

3.1 GENERAL

Requirements

The requirements of all items contained in this section are to be taken into account when pricing these Tender Documents.

Materials

All materials used in the works shall comply with the requirements of the latest British Standard issued by the British Standards Institution or the Malaysian Standards issued by the Standards and Industrial Research Institute of Malaysia (SIRIM), and the Contractor shall produce all necessary certificates to substantiate this fact if so requested by the Architect/S.O. Materials shall be of the best quality. Where no standards are specified, the materials shall be in accordance with the relevant British Standards.

Workmanship

Workmanship generally is to be of the highest standard obtainable and in all cases where either a British Standard Code of Practice or a Malaysian Standard exist and is applicable to any portion of the Works, The Contractor shall allow for complying with the recommended practice of either code unless such procedure would directly conflict with requirements stated elsewhere in these documents.

New Materials

The whole of the materials used in the works shall be new unless otherwise described.

Proprietary Materials

Materials of proprietary manufacture specified hereafter, may be substituted by materials of a different manufacture provided that such substitute are in all respects equal to the original specification and that the S.O.'s prior written approval is obtained to all substitutions affected. All proprietary materials are to be applied in accordance with the manufacturer's instructions.

Preambles Apply To All Trades

The Trade Preambles relating to each particular trade shall apply equally to all work carried out of a similar nature under other trades.

Approved

The term "approved" shall mean approval by the S.O.

3.1 GENERAL (Cont'd)

P.C. Unit Rates

P.C. Unit rates for materials to be supplied by a firm to be nominated by the S.O. shall mean the cost of the material delivered to site for the net quantity required material delivered to be fixed on site. Additional requirement for wastage, loss, entering into a contract of sale etc., labour for fixing, overheads, profit and any other charges shall be covered by the Contractor's overall rate for the item.

P.C. Unit rates for works to be executed complete by a firm to be nominated by the S.O. shall mean the cost of the work for the net quantity required. The Contractor's overall rate shall cover for all other items including attending upon the firm and providing attendance as if this firm was a "Nominated Sub-Contractor". The Contractor's overall rate shall cover for entering into a contract with the selected nominated firm, overheads, profit and all other charges.

Adjustments of P.C. items in the final account will be effected by substituting the invoiced unit rate in lieu of the P.C. Unit rate. No other adjustment will be made.

The Contractor shall note that any contra matters between the supplier or firm nominated and the Contractor shall be matters solely concerning the Contractors and no claims whatsoever shall be made against the employer.

General Metrication Clauses

Where materials are not available in metric sizes the soft conversion method has been used generally to specify dimensions of members i.e. the conversion is a direct conversion only and the actual product, material or structure being manufactured remains physically unaltered. Minimal rounding to the nearest integer or sensible number has been used. Where the material is not available in the metric size specified the Contractor shall provide this in the equivalent imperial size subject to the approval of the S.O. The Contractor shall be deemed to have allowed for this in his rates and no claims whatsoever will be considered consequently.

Relevant Approving Authorities

All workmanships, materials and equipment supplied under this Contract must be to the latest standards and requirements of the relevant approving authorities. The completed works must be tested and made to their satisfaction, so that the whole works can be handed over and accepted by the relevant authorities.

Survey Equipment

The Contractor shall provide at his own expense for the use of the S.O. and to his approval throughout the period of the Contract, all necessary survey equipment and labour.

3.1 GENERAL (Cont'd)

Existing Services

- (a) The Contractor shall notify the S.O. promptly, of any mains, pipes, cables, ducts, poles, manholes, valves and syphon surface boxes, etc., met with during excavation and shall immediately provide adequate support and protection for such services to the satisfaction of the S.O.
- (b) The Contractor shall be held entirely responsible for any damage done thereto during the progress of the Works and to any damage to pipes, mains, cables etc. outside the excavation as a result of earth movement due to faulty or inadequate timbering or otherwise.

Extension Of Time

Claims for extension of time arising from any cause whatsoever shall be made by the Contractor in writing to the S.O. within 14 days of such happening, otherwise no claim for extension of time will be entertained.

Claims For Extras

No claims for extras will be allowed on any account unless an order IN WRITING from the S.O. is produced. All claims for extras shall be made in writing within 14 days of the order from the S.O.

Ordering Materials

The Contractor shall place his orders for specific materials at the earliest possible date after notification of acceptance of his Tender or at such time as may be specifically stated elsewhere herein for any particular materials.

If, in the opinion of the S.O., the Contractor by his failure to deliver on to the job any specified materials within the time stated for same, causes interruptions to or delay in the process of the Works, then in either case the S.O. shall be at liberty to purchase such specified materials in whatsoever quantities he deems necessary and at the rates current in locals markets at the time of purchase and all charges in connection therewith including delivery charges shall be borne by the Contractor and shall be deducted from monies to or to become due to him under this Contract by means of a Variation order and no profit shall be allowed to the Contractor in respect of such items.

3.1 GENERAL (Cont'd)

Samples

Samples of materials shall be submitted for approval within 4 weeks after notification of acceptance of the Contractor's Tender. In the case of rejection, further samples shall be submitted until they are approved. The Engineer may reject any materials or workmanship which in his opinion is not up to the approved standard. All samples submitted shall be free of cost. The approval of the samples by the S.O. shall not relieve the Contractor of his obligations, liabilities and responsibilities under the terms of the Contract.

Watching, Lighting

The Contractor shall provide and maintain all necessary watching by day and by night including lighting, signs barriers required for the protection and safety of the public.

Protection

The Contractor shall provide all things necessary for the proper protection of materials and completed work and shall comply with all the directions of the Engineer in this respect.

Water And Electricity For Works

The Contractor shall provide at his own expense and cost, all water and electricity required for use in the Works and shall make all arrangements with the Local Authorities and pay all costs and fees in connection therewith. All water used for works in the Site shall be fresh, clean and pure from the public water supply mains. He will also provide all temporary water tubing, valves, pumps and storage tanks necessary for the proper execution of the Works and clear away all on completion.

Dumping Materials On Site

All surplus earth materials are to be dumped on the Site as directed by the S.O. unless otherwise ordered. All constructional rubbish are to be disposed of to contractor's own dump site.

Rainproof Shed For Storage Of Cement And Materials

The Contractor shall provide at his own expense a suitable rain-proof shed of adequate size with raised floor to the approval of the S.O. for the storage of cement and materials for the duration of the Contract and shall remove same on completion of the Works and make good to the satisfaction of the S.O.

Provision Of All Services

When required during the Contract, the Contractor shall at his own expense pay all accounts in connection with the telephone service, water supply, and electricity which have been provided on the Site for the use of the Resident Architect/Resident Engineer and his Site Staff.

3.1 GENERAL (Cont'd)

Drainage And Sewerage

When necessary, the Contractor shall provide, erect and maintain proper and adequate drainage and sewerage facilities for the duration of the Contract and all in accordance with the requirements of the Medical, Health and Local Authorities for his own use.

Clearing And Cleaning Site

All rubbish shall be cleared from the Site and roads etc. under construction from time to time as it accumulates and as the S.O. may direct. Particular attention is directed to clearing out the road serving and leaving it entirely free from timber, rubble and other rubbish.

Progress Photographs

The Contractor shall supply monthly progress photographs showing all aspects of the works. The photographs shall be of size 3R. The cost of the photographs shall be borne by the Contractor. The S.O.'s Representative will indicate from time to time where such photographs are to be taken. The negatives of all photographs shall be the property of the Employer and prints may not be produced without the written authority of the Employer or the S.O.

Damage Due To Flood

The Contractor shall take every precaution to prevent flood damage to his equipment, building materials, the temporary and permanent works. No claim for compensation will be allowed.

Instructions And Approval

All instructions to the Contractor shall be in writing and no claims which are based on verbal instructions or on confirmation of the S.O.'s verbal orders by the Contractor will be entertained. Any work which is carried out without the written instructions or written approval of the S.O. shall be at the Contractor's own risk and cost.

Details Inadvertently Left Out

The Specification has been drawn up with the intention of covering the complete execution of the Works. In case there are details which have been inadvertently left out of the Specification or drawings and which may be reasonably implied or inferred and which are usual or essential to complete the Works, the same shall be deemed to be included in the prices provided in the Contract.

Other Contractors Working On Same Site

Other Contractors may be working on the same site and the Contractor is to make allowance in his tender for any disturbances and interferences that may be created by them.

3.1 GENERAL (Cont'd)

Final Cleaning and Clearing

The Contractor shall ensure that all ruins, building materials, site office, open shed, canteen, sacred plan, place of devotion etc., shall be removed from the site upon completion of the Works.

3.2 PILING WORK

GENERAL REQUIREMENTS

General

Unless otherwise specified, all piling shall conform in all respects to BS 8004. All materials and workmanship for piling shall be in accordance with the appropriate sections of this Specification.

Soil Investigation Reports

Any information and reports on site investigations for the Works made available to tenderers are intended for guidance only. The S.O. shall not be responsible for the scope, completeness or accuracy of the information, or for any opinions or conclusions given in the reports.

Tolerances

Setting Out

Setting out shall be carried out from the main grid line of the proposed structure. Immediately before installation of the pile, the pile position shall be marked with suitable identifiable pins; pegs or markers.

Position

For a pile cut-off at or above ground level the maximum permitted deviation of the pile centre from the centre points shown in the drawings shall not exceed 75mm in any direction. For a pile cut off below ground level an increase in this tolerance is permitted as described herein below.

Verticality

The maximum permitted deviation of the finished pile from the vertical is 1 in 75.

Rake

The piling rig shall be set and maintained to attain the required rake. The maximum permitted deviation of the finished pile from the specified rake or the rake shown in the Drawings is 1 in 25.

Forcible correction

Forcible corrections to concrete piles shall not be permitted. Forcible corrections may be permitted to other types of piles only if approved by the S.O. However, no forcible corrections shall be made to piles which have deviated beyond the permissible limits.

3.2 – PILING WORK (Cont'd)

GENERAL REQUIREMENTS (Cont'd)

Piles Out Of Alignment or Position

The Contractor shall, if ordered by the S.O. extract and reinstall any pile which has deviated out of position or alignment by more than specified limit, or alternatively the substructure shall be modified to the approval of the S.O. The cost of such extraction and reinstallation, or any extra cost in the design and construction of a modified foundation shall be borne by the Contractor, if, in the opinion of the S.O. such extra works has been made necessary due to the incompetence and/or negligence of the Contractor.

Piling Programme

The Contractor shall submit to the S.O. his proposed programme for the execution of the piling work at least seven days before commencement of the work. In addition, the Contractor shall inform the S.O. daily of the programme of piling for the following working day and shall give adequate notice of his intention to work outside working hours, if this has already been approved by the S.O.

Records

The Contractor shall keep records of particulars as listed in Table 1 hereof for each pile installed and shall submit two signed copies of these records to the S.O. not later than noon of the next working day after the pile was installed. The signed records shall form part of the records for the Works.

Any unexpected and latent driving conditions shall be noted in the records.

Nuisance and Damage

Noise and Disturbance

The Contractors shall take all necessary precaution in carrying out the work to minimise noise and disturbance during driving.

3.2 – PILING WORK (Cont'd)

GENERAL REQUIREMENTS (Cont'd)

Damage to Adjacent Structures, Utilities

The Contractor's attention is specially drawn to his responsibilities under the Clause "Damage to Property" of the Conditions of Contract. The Contractor is deemed to have familiarised himself with the risks likely to be imposed on adjacent structures and all utilities by the proposed method of piling.

Before commencing any piling works, the Contractor shall accompany the S.O. on a site inspection in order to consider any circumstances, which may indicate the presence of underground mains and services at or near the Site. If, during execution of the works damage is, or likely to be caused to any utilities or adjacent structures, the Contractor shall submit to the S.O. his proposals for repair or avoidance of such damage.

Damage to Piles

The Contractor shall execute the works in such a manner so as to minimise damage to piles.

All piles damaged during handling, transporting, pitching, driving or at any other times shall be replaced by the Contractor at his own expenses and costs.

Safety Precaution

The Contractor shall take safety precautions throughout the piling operations in accordance with the requirements of the relevant laws and by-laws.

Noise and Air Pollution Control

The tenderer shall provide all necessary piling plants and equipment to ensure compliance with Local Authorities requirement that noise measured at a distance of 15m from source shall not exceed 95 decibels.

Definition

Preliminary Pile

A preliminary pile is a pile installed before the commencement of the main piling works for establishing the driving criteria for subsequent working piles and for confirming the adequacy of the design, dimensions and bearing capacity. This pile shall be treated as a working pile unless otherwise directed by the S.O.

Working Pile

A working pile is a pile which is installed as part of the permanent foundation works.

3.2 – PILING WORK (Cont'd)

GENERAL REQUIREMENTS (Cont'd)

Ultimate Load

Where pile test is carried out the ultimate load is defined as the constant load at which the pile continue to settle at a steady rate or the load at which the maximum settlement of the pile top during one continuous loading cycle is one tenth of the pile base diameter or least dimension, whichever is the lesser.

Where pile test is not carried out, the ultimate load is define as the calculated ultimate load, derived from appropriate static bearing capacity calculations.

Design Load

The design load shall be defined in relation to a pile loaded in isolation, without nearby piles being loaded except those providing test reaction.

Where the ultimate load is not measured by means of pile tests, the design load is the lesser of the following:

- a) The calculated ultimate load for the pile divided by the specified factor of safety.
- b) The calculated ultimate load of the pile base together with the calculated shaft adhesion, as derived from appropriate static bearing capacity calculations divided by a factor of safety.

Safety Factor

Unless otherwise specified, the factor of safety shall be taken as not less than 2.5 for piles in compression and not less than 3.0 for piles in tension.

Sequence of Piling

The contractor shall first obtain the S.O.'s approval for his proposed sequence of installation of pipes in a group or in close proximity before implementation. The S.O. reserves the right to order changes to the approved sequence 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.

Working Load

The Working Load is the design load modified to allow for ground effect, pile spacing or any other factors changing the efficiency of the total foundation from that of a single isolated pile and is at least equal to the dead plus imposed loads on the pile together with down drag or uplift loads as appropriate.

3.2 – PILING WORK (Cont'd)

PRECAST REINFORCED CONCRETE PILES

General

The materials to be used and workmanship for precast reinforced concrete piles shall be as specified under Concrete Works. The type of mix to be used shall be as those shown in the Drawings.

Reinforcement

The main reinforcing bars in piles not exceeding 12m in length shall be in one continuous length unless otherwise approved by the S.O.

In piles exceeding 12m long, joints will be permitted in main longitudinal bars at 12m nominal intervals. Joints in adjacent bars shall be staggered at least 1m apart along the length of the pile. Joints shall be butt-welded as specified in Concrete Works. Other means of jointing reinforcement, such as by means of mechanical couplings shall be to the approval of the S.O.

Pile Shoes

The type of pile shoes to be used shall be as shown in the Drawings and shall comply with the following as relevant:

- a) "Chilled-hardened" cast iron shoes as used for making grey iron casting to BS 1452, Grade 10; or
- b) Mild steel to BS 4360, Grade 50B; or
- c) Cast steel to BS 3100, Grade A.

Mild steel straps cast into the shoes shall be as shown in the Drawings. Rock shoes where required shall consist of wrought iron shoes and mild steel straps cast into "Chilled-hardened" cast iron blocks, as shown in the Drawings.

Casting

Piles shall be cast on a horizontal platform in approved moulds to the dimensions as shown in the Drawings. The concreting of each pile shall be completed in one continuous operation and no interruptions will be permitted.

Lifting holes shall be formed during casting in the positions and in accordance with the details shown in the Drawings.

3.2 – PILING WORK (Cont'd)

PRECAST REINFORCED CONCRETE PILES (Cont'd)

Curing, Stripping, Handling and Storage of Piles

Piles made from Ordinary Portland Cement shall be kept damp for a period of at least 10 days after casting. Side forms shall not be stripped less than 3 days after casting. After 14 days, piles may be lifted and removed to a suitable stacking area but they shall not be driven until they are at least 28 days old.

For piles made from rapid hardening cement the above periods may be modified as approved by the S.O.

The method and sequence of lifting, handling, transporting and storing piles shall be such that piles are not damaged. Only the designed lifting and support points shall be used. During transport and storage, piles shall be placed on adequate supports located under the lifting points of the piles.

All piles within a stack shall be in groups of the same length. Packings of uniform thickness shall be provided between piles at the lifting points.

Making Piles

After a pile has been cast, the date of casting, reference number, and the length shall be clearly marked with undeletable marker on the top surface and on the head of the pile. In addition, each pile shall be marked at intervals of 300mm along its length before being driven.

Tolerance in Pile Dimensions

The cross-sectional dimensions of the pile shall not be less than those shown in the Drawings and shall not exceed them by more than 6mm.

Any face of a pile shall not deviate by more than 6mm from a straight edge 3m long laid on the face, and the centroid or any cross-sections of the pile shall not deviate by more than 12mm from the straight line connecting the centroids of the end faces of the pile.

Length of Piles

The length of a pile shall be taken to mean the overall length measured from the tip of the shoes to the cut-off level at 75mm high above the soffit of the pile caps. The length of piles to be cast shall be to the approval of the S.O. Based on the results of pile driving resistance and/or load tests carried out on piles driven on the site, the S.O. may from time to time order the lengths of piles to be modified.

3.2 – PILING WORK (Cont'd)

PRECAST REINFORCED CONCRETE PILES (Cont'd)

Pitching and Driving

Performance of Driving Equipment

The driving equipment to be used shall be of such type and capacity to the approval of the S.O. If drop hammer is used, it shall be of a free fall type and the weight of the hammer shall be as specified in BS 8004.

Pitching of Piles

Piles shall be pitched accurately in the positions as shown on the Drawings. At all stages during driving and until the pile has set or driven to the required length, all exposed piles shall be adequately supported and restrained by means of leaders, trestles, temporary support or other guide arrangements to maintain position and alignment and to prevent buckling and damage to the piles.

Driving of Piles

Each pile shall be driven continuously until the specified set and/or depth has been reached. However, the S.O. 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 he is satisfied that the suspension of driving is beyond the control of the Contractor.

A follower (long dolly) shall not be used for driving end-bearing piles. It may be used for driving frictional piles with prior approval of the S.O.

The Contractor shall inform the S.O. immediately if an unexpected change in driving characteristics or latent condition is encountered.

Where required by the S.O. set shall be taken at approved intervals during the driving to established the behaviour of the piles. A set shall be taken only in the presence of the S.O. unless otherwise approved. The Contractor shall provide all facilities to enable the S.O. to check driving resistances.

Redrive checks, if required, shall be carried out in accordance with an approved procedure.

Pile Drive Log

A detailed record of the driving resistance over the full length of each pile shall be kept. The log shall record the number of blows for every 300mm of pile penetration.

3.2 – PILING WORK (Cont'd)

PRECAST REINFORCED CONCRETE PILES (Cont'd)

Final Set

The final set of a pile other than as friction pile, shall be recorded either as the penetration in millimetres per 10 blows or as the number of blows required to produce a penetration of 25mm.

When a final set is being measured, the following requirements shall be met:

- a) The exposed part of the pile shall be in good condition, without damage or distortion;
- b) The dolly and packing shall be in sound condition;
- 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.
- d) The hammer shall be in good condition and operating correctly;
- e) The temporary compression on the pile shall be recorded if required.

Driving Sequence and Risen Piles

Piles shall be driven in an approved sequence to minimise the detrimental effects of heave and lateral displacement of the ground. When required, levels and measurements shall be taken to determine the movement of the ground or any pile resulting from the driving process. If any pile rise occurs as a result of adjacent piles being driven, the Contractor shall submit to the S.O. his proposals for correcting this at his own cost and to avoid the same in subsequent work.

Preboring

If preboring is specified the pile shall be pitched into a hole pre-bored to the depth shown on the Drawings, unless otherwise instructed by the S.O.

Jetting

Jetting shall be carried out only when the Contractor's detailed proposals have been approved and not for the last 3m of the required depth of penetration.

3.2 – PILING WORK (Cont'd)

PRECAST REINFORCED CONCRETE PILES (Cont'd)

Repair and Lengthening of Piles

Repair of Damaged Pile Heads

Any damaged pile heads shall be cut out of square at sound concrete, and all loose particles shall be removed by wire brushing, followed by washing with water. If the pile is to be subjected to further driving, the head shall be replaced with concrete of an approved grade.

The new head shall be cast truly in line with the remainder of the pile, and be properly cured and allowed to harden sufficiently to develop the strength necessary for further driving.

If a pile has been driven to the required set or depth but sound concrete of the pile is below cut-off level, the pile shall be made good to the cut-off level with concrete of a grade not inferior to that of the concrete of the pile.

The Contractor if required, shall carry out the above work at his own expenses and costs.

Lengthening of Piles

Where piles have to be lengthened, other than by means of welding of steel plates as detailed in the Drawing, the reinforcement shall be stripped of all surrounding concrete for a distance equal to forty four times the diameter of the main reinforcement measured from the pile head for spliced joints and 300mm for butt welded joints and all lateral reinforcement shall be removed. The lengthening bars shall butt on the exposed bars in true alignment and shall be butt welded as specified or shall be spliced with bars of the same diameter as the main pile bars, 88 diameters in length and lapping the main bars for a distance of 30 diameters above and below the joint, and shall be securely bound with 1.63mm soft annealed iron wire.

New binders of similar size shall be provided and spaced at half the centres of the binders in the main body of the pile and shall be securely bound with 1.63mm soft annealed iron wire and the pile extended by concreting in properly constructed mounds to the length required. Care shall be taken to form the joint between the old and new concrete as specified herein before. The extension shall be truly in line with the remainder of the pile, and be properly cured and allowed to harden sufficiently to develop the strength necessary for further driving.

Driving Repaired/Lengthened Piles

Piles which have been repaired/lengthened by adding cast-in-situ concrete as described in 37 and 38 shall not be driven until the added concrete has reached the specified strength of the concrete for the pile.

3.2 – PILING WORK (Cont'd)

PILING TEST

Cutting and Stripping of Pile Heads

When a pile has been driven to the required set or depth, the head of the pile shall be cut off to the level specified or shown in the Drawings. The length of reinforcing bars projecting above this level shall be as shown or specified in the Drawings.

Care shall be taken to avoid cracking or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and made good with new concrete properly bonded to the old at the Contractor's own expenses and costs.

General

Type of Tests Necessary

The "Maintained Load Test" shall be carried out on a test pile. The Contractor shall, if required by the S.O. carry out the "Constant Rate of Penetration Test" on completion of the "Maintained Load Test".

Safety Precautions

When preparing, conducting and dismantling a pile test the Contractor shall carry out the work in a safe manner and shall in addition make such other provisions as may be necessary to safeguard against any likely hazards.

Definitions

Compression Pile

A pile which is designed to resist an axial force such as would cause it to penetrate into the ground.

Anchor Pile

A pile which is designed to resist an axial force such as would tend to cause it to be extracted from the ground.

Test Pile

A compression pile to which a load is applied to determine the load versus settlement characteristics of the pile and the surrounding ground.

Reaction System

The system of kentledge, piles or anchors that provides a resistance against which the pile is tested.

3.2 – PILING WORK (Cont'd)

PILING TEST

Kentledge

The dead weight used in a loading test.

Maintained Load Test

A loading test in which each increment or loading test in which each increment or decrement of load is held constant either for a defined period of time or until the rate of settlement or rebound falls to a specified value.

Constant Rate of Penetration Test (CRP)

A loading test in which the piles is made to penetrate the soil from its position at a constant speed while the force applied at the top of the pile to maintain the rate of penetration is continuously measured. The force versus penetration relationship obtained does not represent an equilibrium condition between load and settlement.

Supervision

All tests shall be carried out only under the direction of an experienced and competent Contractor's Supervisor with approved test equipment and test procedure as specified hereinafter.

All Contractor's personnel operating the test equipment shall have been trained in its use. Tests shall be carried out only in the presence of the S.O.

Reaction System

General

Compression test shall be carried out using a kentledge, anchor piles or specially constructed anchorages as reaction system. The reaction system used shall be designed to transfer safely to the test pile the maximum load required for testing. Full details of the reaction system shall be submitted to the S.O. prior to any work related to the testing process being carried out on the Site.

Kentledge

Where kentledge is to be used, it shall have adequate weight to resist load up to 1.2 times the maximum test load. The kentledge shall be supported on cribwork, beams or other supporting structures disposed around the test pile so that its centre of gravity is on the axis of the pile. Kentledge shall not rest directly on the pile head. The bearing pressure under the supports shall be such as to ensure stability of the kentledge stack and shall not impair the efficiency of the testing operations. The distance from the edge on the test pile to the nearest part of the supports to the kentledge stack in contact with the ground shall not be less than 1.3m.

3.2 – PILING WORK (Cont'd)

Kentledge (Cont'd)

Where anchor piles or ground anchors are to be used, they shall be of adequate strength to resist load up to 1.2 times the maximum test load on the ground in a safe manner without excessive movement or influence on the test pile. The method employed in the installation shall be such to prevent damage to any test pile or working pile.

The Contractor shall ensure that when the test load is applied, the load is correctly transmitted to all the bolts and tie rods. The extension of rods by welding shall not be permitted unless it is known that the steel will not be reduced in strength by welding. The bond stress of the rods in tension shall not exceed normal permissible bond stresses of the type of steel and grade of concrete used.

Where anchor piles are used the centre to centre spacing of the piles from a test pile shall be not less than three (3) times the diameter of the test pile or the anchor piles or 2m whichever

is the greater. Under-reamed tension piles shall not be used. Where permanent working piles are approved by the S.O. to be used as anchor piles, their levels shall be observed during application of the test load to ensure that there is no residual uplift.

Where ground anchors are used, no part of the section of the anchor transferring load to the ground shall be closer to the test pile than three (3) times the diameter of the test pile. Further more, no part of the ground anchor shall be closer to a working pile than one-and-a-half times the diameter of the test pile along the unbonded length of the anchor, and three (3) times the diameter of the test pile along the bonded length of the anchor. Under-reams on ground anchors shall not exceed 170mm in diameter.

Testing Equipment

The Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile heads, the whole system will be stable up to the maximum load to be applied.

The test loads shall be applied by means of a hydraulic jack of adequate capacity fitted with a load-measuring device.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure equivalent to 1 1/2" times the maximum test load without leakage.

Where the C.R.P. test is required, the jack pump capacity shall be adequate to maintain the required rate of penetration. The permissible extension of the jack shall be such that the pile can be moved continuously and without repacking for a distance of at least 50mm.

The measuring device shall be of the type approved by the S.O., capable of registering loads in increments not exceeding 20KN.

3.2 – PILING WORK (Cont'd)

Testing Equipment (Cont'd)

The hydraulic jack and measuring device shall be calibrated together to the approval of the S.O. before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate for the type of equipment used. Certificates of calibration shall be submitted to the S.O.

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of maintained loading test.

Preparation of a Working Pile to be Tested

General

If a test is required on a working pile the Contractor shall prepare the pile for testing to the approval of the S.O.

Driving Records

For each working pile that is to be tested, a detailed record of driving shall be made and submitted to the S.O. daily not later than noon on the next working day.

Cut-off Level

The pile shall terminate at the normal cut-off level or at a level required by the S.O. However, where necessary the pile shall be extended above the cut-off level of working piles so that gauges and other apparatus to be used in the testing process will not be damaged by water or falling debris. If the cut-off level is below ground level, the pile is not extended and there is a risk of the borehole collapsing, a sleeve shall be left in place or inserted above the pile, or other approved action shall be taken. Adequate clearance shall be given between the top of the pile and the bottom of the sleeve to permit unrestricted movement of the pile.

Pile Head for Compression Test

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. An approved mild steel bearing plate shall be mounted on top of the pile head or cap to accommodate the loading and settlement measuring equipment and to prevent damage from the concentrated application of load from the loading equipment.

3.2 – PILING WORK (Cont'd)

Notice of Test

The Contractor shall give the S.O. at least 24 hours, notice of the commencement of test.

Settlement Measurement

An independent reference frame shall be set up to permit measurement of the vertical movement of the test pile. The support for the frame shall be located no closer than 2m from the test pile, and shall be rigidly fixed to the ground to a depth of not less than 1m of concrete surround. In addition, the elevation of the supports shall be checked frequently with reference to a fixed benchmark.

The entire measuring assembly shall be protected against rain, direct sunlight and other disturbances that might affect its reliability. Temperature readings shall be taken when requested by the S.O. The measurement of pile movement be made by four dial gauges rigidly mounted on the reference frame that bear on machined metal or glass surfaces normal to the pile axis fixed to the pile cap or head. Alternatively the gauges may be fixed to the pile and bear on surfaces on the reference frame. The dial gauges shall enable readings to be made to within an accuracy of 0.1mm and shall have a minimum travel of not less than 50mm.

The Contractor may submit other methods of measuring the movement of pile heads for approval.

Test Procedure

General

Throughout the test period all equipment for measuring load and movement shall be protected from the effects of weather. Construction equipment 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 measurement apparatus.

Maintained Load Test

The load shall be applied in increments of 25% of the working load, up to the working load and appropriately smaller thereafter, until a maximum test load of twice the working load is reached. Each increment of load shall be applied as smoothly and as expeditiously as possible. Settlement readings and time observations shall be taken before and after each new load increment.

A time-settlement graph shall be plotted to indicate when the rate of settlement of 0.05mm in 15 minutes is reached. A further increment of load shall be applied when this rate of settlement is achieved or until a minimum time of 2 hours has elapsed, whichever is later. The process shall be repeated until the maximum test load is reached.

3.2 – PILING WORK (Cont'd)

Maintained Load Test (Cont'd)

The test load shall then be decreased in four equal stages and time-settlement readings shall be as described aforesaid until the movement ceases. At least 60 minutes intervals shall be allowed between the unloading decrements.

The maximum test load shall then be maintained for a minimum of 24 hours, and time-settlement readings shall be taken at regular intervals as for the earlier load stages.

Constant Rate of Penetration Test

The load shall be applied to achieve a constant rate of penetration value varying between 0.75mm per minute to 1.50mm per minute. The rate chosen shall suit the jacking equipment used.

Both settlement and time readings shall be recorded at every minute period. Further loading shall be discontinued when the loading varies indirectly as the penetration in the case of end bearing piles in sand or gravel, or when the rate of penetration is constant without further increase in the load in the case of friction piles in clay. Loading shall then be released gradually and rebound readings taken.

Workmanship

Sonic Logging Testing

When required by the Engineer certain piles, cast with provision for sonic logging, shall be tested to detect faults or discontinuities. Testing shall be carried out 7 days after concreting.

Subject to the approval of Engineer, a specialist sub-contractor may be engaged for this purpose. The results of the test should be fully recorded and interpreted for submission to the Engineer for further analysis.

The test equipment shall consist of a signal transmitter probe and a signal receiver probe, which may be lowered into the tubes installed in the piles either in tandem or singly. The results of the sonic testing shall be displayed on a recording oscilloscope at the top of the pile.

The signal emitted by the transducer shall be in the spectrum of 100Hz to 60kHz and of variable emission pulse rate between 1 and 20 cycles per second to suit the testing requirements.

The recording oscilloscope shall be of the storage type with signal modulation representation of the received signal on a horizontal tracing: bright spots correspond to peaks and signal blanks to troughs.

For two or more tubes, measurements shall be taken between adjacent tubes plus either one or two diagonal where applicable.

3.2 – PILING WORK (Cont'd)

Workmanship (Cont'd)

Sonic Logging Testing (Cont'd)

Where piles are founded on rock the necessary equipment shall be available to carry out a 'Fan-shaped Test' whereby the transmitter is lowered into the rock below the toe and brought upwards whilst the receiver is held constant at a fixed depth.

The Contractor shall ensure that the probe is matched to the tube diameter to minimise concrete tube probe signal alteration or misleading results will arise.

Results shall be in the form of time delay versus pile depth. Where tubes are blocked and cannot be cleared by flushing or other means and test results are unobtainable then an alternative non-destructive test approved by the Engineer shall be carried out. In all cases the results shall be recorded on the oscilloscope screen and photographed. The photographs or good quality copies of the photographs shall be submitted to the Engineer together with the Contractor's interpretation of the results within 24 hours of the test. All scales shall be defined on the photographs.

Vibration Test

When required by the Engineer certain piles shall be tested by a vibration test. This test method is to determine the pile length and shape, rigidity of pile in-situ and the overall pile concrete quality.

The head of the pile shall be excited by an electrodynamic vibratory excitor in the frequency range of 20-1,000 Hz. A pick up and recorder will collect and record the pile head's motion. The test will be attended by the Engineer and the Contractor's interpretation shall be submitted to the Engineer within 24 hours of the test.

Seismic Test

When required by the Engineer certain piles shall be tested by the seismic test, to determine the presence of discontinuities in concrete piles. Subject to approval, a specialist sub contractor may be engaged for this purpose.

The head of the pile to be tested shall be cleared of all loose material.

A low range acceleration transducer shall be fixed to the head of the pile. The head of the pile shall be struck with instrumented hammer. The impulse and reflection of the seismic stress wave shall be amplified, recorded on a digital storage oscilloscope and transmitted to a signal conditioner. The oscilloscope display shall be photographed or recorded on a chart recorder and the photographs, records, or good quality copies of the photographs or records shall be submitted to the Engineer together with the Contractor's interpretation of the results within 24 hours of the test.

3.2 – PILING WORK (Cont'd)

Workmanship (Cont'd)

Core Drilling of Completed Piles

When instructed by the Engineer certain completed concrete piles shall be cored.

The Contractor shall cut an 'NX' size test core through the full depth of the pile and a further 4500mm into the ground on which the pile is founded.

The completed core shall be properly marked, logged and arranged on Site for inspection by the Engineer. The cores shall be photographed for record purposes.

If instructed, portions of the core shall be delivered to an approved laboratory for capping and testing for strength in accordance with BS 1881.

Dynamic Pile-Testing

Dynamic pile testing involves monitoring the response of a pile to a heavy impact at the pile head. The impact is often provided by the pile-driving hammer and response is normally measured in terms of force and acceleration or displacement close to the pile head. The results directly obtained refer to dynamic loading conditions. Interpretation in terms of static loading requires soil and pile dependant adjustments and corroboration from experience may be required to correlate testing of this kind with normal static load tests as specified.

Details of the equipment to be used and of the method of analysis of test results shall be provided to the Engineer before commencement of testing. All instruments affixed to the pile for the purpose of measuring stress and movement, and all equipment for receiving and processing data shall be suitable for the purpose. The equipment required to be attached to the pile shall be approximately positioned and fixed to the approval of the Engineer.

The hammer and all other equipment used shall be capable of delivering an impact force sufficient to mobilize the equivalent specified test load without damaging the pile.

The preparation of the pile head for the application of the dynamic test load shall involve where appropriate trimming the head, cleaning and building up the pile using materials which will at the time of testing safely withstand the impact stresses. The impact surface shall be flat and at right angles to the pile axis.

The interpretation of the tests shall be carried out by competent and experienced persons and the report on each test shall be fully evaluated and endorsed by a Professional Engineer and be given to the Engineer within 24 hours of the completion of the test.

Dynamic load tests shall be carried out at appropriate and approved times after pile installation. The time between the completion of installation and testing for a preformed pile shall normally be more than 7 days, and in the case of a cast-in-pile also be such that the pile is not damaged under the impact stresses.

3.2 – PILING WORK (Cont'd)

Workmanship (Cont'd)

Dynamic Pile-Testing (Cont'd)

Where required and appropriate, the permanent penetration per blow and temporary compression of the pile and soil system shall be measured independently of the instruments being used to record the dynamic test data.

Defective Piles

If at any time during the progress of the works any piles are found to be in any way unsatisfactory, they will be condemned and the Contractor shall install at his own expense as many new piles as are required to carry the redistributed load of the condemned piles and shall carry out or bear the cost of carrying out by others any approved alterations to pile cap and pile cap design necessitated thereby.

In the event that any working pile shall have been tested and shall be deemed to have failed the test, or in the event that any working pile shall be found unsatisfactory in any way after the completion of construction of that pile, then:-

- (i) the cost of all testing of such pile shall be borne entirely by the Contractor;
- (ii) all working piles which have not been satisfactorily tested will be deemed not to be acceptable until the Contractor shall have demonstrated entirely at his own cost, to the

satisfaction of the Engineer, that all piles are in compliance with the requirements of the Contract.

Presentation of Results

Results of pile testing shall be submitted in summary form in writing to the Engineer within 24 hours of the completion of the test. The results of pile testing shall be endorsed by an authorised, competent and experienced Professional Engineer who performed the tests and interpret the tests.

- a) For all tests: a copy of the pile construction record.
- b) For compression and tension tests: the maximum sustained load and the maximum settlement or uplift recorded and graph of load against settlement or load against uplift.
- c) For some logging tests or vibration tests: a record of any suspected discontinuities or defects.
- d) For core tests and bedrock proving hole: a record of any discontinuities or defects discovered in the concrete of the rock.

3.2 – PILING WORK (Cont'd)

Presentation of Results (Cont'd)

- e) For dynamic pile testing:
 - (i) the maximum force applied to the pile head;
 - (ii) the maximum pile head velocity;
 - (iii) the maximum energy imparted to the pile.

A full report of the results of the pile testing shall be submitted in writing to the Engineer within 7 days of the completion of the test. The full report shall give the following information where applicable:-

- a) General
 - 1. Site Location
 - 2. Contract Identification
 - 3. Proposed Structure
 - 4. Main Contractor
 - 5. Piling Sub-contractor (if any)
 - 6. Engineer
 - 7. Client
 - 8. Date of Test
- b) Test procedure for compression or tension test
 - 1. Weight of Kentledge

2. Tension pile, ground anchorage or compression pile details
3. Plan of test arrangement showing position and distances of kentledge supports, tension or compression piles and reference frame to test pile
4. Jack capacity
5. Method of load measurement
6. Method(s) of penetration or uplift measurement
7. Proof test by maintained loading
8. Relevant dates and times

c) Dynamic pile test

1. Date of pile installation
2. Date of test
3. Total pile length, including projection above commencing surface at time of test
4. Length of pile from instrumentation position to toe
5. Hammer type, drop and other relevant details
6. Blow selected for analysis
7. Test load achieved (i.e. total mobilized deduced static load)
8. Pile head movement at equivalent design verification load
9. Pile head movement at equivalent design verification load plus 50% of specified working load

3.2 – PILING WORK (Cont'd)

Presentation of Results (Cont'd)

Dynamic pile test (Cont'd)

10. Pile head movement at maximum applied test load
11. Permanent residual movement of pile head after each blow
12. Temporary compression

d) Test Results

1. In graphical form: load plotted against settlement, load plotted against uplift, with times
2. In tabular form: settlement against time, temperature against time, wind speed against time and wave height against time (if applicable)
3. Ground heave
4. Effects on adjacent structure
5. Climatic data for test period

e) Site Investigation

Where a drillhole has been sunk at or near the location of the pile test, the following data shall also be presented.

1. Site investigation report number
2. Drillhole references
3. Drillhole log of core samples

Interpretation of Test Results

The S.O.'s interpretation and conclusions on the test results shall be final. The pile so tested shall be deemed to have failed if:

- a) The residual settlement after removal of the test load exceeds 6.50mm; or
- b) The total settlement under the Design Load exceeds 12.50mm; or
- c) The total settlement under twice the Design Load exceeds 38.0mm, or 10% of pile diameter/width whichever is the lower value; or
- d) Failure of the pile materials (due to suspected defects in the pile); or
- e) Failure of concrete to reach the design compressive strength.

3.2 – PILING WORK (Cont'd)

Any pile or pile group which fails under the above stated conditions shall be replaced by one or more piles to be installed as directed by the S.O. If, in the opinion of the S.O., it is impractical or inadvisable to install substitute piles in place of a failed pile, the contractor shall submit proposals to rectify the defect. Such proposals shall be duly endorsed by a Professional Engineer registered in Malaysia. The proposals are subject to the approval of the S.O.

In addition, the Contractor shall at his own expenses to carry out two (2) more tests. The piles for these tests shall be selected by the S.O.

Abandonment of Pile Test

The load test shall be deemed to have failed if any of the following observations is reached:

- (i) the test cannot be completed due to instability of the kentledge.
- (ii) pre-jacking or pre-loading before the commencement of the test.
- (iii) failure of the pilecap.
- (iv) improper setting of datum.
- (v) disturbed or unstable benchmarks or scales.

Clearance on Completion

On completion of a test all equipment measuring devices, kentledge and its supporting structure shall be dismantled, checked and either stored so that they are available for use in further tests, or removed from the Site.

On completion of a pile loading test, reaction piles and ground anchorages shall be cut off below ground level, and the ground made good with approved material.

For test piles which will not be incorporated into the Permanent Works, the pile cap, if formed in concrete, shall be broken off and resulting material disposed off the Site. If the pile cap is made of steel it shall be cut off and stored so that it is available for use in further tests or removed from the Site. The pile head shall be reduced to a level such that it does not interfere with the Permanent Works.

On completion of a test on a working pile, the test pile cap, if in concrete, shall be striped and left in a state ready for incorporation in the Permanent Works and the resulting material disposed off the Site. If the pile cap is made of steel it shall be cut off and stored so that it is available for use in further tests or removed from the Site as specified.

3.3 EXCAVATION

Site Clearing

The Contractor shall fell and dispose of trees and bushes within the site of the Works as and wherever directed by the S.O.

In any case all trees and bushes within 10ft. on both sides of all pipelines to be laid under the Contract shall be felled and disposed of.

All stumps and roots of trees, bushes and shrubs which are felled as specified above shall unless otherwise directed by the S.O. be grubbed up and removed to a place of deposit to be provided by the Contractor or as directed by the S.O. Brushwood, roots and refuse shall be burnt or removed from the site.

Excavation Generally

The Contractor shall carry out all excavation in whatever materials that may be found and shall deposit all excavated materials so that it will do as little damage and cause as little inconvenience as possible.

All excavations shall be carried out to the required lengths, breadths, depths, inclinations and curvatures as may be necessary for the proper construction of the Works or as shown on the Drawings. All excavations shall be sufficient to provide for the necessary working space, shuttering and any other temporary structures required during construction.

Where so directed by the S.O. the turf and top-soil shall be excavated separately from the subsoil and shall be reserved and stacked separately until required for re-use in reinstatement.

Unless otherwise stated, the excavation, whether in open cut or in trench, shall be proceeded with in such portions at a time as the S.O. may direct and shall not in the first instance be carried down to a depth nearer than 6" above formation level; the last 6" of depth to formation level shall be carried out by manual labour immediately in advance of placing concrete screed, concrete or pipe-laying. The bottoms of all excavations shall be carefully trimmed and levelled, well rammed and consolidated to ensure good solid foundations. The Contractor shall take such steps as are necessary to prevent damage to the formation due to exposures to the weather.

3.3 - EXCAVATION (Cont'd)

Excavation Generally (Cont'd)

Until the S.O. has inspected and approved the excavation no concrete shall be placed, and no pipes shall be laid upon the surfaces prepared by excavation. Any works built upon foundations which have not been approved by the S.O. shall on the order of the S.O. be uncovered or removed by the foundations reinstated all at the Contractor's own expense.

All excavations shall be measured nett and no payment shall be made for the extra lengths, widths and depths to provide for working space, timbering, etc. or for any additional excavation which the Contractor may be permitted to carry out for his own convenience; and no "overbreak" will be paid for. The Contractor shall be deemed to have allowed for such contingencies in his tendered sum and rates for excavation.

In his tendered sum and rates for excavation the Contractor shall include for the re-handling of all excavated materials as often as may be necessary, whether it be used for refilling excavations, for the construction of embankments, slopes, verges, tips, etc., or for covering trenches.

Excavation For Pipe Trenches

Before commencing the excavation of pipe trenches, the routes of the pipelines shall be pegged out accurately. Strong sight rails shall be fixed and maintained at each change of gradient, and at intermediate points not exceeding 200ft. apart. On these rails shall be marked the centre line and the level to which the pipes are to be laid, and such rails shall be maintained in position and at the correct level from the time excavation commences until backfilling is completed.

Not more than 300ft. run of pipe trench shall be opened up ahead of the pipe laying operation.

The trench shall be excavated to such width as will ensure that a working space of 6" will be available on either side of the outside of every pipe when properly aligned. Where pipes are to be laid on a concrete bed the width of the excavation at the bottom of the trench shall be the width of the underside of the concrete bed. At all joints the trench shall be so excavated as to give a working space of not less than 12" all round the joint. Where bends are made by deflecting pipes at joints the trench shall be widened to permit of this operation. The sides of the trench shall be cut vertical, and where necessary shall be protected against caving in by timbering to the satisfaction of the S.O.

3.3 - EXCAVATION (Cont'd)

Excavation For Pipe Trenches (Cont'd)

The trench shall be excavated to the depths intended or shown in the Drawings and shall be finished and trimmed accurately to level and grade. Where no invert levels are shown or indicated, the bottom of the trench shall be graded so that the pipe invert slopes evenly between the adjacent invert levels.

Should the ground be so wet or soft that, in the opinion of the S.O. it does not form a firm base for the pipe, or should rock be encountered at the bottom of the trench, the trench shall be executed 9" below the level intended or shown in the Drawings and then brought back to the correct level with good selected earth or sand well rammed into place. Such deepening of pipe trench and filling back shall be treated as a variation under the terms of the Contract. Should the bottom of the trench be inadvertently excavated below the specified level, it shall be brought back at the Contractor's expense to the correct level with good selected earth or sand carefully rammed into place.

When excavating pipe trenches in carriage ways or other paved surfaces, the Contractor shall first remove all metal, slabs, or bricks forming the existing paving to the width of the trenches and deposit these materials clear of the trenches for re-use in the reinstatement.

Excavation in Rock

If rock be encountered in the excavations, then for the purpose of this Contract, rock is defined as :-

- (a) hard materials which can only be removed by blasting, by pneumatic tools, or by wedging and cannot be removed by the teeth of a mechanical excavator or cannot be broken with a pickaxe; or
- (b) all solid boulders each exceeding 3 cu. ft. if occurring in trenches or each exceeding 6 cu. ft. if occurring in general excavations.

The S.O.'s decision as to whether or not the material of the excavation is classified as rock shall be final.

Where rock is encountered in the excavation it shall be removed at the direction of the S.O. Voids formed by the removal of rock in the base of excavations shall be filled with Grade "D" concrete or suitable material approved by the S.O., well rammed and consolidated to the required levels.

3.3 - EXCAVATION (Cont'd)

Excavation In Rock (Cont'd)

The Contractor shall not use any explosive without the permission of the S.O. in writing, who may subsequently withdraw such permission and no claim for extras will be allowed to the Contractor on account of such withdrawal.

The volume of rock excavated shall be taken as its volume in-situ before it is broken up. The volume of rock on which extra is payable shall be measured and agreed upon weekly between the Contractor and the S.O.

Unauthorised Excessive Excavation

In the event of any excavation including rock excavation being carried out beyond the limits on or against which permanent work is to be supported in accordance with the Drawings, unless otherwise directed or authorised by the S.O., the Contractor shall at his own expense be required to fill the excess excavation with Grade "D" concrete or suitable materials as directed by, and to the satisfaction of, the S.O.

Additional Excavation Ordered by the S.O.

If, after excavating the sites on which the various parts of the Works are to be constructed, it is found that any part of the formation is unsuitable to provide a satisfactory foundation, such portion shall be further excavated to such depths as the S.O. may direct, and refilled to correct formation level with Grade "D" concrete or selected material. Such extra excavation and refilling shall be treated as a variation under the terms of the Contract.

Stability Of Excavations

The Contractor shall be responsible for the stability of the excavations at all times. He shall without claim for extra payment slope the sides of the excavations and/or provide and fix strong and sufficient timbering to support the sides and/or bottom of excavations to prevent against collapse and movement to the satisfaction of the S.O., and shall maintain the same until, in the opinion of the S.O., the construction work is sufficiently advanced to permit the timbering to be withdrawn. Timbering shall be removed only under the personal supervision of a competent foreman.

The S.O. may order close timbering wherever it may appear to him to be necessary, and no claim for extra payment shall be made for this by the Contractor.

3.3 - EXCAVATION (Cont'd)

Stability Of Excavations (Cont'd)

The Contractor shall be responsible for any injury to the work or consequential damages caused by or arising out of the removal of timbering, and any advice, permission or approval given by the S.O. relating to the removal of timbering shall not relieve the Contractor from his responsibility under the Contract.

Timber Left in Excavation

If, as the excavations are being filled in, it is necessary in the opinion of the S.O. to leave in position any timbering, The Contractor shall be paid for it provided that, in opinion of the S.O. the necessity of leaving the timbering has not arisen from carelessness or neglect on the part of the Contractor. Only the actual quantity of timbering left in will be paid for and the Contractor's rate shall include for labour in cutting off at any level as directed by the S.O. and for the disposal of additional surplus excavated materials due to leaving in of timbering.

Excavations to be Kept Clear of Water

The Contractor shall be responsible for keeping dry all excavations, whether in open cut or in trench, so as not to interfere with the work in progress. He shall without claim for extra payment provide, form, fix, maintain and work as and where directed by the S.O. such pumps, wells, drains, dams, and other things necessary to effectively deal with all water which may collect, or find its way into the excavations from any cause whatsoever. Nevertheless, all methods employed for dealing with water shall be to the approval of the S.O. Such approval shall not relieve the Contractor from his liability for any damage to the Works or adjoining land and property or water courses due to his operations.

The Contractor shall carry out any diversion and subsequent restoration of such existing rivers, water courses, land springs, ditches, etc., wherever encountered during the execution of the Works, whether shown on the Drawings or not.

Backfilling of Excavations Other Than Pipe Trenches

No backfilling of any excavation shall be carried out without the prior approval of the S.O. No backfilling shall be carried out until the works therein have been approved by the S.O.

3.3 - EXCAVATION (Cont'd)

Backfilling of Excavations Other Than Pipe Trenches (Cont'd)

In backfilling excavations other than pipe trench excavations, the best and most suitable portions of the excavated material shall be employed. The material shall be deposited and spread in layers of not more than 12" deep; each layer shall be thoroughly rammed and watered if required.

If so directed by the S.O. the backfilling shall be finished off slightly proud of the surrounding ground to allow for settlement, but the Contractor shall make good any settlement which may occur during the construction of Works and during the Defects Liability Period of the Contract at his own expense.

After the pipe laying has been approved by the S.O. and before the pipelines have been satisfactorily tested, only sufficient backfilling of the trench to prevent 'snaking' and to maintain the pipes in position will be permitted, but all joints shall be left exposed. In low lying ground or any other locality where the trench may be filled with water and cause floatation of the pipes, or elsewhere as may be decided by the S.O., the backfilling shall follow the pipe laying as closely as possible.

In backfilling pipe trenches selected materials free from stones or rocks or other hard materials shall be carefully spread along the trench bottom between the pipes and the trench walls to a depth of about 4" and shall be hand rammed. Further layers each of about 4 inches thick of the same materials shall be the spread and rammed in the same manner as the first until the backfill is 12" above the top of the pipes.

The material for the remainder of the trench need not be as carefully selected as the initial filling material, but it shall be reasonably free from stones and hard materials, and shall not be too wet or dry. It shall be placed in 12-inch layers, and thoroughly compacted. Approved mechanical rammers shall be used after the filling has reached the height of 2' 6" above the top of the pipes. Backfilling shall be finished off slightly proud of the surrounding ground to allow for settlement and the Contractor shall make good any settlement during the Defects Liability Period of the Contract, and during the Contract Period.

Where the pipe trench cuts the mettaled surface of a road, the backfilling and tamping shall be carried out with extra care. The Contractor will not be called upon to remetel the road surface, but he shall replace any blocks or metalling removed while excavating the trench in the proper sequence and shall leave the backfilling level with the adjoining road surface, and maintain its level during the Contract Period.

3.3 - EXCAVATION (Cont'd)

Backfilling of Excavations Other Than Pipe Trenches (Cont'd)

If the quantity of selected fill is not available from the excavated material, the Contractor shall at his own expense obtain the balance by excavation in areas approved by the S.O.

Removal of Surplus Spoil

When removing surplus spoil, the Contractor shall, with dispatch, clear up all carriageways, footways, verges affected by his work, and leave the site of the Works clean and tidy. If surplus is tipped into or removed from private property the operations shall be executed with the approval of, and the least possible amount of inconvenience to, the owner and occupier of the same.

The Contractor shall have no right of ownership to the surplus materials excavated.

The Contractor will not be permitted to use sand, gravel, puddle clay, or other material arising out of the excavations for incorporation in the permanent Works, except with the special permission in writing of the S.O.

Hardcore

Hardcore shall be composed of approved broken stone, brick, concrete or other similar approved material free from dust, foreign matter and other impurities. It shall be of approved quality and size. Samples of hardcore material shall be submitted for approval before use.

The approved hardcore material shall be uniformly placed in position in layers to make up to the required level. The interstices in each layer shall be filled and blinded with sand and well watered and rammed. Each layer shall not exceed 9" thick.

3.3 - EXCAVATION (Cont'd)

Embankments

Embankments and filled areas shall be made by depositing approved soil in regular layers not more than one foot in loose thickness. Each layer shall be well compacted with approved mechanical rammers or rollers before the next layer is placed. Compaction shall continue until the soil is at a density not less than that of any adjacent cuttings in the in-situ state. All practical steps shall be taken to avoid the inclusion of excess water in the fill, and the finished surface of each layer shall be sufficiently even to prevent the ponding of rain water in ruts and hollows. The S.O. may direct the filling to stop in inclement weather. In dry weather effective consolidation shall be assisted by watering. If the soil for the fill or the previous layer of compacted soil is too moist for further effective compaction the compaction shall be deferred until, in the opinion of the S.O., it has dried sufficiently. The Contractor shall disk harrow the soil to aid the drying if so directed by the S.O. The fill material shall be obtained from the surplus excavated material at the site of the Works or from approved borrow pits.

3.4 CONCRETE WORKS

Reference Standards

The following are the principal standards referred to in this section :

BS 12	Ordinary Portland cement
BS 340	Precast concrete kerbs, channels, edgings and quadrants
BS 368	Precast concrete flags
BS 812	Testing aggregates
BS 882	Aggregates from natural sources or concrete
BS 1200	Building sands from natural sources
BS 1377	Methods of test for soils for civil engineering purposes
BS 1881	Testing concrete
BS 3148	Tests for water for making concrete
BS 4027	Sulphate-resisting Portland cement
BS 4251	Truck type concrete mixers
BS 4550 Part 1	Methods of testing cement : Chemical tests
BS 5075 Part 1	Accelerating admixtures, retarding admixtures and water reducing admixtures
BS 5328	Specifying concrete including ready mix concrete
BS 6073	Precast concrete masonry units
BS 6213	Selection of constructional sealants
BS 8007	Code of Practice Design of structures for retaining aqueous liquids
BS 8110	Code of Practice for the structural use of concrete
ASTM C227	Potential Alkali Reactivity of Aggregate - Mortar Bar Method
ASTM C289	Potential Alkali Reactivity of Aggregate - Chemical Method
ASTM C295	Petrographic examination of aggregates for concrete
AWWA C652	Disinfection of water storage facilities

1.0 Test Certificates

Manufacturers' certificates for cement and admixtures confirming compliance with the relevant standard for each consignment are required and shall be kept as records for inspection.

The Contractor shall keep available for inspection certificates of calibration for the weighing and dispensing equipment on the concrete batch mixing plant and the test equipment for testing hardened concrete.

The Contractor shall also keep available for inspection certified test results for all test carried out on aggregates, water, fresh concrete and hardened concrete, all as specified.

2.0 Test Equipment

The Contractor shall furnish all equipment and materials necessary for collecting samples and carrying out field and laboratory tests on materials for concrete and on fresh and hardened concrete or shall make arrangements for testing to be undertaken by a commercial laboratory building, which shall also incorporate space for storage of field test equipment and for curing of concrete test cubes in an orderly manner so that they are readily accessible for testing on the due date. The Contractor shall also furnish all weights, containers and other equipment necessary for testing the weigh-batching equipment for concrete materials and the dispensers for admixtures.

The equipment to be used by the Contractor shall include, but shall not be limited to, the following :

- (i) standard slump cone and accessories;
- (ii) machine, moulds and other accessories for compression tests of 150 mm cubes of hardened concrete;
- (iii) equipment for measuring the surface moisture content of aggregate;
- (iv) equipment for gradation of aggregates

3.0 Records of Concreting

An accurate and up-to-date record showing dates, times, weather and temperature conditions when various sections of the Works were concreted shall be kept the Contractor and shall be available for inspection. The Contractor shall also record the results of all tests of concrete and shall identify these results with the parts of the Works of which the sampled material is representative.

The Contractor shall keep a daily record for each grade of concrete, of the number of batches mixed, the number of batches and total volume of concrete placed, the number of batches wasted or rejected and the weight of cement used.

The record shall also include specific details of each location in the Works where concrete was placed, together with the grade of concrete, total volume of concrete placed and the number of batches used for each location. The record shall be kept available for inspection.

4.0 Construction Joints and Lifts

A construction joint is defined as a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement.

The Contractor shall submit to the Engineer for his approval not less than three weeks before the commencement of concreting, drawings showing his proposals for placing concrete on which the position of all construction joints (if different from those shown on the Drawings) and lifts shall be shown. No concreting shall be started until the Engineer has approved the method of placing, the positions and form of the construction joints and the lifts. The construction joints shall be so located as not to impair the strength of the structure. Rebates, keys or notches shall be formed and waterstops inserted as the Contractor may require. The position of construction joints and the size of formwork panels shall be so coordinated that where possible the line of any construction joint coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series. For all exposed horizontal joints and purposely inclined joints, a uniform joint shall be formed with a batten of approved dimensions to give a straight and neat joint line.

Concrete placed to form the face of a construction joint shall have all laitance removed and the aggregate exposed prior to the placing of fresh concrete. The laitance shall wherever practicable be removed by spraying the concrete surface with water under pressure and brushing whilst the concrete is still green. Where the laitance cannot be removed whilst the concrete is still green the whole of the concrete surface forming part of the joint shall be hacked to expose the aggregate. Where aggregate is damaged during hacking it shall be removed from the concrete face by further hacking. All loose matter shall be removed and the exposed surface cleaned by wire brushing, air blasting or washing, and the surface to which fresh concrete is applied shall be clean and damp.

5.0 Movement Joints or Expansion Joints

Movement joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The Contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Engineer demonstrate that the jointing materials can be applied satisfactorily.

The Contractor shall submit to the Engineer for this approval, as soon as practicable after the acceptance of his Tender and not less than three weeks before the commencement of concreting, details of his proposals for the installation of waterstops. These shall show where joints are to be located and details of the intersections and changes of direction to a scale that shown the position of any joint or shape of any moulded section.

As far as possible jointing on Site shall be confined to the making of butt joints in straight runs of waterstops. Where it is agreed with the Engineer that it is necessary to make an intersection or change of direction or any joint, other than a butt joint in a straight run, on Site, a prefabricated joint intersection or change of direction piece shall be made and submitted to such tests as the Engineer may require.

Flexible waterstops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged waterstops shall be replaced and during concreting care shall be taken to place the concrete so that waterstops do not blend or distort.

The surface of set concrete in a movement joint shall, where specified on the Drawings, be painted with two coats of bituminous paint and fresh concrete shall be placed against it only

when the paint is dry. Expansion joints shall be formed by a separating strip of approved preformed joint filler.

Caulking grooves shall be provided as shown on the Drawings. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried, it shall be primed and caulked with approved jointing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and 25 mm width of concrete on either side shall be painted with two coats of paint having the same base as the caulking compound.

6.0 Materials

6.1 Cement

The cement used for any particular mix shall comply with whichever of the following standards is relevant :-

Ordinary Portland cement	BS 12 or M.S. 522
Rapid Hardening Portland cement	MS 522
Low Heat Portland cement	BS 1370
Sulphate-resisting Portland cement	BS 4027 or MS 1037
Portland Pulverized –Fuel Ash Cement MS 1227	Testing to 60 days strength

All cement shall be obtained from suppliers approved by SIRIM.

In addition to obtaining the test certificates to be provided under BS 12 and BS 4027 the Contractor shall confirm that the factory which has produced the cement carries out chemical composition tests in accordance with BS 4550 Part 2 as a matter of course and that records show compliance with the requirements of Clause 6 of BS 12 and Clause 6 of BS 4027 in respect of them. If required, copies of such records shall be obtained and kept for inspection.

When required the Contractor shall provide performance figures for the current output from the manufacturer in respect of chlorides, sulphur as SO₃ and alkali content as determined using the methods of testing described in BS 4550 Part 2, Clause 17, 12 and 16.2 respectively.

