.

- 16.17.10 All traffic must be kept off tiled areas until final set has taken place.

16.18 CARPENTRY, JOINERY AND IRONMONGERY

- 16.18.1 The timber for carpenter's and joiner's work shall be, unless specified otherwise, approved local hardwood. All timber shall be sound and well seasoned, clean, free from wanes, open shakes, large, loose or deal knots and cut square and straight. All timber shall be thoroughly seasoned and equal to the sample approved by the Engineer.

- 16.18.2 All timber for carpenter's and joiner's work shall be treated before fixing with creosote or other approved wood preservative unless required to be painted. Treatment shall be either by brush in two coats, or by immersion to the approval of the Engineer. Surfaces subsequently cut are to be re-treated. This applies to all carpentry timber, including studding, noggings, grounds, beavers, etc. Exposed carpentry shall be treated with approved clear wood preservative instead of creosote.

- 16.18.3 Where plywood is used, it shall be in accordance with B.S. 6566 and shall be of "weather and boil proof quality" and unless stated otherwise, the plywood shall be painted grade on both faces.

16.8.4 Each sheet of plywood shall bear the following markings:-

- a) Manufacturer's name and identification.
- b) B.S. 6566.
- c) Weather and boil proof.
- d) Grade of finish.
- e) Thickness.

Where specified, plywood shall be teak faces on synthetic resin adhesive, and weather and boil proof standard.

16.8.5 Plastic laminated sheeting shall be heat resistant, to an approved manufacture and to be of patterns selected by the Engineer. The laminate shall be fixed with an approved adhesive used in accordance with the manufacturer's instructions.

16.8.6 Nails, spikes, bolts, etc. shall be of the best quality wrought iron and be of appropriate lengths and not less than 1.5 times the thickness of the first timber passed through. No steel nails, screws or other fixings shall be used for joinery works. All such fixings shall be of rustproof material unless specifically stated otherwise. All nails, spikes shall be punched and pelleted.

16.8.7 Unless stated otherwise, all carpenter's and joiner's work shall be fixed with nails. Where described as "screwed", items shall be screwed to hardwood and where described as "plugged", items shall be plugged to either brick or concrete. Items described as "bolted on" shall include for fixing only the bolts and borings through hardwood.

16.8.8 Nails shall be in accordance with B.S. 1210. Unless stated otherwise, all screws shall be brass and comply with B.S. 1210. Wire staples shall comply with B.S. 1494.

16.8.9 The contact surfaces of dowels, tenons, wedges etc., shall be glued with an adhesive complying with the requirements of B.S. 745 or B.S. 1204. Where glued and joinery and carpentry work is likely to come into contact with moisture, the glue shall be waterproof.

16.19 PREPARATION OF TIMBER FOR JOINERY

16.19.1 Samples of all repetitive units shall be supplied for the Engineer's approval before general production commences. All timber shall be stored under cover, properly stickered and stacked to enable air to circulate freely around all faces.

16.19.2 All "wrought" timber shall be sawn, planed, drilled or otherwise machined or worked to the correct sizes and shapes shown in the Drawings. Timber sizes given in the Drawings are in all cases "nominal" dimensions. An allowance of 2.5mm shall be permitted for each "wrought" surface, sawn timber shall be full to the dimensions stated, except that occasional slight variations in sawing are permissible. On piecing, lengthening or unnecessary jointing will not be permitted.

16.19.3 The joiner's work shall be cut and skeleton framed and stacked on site as soon as possible after the Contractor is given possession of the site and receives detailed drawings. It shall be carefully stored and protected from the weather but shall not be wedged up until required for fixing in the building. Any portions that warp or develop shakes or other defects shall be replaced with new before being wedged up. The joinery, unless specified otherwise, shall be the Contractor's own make and must be inspected and approved by the Engineer before being primed.

16.19.4 All machine-made work shall be finished off by hand where required and wrought in the best manner for painting, and shall finish off by the irons where varnishing is required.

16.19.5 All glued joints shall be cross-tongued and all arrises where not moulded shall be slightly rounded. Joiner's work shall be executed in the best possible manner properly screwed, tenoned, moulded, wedged, pinned and glued with all exposed faces wrought and sand-papered as required and the heads of all screws shall be countersunk and pelleted over in grain.