Cement used in the Works shall be ordinary Portland cement unless otherwise specified or found necessary.

Subject to Clause 6.17 (2) no cement shall be used from any factory which shows a current output acid-soluble alkali content greater than 0.6% (calculated as Na₂O+ 0.658 K₂O).

Any cement which is lumpy or partially set shall be rejected and the Contractor shall remove such cement from the Site. Cement which has been stored on the Site for more than forty days and cement which is of doubtful quality shall not be used in the Works unless it has been retested and the test results show that it complies in all respects with the relevant standard.

6.1.1 Transporting and Storage of Cement

The cement shall be transported to the site in a covered vehicle adequately protected against water.

Immediately upon arrival at the Site, cement shall be stored in silos designed for the purpose or in dry weather-tight and properly ventilated structures with floors raised above ground level with adequate provision to prevent absorption of moisture. All storage facilities shall be such as to permit easy access for inspection and identification. Each consignment of cement shall be kept separately and the Contractor shall use the consignments in the order in which they are received.

Cement of different types and from different sources shall be kept in clearly marked separate storage facilities. Cement delivered to the Site in drums or bags provided by the supplier or manufacturer shall be stored in the unopened drums or bags until used in the Works. Any cement in drums or bags which have been opened on the Site shall be used immediately or shall be disposed off.

6.2 Aggregates

6.2.1 Fine aggregate shall consist of natural sand, crushed materials or be a blend as described in BS 882 Section 2.3. The grading shall be in accordance with BS 882 Section 5.2. The maximum quantities of clay, silt and fine dust shall, in any event, not exceed 3% by weight when using the test given in Clause 6.2.4 of BS 812 Part 1.

Limestone or quartzite aggregates shall not be used without the written approval of the Engineer's Representatives.

6.2.2 Coarse aggregate shall comply with the requirements in Table 4 of BS 882 for graded aggregate to the nominal maximum size specified for the appropriate class of concrete and shall be made up from the following single-sized aggregates or well graded.

- (a) 20 mm single sized
- (b) 10 mm single sized

The shape of the aggregates shall be rounded or irregular or angular. The flakiness index, as determined in accordance with BS 812 Part 105, shall comply with the requirement of BS 882 Table 1 and the 10% fines value, as determined by BS 812 Part 3, shall comply with the requirements of BS 882 Table 3.

The aggregates shall be such that concrete when made and tested in accordance with Building Research Establishment Digest 35 (2nd series) shall not show a drying shrinkage greater than 0.065%.

Water absorption of aggregates when tested in accordance with the standard procedure set out in BS 812 Part 2 shall not exceed 3%.

Where aggregates are to be used for concrete of grade G35A and are to be supplied from a location which is not already established as a source of aggregates for high grade concrete the Contractor shall, if so instructed by the Engineer, carry out a petrographic examination of the proposed material in accordance with ASTM C295 and shall forward the results for examination prior to approval of the source.

Unless otherwise instructed the Contractor shall provide an opinion from an approved independent testing laboratory as to whether samples of proposed aggregate exhibit potential reactivity when tested against ASTM Test C289 or by the 'gel pat' method as described in Part IV of 'Reactions between Aggregate and Cement'.

National Building Studies Research Paper Nr 14 by F.E. Jones and published by HMSO, 1952. If either of these tests indicates that the aggregate is potentially reactive such aggregate shall

not be used until a mortar bar test complying with ASTM Test C227 has established an expansion of less than 0.05% after 3 months.

Limestones or quartzite aggregates shall not be used for concrete destined for construction of water retaining structures unless the Contractor is able to demonstrate that they are of types unlikely to have an adverse effect if used in such structures.

The soluble chloride and sulphate contents of aggregate shall be such that the allowable percentage for chlorides and sulphates as given in Clause 7.3.3 and Clause 7.3.4 are not exceeded.

Any rejected aggregate shall be promptly removed from the site.

6.2.3 Aggregate Samples

Before work on trial mixes of concrete is commenced, the Contractor shall make available for inspection samples weighing 50 kg of each aggregate which he proposes to use. The source of each aggregate shall be clearly marked on the container of each sample. Certified test results demonstrating compliance with the relevant quality standard shall be made available at the same time. Samples shall remain preserved at Site for reference.

Samples and certified test results shall be submitted for each new source of aggregate proposed by the Contractor in the course of the Contract.

6.2.4 Storage of Aggregates

The Contractor shall provide means of storing the aggregates at each point where concrete is made such that

- a. each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times;
- b. contamination of the aggregates by the ground or other foreign matter shall be effectively prevented at all times; and
- c. each heap of aggregate shall be capable of draining freely.

The Contractor shall ensure that graded coarse aggregates are tipped, stored and removed from store in a manner that does not cause segregation.

Wet fine aggregate shall not be used until it has drained to a constant and uniform moisture content, unless the moisture content of the fine aggregate is monitored continuously and the amount of fine aggregate and added water is adjusted for each batch to allow for the water contained in the fine aggregate.

If necessary to meet the requirements of this clause, the Contractor shall protect the heaps of fine aggregate against inclement weather.

6.2.5 Sampling and Testing of Aggregates

The Contractor shall sample and carry out a mechanical analysis of the fine aggregate and each nominal size of coarse aggregate in use employing the methods described in BS 812 at least once in each week when concreting is in progress and more often where deemed necessary. The grading of all aggregates shall be within specified limits and should the fraction of aggregate retained on any sieve differ from the corresponding fraction of aggregate in the approved mix by more than 2% of the total quantity of fine and coarse aggregate, the

Contractor shall consider the effect of this difference and, if desirable, shall make an appropriate adjustment to the relative proportions of the aggregates in the mix.

6.3 Water

Water for washing aggregates and for mixing concrete and curing shall be clean and free from harmful matter and satisfy the recommendations in the Appendix to BS 3148. The Contractor shall take periodic samples of the water being used or which it is proposed to use for mixing concrete and test them for quality, including determining the concentrations of sulphates and chlorides, which shall be such that the concrete mix as a whole complies with the specified limit for salt content. If river water is the only source available, the Contractor shall, additionally, arrange for the water to be settled for 24 hours in order that the silt content of the water can be reduced to within an acceptable limit.

6.4 Admixtures

Admixtures shall mean material added to the concrete materials during mixing for the purpose of altering the properties of the concrete mix.

Admixtures containing calcium chloride shall not be used. Proprietary products may only be used if they have been approved by the Consultant Engineer.

Admixtures shall be included in the mix if the Engineer considers that their use will be particularly advantageous to the construction of the Works.

A record shall be kept of the following :

- i. the name of the product used;
- ii. the chemical names(s) of the main active ingredient(s) of the admixture;
- iii. the batches to which admixtures have been added;
- iv. the dosage

Admixtures shall comply with BS 5075.

When more than one admixture is used in a concrete mix the compatibility of the various admixtures shall be ascertained by standard tests and certified by the manufacturers.

Admixtures shall be used in accordance with the manufacturers' instructions.

6.5 Additional Materials

Additional materials such as p.f.a complying with MS 1226, ground granulated blast-furnace slag (g.g.b.f.s) complying with BS 6699 and others may be used provided that the concrete complies with the same grade as would be achieved by Portland cement concrete complying with MS 522 and prior approval of the SO.

7.0 Classification of Concrete Mix

Unless otherwise stated, **concrete mix shall be designed mix**. However, prescribed may be used provided : -

- i. The work is of minor nature or involving a quantity of concrete less than 1 m³.
- ii. The S.O approved is given, and
- iii. The strength of the concrete is still the responsibility of the contractor.

When Portland Pulverized – Fuel Ash Cement or additional material described in Subsection 6.5 is proposed to be used, the concrete mix shall be designed mix only.

Each mix shall be designed to comply with requirements specified and be such that :

- (i) The aggregate shall comprise both fine aggregate and coarse aggregate. The maximum size of coarse aggregate shall be 20 mm unless shown otherwise on the Drawings.*
- (ii) The cement content shall not be below the minimum specified for the grade of concrete nor shall it exceed the maximum where this is specified.*
- (iii) The maximum free water / cement ratio shall be the maximum water / cement ratio measured when the aggregate is saturated but surface dry.*
- (iv) The mixes shall be designed to produce a mean concrete cube strength at 28 days after manufacture such that the conditions in both (a) and (b) below are met :-*
 - (a) the average strength determined from any group of four consecutive test results exceeds the specified characteristic strength by :-*
 - 3 N/mm² for concrete of grades between G20 and G35.*
 - 2 N/mm² for concrete of grade G20 and below.*
 - (b) the strength determined from any test result is not less than the specified characteristic strength minus*
 - 3 N/mm² for concrete of grades between G25 and G35.*
 - 2 N/mm² for concrete of grade G20 and below.*

For any concrete containing admixtures, the strengths shall not be less than those specified but the mixes for the grade of concrete will be separately designed to take account of the effects of the admixtures, and shall have separate trial mixes made and tested.

7.1 Prescribed mix

Unless otherwise specified, the concrete mix shall be as detailed in [Table 1](#). The mix prescribed in the table does not require the use of admixture.

For small volume concreting work less than 1 m³, volume batching is permitted provided prior approval of the S.O is obtained. The proportion shall be as specified in [Table 1A](#).

7.2 Design Mix

For designed mix, the Contractor shall submit a mix design report covering all concrete mixes to the S.O for approval. The design mix shall comply with the requirement as tabulated in [Table 2](#).

It is the responsibility of the Contractor to ensure that the designed mix shall be durable, workable, comply with strength grade and other requirements as specified in the Drawings.

7.2.1 Target Mean Strength

The concrete mix shall be design to have at least the required minimum cement content and to have target mean strength greater than the required grade concrete by at least the current margin.

The current margin for each particular type of concrete shall be determined by the contractor and shall be taken as the lesser of :-

- i. 1.64 times the standard deviation of the cube test on at least on 100 separated batched of concrete of nominally similar proportion of similar materials and produced over a period not exceeding 12 months by the same plant under similar supervision, but not less than 2.5 N/mm² for concrete of grade 15 or 3.75 N/mm² for concrete of grade 20 and above.
- ii. 1.64 times the standard deviation of the cube test on at least on 40 separated batched of concrete of nominally similar proportion of similar materials and produced over a period exceeding 5 days but not exceeding 6 months by the same plant under similar supervision, but not less than 5.0 N/mm² for concrete of grade 15 or 7.0 N/mm² for concrete of grade 20 and above.

7.2.2 Suitability of Proposed Mix Proportions

The Contractor shall submit for the approval of the S.O., prior to the supply of any designed mix, the following informations:-

- i. The nature and source of each material,
- ii. Appropriate existing data as evidence of acceptable previous performance for target mean strength, current margin, workability and water/cement ratio; or full details of the tests on trial mixes carried out in accordance with subsection 7.2.3
- iii. The proposed quantities by weight of each material per cubic meter of fully compacted concrete.

7.2.3 Trial Mixes

As soon as suitable mixes have been designed, one batch from a trial mix for each grade shall be produced in a laboratory using cement and surface dry aggregates known to be typical of the proposed source of supply. The proposed mix proportions for each grade shall be considered satisfactory only if the batch for each grade has the correct cement content and a free water to cement ratio at or below the maximum value for the proposed degree of workability. The proposed workability shall be appropriate to the eventual placing conditions. Where this cannot be pre-determined, the trial mixes shall be designed to have a slump of 100 mm.

When mix proportions have been found satisfactory, a further batch of concrete for each grade shall be made at Site under full scale production conditions using the same mixing time and handled by means of the same plant which the Contractor proposes to use in the Works.

The proportion of cement, aggregates and water shall be carefully determined by weight in accordance with the satisfactory mix design, and sieve analysis shall be made, by the method described in BS 812, of the fine aggregate and each nominal size of coarse aggregate used.

The slump of each batch of each trial mix shall be determined immediately after mixing by the method described in BS 1881 and shall not be outside the limits specified under workability in Clause 7.3.5

Sets of three 150 mm compression test cubes from each batch shall be made by the Contractor from each site trial mix. The cubes shall be made, cured, stored and tested at 28 days after manufacture in accordance with the method described in BS 1881. If the average value of the compressive strength of the three cubes taken from any trial mix is less than the minimum target mean strength determined by the Engineer and used in the mix design or if any individual cube test result falls below 85% of the target mean strength, the Contractor shall re-design that mix and a further trial mix and set of test cubes.

If at any time during the construction of the Works a change is made in the source of cement or aggregate or if the grading of the aggregate alters to such an extent that the fraction of

aggregate retained on any sieve cannot be maintained within 2% of the total quantity of fine and coarse aggregate when adjusted as specified for sampling and testing of aggregates, and these conditions result in a general lowering of cube strengths, then further trial mixes of concrete shall be made and shall be tested until suitable for use.

7.3 Requirement for Concrete

7.3.1 Grades of Concrete

Grades of concrete containing ordinary or sulphate-resisting Portland cement for use in the Works shall be as shown in the table 2.

Concrete grade is that number which represents its 28 day characteristic strength expressed in N/mm².

Characteristic strength is that value of cube crushing strength below which not more than 5% of all test results fail. This condition shall be deemed to be satisfied when test results comply with the specified test requirements.

Notes :

1. All mixes assume 20 mm maximum size aggregates. Refer to Table 6.3 of BS 8110 for adjustments to cement content for different maximum sized aggregates.
2. All mixes assume Class 1 sulphate conditions. Refer to Table 6.1, BS 6110 if concrete is likely to be exposed to sulphate attack (G25, G30 and G35A only).
3. The water cement ratio and minimum cement contents of mixes G35A, G30 and G25 assume SEVERE exposure conditions as defined in Table 3.2 of BS 8110. Refer to Table 3.4 or Table 6.2 for any necessary adjustments due to different exposure conditions.
4. If necessary, admixtures complying with BS 5075 should be used to ensure compliance with the cement content and water / cement ratio requirements, particularly for Grade G35A.

7.3.1.1 Minimum structural concrete strength

All structural concrete to have a minimum strength of 25 N/mm².

7.3.2 Free Water / Cement Ratio

In designing and establishing satisfactory mixes of concrete for any part of the Works the Contractor shall keep strictly within the limitations on free water / cement ratios which may be shown on the Drawings or expressly stated elsewhere as applying to concrete for particular parts of the Works.

7.3.3 Salt And Alkali Content

- (1) The selection and proportioning of ingredients shall be undertaken with the aim that no concrete or satisfactory mix shall contain more than the following total quantities or substances expressed as percentages by weight of cement.
 - (a) For mixes containing ordinary Portland cement to BS 12 :
Total water soluble chlorides : 0.4% (as ratio by mass of total chloride ions to cement content).

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- (b) For mixes containing cement complying with BS 4027 :
Total chlorides : 0.2% (as ratio by mass of total chloride ions to cement content).
- (c) For all mixes :
Total acid soluble sulphates : 4.0% (as ratio by mass of total sulphate ions to cement content).

Tests shall be carried out in accordance with the following standards :

- chloride in aggregates	BS 812	Part 4
- sulphate in aggregates	BS 1377	Part 9
- chloride in mixing water	BS 812	Part 4
- sulphate in mixing water	BS 1377	Test 10

The amounts of chloride and sulphate in the cement shall be taken from the performance figures for current output as described in Clause 3.8.

- (2) The Contractor may use cement with an alkali content greater than 0.6% if the concrete to be made from such cement contains less than 3.9 kg/m³ alkali from all sources including equivalent of any chlorides in the mix.

7.3.4 Max Sulphate Content

The total estimate Sulphate content of any mix, including that present in the cement shall not exceed 4% by weight of cement in the mix. When necessary, test shall be carried out in accordance with B.S. 1881 for each grade of concrete to demonstrate that these limits are not exceeded.

7.3.5 Workability

The workability of each grade of concrete shall be such that satisfactory compaction can be obtained when the concrete is placed and vibrated in the work and that there is no tendency to segregate when it is handled, transported and compacted by the methods which the Contractor proposes to use in the Works.

Workability shall be measured by slump as described in BS 1881. The tolerance on the specified slump shall be ± 25 mm or one third of the designed workability, whichever is the greater.

7.3.6 Cement Content

7.3.6.1 Minimum Cement Content

The minimum cement content shall be in accordance with table 2, unless otherwise shown on the Drawings.

7.3.6.2 Maximum Cement Content

The maximum cement content shall not exceed 550 kg/m³, unless otherwise shown in the Drawings or as approved by the S.O. and special consideration has been given in the design to the increased risk of cracking due to drying shrinkage in thin section or to thermal stress in thicker section.

8.0 Sampling and Testing of Concrete

The Contractor shall provide slump cones and associated equipment and shall measure the workability of concrete in accordance with BS 1881 from time to time during the day at the point where the concrete is being placed.

For each grade of concrete, works test cubes shall be made not less frequently than as follows unless otherwise particularly specified.

For concrete of grade G25 and above - One set of cubes per 50 m³ or part thereof if requested by SO, per day;

For concrete of grade G20 and below - One set of cubes per 100 m³ or part thereof if requested by SO, per day;

Each set of cubes (two cubes per set) shall be made from a single sample taken from a randomly selected batch of concrete and cured for 28 days. On completion of the curing, the specimens shall be tested and the average of the two results shall be taken as the test result.

The procedure for making curing and testing the samples shall be as described in BS 1881 Part 108, Part III and Part 116 respectively.

8.1 Compliance with Specified Requirements

The concrete shall be deemed satisfactory provided that :

- a. The average 28 days strength determined from any group of four consecutive results exceeds the specified characteristic strength by not less than 3 N/mm² for grades G35A, G30 and G25 concrete and 2.0 N/mm² for grade G20 and below.
- b. Each individual test result is not less than the specified characteristic strength minus 3 N/mm² for grades G35A, G30 and G25 concrete and 2.0 N/mm² for grade G20 and below.
- c. The slump shall be appropriate to the placing conditions and shall not vary from the specified value by more than ± 25 mm or one third of the specified value, whichever is the greater.

If only one result in a group of four consecutive results fails to meet the second requirement, that result may be considered to represent only the particular batch of concrete from which the sample was taken, provided that the average strength of the group satisfies the first requirement.

If more than one result in a group of four consecutive results fails to meet the second requirement or if the average strength of any group of four consecutive test results fails to meet the first requirements then all the concrete in all the batches represented by all such results shall be deemed not to comply with the strength requirements.

8.1.1 Prescribed Mix

8.1.1.1 Mix Proportion

A prescribed mix shall be judged on the basis of the specified mix proportions based on the batches observation. The mix proportion shall be within +/- 5% of the values specified. The workability shall be chosen to suit the construction requirements as described in Table 1.

8.1.2 Design Mix

8.1.2.1 Characteristic Strength

The Characteristic Strength of the concrete is the compressive strength below which not more than 5% of the test result may be expected to fall. Compliance with the specified characteristic strength shall be judged by test made on the cube at an average of 28 days. The workability shall be as described in Subsection 7.3.5.

8.1.2.2 Test on Consistency

While work on concreting is in progress, test on the workability of the mix shall be carried out at suitable interval and in addition whenever any material or the proportion of the mix are changed, or when directed by the SO.

8.2 Non-Compliance with Specified Requirements

When the average strength of a group of four consecutive test results fails to meet the first requirement, no further concrete from that mix shall be placed in the work and the Contractor shall establish the cause of the failure and apply such remedies as are necessary.

The Contractor shall within 24 hours of the date of the test notify the Engineer of the proposed action to be taken in respect of any concrete represented by test results which fails to meet any of the requirements. These proposals may include, but shall not be limited to, cutting and testing cores.

Concrete which is ultimately found not to comply with any of the requirements of the Specifications shall be rejected or the Contractor shall carry out any necessary approval remedial measures to the approval of the Consultant Engineer.

8.3 Cutting and Testing of Core Samples

Where cutting and testing of cores has been proposed, cylindrical core specimens of 150 mm nominal diameter shall be cut normal to the face of the hardened concrete for the purpose of examination and testing. The procedure for drilling, examination, measurement and testing for compressive strength shall be in accordance with BS 1881 Part 120. If the crushing strength of the specimen determined in accordance with paragraph 7 of BS 1881 Part 120 is less than the characteristic strength at 28 days for the grade of concrete or if the concrete fails to meet the specified requirements in other respects, the concrete in that part of the Works of which it is a sample shall be considered not to comply with the specified requirements.

9.0 Product of Concrete

9.1 Material Batching

All cement used in the manufacture of concrete shall be measured by weight either with an approved weighing machine or by making the size of each batch of concrete such as to require an integral number of complete bags or drums of cement.

For concrete of grades G25, G30 and G35A the fine aggregate and the several nominal sizes of coarse aggregate shall be measured singly or cumulatively by weight using weigh-batching machines.

For concrete of grade G20 and below, the fine and coarse aggregate will be measured separately either by weight using weigh-batching machines or by volume in gauge boxes.

Weigh-batching machines shall provide facilities for the accurate control and measurement of the aggregates either singly or cumulatively and shall be capable of immediate adjustment by semi-skilled operators in order to permit variations to be made to the mix. All weight dials shall be easily visible from the place at which filling and emptying of the hoppers is controlled.

Each concrete mixing machine shall be of a recognized proprietary make and shall comply as closely as possible to the following specification in respect of the additional of water to the mix :

- a. A device is fitted to measure added water by weight and so constructed that the water inlet and outlet valves are interlocked so that either one of them cannot be opened unless the other is fully closed.
- b. The measuring device is provided with an overflow with a cross-sectional area at least four times that of the inlet pipe and with its discharge point clear of the mixing plant.
- c. The measuring device is fitted with a drain pipe which allows the full quantity of water being measured to be drained off for checking the measurement.
- d. The outlet arrangement of the measuring device is such that between five and ten per cent of the water enters the mixer before the other materials and a further five to ten per cent of the water enters the mixer after the other materials.
- e. The remainder of the water is added at a uniform rate with the other materials.
- f. The water measuring device is readily adjustable so that the quantity of water added to the mixer can, if necessary, be varied for each batch.

Where volume batching is permitted by the Specification, gauge boxes shall be soundly constructed of timber or steel to contain exactly the volume of the various aggregates required for one batch of each mix. They shall have closed bottoms and shall be clearly marked with the mix and aggregate for which they are intended. When calculating the size of the gauge box for fine aggregate, all allowances shall be made for the bulking of the fine aggregate due to the average amount of moisture contained in the stockpile on the Site. Any admixtures which may be used shall be measured separately in calibrated dispensers.

All mixing and batching plants shall be maintained free of set concrete or cement and will be clean before commencing mixing. The accuracy of calibration of the weighing plant, water measuring plant and admixture dispenser shall be checked before carrying out trial mixes, before mixing concrete for inclusion in the Works, after each service or adjustment to the mixing plant, and in any case at least once per month.

9.2 Mixing Concrete

Concrete shall be mixed in batches in plant capable of combining the aggregates, cement and water (including admixtures, if any) into a mixture uniform in colour and consistency, and of discharging the mixture without segregation.

On commencing work with a clean mixer, the first batch shall contain only half the normal quantity of coarse aggregate to compensate for the adhesion of other materials to the drum.

The moisture contents of the aggregates shall be determined before the commencement of each day's concreting and at such intervals during each day as may be necessary. The Contractor shall make due allowance for the water contained in the aggregate when determining the quantity of water to be added to each mix, and shall adjust the amount of water added to each mix to maintain constant the design free water / cement ratio of the mixed concrete.

9.3 Preparing for Concreting

Before placing concrete the Contractor shall remove from the surface of the foundations or previously placed concrete, all oil, loose fragments of rock, earth, mud, timber and other debris, and standing water.

Where specified and elsewhere as deemed necessary the excavated surfaces shall be prepared as specified under concrete protection.

9.3.1 Preparation of Forms before Concreting

Before concreting, all forms shall be thoroughly cleaned out, free from sawdust shavings, dust, mud or other debris.

The inside surfaces of the forms shall, except for permanent formwork, or unless otherwise approved by the S.O., be coated with an approved non-staining form oil or other approved material to prevent adhesion of concrete. Such release agents shall be applied strictly in accordance with the manufacture's instructions and shall not come into contact with the reinforcement or prestressing tendons and anchorage. For any exposed surface only one release agent shall be used throughout the entire area.

All Formwork shall be inspected by the S.O. after preparation and immediately prior to depositing concrete and no concrete shall be deposited until approved of the formwork has been obtained.

9.4 Transporting Concrete

Concrete shall be conveyed from the mixer to its place in the Works as rapidly as possible by methods which will prevent segregation or drying out and ensure that the concrete is of the required workability at the time of placing. The length and drop of conveyors or trunking proposed for delivery of concrete into its position in the Works shall limit the free fall of concrete to 1/5 m and shall be subject to approval by the Engineer. If segregation has nevertheless occurred in any instance, the materials shall be remixed or rejected.

Unless otherwise agreed by the Engineer, truck mixer units and their mixing and discharge performance shall comply with the requirements of BS 4251. Mixing shall continue for the numbers and rate of revolutions recommended in accordance with Item 9 in Appendix "B" of BS 4251 or, in the absence of the manufacturer's instructions, revolutions at a rate of not less than seven revolutions per minute.

9.5 Placing Concrete

Concrete shall be placed and compacted before the initial set has occurred and in any event not later than 45 minutes after the adding of water to cement, aggregate mix.

When pneumatic placers are used, if the end of the placer pipe is not equipped with an energy absorbing device, it shall be kept as close to the work as practicable. Mortar or water used at the beginning or end of a run shall be discharged outside the formwork.

The placing of concrete shall be suspended during heavy rain.

No fresh concrete shall be placed against concrete that has attained its initial set without the formation of a construction joint.

Ready mixed concrete may be used only with the agreement of the Engineer and shall comply with all clauses of this Specification with regard to Concrete.

The concrete shall be carried in purposely made agitators, operating continuously, or truck mixers. The concrete shall be compacted in its final positions within two hours of the introduction of cement to the aggregate. The time of such introduction shall be recorded on the delivery note, together with the weight of the constituents of each mix.

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.

9.5.1 Concreting in Hot /Dry Weather

In hot weather, the Contractor shall take steps to limit the temperature of the concrete as placed and ensure that the maximum temperature of the concrete when leaving the mixer shall not exceed 32 degrees C and that the maximum internal temperature attained during setting does not exceed 70 degrees C.

To achieve this, the Contractor shall provide sun shades over stockpiles of aggregate, cement silos, mixing water tanks and pipelines, and in addition shall carry out the following procedures:

- (i) Shade or wet the outside of the formwork.
- (ii) Apply a fine moisture (fog) spray of clean cool water to shaded areas immediately prior to placing concrete.

If the maximum setting temperature is exceeded, the Engineer will reject any concrete showing signs of cracking.

9.5.2 Concrete Placed in Water

Concrete shall only be placed in water where it is not practicable to place the concrete in the dry, the quantity of cement in any concrete placed in water shall if necessary be increased so that the free water / cement ratio of the mix is not more than 0.47.

Concrete shall not be placed in running water nor shall concrete be allowed to all through water.

Concrete shall only be placed in water with a bottom-opening watertight box or a tremie. Bottom-opening boxes shall not be opened until they are resting on the work, and the lower ends of tremies shall always be kept below the surface of freshly placed concrete.

9.6 Compaction

All concrete placed in situ shall be compacted with power driven vibrators supplemented by hand spading and tamping. The vibrators shall at all times be adequate in number, amplitude and power to compact the concrete properly and quickly throughout the whole of the volume being compacted. Spare vibrators shall be readily on hand in case of breakdown.

Internal vibrators shall be inserted into the uncompacted concrete vertically and at regular intervals. Where the uncompacted concrete is in a layer above freshly compacted concrete the vibrator shall be allowed to penetrate vertically for about 100 mm into the previous layer. In no circumstances shall vibrators be allowed to come into contact with the reinforcement of formwork nor shall they be withdrawn quickly from the mass of concrete but shall be drawn back slowly so as to leave no voids. Internal type vibrators shall not be placed in the concrete in a random or haphazard manner nor shall concrete be moved from one part of the work to another by means of the vibrators.

External vibrators may only be used where expressly approved as being more suitable for use under the prevailing conditions.

The duration of vibration shall be limited to that required to produce satisfactory compaction without causing segregation. Vibration shall on no account be continued after water or excess grout has appeared on the surface.

After the concrete has been thoroughly compacted, the surface shall be worked to a dense true finish with a wooden or steel float to the tolerance given in Table 4.

9.7 Curing of Concrete

Concrete shall be cured by protecting the surface from the effects of sunshines, drying winds, rain, running water or mechanical damage for a minimum continuous period of five days when the cement used in the concrete is ordinary Portland cement. The protection shall be applied as soon as practicable after completion of placing by one or more of the following methods :

- i. by water sprays in continuous operation;
- ii. by covering with hessian or similar absorbent material, or sand kept constantly wet;
- iii. after thorough wetting, by covering with a layer of waterproof fabric kept in contact with the concrete surface;
- iv. by the application of an approved non-staining liquid curing membrane, which is either self removing or easily removed following the curing period, which has a 75% moisture retention standard. The liquid shall be applied to formed surfaces immediately after stripping of the formwork.

10 Attendance of Steel Fixer and Carpenter

During the concreting of all reinforced concrete, a competent steel fixer and carpenter shall be in attendance on each concreting gang, and shall ensure that the reinforcement, formwork and embedded fittings are kept in position as work proceeds.

11 Grout

Grout shall be a cement paste mixture consisting of cement and water or cement, fine sand and water. Cement shall be ordinary or sulphate-resisting Portland cement. The volume of water shall be the minimum necessary to produce a homogeneous mixture suitable for its intended use.

12 Porous Concrete

Porous concrete for use in drainage layers shall be a paste mixture comprising cement, fine and coarse aggregates and water. Cement shall be ordinary or sulphate-resisting Portland cement. The ratio of fine to coarse aggregate shall be 0.15. The volume of water shall be the minimum necessary to produce a homogeneous mixture suitable for its intended use.

The mix shall comply with the following requirements as in Table 3.

13 Porous No-Fines Concrete

No-fines concrete shall be composed of ordinary Portland cement and 40 mm single size aggregate complying with BS 882.

The ratio of aggregate to cement shall be 8 : 1 by volume or 10 : 1 by mass.

The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout.

The concrete shall be compacted by hand only.

14 Mass and Lean Concrete

Mass and lean concrete shall compose of cement, fine aggregate and coarse aggregate in the nominal ratio by volume of 1:3:6 and 1:4:8 respectively. A blinding layer of 50 mm minimum thickness of lean concrete shall be laid on well prepared firm ground before any reinforcement is placed in position.

15 Hardcore

Hardcore, unless otherwise described, shall consist of clean, hard broken bricks, concrete, stone or other chemically inert material broken to pass a 100 mm ring, deposited, spread and leveled, in layers not exceeding 150 mm thick, mechanically well rammed and consolidated and blinded with sand and water. The hardcore shall be to the full thickness as stated or required after ramming and consolidating.

16 Surface Finishes

Finishes shall generally be provided as described below or as specified on the Drawings.

16.1. Formed Surfaces

Class F1

Surfaces against which further concrete is to be placed and surfaces to be permanently concealed by rendering, plastering, etc.

Class F2

All surfaces permanently exposed to view, except where Class F3 is required.

Surfaces either permanently or periodically in contact with stored, retained or flowing liquids.

Surfaces against which a membrane tanking is to be applied.

Class F3

“Ribbed” and “exposed aggregate” finishes.

Surfaces prominently exposed to public view where good appearance is of special importance. Class F3 is also known as “fairfaced” finish.

16.2 Unformed Surfaces

Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, ‘spaded’ or ‘bonded concrete’ or such other special finish as may be particularly specified. Where the class of finish is not specified the concrete shall be finished to Class U1.

Class U1 finish is the first stage for Class U2 and U3 finishes and for a bonded concrete surface. Class U1 finish shall be a leveled and screeded, uniform plain or ridged finish, which (unless it is being converted to Class U2, U3 or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing, surplus concrete being struck off immediately after compaction.

Where a bonded concrete surface is specified, the laitance shall be removed from the Class U1 finish surface and the aggregate exposed while the concrete is still green.

A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the Works.

Class U2 finish shall be produced by manual or mechanical floating of the concrete surface after the initial set has taken place and the surface has hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform ‘sandpaper’ finish free from screedmarks.

Class U1

Surfaces of foundation slabs and other structural members to be subsequently covered by further stages of concrete construction, bonded concrete toppings or cement / sand screeds.

Class U2

All surfaces permanently exposed to view, except where Class U3 finish is required. Surfaces either permanently or periodically in contact with stored, retained or flowing liquids. Surfaces including those of blinding concrete, against which a membrane tanking is to be applied.

Class U3

For hard smooth surfaces to slabs, walls, parapets and other structural members, where exposed to weathering.

16.3 Remedial Treatment of Surface

Any remedial treatment of surface shall be approved by the S.O. following inspection immediately after removing the formwork and shall be carried out without delay.

Any concrete, the surface of which has been treated before being inspected by the S.O. shall be liable to rejection.

17 Dimensions and Surfaces of Finished Concrete

Workmanship in formwork and concreting shall be such that concrete will normally require no making good, surfaces being perfectly compacted, smooth and with no irregularities. Concrete surfaces for the various classes of unformed and formed finishes shall in any event never exceed the maximum permitted tolerances which will be as shown in the Table 4 except where expressly stated otherwise in the Specification or Drawings.

In the table “line and level” and “dimensions” will mean the lines, levels and cross-sectional dimensions shown in the Drawings.

Surface irregularities will be classified as “abrupt” or “gradual”. Abrupt irregularities include, but will not be limited to, offsets and fins caused by displaced or misplaced formwork, loose knots and other defects in formwork materials, and will be tested by direct measurement. Gradual irregularities will be identified by means of a straight template for plane surfaces or its suitable equivalent for curved surfaces, the template being 3.0 m long for unformed surfaces and 1.5 m long for formed surfaces.

18 Building in Pipes

When pipes are carried through walls or floors of concrete structures circular or square openings shall be “boxed out”. Such “boxing out” may incorporate a suitable rubber waterstop. After the Contractor has installed the pipework the surfaces of the opening shall be thoroughly wire brushed and the space unoccupied by the pipe filled with concrete of the same class as the adjacent wall in the manner detailed in the Drawings.

19 Precast Concrete Products

Unless otherwise specified or shown in the Drawings, all precast concrete units shall be manufactured in accordance with relevant British Standards, eg. BS 340 for concrete kerbs, BS 368 for concrete flagstones and BS 6073 for concrete blockwork, whether such units are manufactured on Site or obtained from manufacturers approved by the Engineer.

All precast units shall be handled and stacked so as to avoid damage and ensure that no undue stress is imposed on them. The Contractor shall remove from the site and replace at his own expense any precast units which are damaged due to his own negligence or which are rejected by the Engineer.

All units shall be laid, bedded, jointed and fixed in accordance with the lines, levels and other details as shown in the Drawings. Mortar for bedding and jointing precast units shall consist of one part by volume of ordinary Portland cement to two parts by volume of natural sand or crushed stone by grading of BS 1200 Table 2.

19.1 Surface Water Drains and Aprons

Precast concrete surface water drains shall be cast in 610mm lengths with dimensions as shown in the Drawings. The drains shall be properly bedded and jointed with 1:3 cement sand mortar and laid to falls as directed by the S.O.

19.2 R.C. Lintels and Cills

Precast reinforced concrete lintels shall be built to the full thickness of the walls in which they occur and with 230mm bearing on either side of the opening which they span unless smaller bearings are indicated in the Drawings.

Precast reinforced concrete cills shall be cast to the dimensions as shown on the Drawings.

19.3 Precast Concrete Drain Covers

Precast reinforced concrete slabs over drains shall be reinforced as shown on Drawings. Slabs shall have recesses in their end faces to facilitate removal.

20 Inspection Procedures

Before any concrete is placed, the Contractor shall carry out an inspection to ensure that all preparations are completed, including the provision of the necessary equipment and personnel, and shall ensure that sufficient materials are available to complete the work proposed.

21 Concrete Protection System

Where shown on the Drawings structural concrete in contact with the ground shall be protected by prefabricated membrane tanking. Unless otherwise specified or detailed on the Drawings, in situ concrete surfaces which are to be protected shall have either U2 or F2 finishes as appropriate.

The membrane shall be performed consisting of a 1.5 mm thick rubber / bitumen compound formulated for use in hot climates, backed with 0.3 mm thick PVC sheet. The membrane shall adhere with watertight joints to itself at overlaps and to concrete surfaces prepared with a suitable priming compound. The membrane and primer shall be of reputable manufacture and shall have been used successfully in similar circumstances.

The membrane and primer shall be applied in accordance with the manufacturer's instructions to horizontal, inclined and vertical surfaces.

After the blinding concrete has hardened, the membrane shall be applied, bitumen face downwards, and shall extend at least 150 mm beyond the outer limits of the structure. As soon as the membrane has been applied and before any reinforcement or structural concrete is placed, the membrane shall be covered by a sand / cement screed 50 mm thick, extending over the whole area of the base of the structure. The membrane projection of 150 mm shall be temporarily protected with a layer of board to prevent mechanical damage.

After the concrete structure has been constructed up to ground level and curing is completed, the surfaces which shall be in contact with the ground, or as detailed otherwise on the Drawings, shall be primed with the material supplied by the membrane manufacturer. The vertical membrane shall be bonded onto the concrete surfaces to be in contact with the ground and onto the projection of the base membrane and terminated in a chase 100 mm below ground level. Fillets and reinforcing strips shall be used.

Completed areas of vertical membrane shall be protected from mechanical damage during backfill operations by blinding concrete as shown on the Drawings.

22 Sizes and Sequence of Concrete Pours

Before commencing concreting the Contractor shall submit for approval his detailed proposals for the sequence of placing concrete and the positions of vertical and horizontal construction joints. The proposals shall comply with the following :-

Where limitations in lengths of floor or roof slabs that may be cast without joints in any direction are stated on the Drawings, the slabs shall be subdivided by construction joints into panels of dimensions not exceeding the stated limit on length. The panels shall be separately

concreted in one continuous operation and no panels shall be concreted until the concrete in adjacent panels is at least 7 days old.

Where limitations in lengths of wall that may be cast without joints are stated on the Drawings they shall be divided into segments not exceeding the stated maximum length by vertical joints which are continuous with the floor joints and extend the full height of the walls in an unbroken alignment. Each segment above the top of the wall haunch and the top of the wall shall be cast in a series of lifts each of a length and height to be approved by the Engineer.

Alternate segments in a lift shall be concreted and an interval of 7 days shall elapse before the intervening segments in the same lift are concreted.

At each joint rebates shall be formed to receive sealing compounds as shown on the Drawings.

Each segment of the wall flooring and haunch defined by the floor and wall joints shall be concreted in one continuous operation. Segments shall be concreted alternately and an interval of at least 7 days shall elapse before intervening segments are concreted.

23 Cleaning to Water Retaining Structures

All water retaining structures shall, on completion, be carefully cleaned, as follows :

- (a) The structure shall be cleared of all debris and shall be brushed down on all internal faces with a stiff broom while still dry, and all resulting debris removed; all associated reservoir pipework shall be cleaned in accordance with the specification requirements.
- (b) The structure shall then be flooded with approximately 75 mm of clean water and the whole of the internal faces shall be carefully brushed down with stiff brooms, using the water continuously until all faces are clean; the water shall then be drained off, and the walls and floors hosed and flushed with clean water until perfectly clean.

23.1 Testing of Water Retaining Structures

As soon as possible after completion of water retaining structures but not before the concrete has attained its specified 28 days strength they shall be tested for water tightness by filling with clean water up to the designed top water level. The rate of filling shall be reasonably constant and shall not exceed 2 m of depth in 24 hours except in the case of small structures where a higher rate may be allowed by the Engineer. After filling the structure shall be allowed to stand full (being topped up as necessary) for at least 72 hours, for absorption of water by the concrete to take place, at the end of which period the level shall be accurately noted. The structure shall then be tested for a further period of at least 72 hours (48 hours in the case of channels and smaller structures as agreed) and shall be accepted as watertight if :

- a. no leaks or damp patches on the backs of walls are discernible during period of the test (if the backs of walls are wetted by rainfall or any other cause the test must be delayed until they are dry for at least 72 hours). In the case of individual parts of a structure being tested independently, the division walls also must be watertight;
- b. the floor underdrainage system of the structure (if any) remains dry, or the flow in it before the test is not increased as a result of filling the structure with water;
- c. the recorded change in level of the water in the structure minus the loss of water by evaporation gives a figure which does not exceed 1/2000 of the depth of water originally in the structure.

During the 72 hours test period referred to above the loss of water by evaporation shall be determined by measurement of the loss of water from a shallow watertight tray of 0.4 sq m in area containing not less than 75 mm depth of water and positioned to float on the surface of the water in the structure.

The roofs and manhole covers of the closed reservoirs shall be tested for watertightness before the laying of any roof membrane by general observation from within the reservoir for damp patches or eaks over a period of heavy and prolonged rain but should such a suitable occurrence fail to happen, the roof and fittings shall be hosed down vigorously and this shall be repeated in such a way as to keep the roof wet for 3 successive days.

The roof and fittings shall be deemed satisfactory for water-tightness if there are no discernible leaks or damp patches from inside the reservoir. Remedial measures and retesting shall be carried out at the Contractor's expense until satisfactory.

Should any parts of the structure fail the above tests in any respect, the Contractor shall immediately take steps to ascertain the nature and positions of any defects or leakages, shall empty the structure, and remedy the defects in an approved manner. Note that a damp patch appearing on the outside of the wall must be rectified from the water face, a repair making the outer face only watertight shall not be approved; this applies to bobbin holes also.

When the remedial work has been completed in an approved manner, the testing and if necessary rectification shall be repeated until a satisfactory test is achieved.

If necessary, in extreme cases of lack of watertightness, the structure or any member or section of a member thereof may be rejected.

Any expenses in materials (including the supply of water), plant, labour and all other costs including overheads and profit involved in all satisfactory and unsatisfactory watertightness testing of all the water-retaining structures in the works shall be included in the rates entered by the Contractor in the Bill of Quantities. No payment will be made for work associated with unsuccessful testing.

Any costs, incurred by the Contractor in remedial or replacement work necessary to achieve the satisfactory testing shall be entirely at the expense of the Contractor.

23.2 Disinfection of Water Retaining Structures

Disinfection of water retaining structures shall be carried out by the Contractor after these structures have passed the watertightness test.

The structure shall be emptied. The internal surfaces of the walls, the internal surface of the roof, the internal and external surfaces of all pipes and specials inside the structure, and all other surfaces inside the structure shall be vigorously brushed and flushed with jets of clear, clean water until all foreign materials, dirt and grit which may have accumulated thereon are removed. All water and material accumulated in the cleaning operation shall be discharged or otherwise removed from the structures.

The Contractor shall provide evidence to the satisfaction of the Engineer that the chlorine dosage proposed for disinfection will not adversely affect joint sealant materials.

Chlorination shall be carried out by Method 1 or Method 2 as set out below. The Contractor shall submit details of his proposed method of working to the Engineer for approval before commencing disinfection of any structure.

Method 1

The structure shall then be filled to the overflow level with potable water to which enough chlorine is added to provide a free chlorine residual throughout the structure of not less than 10 mg/l at the end of the appropriate retention period. This shall be not less than 6 hours when the water entering the structure has been chlorinated uniformly by gas-feed equipment or chemical pump or not less than 24 hours when the structure has been filled with water which has been mixed with calcium hypochlorite or sodium hypochlorite within the structure as described in Clause 6.50. The procedure set out in AWWA C652 shall be followed.

At the end of the retention period the free chlorine residual shall be reduced to not more than 2 mg/l by draining and refilling or blending with potable water having a low chlorine concentration, after which the water within the structure shall be sampled to determine the free chlorine residual and for bacteriological analysis to check for the absence of coliform organisms of faecal origin. If the results are unsatisfactory the structure shall be drained and the disinfection procedure shall be repeated. The costs of any re-disinfection shall be borne by the Contractor.

Method 2

A solution of 200 mg/l available chlorine shall be applied directly to all surfaces of the structure which would come into contact with water by suitable brushes or spray equipment. The disinfected surfaces shall remain in contact with the strong chlorine solution for at least 30 minutes after which potable water shall be admitted and the structure shall be filled and tested for bacteriological quality as in Method 1.

23.3 Chlorine Bearing Solution / Mixture for Disinfection

The chlorine bearing solution / mixture shall be prepared using clear, clean water and chlorine, either as liquid chlorine, calcium hypochlorite or sodium hypochlorite.

Liquid chlorine shall be introduced into the water filling the structure to give a uniform chlorine concentration during the entire filling operation. Portable chlorination equipment shall be carefully operated and shall include a liquid chlorine cylinder, gas flow chlorinator, chlorine ejector, safety equipment and an appropriate solution tube to inject the high concentration chlorine solution into the filling water. The solution tube shall be inserted through an appropriate valve located in the inlet pipe and near the structure so that the chlorine solution will mix readily with the inflowing water.

Calcium hypochlorite granules, broken to a size not exceeding 0.6 mm maximum dimension, may be poured into the structure from an opening or placed inside on dry surfaces prior to the introduction of flowing water. They shall be so positioned that a current of water circulating around the structure shall dissolve them during the filling operation.

Sodium hypochlorite shall be applied to the water entering the structure by means of a chemical feed pump, or shall be applied by hand-pouring into the structure and allowing the inflowing water to provide the desired mixing.

24 Sealing Compounds

Sealing compounds for horizontal construction joints shall be hot applied bituminous sealants complying with the requirements of BS 6213. Sealing compounds for vertical and inclined

construction joints shall be bituminous putty of a quality approved by the Engineer's Representative. Both sealing compounds shall be capable of expanding to 110% of their original thickness between parallel faces without separation.

Horizontal floor joints and vertical and inclined joints to be filled with the sealing compound shall first be thoroughly cleaned and dried and an approved primer compatible with the sealing compound shall be applied. Each primer and sealing compound shall be applied in accordance with the manufacturer's recommendations for tropical climates.

Sealing compounds for expansion and contraction joints shall be polyurethane or polysulphide liquid polymer sealants complying with BS 6213 obtained from approved manufacturers. The sealing compound shall be capable of expanding to 133% of its original thickness between parallel faces without extruding and contracting to 67% of its original thickness without separation.

Expansion and contraction joints to be filled with the sealing compound shall first be thoroughly cleaned and dried and an approved primer compatible with the sealing compound shall be applied. Both primer and sealing compound shall be applied in accordance with the manufacturer's recommendations for tropical climates.

25 Joint Fillers

Joint filler shall be either cork joint filler or cellular joint filler.

Cork joint filler shall be waterproof and rotproof and shall not extrude as a result of compression. Cork joint filler shall compress to less than 50% of its original thickness with immediate recovery to 80% or more of its original thickness.

Cellular joint filler shall be a preformed low-compression joint filler made from foam rubber. Cellular joint filler shall recover to its original thickness after each loading and unloading.

26 Waterstops

Waterstops shall be of rubber or PVC and shall be of a type and manufacture approved by the Engineer.

Waterstops shall have a base thickness of > 7 mm at the central point or adjacent to the central bulb.

Waterstops for construction joints shall have upstands at least 15 mm in width at the widest point.

Waterstops for contraction and expansion joints shall have upstands as described above and shall have a central hollow section at least 20 mm wide. The Contractor shall carefully follow the manufacturer's instructions in any work involving the incorporation of waterstops into structures.

Waterstops should be fully continuous when laid and site joints shall be limited to simple butt joints which are to be made with the manufacturer's fusing jig. A careful check shall be made on all joints after completion to ensure that no imperfections exist.

Waterstops shall be securely held in position by the formwork or by means to be approved by the Engineer and the concrete shall be carefully worked around the waterstops to ensure that they are completely embedded and that no air pockets will exist.

27 FORMWORK

27.1 Materials

Formwork shall be constructed of timber, sheet metal or other suitable material which shall inter alia prevent loss of grout when the concrete is placed and vibrated. The Sub-Contractor shall also furnish all struts, braces and ties to withstand the placing and vibrating of concrete and the effects of weather.

Form ties shall be the rod and cone or other proprietary type. They shall be designed so that no part remaining embedded in the concrete and formwork has been removed shall be nearer than 50 mm from the surface in the case of reinforced concrete and 150 mm in the case of unreinforced concrete.

Form ties for use in water-retaining structures shall incorporate a diaphragm of not less than 50 mm diameter welded to the mid-point of the tie, designed to prevent water passing along the tie.

27.2 Design and Detailing

The Contractor shall be responsible for the adequacy and safety of formwork.

The Contractor shall retain as records his calculations and designs for formwork including layout of panels and may be required to submit copies of his calculations to the Engineer.

On formwork to external faces which shall be permanently exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joining lines caused by formwork and by construction joints to ensure continuity of horizontal and vertical lines.

27.3 Formed Surfaces – Class of Finish

Finish to formed surfaces of concrete shall be classified as F1 or F3 as specified in Clause 16.1. Where the class of finish is not specified the concrete shall be finished to Class F1.

27.3.1 Formwork for Class F3

Formwork for Class F3 finish shall be lined with panels of non-staining material with a smooth unblemished surface such as sanded plywood or hard compressed fibreboard. The panels shall be as large as possible and shall be arranged in a uniform pattern and fixed to back formwork by oval nails. Unfaced wrought boarding or standard steel panels shall not be used.

27.3.2 Formwork for Class F2

Formwork for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood or metal panels arranged in a uniform pattern free from defects likely to detract from the appearance of the surface.

27.3.3 Formwork for Class F1

Formwork for Class F1 finish shall be constructed of timber, sheet metal of suitable materials. Surfaces subsequently to be rendered, plastered or tiled shall be adequately scabbled or

roughened as soon as the formwork is removed to reduce the irregularities to not more than half the thickness of such rendering, plastering or bedding for tiles and to provide a satisfactory key.

27.4 Erection of Formwork

All formwork shall be soundly constructed, firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete and the effects of weather. Formwork shall not be tied to or supported by reinforcement.

Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all formwork shall be clean and free from standing water. Joints shall be sufficiently watertight to prevent the escape of mortar or the foundation of fins or other blemishes on the face of the concrete.

All exposed exterior angles on the finished concrete of 90 degrees or less shall be given 20 mm by 20 mm chamfers.

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds 15 degrees from the horizontal (except where such top surface is specified as spaded finish) and shall be anchored to enable the concrete to be properly compacted and to prevent air being trapped.

Formwork in contact with the concrete shall be treated with a suitable non-staining mould oil prior to reinforcement and concrete placement to prevent adherence of the concrete except where the surface is subsequently to be rendered. Care shall be taken to prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Surface retarding agents shall not be used unless specified.

Where ties are built into the concrete for the purpose of supporting formwork, the whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer than 50 mm from the surface in the case of reinforced concrete and 150 mm in the case of unreinforced concrete. Holes left after removal of such supports shall be neatly filled with well rammed dry-pack mortar.

Openings for inspection of the inside of the formwork, for the removal of water used for washing down and for placing concrete shall be provided and so formed as to be easily closed before or during placing concrete. Before placing concrete all bolts, pipes or conduits or any other fixtures which are to be built in shall / be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise.

27.5 Removal of Formwork

Formwork shall be so designed as to permit easy removal without resorting to hammering or levering against the surface of the concrete.

The periods of time elapsing between the placing of the concrete and the striking of the formwork shall be as deemed necessary after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown in the table following, or as determined in accordance with the 'cube cured alongside' procedure as described in CIRIA Report No. 73 (October 1977). Where soffit formwork is constructed in a manner that allows the removal of the majority of the formwork and the retention during and after such removal of a sufficient number of adequate supporting props in an undisturbed condition, the Contractor may remove the formwork at earlier times than are listed below provided that the props are left in position and are not disturbed during removal of the majority of the formwork.

GENERAL SPECIFICATIONS

Position	Times for striking using ordinary Portland cement (days)	Times for striking using Rapid Hardening Portland cement (days)
Beam sides, walls and columns	3	2
Slabs (props left under)	4	3
Props to slabs	10	5
Beam soffits (props left under)	10	5
Props to beams	14	8

Notwithstanding the foregoing, the Contractor shall be responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

28. Building in Plant

The Contractor shall erect all formwork, struts and other temporary work to enable plant to be built-in, and such formwork shall be designed to allow placing of the concrete, mortar or grout so as to fill the voids completely, and to enable air to escape from any cavities during filling. The formwork shall be sealed against pipework and other items of plant to prevent leakage of grout. Formwork shall be supported independently of all plant and pipework.

29. Cement Motar

Motar are mixture of fine aggregate with water and hydraulic cement or lime or a combination of both that hardens after application and is used for jointing.

29.1 Dry-pack Mortar

Dry-pack mortar for filling holes and repairing surface blemishes shall be made from one part by weight of cement and three parts by weight of fine aggregate passing a 1 mm sieve. The colour of the mortar shall match that of the surrounding concrete. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands.

The dry-pack materials shall then be placed and packed in layers each having a thickness not greater than 15 mm. The compaction shall be carried out by use of hardwood stick and hammer and shall extend over the full areas of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction the surface of each layer shall be scratched before further loose material is added. Holes shall not be over filled and the surface shall be finished by laying a hardwood block against the dry-pack fill and striking the block several times.

30. Defects in Formed Surfaces

Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surfaces being perfectly compacted and smooth.

GENERAL SPECIFICATIONS

No making good of any of any sort shall be carried out before the approval of the Engineer is obtained. Any unauthorised making good work done without the Engineer approval shall be undone at the Contractor's expense.

Any minor surface blemishes shall be repaired immediately after inspection by the Engineer and obtaining his approval to do so. Remedial measures may include, but shall not be limited to, the following :

- holes left by formwork supports shall be thoroughly cleaned out to remove all loose material and the sides shall be roughened, if necessary, to ensure a satisfactory bond; they shall then be filled with dry-pack mortar;
- fins, pinhole bubbles, surface discolouration and minor defects may be rubbed down with sacking and cement.
- abrupt and gradual irregularities may be rubbed down with carbonandum and water after the concrete has been fully cured;
- small defects and minor honeycombing shall be chipped out normal to the face of the concrete to a depth of at least 25 mm and filled with dry-pack mortar.
- Dry pack mortar shall be used only where reinforcement has not been exposed in blemishes or areas of honeycombing. If reinforcement has been exposed, the affected area will be broken out such that concrete aggregate can pass behind the reinforcement and the hole then shall be re-concreted. For this purpose a mix using 10 mm aggregate, of the same nominal strength as the concrete broken out may be used, subject to the Engineer's approval.

Where deeper or more extensive defects occur, the methods of repair may include, but shall not be limited to cutting out to a depth of 25 mm with a diamond saw to give a regular edge to the repair and further chipping to form a hole with dovetail shape to sound concrete or to a total depth of 75 mm whichever is the greater. If reinforcing steel is exposed, the concrete shall be removed to a depth of 25 mm beyond the back side of the reinforcement. Steel mesh reinforcement shall then be sprung into the dovetail. The void shall be refilled with concrete or suitable epoxy resin mortar.

The Contractor shall thoroughly clean any hole or defective area that is to be filled and where the surface has been damaged the Contractor shall break out any loose, broken or cracked concrete or aggregate.

Where the remedial work is to be carried out using dry-pack mortar or concrete, the concrete surrounding the hole shall be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted lightly with cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed.

Dry-pack mortar shall be mixed and placed as specified. Where concrete is to be used, the concrete mix shall be placed and compacted into the hole, using formwork as necessary.

Where the remedial work is to be carried out using epoxy resin mortar or other specialist material, the surface of the cleaned hole shall be prepared and primed and the repair material placed, compacted and finished in accordance with the manufacturer's instructions.

Where a defect is too extensive to permit satisfactory repair, either from the point of view of structural integrity or appearance, the concrete containing the defect shall be broken out and replaced.

31 Inspection

No concrete shall be placed against any formwork until its position and alignment has been checked and approved by the Engineer.

32. REINFORCEMENT FOR CONCRETE

32.1 Reference Standards

The following standards are referred to in this section :

BS 4449	Hot rolled steel bars for the reinforcement of concrete.
BS 4461	Cold worked steel bars for the reinforcement of concrete.
BS 4466	Bending dimensions and scheduling of reinforcement for concrete.
BS 4483	Steel fabric for the reinforcement of concrete.
BS 4871	Approval testing of welders working to approved welding procedures.
BS 5135	Process of arc welding of carbon and carbon manganese steels.
BS 8110	Code of Practice for the Structural use of concrete

32.2 Submissions

The following records shall be retained for inspection :

32.2.1 Test Certificates

- Manufacturer's test certificate for each delivery of reinforcing steel. Each certificate shall show the country of origin and test.
- Welder qualification tests.

32.2.2 Data

- Manufacturers' data on accessories.
- Welding procedures.

32.2.3 Drawings

- Reinforcement bending schedules.

32.3 Steel Reinforcement

Steel for reinforcement shall be of the following kinds as may be specified or detailed on the Drawings :

GENERAL SPECIFICATIONS

Type	Designation	Nominal Size (mm)	fy (N/mm ²)
R	Hot rolled plain round mild steel bar (BS 4449)	All sizes	250
Y	Hot rolled deformed high yield bar (BS 4449)	All sizes	460
Fabric	Cold worked deformed high yield bar (BS 4461)	All sizes	460
	Welded hard drawn steel wire (BS 4483)	Up to 12	485

32.4 Accessories

The Contractor shall supply all accessories such as reinforcing steel supports, hold-downs, spreaders, hangers, ie wire and all other incidentals necessary to complete an acceptable installation of all concrete reinforcement. All accessories shall be of steel with the exception of spacers to maintain concrete cover to reinforcement against formed or blinded surfaces which shall be of concrete of the same texture, colour and composition as cast-in-place concrete. Concrete spacers shall be in the form of a truncated cone or pyramid and shall be used with the larger face towards the reinforcing steel. The smaller face of a truncated cone or pyramid shall have a minimum dimension of 50 mm.

32.5 Detailing

Steel reinforcement shall be as shown on the Drawings. When any information relating to reinforcement is missing or apparently incorrect, the Contractor shall immediately request the required information.

32.6 Cutting and Bending of Reinforcement

Bars shall be cut and bent in accordance with the provisions of BS 4466. All bending shall be done cold by application of slow, steady pressure or with the use of an approved bending machine. **Bars shall not be rebent.** Cut and bent bars shall be bundled and labelled for positive identification with the Drawings and bending schedules, until they are incorporated into the work.

Cold worked and hot rolled bars shall not be straightened or bent again once having been bent. Where it is necessary to bend mild steel reinforcement already casted in the concrete, the internal radius of bend shall be not less than twice the diameter of the bar.

32.7 Storage of Reinforcing Bars and Fabric

The Contractor shall stack separately and label different types of reinforcement for positive identification. Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease, earth, paint, or any material which may impair the bond between the concrete and the reinforcement.

Reinforcement shall be wire brushed before fixing to remove loose rust, mill scale, etc. No reinforcement shall be used if corrosion has reduced the area of cross-section below 98% of its original value. Reinforcing steel shall be stored and fabricated under cover on wooden or concrete supports such that the steel is elevated from the ground surface by a minimum of 150 mm.

32.8 Fixing of Reinforcement

All reinforcement shall be securely and accurately fixed in positions shown on the Drawings using approved spacer blocks or chairs. Intersections of bars shall be secured with Nr 16 gauge (1.60 mm) soft iron wire, the ends being turned into the body of the concrete. The Contractor shall ensure that all reinforcement is maintained in position at all time, particular care being taken during placing of concrete.

Concrete cover to reinforcement shall be as specified or detailed on the Drawings, and shall be maintained in accordance with the tolerances specified in BS 8110. Correct concrete cover to reinforcement shall be maintained with the aid of approved spacer pieces. Top reinforcement in slabs shall be maintained in position by means of chairs, the diameter and quantity being sufficient to ensure security of the reinforcement in shape and position.

No part of the reinforcement shall be used to support formwork, accessways, working platforms, or the placing of equipment or for the conducting of an electric current.

32.9 Splicing

Laps and joints including lapping bars, sleeving, threading and other mechanical connections shall be made strictly in accordance with the method specified and at the positions shown on the Drawings or as otherwise approved by the S.O.

32.10 Supporting and Spacer Blocks

Supporting and spacer blocks required for ensuring that the reinforcement is correctly positioned shall be as small as possible consistent with their purpose, of a shape approved by the S.O and designed so that they will not overturn when the concrete is placed. They shall be made of concrete with 10 mm maximum aggregate size and they shall be of at least the same strength and material source as the adjacent concrete. Wire cast in the block for the purpose of tying it to the reinforcement shall be 1.6 mm diameter soft annealed steel wire complying to BS 1052. Other types of spacer may be used only with approval of the S.O.

32.11 Welding of Reinforcement

Reinforcement which is to be welded shall be welded in accordance with the requirements of BS 5135 and the recommendations of the manufacturer. The strength of the parent metal shall not be reduced and the weld shall possess a strength not less than that specified for the parent metal. The welding procedure established by successful trial welds shall be maintained and no departure from this procedure shall be made.

Following the establishment of a satisfactory welding procedure, each welder to be employed on the Works shall carry out welder performance qualification tests on reinforcing bars of the same metal and size as those on the Works. The requirements of BS 4871 shall be observed.

Details of welding procedure and welder qualification tests shall be retained as records.

32.12 Inspection

No concrete shall be placed around any reinforcement until its position has been checked and approved by the Engineer.

33. MEASUREMENT AND PAYMENT**33.1 Measurement of In-Situ Concrete**

Separate measurement shall be made for in-situ :

- (a) plain concrete
- (b) reinforced concrete

For each of the specified classes of finish to the concrete, separate measurement shall be made for formwork or for unformed surface finishes of Class U2 and U3. Unformed surface finish Class U1 and spaded finish shall not be measured for payment. Separate measurement shall be made for steel reinforcement and for movement joints.

- (a) In-situ concrete shall be measured to the dimensions and limits shown on the Drawings. Concrete placed outside these limits shall not be measured for payment. No deduction from the measurement shall be made for :
 - i. Any hole or opening which has an average cross sectional area less than 0.2 sq m or a volume less than 0.1 cu m.
 - ii. Chases, rebates, channels, pipes, ducts, etc. whose cross sectional area is less than 100 sq m.
 - iii. Any chamfer less than 150 mm wide on the splay.
 - iv. The space occupied by any reinforcement, rails, joints or the like embedded in the concrete.

Additional formwork for forming the box-out shall be accounted for under lump sums for small box-outs and by measuring the additional formworks needed for large box-outs.

- (b) Unformed surface finishes (Class U2 and U3) shall be measured as the net area of concrete surface so finished.
- (c) Polyethylene sheet or other protection to foundation surfaces shall be measured as the net area so protected and no additional shall be made for laps and joints.
- (d) Admixtures will not be separately measured; their cost will be deemed to be included in the rates.
- (e) Concrete testing shall not be measured separately, the cost will be deemed to be included in the rates.
- (f) Curing of concrete shall not be measured separately whatever method is used, the cost will be deemed to be included in the rates.

33.2 Measurement of Precast Concrete

Items for precast concrete shall include for the manufacturer and fixing in the Works of the Precast units and all work in connection therewith as specified.

Precast concrete shall be measured as fixed in the Works by numbers of units, by volume, by area or by length as indicated in the Bill of Quantities. Measurement (except where by numbers) shall include the space occupied by joints between units but not by bedding. Otherwise all measurement shall be net except that no deduction shall be made in respect of any purpose formed hole, duct or the like which has an average cross-sectional area less than 25 cm².

No separate measurement for payment shall be made in respect of formwork, surface finishes, reinforcement, joggles, dowels, jointing, bedding or the like for precast concrete unless separate items are expressly provided in the Bill of Quantities.

33.3 Measurement of Formwork

Formwork for each surface finish shall be measured according to the items in the Bill of Quantities under the following categories :

- a. Vertical formwork - to vertical faces of concrete.
- b. Battered formwork - to faces of concrete battered at less than 45 from the vertical.
- c. Soffit formwork - to underside of concrete, either horizontal or sloping at an angle not exceeding 45 from the horizontal, including for cambering of beams.
- d. Top-faced formwork - To top faces of concrete sloping at more than 20 and not exceeding 45 from the horizontal. Top faces of concrete sloping at 20 or less than from the horizontal shall be classed as unformed surface finish and shall not be measured for payment for formwork except where such faces occur in openings, chases, rebates and other similar features. No top-face of concrete surfaces having a spaded finish shall be measured for payment regardless of its slope.
- e. Single curved formwork - To faces of concrete curved to a single radius in one plane.
- f. Double curved formwork - to faces of concrete curved to a double radius.

Formwork shall be measured as the net area of formwork in contact with the surface of the concrete it is required to support. No deduction shall be made in respect of :

- (a) The area occupied by in-situ pipes or ducts passing through the formwork.
- (b) Any hole required in the concrete which is less than 0.5 sq m.

Formwork for movement joints shall not be measured separately. Waterstops, joint fillers, joint sealing or painting of joint faces shall be measured per linear meter or per square meter as described in the Bill of Quantities and shall include for all materials and workmanship require to produce the specified movement joint.

Formwork required for construction joints shall not be measured and shall be deemed to be included in the rates for concrete.

33.4 Measurement of Reinforcement

Reinforcement shall be measured on the basis of the calculated weight of reinforcement detailed on the Drawings or otherwise specified. The weight of reinforcement shall be taken as 0.00785 kg / mm² of cross sectional area per meter length. Bending, fixing, typing and spacing of reinforcement shall be deemed to be included in the rates for reinforcement and no additional measurement will be made for waste in cutting or additional laps introduced by the Contractor to suit his methods of construction.

Reinforcement required in compliance with specified laps of bars shall be included in the weight measured for payment.

GENERAL SPECIFICATIONS

Fabric reinforcement shall be measured as the net area of fabric laid in square meters, and laps shall not be measured.

Notwithstanding anything in this Clause, where reinforcement is specified as being included in other measured work (for example in precast concrete) it shall not be measured for payment.

TABLE 1 – PRESCRIBED MIXES FOR GENERAL USE PER CUBIC METER OF CONCRETE BY WEIGHT BATCHING

GENERAL SPECIFICATIONS

Grade of concrete	28 day characteristic strength of concrete (N/mm ²)	Nominal Max. Size of aggregate (mm)	20		Max free water/cement ratio
		Workability	Medium	High	
		Slump Limit(mm)	25 - 75	75 - 125	
15P	15	Cement (kg) Total aggregate (kg) *Fine Aggregate (%)	280 1800 35 - 50	310 1750 35 - 50	0.6
20P	20	Cement (kg) Total aggregate (kg) *Fine Aggregate (%)	320 1800 25 - 40	350 1750 20 - 45	0.55 - 0.6
25P	25	Cement (kg) Total aggregate (kg) *Fine Aggregate (%)	360 1750 25 - 40	390 1700 30 - 45	0.5
30P	30	Cement (kg) Total aggregate (kg) *Fine Aggregate (%)	400 1700 25 - 40	430 1650 30 - 45	0.45

* Fine aggregate is expressed as a percentage by weight to the total weight of the dry aggregate

TABLE 1A – PROPORTION AND STRENGTH REQUIREMENTS FOR PRESCRIBED MIXES BY VOLUME BATCHING

Mix proportions	Slump limits (mm)	Cubic meter of aggregate per 50kg of cement		Max. free water/cement ratio	Quantity of water (litres)	Characteristic strength of concrete	
		Fine	Coarse (20 mm)			At 7 days (N/mm ²)	At 28 days (N/mm ²)
1:1.5:3 (25P)	25 – 50	0.05	0.1	0.5	25	17	25
1:2:4 (20P)	25 – 50	0.07	0.14	0.55 -0.6	27.5 – 30	14	20
1:3:6	25 - 50	0.10	0.20	-	As approve by SO	-	-

TABLE 2 – DESIGN MIX CONCRETE TEST COMPLIANCE

GENERAL SPECIFICATIONS

Concrete Grade	Crushing Strength (N/mm ²)		Limits of dry aggregate to cement ratio by weight		Min. cement content kg/m ³	Max free water/cement ratio
	Work Tests					
	7 days	28 days	Max	Min		
G35	25.0	35.0	6.0	4.0	340	0.50
G30	21.0	30.0	6.5	4.5	320	0.55
G25	17.0	25.0	7.0	4.5	290	0.60
G20	14.0	20.0	8.0	5.0	260	0.71
G15	10.0	15.0	11.0	-	200	0.90

TABLE 3 – MIX PROPORTION OF POROUS CONCRETE (Refer item 12.0)

Ground Condition	Cement Type	Minimum cement content (kg/m ³)	Maximum Aggregate size (mm)	Characteristic strength at 28 days (N/mm ²)
Non aggressive	Ordinary	230	40	10
Aggressive	Sulphate-resisting	290	40	10

TABLE 4 – MAXIMUM TOLERANCE FOR FINISHED CONCRETE

Maximum tolerance (mm) in:				
Class of finish	Line and level	Abrupt irregularity	Gradual irregularity	Dimension
F1	+/- 30	10	+/- 20	+ 20 -10
F2	+/- 10	5	+/- 10	- 10 - 5
F3	+/- 5	3	+/- 3	+/- 5
U1	+/- 30	10	+/- 20	-
U2	+/- 10	5	+/- 10	-
U3	+/- 5	3	+/- 5	-

3.5 MASONRY

3.51 TERMINOLOGY AND DEFINITIONS

- **Masonry.** Assemblage of units jointed with mortar.
- **Masonry unit.** A block, a brick or a fixing unit.
- **Coordinating size.** The size of a coordinating space allocated to a brick, including allowances for joints and tolerances.
- **Work size.** The size of a brick specified for its manufacture, to which its actual size should conform within permissible deviations.
- **Course.** Layer of masonry that includes a layer of mortar as well as a layer of mortar as well as a layer of units.
- **Jointing.** Finishing of mortar joint as the work proceeds.
- **Panel.** Area of masonry with defined boundaries that may contain openings.
- **Bed joint.** Mortar layer upon which masonry units are set.
- **Movement joint.** Joint designed to permit relative movement of sections of a structure built in masonry to occur in both vertical and horizontal joints.

3.51.1 GENERAL

- **Clay Bricks** shall comply with BS 3921
- **Precast Concrete Bricks** shall comply with BS 6073
- **Calcium silicate bricks** shall comply with BS 187
- **Masonry Cement** shall comply with MS 794:1982
- **Sand** for mortar shall comply with B.S. 1200 and shall be hard clean, fresh water sand, free from adherent coatings and any other impurities.
- **Lime** shall be hydrated lime which is manufactured to B.S. 890:1995 as a dry powder. This greatly improves subsequent workability and long term performance of the mortar.
- **Water** shall be fresh, clean, potable, free from deleterious materials, acids or alkalis.
- **Ties and anchors** shall comply to ...
- **Course reinforcement** shall be 'Exmet' or other equivalent and approved type.

3.51.2 MORTAR

- **All mortar ingredients** shall be mixed with a mechanical mixer with a mechanical mixer with the minimum amount of water needed to produce mortar of workable consistency.
- **Mixes containing cement** shall be used up within two hours of the first contact of the cement with water. All material remaining after this period shall be discarded. Materials which have started to set shall in general not be re-tampered.
- **Mortar materials** for the entire project shall be from the same approved brands and sources to ensure uniformity of mix.
- **Masonry Cement** shall comply with MS 794: 1982.
- **Cement Properties.** Tests for cement properties shall be carried out to MS 794:1982.
- **Mortar Properties.** Tests on mortar prepared by using Masonry Cement shall be carried out using a standard mortar sample prepared as prescribed in MS 794: 1982. The tests to be carried out and required results are as follows:
 - Water Retentivity test
 - 70% minimum and 95% maximum
 - Air entrainment (air content)
 - 10% by volume minimum and 25% by volume maximum
 - Flow
 - 80% minimum and 120% maximum
 - Compressive strength
 - at 7 days 4.0N/mm² minimum
 - at 28 days 6.0N/mm² minimum

GENERAL SPECIFICATIONS

TABLE 1 : REQUIREMENTS FOR MORTAR				
		Mortar Designation	Type of mortar (proportion by volume)	
			Cement : lime : sand (for comparison only)	Masonry cement : sand
↑ Increasing Strength	↓ Increasing ability to accommodate movement due to settlement, temperature and moisture changes	(i)	1:0 to ¼:3	-
		(ii)	1:½:4 to 4½	1:2½ to 3½
		(iii)	1:1:5 to 6	1:4 to 5
		(iv)	1:2:8 to 9	1:5½ to 6½
Direction of change in properties is shown by the arrows		Improvement in bond and consequent resistance to rain penetration		

- **Guideline to the selection of mortar**

GENERAL SPECIFICATIONS

TABLE 2: DURABILITY REQUIREMENTS		
Masonry condition or situation	Quality of masonry units and appropriate mortar designations	
	Clay Bricks	Concrete Bricks
Work below or near external ground level	(iii)	> 15 N/mm ² in (iii)
Rendered external walls	(ii)	>7N/mm ² in (iii)
Internal walls inner leaves	(iii)	>7N/mm ² in (iv)
Rendered parapets	(ii)	>7N/mm ² in (iii)
Free standing boundary and screen walls	(ii)	>15 N/mm ² in (iii)
Earth retaining walls (with waterproofing)	(ii)	>15 N/mm ² in (ii)
Drainage : Surface water	(i)	>20 N/mm ² in (iii)
Drainage : Foul drainage (continuous contact)	(i)	>40 N/mm ² in (ii)

3.51.3 BRICKS

Once samples of bricks have been submitted and approved by the architect or engineer, all bricks used for the Works shall be up to this standard in every respect. No soft, broken, twisted or otherwise defective bricks will be permitted.

CLAY BRICKS shall comply to **BS 3921: 1985**

Sizes. The coordinating sizes and work sizes for bricks shall be given in table 1.

Table 3. Sizes					
Coordinating size			Work size		
Length	Width	Height	Length	Width	Height
225 mm	112.5 mm	75 mm	215 mm	102.5 mm	65mm
Note. The work sizes are derived from the corresponding coordinating sizes by the subtraction of a nominal thickness of 10 mm for the mortar joint.					

- Guideline to measurement of dimension according to BS 3921.** Take 24 bricks samples, remove any blisters, small projections or loose particles of clay adhering to each brick. Place the bricks in contact with each other in a straight line upon a level surface, using the appropriate arrangement for each work size. Measure the overall dimension (length, width or height) to the nearest millimeter, using an inextensible measuring tool long enough to measure the whole row at one time, e.g. a steel tape. Record each result. **Alternatively**, divide the sample in half and form two rows of 12 bricks. Measure each row separately and record the sum of the results for the two rows.

Dimensional deviations. The overall measurements of 24 bricks sampled shall not fall out of the limits given in Table 4. **In addition**, the size of any **individual brick** in the sample shall not exceed the coordinating size given in Table 3.

Table 4. Limit of size		
Work size (see table 1)	Overall measurement of 24 bricks	
	Maximum	Height
mm	mm	mm
215	5235	5085
102.5	2505	2415
65	1605	1515
Note. Where for special reasons closer limits of sizes are required, this can be best achieved by agreement between the specifier and the supplier.		

Compressive strength. Compressive strengths shall be more than 7 N/mm²

Water Absorption. Water absorption shall be less than 7%.

Sampling for tests shall follow general recommendations as stated in BS 3291: 1985

Number of bricks required for testing from consignment of not more than 15, 000 bricks	
PURPOSE	Number of bricks required for sampling
Dimensional checks	24
Determination of compressive strength	10
Determination of water absorption	10

Visual inspection of Clay Bricks

General

- Bricks shall be square and clean upon delivery.
- Bricks shall be inspected for deep or extensive cracks.
- Bricks must be checked for damage to edges and corners.
- Bricks shall be free from pebbles and expansive lime particles.

Colour

- The colour of clay brick is dependent on chemical composition and firing temperature.
- For products made from the same raw clays material, darker colours are associated with higher firing temperature, increased compressive strength and lower absorption rate.
- However, for products made from different raw clays there is no direct relationship between strength and colour or absorption to colour.
- The redness in clay is caused by iron formation of ferrous oxide.
- Recommendations to colour characteristic.
 - Even though there can be no direct relationship between colour to strength or absorption, when choosing testing for samples for laboratory testing, it is recommended to choose samples which are lightest in colour as this may reflect a sample with decreased strength and of high absorption characteristic.

CONCRETE BRICKS shall comply with BS 6073

Nominal size of bricks shall be 210 (L) x 100 (W) x 65mm (H).

Dimension deviation shall be measured according to BS 6073 shall be as follows:

Dimension	Dimensional deviations for bricks
Length	+ 4 mm – 2 mm
Height	+ 2 mm – 2 mm
Thickness	+ 2 mm – 2 mm

Compressive strength. The average crushing strength of 10 bricks shall be more than 7.0 N/mm².

Drying shrinkage shall be tested according to BS 6073 and shall not exceed 0.06%.

Sampling for tests shall follow general recommendations as stated in BS 6073

Number of bricks required for testing from consignment of not more than 10,000 bricks	
PURPOSE	Number of bricks required for sampling
Dimensional checks	10
Determination of compressive strength	10
Shrinkage	4

Visual inspection. Concrete bricks shall be free from surface indentations, cracks, splits and chipping, due to manufacturing process and or transport.

3.51.4 WORKMANSHIP

Laying of masonry units

Setting out

- Build masonry work true-to-line, plumb, square and level, with vertical joints in proper alignment. Lay work from face of coursing to maximum plumb tolerance of 6mm in 2400mm and to maximum tolerance of 3mm in 240mm in the plane. Maximum tolerance of masonry opening shall be 6mm.
- Assume complete responsibility for dimensions, plumbs and levels of this work and constantly check with graduated rod.

GENERAL SPECIFICATIONS

- When setting out masonry, care should be taken to reduce the cutting of masonry units to a minimum and to avoid irregular bond, particularly at openings.
- Great care should be taken to ensure accuracy in the setting out of the first course of masonry units in order to avoid subsequent inaccuracies in the finished work.
- Dimensions should be checked from time to time as the work rises.
- Masonry units should be laid true and regular courses. To avoid excessive deflection, string lines should be supported at not more than 6 m intervals.

Joint thickness.

- The average thickness of both horizontal and vertical mortar joints is normally taken to be 10 mm in any of the jointing surface of the masonry units.
- This joint size allows for irregularities in the masonry units and should accommodate most oversize particles in the fine aggregate whilst being reasonably economical in the use of mortar
- Joint sizes may need to be varied from the nominal 10 mm but the joints in any section of work should be kept as consistent as possible.
- Construct masonry work so that vertical and horizontal joints are of equal and uniform thickness.

Adhesion.

- To achieve good adhesion a mortar must have good workability. Mortar of poor workability will not perform adequately, and will allow air to be trapped between the mortar and the brick, thus preventing good bond formation.
- Bricks with rough bed face and medium suction rates will have high bond characteristics because the mortar will key into the texture of the brick. Conversely, bricks with low suction rates and a smooth texture will have lower bond characteristics.
- Highly porous bricks may rapidly absorb moisture during laying (particularly in warm weather), causing mortar to become insufficiently plastic to allow repositioning of the bricks during leveling. It is possible in such circumstances that no adhesion will be obtained between bricks and mortar. Laying mortar beds in shorter lengths to reduce drying will help. Wetting may assist adhesion, but over wetting may lead to floating on the mortar bed and to excessive efflorescence and staining.

GENERAL SPECIFICATIONS

- Do not shift or tap units after mortar has taken initial set. Where adjustments must be made after mortar has started to set, remove mortar and replace with fresh supply.

Bricklaying

- Lay brick in running English Bond except half brick wall shall be in stretcher Bond. Bond must not be broken.
- The whole of the brickwork shown upon the drawing unless otherwise specified, shall be constructed with standard size clay bricks in mortar as described and leave surface ready for plastering.
- Brickwork shall be carried up perfectly true and plumb in uniform manner. No one portion being raised more than 1m above another at one time. No overhand work shall be permitted and scaffolding shall be carried up as the work proceeds.
- All intersections and angles of walls shall be properly bonded together, and all walls and piers of length and widths not multiples of brick sizes shall be cut and bonded in the best approved manner. No broken bricks shall be used except where required to form bond.
- All half brick walls and partitions shall be reinforced at every fourth course with approved brick reinforcement commencing two courses above floor level.
- Bricks should be laid on a full bed of mortar.
- Immediately after the brick is laid, excess mortar should be struck off the face of the bricks
- Fit masonry closely against electrical and plumbing outlets, fittings and sleeves so that collars, plates and covers will overlap and conceal all cuts.
- Distribute exposed masonry of varying colours, tones and texture evenly over all surfaces to produce a homogeneous blend and to avoid patches and streaks. Do not use units too contrasting in appearance for satisfactory blending.
- Back faces of exposed masonry walls shall be constantly checked to avoid misalignment or tilting of units which cause variations in joint width.
- Fill to top of beams and joists around items passing through masonry walls after items have been installed.
- Where new masonry abuts old or fully set masonry, clean existing surfaces and dampen if necessary to obtain bond.
- Solidly imbed built-in frames in mortar and fill frame voids with mortar or grout as wall is erected.

Fire Separations

GENERAL SPECIFICATIONS

Construct walls of masonry units which provide required fire separation as approved by authorities having jurisdictions for material and thickness.

Construct fire separations without any openings or voids which would compromise the integrity of the separation.

In no case shall unplastered fire separation walls of masonry construction be reduced in any part to a thickness less than the actual dimensions for separation ratings and materials required unless otherwise approved by authorities.

Movement Joints

Construct movement joints in masonry walls at all structural columns and at a maximum of 6m spacing if not otherwise shown on drawings.

Placing movement joints at features of building which such as

- intersecting walls, piers, floors, etc.;
- window and door openings
- change in height or thickness of the wall
- movement joints in the buildings or in floor slabs

Reinforcement may be used to control cracking, which may occur in areas of masonry above or below openings where the vertical cross-sectional area of the masonry is much less than that of the masonry on either side. The reinforcement should be long enough to distribute the vertical cross-sectional area is able to accommodate it and should be adequately protected against corrosion.

Storage on site

Consignments of materials should be placed so that they will normally be used in order of delivery and so as to permit the inspection and sampling of individual consignments. All materials should be inspected both when delivered to site and immediately before use, to check whether they have been subject to deterioration or damage.

Masonry units should be unloaded by machine or by hand on to a dry and reasonably level area or scaffold. It is important that they should be carefully stacked to avoid damage and to ensure stability and should be protected from rain. For concrete masonry units, it is desirable that free circulation of air be provided within the stack so that masonry units may dry out before being built into the work.

Strict precautions should be taken to ensure that stacks of materials on the floor slabs do not overload the structure.

Cement and hydrated lime should be stored off the ground, kept dry and used in order of delivery. Cement of hydrated lime affected by dampness should never be used.

Fine aggregates should be stored apart so that they will not be contaminated.

Protection

Newly erected masonry should be protected against rain to prevent the mortar being washed out of the joint by rain.

When any working platform is not in use, the inner should be turned away from the wall to prevent the splashing of the wall face.

Freshly laid masonry must be protected from drying too rapidly.

Cover top of completed and partially completed wall not enclosed or sheltered, with water proof, non-staining coverings at the end of work day.

Cutting of bricks

Cut masonry units with approved type power saw.

Obtain the architect's approval before cutting any part or area which may impair appearance or strength of work.

Where metal outlet boxes or other similar items occur in masonry walls, cut such recesses or openings in order to provide square clean edges before services are installed. Leave maximum 3mm clearance.

3.51.5 COMPONENTS & MISCELLANEOUS

Lintels. Over all openings and recesses exceeding 150mm square, provide lintels over openings to support masonry above. Under no circumstances are masonry works to be supported by framework of doors, windows, etc. **Lintels** are to be the same width of the masonry units and to have a minimum bearing length of not less than 230 mm or as specified by the engineer on each side of the openings and recesses. Precast lintels shall be supported by hot dipped galvanized steel angles of adequate size and strength, which are mechanically fastened to structural members.

Anchors & reinforcement and bonding

Reinforce all walls constructed of masonry units, with joint mesh reinforcement (Exmet) placed at every 4th courses. Lap reinforcement minimum of 150mm and stop reinforcing 50mm from edge of joints or openings. Reinforcement mesh shall commence two courses above floor level.

Additionally, place mesh reinforcement in first and second bed joints above and below openings greater than 150mm wide. Reinforcing in first bed shall be continuous. Extend reinforcing minimum 600mm beyond each side of opening in second bed joint.

In load-bearing walls, provide mesh reinforcement in top three courses immediately below roof and floor levels.

Anchor masonry walls abutting structural members to the structural members providing lateral support with hot dipped galvanised steel strap anchors. Mechanically fastened or cast 76mm of one end of anchors to structural members at

GENERAL SPECIFICATIONS

300mm centres vertically and 900mm centres horizontally. Embed other end of anchors into mortar filled cores of masonry units to a depth of 229mm.

Provisions for other trades.

Provide all openings in masonry walls where required or indicated for work of other trades.

Co-operate with other trades and accurately locate chases and openings and neatly finish to required sizes.

Where masonry encloses conduit or piping, bring to proper level as directed. Do not cover any pipe or conduit chases or enclosures until advised that work has been inspected, tested and approved.

Co-ordinate work with other trades to conceal pipes and conduits within concrete block cores, except where otherwise indicated or specified.

Where required for termination of metal flashings in existing masonry joints, provide saw cuts in joints.

Provide structural stiffeners for masonry works as shown in structural drawings.

3.6 STEEL AND IRONWORKS

MATERIALS

General

All materials shall conform with the relevant current British Standards or equivalent when one exists, unless otherwise specified. Where British Standards quote both Imperial and Metric units, the Metric units shall apply.

The material supplied shall comply with the following British Standards:-

B.S. 4	-	Structural Steel Sections Part 1. Hot-rolled sections Part 2. Hot-rolled hollow
B.S. 499	-	Welding Terms and Symbols
B.S. 592	-	Carbon Steel Castings for General Engineering Purposes (included in B.S. 3100 - Steel Castings for General Engineering Purposes).
B.S. 639	-	Covered Electrodes for the Manual Metal-Arc Welding of Mild Steel and Medium-Tensile Steel.
B.S. 1719	-	Classification, Coding and Marking of Covered Electrodes for Metal-Arc Welding.
B.S. 2642	-	General Requirements for the Arc Welding of Carbon Manganese Steel
B.S. 3692	-	ISO Metric Precision Hexagon Bolts, Screws and Nuts.
B.S. 4190	-	ISO Metric Black Hexagon Bolts, Screws and Nuts.
B.S. 4320	-	Metal Washers for General Engineering Purposes. Metric Series.
B.S. 4360	-	Weldable Structured Steels.
B.S. 4395	-	High Strength Friction Grip Bolts and Associated Nuts and Washers for Structural Engineering. Metric Series.
B.S. 4449	-	Hot-Rolled Steel Bars for the Reinforcement of Concrete.
B.S. 4604	-	The use of High Strength Friction Grip Bolts in Structural Steelwork. Metric Series.

3.6 - STEEL AND IRONWORKS (Cont'd)

MATERIALS (Cont'd)

General (Cont'd)

- B.S. 4620 - Rivets for General Engineering Purposes. Metric Series.
- B.S. 4870 - Approval Testing of Welding Procedures
- B.S. 4871 - Approval Testing of Welders working to Approved Welding Procedures
- B.S. 4872 - Approval Testing of Welders when Welding when Welding Procedure Approval is not required.
- B.S. 5135 - Metal-Arc Welding of Carbon and Carbon Manganese Steels.

Structural Steel And Section

Structural steel shall comply with Grade 43C or Grade 50B of B.S. 4360 and as indicated in the drawings and the requirements of B.S. 449, Part 1. In addition, Structural Steel Hot-rolled Sections shall comply with the requirements of B.S. 4; Part 1 and Structural Steel Hot-Rolled Hollow Sections with B.S. 4, Part 2. The maximum carbon equivalents shall be in accordance with B.S. 4360.

Bolts, Nut And Washers

Bolts shall be one of the following types as specified on the drawings:

- (a) Black bolts and nuts shall comply with the requirements of B.S. 449 and either B.S. 2708 or B.S. 4190. Plain tapered washers shall comply with the requirements of B.S. 449 and B.S. 3410 or B.S. 4320.
- (b) High strength friction grip bolts, nuts and washers shall comply generally with the requirements of B.S. 3139 or B.S. 4395 for dimensions and B.S. 1768 for materials. Bolts shall be General Grade. Washers for H.S.F.G. bolts shall be Load Indicating Washers appropriate to the type and the quality of the bolt used.
- (c) Washers must be provided beneath the bolt head AND the nut.

3.6 - STEEL AND IRONWORKS (Cont'd)

MATERIALS (Cont'd)

High Strength Friction Grip Bolts

High strength friction grip bolts shall comply with the requirements of B.S. 3139 and shall be of the load indicating type such that the achievement of the proof tensile load can be directly related to the feeler measurements of gap closures on the bolt head or on the washer. The Contractor shall submit to the S.O. for his approval the type of load indicating system he wishes to use together with the name of the manufacturer.

Washers shall be of hardened steel conforming to B.S. 3139 and shall be provided under all nuts.

Where load indicating washers are used, they shall be placed under the head of the bolt.

During the tightening operation, the bolt head shall be prevented from rotating.

Any grip bolts which are slacked after having been fully tensioned once shall be discarded.

Priming And Painting

Pretreatment primer shall be linseed oil modified phenolic resin as binders, zinc chromate, iron oxide and pigment with solid content by volume not less than 40%.

Zinc chromate paint shall be oleoresinous varnish as binders; zinc chromate; zinc oxide as main pigments. Solid content by volume shall exceed 50%. Thickness per coat exceed 50 microns.

Micaceous iron oxide to be used shall be polyamide cured epoxy resin as binders; micaceous iron oxide and mineral extenders as pigment. Solid content by volume shall exceed 50%. Thinner shall be used with approval. The thickness per coat shall exceed 50 microns for dry film and 100 microns for wet films.

Transport And Storage of Steelwork

The greatest care shall be taken in loading, unloading, transporting, stacking and erecting steelwork to avoid marking or damage to be painted or metal coated steelwork.

Painted or metal coated fabricated steelwork which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure no pools of water or dirt can accumulate on the surfaces. Suitable packings shall be laid between the layers of stacked materials. Where cover is provided, it shall be ventilated.

3.6 - STEEL AND IRONWORKS (Cont'd)

WORKMANSHIP

Shop Drawings

The S.O. shall supply the Contractor with all the information necessary for him to prepare and complete his workshop drawings except the calculated fabrication camber. It shall be the Contractor's responsibility for the proper fabrication of the steelwork.

In the event of any contradiction or ambiguity in the information of drawings supplied by the S.O., the Contractor shall obtain from him other information and clarification.

Two copies of all working drawings prepared by or on behalf of the Contractor shall be submitted to the S.O. for approval. The S.O. will verify the correct interpretation of his requirements but will not verify the dimensions and the Contractor shall be entirely responsible for the accuracy of the drawings and the correctness of detail. The Contractor shall not commence fabrication of any item until the working drawings for it has been approved in writing by the S.O.

The Contractor shall supply the S.O. with three (3) copies of all approved drawings.

The dimensions of and approved procedures for all welds shall be clearly specified on the working drawings and the length of weld specified shall be the effective length excluding any craters.

Camber

The main trusses shall be fabricated to the specified camber or to a calculated camber which will ensure that the structure conforms to the vertical alignment shown on the drawings, under full dead load. The camber shall be calculated by the Contractor taking full account of his proposed assembly sequence.

Fabrication

All workmanship and fabrication shall be in accordance with B.S. 449 Part 1.

The Contractor shall permit access at all reasonable items to all places where work is being carried out and shall provide all the necessary facilities for inspection of material and workmanship during fabrication. Under no circumstances is any practice to be adopted which will result in injury to material.

No drifting of holes that would enlarge the holes or distort the metal will be allowed. All edges of sections and plates are to be smooth and free from broken, ragged, burred or notched edges.

All sharp corners and edges which are to receive point shall be round to approximately 6mm radius on completion of fabrication.

3.6 - STEEL AND IRONWORKS (Cont'd)

WORKMANSHIP (Cont'd)

Welding

All welding shall be by electric arc process. Unless specifically excluded, the clauses shall apply equally to shop and site welding.

Unless otherwise described in the Contract, metal-arc welding shall comply with B.S. 2642 and B.S. 5135 as appropriate except for tack welds and temporary attachments for which the procedures laid down in B.S. 2642 shall be followed.

Wherever possible, the welds shall be laid in the flat or horizontal-vertical position.

All parts to be welded shall be accurately prepared so that on assembly they fit closely together. After assembly and before general welding commences the parts shall be strong enough to relative movement of the parts but small enough to be covered by general welding.

Slag shall be removed from welds and spatter from surrounding surfaces after completion of welding and before grid blasting.

Welding procedures shall be designed to eliminate weld cracking and minimise distortion. The welding procedure for making each joint shall be approved by the S.O. before work is commenced and recorded on the shop drawings.

Welding shall not be undertaken when the surfaces are wet from condensation or other causes.

Suitable allowance for weld connections shall be made to ensure the finished dimensions are correct within the specified tolerances.

The general welding programme for shop and site welds, including particulars of the preparation of fusion faces, the method of preheating where required, the methods of making the welds, and the type of electrodes shall be submitted to the S.O. for his approval before the works is put in hand. No departure from the agreed welding programme or from the details shown on the drawings shall be made without the agreement of the S.O. Electrodes and fluxes shall be so chosen that the properties of the deposited metal are not inferior to those of the parent metal. Electrodes for manual arc welding shall comply with B.S. 639 and shall be classified, coded and marked in accordance with B.S. 1719.

The procedure for welding and flame cutting established by the procedure trials shall be strictly followed.

All butt welds shall be complete penetration welds between prepared fusion faces in the fabrication of built-up assemblies. All butt welds in each component part shall be completed, whenever possible, before the final assembly. Where butt welds are to be ground flush, there shall be no loss of parent metal. The final grinding shall be in the direction of the primary load stress.

3.6 - STEEL AND IRONWORKS (Cont'd)

WORKMANSHIP (Cont'd)

Welding (Cont'd)

The position of welds required for temporary attachment shall be agreed by the S.O. before the works commences.

Welding Plant

The welding plant shall be capable of maintaining at the weld, the voltage and current specified by the manufacturer of the electrodes. The Contractor shall supply instruments for verifying voltages and current as and when required by the S.O.

Supervision Of Welding

Welding shall be carried out only under the direction of an experienced and competent supervisor. Unless otherwise agreed by the S.O., a record shall be kept to enable major butt to be identified with the welders responsible with the work but finished work shall be marked by hand stamping for the purpose.

Weld Repairs

Any welding condemned by the S.O. shall be cut out and rewelded to his entire satisfaction.

Welding And Flame Cutting Procedure Trials

Before fabrication is commenced, welding and flame cutting procedure trials shall be carried out using representative samples of materials to be used in the work.

The welding and flame cutting trials shall demonstrate to the satisfaction of the S.O. the procedures to be adopted in the fabrication of the work which shall include:-

- (a) Welding procedure in accordance with B.S 2642 and B.S. 5135
- (b) The heat control techniques required to ensure that the flame cut surfaces of steel are free from cracks, local hardness and other defects which would be detrimental to the finished work.

The trials shall include specimen weld details representative of the actual construction, which shall be welded in a manner simulating the most favourable conditions liable to occur in the particular fabrication. After welding, the specimens shall be held at a temperature not less than 10 degrees Centigrade for a period of not less than 72 hours and shall then be sectioned and examined for cracks and other defects.

3.6 - STEEL AND IRONWORKS (Cont'd)

WORKMANSHIP (Cont'd)

Welding And Flame Cutting Procedure Trials (Cont'd)

The following groups of tests to B.S. 709 shall be carried out in accordance with the Testing Clauses of the specification:-

(a) Butt Welds

Transverse tensile tests. Transverse and longitudinal bend tests. Separate tests shall be performed in each case with the root of the weld in tension and compression respectively.

(b) Fillet Welds

Fillet weld fracture test.

Making

Each piece of steelwork shall be clearly marked in accordance with marking diagram to be prepared by the Contractor. The form of marking shall be subject to the prior approval of the S.O. and shall be such that it is still clear after the transport of the piece to site. Two copies of the drawings correctly showing the marks shall be supplied to the S.O. when the steelwork is despatched.

Machined Surfaces

All machined surfaces shall be carefully protected against corrosion or mechanical damage in handling, storage or service.

Erection

Erection shall be in accordance with B.S. 449. The Contractor shall submit the S.O. complete description of the method he proposes to adopt. The erection procedures and programme shall be subjected to the approval of the S.O. at all stages.

The Contractor shall, as soon as possible, submit to the S.O. for approval, his calculations for the stresses in and the stability of the structure at all stages of erection, for any temporary or permanent material required and for the design of all temporary works, no operation shall be permitted on site without the prior approval of the S.O.

Setting Bearings

Bearings shall be set accurately to line and level as directed by the S.O. making suitable adjustments for the temperature conditions at the time of setting.

3.6 - STEEL AND IRONWORKS (Cont'd)

WORKMANSHIP (Cont'd)

Surface Preparation

Cleaning shall be carried out by manual steel-wire brushing and dusting to remove all loosened material. Excessive brushing of the metal through prolonged application or rotary wire brusher shall be avoided, surfaces shall be primed with one layer of the specified undercoat within four (4) hours of having been cleaned.

Unless otherwise described in the Contract, welds and surfaces which have been affected by welding shall be prepared for painting by the same process as described in the Contract for the adjoining metal.

Painted surfaces shall be cleaned of all dust immediately prior to the application of further paint. Any loose paint and rust shall be removed and repair painting carried out as specified.

Application

Painting shall be carried out by brush or roller.

Brushers and rollers shall be of grades suited to the work and shall be kept in a clean condition throughout the work. Equipment shall be thoroughly cleaned if changing from one type of paint to another or from one colour to another.

Where any work is being carried out above ground level, the Contractor shall erect such scaffolding and ladders as may be required both for the execution of the painting and also for inspection of the work in progress, the cost of such equipment being covered by the rates in the Contract.

All paint shall be supplied to the painters ready for application and addition of thinners or any other material shall be thereafter prohibited.

All painting shall be carried out by skilled painters under competent supervision.

3.6 - STEEL AND IRONWORKS (Cont'd)

WORKMANSHIP (Cont'd)

Application (Cont'd)

Paint shall not be applied during rain, fog or mist, or when condensation has occurred or is likely to occur on steel or dusty conditions. Particular care shall be taken in the application of polyurethane under conditions of high humidity.

Unless otherwise agreed by the S.O., each coat of paint shall be applied to produce a continuous film of paint of uniform and even thickness. Successive coats shall have different shades for identification and each coat shall be thoroughly dry before application of the subsequent coat.

Unless otherwise agreed by the S.O., the paint treatments Ref.E, shall be applied under cover in controlled conditions at the fabricator's works.

The greatest care shall be taken in loading, unloading, stacking and erection of the steelwork to avoid damage to the paintwork. All slings, ropes and chains employed for such shall be rubber- sheathed or similarly protected.

Contact surfaces of high strength friction grip bolted connections shall be unpainted except that the first shop priming coat may extend onto the interface a maximum distance of 12mm. Subsequent coats shall be stopped back by increments of 25mm. All interfaces shall be thoroughly cleaned by hand wire-brushing before assembly.

On bolted interfaces other than high strength friction grip bolt interfaces, the shop priming coats shall be applied to contact faces apart from an overlap of 12mm. Immediately before assembly, surfaces permanently in contact shall have all loose scale and rust remove by pneumatic tools or other approved means, then finally cleaned with power brushes before treating with one coat of lead-based priming paint.

3.6 - STEEL AND IRONWORKS (Cont'd)

PROTECTIVE PAINT SYSTEM FOR STRUCTURAL STEEL

Treatment System

The paint used shall be "ICI" or "Nippon Paint" or other approved and equivalent paint. The painting shall be carried out strictly under the close supervision of the manufacturer. The treatment shall be as follows:

For each treatment, all surfaces shall be treated in the order listed and each process shall be as specified.

- (a) Treatment Ref. E1
 - (1) Manual wire brushing
 - (2) One coat of zinc chromate pretreatment primer
 - (3) Two coats of zinc chromate primer
 - (4) One coat of micaceous iron oxide undercoat
- (b) Treatment Ref. E2
 - (1) Galvanise
 - (2) One coat of pretreatment primer
 - (3) One coat of polyurethane decorative undercoat gutters.
- (c) Treatment Ref. E3
 - (1) Galvanise
 - (2) One coat of polyvinyl butyral based, acid catalysed etching primer
 - (3) One coat of micaceous iron oxide undercoat
- (d) Treatment Ref. E4
 - (1) Galvanise
- (e) Treatment Ref. S1
 - (1) One finishing coat of micaceous iron oxide

3.6 - STEEL AND IRONWORKS (Cont'd)

PROTECTIVE PAINT SYSTEM FOR STRUCTURAL STEEL (Cont'd)

System Treatment (Cont'd)

- (f) Treatment Ref. S2
 - (1) Manual wire brushing
 - (2) Two coats of zinc chromate primer
 - (3) One undercoat of micaceous iron oxide
 - (4) One finishing coat of micaceous iron oxide
- (g) Treatment Ref. S3
 - (1) One coat of polyurethane decorative finish

Treatment To Be Applied

Steel metal surfaces shall be protected as follows:-

Ref.	Treatment	
	<u>At Works</u>	<u>On Site</u>
(a) Trusses, stanchions, universal beams, purlins.		
(b) Stairways, handrails and posts.		
(c) Bolt heads		
	E1	S1
	E2	S3
	E1	S2
(d) Support base plate assembly and base plates.	E1	S1
(e) Outside surface of roof gutters.	E2	S3
(f) Inside surface of roof gutters	E3	S1
(g) Rainwater downpipes	E3	

High strength friction grip bolts, close tolerance bolts and their nuts washers shall be cadmium plated in accordance with B.S. 3082, Part 1.

Black bolts, nuts and washers shall be standardised in accordance with B.S. 729, Part 2.

3.6 - STEEL AND IRONWORKS (Cont'd)

PROTECTIVE PAINT SYSTEM FOR STRUCTURAL STEEL (Cont'd)

Repair Painting

Areas of paint which have damaged during handling, storing, loading and off-loading, transport or erection shall be cleaned to base metal and the edges of the undamaged paint bevelled with sand paper.

The full specified painting system shall then be re-applied and the new paint system shall overlap the existing paint by at least 50mm all round the affected part.

Test On Metal Coatings

Tests and sampling of metal coatings shall be in accordance with B.S. 729 Parts 1 and 2 or B.S. 3382 Part 1.

Testing - General

Steel test certificates shall include a ladle analysis of the chemical composition of the material.

Qualification And Testing of Welders

For the welding of any particular type of joint, welders shall show evidence to the satisfaction of the S.O. of have satisfactorily completed appropriate tests as specified by B.S. 449 and B.S. 2645.

Testing of Welding

The tests shall be carried out by the methods described in B.S. 709. The following requirements shall be met:-

(a) General

The test result of welded joints shall not be inferior, in any respect, to the B.S. test requirements for the parent metal.

(b) Procedure Trial

(i) Tensile and Bend Tests

Should any one of the weld joint test pieces selected for transverse and longitudinal bend test fail to comply with the test, two additional test pieces shall be taken from the joint material represented by the test. Both shall then comply with the test requirements in order to qualify for acceptance.

3.6 - STEEL AND IRONWORKS (Cont'd)

PROTECTIVE PAINT SYSTEM FOR STRUCTURAL STEEL (Cont'd)

Testing Of Welding (Cont'd)

(ii) Revised Procedures

In the event of failure to meet the test requirements, the Contractors shall carry out further trials, using procedures and further tests to the satisfaction of the S.O.

(c) Production Tests

(i) Tensile and Bend Tests

Should any one of the weld joint test pieces selected for transverse tensile and transverse bend tests fails to comply with the test requirements applicable to the parent metal of the joint represented by the test, additional specimens shall be cut from the same production test plates and the test repeated. Should either of the additional tests fails to comply with the requirements, the joint shall be rejected.

(ii) Re-welding and Re-Testing

In the event of failure to meet the test requirements, the welded joint represented by the tests shall be completely cut off. The joint shall then be re-welded and the tests repeated.

(d) Non-Destructive Testing

As directed by the S.O., the Contractor shall carry out non-destructive tests on the welds. The test shall be:-

(i) For Butt Welds

Radiographic examination complying with B.S. 2600 or B.S. 2910 as appropriate and ultrasonic examination complying with B.S. 3923.

(ii) For Fillet Welds

Visual inspection and dye penetrant or magnetic particles tests.

3.6 - STEEL AND IRONWORKS (Cont'd)

PROTECTIVE PAINT SYSTEM FOR STRUCTURAL STEEL (Cont'd)

Testing Of Welding (Cont'd)

The Contractor shall include in his price and programme for the necessary time taken in inspection. The S.O. will required all major welds to be subjected to inspection by gamma-radiography, ultrasonic or non-destructive methods. Where inspection is by gamma-radiography, the Contractor shall make available sufficient space around the part being radiographed against radiation, and shall include in his price and programme for so doing.

Where a weld is, in the opinion of the S.O., faulty, it shall be cut in such a way as not to impair the subsequent strength of the structure and replaced with sound weld to the requirements of the drawings and specification.

Painting

All exposed surfaces of steel, ironwork and other metalwork (except aluminium work) shall be primed and painted as described and the rates for these work shall include for this.

Steel And Ironworks Rates

The rates for all steel and ironworks shall include for all cutting, notching, holes, nails, bolts and bolting, housed ends, mitred ends, angles, junctions heading joints and short length and welding.

Balustrades

Tubular balustrades and railings shall be constructed of mild steel tubing to B.S. 1387 medium grade unless otherwise described. Jointings shall be by welding. Welds shall be filed smooth with curve surfaces true at the point of jointing.

STAINLESS STEEL

Generally

All stainless steel members and sheets shall be from an approved manufacturer.

All stainless steel shall be 18/8 Chromium - Nickel austenitic steel conforming to B.S. Type 304 (corresponding to JIS Grade SUS27 or DIN Grade W4301) and with mechanical properties conforming to B.S. 1449 Part 4.

3.6 - STEEL AND IRONWORKS (Cont'd)

STAINLESS STEEL (Cont'd)

Generally (Cont'd)

The stainless steel surfaces to handrails, balustrades, cladded beams, columns and walls shall be machine polished finished to the Architect's approval. All stainless steel finished shall be clear, uniform finishes, free from defects, marks, scratches and other surface blemishes.

Samples

All Tenderers are required to submit samples of stainless steel components with their Tenders for the Architect's approval.

Further samples shall be submitted at the request of the Architect. The samples are to be of the same finish and workmanship as the Tender requirements.

After the approval of shop drawings, the Sub-Contractor shall fabricate and deliver for Architect's approval prior to fabrication mock-up samples showing full size sections, details of components and assembly method complete with all hardware required.

No claims shall be entertained for the cost of these samples which shall be retained during the Contract Period by the Architect to check the colour and the quality of the sections supplied under this Contract. Materials which in the opinion of the Architect are inferior to the approved samples shall be removed from site and replaced at the Sub-Contractor's own cost. At the completion of the Contract, the samples shall be returned to the Sub-Contractor.

Drawings And Design Of Fixing

All Tenderers are required to submit complete shop drawings and typical section details with their Tenders for the approval of the Architect complete with detail specification describing the sections, fixings, installations, etc. All cost incurred from the supply, constructions, fixing and installation of the materials above shall be deemed to be included in this Tender.

3.6 - STEEL AND IRONWORKS (Cont'd)

STAINLESS STEEL (Cont'd)

Drawings And Design Of Fixing (Cont'd)

Further shop drawings are to be submitted upon request, for approval of design showing full scale details of all parts of the design, fully dimensioned with finish, thickness, profile, jointings, welds, intersections, assembly of various members and construction, reinforcement anchorage and structural support and such details as to fully illustrate all details of the work required to meet this specification.

Manufacture And Installation

All stainless steel members shall be factory fabricated to the best standard of workmanship and under experienced factory supervision and control.

Materials, methods of fabrication, assembly, installation, fastening, supporting, bracing and operating shall be in accordance with the approved shop drawings.

The Sub-Contractor shall verify all dimensions shown in the Tender Drawings with actual site measurements before fabrication. Any cutting to enlarge size of openings or any filling or plastering around frames required after frame installation shall be executed by the Sub-Contractor without additional costs.

The operating devices, mechanism and hardware used in connection with the works shall be built and installed so that they will operate smoothly and freely, without excessive friction, noiselessly and shall be adequate for the purpose of which they are intended.

All joints in frames, handrails, etc. at corners, junctions or intersections shall be of such character and so assembled to be as strong and rigid as adjoining sections. Due care to be taken to ensure that all weld joints are structurally sound.

Unless otherwise specified, all welding work for stainless steel components shall be executed in tungsten inert gas (argon arc) welding and welding rods compatible with the parent metal.

When composite units are to be assembled on site, the Sub-Contractor shall assemble the components into units ready for incorporation in the works.

3.6 - STEEL AND IRONWORKS (Cont'd)

STAINLESS STEEL (Cont'd)

Manufacture And Installation (Cont'd)

Expansion and contraction in horizontal and vertical members exposed to the weather or elements should be allowed for. Any distortion in the members due to such inadequate provisions must be replaced at the Sub-Contractor's own cost.

All stainless steel works shall be securely installed and anchored in position, set plumb, square and level and in proper alignment with other works all in accordance with the approved shop drawings.

Modification

The Sub-Contractor may make minor changes in detailing of the work in order to conform to standard procedures or as required to facilitate field erection. However, no changes whatsoever shall be made without prior approval by the Architect.

The Architect may make minor changes in the details before final approval of the shop drawings. No extra cost shall be allowed because of these changes.

Fixing

It shall be the responsibility of the Sub-Contractor to ensure that the necessary fixings, fasteners, lugs, anchors, etc. are incorporated in the building carcass.

Concealed screws, nuts, bolts, rivets and other fastening devices should be as specified or approved by the Architect.

Storage And Protection

All stainless steel components are to be fully protected by strippable polythene film or other plastic film wrapping before despatch to prevent any damage during transit, handling and storage and from other work during and after installation. Protective coverings are to be retained in position until immediately before use.

Where stainless steel is placed in contact with a dissimilar metal or material likely to result in corrosion, a coat of an approved anti-corrosive and anti-by-metal chemical reaction paint shall be applied before fixing.

3.6 - STEEL AND IRONWORKS (Cont'd)

STAINLESS STEEL (Cont'd)

Storage And Protection (Cont'd)

Damaged components are to be rejected and not fixed in place or they shall be taken down and replaced at the Sub-Contractor's own cost and to the Architect's satisfaction.

At completion of the installation or at such other time as directed by the Architect, all protective materials are to be removed and the surfaces thoroughly cleaned with an approved cleaning agent.

Guarantee

The Sub-Contractor shall provide a written guarantee to the Employer for a period of five (5) years from the Date of Practical Completion to cover against faulty materials, finishes, workmanship, installation and any other defects or design faults. Any defects found within the Guarantee Period shall be remedied and made good to the satisfaction of the Architect all at the expense of the Sub-Contractor.

3.7 ROOFING

Scope : Roof overing and Rainwater goods

3.7.1 ROOF COVERING

Concrete roof slab and RC gutter

Refer to the Concrete Work Section of this specification.

Framework

The Contractor shall ensure that all battens, purlins, rafters and other framing members supporting roofing materials shall be constructed to uniform and correct lines and levels to ensure the proper fixing and use of such materials.

Delivery

The Contractor shall ensure that all roofing materials are delivered to the site of the Works at an early stage to enable weather-proof roofs to be constructed before plastering or other form or surface finish is applied anywhere in the buildings.

Concrete Roof Tiles

Concrete roofing tiles shall comply with MS 797 Part 1 Specification for concrete interlocking roofing tiles. It shall have uniform colour and generally of similar profile obtained from an approved manufacturer. The tiles shall be laid strictly in accordance with the manufacturer's instructions including all fixing accessories.

The tiles shall be delivered to site in an undamaged condition. Damaged or cracked tiles will be rejected.

Ridges and hips are to be finished with ridge tiles to match the roof tiles, bedded at edges and pointed in cement mortar tinted to match. End tiles are to be bedded solid.

Nailing of concrete roof tile

Roof tiles shall be fixed down with 65mm long nails according to the following conditions and requirement:

Below 5 storey	All perimeter roof tiles shall be nailed down.
5 Storey and above	All perimeter roof tiles, exposed eaves tiles and every third course shall be nailed down.

The above fixing detail must also comply with Manufacturer's standard.

Valley tiles

All tiles that form the roof valley shall be machined cut in two straight lines with a gap of 50 to 75mm apart.

Metal Deck

Metal deck roofing shall be pre-painted, with base metal thickness and total coated thickness not less than 0.35 and 0.40mm respectively, hot-dip galvanised steel (Aluminium-zinc coated) sheet complete with ridge capping and colour matching flashing. It is insulated with 50mm thick rock wool, 10kg/m³, aluminium insulation foil and supported on chicken wire netting below. The nails or screws used for fixing down the metal deck shall have cap and bituminous or rubber washer below to ensure water tightness.

Corrugated (Asbestos Free) fibre reinforced Cement sheet

The material shall be of autoclaved fibre cement asbestos-free corrugated sheet, not less than 4mm thick, made from Portland cement, refined sand and specially treated cellulose fibre. Purlin spacing shall not be more than 850mm c/c. The nails or screws used to fix down the roofing sheet shall have cap and bituminous or rubber washer below to ensure water tightness.

3.7.2 RAINWATER GOODS

Refer to Table 1 Rainwater goods – Flashing & Gutters, attached for details and specification on profile, gauge, girth and lap distance.

Galvanised Iron Sheet Flashing

Wall flashing

One edge of wall flashing shall be inserted into a straight machine-cut-groove line on wall plastering. The flashing is fixed to wall with 50 to 65mm long nail or screw at 600 to 900mm c/c. Suitable sealant shall be applied and finished smoothly on the whole groove line to prevent water seeping through.

Fire wall cap flashing

Continuous width flashing shall be used for the fire wall that protruded above the roof covering.

Vent pipe flashing

It shall be sized according to the vent pipe diameter as shown. The hole shall be cut from the flashing and fit the vent pipe tightly. The flashing shall be secured to the vent pipe with two screws and the gap between the flashing and vent pipe shall be filled up with appropriate sealant.

GENERAL SPECIFICATIONS

Eaves Flashing

Eaves flashing is required to prevent the splashing of rain fall into the roof. It shall be secured to the fascia board by 38 to 50mm nails or screws not more than 900mm c/c.

Gutter

All building with 5 storey and above shall have perimeter gutter.

Galvanised Iron Gutter

All galvanised iron sheeting used in gutters shall be of minimum 22 gauge flat GI sheets unless otherwise specified and accurately cut and formed to shape and size as specified and shall comply to B.S. EN 612 :1996 complete with MS bracket and down pipe outlet according to Architectural drawing.

UPVC Gutter

The colour, profile of UPVC gutter and all accessories shall be confirmed by Architect before delivery to site. They shall be UV resistant.

Valley gutter

Valley gutter shall be supported by two numbers of 70x40 HW valley timber and adjoining batten or purlin, or 1 No valley rafter.

Rainwater Downpipes

Down pipes shall be complete with all accessories and fixing to ensure that they are water tight or properly secured to the supporting structure.

GI rainwater downpipes, circular or rectangular, whenever used, shall not be casted in concrete columns but will be exposed and located as shown in the drawings. They shall comply with BS EN 612:1996.

UPVC rainwater downpipes, circular or rectangular, whenever used, either be casted in concrete columns or to be located as shown in the drawings. They shall be UV resistant.

3.8 CARPENTRY

Scope : Generally apply to timber structural work

Delivery And Storage

Co-ordinate delivery with construction schedule. Protect materials from weather and high humidity while in transit and on job site.

Keep all materials clearly identified with all grade marks legible.

Store materials on raised supports.

Cover materials stored on site with tarpaulins or polyethylene sheets to prevent moisture absorption and impairment of structural and aesthetic properties. Ensure proper ventilation.

Store materials on site in such a manner as to prevent any damage or surface scratching.

Protection

Use all means necessary to protect the materials of this section before, during and after installation and to protect the installed work and materials from damage by all other trades.

In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect at no additional cost.

Cooperate with all other trades and do all cutting and trimming, in order to accommodate the work of others.

Centering

The Carpenter is to fix all necessary centering for concrete in floors, walls, roofs, beams, lintels, columns, hearths etc. and for arches, vaults and other masonry works that may be described in this schedule, together with all temporary strutting, bracing and support and to remove same when no longer required.

Tests

The Contractor is to allow for testing prototypes of special construction units.

The Architect is to be at liberty to select any samples he may require for testing.

Clearing Up

The Carpenter is to clean out all shavings, cut ends and other timber waste from all parts of the building before coverings or infillings are constructed. All own waste and rubbish is to be destroyed or removed by main contractor. Sub-contractors shall gather their waste and rubbish to a designated spot near the building to be removed by main contractor.

GENERAL SPECIFICATIONS

Materials

The carpentry materials must conform at least to the appropriate Malaysian Standards (MS). Where no MS exist, the quality of the materials shall be of the most appropriate or in accordance with other acceptable standard.

Timber of local origin shall be as classified by 'The Forest Research Institute' under the following:-

- A. Heavy hardwood
- B. Medium hardwood
- C. Light hardwood
- D. Softwood

Bonding adhesive shall be an approved high solids, rubber contact type adhesive supplied in cartridges.

Nails, spikes and staples shall be galvanise for exterior work, interior highly humid areas and for treated lumber; plain finish elsewhere. Use spiral thread nails where specified.

Fasteners:

- a) To hollow masonry use toggle bolts.
- b) To solid masonry or concrete use expansion shields and lag bolts.
- c) To steel use bolts or power activated fasteners.
- d) Use inorganic fibre plugs where screws specified into concrete or masonry.

Rough hardware eg. bolts, nuts, washers, lags pins, screws for exterior used shall be hot dip galvanised.

Moisture Content of Timber

All timber shall be seasoned to a moisture content of or below the maximum values specified for its position in the structure before fabrication according to CP 112 : 1971 or whatever latest standard available.

The Contractor shall submit a certificate showing the moisture content of the treated timber delivered to site when requested by the Architect.

The Contractor shall provide an electric moisture meter to monitor the moisture content of timber on site. Any timber containing a moisture content in excess of that specified shall be removed from the site as directed by the Architect and shall be replaced at no additional cost to the contract.

Workmanship

Unwrought timber shall be full to the dimensions stated, except that occasional slight variation in sawing is permissible subjected to the approval of the Architect.

All framing shall be jointed as specified, shown on the drawings or as is most appropriate in circumstances. The joints shall be designed and constructed so that they will transmit the loads, and resist the stresses to which they will be subjected and the execution of all jointing shall be to the satisfaction of the Architect.

GENERAL SPECIFICATIONS

Unless otherwise stated, all joints shall be secured with a suitable type and sufficient number of nails.

A butt joint shall wherever possible be secured with nails driven from the far side of the flanking member (if any). The jointing surfaces of all connections exposed to the weather are to be thickly primed except where adhesives are specified.

Surfaces to be in good contact over the whole area of the joint before fastenings to be applied.

No nails, screws or bolts to be placed in any end split. If splitting is likely, holes for nails are to be pre-bored at diameters not exceeding four-fifths diameter of nail. Clenched nails are to be bent at right angles to the grain. Lead-holes are to be bored for all screws.

Nuts are to be brought up tight but care is to be taken not to crush the timber under the washers.

Carefully select all wood members and discard all wood members with defects which will render a piece unable to serve its intended function; lumber may be rejected by Architect, whether or not it has been installed, for excessive warp, twist, bow, crook, mildew, or mould, as well as for improper cutting and fitting.

Carpentry works that do not form an essential part of the main structural fabric shall not be carried out until necessary for the proper completion of the work.

Preservative treatment

Where preservative treatment is specified, the timber are to be of the correct moisture content specified and free from surface moisture and dirt. Treatment is to be carried out after all cutting and shaping is completed and care is to be taken to avoid damage to surfaces of treated timber in subsequent handling, if treated timber is unavoidable cut or damaged, a liberal application of preservative is to be made to cut or damaged surfaces.

The contractor shall submit technical data on the type of preservative treatments to be used for treating timber to the Architect for approval before placing any purchase order.

The contractor shall produce certificates from the timber supplier certifying that all timber are treated with preservative in accordance with the manufacturer's instructions.

The certificates shall include information on the quantities and sizes of timber treated and the net retention of dry salt obtained.

All treated timber shall be thoroughly dry out before incorporation in the works.

All non durable timber used under shelter and above ground contact (roof truss) shall be treated with Copper Chrome Arsenic (CCA) to an average dry salt retention of 5.6kg/m³ according to MS 360.