16.20 JOINERY

- 16.20.1 It shall be the responsibility of the Contractor to ensure that "built-in" joinery works are set plumb and true, and shall not be damaged or displaced by subsequent operations. Where necessary, the joinery works shall be temporarily encased and braced.
- 16.20.2 The Contractor shall also install and secure the fixing dovetails so that these may be "built-in" to the frame while it is being constructed. It shall be the responsibility of the Contractor to ensure that the necessary fixings are incorporated in the frame for "fixed-in" joinery.
- 16.20.3 The Contractor shall also construct such ground works as are necessary to provide a suitable base and fixing for the joinery work. Spaces enclosed in the ground works and within the joinery works, shall be filled-in solid with cement plaster. The Contractor shall secure "fixed-in" joinery so that they are plumb and true to the shapes and dimensions shown in detailed drawings.
- 16.20.4 The Contractor shall perform all necessary morticing, tenoning, grooving, matching, tonguing, housing, Rebating, and all other works necessary for correct jointing. The Contractor shall install all metal plates, screws, nails and other fixings that are necessary for the proper execution of the joinery works. The Contractor shall also carry out all works necessary for the proper construction of all framings, linings, etc. and further supports and fixing in the building.
- 16.20.5 The Contractor shall ensure that all framing shall be jointed, so that joints will transmit the loads or resist stresses to which they will be subjected. The execution of all jointing shall be to the satisfaction of the Engineer.
- 16.20.6 No nails, screws, or bolts are to be placed in any end split. If splitting is likely, holes for nails shall be pre-bored. Clenched nails shall be bent at right angles to the grain. Lead-holes shall be bored for all screws.
- 16.20.7 Nuts shall be brought up tight but care shall be taken not to crush timber under the washers. In glued joints, surfaces in contact shall have a good sawn or planed finish. All cutting edges of tools shall be sharp to avoid "burnishing". The surface of plywood to be glued shall be lightly dressed with sand or glass paper. The sand or glass paper must not be allowed to clot or cause "burnishing". All surfaces to be glued shall be kept clean, free from dirt, dust, sawdust, oil or any other contamination. Adequate pressure shall be applied to glued joints to ensure intimate contact and shall be maintained whilst the glue is setting. Adhesive for joints shall be of approved patented waterproof adhesive.
- 16.20.8 Grounds shall be clean sawn, free from large knots, splayed as required, plugged and fixed to walls at 600mm centres.

16.21 DOORS

- 16.21.1 Door frames shall be of approved local hardwood as shown in detailed drawings and checked for plaster where necessary.
- 16.21.2 The Contractor shall note the typical door frame details and relate the type required for each door openings as shown in the Drawings.
- 16.21.3 Door frames shall be built in as the brickwork proceeds. The method of fixing frames shall consist of building in at the bed joints of each jamb creosoted wood slips or pellets and in the case of reinforced concrete structure plugging 25mm square and 75mm deep hardwood plugs at approximately 600mm centres. The door fixings shall be driven in or bedded in with the projecting edges cut off to a vertical plane (a plumb line being used for this purpose), so that the clear distance between the fixings in the opposite jambs equals the overall width of the frame plus the thickness of the rough ground. The rough ground shall then be placed into position and securely nailed to the jambs and lintols. The fixing of the frames shall be deferred until building is nearing completion. The alternative method of building-in of the frames as the adjacent brickwork is being erected may be used, but the arrises of the frames shall be protected by lightly nailing wood strips to them.
- 16.21.4 All beads surrounding frames of doors where abutting the structure in external walls shall be well bedded in an approved non-extruding mastic sealer to prevent the entry of external air to the building when any movement takes place in timber.

- 16.21.5 All solid doors shall be constructed in approved wrought hardwood in accordance with architectural details. The finished surface shall be prepared for varnishing or painting as described.
- 16.21.6 Skeleton core flush doors, where required shall, unless described otherwise, be beaded with 6mm thick plywood. Plywood for doors shall be of equal or superior quality to that laid down in B.S. 6566 : Grade 1. Bonding of plywood for internal doors shall be moderately weather resistant and for external doors weatherproof as defined in B.S. 6566.
- 16.21.7 Unless described otherwise, the head and both styles shall be lipped with a solid hardwood lipping piece with not more than 13mm exposed and bottom similarly lipped with 18mm exposed lippings and shall be double-tongued and grooved into core or frame, mitre at angles and shall meet the plywood by means of a mitred joint.

16.22 PROTECTION OF CARPENTRY AND JOINERY WORKS

- 16.22.1 The Contractor shall clean out all shavings, cut ends and other waste from all parts of the building before coverings or infillings are constructed. The Contractor shall be responsible for providing and maintaining any boxing or other temporary coverings required for the protection of dressed or finished work that might be damaged during the progress of the work if left unprotected.