Fire resistant treatment

Fire resistant treatment is to be carried out with the materials specified, and the methods used for its application are to conform with the approved manufacturer's instructions. When impregnation is specified, the timber shall be impregnated throughout, or as completely as it is possible, with a liquid which renders the timber fire-resistant.

When surface coating is specified, the compounds shall be applied on the surfaces of the timber to form an unbroken film.

Metal

Metal stirrups, shoes, binding, fixings (including nails, screws and bolts) clips and other accessories shall be appropriate in regard to the type of timber with which they will be in contact and must engage the stresses in the positions the trusses are designed to occupy without undue deflection.

Assembly

Structural units are to be assembled in accordance with the drawings and this specification. All unsatisfactory or damaged members are to be replaced before delivery to the site (or before inclusion in the works). Structural units are to be assembled before delivery to site (or fitted together to ensure correct manufacture if assembly is to be carried out on site). Before bulk manufacture is put in hand a complete assembly of each structural units is to be made to check accuracy. Templates and gauges are to be checked from time to time to discover wear. Members and units are to be marked in accordance with the marking schedule.

Inspection

Facilities are to be given for the Architect to inspect all work in progress in shops and on site.

Shop drawings

Submit shop drawings clearly indicating details of construction, profiles, jointing, fastening and other related details in accordance with clause 1 Shop Drawings'.

Special delivery and storage

Arrange delivery of finished articles so that on-site storage is kept to a minimum. Do not store finished articles on site while there exists any danger of damage from moisture, paint, mortar and other similar contaminants.

Installation

The contractor shall be responsible for methods and safety of construction. Adequate provision shall be made for possible erection stresses.

Structural timber shall be set to correct position and securely braced in place to maintain plumb and true until permanently fixed and held in structure.

Construct continuous members from pieces of longes practical length.

Lay out work carefully and to accommodate work of other trades. Accurately cut and fit. Join work only over solid backing.

Bore holes, fractionally larger than diameter of bolt, for bolted work, true to line. Use plate or washer to prevent nut from bearing directly on wood, and turn up nuts, bolts and lag screws tight at time of installation and again immediately before being concealed with other work or at completion of work.

Co-operate with others engaged in work on the building to the end that proper unity of action will assure orderly progress of work. Do necessary boxing and protecting of sills, jambs, corners and other similar locations required for work of other trades.

Install all materials and components in place true to line, levels and elevations. Set up and secure plumb, rigid and square. Space uniformly.

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Do not notch, bore or cut structural members for pipes, ducts, conduits or other similar items, except as specifically approved in writing by Architect.

All cantilevers shall be effectively counterbalanced by the other portion of the member, and by suitable fixings and by other dead loading.

The anchorage of roof frames, trusses and other structures that require to be secured against displacement shall be suitably incorporated in the joints or by means of extra fixings at all points of support.

Where installing blocking, or plates atop precast concrete wall panels, ensure the use of screws. Secure wood to cast-in inert polyethylene inserts.

Do not use organic fibre or wood plugs under any circumstances.

Beams and binders

Shall be of the dimensions shown on the drawings (if not included in the specification). The larger of the cross-sectional dimensions shall be of the depth unless otherwise stated.

The timber is to be in one piece and in one length between supports. Joints between continuing lengths are to be suitably scarfed or spliced and secured with bolts and plates or metal straps.

Joints into or over posts are to be of the most appropriate type and must be accurately constructed, and reinforced, and reinforced with metal straps where necessary to prevent displacement (or to detail).

Housings, mortise-and-tenon and other joint cuttings must be carefully executed, and performed in such a way that they do not impair the strength and stiffness of the beams or binders.

The ends of beams, binders and other special flexural members are not to be built into walls but are to be supported in accordance with the details to provide an air space for ventilation at all points. Bearings on wall plates, beams, brackets girders, etc. are to be at least 75mm (or to detail). Roof beams shall have a 300x9mm dia MS starter bar cast insitu at not more than 1220mmc/c and 150mm away from all corners for fixing down the wall plate.

Metal hangers or joist shoes are to be designed with a bearing of at least 75mm.

Camber

Camber of special structural units, joists, beams, built-up girders, trusses, etc. to be as specified.

Strutting and bracing

Where the framework of a wall, floor or roof is not otherwise restrained against lateral deformation, it shall be diagonally braced. Lateral braces to restrain against winding and buckling shall be fixed to all beams of depth greater than 3 times their breadth and/or length greater than 50 times their breadth. Lateral braces are to be at centres not exceeding 50 times the breadth of the beam.

Trimming

All works arising from the trimming of openings in the floor and roof frames shall be properly carried out with the materials specified.

Trimmer and trimming joists shall be the same depth as the common joists and of the thickness specified or shown on the drawings.

All mortise and tenon and half depth housing or half-depth bevelled housing joints shall be accurately constructed so that the alignment of the members is maintained while the stresses of the connections are fully engaged.

Timber floor construction

The contractor is to satisfy himself that the conditions necessary for the proper support and fixing of the floor joists is obtained in the plates before proceeding with the construction of the floor.

The joists are to be of the dimensions specified and shall be laid in parallel lines and spaces as directed in this specification.

Suitable arrangements are to be made in the design and construction of the floors so that they shall be structurally continuous where they extend into recesses or across openings in the walls.

Where the floors are supported and contained by walls of concrete or masonry, the joists are to be securely toe-nailed in the wall plates. If the joists are to extend into the thickness of walls constructed of brickwork or masonry, they shall be thoroughly charred and 'brush' creosoted of all surfaces adjacent to the connections or receive other approved treatment, and a clear air space shall be maintained around the timber where it adjoins the concrete or masonry. The framework shall also be arranged so that the first and last joists of each enclosed section shall be 50mm clear of any concrete or masonry in the flanking walls, and at least 12mm clear in the supporting walls.

Timber MUST NOT extend into the thickness of walls which may be liable to dampness.

All joists shall extend at least 75mm (or not less than the depth of the member) beyond the nearest edge of supporting plates unless they are properly secured.

Notching joists

When joists are to be notched over supports, the depth of the notch shall be according to construction drawing details. The bearing surface of all notches shall be cut smooth and true in relation to the surface on which it bears.

Timber roof construction

The Contractor is to satisfy himself that the conditions necessary for the proper support and restraint of the roof are obtained in the walls and other related structures.

The plates, joists, rafters, purlins and other pieces used for the construction of the roof are to be of the dimensions specified and are to be spaced and constructed as directed in this specification and in the working drawings and details.

The spacing of rafters shall be the same as that used for the trusses ~~joists~~ unless otherwise stated.

Overhang edges shall be adequately cantilevered and anchored back to the main roof frame work without weakening it in any way.

Prefabricated Roof Trusses

Timber roof trusses are to be obtained from approved specialist manufacturer designed, supply and installed to the loading below:

- self weight of trusses, battens, bracing and any other elements required for the performance of the truss system.
- metaldeck roofing/concrete roofing tiles and ceiling.
- wind load (in accordance with MS 1553).
- imposed load (in accordance with Uniform Building By Law (UBBL)).
- any other items as directed by the S.O. or his representatives.

Prior to the commencement of roof beam construction, all shop drawings and calculations of roof truss system are to be submitted to the S.O. for approval.

All timber used for prefabricated roof trusses fixed with tooth-metal plates shall be gauged or dressed to ensure uniform thickness and size with a tolerance of not more than 2mm between any two pieces of timber of a joint.

The timber used for roof installation and truss fabrication may be seasoned or at green condition.

Timber Species and Strength Group

Data on relationships of species to strength groups and their grade stresses are in table 3 and 4 of MS 544 Part 2 : 2001 attached .

Standard and select grade timber are as defined by the relevant grading rules in Malayan Grading Rules for Sawn Hardwood Timber, 1968, Section J, Stress Grading.

The truss shall be design according to the strength group and stress grade of the timber chosen.

All the joints in the framework shall be of the most appropriate type, accurately formed, and adequately secured with nail plate. All members are to be of the dimensions shown on the drawings. The arrangement of the separate members and the construction of all joints shall be in accordance with the drawings, and this specification.

Timber Species and Uses

Malaysian timber species and their commercial uses are outlined in the table attached (Malaysian Wood – A guide to their uses. By Malaysian Timber Industry Board).

3.10 ALUMINIUM WORKS

Generally

All aluminium members, unless otherwise specified, shall be extruded and manufactured by approved Malaysian manufacturers.

All aluminium material shall be free from defects impairing strength, durability of appearance and shall be adequate in every way for their purpose. Surfaces shall be clean, straight and true with sharp defined profiles and smooth finish. All sections, sheets, etc., shall be free from bends or waves or other surface imperfections, true and straight vertically and horizontally with all arises, profiles, etc., true and sharp.

Aluminium glazing beads to be of the screwless type, fitted into the extruded frames, unless otherwise specified.

Aluminium sheets shall conform to the requirements of B.S. 1470.

Fixing lugs, screws, nuts, bolts, rivets, fixing anchors, brackets and other fastening devices shall be aluminium.

Finish

All exposed surfaces, except where otherwise specified, shall be machine polished to a clear and uniform finish, free from alloy defects, die marks, scratches and other surface blemishes.

All aluminium curtain walling, fixed panels, windows, etc. unless otherwise stated shall be of approved colour finish process. The finish shall conform to the current accepted standard specification for anodic finishes for Architectural Works with minimum film thickness of 20 microns in accordance to B.S. 1615.

Natural anodised aluminium members shall be processed under electrically controlled conditions to a minimum film thickness of 10 microns and 1.2mm thick in accordance with B.S. 1615:1965.

The aluminium members with anodic coatings shall be sealed by hydration treatment after anodising and tested to the required tolerable porosity and absorptivity levels of the coating.

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The Contractor shall supply a certificate from the Anodiser to verify the anodised finish complies with the specification/preambles.

The certificate shall also give the following particulars :-

- (i) The name, trademark or other means of identification of the Anodiser.
- (ii) The materials specification
- (iii) List of drawings, or both, of significant surfaces.
- (iv) The surface finish prior to anodising.

Tender Drawings And Specification

The Tender Drawings are diagrammatic and do not purport to identify or solve completely the problems of thermal or structural movement, pressure equalisation, vapour barriers, fixings and anchorage, flatness and stability of facing, moisture disposal, etc. The drawings also do not purport to solve problems at the glass line associated with glass movement, pressure fracture of thermal shock.

The Tender Drawings indicate profile and configuration required together with relationship to structural frame and interior building elements. The drawings also contain details which suggest directions for solving some of the major design requirements and the Contractor may use these details and develop them as he deems best.

The Specification is of the "performance" type and include the minimum requirements of the curtain wall system, fixed panels, windows, etc. without limiting the Contractor to the method of achieving such performance.

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Tenderer's Own System

Tenderers are invited to offer their own systems and the said systems are to follow as closely as possible to the requirements of these Specification/Preambles.

All windows are to be designed to withstand loads due to :-

- (i) Wind pressures prevailing in Malaysia (wind loading:24m/per second - approximately 54 miles per hour),
- (ii) Dead loads of infill panels (glass),
- (iii) Live loads which may be imposed and,
- (iv) Rigidity necessary for long span structure.

Aluminium ironmongery, glazing beads, fixing anchors, brackets, attachments and accessories and neoprene glazing gaskets and weather strips shall be included as part of the system offered.

Aluminium windows, hardware, fastening and fixings, etc. shall comply with B.S. 4873.

Patent Rights

The Contractor shall fully indemnify the Employer against any action, claims or demands, costs or expenses arising from or incurred by reason of infringement of letters patent right and design, trade mark or name, copyright or other protected means in respect of any work, materials or thing, system or method of using, fixing, working or arrangement used, fixed or supplied by him.

All payments of royalties payable in one sum or by instalments or otherwise shall be included by the Contractor in prices named in his Tender and shall be paid by him to whom they may be due or payable.

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In the event of any claim being made or action brought against the Employer in respect of any such matters as aforesaid, the Contractor shall be immediately notified thereof and he shall at his sole expense conduct all negotiations for the settlement of the same, or any litigation that may arise therefrom.

Samples And Mock-Up Samples

All Tenderers are required to submit samples of aluminium sections with their Tenders the Architect's approval.

Further samples shall be submitted at the request of the Architect.

Upon approval of shop drawings, the Contractor shall submit for Architect's approval prior fabrication one (1) mock-up sample of part/section of the typical curtain wall, fixed panel, window, etc. showing full size sections, details of components including glazing and sealing materials, assembly method complete with all hardwares required and fixing anchors.

All samples shall be identified with a full laboratory report attached describing in details the finishing process. The finishes and quality of the aluminium for eventual incorporation into the system shall be similar and not inferior to or inconsistent with the approval sample.

No claims shall be entertained for the cost of this sample which shall be retained during the Contract Period by the Architect to check the colour and the quality of the aluminium supplied under this Contract. Aluminium which in the opinion of the Architect, are inferior to the approved sample be removed from site and replaced at the Contractor's own cost. At the completion of the Contract, the sample shall be returned to the Contractor.

Drawings And Design Of the Works Including Fixing System

As the sections which Tenderers propose to use may differ, all Tenderers are required to submit complete shop drawings and typical section details with their Tenders for the approval of the Architect complete with detail specification describing the sections, fixings, installations, etc. including the fixing of system.

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All costs incurred from the design, supply, construction, fixing and installation of the whole Works shall be deemed to be included in this Tender.

After the Contract is awarded, the Contractor shall produce and supply free to the Architect, on his request, for his approval and retention, copies of the shop drawings of all curtain walling, fixed panels, windows, etc. (to a scale 1/4" to 1'0") together with typical details of sections (full size), fully dimensioned with finish, thickness, profile, jointings, welds, intersections, assembly of various members and construction, reinforcement anchorage and structural support and such details as to fully illustrate all details of the work required to meet this specification. The Architect's approval shall be obtained prior to the commencement of any fabrication.

Notwithstanding such approval, the responsibility for the size, dimensions, and other information indicated in the drawings shall remain with the Contractor.

Workmanship And Manufacturer

(i) Generally

The Architect's drawings are essentially schematic except for profiles of exposed surfaces which shall be as indicated. If, in the opinion of the Contractor, a change of profiles is required in order to meet the specification, he shall at once notify the Architect and obtain his written decision before submitting his tender.

The method of assembly, reinforcing and anchorage of the works, where indicated, is schematic. The Contractor shall design and assume full responsibility for the assembly, in an acceptable manner complying with the requirements specified in these documents. All visible joints shall be as shown on the Architect's drawings; hairline joints shall be tightly fitted.

All parts shall be secured concealed means wherever possible and where exposed to view, screw positions are to be indicated on the preliminary drawings. Exposed screws shall be of the countersunk type finished to match the parent metal and shall be evenly and neatly located in an approval manner.

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All components shall be assembled, secured, anchored, reinforced, sealed and made weathertight in a manner not restricting thermal or wind movements of the system. Where possible, sealants shall be concealed.

Design Right, patents and direct supply from Manufacturer

Contractor shall transfer the design rights and patents (if any) to the Client upon award of the Contract. The supply of aluminium profiles from the Manufacturer shall not be exclusive to the Contractor, but to be extended to the Client upon request unconditionally.

Free and noiseless movement of all the components of the system due to thermal effect, structural effect, wind pressure, erection or dead loads, shall be achieved without straining the glass, buckling any component or causing excessive stress to any members or assemblies.

(ii) Manufacture

Aluminium members shall be fabricated to the best standard of workmanship under experienced factory supervision and control.

Materials, methods of fabrication, assembly, installation, fastening, supporting, bracing and operating shall be in accordance with the approved shop drawings.

The Contractor shall verify all dimensions shown in the Tender Drawings with actual site measurements before fabrication. Any cutting to enlarge size of openings or any filling or plastering around aluminium frames/sheets required after frame installation shall be executed by the Contractor without additional costs.

The operating devices, mechanism and hardware used in connection with the Works shall be built and installed so that they will operate smoothly and freely, without excessive friction, noiselessly and shall be adequate for the purpose of which they are intended **and should not be modified for intended use.**

Joints at corners, junctions or intersections shall be electrically welded or mechanically cleated to provide a clean and perfect joint free from surface defects and disfiguration to the anodised finish.

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All joints in frames/sheets at corners, junctions or intersections shall be of such character and so assembled to be as strong and rigid as adjoining sections. Due care to be taken to ensure that all weld joints are structurally sound.

When composite units are to be assembled on site, the Contractor shall assemble the components into units ready for incorporation into the Works.

Expansion and contraction in horizontal and vertical members exposed to the weather or elements should be allowed for. Any distortion in the members due to such inadequate provisions must be replaced at the Contractor's own cost.

Aluminium members shall be fabricated to the best standard of workmanship under experienced factory supervision and control.

Materials, methods of fabrication, assembly, installation, fastening, supporting, bracing and operating shall be in accordance with the approved shop drawings.

The Contractor shall verify all dimensions shown in the Tender Drawings with actual site measurements before fabrication. Any cutting to enlarge size of openings or any filling or plastering around aluminium frames/sheets required after frame installation shall be executed by the Contractor without additional costs.

The operating devices, mechanism and hardware used in connection with the Works shall be built and installed so that they will operate smoothly and freshly, without excessive friction, noiselessly and shall be adequate for the purpose of which they are intended.

Joints at corners, junctions or intersections shall be mechanically cleated to provide a clean and perfect joint free from surface defects and disfiguration to the anodised finish.

All joints in frames/sheets at corners, junctions or intersections shall be of such character and so assembled to be as strong and rigid as adjoining sections.

GENERAL SPECIFICATIONS

When composite units are to be assembled on site, the Contractor shall assemble the components into units ready for incorporation into the Works.

Expansion and contraction in horizontal and vertical members exposed to the weather or elements should be allowed for.

Any distortion in the members due to such inadequate provisions must be replaced at the Contractor's own cost.

(iii) Dimensions/Site Measurements

Before the Contractor commences manufacturing, dimensions of openings shall be checked on site to ensure that all fixed panels, windows, etc. will fit into the said openings and the Contractor shall be responsible for the accuracy of all measurements taken on site. [The permissible tolerances for workmanship and installation is as follow :-](#)

- i) [Maximum deviation from vertical, horizontal or designated position is 1 in 1000.](#)
- ii) [Maximum offset from true alignment at joints between abutting members in line and shall be 1.5mm.](#)

iv) Waterproofing

The fixed panels, windows, etc. must incorporate a drainage proposal to drain and discharge water due to leakage condensation or other causes to the external face of the wall. The drainage of such water must be controlled to ensure that there is no retention of any water on any part of the window systems, etc. or building. Further, this drainage must not cause any damage, corrosion or promote any algae and fungus growth to any part of the window system etc. or building.

(v) Mullions And Transome

The sections of mullions and transome shall be designed to withstand deflection and wind pressure as described in this specification and shall further be rigid enough to

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support and retain the glass under all conditions. The Contractor shall submit calculations to substantiate this, to the satisfaction of the Engineer

With regards to rigidity maximum deviation from vertical, horizontal or designated position shall not exceed 1 mm in 1 metre for all members without any imposition of loads other than its own self weight and the dead load of components (e.g windows or louvers above sliding doors.)

To check for deflection due to self weight and dead load on site, a taut thread fixed at two ends may be used for members already installed and the deflection at the critical point may be measured to ensure compliance.

The minimum thickness of mullion and transome members shall be as follows :-

- a) For members lesser than 1.8 m ~ 1.1mm
- b) For members greater then 1.8 m ~ 1.3 mm

Reinforcing members, where used, shall be completely enclosed and if fabricated from steel shall be galvanised and protected with two coats of zinc chromate. All welded joints shall be similarly protected with two coats of zinc chromate.

Sections of the frame shall be cut and profiled for assembly in the best workmanlike manner. Frames shall be joined rigidly together and finished in a neat and weatherproof construction.

Modifications

The Contractor may make minor changes in detailing of the work in order to conform to standard procedures or as required to facilitate field erection. However, no changes whatsoever shall be made without prior approval by the Architect.

Fixing

All units shall be properly fixed and installed in the positions shown with all necessary lugs, straps, brackets, etc. bedding where required and everything else necessary for the proper fixing of the units all in accordance with the details as shown on the drawings.

GENERAL SPECIFICATIONS

Where couplings are made, either direct or with mullions or transomes, joints must be bedded with mastic. Couplings shall be sealed with good quality butyl mastic.

It shall be the responsibility of the Contractor to ensure that the necessary fixings, fasteners, lugs, anchors, etc. are incorporated in the building carcass; alternatively the Contractor shall construct such groundworks as are required to provide a suitable base and fixing for the aluminium works.

The Contractor is to secure the fixed panels, windows, etc. so that they are plumb and true to the shape and dimensions shown on the approved shop drawings. All joints at head, cill and jambs between metal and concrete shall be pressure grouted with waterproofed cement and sand (1:3) filling and shall be fully caulked with non-setting "Secomastic" (obtainable from Expandite Sdn. Bhd.) or other equal and approved joint sealant compound, as may be specified or as is most appropriate in the circumstances but a clearance is to be maintained in all overhead junctions so that settlements in the building carcass may take place without unnecessarily stressing or otherwise loading the aluminium windows.

The aluminium, fixed panels, windows, etc. shall be adequately protected against corrosion which may be caused by materials permanently adhering to aluminium surfaces such as cement mortar bedding.

All exposed exterior metal components shall be designed, fabricated and installed in such a manner that they produce a visual flatness when viewed from all angles. Any short length distortions, ripples, waves, "oil-canning" or "telegraphing" of fasteners will not be permitted. In the event that metal flatness required interpretation by measurement then this shall be done by measuring and calculating the slope between any two points on the exposed surface that are 3cm apart. Where this slope exceeds 0.5% from the nominal plane of the surface, when measured at the ambient temperature of 28 degrees Celsius and under any combination of performance conditions, then the surface shall be adjusted or replaced as required.

Fixing

All panels shall receive additional special reinforcement against indentation in all areas adjacent to grade or floor areas up to a height of 2m.

GENERAL SPECIFICATIONS

Weep holes, vents and drain holes shall be inconspicuously located in such positions as not to contribute to staining, streaking or marking on fixed panels, windows, etc.

Flashings where required for proper drainage of the cavities in the fixed panels, windows, etc. shall be properly installed and secured to ensure that they will not creep, be displaced, or become a source of noise.

All steel welded at site shall receive two coats of primer after welding using primer similar to that used on the steel. In case of galvanised surface, such welds shall be treated with an approved site cold galvanising process (e.g. Ferraloy, Galvaloy).

The Contractor shall set out and mark datum levels, gridlines, etc. on adjacent existing permanent structures in determining the relative positions of his Works.

Protection And Making Good

All aluminium surfaces shall be covered with a protective film or membrane to prevent damage by staining, abrasion, or other injuries during transportation, handling and installation.

All components shall be delivered to the site in additional individual protective plastic wrappings.

Aluminium works which have been completed shall continue to be protected from damage by other trades.

Any aluminium unit which is damaged in any way shall be taken down and replaced to the Architect's satisfaction and any work disturbed in consequence must be made good at the Contractor's expense.

Obvious Work

The Contractor shall provide all materials or fittings, or perform any work which is obviously necessary to the efficient functioning of the installation, or which is generally provided or performed in accordance with accepted trade practice even though such material or work may not be explicitly mentioned in this Specification or shown on the drawings.

GENERAL SPECIFICATIONS

Inspection

The Architect has the right to inspect the works in progress and all materials which are to be used in the above work. In the event of any dispute regarding the quality of workmanship or material, the Architect reserves the right to order the removal or placement of any material which in his opinion is either not satisfactory or does not meet the requirements of this Specification.

Leave In Perfect Working Order

The Contractor shall before handing over the completed work, oil, ease and adjust all moving parts; take off and re-fixing where necessary and leave in perfect working order.

Cleaning And Clearing

On completion of the works, all protective materials shall be removed and all work thoroughly cleaned with water and detergent. No abrasive shall be used.

Sealant

Quality Assurance

All sealant work shall be carried out by a specialist applicator, approved by the sealant manufacturer, who can substantiate with documented evidence successful installation of the specified sealant over a minimum period of five (5) years in this region prior to the award of this contract. Such evidence and manufacturer's statement of approval shall be submitted to the Architect.

Provide for a technical representative from the manufacturer of the sealant to be on the job site to assure compliance with the manufacturer of the sealant to be on the job site to assure compliance with the manufacturer's directions. The technical supervisor shall be present when the applications start and if required, shall make periodic checks as required.

In addition, the manufacturer of the sealant shall furnish to the Architect a list of projects on which the sealant has been successfully installed for a minimum period of ten (10) years.

GENERAL SPECIFICATIONS

Samples

At the Architect's request, submit samples of material and colour for approval prior to commencing work concerned.

Compatibility

Fillers, gaskets, sealants, primers and substrates used in the same joint shall be compatible with one another. The Contractor shall advise the Architect if the specifications and drawings indicate any incompatibility.

Job Condition

Conform to the manufacturer's requirements for recommended application temperatures and humidity. Check surfaces and areas specified and shown and report any unsatisfactory conditions and/or surface to the Contractor in writing.

Protect all work against damage or disfiguration of other trades against soiling and damages arising out of this work.

Guarantee

Submit a written guarantee from the manufacturer in writing in the name of the Owner that all sealant furnished and installed under this contract shall remain free from all defects and deterioration for a period of 5–10 years from the date of commencement or from the end of defect liability period.

This written guarantee shall cover the faithful performance of the sealant including immediate correction at no expense to the Owner and at such time as the Owner may designated of any defects due to faulty materials or workmanship appearing within the guarantee period, including cost of removing and replacing materials as required.

GENERAL SPECIFICATIONS

Product delivery, storage and handling

All materials, shall be delivered in their original containers in undamaged condition, sealed with labels intact stating:-

- the type of product
- brand name
- the use for which it is intended
- the manufacturer's batch number and date of manufacturer and expiry date of shelf life and period of pot life

All materials which the shelf life or pot life has expired shall be removed from the site and shall not be used for application works.

In general, deliver materials as required for application and keep site storage to a minimum.

All materials and equipment shall be handled in strict accordance with manufacturer's recommendations. Damaged or deteriorated materials shall be removed from site.

Surface preparation

Conform to the manufacturer's instructions and specifications for surface preparation, application procedures and quality control.

Remove rust, millscale and coating from all ferrous metal by wire brush, grinding or sandblasting; remove oils and grease using solvent-based material such as xylol, tolmol or methyl ethyl ketone for cleaning metals; do not use water base cleaning agent or soap detergents.

Recesses for sealant application shall be made during the carrying out of finishing works with foamed strips or other means as approved by Architect. The joints shall be laid straight and true, the depth to extend to the base course and of constant width throughout the length to be provided. The width of the joints shall depend on the type of sealant to be used. The minimum number of joints required to accommodated all movements shall be established by dividing the maximum calculated movement by the maximum recommend joint width for the chosen sealant.

GENERAL SPECIFICATIONS

Where surfaces are exposed to heavy mechanical stresses the edge of the joints must be give additional protection in the form of a brass angle.

Product delivery, storage and handling

All recesses so provided must be dry and clean of any debris, grease, etc before commencement with the application of the sealant.

Mask adjoining work as necessary.

Test substrate for adhesion if required.

Application

Apply sealants, primers, joint fillers, bond breakers to the manufacturer's instructions.

Conform to the manufacturer's printed directions for materials requiring site mixing, heating or special handling. Consult the manufacturer to determine whether sealant may be applied when the ambient temperature of substrate is below 0 deg.C.

Caulk joints in surfaces to be field painted before surfaces are painted. Where surfaces to be caulked are shop primed or are already field painted, check to ensure prime paint or existing paint and sealant are compatible. If they are incompatible, inform Architect and change sealant to a compatible type approved by the Architect.

The recesses are to be primed with a primer, that is compatible to the sealant to be used, according to the sealant manufacturer's instructions and immediately prior to caulking.

To obtain maximum performance from the sealant, it must be supported in the joint by a firm backing to which it does not adhere. Install joint backing to achieve correct joint depth for proper width and depth ratio of sealant.

GENERAL SPECIFICATIONS

In floor joints, where the seal has to withstand loading, a joint filler must be incorporated to provide support for the sealant.

The filler is to be of the same thickness as the joint width and is to extend through the full thickness of the expansion joints.

Apply sealant only after tests have been carried out showing there will be no staining.

Apply sealant under pressure using proper tools and techniques to ensure the required full depth of penetration and proper adhesion to substrate. Superficial pointing with skin bead is not acceptable.

Surface of all sealants to be a full bead smooth, free from wrinkles, sags, air pockets and embedded impurities. After joints are completely filled, they shall be neatly tooled to a slight concave surface.

Materials

Primer/Sealer - Shall be as recommended by the appropriate manufacturer of sealant.

Packing Material/Joint Fillers: Shall be as recommended by the appropriate manufacturer of sealant and shall possess the following qualities:-

- durable and not easily disintegrated
- not affected by light, heat, moisture, freezing and thawing
- possess great compressibility and recoverability

- permits uniform compression
- not broken or damaged by twisting, bending or other normal handling.

Butyl rod or bond breaking type: shall be as recommended by the manufacturer of appropriate sealant and shall be a circular cross section polyethylene backer rod or self adhesive

GENERAL SPECIFICATIONS

Polythene tape bond breaker or suitable flexible material which does not extrude solvents or oil which may interfere with the correct curing of the sealant.

The sealing compound shall comprise of the following factors or as specified by the Architect:-

- It must have low viscosity for ease of application and wetting of joints sides yet must not slump (except for self-levelling or pouring grades)
- It must set or cure rapidly once applied, to avoid being pumped out by movement, but must have a long shelf life and usable pot life
- When cured, a tough elastic product is required for high performance yet the toughness does not cause tearing or adhesion loss
- Durable and maintenance free
- Non-ageing, heat and frost resistant
- Elastic with adequate expansion capacity
- Colour shall be as selected by the Architect

Immediately remove excess compound or droppings, which would set or become difficult to remove from adjacent finished surfaces, using recommended cleaners as work progresses. Do not use scrapers, chemicals, or other tools which could damage finished surfaces.

Soiling of other finished surfaces by sealants is to be avoided by covering the surface with sticker tape. Remove masking tape immediately after joints have been sealed and tooled.

Where specified by the Architect, the sealant is to be protected with the installation of a brass section over it for surfaces exposed to heavy mechanical stresses e.g. vehicular traffic, etc. Application of the sealant is to be avoided during extremes of temperature e.g. high variation in temperature.

GENERAL SPECIFICATIONS

Adjust and clean

Be responsible for making good any spoilage and damage caused by this work; remove rubbish and waste daily, remove droppings and such as work progresses.

At completion replace and repair any defective work and leave perfect.

POWDER COATINGS FOR ALUMINIUM SECTIONS

Compliance

- BS 6469 for aluminium alloy backgrounds
- British coatings Federation: Code of rate practice for application of powder coatings by electrostatic spraying.

Powder Coating Material

- 25 years guaranteed super durable polyester powder coating for aluminium alloy.
- To be obtained from one recognized and approved manufacturers.

Applicator Requirement

- Powder coatings must be applied by an applicator approved by the powder coating manufacturer. Provide evidence of approval to the Client on request.
- Use only one plant of the applicator wherever practical.
- Ensure that the applicator complies with all quality procedures, standards and tests required by the powder-coating manufacturer.
- Ensure that the applicator issues a certificate to the Client on request and before delivery of work to site, confirming that coatings are in accordance with this specification.

GENERAL SPECIFICATIONS

- Ensure that copies of the powder coating manufacturer's and/or applicator's guarantees are issued to the Client on completion of work.

Control Samples – Prior to ordering materials for the works, obtain approval for :-

- Uncoated and powder coated samples of the various grades and forms of background metal to be used.
- Fabrication samples showing joint assembly, how powder coating is affected and how any cut metal edges are protected.

Properties of Coating

- Film thickness, visual appearance, adhesion, impact test, pre-treatment quality, gloss level :-

To comply to the following British Standards : BS 3900 and BS6496

Appearance Of Powder Coatings

- The quality of finish must be consistent and in accordance with BS 6496/BS 6497, clause 10.2. A slight degree of 'orange peel' texture may be acceptable, subject to approval of the Client and the powder coating manufacturer.
- The gloss level of finish must be consistent and when tested in accordance with BS 6496/ BS 6497, clause 4.3 must be within the relevant range given in the powder coating manufacturer's literature.

Coating Thickness

- Ensure that the coating has a minimum continuous film thickness on all specified surfaces of :
 1. 40 microns on aluminium
- No double coating of processed work will be accepted.

GENERAL SPECIFICATIONS

Aluminium Alloy Fabrications : Units may be assembled

- Before powder coatings
- From components powder coated after cutting to size
- From components powder coated before cutting to size, subject to approval of the Client and the powder coating manufacturer.
- Assembly of components resulting in exposure of background metal will not be acceptable.

Fixing

- All exposed metal fixings must be powder coated together with components, or coated with matching repair paint system applied in accordance with the powder coating manufacturer's recommendations.

Fabrication Damage Repair/Replacement

- Check all components before delivery to site for powder coating damage. Report findings and proposed method of repair or replacement to the Client and obtain approval before commencing remedial work.
- Repair components with minor damage as soon as possible by cleaning, abrading and coating with matching repair paint system applied in accordance with the powder coating manufacturer's recommendations.
- Replace components with major damage considered unacceptable for repair.
- Stripping and recoating of components will only be acceptable by prior agreement of the powder coating manufacturer. Stripping, pre-treatment and powder coating are to be in accordance with manufacturer's requirement.
- Over coating of components will not be acceptable.

GENERAL SPECIFICATIONS

Protection

- All powder coated surfaces of components vulnerable to damage during handling and installation, or by subsequent site operations, are to be fully protected throughout the course of these works.
- Protective coverings are to be resistant to all weathers, removable from areas inaccessible after installation, and partially removable and replaceable for access to fixing points during installation or subsequent site operations.
- Any protective tapes used in direct contact with powder coatings are to be low tack, self-adhesive type and light in colour. Their use for application to powder coatings must be approved by the tape manufacturer. Apply and remove in accordance with the tape manufacturer's requirements and the powder-coating manufacturer's recommendations.
- Carry out monthly inspections of protective coverings and promptly repair any deterioration or deficiency.
- Remove protective coverings only when instructed by the Client.

Protection Mock-Ups

- Provide protection mock-ups of powder-coated components as follows : To be agreed.
- Erect protection mock-ups in similar exposure conditions to their proposed installation and agree inspection procedures with the Client.

Site Damage Repair / Replacement

- Any damage to powder coatings caused during and installation, or by subsequent site operations, is to be rectified immediately. Obtain approval before commencing extensive repairs or replacements.

GENERAL SPECIFICATIONS

- Repair components with minor damage by cleaning, abrading and coating with matching repair paint system applied in accordance with the powder coating manufacturer's recommendations.
- Replace components with major damage considered unacceptable for repair.

3.11 - IRONMONGERY SPECIFICATION

GENERAL

GENERAL INSTRUCTIONS

- 1 Work of this section shall conform to the requirements of the Contract Documents.
- 2 Supply all ironmongery in accordance with Drawings and as specified herein.

RELATED WORK SPECIFIED ELSEWHERE

- 1 Steel Doors and Frames
- 2 Timber Doors & Frames

QUALITY ASSURANCE

- 1 Execute this work by a firm who has adequate plant, equipment and skilled workers to perform it expeditiously and is known to have been responsible for satisfactory installations similar to that specified for a period of the immediate past five (5) years.
- 2 Except as otherwise indicated or specified herein, all work shall comply with the Malaysian Codes and all authorities having jurisdiction.
- 3 Where requirements indicated on the drawings or specified herein differ from the Malaysian Codes or authorities having jurisdiction, the more stringent shall govern.

EXPERIENCE

- 1 Ironmongery companies tendering on this project shall be required to make a detailed review of the schedule of ironmongery and satisfy themselves as to its completeness or make whatever allowance in their tender price they consider appropriate to accommodate changes which they envisage may be necessary.

SUBMITTALS

- 1 Submit six (6) copies of the complete proposed Schedule of Ironmongery, listing all ironmongery, listing all ironmongery, giving catalogue references, type numbers, finish, location of each item identified with door if it has not been included in the document.
- 2 Submit to the required trade, templates required in order to make the proper provisions for setting and fitting of all ironmongery. Such Templates shall be as issued by the manufacturers.
- 3 Immediately following award of Contract and before ordering ironmongery, submit cuts, illustrations or samples of the following ironmongery items proposed for this project (if applicable) :
 - 1 Panic Hardware
 - 2 Locksets
 - 3 Latchsets
 - 4 Closers
 - 5 Specialty Items
 - 6 Hinges
 - 7 Strikes

GENERAL SPECIFICATIONS

4. Submit for approval one sample of each component of ironmongery specified. Samples will be retained until project is completed. Identify each sample by tag label indicating applicable specification article number for sample, brand name and number, finish and building location, date and catalogue number. Sample shall be mounted on representative door panels. These samples shall be maintained at the site office throughout the duration of the project.
5. Do not order ironmongery from the manufactures until samples have been approved by the SO. Ironmongery material and finish shall be identical to each approved sample.
6. Upon completion of works, submit manufacturer's parts list, manufacturer's instructions for door closers, locksets, door holders, panic hardware and exit devices. Copies of the warranty and manufacturer contact information shall also be furnished.
7. Maintenance
 - 1 Submit three (3) copies of maintenance instructions for all ironmongery.
 - 2 Brief Employer's maintenance staff regarding the proper care of ironmongery, such as lubrication of lock sets, adjustments for door closers, cleaning and general maintenance.

DELIVERY, STORAGE AND HANDLING

- 1 Package finishing ironmongery separately for each opening. Identification shall correspond with Schedule of Ironmongery. Label all packages legibly indicating manufacturer's number, types, sizes and Schedule of Ironmongery Reference Number. Wrap ironmongery and include in each package screws, bolts and fastenings necessary for proper installation.
- 2 Deliver all items of ironmongery in original packages to the job site or factory of respective trades. Clearly mark each item with the proper opening number. Ironmongery delivered without official packaging from the proposed manufacturers shall be **rejected**.
- 3 Provide a signed receipt for ironmongery delivered.
- 4 Wrappings on knobs, handles, push plate or pulls: adhesive coated paper of a type easily removed without marring finish of ironmongery.
- 5 Any ironmongery with dents, stains, scratches and other deformity shall not be acceptable and shall be remove from the site.

WARRANTY

- 1 The minimum warranty period for ironmongery shall one (1) year generally and five (5) years for door closers. For coated products (ie powder coating) the warranty period shall be minimum five (5) year for the coating.
- 2 The contractor must submit copies of warranty certificate issued by the manufacturer.

REFERENCE STANDARDS

- 1 Where there is in existence a relevant British Standard Code of Practice, Draft BX of IN Standard applicable to this work, then the recommendations and requirements of such document shall be considered as a minimum standard for the work described and must be complied with.
- 2 Nothing in paragraph 1.8.1 relieves the Contractor of responsibility for providing a higher standard than the relevant Code of Standard where it is required to comply with other section of the Specification.
- 3 This work shall be in accordance with :

MS 1060: 1986, MS 1062: 1986 and BS 5750
Locks and Latches : BS 5872:1980
Overhead Closers : BS 6459 PT1:1984
Handles: BS 4951:1973 Category 1
Panic Latches : BS 5725 Part 1

or ASTM, ML and ASA requirements.

PRODUCTS

GENERAL

- 1 Carefully check and verify Ironmongery Schedule against drawings to ensure that ironmongery listed can be used as specified. Inform the SO of any recommendations concerning quality, quantity, operation or function of ironmongery selected, prior to submission of tender.
- 2 Ironmongery Schedule is a guide for location and type ironmongery to be used and is not necessarily an exact list of quantities or qualities required to complete the entire project. This subcontractor shall complete, for review, a separate schedule based upon his own assessment of the requirements.
- 3 Be responsible to ensure that all ironmongery selected will function satisfactorily and adequately for a quality office installation, and that it will meet with all requirements of the Building Code and jurisdictional authorities.
- 4 Ironmongery which fails to function satisfactorily by reason of improper selection or installation shall be replaced with proper ironmongery at the Contractor's expense, including all remedial and installation costs. This shall include the cost for replacing the door or window affected if so required.
- 5 The contractor (and their subcontractor is so required) and manufacturer's representative shall visit the project during installation of the ironmongery and be responsible for the correct application and shall so certify in writing at the completion of the work.
- 6 Each ironmongery item of the same type shall be of the same design and the product of the same manufacturer. This shall include all internal components (ie cylinders) and keys.
- 7 Finishing Ironmongery: of manufacture as approved, for heavy duty use, of excellent workmanship, with finishes as listed.

- 8 Fire Rated Assemblies :
- 1 Ironmongery shall be selected and installed in accordance with applicable codes and regulations and to approval of the Malaysian Fire Services Department (Jabatan Bomba dan Penyelamat Malaysia).
 - 2 Provide fire exits with labelled ironmongery. Submit written certification of conformance to Code requirements for each type of ironmongery prior to delivery.
 - 3 Locksets and latchsets in fire exits shall have 19 mm throw minimum.
- 9 Items of ironmongery shall be supplied with the proper type of screws. Items to be attached to masonry or concrete shall be supplied with lead shields, lag screws, bolts or other fastening devices as required to provide the best means of application. Exposed screws: Phillips (cross) or Robertson (square) heads.
- 10 Exposed surfaces to specified finish symbol. Where anchors are exposed, they shall match ironmongery finish of the item on which they are used. Metal finishes shall be free from defects, clean, unstained and of a uniform colour for each type of finish required.

IRONMONGERY SCHEDULE

The ironmongery schedule shall be as per the attached Appendix.

EXECUTION

COORDINATION

- 1 Before furnishing ironmongery, check drawings for ironmongery requirements, verify door swings, check shop drawings, frame and door lists and advice in writing if revisions are required. Ensure early delivery of ironmongery required on this project.
- 2 Supply to metal frame and door manufacturers, complete information and templates required to provide reinforcing for the application of *ironmongery*.
- 3 For the installation of ironmongery to timber work, care must be taken to all drilling, sawing or cutting to the door panel or door frame. The Contractor must ensure all exposed surfaces on the door or door frame disturbed shall be sanded and finishes be touch up on completion of all installation.

MOUNTING HEIGHTS

Ironmongery shall be mounted the following distances from the finished floor measured to the centre of the ironmongery, unless indicated otherwise on the drawings or in the Building Code:

Top Hinge	250mm from head of door to top
Bottom Hinge	265mm from finished floor to bottom of hinges
Intermediate Hinge	Centred between top and bottom hinges
Locksets, Latchsets	1000 mm
Mortise Night Latches	1450 mm

Panic Device Crossbar	1000 mm
Push Plates	1100 mm
Guard Bars	1100 mm
Door Pulls	1100 mm
Blank Strike	1450 mm
Blank Fronts	1450 mm

FIELD QUALITY CONTROL

- 1 Ensure that each box contains all of the ironmongery listed for the door openings. If the ironmongery is not complete, be responsible for paying any additional charges incurred shall be by the installer.
- 2 Ironmongery shall be inspected after installation by the ironmongery supplier’s representative, who shall certify in writing that all ironmongery has been supplied and installed in accordance with the specifications and ironmongery manufacturer’s recommendations and is functioning properly.

KEYING

- 1 Master key (keys that open all locks to a particular series) locksets and factory register system (If required and stated specifically in the drawings or schedule). Final keying arrangements shall be approved by the SO. Submit grandmaster and master keys directly to the Employer.
- 2 Change keys (keys that only open specific lock or other locks that are keyed alike) shall be stamped “Do Not Duplicate”. Allow for visual keying (a specification that all keys and the visible portion of the front of all lock cylinders be stamped with standard keying symbols) if a master key is specified.
- 3 Key door and cabinet locks which are to be keyed differently, keyed alike, keyed alike in groups, master-keyed, grandmaster-keyed, great-great-grandmaster keyed as directed. All keying arrangements are subject to the SO’s approval.
- 4 Provide **approved high security** cylinders for all locksets with a minimum of 5 pins in each cylinder. Provide locksets with two (2) cut keys and with key code number stamped on bow of key and face of cylinder. Factory master-key and grandmaster-key all cylinders if specified. Construction master-key for all locks shall be provided if so specified.. Submit grandmaster-keys and master-keys for each master-keyed group in the number required by the SO.
- 5 Obtain written approval of the complete keying layout prior to placing lock order with the factory.
- 6 All keys shall be appropriately tag with unit number or door identification prior to handover to the Employer.
- 7 If requested, the contractors must supply up to 2 key blanks per lock installed.

KEY CABINET (If requested)

- 1 Index, tag and set up permanent keys in key cabinet and deliver to job site at time of building take-over by the Employer. Keep permanent keys under strict security control at all times. Set up indexing as required by the Employer.
- 2 Key cabinet to be wall type, for 150 keys with ability to expand to 250 capacity. Cabinet to come complete with key holders and visible index hooks. Cabinet selected to be to approval of Architect.

- 3 Instruct the Employer in the proper use of key control system.

LATCHES

- 1 All latches shall be mortise type: style and finish to be selected later.
- 2 Provide latches on all fire rated doors.

PUSH PLATES / KICK PLATES

- 1 Push plates and kick plates shall be 3 mm by width of door. Height shall be as specified.
- 2 Push plates and kick plates shall be of stainless steel.

3.12 PLASTERING

Cement

The cement shall be 'QuickPlast' ready-mixed masonry cement or equivalent.

Sand

All sand used in the works to be as specified in Engineer's Specification for Concrete Works but is to be fine sand of light colour and to be approved by the Architect or S.O.

Lime shall not used in plastering.

Preparation of Surfaces

Brickwork and concrete shall be thoroughly cleaned free from oil or traces of foreign material before plastering.

Hack back all damaged, loose or contaminated rendering and plastering and cut out all large cracks. Undercut all edges and make good fine cracks with an approved filler trowelled smooth and perfectly level with adjoining surface.

Spatter dash is not required for concrete walls and ceiling in general. Wetting of substrate is recommended if it is too dry before plastering.

Cement and Sand Plastering (Externally and Internally)

The mortar for plastering shall be composed of one portion of QuickPlast with 5 portion of grade sand and mix thoroughly in a drum mixer with water until a homogeneous plaster. Apply 10 mm to 15 mm thick per layer as per manufacturer's instructions.

The mortar for plastering must be used within 140 minutes after mixed.

To provide a vertical/horizontal break joint with a chamfer shape as practicable for placing adjacent plaster wall finish.

Evenness of the plaster surface finish shall not more than 4 mm per 1200 mm. Walls meet at right angles shall not more than 4 mm per 300 mm.

Base coat shall be rough. When dry, 2nd coat of application shall be glazed smooth and finished with quick skim or equivalent plaster finishes with a steel trowel internally and externally require "brush" finishes.

Brickworks

All brickwall - 20mm thick in two coats of QuickPlast (Unless otherwise described) consisting of :-
 (a) 18mm thick base coats of QuickPlast
 (b) 2mm thick finishing coat of QuickSkim or Skim Coat Plaster

For two coat work, the base coat shall be moistened before application of finishing coat. All arrises in plastering shall be slightly rounded.

Concrete

Soffit of slab only - 1.0 to 2.0mm thick of skim coat plaster or equivalent.

Other surfaces - 2.0 to 5 mm thick of skim coat plaster and finished with 1.0 to 3.0mm thick of quick skim or equivalent.

GENERAL

PLASTERING ACROSS CONCRETE COLUMNS/BEAMS/WALLS

When concrete occurs in a brick or block background, allow for differential movement as follows: fix expanded metal lathing over to walls on each side; apply first coat to lathing and cut through on both sides, before first coat has set, apply second coat. Use Expamet Strip Mesh 100mm wide or equivalent to tight coat galvanized steel.

PLASTERING ACROSS DIFFERENT BACKGROUNDS

Fix metal lathing across the junctions.

PLASTERING ACROSS OPEN CHASES, ETC.

Bridge with expanded metal lathing securely fixed on both sides.

REPAIR AND MAKE

All making good is to be cut out to a rectangular shape, the edges undercut to form dovetailed key and finished flush with face of surrounding plaster.

Cut out and make good all cracks, blister and other defects and leave the whole of the work perfect on completion.

PARTIALLY OR WHOLLY SET PLASTER

No partially or wholly set plaster or paving will be allowed to be used or re-mixed and must be removed from the site.

ANGLE AND CASING BEADS

Angle bead and casing beads shall be used as approved by the Architect/S.O and to be used strictly in accordance with the manufacturer's instruction. To provide external or internal angle bead to all vertical edge, or corner of column, brickwall in plasterwork to resist chipping or cracking.

The expanded wings anchor securely in the full depth of plaster on either side of the arris.

The beading shall be a straight-edge, vertical, neat in quality.

METAL LATHING

Metal lathing shall be (Expamet) tight galvanised expanded metal of the weight described and complying in all other respect with B.S. 1369. Weight shall be not less than 1.2kg/m² for light weight plaster 1.6 kg for plasters and 1.9kg for external rendering. Metal lathing for use with projection plaster shall be of the ribbed type.

GRC COPING

GRC window coping or equivalent as approved by the Architect/S.O should be rigidly installed in accordance with manufacturer's instruction. No visible crackline and squareness to all angles.

SPLATTER DASH

Splatter dash shall consist of a mixture of one volume of Portland cement and two volumes of clean, sharp, coarse sand prepared as thick slurry and shall be hand "thrown" to a thickness of 3 mm to 6 mm. It shall be left as thrown but wetted with a fine spray when necessary to ensure proper setting.

GENERAL LABOURS, PRICES AND MEASUREMENTS

Prices for plastering, rendering etc. shall include for raking out joints of brickwork and masonry or hacking concrete as key.

Plastering to timber surfaces are to be on one layer of gauge "Exmet" wire mesh and the rates for plastering shall include for this.

All edges to be plastered together with angle beads and casing beads and rates shall be inclusive of this.

The description of each item of plastering etc. shall be held to include for narrow widths and small quantities, provision of small sample panels, temporary rules, joints between different types of plastering, interval angles, arises, quirks, rounded coves and external angles not exceeding 1" radius and mitres, stops, etc. on cornices, mouldings, enrichments, coves, skirting, gutters and strings, all making good and other sundry items of a like nature.

3.13 FINISHES

Generally

Unless otherwise specified by the Architect, followings shall be the specification of materials and workmanship for Finishes as well as the quality expectation.

Cement

The cement shall be as previously described in "Concrete Works".

Sand

The sand for screed shall be naturally occurring sand and crushed stone, hard, clean and free from **impurities and** shall comply in all respects with B.S.1199.

Mortar Aggregate

Clean, sharp, fresh water river sand free from impurities and shall be washed/screened if required by the Architect.

Water

Fresh, clean, potable, free from deleterious materials, acids or alkalis.

Product delivery, storage and handling

Deliver and store all materials undamaged in original wrapping or containers with manufacturer's labels and seal intact. The materials shall be stored at least 300mm off the ground, in a dry, clean and well ventilated place.

Job Condition

Inspect all surfaces. Do not commence work until the work which is to receive it and the site conditions are satisfactory during and after application. Avoid adverse conditions which are detrimental to the production of a first class finish.

Mock-up Units

Contractors are required to carry out mock-up unit/units selected by the architect. The approved **mock-up unit** shall form a standard for this Work and no work of an inferior quality will be allowed. Do not start final work until approval of **mock up units** is given by the Architect.

GENERAL SPECIFICATIONS

Sample Board

A set of approved tile samples to be kept at site office.

Special Protection

During construction, protect finished surfaces from abrasion by foot and wheel traffic. Ensure that work of this section and other sections incorporating the use of oils and other electricious materials, are not performed on finished areas, unless finished areas are fully protected by approved methods. Co-operate with other traders to ensure finished work is not damaged.

The bathroom tiles upon inspection and ponding test shall be protected with self-adhesive plastic sheet to prevent damages and staining.

Surface preparation of concrete substrate

Surfaces of concrete slabs to receive a setting bed shall be wood floated until they are level to true lines shown, free of depressions and left ready to receive finish.

Where floor drains occur, floors are to be level around walls and have a minimum 1.5mm per 300mm uniform pitch to drains, unless indicated otherwise.

Unless otherwise specified, steel trowel to smooth and even surface to within 3mm tolerance when measured in any direction using 3 metre straight edge.

Sprinkling of dry cement or dry cement and sand mixture over concrete surfaces will not be acceptable.

For areas scheduled to have floor sealer coating, resilient covering, carpeting, monolithic concrete floor finish, the surface shall be thoroughly floated with 90.7kg 508 disc power floating machine until compacted and the floating operation shall continue until sufficient mortar is brought to the surface to fill all voids. When the floor has hardened sufficiently so that excess fines will not be brought to the surface, the floor shall be trowelled with a steel trowel to a smooth surface free from pin holes and other imperfections. An approved type rotary mechanical trowel with steel blades may be used for this operation providing that disc lines are removed and a smooth, hard burnish results.

Curing

Cure new concrete slab surfaces, which are to receive bonded toppings and bonding base for quarry and ceramic tile, by using removable covers. Seal concrete surfaces with waterproof paper or polyethylene sheet, having lapped, taped joints. Quality of covering shall be sufficiently heavy to be resistant to tearing and puncturing. Take all precautions to avoid any damage to sealed covering. Keep covering in place for minimum seven (7) consecutive days. Ensure that concrete is kept continually moist during curing period. [Approved curing compound may be used.](#)

Alternatively, moist cure the above concrete slab surfaces by using burlap or canvas coverings.

GENERAL SPECIFICATIONS

For other new concrete slabs which are to receive plain floor hardener and resilient flooring, apply a combination curing and sealing compound to floor surfaces at rate and method recommend by compound manufacturer. Before applying compound, ensure surfaces have hardened sufficiently to prevent marring and are free from any surface water.

Crack repair

Prior to completion of the project and in any case not sooner than 28 days after new concrete has been placed, examine concrete floor surfaces and repair all major cracks in them. Rout cracks out with mechanical router. Leave cracks clean.

Mixing

All mortar ingredients shall be mixed in a mechanical mixer with the minimum amount of water needed to produce a mortar topping of workable consistency. Mortar topping shall be thoroughly mixed until all ingredients are uniform in colour.

Mixes shall be used up within 2 hours of the first contact of the cement with water. All material remaining after this period shall be discarded.

Hardener finish

Monolithic Application: The concrete floor slabs are to be brought to the finished floor level and while still plastic - within 3 hours of laying, the first portion of hardener topping shall be broadcasted over the freshly laid concrete surface within 3 hours of laying at a specified rate immediately after the initial compaction of the slab. The hardener shall not be broadcasted over wet surfaces in order that the finishing will not produce a weak layer at the top.

Hand trowelling along all joint edges shall be carried out to ensure full compaction and elimination of lips and spillage of mortar onto the adjacent hardened concrete.

Float the surface manually with a wooden trowel, when the 'dry-shake' has attained uniformly in colour. Do not use steel trowel.

The balance of the hardener material shall then be broadcasted uniformly over the first application. The topping shall be allowed to absorb sufficient surface moisture prior to floating.

When the concrete surface is sufficiently stiff to take the weight of a trowelling machine and operator, power trowel successively with the blades tilted at an angle to the desired finish texture.

GENERAL SPECIFICATIONS

The concrete surface shall then be cured with the appropriate curing compound in accordance with the manufacturer's directions.

Protection shall be provided in case of inclement weather until final set is achieved.

The finished floor shall be adequately protected by using polythene sheet or sand blinding against damage by other trades.

Non-monolithic application

The cured base concrete floor slab shall be well cleaned, hacked and wetted to secure a good bond.

A cement slurry bond coat shall be brushed over the prepared and cleaned surface immediately before the granolithic topping is laid.

Non-monolithic application

Surface of all granolithic paving shall be kept damp for a period of at least 7 days after laying, by thickly covering with wet sand or sawdust, hessian or polythene membrane kept moist by frequently sprinkling with water applied through a rose.

The finished surface shall be adequate protected against damage by other trades.

Chemical hardener/sealer

Floor surfaces to receive chemical hardener/sealer coatings shall be dry, clean and free from dust, oil, paint or other deleterious matters.

Prepare solution of sealer coats in accordance to manufacturer's written instructions.

Flush solution on floor and distribute uniformly with long-handled brush. Mop up excessive solution and allow floor to dry before application.

Coverage shall varies according to the porosity of the floor. The floor shall be completely saturated and hardened to the satisfaction of the Architect.

General Labours, Prices and Measurement

At junction between differing type of finishes, the finished level must be completely flushed.

The description of each item of paving shall be held to include for provision of some small panels, temporary rules and battens, all rounded angles, arises and making good and any other sundry items of like nature.

GENERAL SPECIFICATIONS

Workmanship

The concrete sub-floor to receive screed or paving shall be brushed with a stiff broom it is hardened to remove laitance and give a roughened surface. Alternatively, the surface shall be thoroughly hacked if so directed by the Architect/S.O. at the Contractor's own expense.

Paving shall be laid in alternate bays not exceeding 150F.S., unless otherwise directed by the Architect/S.O. If the concrete sub-floor has been laid in bays, then the joints of the pavings must occur exactly above the joints of the sub-floor.

Paving laid using a wet process shall be kept damp and free from heavy traffic for a minimum period of seven days.

Where a fall is required this shall be achieved by varying the thickness from one end to the other. The minimum thickness however shall not be less than 13mm at the lower end.

Cement and Sand (1:3) Screed and Pavings

The cement and sand for screeds and pavings shall be composed of one part of cement and three parts of sand mixed in approved mechanical mixers. The water shall be added to the mix in a manner approved by the Architect. The water content of the screed mix must be only the minimum to give workability.

The paving must be thoroughly tamped and levelled within 30 minutes of laying and re-trowelled to a smooth finish free of trowel marks after the initial set has taken place (approximately 2 hours after laying).

The paving shall be rubbed down, if necessary to produce a smooth even surface.

To apron slab or as required, cement paving shall be finished to an even finish with steel trowel or float. Screed as backing for floor and wall to receive tiles and other finishes shall be finished even and true to exact line, level or falls required.

Screeds to receive tiles bedded in mortar shall be scratched to form key and where adhesive is to be used for fixing, the screed shall be steel trowelled to a smooth even surface, unless otherwise stated. The water content in the screed mix shall be the minimum required to give a workability.

Wall Tiling

Tiles are to be bedded in cement and sand (1:3) at least 6mm (1/4") thick or on approved adhesive on a prepared screed and the joints are to be grouted [white cement unless otherwise specified by the architect](#).

Tiles are to be laid to regular line and pattern as required with even joints [of 1mm to 2mm wide](#).

GENERAL SPECIFICATIONS

Tiling to ends of walls, faces or piers or other narrow surface between two external angles is to be set out symmetrically in the width. Tiling is to be set out where possible so that cut tiles occur only at internal angles.

Where cushion edged tiles are used, no cut edge of a tile is to abut an uncut edge except at an internal angle; otherwise, both tiles are to be cut. Tiles are to be sorted and cut out so as to minimise the effect of any unavoidable minor variation in colour.

Cutting is to be neatly and accurately carried out. Holes for screws, \varnothing bolts, sanitary piping outlet or any other openings are to be drilled with a special drill, and not cut.

Wall tiles to be soaked in water for at least six (6) hours and drained before fixing unless adhesive cement is used.

All wall tiles laid shall be free from hollow sound.

Plastic spaces shall be used in between corners of tiles to ensure consistent spacing between tiles

External angles of wall tiles to be laid with pvc angle beads with matching colour unless otherwise specified by the architect. However, for Semi-Dees and Bungalows, all external angles must be laid using belve edge joint method.

Floor Tiles

Floor tiles shall be laid to approved pattern, bedded and jointed in cement and sand (1:3) mortar (using dry mixed method) and pointed in cement mortar or unless otherwise specified by the architect.

Tiles are to be set out symmetrically within each area and laid to regular line and pattern as required. Tiles in patterned mounted panels are to be adjusted as necessary at margin of pavings to avoid a broken pattern and to reduce cutting. Cutting is to be neatly carried out. Joints to be 2mm to 3mm wide for tile size not exceeding 300mm x 300mm and 4mm to 5mm wide for tile size exceeding 450mm x 450mm. and joints between adjacent panels of tiles are to match those between individual tiles.

Clean off dirt, stains etc. and made good and/or replace damaged and defective tiles and cleaned with mild hydrochloric acid which shall be diluted with water to less than 5% concentration. All metal sanitary fittings and ironmongeries and etc shall be properly protected while using the acid.

GENERAL SPECIFICATIONS

Where room dimensions are not in exact multiple of the tile, slab or block dimensions they shall be so cut that equal margin occur at both or all sides of the rooms as the case may be or unless otherwise specified by the architect.

Before laying, all tiles delivered to site must be selected to ensure only the even / flat tiles are used to ay. All uneven tiles must not be used and shall be rejected. A 3mm thick aluminium dividing strip shall be used in between the meeting line of 2 different types of tiles on floor finishes.

All floor tiles laid shall be free from hollow sound.

Timber Parquet Flooring

Parquet flooring shall be constructed of 10mm (3/8") thick kiln dried tanalised Kempas as specified butt jointed tiles.

Samples of the parquet tiles shall be submitted for approval by the S.O. as and when directed. Samples which are approved shall indicate the standard to be maintained in the execution of the Works. The tiles shall be regular machine made, even and consistent in size with sharp well defined arises, matching colour, texture and grain and free from splits, chips and blemishes.

No **parquet** tiles shall be laid until the base surface is completely dry, clean and free of loose material to provide a good keyed surface to receive the **parquet**. The screeded surface to receive the **parquet** shall be finished with a steel float and must be absolutely level. The **parquet** shall be laid to an approved pattern with an approved adhesive.

GENERAL SPECIFICATIONS

Polishing of the flooring is to be carried out by a mechanical polisher in accordance with the manufacturer's instructions. All defects, blemishes etc. shall be made good with an approved filler. Any damaged, stained or discoloured **parquet** shall be replaced.

Apply three coats of approved **polyurethane** lacquer on the parquet flooring.

Ceiling Finishes

Ceiling finishes used generally are as follows:-

Asbestos Free Ceiling Board

Unless otherwise specified by the Architect, the asbestos free ceiling boards shall be in panels of 1220mm x 610mm x 3.2mm thick secured to 2" x 4" timber joint at not more than 2'0" and 2" x 2" noggings at not more than 4'0" centres and covered with 1 1/3" x 4/3" wrot timber beads.

Mineral fibre ceiling

Mineral fibre board shall be Armstrong 'Wispertone' sheet in panels of 1220mmx610mm non-combustible mineral fibre ceiling acoustible ceiling or other equal and approved in suspended aluminium T-system unless otherwise specified by the Architect.

Fibrous plaster ceiling

Fibrous plaster ceiling shall be 10mm thick Custom fibrous plaster ceiling or other equal and approved fibrous plaster ceiling including G I suspension system in concealed grids with all joints taped and all fixing shall be carried out strictly in accordance with manufacturer instructions.

Metal ceiling

Metal ceiling shall be DAMPA D-10-Type 'O' (Aluminium perforated-internally) and Type 'N' (Aluminium unperforated-externally) lineal ceiling or other equal and approved in concealed galvanised steel suspension system unless otherwise specified by Superintending Officer. All fixing carried out strictly in accordance with the manufacturer instructions.

The rates for the ceiling shall include for trimmings around perimeter edges, cutting of opening for light fittings and air-condition diffuser, etc.

MARBLE SLAB

Generally

- A All marble supplied shall be in accordance to the finish requirements and colour selection as specified by the S.O. (Refer to Schedule of Finishes)
- B Generally the stone shall be pre-cut before delivery to the specified sizes for efficient use. Any irregular sizes shall be carefully cut on site to the required dimensions.
- C The Contractor shall comply with the manufacturer's instructions and recommendations for installation and the use of mortars, grout, sealant and adhesives etc.

All marble shall be sound with no natural faults which may lead to fracture and cut to precise shapes and sizes as required or as directed by the S.O. on site.

All marble when delivered to the site after cutting and polishing done in the factory, shall be sound and free from defects, with sharp well defined arises, free from cracks, chips and blemishes that would affect its appearance, durability or permanency.

Samples of the proposed materials shall be submitted free of charge to the S.O. for approval. These samples shall be properly labeled for easy identification against references in the Schedule of Supply. These samples shall be kept by the S.O. who shall have the power to reject all such materials that do not correspond with the approved samples.

Generally, marble shall be laid to patterns. Marble that are to be laid to patterns and to be matched shall be clearly labeled using a referencing system to facilitate easy identification for correct sequence of laying. Any such referencing system shall also be expressed in the shop drawings to enable cross-reference between the marble and the shop drawings. Also, top and bottom of marble shall be clearly marked.

Preparation of Work

- D The Contractor shall not proceed with work until the recommended work conditions and setting out his work before ordering or final off-site cutting of stone. No extras will be allowed for claims arising out of adjusting the contract works to comply with building tolerances. The Contractor's attention is drawn to the necessity of following

GENERAL SPECIFICATIONS

the setting out of joint lines of the stonework to the building grids as shown on the drawings.

Obvious Work

The Contractor shall provide all materials and perform any work which is obviously necessary for the complete installation of each area of the works even though such materials, or works may not be explicitly mentioned in this Specification or shown on the Drawings attached to this Specification. The supply of all that is requisite for the complete installation of each and every area of the works to the satisfaction of the S.O. together with their handing over to the Employer in good condition shall be undivided responsibility of the Contractor.

Before submitting his tender, the Tenderer shall familiarize himself with all the features of the building and site which may affect his work and no extra payment shall be allowed for additional work due to the failure of the Tenderer to obtain necessary information.

Dimensions

All dimensions shown on the Tender Drawings are indicative and must be checked and verified on site by the Contractor before commencement of cutting and delivery of the marble works for installation.

Tolerance and Dimensional Properties of the Supplied Stone

- E The dimensions of stones shall be worked to those shown or indicated on the approved design drawings of the Contractor, and any approved shop drawings, and Contractor shall be responsible for the accuracy and setting out of stones and stonework.
- F Stones shall hold out reasonably square at its back without corners broken away whereby the strength of the cram fixing is impaired.
- G Variation of face dimensions on any stone shall not exceed 1mm in 900mm.
- H Total variation of thickness on any stone shall not exceed +3mm.
- I All stones, unless otherwise designed, shall stand up square at all face corners, so that any deviations in length of height dimensions are reasonably uniform.
- J All exposed edges of stonework shall be rounded off.

Cutting, Drilling and Fitting

- K The Contractor shall allow for all cutting, drilling and fitting of stone required to accommodate the work of other trades. In cutting and fitting, carefully cut and grind edges to a neat tight fit. Cutting shall be executed in such a manner so as not to impair strength or appearance of stone.

Delivery, Storage and Handling

The contractor shall :-

- A Handle all stone units by such method as will guard against any damage whatsoever during transit to and upon delivery at the site.
- B Store stone on non-staining dry wood planking of platforms set not less than 100mm above the ground. Cover stone with non-staining tarpaulins, building paper and / or board during the storage.
- C Inspect stone units upon arrival at site. Damaged, defective or defaced units shall not be used and re-order of replacement units must be done immediately.
- D Any stonework that shows signs of staining, discolorations, soiling, spalling, breakage chipped surfaces or edges after installation shall be removed and replaced by the Contractor at his own expense. Patching is not permitted.
- E Clearly identify the location and orientation of each stone.

Treatment of Stone

- F Treatment of Stone to back, and unexposed edges shall be coated with silicone waterproofing, which will prevent moisture penetration into the stone.

Erection Workmanship (wall marble)

- G The Contractor to ensure that erection of all stonework shall be fixed by skilled workers and experienced in this trade.
- H Before work commences, the Contractor shall provide a method statement, which sets out in detail his proposed methods of carrying out the works, including details of plan and layout required and sequence of the work.
- I When fixed in position, all stone shall have their faces in exact planes and be truly vertical. All joints shall be truly horizontal, as required.
- J Before fixing of stones, horizontal datum lines shall be set out, using piano wire or other approved methods.
- K All laying methods (wet or dry) shall be as specified and shall be in strict compliance with the manufacturer's instruction.
- L The Contractor shall carry out a dry lay of marble for the S.O.'s prior approval before commencing work.
- M The samples once approved, will set the standard of material, workmanship and finish to be attained in the installation for the rest of the finishes.

Joints

- A The Contractor shall be responsible for the accuracy of setting out of joints and the proper fitting-in of the stones
- B All joint surfaces shall be cleaned free of dirt, dust, grease or other deleterious materials before sealant are applied.
- C Pointing to all joints, except those requiring sealant, with coloured cement and approved propriety material as specified. Colour to the S.O.'s approval.

Cleaning

- D The Contractor shall be responsible for cleaning and be aware that;
- E Upon completion of the Works remove all temporary protection from the Stonework.
- F Examine all work and repair all damages. In the event damage is irreparable or repair is not approved by the S.O. removal and replacement shall be at the Contractor's expense, Re-pointing of joints with sealant as necessary.
- G After possibility of stain from other operations have passed, carefully polish with approved cleaning compound.
- H Polished stone shall be protected with plastic sheets and plywood, and taped down.

Laying Workmanship (Floor Marble)

- E The Works described in this Specification shall be performed by workmen skilled in the laying of all marble works. All necessary works shall be executed in a professional manner so as to present a neat and finished appearance.
- F On completion of installation, no dirt, spots or marks shall appear on the exposed surfaces. All works shall be properly protected by plastic sheets and plywood, and taped down.
- G The S.O. shall decide whether or not the finished piece of work is satisfactory; and if, in his opinion, any material or works that were not installed or finished, the Contractor shall remove the material or works rejected and shall re-install at his own expense with new material to the satisfaction of the S.O.
- H The Contractor shall carry out a dry lay of marble for the S.O.'s prior approval before commencing work.
- I The samples once approved, will set the standard of material, workmanship and finish to be attained in the installation for the rest of the finishes.

Materials

Warranty

- A The Contractor is required to **warranty** the completed works for a period of twenty four (24) months form the day named in the Certificate of Practical Completion of the Contract on all materials and workmanship.
- B The **warranty** shall undertake to indemnify the Employer in respect of the replacement costs of any portion of the materials which may prove to be defective in the above described manners within the **warranty** period.
- C The wording of the written warranties shall be approved by the S.O. before its execution.

DETAILED SPECIFICATIONS AND CODES

- D All applicable standard specifications and codes shall establish a minimum standard of quality and shall not be construed to be a limit of perfection of quality for any of the materials to be furnished or utilized in this work. The S.O. reserves the right to select and / or accept only the best grades of standard products which in his opinion will provide finished work of recognized performance, characteristics suitable for the various and respective surfaces. Materials of questionable or unknown quality shall not be approved.
- E The following specifications form part of this Specification and will serve as a basis for approval of minimum standards of materials applicable thereto.

Cement

- F Cement shall be ordinary Portland cement complying with BS 12.

Sand

- G Sand for mortar shall comply with the requirements of BS 1200 and shall be clean, sharp naturally occurring sand or shall consist of crushed rock or gravel. It should be clean, hard, free from adherent coatings and vegetable matter, It shall not contain soft, porous or flaky grains or crushed dust, alkali, loam, clay or any deleterious organic matter.

GENERAL SPECIFICATIONS

- H Sample shall be submitted to and be approved by the S.O. before commencement of work. The sand shall be kept clean and be re-washed if necessary.

Water

- A Water to be clean, free from acids, alkalis and other harmful matter.

Mixing of Ingredients

- B The mortar is to be hand mixed on a non-absorbent close platform with kerb. Gauge boxes are to be used for measuring all materials which are to be strike measured and not tamped down. The ingredients are to be mixed dry until thoroughly incorporated and then clean water is to be added through a hose. The mortar is to be mixed in small quantities and used within one hour after mixing. Mortar boards and mixing platforms are to be cleaned off daily and any mortar left over must be removed.

Cement Mortar

- C Generally marble are to be bedded in cement and sand (1:3) and painted in white/tinted cement to match marble.

Water Content

The water content of the mix must be only the minimum required to give a workable mix. The paving must be thoroughly rammed within 30 minutes of laying and the surface trowelling must be delayed until the paving is stiffened sufficiently to prevent laitance being brought to the surface by the trowel. The paving shall be rubbed down, if necessary, to produce a smooth even surface.

Transport of Materials

- D The Contractor shall transport all the marble required for the works to the site. The Contractor shall deliver the materials to the site in adequate time for its preparation and construction according to the approved programme.
- E The Contractor shall pack the marble in timber boxes so as to facilitate handling and protection same damage or deterioration in transit.
- F The Contractor's packing list shall include the following :-
- a. Number of packages in shipment
 - b. Weight, dimension and volume of each package
 - c. A complete detailed listing of each item contained within each package, clearly identifying each item and quantity thereof.

Protection of Works

- A The Contractor shall protect all works in accordance with the usual trade practices by means of slurring, papering, casting, sheeting, etc. at his sole risk and he shall replace any damaged work at his own expense.

Open Book Design

- B Marble are to be laid in open book design and must be of best quality marble having consistent colour, texture and grain. These tiles shall be laid in such a manner so that the grains will appear in pattern. Adjacent pieces of marbles shall be cut from the same block or marble. Excessive variation in tone and vein patterns will not be accepted.
- C In this connection, tenderers are to give their own proposal and all drawings, diagrams or pictures necessary for the purpose of illustrating the proposal must be submitted with the tender.

Shop Drawings and Modifications

- A The Contractor shall after consultation with the S.O. and from details supplied by the S.O. produce accurately dimensioned shop drawings illustrating all construction details and correct sequence of laying for S.O.'s approval prior to any commencement of manufacturing.
- B When preparing shop drawings, the marble tiles shall be properly centered to avoid small cuts of less than 75mm width. Some adjustment will therefore be necessary on the indicative arrangement shown in the tender drawings.

Site Layout

- C The polished marble shall be laid out on site for inspection and approved by the S.O. before fixing. Any slabs / tiles rejected shall be removed from site.

Paving

Concrete Sub-Floor

- D The screeded concrete sub-floor shall be brushed with a stiff before it has hardened to removed laitance and give a roughened surface. Alternatively, the surface shall be thoroughly hacked if so directed by the S.O. at the Contractor's expense.

Laying

- E The Contractor is responsible for finishing the sub-floor or screeded to levels. The Contractor shall include **water proofing using Formdex Plus** and to make up to the final level of finishes.
- F Paving shall be laid in alternate bays, unless otherwise directed by the S.O. If the concrete sub-floor has been laid in bays, then the joints of the paving must occur exactly above the joints of the sub-floor. All joints shall be grouted with grouts approved by the S.O.
- G Floors generally shall not be laid until after all wall finishes have been completed, unless otherwise directed. The Contractor is to make good at his own expense any damage he may inflict upon the existing finishes.

3.14 GLAZING

Generally

All glass shall comply with the requirement of B.S. 952 or equal and approved.

Samples

Samples and details of glass offered shall be submitted to the S.O. for approval as and when directed. The samples to be submitted shall be of sizes not less than 1' 0" x 1' 0".

Quality

The glass throughout is to be the best of its respective kind, free from specks, bubbles and other defects.

Clear Float Glass

All clear float glass shall be of 'Selected Glazing Quality' of the weights as required.

Obscured Glass

Obscured glass be plain rolled sandblasted to be cut and glazed so that the direction and face of the pattern is the same throughout. Fix panes with patterned side inside unless otherwise described.

Tinted Glass

Tinted glass shall be Coolpane Grey Glass manufactured by Messrs Malaysian Sheet Glass Bhd or other equal and approved.

The glass shall be glazed using flexible compounds, sealants, preformed strips or neoprene gaskets approved by the S.O.

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Wired Glass

Wired glass shall be georgian wired and where required to be 'lined up', it is to be cut so that the wires in adjacent panes line up both horizontally and vertically.

Louvre Blades

Glass louvre blades are to have all edges ground down smooth and shall be from an approved manufacturer.

Cleaning

On completion, glass shall be cleaned on both sides and any broken, scratched, cracked or defective panes shall be replaced to the satisfaction of the S.O.

Putty

Putty for glazing to metal shall be approved tropical metallic glazing compound.

Putty for glazing to timber shall be approved tropical putty.

Glazing With Putty

The glass shall be neatly cut to fit rebates with 1.5mm clearance all round and shall be secured into metal frames by means of spring clips before putty is applied.

The glass shall be well bedded and carefully back putted, sprung in and fixed with beads. The glass shall be neatly cut to fit the rebates, with 1.5mm clearance all round and the rebates shall be primed before glazing.

Glazing With Beads

Glass to wood shall be in putty and fixed with beads.

GENERAL SPECIFICATIONS

Thickness of Glazing

Unless specified otherwise by the Architects, the following thickness shall apply :-

For all louvers (fixed and adjustable) ~ 4 mm

For all doors, windows and mirrors
fixed (top hung, side hung, pivoted,
or sliding) with dimension not
exceeding 0.75 m ~ 5 mm

- Ditto - with dimension exceeding
0.75 m but less than 2.5 m ~ 6 mm

Specialised Use of Glass

The above specification does not cover the following applications :-

- a) Staircase balustrade
- b) Skylights
- c) Floor plates
- d) Shower cubicles
- e) Sliding doors in show houses

Unless specified by the Architects, the Contractors on their specialists may propose special purpose glass for their approval.

Protection

The price for glazing shall include for protection.

GENERAL SPECIFICATIONS

Completion

On completion, all glass shall be cleaned on both sides and any broken, cracked or defective panes shall be replaced to the satisfaction of the Architect/S.O.

GENERAL SPECIFICATIONS

3.15 PAINTING

Generally

Unless otherwise specified by the Architect, followings shall be the specification of materials and workmanship for Painting as well as the quality expectation.

Paints

All paint finishes shall be premium quality throughout **and as specified in the painting schedule**. The product desired must be submitted to the Architect for prior approval.

All cement based and emulsion paints, fungicidal wash, aluminium wood primer, metallic primer, aluminium and gloss enamel paint shall be as specified herein.

Cement Based Paint

Cement based paint to be mixed and applied strictly in accordance with the manufacturer's instructions.

Primer

Priming paints shall be :-

- (a) Approved PRIMER **as per painting schedule or approved equivalent** for plaster, concrete, asbestos, cement, rendered blockwork surfaces
- (b) Approved aluminium wood primer for woodwork
- (c) Approved red oxide primer/zinc chromate primer/red lead primer for steel surfaces
- (d) Approved "etching" primer followed by zinc chromate primer for galvanised iron, **zincalume, electro galvanised**, aluminium and non ferrous metal surfaces

Undercoat

Undercoating paints shall be **as per painting schedule** or approved **equivalent** for steel and woodwork.

Knotting

Knotting shall be in accordance with B.S. 1336 and oil stains shall comply with B.S. 1215.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Finishing Paints

Emulsion paint shall be [as per painting schedule or approved equivalent](#) for all exterior plaster, concrete, cement, rendered blockwork surfaces and also for all interior plaster, concrete, cement, rendered blockwork surfaces.

Enamel paint for interior and exterior woodwork and steel-work shall be [as per painting schedule or equivalent](#).

Waterbased acrylic paint for exterior woodwork shall be [as per painting schedule or equivalent](#).

Stopping

Stopping for plasterwork shall be an approved plaster based filler. Stopping for exterior woodwork shall be whitelead paste to B.S. 2029. For interior woodwork putty shall be to B.S. 544.

Bituminous Paint

Bituminous paint shall be of an approved brand and applied strictly in accordance with the manufacturer's instructions.

Silicone Based Water Repellants

Silicone based water repellants shall conform to B.S. 3826, Class "A".

Varnish

Varnishes [for wood work except timber flooring](#) shall be polyurethane based and [as per painting schedule or equivalent](#). The Contractor shall supply leaflets and samples indicating the type of varnish he wishes to provide for the Architect's approval.

Paint Removers

Paint and varnish removers shall be of the non-caustic, non-inflammable, solvent type.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Road Line Paint

Road line paint shall be as per painting schedule or equivalent. (non-reflective yellow).

Painting Schedule

Unless otherwise specified by the Architect, following shall be the painting schedule :-

- a] Plastered surfaces and fair-faced concrete surfaces :
 - i] Internally - One coat alkali-resisting primer
Two coats emulsion paint
 - ii] Externally - One coat alkali-resisting premier
Two coats emulsion paint (fungus-resisting)
- b] Timber Surfaces :
 - i] Skirting
Plywood lining
Handrailing
Ceiling lining - Fill, stain and varnish to matt semi-gloss or
gloss finish as directed by the Architect
 - ii] Timber Door
& Window frames - One coat fungus resisting Aluminium Wood,
one undercoat and two coats of Gloss Paint
 - iii] Other timber
surface generally - One undercoat and two coats of Gloss Paint
- c] Metal Surfaces :
 - i] Generally
Galvanised iron
sheet/flashings,
Steel door and
window
window
Grilles
Steel security bars
Steel handrailing
Balusters, etc
Mild steel gate - One coat metallic primer
(red oxide/zinc chromate)
Two coats alkyd resin based paint
(gloss finish)
 - ii] Rainwater downpipes
Exposed gutters
Exposed galvanised
Pipes generally - One coat mordant solution
One coat metallic primer
Two coats alkyd resin based paint

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

- d] Other surfaces
 - i] Softboard, chipboard - One coat primer
Two coats emulsion paint
 - ii] Asbestos cement - One coat alkali-resisting primer
Two coats emulsion paint
 - iii] Facing brickwall - Two coats silicone paint (gloss) of approved manufacture
- e] Type of paint - Jotun / Sissons / ICI or equivalent

Materials For Multiple Coating

All materials for multiple coating i.e. priming, undercoat and finishing coat shall be obtained from the same manufacturer and shall be those recommended by the Manufacturer as suitable for using together and for the surfaces concerned.

Delivery of Materials

Materials for painting shall be delivered to the site in the original sealed containers and shall be used strictly in accordance with the manufacturer's instructions.

All paints, varnishes, distempers and other surface coatings delivered to the site shall be properly labelled by the manufacturer stating:-

- (a) Type of product
- (b) Brand name, if any
- (c) Use for which it is intended, i.e. primer, undercoat or finish coat
- (d) Manufacturer's batch number.

N.B. : The label shall be a PRINTED label, type-written label will NOT be accepted.

Within 30 days from the award of the contract, the contractor is required to submit the manufacturers' estimated total paint quantity required for the project. A monthly confirmation from the paint manufacture that all paint delivered to site are authentic is also required to be submitted.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Surface Preparation For Plaster

Plastered, rendered, concrete, brick and similar surfaces are to be prepared for decoration as follows:-

- (a) Cracks and other imperfection are to be pointed or cut out and made good.
- (b) Surface is to be allowed to dry out for as long as possible, and in no case less than 7 days for distempers, cement paints and acrylic emulsion paints, or less than one month for oil paints.
- (c) Any efflorescence is to be removed by dry brushing followed by a damp cloth. This is to be repeated until no further efflorescence appears within 48 hours.
- (d) Surface is to be rubbed down to remove all plaster nibs and other irregularities, and brushed down to remove dust.

Surface Preparation For Metal-Work

Metal surfaces are to be prepared for decoration as follows:-

- (a) Dirt and grease is to be removed by wiping or washing
- (b) Rust, scale or loose priming paint is to be removed back to bare metal by wire brushing or chipping as required
- (c) Surface is to be rubbed down to remove irregularities
- (d) Bare patches in metalwork delivered primed are to be brought forward with the appropriate primer before receiving the treatment specified

Surface Preparation For Woodwork

Surface of woodwork are to be prepared for decoration as follows:-

- (a) Dirt, grease etc. is to be cleaned off
- (b) Surface is to be rubbed down with glass paper to remove all projecting fibres, particular attention being paid to mouldings. Dust is to be removed.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Surface Preparation For Woodwork – Cont'd

For woodwork to be painted (not varnished or polished) the following additional treatment is required:-

- (c) Knots and resin pockets are to be scrapped and given two thin coats of patent knotting consisting of shellac dissolved in methylated spirits, free from resin
- (d) After priming cracks, nail holes, open joints and other imperfections are to be made good with hard stopping consisting of paste white lead and gold size stiffened with whiting. Linseed oil putty is not to be used

Priming

Joinery to be painted is to be primed before delivery to the site or, in the case of joinery prepared on site, as soon as possible after preparation. Surfaces subsequently cut or damaged are to be re-primed.

Hidden faces of joinery, such as back of boarding, frames, skirtings, architraves, etc., and bottom edges of doors, are to be primed before fixing. Where adjacent faces have polished or natural finish, an approved clear preservative shall be used instead.

Steel and ironwork to be painted, except plumbing pipework and electrical conduit, is to be primed before assembly or fixing, including laps, ends for building in, and other concealed parts.

Head of nails in linings to be distempered or emulsion painted are to be spotted with one coat of primer and one undercoat of oil paint before the lining is decorated.

Finished Quality

Finished paintwork and decoration is to be of uniform finish and colour, free from blemishes, brushmarks and takiness.

Edges of paintwork are to be accurately cut in to line, and disfigurement of adjacent surfaces to be avoided. Painting of sashes etc. glazed with putty is to overlap the putty onto the glass, to finish exactly on the sight line of the rebate.

Bolts, handles and other surfaces ironmongery and cover plates and removal fittings are to be removed before painting or decoration is carried out and subsequently replaced.

Preparation of Previously Painted Surfaces

Where paintwork has blistered or flaked, it is to be sandpapered down to a firm surface or, if necessary, removed before re-painting is undertaken.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Application

- a) Apply products at the container consistency and do not thin or otherwise alter except in accordance with the manufacturer's instructions.
- b) Apply all in-situ coats by brush, except where the manufacturer's recommend spraying or other method or where the Superintendent's approval is otherwise obtained.
- c) Apply all coats evenly to prevent air bubbles, runs, brush marks, sags, blotches and other defects and to ensure uniform finish and colour.
- d) Do not apply coat to a surface which has not been properly prepared as specified, or to a previous coat which is not thoroughly dry and clean.

Application

- e) Allow for sanding of previous coats, as recommended by the manufacturer or as later specified.
- f) Before commencing application, ensure that there is satisfactory ventilation and that the atmosphere is free of dust.
- g) Unless stated otherwise in the directions of the manufacturers of the finishes specified, all surfaces shall be thoroughly dry before painting.
- h) Do not apply external coats in weather which is likely to have and adverse effect on the finish.
- j) Drying times between coats shall be as recommend by the manufacturers of the paint or finish

Sanding

- a) Sand down wood surfaces as necessary in direction parallel to the grain and using a grade of sandpaper suited to the application.
- b) Keep sanding to previous coats as light as possible to achieve a satisfactory surface for subsequent coats, hand sanding with a soft-surfaced sanding block and suitable grade sandpaper.
- c) Brush or wipe off dust as the sanding proceeds and at completion of sanding.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Making Good

Make good any defects, including repainting of the whole plane or surface in which such defects appear.

Making good shall include cutting out, stopping, etc. as necessary, and shall not be limited to patching or final costs.

Workmanship

All painting is to be carried out by skilled workmen according to the best current practice and in strict accordance with the Manufacturer's instructions.

Each coat of painting is to be inspected and approved before the subsequent coat is applied.

Primed or undercoated woodwork or metalwork shall not be left for an undue period before completing the painting process. All coats of paint must be thoroughly dry before subsequent coats are applied, rubbed down with fine glass paper where necessary and dusted off.

The priming, undercoat and finishing coats of paint shall be obtained from the same manufacturers. The tints of undercoats are to approximate those of the finishing colour.

In order to indicate the number of coats applied, a difference shall be made in the tint of each succeeding coat.

The varnish shall not show any green or other discoloration or retardation of drying and the finished film resulting from the test shall be free from imperfection such as cissing or siling.

Floors, fittings and other works shall be properly covered up and protected and all painting containers, etc. shall be placed on impervious coverings on floors, sills, etc.

No painting or decoration is to be carried out externally and internally unless moisture content of plaster wall is less than 17% which shall be tested with protimeter.

No finishing coats are to be applied until all dust and rubbish has been removed from that area.

Colour Selection

The colours and tints of paints and decorative wood finish shall be selected by the Architect/S.O. and the priming, undercoats and finishing coats shall be differing tints as directed and shall be obtained from the same manufacturer.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Painting On Timber and Metalwork

Unless otherwise described herein all exposed surfaces of woodwork including plywood etc. and all exposed surfaces of metalwork including pipings flashings etc. shall be appropriately primed and painted with one undercoat and two gloss finishing coats to the approval of the Architect/S.O. and the rates inserted in these Bills of Quantities for the woodwork and metalwork shall include for this.

Galvanized metal surfaces shall be degreased with an approved solvent, primed with "Etch Primer" or equivalent and painted with with one undercoat and two finishing coats of gloss enamel paint.

Ungalvanised metal surfaces shall be prepared, primed with one coat of zinc chromate primer and painted with one undercoat and two finishing coats of gloss enamel paint.

Wrot timber surfaces shall be knot, primed, stopped and painted with one coat of aluminium wood primer, one undercoat and two finishing coats of gloss enamel paint.

Decorative door surfaces and parquet flooring shall be sanded down or grinded, stopped and painted with three coats or polyurethane-based paint.

Unexposed surfaces of metal and woodwork shall be primed only in the manner described above.

Information and Facilities to Suppliers

The Contractor shall supply the paint manufacturers with relevant details of the materials required to comply with the description in this Specification. The manufacturers shall be given every facility for inspecting the work during progress in order to ascertain that the materials are being used in accordance with their instructions and they are to be allowed to take samples of their products from the site if they so desire.

Testing and Use of Materials

The materials as delivered and as used from the painter's kettles will be analysed and tested periodically and when directed by the S.O. and sampling tines shall be provided for this purpose. The Contractor shall arrange for prompt delivery to an approved testing station or laboratory. The materials are to be used exactly as received from the maker in accordance with the maker's instructions and the addition of thinners, driers or other materials will only be permitted when specially required by the maker and the procedure approved by the S.O.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Malpractices

In order to eradicate any malpractice by way of unauthorised addition of thinners or driers, or other adulteration of paint, the attention of the Contractor is specially drawn to the following:-

- (a) Adequate supervision during the painting work must be given by the Contractor to ensure that the paint is not adulterated.
- (b) If cases of unauthorised or excessive thinning or other adulteration are discovered, the S.O. will exercise the power contained in this contract to require the removal from site of the workman or workmen concerned.
- (c) The Contractor shall exhibit or cause to be exhibited a notice drawing the attention of the workmen to the S.O.'s requirements to use paint as supplied by the manufacturer and the penalty of a breach of this requirement.
- (d) If the S.O. approves sub-letting of the work, such approval will not relieve the Contractor of his responsibility for observance of the above requirement.

Sub-Contractors should be warned, however, that if any malpractice is discovered, the approval will be withdrawn and the Sub-Contractor will be required to leave the site.

Taking Samples

Samples will be taken by the S.O. The tins will be filled 7/8 full after the contents of the container or kettle have been thoroughly stirred and mixed. Relevant details of the material sampled shall be recorded.

Making Good

Any cracks or defects appearing in painted surfaces before completion or before the expiration of the Defects Liability Period shall be cut out, stopped, primed and painted. Affected woodseal areas shall be sanded and re-coated and made good to the satisfaction of the S.O. Cracks occurring in walls shall be filled with appropriate fillers and shall be repainted as directed by the S.O.

GENERAL SPECIFICATIONS

PAINTING (Cont'd)

Protection

All other works, fittings, pavings etc. are to be covered up and protected as necessary during decoration, and any splashes and paint marks are to be removed on completion.

Warranty

The contractor is required to provide a warranty for the completed external painting works for a period of 5 years from the day named in the Certificate of Practical Completion of the contract on the materials and workmanship.

The warranty shall be made transferable to the registered house owner who shall then possess the right to enforce the terms and conditions of such warranty.

3.16 WATERPROOFING

Quality Assurance

All waterproofing system work shall be carried out by a specialist applicator, approved by the waterproofing system manufacturer, who can substantiate with documented evidence, successful installation of the specified waterproofing systems over a minimum period of five (5) years in this region prior to the award of this contract. Such evidence and manufacturer's statement of approval shall be submitted to the Architect.

Provide for a technical representative from the manufacturer of the waterproofing system to be on the job site to assure compliance with the manufacturer's directions. The technical supervisor shall be present when the applications start and if required, shall make periodic checks as required.

In addition, the manufacturer of the waterproofing system shall furnish to the Architect a list of projects on which the waterproofing system has been successfully installed for a minimum period of five (5) years.

Samples

At the Architect's request, submit duplicate samples of materials for approval prior to commencement of work concerned.

Shop Drawings

Prepare complete installation drawings, showing proposed layout pattern of waterproofing system and methods of termination and flashing of protrusions and submit drawings in duplicate to the Architect for review.

Also submit in duplicate technical data and information literatures on waterproofing system regarding proper ties and application procedures to the Architect for review.

Warranty

Submit a joint warranty from both the contractor and manufacturer in writing, in the name of the owner that all waterproofing system furnished and installed under this contract shall remain fully watertight and free from all defects for a period of ten (10) years from the day named in the of Certificate of Practical Completion (CPC). This joint warranty shall be made transferable to the registered house owner who shall then possess the right to enforce the terms and conditions of such warranty.

This written joint warranty shall cover the faithful performance of the waterproofing system, including immediate correction, at no expense to the owner and at such time as the owner may designate, of any defects due to faulty materials or workmanship appearing within the warranty period, including cost of removing and replacing materials as required for access to waterproofing system installed.

Product delivery, storage and handling

Deliver and store all materials in their original packaging in undamaged condition, sealed with labels intact, having manufacturer's name, brand, weight and other references to accepted standards clearly shown.

Make all necessary arrangements with regard to delivery and storage on the site and schedule deliveries accordingly. In general, deliver materials as required for installation and keep site storage to a minimum.

Protect all materials from damage, weather and store in dry, clean and secured place.

Handle materials and equipments in strict accordance with manufacturer's recommendations. Damaged or deteriorated materials shall be removed from the site.

Job Condition

Conform to manufacturer's requirements for minimum application temperatures and humidity. Check surfaces and areas specified and showed to be waterproofed.

Examine concrete surfaces to be waterproofed for visible structural defects. Do not start any work until condition is suitable for application of waterproofing system.

Take all necessary measurements and levels at the building. The work shall be laid out to accurately fit the conditions at the building and with all adjacent work.

Tests

Contractor shall conduct the water leakage test to the satisfaction of the Architect. Any leakage in the waterproofing system installed shall be rectified at no extra cost to the contract to the approval of the Architect.

Water leakage test shall only be carried out after all water proofing system has cured for a minimum period. All outlets shall be temporarily sealed. Flood all waterproofed surfaces to a minimum of 25mm water depth (as measured from the highest point of the area) for minimum 72 hours to the satisfaction of Architect.

Water leakage tests for minimum 72 hours shall also be carried out after the installation of sanitary fittings to the satisfaction of Architect.

Surface Preparation

All surfaces receiving waterproofing system shall be prepared strictly in accordance with manufacturer's written directions and recommendations.

Ensure that concrete and masonry surfaces are properly cured, smooth, dry, firm and free from surface pitting and honeycombing. Remove fins, rough and sharp projections, loose particles, ridges, laitance, cracks, grease, asphalt, oil, form release agents and other

Surface Preparation (Cont'd)

Irregularities and foreign matters which could be detrimental to the application and adhesion of the waterproofing system to the substrate to be waterproofed.

Fill voids, surface pittings, honeycombing, cracked and spalled surfaces with filler materials as recommended by the waterproofing manufacturer. Repair pour joints and provide a surface satisfactory for application of waterproofing system.

Expansion, construction and control joints shall be properly sealed in accordance with waterproofing manufacturer's recommendation.

Cracks must be repaired to original profile with non-shrink grout or approved material by manufacturer. Architect may request contractor to carry out water leakage test prior to waterproofing works if serious water seepage is observed underneath the area to be waterproofed.

Remove loose particles and foreign matters with compressed air or scraper and wire brush and flush down thoroughly with clean water.

Clean all exposed metal surfaces (pipes, sleeves, drains, vents, etc.). Remove paint, oil, grease, rust, scale or other foreign matters.

Ensure that all horizontal surfaces (base and topping slab) to be waterproofed are even with gradient fall towards discharge outlets before proceeding with application of the waterproofing system unless specified otherwise.

Angle Fillet

A continuous angle fillet (25mm x 25mm) shall be installed at all internal corner between horizontal and vertical surfaces and reinforcement fabric shall be placed on the angle fillet prior to the application of waterproofing system unless specified otherwise. The fillet material is usually in ratio 1:3 cement and sand with 1:4 bonding agent and water.

Upturns / Pipes and Penetrations

All waterproofing shall include the forming of minimum 300 mm height of upturn around the vertical surface of the waterproofed area.

Waterproofing membrane shall be dressed up at pipe penetrations to the finished floor level and dressed down to at least 50 mm into the floor outlet. The membrane shall be applied around the pipe at a horizontal width recommended by manufacturer and this coating shall be overlapped with the subsequent membrane applied to the entire area.

Sheet Membrane System

This sheet membrane system shall apply to self-adhesive waterproofing membrane, torch-on waterproofing membrane, hot-applied rubberised asphalt waterproofing membrane or any other sheet waterproofing products available in the market.

Sheet Membrane System (Cont'd)

Application of waterproofing system shall be strictly in accordance with manufacturer's specification and recommendation.

All surfaces to which the membrane is to be applied must be primed with primer approved by the membrane manufacturer. Rate and procedures of application shall be strictly in accordance with the manufacturer's directions.

Primers shall be dried one (1) hour or until tack free. Surfaces not covered by membrane within the period specified by manufacturer shall be reprimed. Keep primed area free from dust.

Membrane shall be laid from the LOW POINT TO THE HIGH POINT, across the fall line so that the laps shed water as do shingles on roof.

Ensure that there are no entrapment of air and formation of wrinkles during installation of membrane.

Each sheet of membrane shall overlap a width recommended by the manufacturer and shall be rolled down completely and firmly with a heavy rubber roller or other method/devices as recommended by the manufacturer, to ensure continuity of bond so as to achieve a watertight installation and adhesion.

All inside and outside corners shall be double covered with membrane by applying an initial strip of a width recommended by the manufacturer, centred along the axis of the corner. A 25mm x 25mm cant strip or mortar fillet shall be used on inside corners. Outside corners shall be rounded.

Avoid stretching membrane at corner or other detail area.

All construction, control and expansion joints shall be double covered with membrane to a width recommended by the manufacturer.

Areas around drains, posts or other protrusions shall be double covered with membrane for a minimum of 150mm in each direction from the protrusion, then liberally coated with approved mastic over edges of membrane.

Horizontal membrane shall preferably be laid prior to the application of the vertical membrane. The horizontal membrane shall be bonded to the vertical surface at the minimum height recommended by the manufacturer so that the vertical membrane can overlap the upturned horizontal membrane.

Membranes shall be finished off by grouting them into reglets. Other methods of finishing shall be submitting to the Architect for review and approval.

Liquid Waterproofing System

This shall include any waterproofing products that come in liquid form. Application of waterproofing system shall be strictly in accordance with the manufacturer's specification and recommendation.

Liquid Waterproofing System (Cond't)

Bituminous / rubberised type of waterproofing or approved equivalent shall be used unless specified otherwise by Architect. Elongation at break of this type of waterproofing material shall be more than 100% or approved equivalent.

Application of waterproofing system shall be strictly in accordance with the manufacturer's specification and recommendation.

All surfaces to which the membrane is to be applied must be primed with primer recommended by the manufacturer. Rate and procedures of application shall be in strict accordance with the manufacturer's direction.

Primed surfaces not coated with waterproofing membrane with the recommended period shall be reprimed. Keep primed area free from dust and dirt.

Application of material on prepared surfaces shall be by brush, roller, trowel, spray, a combination of these methods or other methods specified by manufacturer.

All sealed expansion, construction and control joints at inside and outside corners, junction, outlets or where excessive movements are anticipated shall be applied with an initial band of thickness and width recommended by manufacturer. The band applied shall then be allowed to cure before application of subsequent coat.

Several thin coats shall be applied at different direction to achieve the required wet film thickness, rather than applying one thick layer. Thickness of membrane installed shall be checked with a wet film thickness gauge. Thickness of membrane shall not be less than that specified and recommended by the manufacturer.

The curing period for each coat shall follow manufacturer's specifications.

Powder Waterproofing System

This shall include any waterproofing that comes in powder form and need to be mixed with other ingredients e.g. water, resin, etc, before application.

Rubberised / flexible type of waterproofing or approved equivalent shall be used unless specified otherwise by Architect. Elongation at break of this type of waterproofing material shall be more than 100% or approved equivalent.

Applications of waterproofing system shall be strictly in accordance with the manufacturer's specification and recommendation.

Mix ingredients strictly in accordance with the manufacturer's specification. Mix adequately and thoroughly until it blends completely. Do not add water/ liquid that exceeds manufacturer's recommendation. If power mixing is utilised, add dry ingredients to the liquid.

The mixture shall be used up within the recommended time. Discard unused mixture that had begun to set. On no account shall workability of the mixture be restored with addition of extra water / liquid.

Powder Waterproofing System (Cont'd)

Before application, all surfaces shall be thoroughly dampened with clean water but no loose standing water shall be on the surface, unless specified otherwise by manufacturer.

Application of the slurry coat onto the substrates shall be by brush, roller or spray method, in alternate horizontal and vertical directions.

Several thin coats shall be applied at different direction to achieve the required wet film thickness, rather than applying one thick layer. Thickness of membrane installed shall be checked with a wet film thickness gauge. Thickness of membrane shall not be less than that specified and recommended by the manufacturer.

The curing period for all coatings shall follow the manufacturer's specification or recommendation.

When horizontal waterproof screeding had dried sufficiently to allow foot traffic, form concave fillets at all junctions of floor and internal wall angles.

Ensure that waterproofing materials are firmly pressed into all voids and levelled. Working joints must not occur at vertical angles or coincide in successive coats.

All work must be trowelled to the required finish as the work proceeds.

Where waterproofing is done in damp, unventilated conditions, ensure each slurry coat is dry before the subsequent coat(s).

Do not dampen surfaces between slurry coats. Do not apply second or subsequent coat to the surface that is wet due to condensation. Wipe dry the surface and provide ventilation.

After completion of waterproofing system, allow coating to cure sufficiently before the finishing concrete, tiling etc.

Damp Proof Membrane

0.25mm thick polythene sheet shall be provided underneath ground floor slab unless specified otherwise. Polythene sheet shall fully cover the surface which to be damp proofed and protected from damage. Each polythene sheet shall be overlapped to ensure effectiveness of the damp proof system.

Precautions / protections

Care must be taken not to puncture or tear the membrane prior to covering it. Do not allow unauthorised activities on the unprotected membrane and/or constant exposure to high temperatures.

Notify the Architect for the inspection of the membrane system laid prior to commencement of covering works. Inspection by the Architect and Owner shall not relieve the contractor of his responsibility to ensure a watertight waterproofing installation.

Precautions / protections (Cond't)

Protection shall be provided immediately after application of waterproofing, but ensure membrane is properly cured if protection need to be laid on the waterproofed surface.

Protection surfaces shall be screeded to fall towards discharge outlet with a slope of minimum 2% or preferably 3% to receive the finishing work unless otherwise specified.

Screeded flat roofs are to be immediately protected by laying clean gunny bags over the area and to remain without traffic and any activities for two days. [Shifted from roofing specs]

All pipes and floor openings in waterproofing areas shall be fitted with temporary caps to avoid dropping of debris or any object(s) that will cause pipe chokage.

If steel is placed directly onto unprotected membrane, use wood blocks or chair totally supported on metal lids or pieces of flat asbestos cement sheet to prevent sharp edges of steel from puncturing the membrane.

If a job must be left partially complete, the exposed edges of the outside strips shall be adequately protected as recommended by the manufacturer, to ensure that water will not seep under the membrane before it is completely installed.

Ensure that the membrane will not be in direct contact with incompatible materials, which will be detrimental to the performance of the membrane.

Only sufficient membrane shall be laid which can be protected as work proceeds. Ensure that overlaps are adequately bonded.

When a brick skin is applied to the face of the vertical membrane, care must be taken not to damage the membrane. A gap of 12mm to 18mm shall be left, which is to be filled with cement sand mortar as work proceeds.

Alternatively, membrane on vertical surfaces to be backfilled shall be protected with protection boards as specified by the Architect. Protection boards shall be adhered to membrane with mastic recommended by the manufacturer or by bracing until backfill is placed. Butt boards tightly together.

Membranes left exposed on parapet or the top of foundation wall must be covered with approved weather resistant flashings.

Adjust and clean

Repair, remove and clean all drips or smears on exposed finished surfaces or surfaces to be subsequently finished. Clean off immediately as directed by and to the satisfaction of the Architect.

Protect all adjacent surfaces from damages due to waterproofing installation operation.

As work proceeds and on completion, clean up and remove from the premises all rubbish and surplus materials resulting from this work.

Proprietary System

GENERAL SPECIFICATIONS

Waterproofing system used for various areas of works shall be 'Vandex' (obtainable from Hitchins (M) Sdn Bhd's) Waterproofing systems or approved equivalent. Application of the systems shall strictly be in accordance with the manufacturer's specifications. Procure and furnish the warranty as stipulated in section "Warranty" in this specification.

3.17 PLUMBING AND SANITARY INSTALLATION

Cold Water Plumbing

By-Laws

All plumbing work shall with the relevant Local Authorities By-laws. The work shall be carried out by a licensed specialist approved by the Architect.

The Contractor shall execute the work in strict conformity with the approved plans and shall arrange for the necessary formalities to be complied with.

Materials of Pipes/Fittings

Cold water piping above ground shall be high density polyethylene (HDPE), PN10 TO M.S. 1058 with 4 galvanised steel, sleeve pipe where crossing drain (Class B).

Cold water supply piping from the mains to the meter shall be high density polyethylene (HDPE) pipes in M.S. 1058. Cold water piping from the water tank shall be PVC pipes (Class E).

All pipes fittings shall be suited for the operating pressures envisaged as designed.

All pipe diameters given are clear internal diameters.

Pipe Installations

All installations shall be done according to proper drawings. Special care shall be taken in the arrangement of piping to ensure a neat finishing and alignment.

All pipes and fittings shall be thoroughly cleaned and free from burr, scale and obstructions before erection. Clean sharp pipe cutters, not hacksaws, shall be used to cut metal pipes. Threads shall be cut with clean sharp die.

Connections shall be as direct and as few as possible. Valves and fittings shall be grouped where this will not affect their operations, to reduce the number of joints to a minimum.

All necessary valves and other fittings shown on the drawings and required for proper valving of the whole installations shall be supplied and installed. Every section of major branch supply piping shall be controlled by a stop-valve at the point of connection to the supply.

Pipe connection of 63mm (2½") diameter and above connect to equipment shall be flanged joints and pipe connections below 63mm (2½") diameter shall be screwed unions to permit removal for maintenance without disturbing other pipes.

All pipeworks shall be run in false ceilings, ducts or chase in wall.

Pipe Joints

The number of demountable joints, e.g. flanges, unions, etc. shall be kept to a minimum.

All screwed joints shall be of approved jointing compound. Machined flanges shall be used for flanged joints.

PLUMBING (Cont'd)

Cold Water Plumbing (Cont'd)

Pipe Supports

True alignment is of importance. Flanged gasket shall be of asbestos composition or cotton duck reinforced rubber gaskets suitable for the temperature and pressure of the particular system.

The Contractor shall supply and install all necessary pipe supports, hangers, anchors or guides required for proper support.

Riser shall be supported at each floor with mild steel riser clamps.

Horizontal pipe runs shall be supported on hangers of split ring or clevis type.

Where practical, supports and hangers shall be located immediately adjacent to any change in direction and at valves and heavy equipment.

Where pipe lines run in a common group they shall be supported from a common hanger bar fabricated from mild steel sections.

Pipe supports and hangers shall be spaced at intervals not exceeding the following:-

<u>Nominal Pipe Spacing</u>	<u>Hanger Rod Diameter</u>	<u>Horizontal Spacing</u>
Up to 19mm (3/4")	6mm	1.80m (6'0")
25mm (1") to 32mm (1 1/4")	6mm	1.80m (6'0")
38mm (1 1/2") to 63mm (2 1/2")	10mm	3.00m (10'0")
Above 63mm (2 1/2")	12mm	3.7m (12'0")

Vertical pipes shall be supported at least at the top and bottom of each riser, at each floor level, and at each isolating valve. In addition, a further support shall be provided between floor levels for pipes smaller than 32mm diameter.

Sleeves and Cover Plate

The Contractor shall supply and install sleeves where pipes penetrate through walls, floors, etc. Cover flanges shall be installed to the point of penetration by pipes or fittings at walls or ceiling where exposed to view.

Workmanship

The work shall be inspected and tested during installation at agreed stages.

All work which will be concealed shall be tested before it is finally enclosed.

PLUMBING (Cont'd)

Cold Water Plumbing (Cont'd)

Workmanship (Cont'd)

A final test shall be made upon completion for soundness and performance to the satisfaction of the Local Authorities.

Valves and Fittings

All valves and fittings necessary for the correct control, operation and maintenance of all services shall be provided and installed to the satisfaction of the Architect. Samples shall be submitted for Architect's approval before installation. Valves shall be installed where they are easily accessible for maintenance and operating purposes.

Each valve shall be of the same nominal size as the line in which it is installed, except for control, pressure reducing and similar valves which shall be correctly sized for the duty concerned.

Valves shall be of replaceable components, valve bodies up to 63mm (2½") shall be brass construction with screw connection and cast iron or steel construction with flanged connections for valves 76mm (3") and above.

Before installation, every valve shall be blown out with air to remove any foreign matter lodged in the valve.

All bib, pillar, globe and stop tap of the ordinary screwdown pattern and of nominal size not exceeding 50mm shall comply with B.S. 1010. Every bib, pillar, globe and stop tap other than ordinary screw-down pattern shall be capable of resisting a pressure of at least 300 p.s.f. and every valve, spindle and other internal part and where the nominal size of the tap does not exceed 50mm the body thereof shall be made of a corrosion resisting alloy. Bib taps shall be secured by means of back plat elbow screw to walls or tees.

Traps to sinks, baths, etc. shall be anti-siphon type made of non-corrosive materials. The traps shall be equal in quality and performance to "Grevak" trap or approved equivalent. Traps for basin shall be mild steel bottle trap complying with the requirements of B.S. 3943 unless otherwise stated.

All sluice valve of nominal size of 50mm or more shall comply as regards to materials, workmanship finish and testing with B.S. 1218 for sluice valves for waterworks purposes.

All ball valve of nominal size not exceeding 50mm shall comply with B.S. 1212 for ball valves (Portsmouth Type or approved equivalent) excluding floats. Copper floats shall comply with the requirements of B.S. 1968.

All valves shall be of approved manufacture and generally constructed in accordance with relevant British Standard Specifications.

i. Stop Cocks

Stop cocks shall be used to isolate fixtures for maintenance purposes.

All stop cocks and valves not exceeding 50mm diameter shall be cast iron to B.S. 1212 with copper float to B.S.1968.

PLUMBING (Cont'd)

Storage Water Tanks

General

Cold water storage tanks shall be sited at locations indicated on the Drawings and be of the capacities noted.

The tanks shall be of Glass-Fibre Reinforced sectional construction with close-fitting covers and conforming to Jabatan Bekalan Air, SIRIM or any local authorities having jurisdiction over the installation.

Tanks shall be designed, supplied and installed by the Contractor. Details of tanks shall be as shown on the Contract Drawings and all connections shall be flanged. The tanks shall also be inert, durable, non-corrosive, non-toxic and physiologically safe.

Each tank shall be braced internally or externally as necessary to ensure complete structural stability. All internal braces and supports shall be of stainless steel.

Tanks shall be tested and approved by the relevant authorities.

Tank Fittings

The Contractor shall be responsible for ensuring that all fittings are correctly positioned.

All bolts and nuts used for the erection of the tanks shall be of stainless steel.

Tank fittings shall be provided with but not limited to the following:-

- a) Equilibrium ball valve(s) or inlet pipe (as indicated).
- b) Connection for water outflow header.
- c) Connection for vent pipes.

PLUMBER (Cont'd)

SANITARY SYSTEM

General

This section of the specification details the General Requirements for the Sanitary System, which shall be followed except when otherwise stated.

The Specification and the accompanying drawings indicate the extent and general arrangement of the system. If any departures from the contract drawings are deemed necessary by this contractor, details of such departures and reasons therefore shall be submitted to the Consulting Engineer for approval, prior to installation.

All materials, fittings, fixtures, apparatus and all other items shall be the best quality of their respective kinds, free from defects and approved for used by the respective Authorities as defined herein after.

This specification is general and covers the various methods and materials which may be required. It is the responsibility of this contractor to ascertain from the specification and the accompanying drawings the specific requirements of this project.

It is not to be construed that an omission of a specific reference to any part of the works in the specification and/or the drawings means that work is excluded from the contract.

Authorities

All works carried out under this section shall conform in every respect to the Local Ordinance and any amendments in force during the contract period.

Standards

The following standards in their latest edition apply throughout:

<u>Item</u>	<u>B.S.</u>
Cast Iron	416 : 1967
	1211 : 1968
Glazed Pipe	65 : 1966
	540 : 1966
Asbestos Cement Pipe	582 : 1965
UPVC Pipe	4514 : 1969
	5255 : 1976

PLUMBING (Cont'd)

SANITARY SYSTEM

Systems

Waste

A separate waste pipe shall be provided for the following classes of foul water except where a combined pipe system is used:-

- a. Dirty Mwater from baths, basins, wash troughs, and other waste containing a small proportion of soap and/or dirt.
- b. Greasy water from kitchen or scullary sinks and/or equipment where grease traps or interceptors are required.

Soil

Soil pipes shall be provided from water closets, urinals, sinks and/or other equipment where the foul water may contain faecal matter, urine and other contaminations of a similar nature.

Combined Waste and Soil System (One Pipe System)

A combined system is where the waste and soil pipes are combined with the appropriate vents into one pipe conveying foul water.

Vents

a. General

All the sanitary pipe systems and fixtures must be vented. The only exception being basins which are provided with anti-siphonage arrangements.

- b. Where there is more than one fixture or the water seal is reduced, a vent pipe shall be supplied to the fixture trap or traps.

c. Soil and/or one pipe system

Soil pipes and/or one pipe systems shall in all cases be vented by the upward extension of the soil or combined pipe stack.

d. Anti Siphonage

1. To prevent the loss of water seal in traps the antisiphonage pipes shall be carried up from each fixture to the branch or main vent pipe above the level of such fixtures.
2. Except in special cases, and with the approval of the Authorities, anti-siphonage vent pipes should connect to the waste pipes, combined pipes, or soil pipes on the opposite side of the water seal to the fixtures at point not less than 3" or more than 1' - 0" from the crown of the trap except in the case of baths and closet pans, where the vent pipes shall not be more than 4' - 0" from the crown of the trap.

PLUMBING (Cont'd)

Sanitary System

Vents (Cont'd)

3. No other fixtures shall be connected to the soil, waste or combined pipes at any point between the anti-siphonage pipe and the trap which it serves.
- e. Vent Pipe Grade and Connection
1. The lower end of all vertical lines of vent pipes shall connect, full size, at not less than a 45 angle to the horizontal with a soil, waste or combined pipe.
 2. All offsets shall be at a grade of not less than 45 angle to the horizontal.
 3. Vent pipes shall not be used as waste, combined, or soil pipes except with the written permission of the Authorities.

Piping Materials

Main waste and all soil pipes shall be cast iron to B.S.416:1967 unless otherwise stated in the drawings.

Main vent pipes shall be cast iron to B.S. 416:1967

Branch vent pipes of 2" diameter and below shall be galvanised to B.S.1387:1967 heavy grade.

Waste pipes of 1½" diameter from wash basin or sink shall be galvanised steel to B.S.1387 - heavy grade.

All materials not specifically mentioned above shall conform to the latest edition of their respective British Standard Specifications and shall be to the approval of the Authorities.

Traps

All traps shall be cast iron, free from holes, sand cores, cracks etc and completely lined internally with glass enamel.

Grease traps shall be fitted with an approved tight fitting cover designed to prevent the emission of odours.

In machine rooms the floor trap shall be of the oil interceptor type which shall be connected to a disconnector trap and vented.

Cleaning Eyes and Inspection Openings

Inspection and cleaning eyes shall be provided on all soil, waste and combined pipes so as to provide access for the proper inspection and cleaning of the entire length of pipe.

In all cases where the vertical stack of soil or combined pipes provides for closets 4' - 0" or more above ground level, a flanged inspection opening 8" in length fitted with a cover and secured with non-corrodible bolts and nuts shall be provided near the foot of the stack.

PLUMBING (Cont'd)

Sanitary System (Cont'd)

Cleaning Eyes and Inspection Openings (Cont'd)

Inspection openings to soil, waste and combined pipes shall be provided with an insertion cloth or washer.

Pipe Joints

All cast iron joints shall be made by caulking the cast iron socket with molten lead.

Where other piping materials are used the pipe joints shall conform to relevant BS, Specification and to the approval of the Authorities.

Connections To Sanitary Fittings Etc.

The cistern flush pipe shall be connected to the closet pan by 4 lbs. lead cap piece packed to approval.

The flush pipe shall be connected to the cistern by a brass union soldered to drawn steel pipe.

Outlet fitting to baths, sinks, basins, troughs, etc. shall be made with locknuts and washers to the fixture and a union to the waste pipe.

Vent pipes shall be connected to pans with a lead cap piece and copper pipe.

Overflows shall be connected to nearest drain.

Pipe Clamps and Supports

Soil, waste, combined and vent pipes shall be clamped or fixed at 6'-0" centres or less.

Pipe hooks, clamps and clips shall be of the same material as the pipe.

The clips or clamps on cast iron shall be placed tight up against the head or underside of the collar.

Extension clips are to be used where it is necessary to run the pipe clear of the wall.

Pipe fixings shall be set in lead, with 'T' headed bolts, or other approved methods. Wooden materials are NOT allowed.

Manholes

This sub-contractor shall construct all manholes as shown on the accompanying drawings.

Each manhole shall be of sufficient size to accommodate all branch pipe.

Each manhole shall be constructed with at least 6" thick concrete base and 9" brick walls. The bricks shall be of the verified type and shall be laid in English bends. The cement mortar shall be 1:3 and the joints must be completely filled with mortar.

PLUMBING (Contd.)

Manholes (Contd.)

Each manhole shall be rendered on the inside and outside with 1:2 rendering. The inside shall be finished with high alumina cement rendering to the Local Authorities requirement.

A cast iron frame with cover shall be set on top of each manhole, level with the ground with lid fitted onto it. The frame shall be properly bedded and fixed. Both sides of the cover and frame shall be painted with black bituminous paint before fixing in position. Air tight gaskets shall be provided wherever necessary.

All inverts shall be formed with glazed pipes or approved equivalent, with properly bent branches.

When a manhole is located within a building the cover shall be of the double sealed type and shall have copper (or stainless steel) lined rims on both frame and cover for floor finishing.

Testing

Completed pipework shall be tested progressively for leaks, preferably in sections. The test shall be carried out as follows:

- a. All openings below the top section shall be hermetically sealed, and if considered necessary by the Consulting Engineer, to an additional height as instructed.
- b. The system shall be filled with water to the highest point.
- c. The water level shall be maintained by the system at its filled height for a period of fifteen (15) minutes.
- d. The quantity of water added to maintain the level must not exceed three (3) measured gallons (Imp) for every fifty (50) joints, proportionately more or less for a lesser or greater number of joints.
- e. Every pipe and joint shall be carefully examined for leaks while the system is filled with water.

PLUMBING (Contd.)

Painting

General

This section of the specification details the requirements for painting in this project.

Only the best quality primers and paints shall be used.

On special materials such as insulation, the primer and paints shall be as recommended by the material manufacturer.

All items to be painted shall be first cleaned and prime coated followed by two coats of gloss finishing paints.

On all non-metallic items, the paint used shall be Acrylic Emulsion with mildew inhibitor additive.

Colours

Piping

- | | | | |
|----|-----------------------------------------|---|------------------------------|
| a. | Cold water and/or cold water make-up | - | White |
| b. | Soil, waste and drain | - | Black |
| c. | Pipe and other items exposed to weather | - | Two coats of aluminium paint |
| d. | Pipe hangers and support | - | Black |

Valves

- a. All valves shall be painted as the pipe except the handles which shall be painted red.

Electrical

- | | | | |
|----|------------------------------------|---|--------------------|
| a. | Line or high voltage conduit | - | Orange |
| b. | Control conduit (24 Volts or less) | - | Brown |
| c. | Switchboards and control panels | - | Hammer Finish Grey |

Miscellaneous

- | | | | |
|----|----------------|---|---------------------------------|
| a. | Water tanks | - | White unless otherwise required |
| b. | Pumps & Motors | - | Pale Blue |

Directional Arrows

All directional arrows shall be in black and painted on visible sides of all piping except drain pipes, at 6' centres.

The size of arrows shall be 3" long on pipes up to 2" diameter and 6" long on pipes 2½" diameter and over.

PLUMBING (Contd.)