16.23 IRONMONGERY

- 16.23.1 The Contractor shall supply samples of all ironmongery to be used on the Works. The ironmongery throughout shall be of approved manufacture, well made and equal in every respect to the samples to be deposited with the Engineer. Fittings shall comply with the appropriate British Standards as follows:-

B.S. No.	Fittings
5872	Locks and latches
1210	Wood screws
7352	Hinges

- 16.23.2 Articles shall be fixed with screws of suitable type and size. All locks to the buildings shall be operated with a master key system (two master keys shall be supplied) and shall be provided with two keys, no key to pass a second lock.

16.24 PLASTERING AND WALL TILING

- 16.24.1 All joints in brickwork, etc. shall be raked clean for not less than 10mm deep before any plaster or rendering is applied. All concrete surfaces shall be hacked or otherwise suitably roughened to provide a key.
- 16.24.2 All surfaces to be plastered must be brushed clean and well wetted before each coat is applied. All cement plaster shall be kept continually damp in the interval between application of coats and for 7 days after application of the final coat.
- 16.24.3 All cement used in the Works shall be as described under Section 9. All sand used in the Works shall be as described under Section 9 but shall be fine sand, of light colour and shall be approved by the Engineer.
- 16.24.4 Metal lathing shall be mild steel ribbed expanded type metal lathing weighing not less than 1.63kg/m² conforming to B.S. 1369. All sheets shall be lapped not less than 25mm at the sides and ends. Overlaps shall not occur at angles or curves and end laps shall occur only at supports. Sides of sheets shall be wired together with galvanised wire of not less than 1.2mm diameter every 75mm between supports. Cut ends or wire used for fastening, etc. shall be bent inwards and not towards the plaster finishing coat.
- 16.24.5 The fixing centres should normally be not greater than 350mm apart for mesh weighing 1.63kg/m² of 10mm or 6mm mesh. Proprietary types of metal lathing shall be fixed strictly in accordance with the manufacturer's instructions.
- 16.24.6 All mortars for plastering shall be mechanically or hand mixed as directed by the Engineer and the Contractor shall make allowance for the use of additional cement necessitated by the method of mixing instructed. Only whole bags of cement shall be used in any one batch of mix.
- 16.24.7 The cement screeds shall be composed of one part of cement to three parts of sand by volume. The Contractor shall prepare a sample one square metre of each type of plastering as directed until the quality,

texture and finish required is obtained and approved by the Engineer after which all plastering executed shall equal the approved samples.

- 16.24.8 All arrises, internal angles, external angles, etc. shall be clean and slightly rounded with neatly formed mitres.
- 16.24.9 The cement -sand plain face shall be mixed on clean boards in a sheltered place or in a batch mixer and shall consist of one part of cement to six parts sand mixed with an approved mortar plasticiser used strictly in accordance with the manufacturer's instructions. It shall be applied in two coats to a total thickness of 12mm or 20mm. The first coat shall be 9mm or 14mm thick rough plastering and shall be cross-scored to receive the second coat which shall be 3mm or 6mm thick trowelled to a smooth surface with a steel trowel where used internally or finished with a wood float where used externally.
- 16.24.10 All internal brick walls and external brick walls shall have 20mm thick cement and sand plain face except where fair face brickwork occurs. All exposed concrete surfaces shall have 12mm thick cement and sand plain face except where otherwise described.
- 16.24.11 Concrete surface flush with plastered brick walls shall have 20mm thick cement and sand plain face. Concrete surface flush with fair face brick walls shall be left with a smooth fair face finish.
- 16.24.12 All cracks, blisters and other defects shall be cut out to a rectangular shape, the edges undercut to form dovetailed key and the surface repaired and finished flush with face of surrounding plaster. The whole of the work shall be left in a perfect condition on completion.

16.25 WALL TILING

- 16.25.1 Wall tiling shall be as shown in the Drawings.
- 16.25.2 In normal areas, plaster work should not exceed normal thickness and should be carried out at least four weeks after the walls have been completed. The plaster work should be completed at least two weeks before tiling is applied. Tiles should be fixed to the plaster, which must be smooth and flat using an approved adhesive which complies with B.S. 5385.
- 16.25.3 In shower areas and similar areas subject to frequent soaking, tiles should be fixed using a suitable adhesive. Tiling to showers should be to a height at least two tiles above the shower head or to ceiling level if the shower head is at ceiling level.
- 16.25.4 Movement joints will be supplied in the tiling to coincide with structural joints passing completely through the wall. In addition, joints will be required at 3 to 4.5 metre intervals vertically and horizontally in large areas or where directed.

16.26 ALUMINIUM AND MILD STEEL DOORS AND WINDOWS

- 16.26.1 Aluminium and mild steel doors and windows, including all ancillary fittings shall be as shown in the Drawings. Steel windows and doors shall be rust proof galvanised by hot-dip process in accordance with B.S. 729.