Painting (Contd.)

Testing, Balancing and Commissioning

General

This section of the specification details the requirements for testing, balancing, and commissioning of the systems during and after the completion of the installation.

Only experienced licensed plumber shall be employed to carry out all the tests and adjustments and to attend all the inspections by the relevant authorities. The SO shall be notified 48 hours before the testing. The SO shall witness and record the entire test procedure, and issue the certification of approval or rejection within 24 hours upon submission.

The pressure gauges to be used for testing procedure shall be calibrated by an independent laboratory or shall be brand new item with factory calibration certification.

All costs incurred in all the tests and demonstrations including any fees, instruments and labour shall be included in the tendered sum.

The minimum facilities provided for the tests shall consist of pressure gauges, flowmeters and tachometers.

Testing – Cold and hot Plumbing works

All water pipe work shall be hydrostatically tested in sections during installation and as a whole system after the completion. Where connections are concealed in walls or partitions, the test shall be made before covering up.

The test pressure shall be:

- Incoming Water Piping system –

Local Water Supply Board
Puas – minimum 80 PSI
SAJ – minimum 60 PSI

- Distribution Piping System – Minimum 60 PSI

Testing Procedure

- 1) Ensure all end pipes are closed.
- 2) Check all the valves along the tested pipeline are fully opened.
- 3) Install one no of pressure gauge at pipe end
- 4) Fill section with clean ambient temperature water. Do not pressurize.
- 5) Soft hammering the pipes especially at joint ensure no air is trapped in the system.
- 6) Allow the system to stand for one hour to allow temperature to stabilize and equilibrium reached.

PLUMBING (Contd.)

Tests (Contd.)

Testing -Soil, Waste and vent Piping

- 7) If there is no leakage detected, remove any remaining air .Start to test the pipe by pressurising the pipe using manual or engine pump depends on pipe size and distance, to the required testing pressure.
- 8) Check the entire pipe for leakages.
- 9) Repeat procedure from 1-8 till no leakages are noted.
- 10) Hold the pressurised water in pipeline for 24 hrs and compare the reading with the first taken. No additional pressurisation is allowed.
- 11) If the water pressure does not drop more than 5% after 24 hrs, the test is accepted.

Sewers shall be tested in accordance with the British Standard Code of Practice CP 2005:1968 (Sewerage). No sewer works shall be covered up until they have been checked and approved by the Consulting Engineer. The test shall be carried out before the pipes are hunched with concrete and repeated after backfilling the trenches. Should the pipes be damaged during or after backfilling the contractor shall at his own expense have the pipes uncovered, repaired or replaced and retested.

Hydrostatic or smoke test shall be applied to soil, waste and vent piping.
Flow test shall be carried out to soil and waste piping by using a ping pong ball flushes from one end to another.

The Consulting Engineer shall be notified 48 hours before the tests are performed.

Test readings shall be recorded and submitted to the Consulting Engineer.

Reliability Test – upon completion

Upon complete installation of all equipment and fittings, the contractor shall carry out trial runs of the entire system with his own men to satisfy himself that the equipment and fittings area ready and fit for commission. He shall then notify the S.O. in writing of the date on which the testing will commence.

The reliability test shall be carried out by the contractor with his own men under full working conditions and in the presence of the S.O. in order to prove that all equipment and fittings fulfil their working duties satisfactorily and efficiently, and that all systems complies with their specified duties as regards to water tightness, free of blocking, capacity, head, efficiency and etc. The reliability test shall include checking of all water outlets and flushing of all sanitary water closets.

The reliability test shall be considered as having been satisfactorily concluded if all equipment fulfils its specified duties under full working conditions.

Two copies of all measurements, test data, including plotted curves, and original chart records shall be presented to the S.O.

PLUMBING (Contd.)

Tests (Contd.)

Testing -Soil, Waste and vent Piping

All costs incurred in all these tests and demonstrations including water, fees, instruments, labour and etc shall be included in the tendered sum.

Cleaning Out Of System

The water supply system shall be cleaned and flushed out using water. Valves and any equipment liable to be damaged shall be disconnected prior to cleaning out. Strainers shall be cleaned upon completion of the cleaning out operation.

After cleaning out, the water tanks shall be filled with water and a sterilising chemical such as calcium chloride added to achieve a chlorine concentration of 50 ppm. Each outlet shall then be opened progressively away from the tank and closed when the water discharging from the outlet smells of chlorine. On completion of the procedure the whole system be allowed to stand for at least 12 hours before it is drained completely and refilled for use.

3.18 SANITARY INSTALLATION

SANITARY FITTINGS

Sanitary Fittings And Accessories

Supply and fix the Sanitary Fittings all in accordance with approved practice and manufacturer's recommendations and instruction.

For the introduction of new brand of sanitary vitreous China Water Closet Pans the manufacturer must obtain Sirim's Approved Certification which to be tested in accordance to MS 1522: 2001 or any latest revision..

In additional to the above, the following flushing tests are to be carried out by supplier and witnessed by client and consultant to ensure sufficient flushing and cleaning capacity.

- 1) Newspaper test: when testing in accordance with Appendix A of MS1522, a pan shall discharge from the outlet spigot of pan all the paper in 4 out of 5 tests.
- 2) Simulating Solid Test: when testing in accordance with Appendix B of MS1522, a pan shall discharge from the outlet spigot of pan all the test pieces in 8 out of 10 tests.
- 3) Sawdust Test: when testing in accordance with Appendix C of MS1522, no sawdust shall remain in pan .
- 4) Ball test: when testing in accordance with Appendix D of MS1522, a pan shall flush from the outlet spigot of pan the ball in 4 out of 5 tests. Pin pon ball and golf ball are to be used separately in order to ensure compliance.
- 5) Toilet paper test: when testing in accordance with Appendix A of MS1522, a pan shall discharge from the outlet spigot of pan all the toilet paper in 4 out of 5 tests.

Please refer to the MS 1522:2001 for detail testing procedure.

Protection of Sanitary Fittings

The Contractor shall take every precaution the various sanitary fittings once they have been installed and shall wrap every fitting with building paper or other method to ensure that they are not used during the process of the work. Just prior to completion of the works, the Contractor shall remove such protective wrapping and clean all surfaces for handling over.

Rates

Rates for each item of sanitary fitting shall be held to include for all fixings, connections to water supply, soil, anti-siphon, etc. as required.

3.19 - DRAINAGE WORKS

GENERAL

This work shall consist of the construction of surface drains, subsoil drains, pipe culverts, box culverts, sumps and other drainage structures in accordance with this Specification or as directed by the S.O. Drainage works shall be constructed to the lines, levels, grades and cross-sections shown on the Drawings or as directed by the S.O.

EXCAVATION AND BACKFILLING FOR DRAINAGE WORKS

Description

This work shall consist of excavation for the construction of surface drains, subsoil drains, cast in situ box culverts, and other drainage structures, except pipe culverts, not otherwise provided for in this Specification, and shall include furnishing, placing, compacting and shaping foundation bedding materials, backfilling excavations against completed structures with suitable material or granular backfill where specified, and the removal and disposal of all excess excavated material, in accordance with this Specification and as shown on the Drawings and as required by the S.O.

Excavation and backfill for pipe culverts and precast box culverts shall be in accordance with the provisions of Section 3.19 (R.C Pipe Culvert).

Materials

Excavation

Material excavated shall be classified as common excavation or rock as defined in Section 3.2 of this Specification.

Granular Bedding Material

Granular bedding material for the foundations of structures shall be suitably graded broken rubble, crushed stone, crushed gravel, sand or other material as specified on the Drawings or as required by the S.O.

Concrete Bedding

Concrete bedding or blinding for the foundations of structures shall conform to the requirements of Section 3.3 of this Specification for the class of concrete specified on the Drawings or required by the S.O.

Ordinary Backfill Material

Ordinary backfill material shall be suitable material as defined in Section 3.2 of this Specification. The maximum particle size of the backfill material shall be 50mm.

Granular Backfill Material

Granular backfill material shall be sand, crushed stone, crushed gravel or a mixture of crushed and natural aggregates, shall be essentially free from vegetative and other organic matter and clay, and shall not contain lateritic or concretionary materials.

The material shall conform to the following physical and mechanical quality requirements :

- i) the fines shall be non-plastic;
- ii) sand shall have a gradation conforming to the envelope shown in Table 3.1;

TABLE 3.1 - GRADING LIMITS FOR SAND BACKFILL

B.S. Sieve Size	% Passing By Weight
10.0 mm	100
5.0 mm	90 - 100
1.18 mm	45 - 80
300 um	10 - 30
150 um	2 - 10

- iii) material other than sand shall have a gradation conforming to one of the envelopes shown in Table 3.2.

TABLE 3.2 - GRADING LIMITS FOR GRANULAR BACKFILL OTHER THAN SAND

B.S. Sieve Size	% Passing By Weight		
	A	B	C
37.5 mm	100	-	-
28.0 mm	70 - 100	100	-
20.0 mm	60 - 90	70 - 100	100
10.0 mm	45 - 75	45 - 75	-
5.0 mm	30 - 60	35 - 65	45 - 75
2.0 mm	20 - 50	25 - 50	30 - 60
425 um	10 - 30	10 - 30	15 - 35
75 um	0 - 2	0 - 2	0 - 2

Concrete Backfill

Concrete backfill where specified shall be of the grade as shown on the Drawings and shall conform to Section 3.3 of this Specification.

Excavation

The Contractor shall notify the S.O. sufficiently in advance of the beginning of any excavation so that cross-section elevations and measurements may be taken of the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the S.O.

Trenches and foundation pits for structures and structure footings and underdrains shall be excavated to the lines, grades and elevations shown on the Drawings or as directed by the S.O. Excavations must be kept free from water and temporary drains, sumps and pumps shall be provided when necessary. The rate of excavation and backfill shall be approved by the S.O. The elevations of the bottoms of footings shown on the Drawings are approximate only and the S.O. may order in writing such changes in the dimensions or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

Boulders, logs and other objectionable materials encountered in excavation shall be removed.

After each excavation is completed the Contractor shall notify the S.O. to that effect and no footing, bedding material or structure shall be placed until the S.O. has approved the depth of excavation and the character of the foundation material.

Rock and other hard foundation material shall be cleared of all loose material and cut to a firm surface, either level or stepped or serrated, as specified or shown on the Drawings or directed by the S.O. All seams and crevices shall be cleared out and grouted with Portland cement grout at the time the footing is placed.

All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall be deferred until just before the footing is to be placed. When, in the opinion of the S.O., the foundation material is soft or mucky or otherwise unsuitable, the Contractor shall remove the unsuitable material and insert foundation fill material or concrete as specified or shown on the Drawings or directed by the S.O. If foundation fill material is required it shall be placed and compacted in layers not more than 150 mm thick or as directed by the S.O. The degree of compaction shall be equivalent to that of the surrounding foundations.

All excavation surfaces and surfaces of backfill material against which concrete is to be placed shall be even and firm and true to line and level.

All excavated material, so far as suitable, shall be utilized as backfill or embankment. The surplus material, whether or not temporarily allowed to be placed within a stream area, shall be finally disposed of in such a manner as not to obstruct the stream nor otherwise impair the efficiency or appearance of the works, nor is it to endanger the partly finished structure.

Excavated material suitable for use as backfill may be deposited by the Contractor in storage piles at points convenient for rehandling of the material during the backfilling operation.

Excavated material shall be deposited in such places and in such a manner as not to cause damage to highway, services or property either within or outside the road reserve, and so as to cause no impediment to the drainage of the Site or surrounding area.

Backfilling with Ordinary
Or Granular Backfill Material

All spaces excavated under this Specification and not occupied by a permanent structure shall be backfilled. Backfill material shall be free from large lumps, wood and other extraneous material.

Backfill not within the embankment areas shall be placed in layers not more than 250 mm in depth (compacted measurement) and shall be compacted to a density comparable with the adjacent undisturbed material.

Backfill within the embankment areas shall be made with approved material placed in uniform layers not to exceed 150 mm in depth (compacted measurement) and each layer shall be constructed in accordance with Section 3.2 of this Specification except that mechanical tampers may be used for compaction. Each layer of backfill shall be wetted uniformly as necessary and compacted to the same requirements as the adjacent earthwork as specified in Section 3.2 of this Specification. Unless otherwise approved by the S.O., hand tamping will not be accepted.

In placing backfill and embankment, the material shall be placed insofar as possible to approximately the same height on both sides of the structure. If conditions require backfilling appreciably higher on one side, the additional material on the higher side shall not be placed until permission is given by the S.O. or until the S.O. is satisfied that the structure has enough strength to withstand any pressure created.

Backfill for embankment shall not be placed behind the walls of box culverts until the top slab is placed for the required time and not less than three days. Backfill and embankment behind abutments held at the top by superstructure shall be carried up simultaneously behind opposite abutments and side walls.

No backfilling shall be placed against any structure until permission have been given by the S.O. Jetting of fill or other hydraulic methods involving, or likely to involve, liquid or semi-liquid pressure shall be prohibited.

Special care shall be taken to prevent any unduly high pressures against the structures.

The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be a horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled.

CHANNEL EXCAVATION

Description

This work shall consist of excavation for waterway channels both inside and outside the road reserve as shown on the Drawings or directed by the S.O., and shall include all required excavation for widening, training or permanently diverting rivers, streams and irrigation and drainage channels other than drains and ditches appurtenant to the roadway, except excavation of topsoil for use in the Works and excavation required for clearing and grubbing. This work shall also include the backfilling of old channels, haulage to their points of utilization in the Works or the removal and disposal of all excavated materials, the construction of appurtenant bunds, dikes and berms, and the shaping and finishing of all earthworks involved in the construction of channels in accordance with the required lines, levels, grades and cross-sections.

Materials

Channel excavation shall be classified as common excavation or rock as specified in Section 3.2 of this Specification.

Construction Methods

All suitable materials removed from channel excavations shall be used for backfilling waterways to be abandoned and constructing bunds, dikes and other earth appurtenances as required. Surplus suitable materials shall be used as far as is practicable in constructing the roadway. The Contractor shall provide borrow of satisfactory quality and approved by the S.O. should this be necessary to complete the work. Borrow which is required to replace suitable excavated materials needed for construction which the Contractor elects to waste shall not be paid for.

Excavated unsuitable materials, suitable material surplus to that needed for construction and suitable material that the Contractor elects to waste, shall be disposed of at designated areas in such a manner as to present a neat appearance and not obstruct flow in any channels, ditches or drains, nor cause damage to highway works or property, all to the satisfaction of the S.O.

During construction, channel excavations shall be kept drained as far as is practicable and the work shall be carried out in a neat and workmanlike manner.

All channels and appurtenances shall be excavated and constructed to the lines, levels, grades and cross-sections shown on the Drawings or as directed by the S.O. Excavation beyond the limits required shall not be paid for and shall be backfilled at the Contractor's expense as directed by the S.O. should he deem it necessary.

Sections of channel abandoned owing to diversions shall be backfilled as directed by the S.O.

SURFACE DRAINAGE

Surface Drainage Types

Surface drains of the types shown on the Drawings shall be constructed to the lines, levels, grades and cross-sections as specified or as directed by the S.O. Surface drains shall include interceptor drains, roadside drains, embankment toe drains, shoulder drains, bench drains, berm drains, median drains, outfall drains, cascade drains, etc.

Any of the above drains may be constructed either unlined or lined using cast in situ concrete, precast or porous concrete drain sections, or stone pitching.

Surface Drain Construction

Unlined Drains

Excavation for unlined drains shall be trimmed to form a smooth, firm surface to the required lines, levels, grades and cross-sections as shown on the Drawings or as required by the S.O.

Any areas of over excavation shall be made good to the satisfaction of the S.O., all at the Contractor's expense.

Cast In Situ Concrete Drains

Excavation shall be carried out to the lines and levels as specified and as shown on the Drawings. Templates which may be of timber or steel shall then be provided to ensure the thickness and shape of the concrete drains. The concrete shall be poured in sections not exceeding 2 m in length and shall be carried out between end forms in alternate bays. Construction joints shall not be formed in the inverts.

All concrete shall be grade 20/20 concrete unless otherwise specified and shall conform to the requirements of Section 3.2 of this Specification. Weep holes shall be cast in situ as shown on the Drawings or as directed by the S.O.

Precast Concrete Drain Sections

Precast concrete block inverts shall be of the shapes and dimensions as shown on the Drawings and shall be of grade 20/20 concrete conforming to the requirements of Section 3.2 of this Specification or of porous concrete unless otherwise specified. The precast concrete drain sections shall be manufactured using good quality moulds and the finished product shall be round and have smooth inside surfaces all to the approval of the S.O. Ready made precast concrete drain sections may be used subject to the approval of the S.O. Samples of ready made drain sections shall be submitted to the S.O. for his approval before placing of orders. Notwithstanding any approval given by the S.O., any defective or broken drain section shall be replaced by the Contractor at his own expense before or after laying in position.

Precast concrete drain sections shall be laid on concrete bedding in trenches excavated to the lines and levels as specified and jointed to produce a neat even alignment and gradient. The joint shall be grouted with 1:3 cement mortar complying with this section and weep holes shall be provided as shown on the Drawings or as directed by the S.O.

Porous concrete shall comply with the requirements of porous concrete for pipes as described in M.S. 525. Cement and aggregates used in the manufacture of the porous concrete drain sections shall conform to the requirements of Section 3.2 of this Specification.

Mass concrete for bases shall be of grade 10/25 concrete or as specified and to the dimensions and thicknesses as shown on the Drawings.

STONE PITCHING

Description

The work shall consist of the construction of all structures or parts of structures to be composed of stone pitching either grouted or ungrouted as shown on the Drawings or as directed by the S.O. including erosion protection pavements and aprons, drain linings, culvert inlets and outlets, etc. The work shall be carried out all in accordance with this Specification and to the lines, levels, grades, dimensions and cross-sections shown on the Drawings and as required by the S.O.

Materials

Stone

Stone shall be clean rough quarry stone, or pit or river cobbles, or a mixture of any of these materials, and shall be essentially free from dust, clay, vegetative matter and other deleterious materials. Individual pieces of stone shall be approximately cubical or spherical and shall have least dimensions in the range 100 to 150 mm and a maximum dimension of 250 mm, maximum, unless otherwise specified. The stone shall be hard, tough, durable and dense, resistant to the action of air and water, and suitable in all respects for the purpose intended.

Cement Mortar

Cement mortar, unless otherwise specified, shall contain 1 part ordinary Portland cement to 3 parts fine aggregate by volume. Water shall be added to the mix to produce a suitable consistency for the intended use, all to the satisfaction of the S.O. The constituent materials of the mortar shall comply with the appropriate requirements of Section 3.3 of this Specification.

The ingredients for mortar shall be measured in proper gauge boxes and mixed on a clean boarded platform or in an approved mechanical batch mixer.

All mortar shall be used within 30 minutes of mixing and no reworking of mortar shall be permitted thereafter.

Construction Methods

Grouted Stone Pitching

Prior to constructing grouted stone pitching, the surfaces against which it is to be placed shall have been finished in accordance with the appropriate provisions of this Specification. Notwithstanding any earlier approval of these finished surfaces, any damage to or deterioration of them shall be made good to the satisfaction of the S.O. before grouted stone pitching is placed.

Construction of grouted stone pitching shall commence at the lowest part of each structure or section of a structure and continue progressively upward. Long structures such as drain linings and slope protection pavements shall be constructed in sections of practicable length, to the satisfaction of the S.O. The surface against which the work is to be placed shall be moistened with clean water a little in advance of construction, and covered with a layer of

cement mortar about 50 mm thick, Stones shall then be firmly set by hand into the mortar, densely packed against adjacent stones and built up to form a stone structure of more or less uniform thickness which shall nowhere be less than 150 mm (measured perpendicularly to the surface covered). All the while that stones are being placed, all voids in the structure shall be packed solidly with mortar and stone spalls; however the surfaces of stones in the exposed faces and edges shall not be covered with mortar. The exposed surfaces and edges of the structure shall be constructed such that they have as large a proportion as practicable composed of stone faces. Weep holes shall be provided as shown on the Drawings or as directed by the S.O.

Mortar which has been mixed for more than 30 minutes shall not be used in the works. Nor shall mortar be laid against the supporting surface more than 2 minutes before pitching stone and building up the structure to full thickness is commenced on any section of the work, as the construction advances.

The work shall be carried out and finished all to the satisfaction of the S.O.

UngROUTED Stone Pitching

Where shown on the Drawings, ungrouted stone pitching shall be hand set to provide maximum interlocking effect. The stones, the largest of which shall be used at the bottom, shall be well bedded on a 75 mm layer of gravel or aggregate rammed to an even surface. The whole work shall be finished to the satisfaction of the S.O.

GABIONSDescription

This work shall consist of the construction of miscellaneous erosion protection and retaining structures to be composed of stone filled wire mesh gabions. The work shall be carried out all in accordance with this Specification and as shown on the Drawings and/or as approved by the S.O.

MaterialsWire Mesh Gabions

Gabions shall be rectangular baskets of the required dimensions as shown on the Drawings or ordered by the S.O. Unless otherwise specified, they shall be of the following standard dimensions :-

- i) width - 1.00 metre;
- ii) length - 1.00, 2.00 or 3.00 metres;
- iii) height - 0.50 or 1.00 metre.

Gabions longer than 1.00 m shall be divided into compartments of equal length not exceeding 1.00 m by wire mesh diaphragms securely tied along all edges. Each gabion or compartment of a gabion shall be provided with at least 4 cross-connecting wires if its height is 0.50 m or less, and with at least 8 cross-connecting wires if its height is in the range 0.50 to 1.00 metre.

Gabions shall be fabricated from steel wire manufactured in accordance with B.S. 1052 and galvanised in accordance with M.S. 407, or such similar standards as the S.O. shall approve. The galvanised wire sizes used shall be in accordance with Table 3.3.

TABLE 3.3 - GALVANISED WIRE SIZES FOR GABIONS

Type of Wire	Minimum Diameter
Selvage (perimeter) wire	3.50 mm
Mesh wire	2.70 mm
Tying and connecting wire	2.20 mm

Gabion mesh shall be triple twisted and shall have a uniform hexagonal pattern with openings of 100 x 120 mm or less. The mesh shall be securely tied to selvage wires to form rectangular panels which shall be securely wired together to form the completed gabion baskets. The ties and connections for each gabion basket shall comprise not less than 8% of its total weight, and the fabrication shall be all to the satisfaction of the S.O.

Polyvinyl Chloride Coating

When specified on the Drawings, all wire used in the fabrication of gabions and in the wiring operation during construction shall, after galvanising, have extruded on to it a coating of polyvinyl chloride (PVC). The PVC coating, not inclusive of galvanising, shall nowhere be less than 0.55 mm in thickness.

Stone

Stone fill for gabions shall be clean rough quarry stone, or pit or river cobbles, or a mixture of any of these materials, and shall be essentially free from dust, clay, vegetative matter and other deleterious materials. Individual pieces of stone shall have least dimensions not less than 20 mm larger than the gabion mesh openings and greatest dimensions not more than 250 mm. The stone shall be hard, tough, durable and dense, resistant to the action of air and water, and suitable in all aspects for the purpose intended. The material shall be approved by the S.O.

Construction Methods

Prior to placing gabions, the surface on and against which they are to be constructed shall have been prepared and finished in accordance with the relevant provisions of the appropriate Sections of this Specification. Notwithstanding any earlier approval of these finished surfaces, any damage to or deterioration of them shall be made good to the satisfaction of the S.O. before gabions are placed.

Each gabion basket shall be put in place in its turn, completely fabricated except for the fastening down of the lid, stretched to the correct shape and dimensions, and fastened securely to all contiguous baskets along each edge with tying wire. The basket shall then be tightly packed with approved stone by hand in such a manner that voids are kept to a practicable minimum and are uniformly distributed in the stone mass. Finally, the lid of the basket shall be securely fastened down with tying wire along all hitherto unfastened edges, all to the satisfaction of the S.O. In no case shall the weight of the finished gabion be less than 1300 kg per cubic metre.

As a gabion structure is built up, backfilling against finished gabions shall be carried out as necessary for proper progressive construction, all in accordance with the relevant provisions of the appropriate Sections of this Specification. Unless otherwise specified, vertical joints between gabions shall be staggered in gabion structures in a pattern similar to the joints in running bond brickwork.

BRICKWORK

Description

This work shall include the laying of brickwork to the lines, levels and grades shown on the Drawings and/or as directed by the S.O.

Materials

Common Bricks

Bricks shall be machine-made wire-cut clay bricks obtained from manufacturers approved by the S.O. Samples of all bricks intended for use in the Works shall be submitted to the S.O. for his approval.

Cement Mortar

Cement mortar for brickwork shall comply with the requirements of this Section.

Construction Methods

Brick Laying

Brickwork shall be executed with cement mortar and shall be of the thickness and bonds as shown on the Drawings. Bricks shall be kept damp until used and shall be laid on a full bed of mortar. The brickwork shall be true to line and plumb, and courses shall be kept truly level. The thickness of mortar joints shall not exceed 10 mm and shall be such that 4 courses of brickwork forms a height of 300 mm. Newly laid brickwork shall be protected from the harmful effects of sunshine, rain, running and surface water and shocks. Any brickwork that is damaged shall be taken down and rebuilt and the joints raked out and pointed as directed by the S.O. Any such remedial work shall be at the Contractor's own expense.

Plastering Brickwork

All exposed brickwork surfaces shall be plastered. The plaster shall be applied in 2 coats generally to a total thickness of 20 mm and shall be finished with a steel trowel for internal surfaces and with a wooden float for external surfaces.

Plain plaster shall consist of 1 part masonry cement complying with M.S. 794 to 3 parts of sand by volume. Where ordinary Portland cement is used, plasticiser of a type approved by the S.O. may be added to the mix in accordance with the manufacturer's instructions.

Ordinary Portland cement and water shall comply with the appropriate requirements of Section 3.3 of this Specification.

Weep holes shall be provided as shown on the Drawings or as directed by the S.O.

SUBSOIL DRAINS

Description

This work shall include the supply and installation of subsoil drains constructed in accordance with this Specification at the locations and in accordance with the lines, levels and grades as shown on the Drawings and/or as directed by the S.O.

Materials

Pipes

Porous concrete pipes for subsoil drains shall comply with M.S. 525.

Clay pipes for subsoil drains shall comply with B.S. 1196.

Polyvinyl Chloride (PVC) pipes for subsoil drains shall comply with Australian Standard Specification 2439 or B.S. 3656.

Filter Material

Unless otherwise indicated on the Drawings the filter material for subsoil drains shall consist of hard, clean, crushed rock or gravel conforming to the grading limits given in Table 3.4.

The aggregate crushing value of the material shall not exceed 30 per cent.

TABLE 3.4 - GRADING LIMITS FOR FILTER MATERIAL

B.S. Sieve Size	% Passing By Weight
63 mm	100
37.5 mm	85 - 100
20 mm	0 - 20
10 mm	0 - 5

Filter Cloth

Where indicated on the Drawings trenches for subsoil drains shall be lined with geotextile fabric Type D.

Type D fabrics shall be thermally bonded, non woven geotextile and shall be used in subsoil drain, weephole and other related drainage works.

The fabrics shall have the following properties :-

Requirements	Units	Type D
Minimum apparent opening	Microns	100
Maximum apparent opening	Microns	300
Minimum permeability under 100 m head	Litre/m ² /sec	50
Minimum trapezoidal tear strength (N) (ASTM D1117)	Newton	200
Minimum CBR puncture resistance (DIN 54307)	Newton	800
Minimum unit weight	Gram/m ²	100

Cement Mortar

1:3 cement mortar for use in pipe joints shall comply with this Section.

Construction Methods

Excavation for subsoil drains shall be carried out all in accordance with the appropriate provisions of Section 3.19 (Excavation and Backfilling For Drainage Works).

Filter material as described above shall be placed and uniformly compacted by a suitable method approved by the S.O. to form a firm, even bedding for the pipe drain as shown on the Drawings.

The pipe sections shall be set firmly against the filter material bedding with the flow lines in the design position. For pipes with mating joints, the receiving ends shall be upgrade, and the pipe joints shall be fully mated. For butt jointed pipes with collars, the pipe sections shall be fully contiguous, and the collars properly centred over the joints.

Joints shall be spot mortared as necessary to hold the pipe sections correctly centred and aligned, but not so as to unduly restrict the infiltration of water through the joints.

Slotted or perforated pipes shall be tightly wrapped in filter cloth such that the entire length of the mortared pipe is covered by at least 2 layers of cloth. All joints in both layers shall have an overlap of at least 100 mm and joints in the outer layer shall be offset by at least 300 mm from joints in the inner layer, all to the satisfaction of the S.O.

After pipe laying and, if appropriate, wrapping has been approved by the S.O., the remainder of the filter material shall be placed and uniformly compacted by a suitable method approved by the S.O. to form a dense, even surround to the pipe as shown on the Drawings. Care shall be taken that the pipe is neither damaged nor displaced.

Backfill shall then be placed and compacted in accordance with the appropriate provisions of Section 3.19 (Backfilling with Ordinary or Backfilling Material).

Filter material shall be deposited in layers each not exceeding 225 mm loose depth and lightly compacted.

R.C. PIPE CULVERTS

Description

This work shall comprise the supply and installation of reinforced concrete pipe culverts, inclusive of excavation, backfilling, jointing, bedding, construction of headwalls, wingwalls, aprons and sumps and channel protection works, all in accordance with this Specification and the details shown on the Drawings.

Materials

Pipes

Reinforced concrete pipes shall conform to the requirements of M.S. 881 and shall be supplied by manufacturers approved by the S.O.

Rebated pipes of diameter 600 mm and above shall be internally rebated.

Collars shall be precast with grade 25 concrete and shall be suitably reinforced all in accordance with Section 3.3 of this Specification. The width of the collar shall be not less than 150 mm and the minimum thickness shall be 50 mm.

Rubber rings for spigot and socket pipes shall comply with the requirements of Type 2 as specified in B.S. 2494.

Cement Mortar

1:3 cement mortar for jointing of reinforced concrete pipes shall conform to the requirements of this Section.

Bedding Material

Type A bedding shall consist of grade 20/20 concrete complying with Section 3.3 of this Specification.

Type B bedding shall consist of crushed granular material having a compaction fraction value of 0.2 or less. The testing of pipe bedding material shall be carried out as follows :-

- a. The following apparatus shall be used :-
 - i) Open ended cylinder 250 mm long and 145 mm to 160 mm internal diameter.
 - ii) Metal rammer with a striking face 40 mm diameter and of total mass 1 kg.

- b. Method

A representative sample of the material shall be prepared with moisture content equal to that of the material at the time it is to be used. The cylinder shall be placed on a firm flat surface and filled with the material by pouring from a minimum height. No additional compaction shall be given to the material in the cylinder. The material shall be struck off level with the top of the cylinder and the surplus material removed. The cylinder shall then be lifted clear of its contents and placed on a fresh area of flat surface.

The material shall be quartered and each quarter successively replaced in the cylinder and vigorously tamped with the rammer until no further compaction is observed.

The distance of the level of the material below the top of the cylinder shall be measured and divided by the cylinder height to obtain the compaction fraction value.

Type B bedding also shall conform to the following grading limits :-

BS Sieve Size (mm)	% Passing By Weight
37.5	100
20	95-100
10	0-100

The soluble sulphate content shall not exceed 2g of sulphate (as SO₃) per litre when tested in accordance with Test No. 10 of BS1377.

Excavation and Backfilling for R.C. Pipe Culverts

Excavation

(a) *General*

Unless otherwise directed by the S.O., prior to construction of a pipe culvert, the earthworks at the required location shall have been constructed to a level at least 600 mm above the top of culvert design levels or to the top of subgrade levels, whichever is lower.

Pipe culverts specified to be constructed in trench conditions shall be excavated in accordance with trench method as below.

Where drainage conditions or other circumstances so require, the S.O. may direct the Contractor to construct the pipe culvert without first constructing the earthworks to the level specified above, in which case excavation and foundation preparation shall be in accordance with open ground method as below.

(b) *Trench Method*

The trench to receive a culvert pipe shall be of sufficient width and depth to enable the placing of bedding material and construction of pipe joints in accordance with this Specification, and the bottom of the trench shall be trimmed to a suitably smooth plane surface which shall be kept free from water, all to the satisfaction of the S.O. Where rock or other hard unyielding foundation material is encountered in the trench, it shall be excavated to a depth below the bottom of pipe design levels of at least 300 mm or 12.5 mm per 300 mm of fill to be placed over the top of the pipe, whichever is greater, up to a maximum of 75% of the internal diameter of the pipe. The hard material so excavated shall be replaced with suitable material uniformly compacted in layers of not more than 150 mm compacted thickness to provide satisfactory support for the pipe, all to the satisfaction of the S.O.

(c) *Open Ground Method*

Where existing ground levels are above top of bedding material design levels and firm foundation materials are encountered, excavation and foundation preparation shall be similar to that described in the trench method above. Otherwise a firm foundation plane shall be prepared, which shall be essentially free draining along the line of the culvert, by trimming the existing ground, or such fill as it is necessary to place and compact, over a width sufficient to permit satisfactory construction of the pipe bedding, all to the satisfaction of the S.O. Hard materials shall be excavated from the pipe foundation over a width equal to the outside diameter of the pipe to the same depth as specified in the trench method, and shall be replaced with suitable material uniformly compacted in layers of not more than 150 mm compacted thickness to provide satisfactory support for the pipe, all to the satisfaction of the S.O.

Where soft or unstable soil is encountered in the foundation, it shall be excavated over a width of at least 1.5 times the outside diameter of the pipe on each side of the culvert centre-line to the depth directed by the S.O., and replaced with suitable material uniformly compacted in layers of not more than 150 mm compacted thickness to provide satisfactory support for the pipe, all to the satisfaction of the S.O.

Backfilling

Backfilling against reinforced concrete pipe culverts and their appurtenant structures shall be carried out in accordance with the construction methods described in Section 3.19 (Backfilling with Ordinary or Granular Backfilling Material), using material conforming to the requirements of Section 3.19 (Granular Backfilling Material). Special care shall be taken to properly compact backfill against the undersides of culvert pipes without disturbing or damaging the pipes and joints. Backfill shall be built up evenly on both sides of each pipe culvert along its entire length.

Heavy plant and equipment shall not operate within 1.5 m of any pipe culvert until backfilling and, where appropriate, pavement construction has advanced to a stage which provides at least 600 mm of cover to the culvert. Subject to the approval of the S.O., light compaction equipment may be operated above pipe culverts after a minimum of 300 mm of cover has been placed and compacted.

Installation of R.C. Pipe Culverts

General

The type, size and class of pipe to be installed at each location shall be as shown on the Drawings or as directed by the S.O. Culverts shall not be installed at any location until the type of pipe, the exact location, the lines, levels and grades, the length of pipe and details of inlet and outlet structures have been confirmed by the S.O. In addition, special requirements recommended by the manufacturer with respect to assembly and installation shall be complied with. Especially where elliptically reinforced pipe sections are used, care shall be taken to ensure that the loading axes are positioned exactly vertically.

Butt Ended Pipe Culverts with Precast Concrete Collars

The pipes shall be laid on Type A bedding in conformity with the dimensions shown on the Drawings. Before placing any concrete bedding, the pipes shall be assembled complete with precast concrete collars to the correct levels and grades on precast concrete spacing blocks of the same class of concrete as the bedding material and of sufficient size to eliminate any risk of settlement of the pipes before or during concreting.

All joints shall be fully mortared with 1:3 cement mortar before concreting of the cradle, all to the satisfaction of the S.O. The concrete cradle shall be cast as one monolithic unit. Alternatively, part of the concrete cradle below the underside of the pipe may be constructed monolithically at least 24 hours before the assembly and mortaring up of the pipe sections and collars, on condition that shear connectors are provided across horizontal construction joints to the satisfaction of the S.O.

During installation, the ends of the pipes shall be butted and the collar centred about the joint using wedges or other approved means. The annular shall be completely filled with 1:3 cement mortar with only sufficient water added to ensure adequate workability and the wedges removed before finally fairing the joint. Special care shall be taken to ensure that excess cement mortar is neatly cleaned off. For pipes over 900 mm in diameter the jointing space shall be filled from inside the pipe after completion of embankment construction using 1:3 cement mortar. Then installed, the clearance between the outer diameter of pipe and the inner diameter of collar shall be at least 20 mm.

Following pipe assembly and mortaring up as above, the remainder of the cradle shall be cast monolithically, all to the satisfaction of the S.O.

Where vertical construction joints in the concrete cradle are unavoidable due to circumstances on Site, transfer bars shall be provided to the satisfaction of the S.O.

Special care shall be taken when placing the concrete cradle to avoid the entrapment of air underneath the pipe. To eliminate this possibility, concrete shall be placed to one side of the pipe only until such time as the level of the concrete surface rises above the underside of the pipe on the side remote from that on which concrete is being placed. The concrete shall then be brought up at the same level on both sides of the pipe.

Rebated Pipe Culverts

The pipes shall be laid on Type A bedding in conformity with the dimensions shown on the Drawings.

The method of construction shall follow that described in Section 3.19 (Bult Ended Pipe Culvert With Precast Concrete Collar) for butt ended pipe culverts except for the exclusion of precast concrete collars.

The rebated joint shall be internally flush and fully mortared with 1:3 cement mortar, all to the satisfaction of the S.O.

Spigot and Socket Pipe Culverts

The pipes shall be laid on Type B bedding in conformity with the dimensions shown on the Drawings. The bedding material shall be accurately shaped by a template to fit the lower part of the pipe exterior for a height of at least 10% of the outside diameter of the pipe. Gaps shall

be left in the bedding material and recesses dug in the earth foundation of sufficient width and depth to accommodate the socket without it resting on the bottom of the recess. The widths of the recesses in the foundation and the bedding shall both exceed the width of the socket by more than 50 mm.

Jointing of the pipes shall be carried out strictly in accordance with the manufacturer's recommendations, all to the satisfaction of the S.O.

Concrete pipes as specified above shall be laid true to line and level, each pipe being separately boned between sight rails. Pipes shall be laid in an upstream direction with the sockets towards the inlet and shall rest on even foundations for the full length of the barrel. Rubber ring joints shall be installed strictly in accordance with the manufacturer's instructions. Prior to jointing, rubber rings and jointing surfaces shall be cleaned of all contaminants except for specified lubricants. The spigot of each pipe shall be inserted concentrically in the socket of the one previously laid, and the pipe then adjusted and fixed in its correct position with the spigot correctly entered in the socket.

Care shall be taken to see that the rubber ring is adequately compressed to seal the joint. All pipes shall be laid to the satisfaction of the S.O.

CORRUGATED METAL PIPE CULVERTS

Description

This work shall comprise the supply and installation of bolted, corrugated metal pipe culverts inclusive of excavation, backfilling, jointing; bedding, construction of headwalls, wingwalls, aprons and sumps and channel protection works, all in accordance with this Specification and the details shown on the Drawings.

Materials

Pipes

The pipe sections shall be fabricated from zinc-coated (galvanised) steel sheets conforming to AASHTO M218 or from structural plates conforming to AASHTO M167 depending on the pipe size requirements.

The dimensions of the pipes shall conform to AASHTO M36. All pipes shall be clearly identified by marking on each section the following information :-

- i) name of manufacturer;
- ii) diameter of pipe;
- iii) gauge number;
- iv) date of manufacture.

The above markings shall have been marked by the manufacturer.

The Contractor shall submit to the S.O. the material test certificates from the manufacturer showing the chemical composition and mechanical properties of the base metal and the amount of zinc coating for every lot of pipes supplied. The S.O. may order further tests in the sections supplied to Site at the rate of not more than 1 in 100.

All costs on such tests shall be borne by the Contractor.

Bitumen Coating

Where specified, the pipe sections or plates shall be coated with an approved bitumen coating at the factory by the hot-dip process for Type A as specified in AASHTO M190. Before coating, any damage to the galvanising shall be made good in a manner approved by the S.O.

Bolts and Nuts

All bolts and nuts shall be of high strength carbonated steel meeting the provisions of ASTM A449 and ASTM A563 Grade 'C' respectively. The galvanising on bolts and nuts must meet the requirements of ASTM A153.

Diameters of bolt holes in the longitudinal seams, except those at the plate corners, shall not exceed the bolt diameter by more than 3 mm. The bolt holes in the circumferential seams, including those at the plate corners, shall not exceed the bolt diameter by more than 6 mm. The minimum distance from the centre of a hole to the edge of a plate shall be 1.75 times the diameter of the bolt.

For pipe material conforming to AASHTO M218 (corrugation 68 mm pitch x 13 mm depth) with diameters of 1500 mm or smaller, 12 mm diameter bolts shall be used. Bolt holes along circumferential seams shall have spacings of not more than 314 mm.

For pipe material conforming to AASHTO M167 (corrugation 150 mm pitch x 50 mm depth) with diameters of 1500 mm or larger, 19 mm diameter bolts shall be used. Four bolt holes per 300 mm of longitudinal seam shall be provided and these shall be staggered in rows 51 mm apart with holes in one row in the trough and holes in the other row in the crest of the corrugation. Bolt holes in the circumferential seams shall have spacings of not more than 254 mm.

Notwithstanding the above, the Contractor shall satisfy the S.O. as to the adequacy of all bolted connections.

Cement Mortar

1:3 cement mortar shall comply with the requirements of this Section.

Bedding Material

Corrugated metal pipe culverts shall be bedded on Type B bedding as specified in this Section.

Excavation And Backfilling For Corrugated Metal Pipe Culverts

Unless otherwise directed and/or approved by the S.O., the pipe culvert shall be laid in a trench excavated in accordance with trench method as specified in this Section.

Where the open ground method is approved, the work shall comply with open ground method as specified in this Section.

Installation Of Corrugated

Metal Pipe Culverts

General

The culvert sections shall be assembled, strutted, and protected during construction in accordance with the manufacturer's instructions. Special attention shall be given to the sequence of tightening bolts and the specified torque to be applied during assembly. After assembly the bitumen coating shall, where damaged, be repaired and made good with further application of the bitumen coating.

Mortar Lining

For corrugated metal pipe culverts of 1800 mm diameter or more, or where directed by the S.O. for pipes of smaller diameters, a 1:3 cement mortar lining shall cover the inverts of the pipes to a thickness of 25 mm above the crest of the corrugations over a minimum of one third of the circumference centrally placed along the entire length of the culvert. The lining shall be constructed after completion of earthworks and wingwalls.

PRECAST BOX CULVERTS

Description

This work shall comprise the supply and installation of precast box culverts inclusive of excavation, backfilling, jointing, bedding, construction of headwalls, wingwalls, aprons and sumps and channel protection works, all in accordance with this Specification and the details shown on the Drawings.

Materials

Precast Box Culverts

Precast box culverts shall be of approved manufacture complying with Australian Standard Specification 1597 Part I, or any equivalent alternative standard acceptable and approved by the S.O.

Cement Mortar

1:3 cement mortar for jointing of precast box culvert sections shall conform to the requirements of this Section.

Bedding Material

Precast box culverts shall be bedded on Type B bedding as specified in this Section.

Excavation And Backfilling

Excavation For Precast Box Culverts

Unless otherwise directed by the S.O., prior to construction of a precast box culvert, the earthworks at the required location shall have been first constructed to a level at least 600 mm above the top of the culvert design levels or to the top of subgrade levels, whichever is lower, and the precast box culvert shall then be constructed in a trench excavated in accordance with trench method as specified in this Section.

Where drainage conditions or other circumstances so require, the S.O. may direct the

Contractor to construct the precast box culvert without first constructing the earthworks to the level specified above, in which case excavation and foundation preparation shall be in accordance with open ground method as specified in this Section.

Backfilling

Backfilling against precast box culverts and their appurtenant structures shall be carried out in accordance with the construction methods described in Section 3.19 (Backfilling with Ordinary or Granular Backfilling Material) , using material conforming to the requirements of Section 3.19 (Granular Backfilling Material). Special care shall be taken to properly compact backfill without disturbing or damaging the precast box culvert sections. Backfill shall be built up evenly on both sides of each box culvert along its entire length.

Unless otherwise approved by the S.O., heavy plant and equipment shall not operate within 2.0 m of any precast box culvert until backfilling and, where appropriate, pavement construction has advanced to a stage which provides at least 300 mm of cover to the culvert.

Installation Of Precast Box Culverts

The type and size of precast box culvert to be installed at each location shall be as shown on the Drawings or as directed by the S.O. Precast box culverts shall not be installed at any location until the exact location, the lines, levels and grades, the length of culvert and details of inlet and outlet structures have been confirmed by the S.O. In addition, special requirements recommended by the manufacturer shall be complied with.

Precast box culverts shall be laid on Type B bedding as specified in this Section conformity with the dimensions shown on the Drawings. Where specified on the Drawings or directed by the S.O., Type B bedding shall be laid on a layer of crushed aggregate of maximum particle size not exceeding 50mm.

All joints shall be fully mortared with 1:3 cement mortar, all to the satisfaction of the S.O. In addition, a 3 mm layer of 1:3 cement mortar shall be spread on top of the legs of the invert in order to ensure uniform bearing between the invert and lid.

Lifting holes shall be filled with 1:3 cement mortar.

EXTENSION OF CULVERTS

Extension Of Pipe Culverts

The existing wingwalls, aprons and concrete bedding shall be demolished wherever indicated on the Drawings to expose the existing pipe culvert on the side(s) to be extended. The end of the existing pipe culvert to be extended shall then be wire-brushed or some other means employed to give a clean pipe end.

Extension joints shall be formed as shown on the Drawings by injecting Thioflex 600 - Gun Grade (manufactured by Expandite) or its equivalent to a thickness of not less than 25 mm in the 15 mm wide gap between the existing pipe and the new pipe. The remaining space in the gap shall then be filled with Flexcell Expansion Filler or its equivalent.

Bakau piles shall be installed as shown on the Drawings, unless otherwise directed by the S.O.

Extension Of Box Culverts

The existing wingwalls, aprons and concrete bedding shall be demolished wherever indicated on the Drawings to expose the existing box culvert on the side(s) to be extended. The end of the existing box culvert to be extended shall then be wire-brushed or some other means employed to give a clean surface.

Extension joints shall be formed as shown on the Drawings by injecting Thioflex 600- Gun Grade (manufactured by Expandite) or its equivalent to a thickness of not less than 25 mm in the 15 mm wide gap between the existing box culvert and the new box culvert section. The remaining space in the gap shall then be filled with Flexcell Expansion Filler or its equivalent.

Bakau piles shall be installed as shown on the Drawings, unless otherwise directed by the S.O.

HORIZONTAL DRAIN

Pipe

UPVC pipes (of class D minimum) shall be used. The diameter and length of pipe and slot size and spacing shall be as shown in the Drawings.

Installation

Pipes shall be wrapped around with a geotextile filter fabric of Type D and secured before being placed into the predrilled hole. The mouth of the horizontal drains shall be covered with cement mortar plug and a U channel discharge drain shall be provided as shown in the Drawing.

Construction

Drilling Method

Drilling method normally involve a rotary, percussive or rotary percussive mechanism and, occasionally, vibratory driving technique. Core drilling is rarely used for anchorage holes because of the high cost and the belief that the smoothness of the bore reduces the bond capacity. Any drilling machine or procedure may be employed that can supply a stable hole that is of adequate dimensions within the permitted tolerances and free of obstruction or major protrusion in order to accommodate the tendon without applying a mechanical thrust.

Ground Disturbance

The drilling method shall preferably be chosen to give the minimum disturbance to the surrounding ground. In general, care shall be taken not to use high pressure with any flushing media in order to minimise the risk of hydrofracture of the surrounding ground, particularly in built-up area and where anchors are installed at shallow depth. In this connection, a free passage to the surface shall be desirable to prevent the build-up of excessive pressure in the surrounding strata. A free passage or open return also permits the driller to monitor major changes in ground type from the drill cutting or flush.

Hole Stability

Hole stability is critical and special care shall be required to ensure that the drilling or flushing method does not give rise to excessive loss of ground compared with the nominal volume of the drill hole.

Entry Point

Unless other specified, the drill hole entry point shall be positioned within a tolerance of 75mm.

Diameter

The drilled hole shall have a diameter not less than the specified diameter. Allowance for swelling may be necessary if the hole is open for several hours, such as in over consolidated clays or marls.

Straightness

Localized distortions such as sudden change of drill hole section or deviation from the straight (see figure 3.1) shall be avoided in order to facilitate tendon installation and to minimize friction losses during the stressing operation, if any.

Records

During the drilling operation, all changes in ground type shall be recorded together with notes on water levels encountered, drilling rates, flushing losses or gains and stoppages.

Safety

With regard to safety precautions, attention shall be directed to the Code of Safe Drilling Practice (British Drilling Association, 1981) and the manufacturer's recommendations.

3.20 ROADS AND PAVED AREAS

UNBOUND PAVEMENT COURSES

Lower Subbase

Description

This work shall consist of furnishing, placing, compacting and shaping lower subbase material on a prepared and accepted subgrade in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

Lower subbase material shall be inorganic soil, gravel, weathered or fragmented rock, or a mixture of any of these materials, essentially free from vegetative and other organic matter and expansive clay minerals. It shall have a maximum particle size of 75 mm or less, and shall have a CBR value not less than that shown on the Drawings when compacted to 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (4.5 kg rammer method) and soaked for 4 days under a surcharge of 4.5 kg.

Construction Methods

Prior to placing any lower subbase material, the underlying subgrade (particularly the top 300 mm of the subgrade) shall have been shaped and compacted, in accordance with the provisions of Section 3.2 (Subgrade). Notwithstanding any earlier approval of finished subgrade, any damage to or deterioration of the subgrade shall be made good to the satisfaction of the S.O. before lower subbase is constructed.

Lower subbase shall be placed over the full width of the formation to the required thickness as shown on the Drawings or directed by the S.O. in one layer or more, each layer not exceeding 200 mm compacted thickness. Where two or more layers are required they shall be of approximately equal thickness and none shall be less than 100 mm compacted thickness.

Each layer of lower subbase shall be processed as necessary to bring its moisture content to a uniform level throughout the material suitable for compaction, and shall then be compacted using suitable compaction equipment approved by the S.O. to not less than 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (4.5 kg. rammer method). Compaction shall be carried out in a longitudinal direction along the roadbed, and shall generally begin at the outer edge and progress uniformly towards the crown on each side in such a manner that each section receives equal compactive effort, all to the satisfaction of the S.O.

The lower subbase shall be finished in a neat and workmanlike manner, and shall have an average thickness over any 100 metre length not less than the required thickness. The top surface of the lower subbase shall have the required shape, super elevation, levels and grades, and shall be everywhere within the tolerances specified in Section 3.2 (Surface level of Pavement Course)

Subbase

Description

This work shall consist of furnishing, placing, compacting and shaping subbase material on a prepared and accepted subgrade or lower subbase in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

Subbase material shall be a natural or prepared aggregate comprising crushed rock, weathered or fragmented rock, gravel or crushed gravel, sand, or a mixture of any of these materials. It shall have a small proportion of plastic or non-plastic fines and shall be essentially free from vegetative and other organic matter, expansive clay minerals and lumps of clay. The material shall conform to the following physical and mechanical quality requirements :-

- i) the liquid limit shall be not more than 25%;
- ii) the plasticity index shall be not more than 6;
- iii) the aggregate crushing value when tested in accordance with M.S. 30 shall be not more than 35;
- iv) unless otherwise specified on the drawings or directed by the S.O., the material shall have a CBR value of 30 or more when compacted to 95% of the maximum. dry density determined in the B.S. 1377 Compaction Test (4.5 kg rammer method) and soaked for 4 days under a surcharge of 4.5 kg;
- v) the gradation shall conform to one of the envelopes shown in Table 4.1 with the fraction passing the B.S. 75 um sieve not greater than 2/3 of the fraction passing the B.S. 425 um sieve.

TABLE 4.1 - GRADATION LIMITS FOR SUBBASE MATERIAL

B.S. Sieve Size	% Passing By Weight					
	A	B	C	D	E	F
50.0 mm	100	100	-	-	-	-
25.0 mm	-	79 - 95	100	100	100	100
9.5 mm	30 - 65	40 - 75	50 - 85	60 - 100	-	-
4.75 mm	25 - 55	30 - 60	35 - 65	50 - 85	55 - 100	70 - 100
2.00 mm	15 - 40	20 - 45	25 - 50	40 - 70	40 - 100	55 - 100
425 um	8 - 20	15 - 30	15 - 30	25 - 45	20 - 50	30 - 70
75 um	2 - 8	5 - 20	5 - 20	5 - 20	6 - 20	8 - 25

Construction Methods

Prior to placing any subbase material, the underlying subgrade (particularly the top 300 mm of the subgrade) or lower subbase shall have been shaped and compacted in accordance with the provisions of Section 3.2 (Subgrade) or Section 3.20 (Lower Subbase) as appropriate. Notwithstanding any earlier approval of finished subgrade or lower subbase, any damage to or deterioration of the subgrade or lower subbase shall be made good to the satisfaction of the S.O. before subbase is constructed.

Subbase shall be placed with equipment approved by the S.O. over the full width of the formation to the required thickness as shown on the Drawings or directed by the S.O. in one layer or more, each layer not exceeding 200 mm compacted thickness. Where two or more layers are required they shall be of approximately equal thickness and none shall be less than 100 mm compacted thickness.

Each layer of subbase shall be processed as necessary to bring its moisture content to a uniform level throughout the material suitable for compaction, and shall then be compacted using suitable compaction equipment approved by the S.O. to not less than 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (4.5 kg rammer method). Compaction shall be carried out in a longitudinal direction along the carriageway, and shall generally begin at the outer edge and progress uniformly towards the centre on each side except on superelevated curves where rolling shall begin at the lower edge and progress uniformly towards the higher edge. In all cases compaction shall be carried out in such a manner that each section receives equal compactive effort, all to the satisfaction of the S.O.

Throughout the placing, adjustment of moisture content and compaction of subbase material, care shall be taken to maintain a uniform gradation of the material and prevent its separation into coarse and fine parts, all to the satisfaction of the S.O.

The subbase shall be finished in a neat and workmanlike manner; its width shall be everywhere at least that specified or shown on the Drawings on both sides of the centre-line; and its average thickness over any 100 metre length shall be not less than the required thickness. The top surface of the subbase shall have the required shape, superelevation, levels and grades, and shall be everywhere within the tolerances specified in Section 3.2 (Surface Levels of Pavement Course).

Construction plant and its method of deployment used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the subgrade or pavement courses already constructed.

The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

Gravel Surfacing

Description

This work shall consist of furnishing, placing, compacting and shaping gravel surfacing material on a prepared and accepted subgrade or lower subbase in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

Gravel surfacing material shall be a natural or prepared soil-aggregate mixture comprising gravel and sand size particles together with a small proportion of plastic fines, and shall be essentially free from vegetative and other organic matter, expansive clay minerals and lumps of clay. The material shall conform to the following physical and mechanical quality requirements ;-

- i) the liquid limit shall be not more than 35%;
- ii) the plasticity index shall be in the range 4 to 10;
- iii) the aggregate crushing value when tested in accordance with M.S. 30 shall be not more than 35;
- iii) the gradation shall conform to one of the envelopes shown in Table 4.2 with the fraction passing the B.S. 75 um sieve not greater than 2/3 of the fraction passing the B.S. 425 um sieve.

TABLE 4.2. GRADATION LIMITS FOR GRAVEL SURFACING

B.S. Sieve Size	% Passing By Weight			
	A	B	C	D
37.5 mm	100	100	100	100
12.5 mm	45 - 75	55 - 85	60 - 100	-
4.75 mm	30 - 60	35 - 65	50 - 85	55 - 90
2.00 mm	20 - 45	25 - 50	40 - 70	40 - 70
425 um	15 - 30	15 - 30	25 - 45	20 - 50
75 um	8 - 20	8 - 20	8 - 20	8 - 25

Material with a maximum particle size of 37.5 mm, while otherwise not conforming to the gradation specification but satisfying the other requirements, shall be acceptable provided that it shall have a CBR value of 30 or more when compacted to 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (4.5 kg rammer method) and soaked for 4 days under a surcharge of. 4.5 kg.

Construction Methods

Prior to placing any gravel surfacing material, the underlying subgrade (particularly the top 300 mm of the subgrade) or lower subbase shall have been shaped and compacted in accordance with the provisions of Section 3.2 (Subgrade) or Section 3.20 (Lower Subbase) as appropriate. Notwithstanding any earlier approval of finished subgrade or lower subbase, any damage to or deterioration of the subgrade or lower subbase shall be made good to the satisfaction of the S.O. before gravel surfacing is constructed.

Gravel surfacing shall be placed to the required width and thickness as shown on the Drawings or directed by the S.O. in one layer or more, each layer not exceeding 200 mm compacted thickness. Where two or more layers are required they shall be of approximately equal thickness and none shall be less than 100 mm compacted thickness.

Each layer of gravel surfacing shall be processed as necessary to bring its moisture content to a uniform level throughout the material suitable for compaction, and shall then be compacted using suitable compaction equipment approved by the S.O. to not less than 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (4.5 kg rammer method). Compaction shall be carried out in a longitudinal direction along the carriageway, and shall generally begin at the outer edge and progress uniformly towards the centre on each side, except on superelevated curves where rolling shall begin at the lower edge and progress uniformly towards the higher edge. In all cases compaction shall be carried out in such a manner that each section receives equal compactive effort, all to the satisfaction of the S.O.

Throughout the placing, adjustment of moisture content and compaction of gravel surfacing material, care shall be taken to maintain a uniform gradation of the material and prevent its separation into coarse and fine parts, all to the satisfaction of the S.O.

The gravel surfacing shall be finished in a neat and workmanlike manner; its width shall be everywhere at least that specified or shown on the Drawings on both sides of the centre-line; and its average thickness over any 100 metre length shall be not less than the required thickness and its minimum thickness at any point shall be not less than the required thickness minus 20 mm. The top surface of the gravel surfacing shall have the required shape, superelevation, levels and grades, and shall be everywhere within 10 mm of the required plane or such higher, approximately parallel plane, as the S.O. shall approve.

Crushed Aggregate Roadbase

Description

This work shall consist of furnishing, placing, compacting and shaping crushed aggregate roadbase material on a prepared and accepted subgrade or lower subbase or subbase in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

Crushed aggregate roadbase material shall be crushed rock, or crushed gravel, or a mixture of crushed and natural aggregates, which is hard, durable, clean and essentially free from clay and other deleterious materials.

The material shall conform to the following physical and mechanical quality requirements ;

- i) the plasticity index shall be not more than 6;
- ii) the aggregate crushing value when tested in accordance with M.S. 30 shall be not more than 30;
- iii) the flakiness index when tested in accordance with M.S. 30 shall be not more than 30;
- iv) not less than 80% of particles retained on the B.S. 4.75 mm sieve shall have at least one fractured face;
- v) the weighted average loss of weight in the sodium sulphate soundness test (5 cycles) when tested in accordance with AASHTO Test Method T 104 shall be not more than 12%;

- vi) the material shall have a CBR value of not less than 80 when compacted to 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (45 kgrammer method) and soaked for 4 days under a surcharge of 4.5 kg;
- vii) the gradation shall comply with the envelope shown in Table 4.3 for the type specified.

TABLE 4.3 - GRADATION LIMITS FOR CRUSHED AGGREGATE ROAD BASE

B.S. Sieve Size	% Passing By Weight	
	Type I	Type II
50.0 mm	100	100
37.5 mm	95 - 100	85 - 100
28.0 mm	-	70 - 100
20.0 mm	60 - 80	60 - 90
10.0 mm	40 - 60	40 - 65
5.0 mm	25 - 40	30 - 55
2.36 mm	15 - 30	-
2.00 mm	-	20 - 40
600 um	8 - 22	-
425 um	-	10 - 25
75 um	0 - 8	2 - 10

Construction Methods

Prior to placing any crushed aggregate roadbase material, the underlying subgrade or lower subbase or subbase shall have been shaped and compacted in accordance with the provisions of the appropriate Section of this Specification. Notwithstanding any earlier approval of finished subgrade or lower subbase or subbase, any damage to or deterioration of the subgrade or lower subbase or subbase shall be made good to the satisfaction of the S.O. before crushed aggregate roadbase is constructed.

Crushed aggregate roadbase shall be placed to the required width and thickness as shown on the Drawings or directed by the S.O. in one layer or more, each layer not exceeding 200 mm compacted thickness. Where two or more layers are required they shall be of approximately equal thickness and none shall be less than 100 mm compacted thickness. Spreading shall be done by a mechanical spreader approved by the S.O. or, if approved by the S.O., by motor grader.

Prior to spreading, crushed aggregate roadbase shall be processed as necessary to bring its moisture content to a uniform level throughout the material suitable for compaction. Spread material shall be maintained at the correct moisture content for proper compaction by sprinkling with water or drying as may be necessary, and shall be compacted using suitable compaction equipment approved by the S.O. to not less than 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (4.5 kg rammer method).

Compaction shall be carried out in a longitudinal direction along the carriageway, and shall generally begin at the outer edge and progress uniformly towards the centre on each side, except on superelevated curves where rolling shall begin at the lower edge and progress uniformly towards the higher edge. In all cases compaction shall be carried out in such a manner that each section receives equal compactive effort, all to the satisfaction of the S.O.

Throughout the placing, adjustment of moisture content and compaction of crushed aggregate roadbase material, care shall be taken to maintain a uniform gradation of the material and prevent its separation into coarse and fine parts, all to the satisfaction of the S.O.

The crushed aggregate roadbase shall be finished in a neat and workmanlike manner; its width shall be everywhere at least that specified or shown on the Drawings on both sides of the centre-line; and its average thickness over any 100 metre length shall be not less than the required thickness. The top surface of the crushed aggregate roadbase shall have the required shape, superelevation, levels and grades, and shall be within the tolerances specified in Section 3.20 (Surface Levels of Pavement Course).

Construction plant and its method of deployment used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the pavement courses already constructed.

The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious material.

Wet-Mix Macadam

Description

This work shall consist of furnishing, placing, compacting and shaping wet-mix macadam roadbase material on a prepared and accepted lower subbase or subbase in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

The coarse aggregate shall consist of hard, clean, durable crushed rock and the fine aggregate of crushed rock or sand. The aggregate shall be well graded and lie within the grading limits shown below. The particle size shall be determined by Test 7a of BS 1377.

BS Sieve Size	Percentage By Weight
50 mm	100
37.5 mm	95 - 100
20 mm	60 - 80
10 mm	40 - 60
5 mm	25 - 40
2.36 mm	15 - 30
600 um	8 - 22
75 um	0 - 8

The moisture content of the wet-mix macadam shall be the optimum \pm 0.5 per cent as determined in accordance with the Vibrating Hammer Method Test in BS 1377. The Contractor shall ensure that the moisture content is maintained between these limits during laying and compacting.

Construction Methods

Prior to placing any wet-mix macadam material, the underlying lower subbase or subbase shall have been shaped and compacted in accordance with the provisions of the appropriate section of this Specification. Notwithstanding any earlier approval of finished lower subbase or subbase, any damage to or deterioration of the lower subbase or subbase shall be made good to the satisfaction of the S.O. before wet-mix macadam roadbase is constructed.

The material shall be laid using a paving machine and compacted in layers. Any areas of compacted material having a loose surface deficient in fines due to segregation or otherwise shall be made good by being removed and replaced with properly graded material.

Transport vehicles carrying plant-mixed 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 site 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.

All material shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. Except where otherwise specified, the material shall be spread in one layer so that after compaction the total thickness is as specified.

Except where the required number of passes is established from compaction trials as described below, compaction shall be carried out by the methods specified in Table 4.16.

Compaction shall be completed as soon as possible after the material has been spread.

Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse joints.

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. All loose, segregated or otherwise defective areas shall be removed and relaid with new material to the full thickness of layer and re-compacted. The Contractor shall programme the laying of the wet-mix macadam and the subsequent pavement courses and take such other steps as may be considered necessary to afford protection to the roadbase.

Definitions and Requirements associated with Table 4.1.6.

- A. Number of passes is the number of times that each point on the surface of the layer being compacted has been traversed by the compaction plant (or struck, in the case of power rammers).
- B. The number of passes required with each type of compactor is a function of the mass of the machine, and the compaction plants in Table 4.16 are listed in terms of their masses. The mass per metre width of roll is the total mass on the roll divided by the total roll width. Where a smooth-wheeled roller has more than one axle the machine shall be assessed on the basis of the axle giving the highest value of mass per metre width.

- C. For pneumatic tyre rollers mass per wheel is the total mass of the roller divided by the number of wheels. In assessing the number of passes of pneumatic tyre rollers, the effective width shall be the sum of the widths of the individual wheel tracks together with the sum of the spacing between the wheel tracks, provided that each spacing does not exceed 230 mm. When the spacing exceeds 230 mm, the effective width shall be taken as the sum of the widths of the individual wheel tracks only.
- D. Vibrating rollers are self-propelled or towed smooth-wheeled rollers having means of applying mechanical vibration to one or more rolls :
- (i) The requirements for vibrating rollers are based on the used of the lowest gear on a self propelled machine with mechanical transmission and a speed of 1.5 - 2.5 km/hr for a towed machine, or a self propelled machine with hydrostatic transmission. If higher gear or speed are used an increased number of passes shall be provided in proportion to the increase in speed of travel.
 - (ii) Where the mechanical vibration is applied to two rolls in tandem, the minimum of passes shall be half the number given in the Table 4.16 for the appropriate mass per metre width of one vibrating roll. If one roll differs in mass per metre width from the other, the number of passes shall be calculated as for the roll with the smallest value. Alternatively, the machine may be treated as having a single vibrating roll with a mass per metre width equal to that of the roll with the higher value or, if appropriate, each roll may be assumed to be attached to a separate machine and the requirements of Note H applied.
 - (iii) Vibrating type rollers operating without vibration shall be classified as smooth-wheeled rollers.
 - (iv) Vibrating rollers shall be operated with their vibrating mechanism operating only at the frequency of vibration recommended by the manufacturers. All such rollers shall be equipped with or provided with a device which shall indicate the frequency at which the mechanism is operating.
- E. Vibrating-plate compactors are machines having a base-plate to which is attached a source of vibration consisting of one or two eccentrically weighted shafts.
- (i) The mass per unit area of the base-plate of a vibrating plate compactor is calculated by dividing the total mass of the machine in its working condition by the area in contact with compacted soil.
 - (ii) Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at travelling speeds of less than 1km/hr but if higher speeds are necessary the number of passes shall be increased in proportion to the increase in speed of travel.
- F. Vibro-tampers are machines which an engine driven reciprocating mechanism acts on a spring system, through which oscillations are set up in a base-plate.
- G. Power rammers are machines which are actuated by explosions in an internal combustion cylinder. Each explosion being controlled manually by the operator.

- H. Combinations of different types of plant shall be permitted, in which case the number of passes for each type shall be such proportion of the appropriate number in Table 4.16 as shall together produce the same total compactive effort as any type operated singly in accordance with Table 4.16.

TABLE 4.16 - COMPACTION REQUIREMENTS FOR GRANULAR MATERIALS

Type of compaction plant	Category	Number of passes for layers not greater		
		110 mm	150 mm	225 mm
Smooth wheeled	Mass per metre width of roller :			
	Over 2700 kg up to 5400 kg	16	Unsuitable	Unsuitable
	Over 5400 kg	8	16	Unsuitable
Pneumatic tyre roller	Mass per wheel :			
	Over 4000 kg up to 6000 kg	12	Unsuitable	Unsuitable
	Over 6000 kg up to 8000 kg	12	Unsuitable	Unsuitable
	Over 8000 kg up to 12000 kg	10	16	Unsuitable
	Over 12000 kg	8	12	Unsuitable
Vibrating roller	Mass per metre width of vibrating roll :			
	Over 700 kg up to 1300 kg	16	Unsuitable	Unsuitable
	Over 1300 kg up to 1800 kg	6	16	Unsuitable
	Over 1800 kg up to 2300 kg	4	6	10
	Over 2300 kg up to 2900 kg	3	5	9
	Over 2900 kg up to 3600 kg	3	5	8
	Over 3600 kg up to 4300 kg	2	4	7
	Over 4300 kg Over 5000 kg	2	4	6
	Over 500 kg	2	3	5
Vibrating plate compactor	Mass per unit area of base plate :			
	Over 1400 kg/m ² up to 1800 kg/m ²	8	Unsuitable	Unsuitable
	Over 1800 kg/ up to 2100 kg/ m ²	5	8	Unsuitable
	Over 2100 kg/ m ²	3	6	10
Vibro temper	Mass :			
	Over 50 kg up to 65 kg	4	8	Unsuitable
	Over 65 kg up to 75 kg	3	6	10
	Over 75 kg	2	4	8
Power rammer	Mass :			
	100 kg up to 500 kg	5	8	Unsuitable
	over 500 kg	5	8	12

Compaction shall be carried out in accordance with this clause amended as necessary following compaction trials to ensure that the methods adopted are sufficient to produce a compacted density of not less than 98 per cent of the maximum dry density as determined by BS 1377, Test 13.

BITUMINOUS PAVEMENT COURSESBitumen Prime CoatDescription

This work shall consist of the careful and thorough cleaning of the surface of a prepared and accepted crushed aggregate roadbase, and the furnishing and application to the cleaned roadbase surface of a bituminous priming material, all in accordance with this Specification and the lines, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

The bituminous priming material shall be either cut-back bitumen or bitumen emulsion as stated in the Bill of Quantities.

Cut-back bitumen shall be grade RC-70 or MC-70 conforming to the requirements of M.S. 159.

Bitumen emulsion shall be slow setting, grade SS-1 or SS-1K, conforming to the requirements of M.S. 161, as appropriate to the type of roadbase material to be primed and approved by the S.O.

Equipment

The equipment used by the Contractor shall include a power broom, a compressed air blower, a self-propelled pressure distributor for bituminous material, and as necessary, equipment for storing and heating bituminous material.

(a) *Power Broom*

The power broom shall be a rotary type specifically designed for sweeping road surfaces, and shall be approved by the S.O.

(b) *Compressed Air Blower*

The compressed air blower shall comprise a portable air compressor of 3 cu.m/min. in capacity at 0.7 N/sq.mm delivery pressure with a suitable hose and nozzle for blowing clean a road surface after power brooming, and shall be approved by the S.O.

(c) *Pressure Distributor for Bituminous Material*

The distributor shall be a purpose built model of recognised manufacture and shall be approved by the S.O. It shall conform to the requirements described hereunder.

The distributor shall have a suitable capacity and shall be equipped with a gas or oil fired heating system capable of heating a full charge of bituminous material to 180 °C. The heating system shall be such that overheating of the bituminous material will not occur and shall be of a type in which flames from the burner do not come into direct contact with the casing of the tank containing the bituminous material. The tank shall be insulated in such a manner that when filled with bituminous material at 180 °C and not heated, the drop in temperature shall be less than 3 °C per hour. A thermometer shall be provided to measure continuously the temperature of the bituminous material in the tank and shall be so arranged that the highest temperature in the tank is measured. The tank shall be fitted with an accurately calibrated

dipstick or contents gauge, and the pipe for filling the tank shall be fitted with an easily replaceable filter.

The distributor shall run on pneumatic tyred wheels of such width and number that the load produced on the road surface when the vehicle is fully charged shall not exceed 12 kg/mm of tyre width. The vehicle shall be equipped with a 'fifth wheel' tacheometer system to accurately measure its forward speed during spraying operations.

The distributor shall be equipped with a full circulation type spray bar with nozzles from which the bituminous material is sprayed on to the road surface uniformly over the full spraying width. The spraying width shall be variable in increments of not more than 100 mm up to a maximum of 5.0 metres. The spraying pump shall be driven by a separate power unit and shall be equipped with an accurate pressure gauge and an accurate flow rate gauge or meter. On the suction side the pump shall be fitted with an easily replaceable filter. The spray bar and pump shall be so designed that bituminous material at even temperature and uniform pressure may be sprayed uniformly over the spraying width at controlled rates in the range 0.25 to 8.0 litres/sq.m at normal distributor operating speeds, such that deviation from the prescribed rate of application shall not exceed 10%.

The distributor shall be equipped with a hand spraying system.

The meters for the 'fifth wheel' tachometer system and the bituminous material pumping flow rate, pumping pressure and temperature shall be located in such a manner that the vehicle driver can easily read them, while operating the distributor. The spray bar shall be controlled by a second operator riding at the rear of the vehicle in such a position that all the discharge sprays are in his good view.

All measuring equipment on the distributor shall have been recently calibrated, and accurate and satisfactory records of the calibrations shall be submitted to the S.O., If in the course of the work the rates of application of bituminous material are found to be inaccurate, the distributor shall be withdrawn from the Works and recalibrated to the satisfaction of the S.O. before being returned to service.

The S.O. may require such performance tests as he considers necessary to check that the distributor is operating satisfactorily. As directed by the S.O., the Contractor shall make the distributor and its equipment available for such tests and shall supply all necessary assistance, materials, tools, testing apparatus, etc., all at the Contractor's own expense.

(d) *Storage and Heating Facilities for Bituminous Material*

Tanks for storage of bituminous material shall have a capacity suited to the proposed rate of utilisation of the material and the method and frequency of its delivery to the Works, all to the satisfaction of the S.O. The tanks and, where necessary, barrel decanters shall be equipped with heating systems which provide for effective and positive control of the temperature of the bituminous material at all times up to the temperature required for utilisation. The method of heating shall be such that neither flames nor the products of combustion shall come into direct contact with the bituminous material or the casing of its immediate container, and such that no portion of the bituminous material shall be subject to overheating.

Construction Methods

(a) *General Conditions*

Bitumen prime coat work shall only be carried out in dry, warm weather when the surface to be treated is essentially dry.

(b) *Surface Preparation and Cleaning*

Prior to applying the prime coat, the crushed aggregate roadbase shall have been shaped and compacted in accordance with the provisions of Section 3.20 (Crushed Aggregate Roadbase). Notwithstanding any earlier approval of finished crushed aggregate roadbase, any damage to or deterioration of the roadbase shall be made good to the satisfaction of the S.O. before prime coat is applied.

Immediately prior to applying the bituminous material, the full width of the surface to be treated shall be swept using a power broom followed by a compressed air blower and, if necessary, scraped using hand tools to remove all dirt, dust and other objectionable material, all to the satisfaction of the S.O.

(c) *Application of Bituminous Material*

The bituminous priming material shall be sprayed on to the cleaned roadbase surface by means of a pressure distributor. Any areas inaccessible to the distributor spray bar shall be treated using the distributor's hand spraying system. The rate or rates of application shall be as directed by the S.O. based on the results of test applications, but shall usually be in the range 0.5 to 1.0 litre/sq.m. The temperature of cut-back bitumen shall be maintained in the range 50 °C to 70 °C during spraying operations. For bitumen emulsions, the spraying temperature shall be in the range 25 °C to 45 °C.

If necessary, in order to prevent the bituminous material from flowing on the sprayed surface, the prescribed prime coat shall be applied in two separate spraying operations. Where the condition of the treated surface indicates that it is necessary, bituminous material additional to that prescribed shall be applied as the S.O. shall direct.

Prime coat shall be distributed uniformly over the surface to be treated without streaking; the quantities applied shall not deviate by more than 10% from those prescribed. Areas with insufficient bituminous material shall be resprayed as necessary- to make up the deficiency, all to the satisfaction of the S.O.

The surfaces of structures, road furniture and trees adjacent to the areas being sprayed shall be protected in such a manner as to prevent their being spattered or marred by bituminous material. Bituminous material shall not be discharged into road drains, gutters, etc.

(d) *Curing and Opening to Traffic*

Prime coat shall normally be left undisturbed for at least 24 hours after application and shall not be opened to traffic until, in the opinion of the S.O., it has penetrated the roadbase and cured sufficiently so that it will not be picked up by the wheels of vehicles.

The Contractor shall maintain the prime coat, all to the satisfaction of the S.O., until the overlying pavement course is constructed, which shall not be within 24 hours after the application of the bituminous priming material nor within such longer period as is required, in the opinion of the S.O., for the prime coat to achieve maximum penetration of the roadbase and become fully cured.

Bituminous Tack Coat

Description

This work shall consist of the careful and thorough cleaning of the surface of a prepared and accepted bituminous or bitumen primed pavement course, and the furnishing and application to the cleaned surface of a bituminous tack coat prior to the construction of an overlying bituminous pavement course, all in accordance with this Specification and the lines, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

Bituminous tack coat material shall be rapid setting bitumen emulsion of grade RS-1 or RS-1K conforming to the requirements of M.S. 161.

Equipment

The equipment shall be as specified in Sub-Section 3.20 (Bitumen Prime Coat).

Construction Methods

(a) *General Conditions*

Bituminous tack coat shall only be applied to a clean, dry, bituminous or bitumen primed surface.

Bituminous tack coat shall only be applied as far in advance of the construction of the overlying bituminous pavement course as is necessary to achieve a satisfactory degree of tackiness before the overlying material is placed, all to the satisfaction of the S.O.

(b) *Surface Preparation and Cleaning*

Prior to applying bituminous tack coat, the surface to be treated shall have been prepared in accordance with the appropriate Sections of this Specification. Notwithstanding any earlier approval of this surface, any damage to it or deterioration of it shall be made good before tack coat is applied.

Immediately prior to applying bituminous tack coat, the full width of the surface to be treated shall be swept using a power broom followed by a compressed air blower, and if necessary, scraped using hand tools, to remove all dirt, dust and other objectionable material, all to the satisfaction of the S.O.

(c) *Application of Bituminous Material*

The bituminous tack coat shall be sprayed on to the cleaned bituminous or bitumen primed surface by means of a pressure distributor. Any areas inaccessible to the distributor spray bar shall be treated using the distributor's hand spraying system. The rate or rates of application shall be as directed by the S.O. based on the results of test applications, but shall usually be in the range 0.25 to 0.55 litres/sq.m. The temperature of the bituminous material shall be maintained in the range 25 °C to 45 °C during spraying operations.

Tack coat shall be distributed uniformly over the surface to be treated without streaking; the quantities applied shall not deviate by more than 10% from those prescribed. Areas with bituminous material in excess of these limits shall have the excess removed at the Contractor's expense, and areas with insufficient bituminous material shall be resprayed as necessary to make up the deficiency, all to the satisfaction of the S.O.

The surfaces of structures, road furniture and trees adjacent to the areas being sprayed shall be protected in such a manner as to prevent their being spattered or marred by bituminous material. Bituminous material shall not be discharged into road drains, gutters, etc.

Traffic shall be kept off the tack coat at all times, and the Contractor shall maintain the tack coat, all to the satisfaction of the S.O., until the overlying pavement course is constructed.

Bituminous Surface Dressing

Description

This work shall consist of the careful and thorough cleaning of the surface of a prepared and accepted bituminous or bitumen primed pavement course, and the furnishing and placing on the cleaned surface of one or two applications of bituminous material and cover aggregate, all in accordance with this Specification and the lines, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

When one application of bituminous material and cover aggregate is placed the term 'single bituminous surface dressing' (SBSD) shall apply, and when two applications of bituminous material and cover aggregate are placed, the term 'double bituminous surface dressing' (DBSD) shall apply.

Materials

(a) *Bituminous Material*

Bituminous binder for bituminous surface dressing shall be penetration graded bitumen, or cut-back bitumen, or bitumen emulsion as shown on the Drawings or otherwise specified.

Penetration graded bitumen shall be 80-100 grade conforming to M.S. 124.

Cut-back bitumen shall be grade RC-70 or MC-70 conforming to M.S. 159.

Bitumen emulsion shall be rapid setting of grade RS-1, RS-1K, RS-2, RS-2K or RS-3K conforming to M.S. 161. The grade of emulsion selected shall be anionic or cationic as appropriate to the type of rock from which the cover aggregate is derived, and shall be approved by the S.O.

(b) *Additives for Bituminous Material*

An adhesion and anti-stripping agent shall be added to the bituminous material if the S.O. shall so direct or approve. The additive shall be of a type approved by the S.O. and the required quantity of additive shall be thoroughly mixed with the bituminous material in accordance with the manufacturer's instructions or as directed by the S.O. for such time as is necessary to produce a homogenous mixture.

(c) *Aggregates for Bituminous Surface Dressing*

For single bituminous surface dressing the cover aggregate shall be nominal 20 mm, 14 mm, 10 mm or 6 mm size chippings as shown on the Drawings and/or directed by the S.O.

For double bituminous surface dressing the cover aggregate for the first application of bituminous material and cover aggregate shall be nominal 20 mm size chippings, and the cover aggregate for the second application of bituminous material and cover aggregate shall be nominal 10 mm size chippings.

Cover aggregates shall be screened, crushed stone and shall comprise clean, dry, hard, tough, sound, angular and cubical chippings free from vegetative and other organic matter, clay and other deleterious substances, and containing few, if any, flaky or elongated particles. Dusty chippings shall be washed clean, all to the satisfaction of the S.O. Cover aggregates shall conform to the following physical and mechanical requirements :-

- i) using the type of bituminous material to be used in the Works, treated with additive if so required, the coated area in the coating and stripping test for bitumen aggregate mixtures, AASHTO Test Method T 182, shall not be less than 95%;
- ii) the aggregate crushing value when tested in accordance with M.S. 30 shall be not more than 30;
- iii) the weighted average loss of weight in the sodium sulphate soundness test (5 cycles) when tested in accordance with AASHTO Test Method T 104 shall be not more than 12%;
- iv) the flakiness index when tested in accordance with M.S. 30 shall be not more than 25;
- v) the polished stone value when tested in accordance with M.S. 30 shall be not less than 40;
- vi) the gradation shall conform to the appropriate envelope shown in Table 4.4.

TABLE 4.4 - GRADATION LIMITS FOR BITUMINOUS SURFACE DRESSING

B.S. Sieve Size	% Passing By Weight			
	Nominal 20mm Chippings	Nominal 14mm Chippings	Nominal 10mm Chippings	Nominal 6mm Chippings
25.0 mm	100	-	-	-
20.0 mm	85 - 100	100	-	-
14.0 mm	0 - 20	85 - 100	100	-
10.0 mm	-	0 - 20	85 - 100	100
6.3 mm	-	-	0 - 20	85 - 100
4.75 mm	0 - 5	0 - 5	0 - 10	0 - 25
2.36 mm	0 - 2	0 - 2	0 - 2	0 - 10

Equipment

The Contractor shall provide all the plant and equipment necessary for executing the work in accordance with this Specification, and shall furnish the S.O. with such details of particular items of equipment, e.g. manufacturer, model type, capacity, weight, etc., as the S.O. shall require.

The equipment shall include a power broom, a compressed air blower, a self-propelled pressure distributor for bituminous material, all necessary equipment for storing and heating bituminous material, aggregate spreading equipment, a suitable number of tip-trucks and a self-propelled pneumatic tyred roller.

(a) *Power Broom*

The power broom shall be as specified in Section 3.2 (Butimen Prime Coat).

(b) *Compressed Air Blower*

The compressed air blower shall be as specified in Section 3.2 (Butimen Prime Coat).

(c) *Pressure Distributor for Bituminous Material*

The distributor shall be as specified in Section 3.20 (Bitumen Prime Coat).

(d) *Storage and Heating Facilities for Bituminous Material*

Storage and heating facilities for bituminous material shall be as specified in Section 3.20 (Bitumen Prime Coat).

(e) *Aggregate Spreading Equipment*

Aggregates shall be placed using mechanical spreaders of a type approved by the S.O. The spreaders shall be capable of applying aggregate uniformly over the full width of the area being treated and shall have controls to regulate the rate of spread as required by this Specification, all to the satisfaction of the S.O.

(f) *Tip- Trucks*

The Contractor shall provide a suitable number of tip-trucks of a type approved by the S.O., capable of spreading aggregate in accordance with this Specification.

(g) *Pneumatic Tyred Roller*

The pneumatic tyred roller shall be of recognised manufacture and shall be approved by the S.O. It shall conform to the requirements described hereunder.

The pneumatic tyred roller shall be self-propelled and capable of being reversed without backlash; it shall be equipped with power steering and dual controls allowing operation from either the left or right side.

The roller shall have nine wheels equipped with smooth treaded tyres all of the same size and construction, and capable of operating at inflation pressures of up to 0.9 N/sq.mm. Five wheels shall be on the driven axle and four on the steering axle, all equally spaced on both axles and arranged so that the tyres on the steering axle track midway between those on the driven axle with a small overlap. The roller shall be equipped with water tanks, sprinkler systems and pads of coconut matting to keep all tyres evenly wetted during operation.

The roller shall be equipped with means of adjusting its total weight by ballasting so that the load per wheel can be varied in the range 1.0 to 2.0 tonnes. In operation, the ballasted weight and the tyre inflation pressure shall be adjusted to meet the requirements of each particular operation. Each tyre shall be kept inflated at the specified pressure such that the pressure difference between any two tyres shall not exceed 0.04 N/sq.mm. Means shall be provided for checking and adjusting tyre pressures at all times at the place of the works.

The Contractor shall provide the S.O. with a calibration chart for the roller showing the relationship between the quantity or depth of ballast and total weight, and also a chart showing the relationship between wheel load, tyre inflation pressure and contact pressure.

Construction Methods

(a) *General Conditions*

Bituminous surface dressing shall only be carried out in dry, warm weather when the surface to be treated is dry. Work shall be discontinued when rain appears imminent and during periods of strong wind.

The S.O. may order the discontinuation of work on account of adverse weather, unsatisfactory condition of materials, equipment or surface to be treated, or such other conditions as he shall consider detrimental to the work.

(b) *Surface Preparation and Cleaning*

Prior to constructing a: bituminous surface dressing, the surface to be treated shall have been prepared in accordance with the appropriate Sections of this Specification. Notwithstanding any earlier approval of this surface, any damage to or deterioration of it shall be made good before surface dressing is commenced.

Immediately prior to commencing surface dressing, the full width of the surface to be treated, together with an additional 300 mm width on each side, shall be swept using a power broom followed by a compressed air blower and, if necessary, scraped using hand tools to remove all loose particles, dirt, dust and other objectionable material, all to the satisfaction of the S.O.

In double bituminous surface dressing construction, the surface of the first application of bituminous material and cover aggregate shall be similarly made good and cleaned, immediately prior to commencing the second application.

(c) *Application of Bituminous Material*

The bituminous material for a single bituminous surface dressing or for each application of bituminous material and cover aggregate of a double bituminous surface dressing shall be sprayed on to the cleaned surface to be treated by means of a pressure distributor. Any areas inaccessible to the distributor spray bar shall be treated using the distributor's hand spraying system.

The rate or rates of application shall be as directed by the S.O. based on the results of laboratory tests and/or test applications but for penetration graded bitumen shall usually be in the appropriate range given in Table 4.5.

TABLE 4.5 - RATES OF APPLICATION OF PENETRATION GRADED BITUMEN

Nominal Size of Aggregate	Rate of Application of Penetration Graded Bitumen
20 mm	2.0 - 3.0 litre/sq.m
14 mm	1.5 - 2.2 litre/sq.m
10 mm	1.0 - 1.5 litre/sq.m
6 mm	0.7 - 1.0 litre/sq.m

The rates of application for cut-back bitumens and bitumen emulsions shall be commensurately higher depending on their residual bitumen contents.

The temperature of the bituminous material shall be maintained during spraying operations within the appropriate range given in Table 4.6.

The bituminous material shall be distributed uniformly over the surface to be treated without streaking; the quantities applied shall not deviate by more than 10% from those prescribed. The rate of application shall be checked for each spraying run by measuring the volume of bituminous material in the distributor before and after spraying and the area treated. Adjustments shall be made as necessary to ensure that the prescribed rate of application is maintained in subsequent runs. Spraying shall be discontinued immediately if any defect develops in the distributor, and it shall not be resumed until the fault has been rectified to the satisfaction of the S.O.

The spraying of bituminous material over any portion of the surface to be treated shall not be carried out more than two minutes in advance of placing the cover aggregate on that portion at the specified rate; and the progress of spraying the bituminous material shall be restricted as necessary to comply with this requirement.

TABLE 4.6 - SPRAYING TEMPERATURE FOR BITUMINOUS MATERIAL

Bituminous Material	Spraying Temperature
80-100 penetration grade bitumen	150 °C to 150 °C
Cut-back bitumen grade RC-70 or MC-70	50 °C to 65 °C
Bitumen emulsions	25 °C to 45 °C

Bituminous materials shall not be heated to spraying temperatures too soon in advance of requirements. Any bituminous material which has been heated to spraying temperature for more than ten hours or which has been overheated shall be rejected.

In cases where the bituminous material is applied in lanes there shall be a small overlap of bituminous material at the joints between lanes equal in width to the edge strip of the sprayed area which does not receive the full rate of application of bituminous material. For double bituminous surface dressing, joints in the second application of bituminous material shall be offset from those in the first application by 150 - 300 mm for longitudinal joints and by at least 1.0 metre, where possible, for transverse joints.

Each spraying run shall commence and terminate on lengths of building paper placed across the full spraying width immediately before and after the section to be sprayed. Sufficient building paper shall be placed so that the distributor may be started and stopped with the spray bar over paper, and so that the correct distributor road speed and rate of spraying can be maintained over the entire length of the section to be sprayed, all to the satisfaction of the S.O. Immediately after use and before application of cover aggregate, the building paper shall be removed. and disposed of in a manner approved by the S.O.

Provision shall be made for a volume of bituminous material of at least 10% of the capacity of the distributor, or such other quantity as the S.O. shall direct, to remain in the distributor tank at the completion of each spraying run, in order to avoid air entrapment within the bitumen spraying system.

The surfaces of structures, road furniture and trees adjacent to the areas being sprayed shall be protected in such a manner as to prevent their being spattered or marred by bituminous material. Bituminous material shall not be discharged into road drains, gutters, etc.

(d) *Application of Cover Aggregate*

Before each spraying run of bituminous material commences, sufficient aggregate to provide full cover at the prescribed rate of application over the entire area to be sprayed shall have been loaded in trucks at the Site of the Works in readiness for spreading.

Immediately following the application of the bituminous material, the clean, dry cover aggregate shall be uniformly spread over the bituminous material using mechanical spreaders approved by the S.O. The aggregate shall be placed as quickly as practicable after the application of bituminous material on all parts of the area to be covered, and for no portion of the surface to be treated shall there be a delay of more than two minutes between the application of the bituminous material and the spreading of the aggregate.

The trucks feeding the aggregate to the mechanical spreaders shall operate backward during aggregate spreading in order that the wheels of the spreaders and trucks shall not run on uncovered bituminous material.

The rate of application of cover aggregate shall be as directed by the S.O. based on the results of laboratory tests and/or tests applications, but shall usually be in the appropriate range given in Table 4.7.

TABLE 4.7 - RATES OF APPLICATION OF COVER AGGREGATE

Nominal Size of Aggregate	Rate of Application	
20 mm	17 - 27	Kgfsq.m
14 mm	12 - 18	kgfsq.m
10 mm	8 - 12	kgfsq.m
6 mm	5 - 8	kgfsq.m

The rate of application shall be checked for each spraying run from measurements of the quantities of aggregate in the trucks and the area treated, or by sampling and measuring the aggregate spread on the road. Any bare or insufficiently covered areas shall be made good by hand spreading as quickly as possible. Aggregate in excess of the rate prescribed shall be evenly distributed over the surface or removed as quickly as possible, all to the satisfaction of the S.O.

In cases where the surface dressing is constructed in lanes, the edge of the aggregate spread adjacent to an untreated lane shall coincide with the edge of the sprayed area which receives the full rate of application of the bituminous material. This will leave a narrow strip of bituminous material of partial thickness which shall be overlapped by the bituminous material spray and aggregate spread of the adjacent lane.

Immediately following the spreading of the aggregate to the satisfaction of the S.O., the aggregate shall be rolled with a pneumatic tyred roller approved by the S.O. to embed the aggregate in the bituminous material. Rolling shall commence as quickly as practicable after the application of the bituminous material and aggregate on all parts of the area to be covered, and for no portion of the surface to be treated shall there be a delay of more than 3 minutes between the application of the bituminous material and the commencement of rolling.

The pneumatic tyred roller shall be ballasted to an operating weight of 9 - 10 tonnes and its tyre inflation pressure shall be 0.53 N/sq.mm for surface dressing work. Rolling shall be continued for as long as is necessary to thoroughly embed the aggregate in the bituminous material, all to the satisfaction of the S.O.

When, in the opinion of the S.O., the bituminous material has hardened sufficiently to prevent the dislodgement of embedded aggregate by the action of the power broom, all loose aggregate shall be swept from the treated surface using the power broom and compressed air blower and disposed of to the satisfaction of the S.O. Where the dressing so prepared is the first application of a double bituminous surface dressing, construction of the second application of bituminous material and cover aggregate shall then proceed as soon as is practicable.

(e) *Opening to Traffic*

Bituminous surface dressing shall normally not be opened to traffic until such time as, in the opinion of the S.O., the surfacing shall have developed sufficient strength to withstand normal traffic forces without dislodgement of the aggregate. This will usually be not less than 24 hours after the completion of rolling. Where it is necessary to allow earlier use of the finished surface to facilitate the movement of traffic, vehicles may be allowed to run on the work after rolling has been completed, provided that speeds are restricted to 30 km per hour or less and sharp turning movements are prohibited. The finished surface shall subsequently have to be closed temporarily to enable the loose aggregate to be swept off and disposed of as described in Section 3.20 (Construction Bituminous Surface Dressing).

Ideally, the first application of bituminous material and cover aggregate of a double bituminous surface dressing should not be opened to traffic before construction of the second application. However, where it is necessary to facilitate the movement of traffic, the first application may be opened to traffic prior to construction of the second application. Nevertheless, traffic movement on the completed first application shall be kept to a practicable minimum and the second application shall be constructed as soon as is practicable after the completion of the first.

Asphaltic ConcreteDescription

This work shall consist of furnishing, placing, shaping and compacting asphaltic concrete binder course and/or wearing course on a prepared and accepted bituminous or bitumen primed pavement course, and shall include the careful and thorough cleaning of surfaces which are to be covered without receiving a bituminous tack coat. The work shall be carried out all in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials(a) *Aggregates*

Aggregate for asphaltic concrete shall be a mixture of coarse and fine aggregates and, if necessary, mineral filler. The individual aggregates shall be of sizes suitable for blending to produce the required gradation of the combined aggregate, all to the satisfaction of the S.O.

Coarse aggregates shall be screened crushed hard rock, angular in shape and free from dust, clay, vegetative and other organic matter, and other deleterious substances. They shall conform to the following physical and mechanical quality requirements :-

- i) the aggregate crushing value when tested in accordance with M.S. 30 shall be not more than 30;
- ii) the weighted average loss of weight in the sodium sulphate soundness test (5 cycles) when tested in accordance with AASHTO Test Method T 104 shall be not more than 12%;
- iii) the flakiness index when tested in accordance with M.S. 30 shall be not more than 30;
- iv) the water absorption when tested in accordance with M.S. 30 shall be not more than 2%;

- v) the polished stone value when tested in accordance with M.S. 30 shall be not less than 40 (only applicable to aggregates for wearing course).

Fine aggregates shall be clean natural sands, screened quarry fines, or mining sand. Mining sand shall be thoroughly washed before use. Other types of fine aggregate may be used subject to the approval of the S.O. Fine aggregates shall be non-plastic and free from clay, loam, aggregations of material, vegetative and other organic matter, and other deleterious substances. They shall conform to the following physical and mechanical quality requirements :-

- i) the weighted average loss of weight in the sodium sulphate soundness test (5 cycles) when tested in accordance with AASHTO Test Method T 104 shall be not more than 12%;
- ii) the water absorption when tested in accordance with M.S. 30 shall be not more than 2%.

Notwithstanding compliance with the requirements of this Specification, limestone aggregates shall not be permitted for use in wearing course.

The gradation of the combined coarse and fine aggregates, together with ordinary Portland cement added as an adhesion and anti-stripping agent and, if necessary, any other mineral filler, shall conform to the appropriate envelope shown in Table 4.8.

The gradation envelopes in the above Table are purposely wider than the tolerances for good works control of asphaltic concrete mixes. For each type of mix required in the Works, the Contractor shall establish a job mix formula gradation which shall consist of a single definite percentage passing for each sieve size in the above Table and shall produce a smooth curve within and essentially parallel to the appropriate gradation envelope. This job mix formula gradation, with the allowable tolerances for a single test as specified in Section 3.20 (Asphaltic Concrete Mix Design), then becomes the job control envelope and this job control envelope must be totally within the limits of the appropriate gradation envelope in the above Table.

(b) *Mineral Filler*

Mineral filler shall be finely divided mineral matter such as rock dust, limestone dust, hydrated lime, hydraulic cement, or such other suitable material as the S.O. shall approve. At the time of mixing with bitumen it shall be sufficiently dry to flow freely and shall be essentially free from agglomerations. Not less than 70% by weight shall pass the B.S. 75 um sieve.

(c) *Bituminous Material*

Bituminous binder for asphaltic concrete shall be penetration graded bitumen of 80-100 grade conforming to M.S. 124.

(d) *Anti-Stripping Agent*

Ordinary Portland cement shall be added to the combined aggregate for asphaltic concrete to serve as an adhesion and anti-stripping agent. The amount of cement added for this purpose shall be 2% by weight of the combined aggregate. (Additional cement may also be added, if necessary, to serve as filler.)

Ordinary Portland cement for this purpose shall conform to the requirements of M.S. 522 and shall be dry, free flowing and free from agglomerations at the time of use.

Notwithstanding the use of ordinary Portland cement as an anti-stripping agent as specified above, the Contractor shall be responsible for ensuring that the bitumen binder adheres satisfactorily to the aggregate and does not strip from it during the service life of the asphaltic concrete.

Accordingly, the Contractor shall carry out bitumen stripping tests with the proposed aggregates to demonstrate to the complete satisfaction of the S.O. that the aggregates will perform satisfactorily in service with the specified bitumen binder. Such tests shall be carried out in accordance with AASHTD Test Method T 182, or such other test methods as the S.O. shall direct or approve. When AASHTO Test Method T 182 is used, the coated area at the end of the mixture's period of immersion in water shall be not less than 95%.

Where, in the opinion of the S.O., ordinary Portland cement does not perform satisfactorily as an anti-stripping agent, the Contractor may propose to use another adhesion and anti-stripping agent in addition to, or wholly or partially instead of, the ordinary Portland cement specified above. Such agent shall be of a type approved by the S.O. and shall be thoroughly mixed with the bituminous binder, all in accordance with the manufacturer's instructions. In such a case, the agent shall be added to the bitumen binder used in the bitumen stripping tests in the appropriate amount and manner.

Aggregate which does not perform satisfactorily in the bitumen stripping tests, using the approved adhesion and anti-stripping agent when appropriate, shall not be used in asphaltic concrete.

TABLE 4.8 - GRADATION LIMITS FOR ASPHALTIC CONCRETE

Mix Type	Wearing Course	Binder Course
Mix Designation	ACW 20	ACB 28
BS Sieve Size	% Passing By Weight	
37.5 mm	-	100
28.0 mm	100	80 - 100
20.0 mm	76 - 100	72 - 93
14.0 mm	64 - 89	58 - 82
10.0 mm	56 - 81	50 - 75
5.0 mm	46 - 71	36 - 58
3.35 mm	32 - 58	30 - 52
1.18 mm	20 - 42	18 - 38
424 um	12 - 28	11 - 25
150 um	6 - 16	5 - 14
75 um	4 - 8	3 - 8

Asphaltic Concrete Mix Design(a) *Job Mix Formulae*

After obtaining supplies or production (as applicable) of all aggregates consistent as to gradation and other qualities, the Contractor shall propose a job mix formula for each class of mix required in the Works. In order to attain optimum quality of the mixtures, the job mix formula for each class shall be prepared on the basis of testing several trial gradations within the limits set in Table 4.8 at an appropriate range of bitumen contents. As a guide to the testing range of bitumen contents, the design bitumen content will usually be in the appropriate range given in Table 4.9.

TABLE 4.9 - DESIGN BITUMEN CONTENTS

ACW 20	4.5 - 6.5 %
ACB 28	4.0 - 6.0 %

A sample of each trial mix (i.e. each combination of trial gradation and bitumen content) shall be subject to a comprehensive Marshall method test and analysis as follows :-

- i) preparation of specimens for the standard stability and flow test in accordance with AASHTO Test Method T 245 using the 75 blows/face compaction standard;
- ii) determination of the bulk specific gravity of the specimens in accordance with AASHTO Test Method T 166;
- iii) determination of the stability and flow values in accordance with AASHTO Test Method T 245;
- iv) analysis of the density and voids parameters to determine the percentage of voids in the compacted aggregate, the percentage of voids in the compacted aggregate filled with bitumen, and hence the percentage of air voids in the compacted mix.

For each trial mix conforming to a proposed job mix formula, the parameters of the above tests and analyses shall conform to the requirements of the appropriate type of mix as given in Table 4.10.

**TABLE 4.10 - TEST AND ANALYSIS PARAMETERS
FOR ASPHALTIC CONCRETE**

Parameter		Wearing Course	Binder Course
Stability	S	> 500 kg	> 450 kg
Flow	F	> 2.0 mm	> 2.0 mm
Stiffness	S/F	> 250 kg/mm	> 225 kg/mm
Air voids in mix		3.0% - 5.0%	3.0% - 7.0%
Voids in aggregate filled with bitumen		75% - 85%	65% - 80%

Air voids shall be defined as the small pockets of air between the coated aggregate particles in a compacted asphaltic concrete mix. The portion of the bitumen absorbed into the aggregate particles must therefore be allowed for when calculating the air voids. For combined aggregate with a water absorption of not more than 2.0%, the absorbed bitumen may be estimated on the basis that the absorption of bitumen will be approximately 20% of the water absorption.

Voids in the aggregate of a mix shall be calculated on the basis of the weighted average bulk specific gravity on an oven dried basis of the coarse and fine aggregate fractions (separated by the ASTM # 10 sieve or B.S. 2.0 mm sieve) as determined in accordance with AASHTO Test Method T 84 and T 85 as applicable.

The Marshall density of an asphaltic concrete mix is defined as the average density of a set of three (3) test specimens moulded for the standard stability and flow test in accordance with AASHTO Test Method T 245 using the 75 blows per face compaction standard.

The Contractor shall submit to the S.O. full details of his proposed job mix formula for each class of mix required in the Works including :-

- i) the gradation analysis of each aggregate to be used in the mix;
- ii) the proportions for cold batching the aggregates;
- iii) the mixing plant screen sizes, the smallest of which shall generally be not more than 3.2 mm;
- iv) the gradation analysis of the aggregate in each of the mixing plants hot bins and of the mineral filler (including any ordinary Portland cement added as anti-stripping agent);
- v) the job mix formula gradation of the combined aggregate and filler;
- vi) the proportions for combining the hot bin aggregates and filler;
- vii) the bitumen content (by weight of total mix);
- vii) the dry and wet mixing times if a batch plant is to be used, or the mixing time if a continuous mix plant is to be used;

- viii) the full results of the comprehensive Marshall method tests and analyses as described above for each trial mix used in determining the job mix formula.

The S.O. may require changes of any of the factors in each proposed job mix formula and further tests and analyses in order to attain optimum quality of the asphaltic concrete mixes.

(b) *Plant Trials*

After having received the S.O.'s preliminary approval of his proposed job mix formulae, the Contractor shall arrange to mix, lay and compact asphaltic concrete conforming to the proposed formula for each class of mix required in the Works. A minimum of 10 tonnes of each mix shall be placed in trial areas to demonstrate to the satisfaction of the S.O. that the mixing, laying and compacting equipment conforms to the requirements of this Specification, and that the proposed mixes are satisfactory. The trial areas shall not be part of the Contract Works but shall be provided by the Contractor at his own expense. They shall be approved by the S.O.

As directed by the S.O., comprehensive sampling and testing of each class of mix shall be carried out to check for satisfactory compliance with its job mix formula, and for a satisfactory degree of compaction.

As a result of the plant trials, the S.O. may require amendments to the job mix formulae, further tests and analyses, and possibly additional plant trials before finally approving the mixes for full scale production and use in the Works.

(c) *Compliance with the Job Mix Formulae*

The S.O.'s final approval of the job mix formulae shall bind the Contractor to furnish asphaltic concrete mixes meeting the precise gradations and bitumen contents specified in these formulae within the tolerances set forth in Table 4.11.

Modifications to a job mix formula may only be made with the approval of the S.O. Should the S.O. at any time have reason to believe that the materials and methods of mixing and laying are different from those approved, he shall so advise the Contractor, and may order that asphaltic concrete works be discontinued pending further trials and testing.

**TABLE 4.11 - TOLERANCES FOR ASPHALTIC
CONCRETE MIXES**

Parameter	Permissible Variation % By Weight of Total Mix
Bitumen.	$\pm 0.2\%$
Fractions of combined aggregate passing 5.0 mm and larger sieves.	$\pm 5.0\%$
Fractions of combined aggregate passing 3.35 mm and 1.18 mm sieves.	$\pm 4.0\%$
Fractions of combined aggregate passing 425 μm and 150 μm sieves.	$\pm 3.0\%$
Fraction of combined aggregate passing 75 μm sieve.	$\pm 2.0\%$

Equipment

The Contractor shall provide all the plant and equipment necessary for executing the work in accordance with this Specification and shall furnish the S.O. with such details of particular items of equipment, e.g. manufacturer, model type, capacity, weight, operating features, etc., as the S.O. shall require.

(a) *Road Cleaning Equipment*

Road cleaning equipment will be required where asphaltic concrete is to be laid on a surface which is not to receive a tack coat. The equipment shall be the same as that required for preparing a surface for a tack coat and shall include a power broom and compressed air blower as specified in Sections 3.20 (Bitumen Prime Cost).

(b) *Asphalt Mixing Plant*

The asphalt plant shall be either a batch plant or a drum mix plant or a continuous mix plant of recognized manufacture and shall be approved by the S.O. It shall conform to the requirements described hereunder.

The mixing plant shall have a capacity suited to the Works and sufficient to enable the paver to operate more or less continuously when paving at normal speeds at the required thicknesses. The plant shall be so designed as to enable consistent production of asphaltic concrete mixes within the tolerances prescribed in this Specification, all to the satisfaction of the S.O.

Scales for all weigh boxes or hoppers shall be of the springless dial type, accurate to within

0.5% of the maximum load that may be required. Scale dials and pointers shall be easily read from their operator's normal position without significant parallax errors. Scales shall be substantially constructed so that they shall maintain their accuracy after initial adjustment. The Contractor shall furnish not less than ten 25 kg test weights at the plant for checking, adjusting and calibrating scales.

Tanks for storage of bitumen shall have a capacity suited to the proposed rate of utilization of the material and the method and frequency of its delivery to the Works, all to the satisfaction of the S.O. The tanks shall be provided with means of measuring the volume of their contents at all times and of drawing off samples of the contents. The bitumen feeding system shall provide for continuous circulation of hot binder through the system and back into the feed tank. The end of the return line discharging into the feed tank shall always be kept submerged in the bitumen in the tank in order to prevent oxidation of the returning hot binder. The storage tanks, and where necessary barrel decanters, and all elements of the bitumen feeding system shall be equipped with heating systems or insulating jackets as necessary to provide for effective and positive control of the temperature of the bitumen at all times up to the temperature required for utilisation. The method of heating shall be such that neither flames nor the products of combustion shall come into direct contact with the bitumen or the casing of its immediate container, and such that no portion of the bitumen shall be subject to overheating.

The plant shall be provided with accurate mechanical means for uniformly feeding the aggregates into the dryer so that uniform production and temperature of the heated aggregates will be obtained. A separate feed bin with an adjustable gate opening shall be provided for each aggregate to be included in the combined aggregate for the mix; normally four bins will be required. The feed bins and gates shall be so constructed and equipped that they shall be readily accessible for calibrating at all times, and shall provide for a continuous and uniform flow of each aggregate required in the mix.

The plant shall have a rotary drum dryer of satisfactory design for drying and heating the combined aggregate so that its temperature will be at the required level at the time it is mixed with the bitumen. The burner shall be so designed that complete combustion of the fuel will be obtained, and the aggregate will remain clean and not become coated with soot or oil.

The plant shall be equipped with four (or more) screens, the smallest of which shall generally be not more than 3.2 mm. The screens shall have a normal capacity slightly in excess of the maximum output of the mixing plant. The screens shall be readily accessible for inspection.

The plant shall include four (or more) storage bins for screened aggregates, each with a capacity of not less than twice the pugmill dead load capacity. The bins shall be arranged so as to provide separate dry storage for each screened fraction of the aggregate. Each bin shall be provided with an overflow pipe of such size and location as to prevent any backing up of material into other bins. Each bin shall be so constructed that representative aggregate samples can be readily obtained, and shall have means for observing the aggregate level. Separate dry storage shall be provided for mineral filler, and the plant shall be satisfactorily equipped to feed filler into the mixer.

Satisfactory means by either weighing or metering shall be provided to obtain the prescribed amount of bitumen in the mix within the specified tolerance. Means shall be provided for checking the quantity or flow rate of binder entering the mixer. Suitable means shall be provided for maintaining the prescribed temperature of the bitumen in the pipelines, weigh bucket or flow meter, and spray bars.

An armoured thermometer with a range of 30 °C to 200 °C shall be fitted in the bitumen feed

line at a suitable location near the discharge valve at the mixer unit. Suitable dial-scale mercury actuated thermometers, electric pyrometers or other thermometric instruments shall be fitted at the discharge chute of the dryer and in each hot aggregate storage bin to indicate the temperatures of the heated aggregates.

The plant shall be equipped with a dust collector so constructed as to waste the material collected or feed it uniformly to the heated aggregate.

The plant shall be equipped with adequate and safe stairways to the mixing platform and sampling locations, and guarded ladders and cat-walks shall provide access to all other positions as necessary for proper operation, inspection and maintenance of the plant, all to the satisfaction of the S.O. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be properly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform, and clear and unobstructed passage shall be maintained at all times in and around the truck loading area, which shall be kept free from drippings from the mixer.

Special Requirements for Batch Plants

Each storage bin for screened aggregate shall be provided with a bottom outlet gate so constructed as to prevent leakage when closed. These gates shall have a quick and complete closing action.

The plant shall be equipped with a weigh box or hopper for accurately weighing out aggregate from each of the screened aggregate storage bins. The weigh box or hopper shall be suspended from its scale's lever mechanism and shall be sufficiently large to hold a full batch equal to the pugmill capacity without hand raking or spilling of the aggregate. The discharge gate shall be so constructed as to allow rapid and complete emptying of the weigh box or hopper into the mixer, and prevent leakage when closed.

The plant shall be equipped with a binder weigh bucket which shall be charged through a fast acting non-drip valve in the binder feed pipe located directly over the bucket. The bucket shall be suspended from its scale's lever mechanism and shall have a capacity sufficient to weigh out binder up to 20% of the weight of the pugmill dead load capacity. The bucket shall have a discharge mechanism which shall provide for rapid and complete emptying of the bucket in a thin uniform sheet or multiple sprays over the full length and width of the mixer. The discharge mechanism shall not leak or drip when closed.

The batch mixer shall be a suitable twin-shaft pugmill, with a capacity of at least 500 kg of asphaltic concrete, capable of producing a thoroughly homogeneous mixture. The clearance of the paddle blades from all fixed and moving parts of the mixer shall be not more than 20 mm. If the pugmill is not enclosed it shall be equipped with a dust hood to prevent loss of fines from the mixture. The discharge gate shall be so constructed as to allow rapid and complete emptying of the mixer, and prevent leakage of any mix constituent when closed.

The mixer shall be equipped with an accurate time lock system for controlling the operations

of a complete mixing cycle. It shall lock the aggregate weigh box or hopper gate after charging the mixer with aggregate, until the closing of the mixer gate at the completion of the mixing cycle; it shall lock the binder weigh bucket discharge mechanism during the dry mixing and wet mixing periods. (The dry mixing period is defined as the interval of time between the opening of the aggregate weigh box or hopper gate and the start of discharging the binder weigh bucket. The wet mixing period is defined as the interval of time between the start of discharging the binder weigh bucket and the opening of the mixer gate.) The dry and wet mixing periods shall both be adjustable in increments of not more than 5 seconds from zero to not less than 120 seconds total for dry and wet mixing.

Special Requirements for Drum Mix Plants

The cold material feeder unit shall consist of not less than 5 compartments with suitable heaped capacity appropriate for the plant. Each bin shall be provided with a control gate and measuring feeder suitable for accurate blending of the aggregates on to the cold feed collecting conveyor. The cold feed system shall incorporate a device for moisture compensation capable of producing an accurate and continuous blend of the individual aggregate sizes from the cold feed compartment.

The drum mixer shall be of an inclined, oil-fired and parallel flow type in which the aggregates and exhaust gases flow in the same direction. The drum mixer length to diameter ratio shall be such as to ensure efficient drying and intimate mixing of aggregate, filler and binder over the full range of rated operating efficiencies. A bypass chute shall be incorporated for sampling of cold aggregate.

Freshly mixed material shall be delivered and stored in a surge silo through a proper conveyor system.

Special Requirements for Continuous Mix Plants

Each storage bin for screened aggregate shall be provided with an accurately controlled variable orifice gate discharging on to an aggregate feed mechanism. The discharge orifice shall be rectangular with one dimension variable by means of an adjustable and lockable gate, which shall have an indicator showing the distance it is open. These gates shall be used for accurately proportioning the screened aggregates for the mix.

The plant shall have means of calibrating the aggregate bin discharge gate openings by weighing test samples obtained by diverting the aggregate fed out of each bin into a suitable test box. Test boxes shall have a capacity of not less than 100 kg each.

The plant shall have satisfactory means of effecting positive interlocking control between the flow of screened aggregates from the storage bins and the flow of binder from the meter or other proportioning device. This control shall be accomplished by interlocking mechanical means or another positive method satisfactory to the S.O.

The continuous mixer shall be a suitable twin-shaft pugmill with an adjustable dam and

paddles with reversible blade pitch for adjusting the volume of mixture held in the pugmill. The clearance of the paddle blades from all fixed parts of the mixer shall be not more than 20 mm. The binder shall be fed into the mixer through a spray bar directed on to the aggregate across the full width of the pugmill at the feed end. The discharging mixture shall pass over the dam into a hopper with a discharge gate so constructed as to allow rapid and complete emptying of the hopper, and prevent leakage of the mix when closed. The mixer shall be equipped with a permanent gauge for measuring the depth of mixture in the pugmill and a manufacturer's calibration plate showing the volume of mixture in the pugmill at each increment of depth.

The mixing time shall be determined using the formula :-

$$\text{Mixing time (seconds)} = \frac{\text{Dead weight of mix in pugmill (kg)}}{\text{Pugmill output (kg per second)}}$$

and for a given output it may be varied slightly by adjusting the depth (and hence weight) of the mixture held in the pugmill by varying the dam height, the configuration of the paddle blades, or both. However for substantial adjustments of the mixing time, in order to maintain the depth at a level compatible with efficient mixing, i.e. so that the paddle tips just break out of the mixture at the height of their action, the rate of feed of materials to the mixer (and hence output) should be changed.

(c) *Tip-Trucks*

The Contractor shall provide a suitable number of tip-trucks of a type approved by the S.O. for transporting asphaltic concrete from the mixing plant to the paving works. The trucks shall have trays with smooth, flat beds and sides, and shall have load capacities of not less than 5 tonnes. Prior to loading, the inside of each truck tray shall be lightly and evenly coated with a soap or detergent solution, or such other liquid as the S.O. shall approve, to prevent adhesion of the asphaltic concrete. The trucks shall be equipped with covers of canvas or other suitable material to protect the asphaltic concrete.

(d) *Asphalt Paver*

The asphalt paver shall be of recognized manufacture and shall be approved by the S.O. It shall conform to the requirements described hereunder.

The paver shall be self-propelled and capable of reverse as well as forward travel. It shall be equipped with a hopper at the front designed to receive the paving mixture from tip-trucks, and shall have a mechanical distribution system for spreading the mixture evenly and without segregation over the surface to be paved in front of a screeding and compacting unit which shall be equipped with a suitable heating device. The screeding and compacting mechanism shall be capable of confining the edges of the material being laid without the use of stationary side forms, shall be adjustable to strike off the mixture to the thickness and cross-section shape required, and shall be controlled by an automatic levelling device to, produce an even carpet of bituminous mixture with a uniform surface texture free from indentations, ridges, tear marks or other irregularities. The paver shall be capable of laying the bituminous mixture in paving widths in the range 2.5 to 3.75 m and of finishing the pavement layer true to the required lines, grades, levels, dimensions and cross-sections, subject to compaction by rolling, all to the satisfaction of the S.O.

(e) *Rollers*

A pneumatic tyred roller and two steel wheeled tandem rollers shall be provided. However, a three wheeled steel roller may be substituted for one of the tandem rollers if the S.O. shall so approve. All rollers shall be of recognized manufacture and shall be approved by the S.O.

The pneumatic tyred roller shall be as specified in Section 3.20 (Bituminous Surface Dressing). Steel wheeled rollers shall conform to the requirements described hereunder.

Steel wheeled rollers shall be self-propelled and capable of being reversed without backlash; they shall be equipped with power steering and dual controls allowing operation from either the left or right side. They shall be equipped with water tanks, sprinkler systems and scraper blades to keep all wheels evenly wetted and clean during operation.

Each steel wheeled roller shall be ballasted so that its total operating weight is in the range 8 to 10 tonnes and its driven roll (or rolls) shall exert a rolling force of not less than 3.5 tonnes/metre of roll width. The Contractor shall provide the S.O. with a calibration chart for each roller showing the relationships between the quantity or depth of ballast and total weight and rolling force.

Construction Methods

(a) *General Conditions*

Asphaltic concrete paving work shall only be carried out in dry weather when the surface to be covered is dry, or if so specified, has received a bituminous tack coat which shall have achieved a satisfactory degree of tackiness, all to the satisfaction of the S.O. All laying, rolling and finishing work shall be carried out during daylight hours, unless the Contractor shall have provided suitable flood-lighting for the job site, to the satisfaction of the S.O.

The S.O. may order the discontinuation of work on account of adverse weather, unsatisfactory condition of materials, equipment or surface to be paved, or such other conditions as he shall consider detrimental to the work.

Construction plant and its method of deployment used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the pavement courses already constructed.

The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

(b) *Surface Preparation and Cleaning*

Prior to constructing an asphaltic concrete pavement layer, the surface to be covered shall have been prepared in accordance with the appropriate Sections of this Specification. Notwithstanding any earlier approval of this surface, any damage to or deterioration of it shall be made good before asphaltic concrete paving work is commenced.

If the surface to be covered is not to be provided with a bituminous tack coat, then immediately prior to commencing asphaltic concrete paving, it shall be swept using a power broom followed by a compressed air blower and, if necessary, scraped using hand tools to remove all loose particles, dirt, dust and other objectionable material, all to the satisfaction of the S.O.

If the surface to be covered is to be provided with a bituminous tack coat, then this shall be

applied all in accordance with the provisions of Section 3.20 (Bituminous Tack coat)

(c) *Aggregate Handling and Heating*

Each aggregate to be used in the asphaltic concrete mixes shall be stored in a separate stockpile near the mixing plant. Stockpiles of sand and other fine aggregates shall be kept dry using waterproof covers and other means as necessary. In placing the aggregates in the stockpiles and loading them into the mixing plant's cold aggregate feed bins, care shall be taken to prevent segregation or uncontrolled combination of materials of different gradation. Segregated or contaminated materials shall be rescreened or rejected for use in the Works and removed from the mixing plant site.

The aggregates shall be fed into the dryer at a uniform rate proportioned in accordance with the appropriate job mix formula. The rate of feed for each aggregate shall be maintained within 10% of the rate prescribed, and the total rate of feed shall be such that the plant's screens shall never be overloaded.

The aggregates shall be dried and heated so that when delivered to the mixer they shall be at a temperature in the range 150 °C to 170 °C.

Immediately after heating, the aggregates shall be screened into four (or more) fractions which shall be separately stored in the hot aggregate storage bins in readiness for mixing. . Ordinary Portland cement and/or other mineral filler to be used in the mix shall be stored separately and kept completely dry. Its rate of feed into the plant shall be accurately controlled by weight or volumetric measurement, all to the satisfaction of the S.O.

(d) *Heating of Bitumen*

The binder shall be heated so that when delivered to the mixer it shall be at a temperature in the range 140 °C to 160 °C.

(e) *Mixing Asphaltic Concrete*

The mixing plant shall be so coordinated and operated as to consistently produce asphaltic concrete mixes within the tolerances prescribed in this Specification, all to the satisfaction of the S.O.

Mixing in Batch Plants

For each batch the screened hot aggregates shall be weighed out into the aggregate weigh hopper in accordance with the proportions prescribed in the appropriate job mix formula; the sequence of weighing out shall commence with the largest sized aggregate and progress down to the fines, unless the S.O. shall otherwise approve. Mineral filler shall be weighed out into the filler weigh hopper, where this is provided, or added last to the aggregate weigh hopper, in accordance with the job mix formula proportions.