16.27 VEHICULAR DOORS AND ROLLER SHUTTERS IN MAINTENANCE WORKSHOP

- 16.27.1 The doors for the vehicle and mechanical workshops shall be as shown in the Drawings or similar approved. Doors shall be provided with suitable external and internal opening mechanisms, key operated locks, complete with galvanised finish at the factory. Roller shutters are to be in self-finished aluminium.
- 16.27.2 The Contractor shall submit details of the proposed doors, shutters and ancillary equipment for approval and obtain this approval in writing before placing a firm order.

16.28 EAVES GUTTERS

- 16.28.1 Eaves gutters shall be of 26 Grade galvanised iron complete with all necessary angles, stopped ends, nozzle pieces, etc. and supported on mild steel hangers at 1200mm centres.
- 16.28.2 Galvanised iron gutters shall be jointed with red lead cement or approved mastic and secured with galvanised gutter bolts.

16.29 RAINWATER PIPES AND FITTINGS

- 16.29.1 Rainwater pipes and fittings shall be of 26 Grade galvanised iron or of UPVC, and shall be complete with all necessary swannecks, bends, shoes and heads, etc. All UPVC pipe joints shall be glued with an approved sealant.

16.30 SANITARY FITTINGS

- 16.30.1 Sinks, lavatory basins, urinals, w.c. pans and the like shall be of vitreous china.
- 16.30.2 W.c. pans shall be bedded in red lead and screwed down with brass screws. Where on concrete floors, the pans shall be screwed to hardwood plugs let into concrete. Traps shall be connected to drains with an approved mastic (not cement mortar).
- 16.30.3 Where stoppers are supplied to anti-siphonage arms or to sinks or basins (where two taps are not fitted), they shall be bedded in red lead.
- 16.30.4 Supply and fix the sanitary fittings all as described and in the positions shown in the Drawings.

16.31 LABORATORY BENCHES

- 16.31.1 Laboratory benches and sinks shall be proprietary fittings with ceramic worktops and stainless steel.

16.32 ROOFING TILES

- 16.32.1 Roofing tiles shall be as shown on the drawings or similar approved. Tiles to be installed in accordance with the manufacturer's recommendations and as shown in their technical brochure. Also trims, ridges and flashing to be supplied and fitted as detailed.

16.33 ROOF INSULATION

- 16.33.1 Insulation materials shall be as shown in the Drawings.

16.34 GLAZING MATERIALS

- 16.34.1 All glass shall be of approved manufacture complying with B.S. 952, to be of the qualities specified and free from bubbles, smoke wanes, air holes and other defects.
- 16.34.2 Glass shall be delivered to site in cut sizes in packages bearing the manufacturer's name and/or trademark. The type, quality, thickness or weight of the glass shall be clearly marked on the package.
- 16.34.3 All glass shall be stored under conditions recommended by the manufacturer.
- 16.34.4 Sheet glass shall be "Ordinary Glazing Quality" (0.0.). Tinted glass shall be Anti-sun or Grey Sheet Glass. Polished plate glass shall be "glazing glass" (G.G.) quality. Obscured glass shall be narrow-reeded or of quality approved by the Engineer.

16.35 GLAZING

- 16.35.1 In cutting glass, proper allowance shall be made for expansion. Each square of glazing shall be in one whole sheet. All glass edges shall be clean cut to exact sizes allowing expansion tolerances as recommended by the glass manufacturer.
- 16.35.2 Glass having chipped or damaged edges of any sort shall be rejected. All sashes shall be glazed in a closed position and not opened until compounds are set. All materials shall be used strictly according with the manufacturer's instructions. Rebates to receive glass shall be primed and painted one coat of oil paint prior to glazing.
- 16.35.3 Glazing shall be carried out in accordance with B.S. 6262. All rebates shall be clean, dry and free from oil or grease. Painted steel and zinc sprayed surfaces require no further preparation. Hot-dip galvanised frames which have been weathered or etched provide suitable glazing surface so long as all traces of mordant have been removed.

16.35.4 The minimum thickness of glass shall be 6mm. Mirrors shall be 6mm thick polished plate glass, "Silvering" quality and natural tinted. The silver deposit shall be protected against moisture by an electro-copper backing followed by a coating of "Shellac" varnish and paint.

16.35.5 Louvre blades shall be of 6mm thick obscure translucent and/or tinted sheet glass or wired glass, the types and tints shall be selected by the Engineer.

16.36 FIXING GLASS

16.36.1 All single sheet glass shall be back puttied, bedded and fore puttied prior to bead fixing with putty. Putty for glazing in wood sashes shall be an approved tropical putty and for glazing to metal, an approved patent mastic shall be used. All putty shall conform to B.S. 544. The glass shall be well-bedded and carefully back puttied.

16.36.2 Glass in metal windows shall be secured with spring clips and patent mastic. The glass shall be neatly cut to fit the rebates with 1.5mm clearance all round.

16.36.3 On completion, all glass inside and out, shall be cleaned. Any cracked, scratched or broken panes to be replaced and left in good condition to the satisfaction of the Engineer.

16.37 VINYL FLOOR TILES

16.37.1 Vinyl sheet tiles shall be as shown in the Drawings to B.S. 3260 and laid with approved adhesive in accordance with the manufacturer's printed instructions. After laying any adhesive on the surface shall be removed by cleaning.

16.38 ACOUSTICAL SUSPENDED CEILING COMPONENTS

16.38.1 Acoustical suspended ceiling components shall be at least 600mm and 1200mm x 15mm thick, and shall be set out symmetrically so that equal cuts occur at opposite sides of the area.

16.38.2 The grit suspension system shall consist of hot-dipped galvanised mild steel with aluminium capping in modules of 600mm x 1200mm. Each module shall have the following minimum dimensions:-

Main tee	35mm (H) x 25mm (W)
Cross tee	25mm (H) x 25mm (W)
Wall angle	25mm (H) x 20mm (W)

Two metal spines 600mm long shall be glued to the bank of each sealing board as stiffeners.

16.38.3 Strap hangers shall be fixed to concrete soffits at not more than 200mm centres, by means of concrete inserts, cast in or post drilled. "Shot fired" anchor systems will not be permitted. The rigidity of the suspended ceiling shall be such that it cannot ripple or vibrate when subjected to wind or draughts penetrating the room.

16.38.4 Angle trims which will be visible shall be applied at the perimeter and all openings where the tile edges are not otherwise trimmed e.g. by light fittings. Tiles shall be fixed so that they are true and level. Broken or damaged tiles shall be removed and replaced.

16.38.5 At intervals, tiles shall be arranged for easy removal and replacement for possible modifications to services in the ceiling void.

16.39 METALLIC CEILING PANELS

16.39.1 Metallic ceiling panels shall be as shown in the Drawings.

16.40 STEEL SHEET ROOFING

16.40.1 Galvanised steel sheet roofing shall be as shown on the drawings. This is to be installed in accordance with the manufacturer's recommendations and as shown in their technical brochure. Also trims, ridges and flashings to be sufficient as detailed.

- 16.40.2 Sheets shall be ordered and fixed in as long lengths as possible. The Contractor shall make all laps at sides and ends, make turn ups and turn downs as required and provide and fix all standard and non-standard ridge, hip, eaves and other flashings. End laps shall be sealed with an approved non-hardening mastic sealant.
- 16.40.3 Where sheets are shown to have a self-finished coloured face, the finish shall be the manufacturer's system.
- 16.40.4 Cutting of sheets shall be avoided where possible but where necessary cutting shall at 45°. Sheets shall be brushed clean after cutting to remove fine steel particles and edge burrs shall be removed.
- 16.40.5 Where pipes, etc., penetrate sheeting, the hole shall be weathered with a 24.5kg/m² flashing dressed around and soldered to the pipe and with a collar strapped on. The flashing shall be dressed to the profile of the sheeting and soldered on.
- 16.40.6 Where sheets or flashings are described as fixed, the Contractor shall allow for all fixings in accordance with best trade practices and manufacturer's recommendations. All holes shall be made by drilling.

16.41 GALVANISED STEEL FLASHINGS

- 16.41.1 Galvanised steel flashings shall be in 24 SWG galvanised mild steel and shall be worked to the required shapes.
- 16.41.2 Cover flashings at junctions of roofs with walls (and similar) shall have the top edge turned into a groove, wedged with galvanised steel wedges and pointed in approved mastic compound and shall be dressed down the face of the wall and over the roofing.

16.42 TAPS AND SANITARY FITTINGS

- 16.42.1 Bib taps for sinks shall be chromium plated screw-down pattern with capstan heads as B.S. 1010. They are to have coloured plastic inserts, red for hot services and black or white for cold services. Draw-off taps indicated as being fitted with a hose union shall be brass high pressure screw-down pattern threaded for union with crutch handles as B.S. 1010.
- 16.42.2 Ball valves shall be high pressure "Portsmouth" pattern as B.S. 1212. Plastic floats conforming to B.S. 2456 may be used instead of copper floats if they have equal lifting capacity.