The hot binder shall be weighed out into the binder weigh bucket in accordance with the proportions prescribed in the job mix formula.

The hot aggregates and filler shall be discharged into the pugmill and mixed dry for the dry

mixing time prescribed in the job mix formula, which shall usually be in the range 5 to 10 seconds. The hot binder shall then be added, and wet mixing performed for the wet mixing time prescribed in the job mix formula; this shall be sufficient so that all particles of aggregate are uniformly coated with bitumen, and shall usually be 45 seconds or more for dense graded mixtures.

The volume of each batch shall be such that the tips of the pugmill paddle blades just break out of the mixture at the height of their action.

After the completion of wet mixing, each batch of asphaltic concrete shall be discharged from the pugmill either into a storage hopper or directly into a truck for hauling to the paving site. Care shall be taken that no segregation of the mix occurs.

Mixing in Continuous Mix Plants

The screened hot aggregates and filler shall be fed continuously from their storage bins in accordance with the proportions prescribed in the appropriate job mix formula, combined in the plant, and fed continuously into the mixer. The hot binder shall be sprayed on to the combined aggregate as it enters the pugmill at the rate required to achieve the bitumen content prescribed in the job mix formula. The materials shall then be carried through the pugmill and in the process be thoroughly mixed by the action of the paddles and discharged over the dam into the storage hopper. The mixing time (as defined in Section 3.20 (Asphaltic Concrete)) shall be as prescribed in the job mix formula; this shall be sufficient so that all particles of aggregate are uniformly coated with bitumen, and shall usually be 45 seconds or more for dense graded mixtures.

The plant shall be so adjusted as to maintain the level of mixture in the pugmill such that the tips of the paddle blades just break out of the mixture at the height of their action.

(f) *Transportation of Asphaltic Concrete*

Asphaltic concrete shall be transported from the mixing plant to the site of the paving works in loads of not less than 5 tonnes using tip-trucks as specified in Section 3.20 (Asphaltic Concrete). Except where asphaltic concrete is to be hand laid, it shall be discharged directly into the paver hopper, as required, from the tiptrucks. Care shall be taken in the truck loading, hauling and unloading operations to prevent segregation of the mix. During transportation, the asphaltic concrete shall be protected from contamination by water, dust, dirt and other deleterious materials.

The temperature of asphaltic concrete immediately before unloading from the truck either into the paver hopper or on to the road for hand spreading shall be not less than 125 °C. Any load which has cooled below the specified temperature in the truck shall be rejected for use in the Works and removed from the Site of the Works.

(g) *Laying Asphaltic Concrete*

The sequence of laying operations shall be planned in advance by the Contractor and approved by the S.O. Generally each paving layer shall have a compacted thickness of not less than twice the nominal maximum aggregate size of the mixture, and not more than 100 mm. Where applicable, e.g. on superelevated sections and on carriageways with cross-slope in one direction only, laying shall commence along the lower side of the carriageway and progress to the higher side. Laying shall not be carried out in a downhill direction along any section of road.

As far as is practicable, laying shall be carried out using a paver approved by the S.O. Hand-

casting of bituminous mix on to the machine finished surface shall be kept to the practicable minimum necessary for correcting blemishes and irregularities. In any areas inaccessible to the paver, laying shall be carried out by hand methods using rakes, lutes and other hand tools, all to the satisfaction of the S.O. All laying of bituminous mix shall be such that after compaction by rolling the specified course or layer thickness and surface profile shall be achieved. Care shall be taken to achieve a uniform surface texture free from indentations, ridges, tear marks or other irregularities, and to prevent segregation of the mix.

At the commencement of initial rolling the temperature of asphaltic concrete shall be not less than 110 °C. Material which has cooled below the specified temperature before laying shall not be used and shall be removed from the Site of the Works. The Contractor shall provide accurate thermometers at the paving site at all times, and shall check the temperature of asphaltic concrete in the paver hopper at regular intervals and before laying restarts after each interruption of the paving operation.

As far as is practicable, the paver shall be operated continuously and the supply of bituminous mix shall be regulated so as to enable continuous paving. Transverse joints in a paving lane shall be kept to a practicable minimum, and intermittent stopping and restarting of the paver shall be avoided as far as is practicable.

Care shall be taken that no bituminous mix is placed on expansion joints at bridges, inspection covers for utilities ducts, drainage and sewerage manholes and the like, and that catch pits, drainage openings through kerbs, etc., remain properly open and serviceable. During laying operations, such areas and openings shall be protected by suitably shaped and secured boards or other materials approved by the S.O., and compaction of mix in the immediately surrounding or adjacent areas shall be completed by hand methods, all to the satisfaction of the S.O. Alternatively, bituminous mix shall be laid and compacted by hand methods as necessary around surfacing discontinuities of these types, all to the satisfaction of the S.O.

(h) *Construction Joints*

Existing bituminous surfacing which new bituminous mix is to adjoin shall be cut back to present a straight, vertical edge not less than 25 mm deep and a smooth transition section not less than 0.5 metre long against which to lay the new material. The specified thickness of the new surfacing shall be built up gradually from the vertical joint to avoid any bumps or ridges across the carriageway.

Where longitudinal or transverse joints are required in a layer of bituminous mix under construction, the material first laid and compacted shall be cut back to a vertical face for the full thickness of the layer on a line satisfactory to the S.O. before the adjacent area is paved.

At all construction joints, a thin uniform coating of bitumen emulsion of grade RS-1 or RS-1K shall be brushed on to the vertically cut joint faces some 10 to 15 minutes before laying the next section of bituminous mix commences to ensure good bonding. Also, all contact surfaces of kerbs, gutters, manholes, catchpits, etc., shall be similarly treated with a coating of bitumen emulsion before bituminous mix is placed against them.

Construction joints in a layer of bituminous mix shall be offset from those in any immediately underlying bituminous layer by at least 100 mm for longitudinal joints and at least 0.5 metre, where possible, for transverse joints.

(i) *Compaction of Asphaltic Concrete*

For each layer of asphaltic concrete, compaction by rolling shall commence as soon after laying as the material will support the rollers without undue displacement; nevertheless the temperature of asphaltic concrete at the commencement of rolling shall be not less than 110 °C.

In any areas inaccessible to the rollers, proper compaction shall be carried out using vibrating plate compactors, hand tampers or other suitable means, all to the satisfaction of the S.O.

Initial (or breakdown) rolling shall be carried out with an approved steel wheeled tandem roller or three wheeled steel roller. The principal heavy rolling shall be carried out with an approved pneumatic tyred roller immediately following the initial rolling; the pneumatic tyred roller shall be ballasted to an operating weight of not less than 15 tonnes and its tyre inflation pressure shall be not less than 0.7 N/sq.mm. The final rolling shall be carried out with an approved steel wheeled tandem roller and shall serve to eliminate minor surface irregularities left by the pneumatic tyred roller.

All rollers shall operate in a longitudinal direction along the carriageway with their driven wheels towards the paver. Rolling shall generally commence at the lower edge of the paved width and progress uniformly to the higher edge, except that where there is a longitudinal construction joint at the higher edge, this shall be rolled first ahead of the normal pattern of rolling. Generally, successive roller passes shall overlap by half the width of the roller, and the points at which the roller is reversed shall be staggered. However, when operating on gradients in excess of 4%, the breakdown roller shall not pass over any previously unrolled mix when operating in the downhill direction.

(j) *Sampling and Testing*

Samples of freshly mixed asphaltic concrete material shall be taken in the first two hours and every two hours thereafter to determine aggregate grading and binder content. If any of these test show results which are not in accordance with the approved job mix formulated within permissible tolerances set forth in Table 4.11 suitable adjustments shall immediately be made to ensure compliance therewith. Samples of the mixed material shall be taken twice a day for making Marshall specimens to determine stability, flow and unit weight. All sampling and testing required shall be undertaken by the Contractor. The S.O. will also carry out such testing as he considers necessary to ensure compliance with the Specification.

(k) *Asphaltic Concrete Overlay*

The minimum thickness of asphaltic concrete wearing course overlay at any place shall not be less than the required thickness as specified or shown on the Drawings. The overlay at the edge and at expansion joint shall be finished in a neat and workmanlike manner as in accordance to the Specification or as directed by the S.O. The top surface of the overlay shall have the required shape, superelevation, levels and grades and shall be everywhere within the tolerances specified in Specification Section 3.20 (Horizontal Alignment, Surface Levels and Surface Regularity of Pavement Course).

The existing bituminous surfacing to be overlaid shall have been scarified, cut-back, make good, cleaned and prepared as in accordance with the appropriate sections of this Specification and a bituminous tack coat applied on it, all in accordance with the provisions of Specification 3.20 (Bituminous Tack Coat)

Bituminous Macadam

Description

This work shall consist of furnishing, placing, shaping and compacting bituminous macadam roadbase and/or levelling course and/or binder course and/or wearing course on a prepared and accepted bituminous or bitumen primed pavement course, and shall include the careful and thorough cleaning of surfaces which are to be covered without receiving a bituminous tack coat. The work shall be carried out all in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

Materials

The materials for bituminous macadam (aggregates, mineral filler, bituminous binder and anti-stripping agent) shall comply with all the requirements of Section 3.20 (Asphaltic Concrete) except for the combined gradation requirements.

For each bituminous macadam mix, the gradation of the combined coarse and fine aggregates, together with ordinary Portland cement added as an adhesion and anti-stripping agent and, if necessary, any other mineral filler, shall conform to the appropriate envelope given in Table 4.12. The binder content shall also be in accordance with Table 4.12.

Where the characteristics of the aggregates require a binder content other than that given in the above Table, the revised target binder content shall be agreed between the Contractor and the S.O. and the same tolerances shall apply.

Equipment

The equipment shall be all as specified in Section 3.20 (Asphaltic Concrete)

Construction Methods

All the provisions of Section 3.20 (Asphaltic Concrete) for the construction of asphaltic concrete pavement courses shall apply as appropriate to the construction of bituminous macadam pavement courses with the following variations and additions.

(a) *Aggregate Heating*

The aggregates shall be dried and heated so that when delivered to the mixer they shall be at a temperature in the range 140 °C to 160 °C.

(b) *Rolling Temperature*

The temperature of bituminous macadam at the commencement of rolling shall be not less than 100 °C.

(c) *Compacted Density*

The compacted density of bituminous macadam shall be as follows :-

<u>Type of Pavement Layer</u>	<u>Required Compacted Density</u>
Bound roadbase	90 - 100% Marshall density
Levelling course	90 - 100% Marshall density
Binder course	90 - 100% Marshall density
Wearing	90 - 100% Marshall density

The Marshall density of a bituminous macadam mix is defined as the average density of a set of three test specimens moulded in the same way as asphaltic concrete specimens are prepared for the standard stability and flow test in accordance with AASHTO Test Method T 245 using the 75 blows per face compaction standard. The bulk specific gravity of the specimens shall be determined in accordance with AASHTO Test Method T 166.

The Marshall density of each mix shall be determined using a sample (or samples) taken from the mixing plant soon after the commencement of preparing each mix for the Works.

(Note: Stability and flow tests are not normally required for bituminous macadam mixes.)

(d) *Finished Bituminous Macadam*

Bituminous macadam roadbase shall be finished in a neat and workmanlike manner; its width shall be everywhere at least that specified or shown on the Drawings on both sides of the centre-line; and its average thickness over any 100 metre length shall be not less than the required thickness. The top surface of bituminous macadam roadbase shall have the required shape, superelevation, levels and grades, and shall be everywhere within the tolerances specified in Section 3.20 (Surface Levels Of Pavement Course)

Bituminous macadam levelling course shall be finished in a neat and workmanlike manner; its dimensions shall be as specified or shown on the Drawings or as directed by the S.O., all to the satisfaction of the S.O. The top surface of bituminous macadam levelling course shall have the required shape, super elevation, levels and grades, and shall be everywhere within the tolerances for binder course specified in Section 3.20 (Horizontal Alignment, Surface Levels and Surface Regularity of Pavement Courses)

Bituminous macadam binder and wearing courses shall be finished in a neat and workmanlike manner; their widths shall be everywhere at least those specified or shown on the Drawings on both sides of the centre-line; the average thickness over any 100 metre length shall be not less than the required thickness, and the minimum thickness at any point shall be not less than the required thickness minus 5 mm. The top surface of a wearing or binder course shall have the required shape, superelevation, levels and grades, and shall be within the tolerances specified in Section 3.20 (Horizontal Alignment, Surface Levels and Surface Regularity of Pavement Courses)

TABLE 4.12 - GRADATION LIMITS AND BINDER CONTENTS

FOR BITUMINOUS MACADAM

Mix Type	Bound Roadbase	Bound Roadbase	Levelling Course	Binder Course	Binder Course	Wearing Course	Wearing Course
Mix Designation	BMR40	BMR28	BML10	BMB28	BMB20	BMW14	BMW20
B.S. Test Sieve	% Passing By Weight						
50.0 mm	100	-	-	-	-	-	-
375 mm	95 - 100	100	-	100	-	-	-
28.0 mm	70 - 94	90 - 100	-	90 - 100	100	-	100
20.0 mm	-	71 - 95	-	71 - 95	95 - 100	100	95 - 100
14.0 mm	56 - 76	56 - 80	100	58 - 82	65 - 85	95 - 100	65 - 85
10.0 mm	-	-	85 - 100	-	52 - 72	70 - 90	52 - 72
6.3 mm	44 - 60	44 - 60	30 - 60	44 - 60	39 - 55	45 - 65	39 - 55
3.35 mm	32 - 46	31 - 45	15 - 25	32 - 46	32 - 46	30 - 45	32 - 46
1.18 mm	-	-	-	-	-	15 - 30	-
300 um	7 - 21	7 - 21	-	7 - 21	7 - 21	-	7 - 21
75 um	2 - 8	2 - 8	2 - 6	2 - 8	2 - 8	3 - 7	2 - 8
Binder Content	$3.5 \pm 0.5\%$	$4.0 \pm 0.5\%$	$5.1 \pm 0.5\%$	$4.7 \pm 0.6\%$	$4.7 \pm 0.6\%$	$5.0 \pm 0.5\%$	$4.9 \pm 0.5\%$

SHOULDERSDescription

This work shall consist of furnishing, compacting and shaping earth or gravel shoulder material on a prepared and accepted subbase or lower subbase or subgrade, all in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and/or as required by the S.O.

For paved shoulders, the bituminous surfacing and underlying pavement courses shall be constructed as described in the appropriate Sections of this Specification.

MaterialsEarth Shoulders

Earth shoulder material shall be suitable material as described in Section 3.2.

Gravel Shoulders

Gravel shoulder material shall conform to the requirements for gravel surfacing material set forth in Section 3.20 (Gravel Surfacing)

Construction Methods

Shoulders shall be constructed in stages or in one operation as directed or approved by the S.O., but in no instance shall a shoulder be built up to a level higher than that part of the abutting carriageway structure which has been completed and accepted.

Prior to placing any shoulder material, the underlying subbase or lower subbase or subgrade

shall have been shaped and compacted in accordance with the provisions of Section 3.20 (Subbase), and the abutting carriageway structure course or courses shall likewise have been shaped and compacted in accordance with the provisions of the appropriate Sub-Section or Sub-Sections of this Specification. Notwithstanding any earlier approval of the underlying and abutting pavement courses, any damage to or deterioration of these underlying and abutting pavement courses shall be made good to the satisfaction of the S.O. before shoulder construction proceeds.

Shoulders shall be placed to the required width and thickness as shown on the Drawings or directed by the S.O. in one layer or more, each layer not exceeding 200 mm compacted thickness at the point of maximum thickness. Where two or more layers are required they shall be of approximately equal shape and thickness, and none shall be less than 100 mm compacted thickness at the point of maximum thickness.

Each layer of shoulder material shall be processed as necessary to bring its moisture content to a uniform level throughout the material suitable for compaction, and shall then be compacted using suitable compaction equipment approved by the S.O. to not less than 95% of the maximum dry density determined in the B.S. 1377 Compaction Test (4.5 kg fammer method). Compaction shall be carried out in a longitudinal direction along the shoulder and shall generally begin at the outer edge and progress uniformly towards the carriageway, except on superelevated curves where rolling shall begin at lower edge and progress uniformly towards the higher edge. In all cases, compaction shall be carried out in such a manner that each section receives compactive effort appropriate to its thickness, all to the satisfaction of the S.O.

Throughout the placing, adjustment of moisture content and compaction of shoulder material, care shall be taken to maintain a uniform gradation of the material and prevent its separation into coarse and separate parts, all to the satisfaction of the S.O.

Where shown on the Drawings or directed by the S.O., earth shoulders shall be turfed in accordance with Section 3.2 (Turfing).

Shoulders shall be finished in a neat and workmanlike manner. The total width of carriageway and shoulder shall be everywhere at least that specified or shown on the Drawings on both sides of the centre-line. The top surface of each shoulder shall have the required shape, superelevation, levels and grades, shall be everywhere within 10 mm of the required plane, and shall provide a flush joint with the carriageway surface and shall be uniformly free draining away from the carriageway, all to the satisfaction of the S.O.

HORIZONTAL ALIGNMENT, SURFACE LEVELS AND

SURFACE REGULARITY OF PAVEMENT COURSES

Horizontal Alignment

The horizontal alignment shall be determined from the centre-line of the pavement surface shown on the Drawings. The edges of the pavement as constructed and all other parallel construction lines shall be correct within a tolerance of + 50 mm and minus 0 mm from the centre-line, except for kerbs, channel blocks and edge lines which shall be laid with a smooth alignment within a tolerance of + 25 mm and minus 0 mm from the centre-line as to avoid kink.

Surface Levels of Pavement Courses

The design levels of pavement courses shall be calculated from the vertical profile, crossfall and pavement course thicknesses shown on the Drawings. The level of any point on the constructed surface of a pavement course shall be the design level subject to the appropriate tolerances given in Table 4.13.

The combination of permitted tolerances in the levels of different pavement courses shall not result in a pavement thickness less than that shown on the Drawings. Each pavement course shall have an average thickness not less than that shown on the Drawings.

The finished surface level of the laid wearing course shall not deviate vertically at any point from the true pavement surface by more than ± 6 mm.

However, the combination of permitted tolerances in the levels of different pavement courses shall not result in a reduction of the wearing course thickness by more than 5 mm from that specified for a flexible road nor a reduction in the thickness of the whole pavement, excluding the sub-base by more than 15 mm from the specified thickness.

For checking compliance with Table 4.13, measurements of surface levels shall be taken at a grid of points at 10 metre centres longitudinally, and at 2 metre centres transversely starting one metre from the edge of the pavement. At junctions the grid point spacing shall be agreed with the S.O. In any length of pavement compliance with the requirements of Table 4.13 shall be regarded as met when not more than one measurement in ten exceeds the tolerances permitted in Table 4.13 but this one measurement shall not exceed 5 mm more than the tolerance for the layer concerned.

TABLE 4.13 - TOLERANCES IN SURFACE LEVELS OF

PAVEMENT COURSES

Pavement Course	Tolerance
Binder Course	± 6 mm
Binder Course	± 6 mm
Bituminous Roadcourse	± 12 mm
Non Bituminous Roadcourse	± 15 mm
Subbase and Lower Subbase	± 15 mm - 20 mm
Formation	+ 20 mm - 30 mm

Surface Regularity

The regularity of surfaces shall be within the relevant limits given in Table 4.14.

A longitudinal irregularity is a variation in profile of the road surface as measured by the rolling straight-edge or wedge and straight-edge device. The permissible number of such longitudinal irregularities is indicated in Table 4.14.

The traverse length of 300 m and its associated maximum permissible number of irregularities shall apply wherever the continuous length of the completed carriageway is 300 m or more, whether or not it is constructed in shorter lengths.

Where the total length of pavement is less than 300 m the measurements shall be taken on 75 m lengths.

The transverse regularity of a newly laid surface shall be measured with a 3 m straight-edge and shall have no greater depression under the straight-edge than that shown in Table 4.14.

Compliance with Table 4.14 shall be tested by a rolling straight edge of the type designed by the British Transport and Road Research Laboratory or an approved wedge and straight edge device operated parallel to the centreline of the pavement and 1.2 metres from the near side edge of each lane of the pavement.

Pavements shall be measured transversely for irregularities at points decided by the S.O. by a 3.0 m long straight edge placed at right angle to the centreline of the road.

For lengths less than 75 m of wearing courses, basecourse and concrete pavement, or where the use of the rolling straight edge is impracticable, the surface regularity shall be tested where necessary at points decided by the S.O. with a straight edge 3.0 m long placed parallel with or at right angle to the centreline of the road. The maximum allowable deviation of the surface below the straight edge shall be :-

For pavement surfacing : 3 mm

For basecourse surfacing : 6 mm

TABLE 4.14 - TOLERANCES FOR SURFACE IRREGUIARITIES

Class of Surface Regularity	Longitudinal Direction				Transverse Direction
	Maximum Permissible Number of Surface Irregularities				Maximum Permissible Depth of Transverse Irregularities
	Depth Exceeding 4 mm		Depth Exceeding 7 mm		
	over traverse length of 300 m	over traverse length of 75 m	over traverse length of 300 m	over traverse length of 75 m	
Class SRI	20	9	2	1	4 mm
Class SR2	40	18	4	2	8 mm
Class SR3	60	27	6	3	12 mm
No longitudinal irregularity exceeding 10 mm shall be permitted for Class SRI Surface Regularity and no longitudinal irregularity exceeding 15 mm shall be permitted for Class SR2 and Class SR3 Surface Regularities.					
The class of Surface Regularity for each portion of the Works shall be as stated on the Drawings or in the Bills of Quantities.					

Rectification

Where any tolerance is exceeded the Contractor shall determine the full extent of the area which is out of tolerance and shall make good by rectifying the surface of the pavement course or formation in the manner described below :-

(a) Formation Level

If the surface is too high it shall be trimmed and recompactd in accordance with the requirements of the Contract. If the surface is too low the deficiency shall be corrected by the addition of fresh suitable material of the same classification laid and compacted to Specification.

(b) Roadbase and Subbase

Where these consist of unbound material the top 75 mm shall be scarified, reshaped with added material as necessary and recompactd all to the Specification. The area treated shall not be less than 30 metres long and 2 metres wide or such other area to be determined by the S.O. as necessary to obtain compliance with the Specification.

Coated macadam roadbase shall have the full depth of the top layer removed and replaced with fresh material laid and compacted to the Specification. Any area so treated shall be at least 5 metres long and not less than one lane wide.

Alternatively, for low area in flexible pavement the Contractor may at his own expense and only with the S.O. approval make up low area with the material of the layer immediately above the one being rectified, when the subsequent layer is laid.

(c) Basecourse and Wearing Course

These shall have the full depth of the layer removed and replaced with fresh material laid and compacted to the Specification.

Where the surface level is too high or too low the area rectified shall not be less than one lane wide and at least 5 metres long if basecourse or 15 metres long if wearing course.

Where the number of surface irregularities exceed the limits in Table 4.14 the area to be rectified shall be 300 metres or 75 metres long as appropriate and not less than one lane wide, or such less length to be determined by the S.O. as necessary to make the surface regularity conform with the limits.

Testing of the wearing course for compliance with Table 4.13 and Table 4.14 shall be carried out as soon as practicable after completion of the surfacing, and remedial works completed before the road is opened to traffic.

(d) Concrete Slab

Concrete slab shall be rectified by grinding or bump cutting using saws. Large depressions which cannot be dealt with this way shall be rectified by cutting out the surface and replacing by a thin bonded surface repair to the extent required by the S.O.

Retexturing of bump cut area shall be carried out by sawing grooves in accordance with the Specification. Texturing replaced surfaces shall be by brushing in accordance with the Specification. Remedial works involving the placing of fresh concrete shall be completed at least 20 days before that section of the Works is opened to traffic.

TRANSPORTING, LAYING AND COMPACTING OF ROAD PAVEMENT MATERIALS CONTAINING BITUMEN BINDER

Bituminous materials shall be transported in clean vehicles and shall be covered over when in transit or awaiting 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.

The mixed material shall, as soon as possible after arrival at the Site be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be so regulated as to enable the paver to be operated continuously and it shall be so operated whenever practicable.

Road pavement materials having bitumen as the binder shall be spread, levelled and tamped by approved self propelled pavers, capable of laying to the required widths, profile, camber or crossfall. The rate of travel of the paver and its method of operation shall be adjusted to ensure an even and uniform flow of material across the full laying width, freedom from dragging or tearing of the material and minimum segregation.

The surface on which the material is to be laid shall be cleaned to the satisfaction of the S.O.

Hand laying of any bituminous material shall be permitted only in the following circumstances :

- (i) for laying regulating course of irregular shape and varying thickness in small areas;
- (ii) in confined space where it is impracticable for a paver to operate;
- (iii) at the approach to expansion joints at bridges.

Hand raking of wearing course material which has been laid by a paver and the addition of such material by hand spreading to the paved area for adjustment of level shall be permitted only in the following circumstances:

- (i) at the edge of the layer of material and at gullies and manholes;
- (ii) at the approach to expansion joints at bridges;
- (iii) where otherwise agreed by the S.O.

Material shall be compacted as soon as rolling can be effected without causing undue displacement of the mixed material and while this has at least the minimum rolling temperature specified. The material shall be uniformly compacted.

CORRUGATED SHEET STEEL BEAM HIGHWAY GUARDRAILDescription

This work shall comprise the supply and installation of corrugated sheet steel beam highway guardrails inclusive of bolts, nuts, posts and other ancillary works, all in accordance with this Specification, and the Drawings, and as directed by the S.O.

MaterialsBeam Element

Unless otherwise specified on the Drawings, corrugated sheet steel beam highway guardrails shall conform to the requirements of AASHTO Specification M180 for Class 'A' Type II (galvanised) guardrail with effective length of beam 3810 mm (12 feet 6 inches). Guardrails shall be fabricated and furnished complete with terminal or buffer sections, connecting and splicing bolts, nuts and washers, etc., all conforming to the requirements of AASHTO Specification M180 and as necessary for erecting the guardrails as shown on the Drawings or as required by the S.O.

Steel Posts

Steel posts shall be channel sections of dimensions as shown on the Drawings and the material shall conform to B.S. 449 Part 1 Grade 43. The block-out pieces, if used, shall be channel sections of dimensions as shown on the Drawings and shall be of the same material as that used for the posts. Both the posts and block-out pieces shall be hot-dip galvanised in accordance with Section 3.20 (Beam Element)

Installation of GuardrailsSetting Post

Before posts are erected, the alignment and finished levels of the guardrails shall be set accurately on site for approval by the S.O.

Post holes at the correct positions shall be dug either manually or mechanically to the required level. The posts shall then be set plumb in the holes with the front face forming a smooth line to the approval of the S.O. After the posts are in place, the holes shall be backfilled with grade 20/20 concrete compacted in such a manner as not to displace the posts from correct alignment as shown on the Drawings. Posts may be installed by means of driving with suitable equipment if the S.O. is satisfied that the Contractor is capable of installing the post to the designed depth, line and level, accurately.

Posts shall be spaced as indicated on the Drawings.

Pacing Beams

The guardrail beams shall be fixed and firmly bolted together with the black out pieces on to the post to the lines and grades as shown on the Drawings, and as directed by the S.O.

Auchorages

Anchorages shall be constructed as shown on the Drawings and as directed by the S.O.

Marking and Storage

Marking

Marking shall be in accordance to the contract and as directed by the S.O.

Storage

All galvanised beam elements, terminal sections, bolts, nuts and washers and posts shall be stored under a cover that will protect them from rain until they are erected or used. While in storage, the material shall not be in direct contact with the soil and there shall be a minimum space of 300 mm between the lowest most elements and the ground surface.

Basis of Acceptance

Beam Elements

All material shall be subjected to inspection and sampling in accordance with AASHTO Specification M180 at a sampling rate of 1 in every 200 or as directed by the S.O.

The Contractor shall provide and arrange the testing facilities and the test pieces as and when requested by the S.O. The cost of all sampling and testing shall be borne by the Contractor. If, in the subsequent installation, there is detection of non-compliance with the requirements of this Specification through random sampling carried out by the S.O., then the material of the lot will be rejected and the Contractor shall remove the same from the Site at his own cost.

Steel Posts and Block-Outs

For each lot of 200 pieces or less of either steel posts or steel block-outs supplied to the Site, the Contractor shall submit certificates from an approved testing laboratory certifying compliance with the properties required and the mill certificate. However, the S.O. reserves the right to conduct further tests on the materials supplied.

The Contractor shall provide and arrange the testing facilities and test samples at his own expense as and when instructed by the S.O. The steel which has been rejected by the S.O. shall be removed from the Site.

Protection Against Corrosion

Individual sections of the columns, base-plates, doors and bracket arms shall be protected against corrosion by hot-dip galvanizing the sections both internally and externally, all in accordance with B.S. 729. All welding works shall be completed before galvanizing.

Treatment prior to galvanizing shall include degreasing, rinsing, pickling, further rinsing and fluxing.

The galvanized columns and bracket arms shall be of prime finish and of good uniformity, i.e. they shall be free from injurious defects such as blisters, flux and uncoated spots.

The planted section of columns and the base-plates shall be factory-coated with bitumen using the hot-dipping process conforming to AASHTO M 190.

TRAFFIC SIGNS

Description

This work shall consist of the supply, assembly, erection and installation of sign faces, sign plates, posts and backing frames, all in accordance with the details shown on the Drawings and as specified herein. It shall include all excavation and backfilling, all necessary foundations, anchorages, fixtures and fastenings, brackets, lighting units and electrical installations where required, application of paints and finishes, etc., to complete the work all to the satisfaction of the S.O.

Sign Definitions

For the purpose of this Specification, traffic signs are defined as follows :-

- i) Non-illuminated signs are those signs which are not lit either internally or externally and shall be retro-reflective;
- ii) Externally illuminated signs are those which comprise either retro reflective or non-retro-reflective facing with external lighting luminaire.

Sign Classification

For the purpose of this Specification, the following classifications shall apply :-

(a) *Permanent Traffic Signs*

Any of the traffic signs defined in Section 3.20 (Sign Definitions) above or any part thereof as designated on the Drawings or as directed by the S.O. to remain in position upon completion of the Works.

(a) *Temporary Traffic Signs*

Any of the traffic signs defined in Section 3.20 (Sign Definitions) above or any part thereof designed by the Contractor with the approval of the S.O. which will not remain in position at the completion of the Works.

Standard

All traffic signs shall, except where specified otherwise, comply with the requirements of ARAHAN TEKNIK (JALAN) Series 2, published by Cawangan Jalan, Ibu Pejabat JKR, Kuala Lumpur.

Permanent Traffic Signs

General Requirements

Permanent traffic signs shall be constructed, assembled, located and erected as shown on the Drawings or as directed by the S.O.

Each complete traffic sign or part thereof shall be capable of passing the tests specified in B.S. 873.

All externally illuminated traffic signs shall comply with Category 1 luminance of B.S. 873 unless otherwise shown on the Drawings.

Before the commencement of fabrication of any traffic sign, unless otherwise shown on the Drawings, the Contractor shall submit for the S.O.'s approval the details of fabrication drawings for all signs.

All traffic sign housings shall be provided with vandal and weather resistant locks. Keys, in the quantities determined by the S.O., shall be provided to the S.O. Types of lock shall be kept to a minimum.

Traffic signs shall be carefully handled to prevent damage (methods shall include the use of proper slings), and shall be transported and stored in accordance with the manufacturer's instructions.

Foundations

The type and size of foundations for permanent traffic signs shall be as shown on the Drawings and, unless otherwise stated therein, shall comply with this Specification.

All excavations, erection of formworks, placing of reinforcement, etc., for foundations shall be carried out in compliance with this Specification and shall be approved by the S.O. before placing of concrete and backfilling.

Unless otherwise shown on the Drawings, signs supported by a single post placed in the ground shall have the post installed centrally in 300 mm diameter holes filled with grade 20/20 concrete complying with Section 3.3 of this Specification to within 450 mm of the ground surface. The hole shall be excavated either mechanically or manually.

Posts shall be supported for a minimum of three (3) days after placing the concrete. Backfilling shall not take place until at least 48 hours after placing the concrete, or other period agreed by the S.O.

Where signs are illuminated, provision shall be made for cable entry through the foundation by means of ducting as shown on the Drawings.

Where pockets are formed in concrete foundations their plan dimensions shall be 100 mm larger than those of the post.

All backfilling of foundation pits and reinstatement of existing surfaces above the foundations shall comply with the relevant requirements of this Specification.

Posts

Posts for permanent traffic signs shall be as shown on the Drawings and shall comply with B.S. 873.

Posts shall be of tubular hollow section steel of not less than 50 mm outside diameter complying with B.S. 1387.

Unless otherwise shown on the Drawings, posts shall not protrude above the top of the sign unless supporting an external luminaire where the protrusion shall be kept to a minimum.

Signs erected on a single post shall be positioned so that the post is in the centre of the sign, unless otherwise shown on the Drawings.

Compartments for electrical equipment shall be as shown on the Drawings. In the case of signs supported by more than one post, such compartments shall be on the post furthest from the carriageway unless otherwise directed by the S.O.

Flange plates shall have holes or slots as shown on the Drawings to accommodate any holding down bolts.

Sign Plates

All permanent sign plates shall be as shown on the Drawings and shall comply with B.S. 873. Sign plates shall be made of 10 S.W.G. sheets of aluminium alloy HS 30-WP conforming to B.S. 1470 with a minimum thickness of 3 mm.

A sign plate not exceeding 1.2 m in height and 2.4 m in width shall be made from a single sheet.

Where more than one sheet is used to make up a sign plate, the sheets shall be rectangular, of approximately the same size and shape, and the position of the joints shall be to the approval of the S.O.

Sign plates shall be drilled at all locations where rivets or bolts are required for attaching the plate to the backing frame or fixings before application of the sign face. However, riveting shall be carried out only after the application of the sign face.

Subject to the S.O.'s approval, double sided "Very High Bond" (V.H.B.) tapes may be used as an alternative to rivets. Nevertheless, the tape shall comply with the following requirements :-

- i) Peel Adhesion - 440 N per 100mm;
- ii) Tensile Adhesion - 910 kPa;
- iii) Dynamic Shear - 550 kPa.

Where top and bottom light spill screens are required as shown on the Drawings, these shall extend for the whole width of the sign, be fabricated out of the same material as the sign plate and shall have corners cut to the same radius as the other corners of the sign plate.

Top and bottom light spill screens shall be considered part of the sign plate and any stiffeners and mounting fittings shall be designed to accommodate the combined size.

Sign Faces

Sign faces for permanent traffic signs shall be as shown on the Drawings and shall comply with the 'Draft Malaysian Standard Specification for Reflective Sign Face Materials' (SIRIM Reference D111 [ISCF]), and on replacement of this draft, the respective Malaysian Standard Specification.

All retro-reflective plastic sheeting shall be fixed in accordance with the manufacturer's instructions.

Unless otherwise agreed by the S.O., sign faces shall be formed from a single piece of plastic sheeting.

Where, with the agreement of the S.O., more than one plastic sheet is used, the number of sheets shall be kept to a minimum. All faces up to 1 m in size shall be produced with a single sheet and no joint will be accepted.

Only vertical and horizontal joints shall be permitted and all joints in plastic sheeting shall be overlapped by not less than 6 mm. The overlap in the horizontal joints shall be from the top and the vertical joints shall be from the left; butt joints in plastic sheeting will not be accepted. Plastic sheeting shall be applied evenly over the whole surface of the sign plate and shall adhere fully. It shall be free from twists, cracks, folds or cuts, air bubbles and air blemishes.

All plastic sheetings used on the same sign shall be carefully matched for color to produce a uniform appearance both by day and by night. Non-uniform shades of color on anyone sign will not be accepted.

The edges of all plastic sheeting shall be sealed. Edge sealing shall be continuous and uniform and shall also be applied to all bolt and rivet holes.

A coat of clear lacquer shall be applied to the whole of the face and edges of each finished sign plate at the time of fabrication. The lacquer shall be continuous and uniform and shall be of the type specified or supplied by the manufacturer of the sheeting material.

Where sheeting is applied to extruded sections by pressure roller, it shall extend over the top and bottom edges of these sections by not less than 3 mm.

Any cut-out letters, numerals, symbols and borders shall be of material compatible with the sheeting to which they are applied. They shall be applied in accordance with the sheeting manufacturer's instructions.

Screen processed letters, numerals, symbols and borders shall be screen printed with materials in accordance with the sheeting manufacturer's instructions. Any inks, pastes and finishing coats used shall be compatible with the sheeting material.

The finish of all sign faces shall be capable of passing the tests described in B.S. 873, and the standards of fabrication and workmanship shall be such that under normal conditions of service and proper maintenance, the sign faces shall last not less than 5 years without any serious blemishes or defects for Engineering Grade retro-reflective sheeting and 8 years for High Intensity retro-reflective sheeting. The Contractor shall furnish to the S.O. a letter of warranty for the specified period for all sign faces from the supplier of the sheeting or the sign fabricator.

Backing Frames

Backing frames for permanent traffic signs shall be as shown on the Drawings and shall comply with this Specification.

Signs exceeding 600 mm in height or width shall be stiffened by means of angles while signs exceeding 1m in height or width shall have as backing frame fabricated from 40 mm x 40 mm x 3 mm angles. The angles used for the backing frames shall be made from aluminium alloy HE9-TE conforming to B.S. 1474.

The angles shall be welded, bolted or riveted together to form the backing frames as shown on the Drawings.

Backing frames shall not project beyond the face of the sign.

Where large signs are built in sections, the backing frames of these sections shall be bolted together with 8 m diameter bolts at not more than 200 mm centres.

The details of joints between angles of the backing frame and of joints between sections of large signs shall be to the approval of the S.O.

The sign plate shall be riveted or bonded with double sided V.H.B. tape to the backing frame after the application of the sign face.

Construction and Assembly

Traffic signs shall be constructed and assembled as shown on the Drawings and shall comply with B.S. 873.

All sign plates, backing frames, purlins, posts and other components shall be de-burred prior to assembly.

Where framing and stiffening are not an integral part of the sign plate, their joints shall be welded or joined with suitable brackets utilising nuts, bolts and washers.

Where purlins are adopted, they shall be attached to each vertical member of the backing frame and the sign stiffening and framing shall be continuous in the vertical direction. Unless otherwise permitted by the S.O., purlins shall be spaced equally apart. Connections shall be made at every point where a purlin crosses a post.

Where purlins are not adopted, the sign stiffening and framing shall be continuous in the horizontal direction.

All rivets and other devices used in the fixing of sign plates to their stiffeners or backing frames, or those used in the construction of housings, shall be of a material compatible with the materials being joined.

Spacing of rivets or other devices used in the fixing of sign plates to their stiffeners or backing frames shall be uniform and shall not exceed 150 mm around the outside edge of any sheet or section of a sheet, and shall not exceed 300 mm on cross braces. Hollow rivets shall be filled with a plastic plug flush with the head of the rivet.

An additional washer of neoprene, nylon or other material approved by the S.O. shall be used against the sign face to protect it from the effects of any metal nuts, bolts, washers and/or screws.

Where traffic signs, including external lighting luminaires or their supports, are required to have holding down bolt fixings, the bolts shall be lightly greased before final installation and they and their anchorages shall be installed so as to achieve the loadings, torque settings and requirements shown on the Drawings.

Sign plates shall be connected to posts by a method approved by the S.O.

Banding systems shall be of stainless steel.

Where ferrous components are permitted, any drilling of such components shall be completed before the application of any finish.

Any hole drilled to accommodate rivets or bolts in plates with plastic sheeting shall, immediately prior to the insertion of the rivet or bolt, have a clear lacquer, as recommended by the manufacturer of the plastic sheeting, applied to its edge to prevent the ingress of moisture. The surfaces of rivets or bolts exposed on the sign face shall be colored by a material approved by the S.O. to match that part of the face.

Traffic signs to be erected on road lighting columns shall have fixings compatible with the column cross-section and finish. Unless otherwise permitted by the S.O., columns shall not be drilled and wiring shall be contained in approved external conduits.

In addition to the requirements of this Specification, variable message traffic signs shall be of a type approved by the relevant authorities.

Location and Erection

The approximate location of each permanent traffic sign shall be as shown on the Drawings. All traffic signs shall have their exact location determined by the S.O. and recorded on the as-built Drawings.

All posts shall be erected plumb and where two or more posts are provided for any one sign, the face of the posts shall be lined up.

Signs erected on two posts shall have each post positioned so that the distance from the centre of the post to the edge of the sign plate is 300 mm unless otherwise directed by the S.O.

Any pockets formed in concrete foundations to receive the posts shall immediately prior to erection be cleaned out. The posts shall be placed centrally in the pockets and be bedded on and filled up to finished foundation level with grade 20/20 concrete.

Traffic signs mounted on gantries shall be erected as shown on the Drawings.

No traffic sign shall be dismantled, resited or removed without prior approval from the S.O.

Covering of Permanent Traffic Signs

Where it is required in the Contract that permanent traffic signs are to be blanked-out or are to have an alternative message, the covering to be adopted shall comply with the following requirements.

The covering shall be 1.5 mm (16 S.W.G.) thick made from a material compatible with that of the sign plate, or a material approved by the S.O.

Cover plates shall be fixed by means of 5 mm diameter stainless steel bolts, washers and nuts or non-ferrous rivets not more than 600 mm apart, the bolts passing through 12 mm diameter, 5 mm thick plastic distance pieces between the sign face and cover plate. Any holes remaining in the finished sign face shall be filled with blocked rivets colored on the face by methods approved by the S.O.

Where self-adhesive plastic rum is used, it shall be compatible with the sign face materials and be applied and removed in compliance with the manufacturer's instructions.

All loose covering used must be sufficiently opaque to prevent reflection from the covered sign and be securely fastened to the back of the sign. Under no circumstances shall tape or other adhesive material be applied to the face of the sign. A minimum space of 50 mm shall be left between the covering and the face to permit airflow over the sign.

Traffic signs which are to be covered shall not be erected on trafficked highways without the covering in place.

Removal of any covering shall be carried out with minimum disturbance to traffic and only after the S.O. has given his approval.

Irrespective of any requirement in the Contract to cover signs, any traffic sign erected at such a time that its legend does not relate either wholly or in part to the traffic movement and route in operation, shall have its sign face securely covered with one of the materials described above until such time as the S.O. authorises its removal.

Temporary Traffic Signs

Temporary traffic signs shall be constructed either as non-illuminated or externally illuminated signs as directed by the S.O.

Location and erection of temporary traffic signs shall be in accordance with ARAHAN TEKNIK (JALAN) 2C/85. Erection of temporary traffic signs mounted on posts shall comply with Section 3.20 (Location and Erection).

Any temporary covering of temporary traffic signs shall comply with Section 3.20 (Covering of Permanent Traffic Signs).

Removal of temporary traffic signs shall be carried out as soon as they become superfluous or a hazard to traffic. Methods of removal and making good shall be submitted to the S.O. for approval beforehand. Making good shall be carried out immediately after removal of the traffic sign to the satisfaction of the S.O.

Traffic Signs On Gantries

Where traffic signs are erected on gantries, the signs shall comply with the relevant requirements of this Specification.

Fabrication and construction of gantries shall be as shown on the Drawings and as directed by the S.O.

Preparation and Finish of Metal and Other Surfaces

Traffic Signs shall be prepared, protected against corrosion and finished in compliance B.S. 873.

Faces of sign plates shall be prepared to receive sign face materials in compliance with B.S. 873 and in accordance with the manufacturer's recommendations.

Steel backing frames, fittings and purlins shall be prepared and protected in compliance with B.S 873.

Steel posts and post housings shall be prepared and protected in compliance with B.S 873.

Backs of aluminium of aluminium alloy sheets forming plate signs and external parts of luminaire housings and other permanently exposed components shall, to prevent retro-reflection, be dulled with paint using a method approved by the S.O.

Ferrous steel shall be finished both inside and out by galvanising, electro-plating or application of zinc or aluminium spray or other equivalent finish approved by the S.O.

Aluminium and other metals shall be left untreated unless otherwise shown on the drawings.

Unless otherwise shown on the Drawings, stainless steel shall be left untreated except where the component is visible against the sign face when it shall be colored on the face by methods approved by S.O.

External surfaces shall be prepared and protected as described in the Contract. Cabinets and feeder pillars shall have final coats of paint applied on Site after final installation, including the fittings of any internal apparatus required as part of the permanent works. Internal surfaces shall, unless otherwise shown on the Drawings, received the same treatment as for external surfaces except the final paint coats shall be applied before internal components are installed.

ROAD MARKINGS

Description

This work shall consist of the supply of road marking material and its application to form continuous or intermittent lines, letters, arrows, symbols or figures. The markings shall be white or yellow laid to the dimensions and at the locations shown on the Drawings and as specified herein or as directed by the S.O. The work includes the supply of all labour, tools, equipment, materials, and warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work.

Road Marking Materials

The marking material shall be one of the types detailed below as indicated on the Drawings or as directed by the S.O.

(a) *Thermoplastic Material*

Thermoplastic material shall comply with the requirements of B.S. 3262 Part 1. Yellow thermoplastic material shall be of standard color B.S. 381C No. 356 (Golden Yellow).

(b) *Road Marking Paint*

Road marking paint shall comply with the requirements of M.S. 164. Yellow paint shall be of standard color B.S.381C No. 356 (Golden Yellow).

Preparation Of Site

Thermoplastic material and road marking paint shall be applied only on a surface which is clean and dry. It shall not be laid over loose detritus, mud or extraneous matter or over old material or paint marking incompatible with the paint being applied.

A tack coat compatible with the marking material shall be applied in accordance with manufacturer's instructions prior to the application of thermoplastic material.

If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration, the primer or undercoat shall be fully compatible with the marking paint and the road surface. The rate of application of tack coat, primer or undercoat shall be in accordance with the manufacturer's instructions and to the satisfaction of the S.O.

Preparation Of Material On Site

(a) *Thermoplastic Material*

Thermoplastic material shall be supplied in block or powder form. If the material is supplied in block form it shall be broken into pieces, each weighing not more than 4 kg, which shall be melted in a heater fitted with a mechanical stirrer to prevent local overheating.

A thermometer of sufficient accuracy shall be used during laying to ensure that overheating of the material does not occur.

Once molten hydrocarbon resins shall be used within 6 hours and wood and gum resins shall be used within 4 hours. The material shall not be heated beyond the manufacturer's specified temperature during application. Excess material shall be discarded on completion of application.

(b) *Road Marking Paint*

All paint shall be thoroughly stirred before application to keep the pigments in uniform suspension. The use of thinners or other additives shall not be permitted unless otherwise approved by the S.O.

Laying

Centre lines, lane lines and edge lines shall be marked by approved mechanical means or as directed by the S.O. Other markings shall be applied by brush, spray, screed, hand-propelled or self-propelled machine according to the marking configuration and the type of marking material approved for use. The rate of application of the marking material for each coat shall be that recommended by the manufacturer unless otherwise specified. When more than one coat is used, the succeeding coat shall not be applied until the previous coat has fully set.

Road markings of a repetitive nature other than centre lines, lane lines, etc., shall, unless otherwise decided by the S.O., be set out with stencils which comply with the size and spacing requirements as shown on the Drawings.

Protection Of Marking

All markings shall be protected from traffic until they have dried sufficiently so that no pick-up by vehicle tyre will occur.

Reflectorisation

Solid glass beads to be incorporated in marking materials prior to application to road surfaces shall be Class 'A' glass beads complying with the requirements of Table 1 of B.S. 6088 (see Table 6.1).

Solid glass beads for additional surface reflectorisation shall be Class 'B' glass beads complying with the requirements of Table 2 of B.S. 6088 (see Table 6.2).

Thickness

The determination of thickness shall be in accordance with B.S. 3262 Part 3, Appendices B and C.

TABLE 6.1 - CLASS 'A' GLASS BEADS : PARTICLE SIZE DISTRIBUTION, ROUNDNESS AND DEFECTS

B.S. Sieve		Percentage Retained	Min. % Spherical Beads by mass as tested in accordance with Appendix C	Max. % Defective Beads as tested in accordance with Appendix C
1.18	mm	0 to 3	70	30
850	mm	0 to 10		
425	um	90 to 100		

TABLE 6.2 - CLASS 'B' GLASS BEADS : PARTICLE SIZE DISTRIBUTION, ROUNDNESS AND DEFECTS

B.S. Sieve		Percentage Retained	Min. % Spherical Beads by mass as tested in accordance with Appendix C	Max. % Defective Beads as tested in accordance with Appendix C
850		0 to 5	80	20
800		5 to 20		
300		30 to 75		
180		10 to 30		
Below 180		0 to 15		

(a) *Thermoplastic Material*

Thermoplastic material shall be laid to the following thickness :-

- i) for synthetic hydrocarbon resin binder :
- Screed lines : not less than 2 mm nor more than 5 mm;
 - sprayed lines other than yellow lines: not less than 1.5 mm;
 - sprayed yellow edge lines (for 'no parking', 'no waiting', etc.) : not less than 0.8 mm.
- ii) for gum or wood resin binders :-
- screed lines : not less than 3 mm not more than 5mm;
 - sprayed lines other than yellow lines : not less than 2 mm;
 - sprayed yellow edge lines for 'no parking', 'no waiting', etc.): not less than 2 mm nor more than 3 mm.

Tolerance on Width

The tolerance on the specified width of the marking shall be within the range of + 10% and minus 0%.

Defective Materials or Workmanship

Materials which are defective or which have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location, shall be removed by approved chemical or mechanical means. To the extent necessary, the road pavement shall be made good and the markings reapplied all at the Contractor's own expense and to the approval of the S.O.

Where directed by the S.O., existing markings shall be removed in the same manner as above.

Clearing Up

The Contractor shall clean up all spatters, splashes and smirches of marking material completely to the satisfaction of the S.O.

CONCRETE KERB

Description

This work shall consist of the supply and installation of cast in situ or precast concrete kerbs constructed at the locations and in accordance with the lines, levels, grades, dimensions and types as shown on the Drawings, all in accordance with this Specification.

Materials

Concrete for kerb sections shall be grade 25/20 concrete unless otherwise indicated on the Drawings and shall conform to the requirements of Section 3.3 of this Specification.

Unless otherwise shown on the Drawings, bedding shall be grade 10/25 concrete.

The type of kerbs to be used (see figure 1.1) is depending on the type of road, design speed and pedestrian usage. The type and location shall be decided by the S.O. unless otherwise specified on the drawings and shall be meet the following criterias :-

- a) high kerb or standard barrier kerb is only suitable for road with speed limit below 70 kph.
- b) low kerb (standard mountable or semi mountable) is suitable for road with low and high speed limit and also shall be used at parking area and around the trees.
- c) drop kerb at level pedestrian crossing (see figure 1.2) shall be used to allow for wheel chair.

Installation of Kerbs

Excavation

Excavation shall be made to the required depth and the base shall be trimmed and compacted to a firm and even surface. All soft and unsuitable material shall be removed and replaced with suitable material as defined in Section 3.2 of this Specification. The bedding material shall then be placed and compacted to form a bed of required thickness as shown on the Drawings.

Cast In Situ Kerb

When a cast in situ kerb is placed next to a concrete pavement, expansion joints in the kerb shall be located in line with expansion joints in the pavement. Expansion joints shall be formed at intervals shown on the Drawings using preformed filler 10 mm in thickness in accordance to the Specification for preformed joint filler.

Concreting shall generally be in accordance with the requirements of Section 3.3 of this Specification. Forms shall not be removed within 24 hours of the concrete being placed. Minor defects shall be repaired with mortar containing 1 part Portland cement to 2 parts sand.

After placing and compaction, the concrete shall be covered with suitable material and kept moist for a period of 7 days.

Material for joint filler shall be a non-extruding fibre board, closed cell expanded polythylene foam, or a natural or resin-bonded cork sheet and shall be of such a quality that it can be satisfactorily installed in position at the joint.

Proprietary filler shall be of the type shown on the Drawings or similar approved.

Joint filler board shall meet the requirements given when tested in accordance with the procedures in the followings clauses :-

a) Weathering Test

Three specimens, each 115 mm square ± 2.5 mm, shall be placed in a ventilated drying oven maintained at a temperature of 55 ± 5 °C for 7 days, after which they shall immediately be immersed in water at room temperature for 24 hours.

The specimens shall be removed from the water and air dried at room temperature for 48 hours before examination.

The material shall be deemed to have passed the weathering test if the specimens show no signs of disintegration or shrinkage.

b) Compression and Recovery Test

Two of the specimens which passed the weathering test, and two new specimens, each trimmed to 100 mm square ± 0.5 mm, shall be subjected to three applications of load at 24 hour intervals in a compression test machine complying with BS 1610, with auxiliary platens 100 mm², minimum 13 mm thick. During each application of load each specimen shall be compressed to 50% of its original thickness at a rate of strain of 1.3 mm per minute. The load required to achieve this amount of compression shall be not less than 0.07 N/mm² nor more than 10N/mm² for material to be used in pavements and not less than 0.07 N/mm² nor more than 0.4N/mm² for material to be used in bridge joints. The load shall be released immediately when the required degree of compression is reached and after the third application a recovery period of 30 minutes shall be allowed after which the thickness of the specimen shall be measured.

This thickness, expressed as a percentage of the original thickness, is the 'recovery' value of the specimen. The thickness shall be measured to an accuracy of 25 μ m. The two new specimens shall be weighed before and after testing. The difference in mass shall be determined with an accuracy of 0.1% and shall be expressed as a percentage of the original mass of specimen.

The material shall be deemed to have passed the test if all four specimens have recovery values of at least 70% and the two new specimens have not suffered a reduction of mass in excess of 1%.

c) Extrusion Test

The third sample which passed the weathering test shall be trimmed to 100 mm square ± 0.5 mm and be subjected to the following extrusion test.

The extrusion mould shall be 100mm x 100 mm (+ 0.5, - 0) internally, of sufficient

depth to test the sample as received, open one side only and fixed rigidly to a base plate. The mould shall be provided with a closely fitting pressure plate which shall fit without binding, and with an accurate horizontal measuring dial gauge or measuring device accurate to 25 μ m. The specimen shall be mounted in the extrusion mould and loaded once as described in the compression and recovery test. The extrusion at the open side of the mould shall be measured with the gauge when the specimen is compressed to 50% of its original thickness and before release of the load.

The material shall be deemed to have passed the test if the extrusion of free edge does not exceed 6 mm.

d) Immersion Test for Cork Filler Board

For cork filler board two specimens each 115 mm x 115 mm \pm 2.5 mm shall be prepared and the thickness of each shall be determined to the nearest 25 μ m before the specimens are immersed in boiling water for one hour. After removal from the water the specimens shall be allowed to cool to room temperature and after 15 minutes at this temperature their thickness shall be remeasured to the nearest 25 mm.

The material shall be deemed to have passed that test if both specimens have a thickness of not less than 140% of their thickness before immersion.

e) Acid Test for Resin Bonded Cork Filler Board

For resin bonded cork filler board two specimens each 115 mm x 115 mm \pm 2.5 mm shall be immersed in hydrochloric acid of a specified gravity of 1.18 at room temperature which is then brought to the boil and maintained thus for one hour when the specimens shall be removed and rinsed in water.

The material shall be deemed to have passed the test when after examination the specimens show no evidence of serious disintegration, friability or lack of resilience. Discoloration or minor swelling shall not be considered as failure.

Precast Concrete Kerb

Precast concrete kerbs shall be cast using steel moulds and shall be of the types as shown on the Drawings.

Each kerb shall be set so that its front top arris conforms to the line and grade required. All spaces under the kerb shall be filled with bedding material which shall be thoroughly tamped.

Kerbs shall be laid with joints as narrow as possible and filled with mortar containing 1 part Portland cement to 2 parts sand. Where a Portland cement concrete pavement is to be constructed contiguous to a kerb, expansion joints shall be constructed in the kerb directly in line with pavement expansion joints. The expansion joint in the kerb shall be 20 mm in width and shall be filled with an expansion joint filler of the same nominal thickness as the pavement joint. Any voids between filler and the concrete kerb shall be filled with mortar.

The expansion joint filler shall be in accordance with the Specification for preformed joint filler.

Slipforming for Concrete Kerb

In situ concrete kerbs shall be laid by an approved automatic kerbing machine or, if practicable in the case of concrete pavements, by the concrete paver itself. The kerbs shall be dense with regular sides, edges, arrises and chamfers, finished to a fine surface free from blow holes and dragging, and shall be impervious.

Backfilling

The spaces in the front and back of each kerb shall be refilled to the required elevation with suitable material approved by the S.O. which shall be tamped in layers of not more than 150 mm until properly compacted.

The finished work shall be true to line and level and shall present a smooth appearance free from kink and distortion visible to the eye. Any deviation more than 3 mm in 3 m from line and level shall be made good by lifting and relaying.

BRASS PLAQUE

Description

This work shall consist the supply, fabrication and installation of brass plaque. The work shall be carried out all in accordance with the Specification and the shape and dimensions shown in the Drawings and as directed by the S.O.

Materials

The material for the plaque shall be yellow brass alloy designation SCB 6 as specified in BS 1400.

Fabrication

The plaque shall be of size 420 mm x 297 mm x 3.2 mm thick and shall be free from any damage and defect. The background shall be of a dark oxidised finished.

3.21 FENCING

Chainlink Fence

Chainlink fencing shall be P.V.C. coated 9 s.w.g. overall diameter and minor core diameter of 12 s.w.g. galvanised wire in 2" mesh supported on 2 1/2" x 3/16" m.s. angle line posts and struts spaced at not more than 10' 0" centres and with 3 strands straining wire of 8 s.w.g. P.V.C. coated galvanised wire.

The wire size and mesh size shall conform to the tolerances specified in B.S. 1052:1980 and B.S.4102:1963 respectively.

Painting

All non-galvanised metal surfaces shall be painted with one coat red lead metal priming prior to erection one coat undercoat and two coats synthetic resin gloss finish paint in a colour to be selected.

Footing

All line posts and struts shall be embedded in mass concrete footings 405mm minimum depth and 200 x 200mm square minimum plan area.

1 **SCOPE OF WORKS AND ELECTRICAL INSTALLATION SERVICES**

PREAMBLE

1.1 Regulations and Standards

All designs, works performed, materials and equipment installed shall confirm to the standards, regulations and by-laws of the authorities having jurisdiction over the electrical installations. These include :-

- a) Suruhanjaya Tenaga (ST)
- b) Local Electricity Supply Authority (Tenaga Nasional Berhad-TNB)
- c) Jabatan Bomba & Penyelamat Malaysia (JBPM)
- d) Jabatan Kesihatan dan Keselamatan Pekerjaan Am (DOSH)
- e) Department of Environment (Jabatan Alam Sekitar-JAS)
- f) The Department of Civil Aviation of Malaysia (DCA)
- g) Illuminating Engineering Society (IES)
- h) National Fire Protection Association (NFPA)
- i) Suruhanjaya Komunikasi dan Multimedia (SKM)
- j) Telekom Malaysia Berhad (TMB)
- k) Sirim acceptance certificates
- l) All other authorities having jurisdiction in the area concerned

The following standards shall generally be applicable to the design of the electrical systems. Where there is difference in standards or requirements between two documents or between a document and the specific requirements of the local authorities having jurisdiction, the more stringent standard or requirement shall be applicable.

- a) 16th Edition of IEE Wiring Regulations, latest edition
- b) Electricity Supply Act/Regulation, latest edition
- c) Malaysian Standards/British Standards
- d) Malaysian Standards Codes of Practice/British Standards Codes of Practice
- e) Uniform Building By-Law, latest edition
- f) Factories and Machinery Act
- g) Chartered Institution of Building Services (CIBS)
- h) Jabatan Alam Sekitar (DOE) rules and regulations

2 **SCOPE OF WORKS**

- 2.1 Except for materials and equipment which may be supplied to the Sub-Contractor by others, this Sub-Contract shall include for the supply delivery to site, installation, testing and commissioning of the electrical equipment, materials, wiring, cabling and all other items comprising the Sub-Contract Works and described hereunder and indicated on the Drawings accompanying this document.
- 2.2 Except for materials and equipment which may be supplied to the Sub-Contractor by Employer or others, the installation works covered by this Specification of Electrical Installation and Telephone Wiring Services and the accompanying Drawings shall include for the supply delivery to site, installation, testing and commissioning into service of the electrical equipment, materials, accessories and all other items required to complete the installation as described hereunder and indicated on the accompanying drawings.
- 2.3 The Sub-Contractor is required to carry out the following works comprising this Sub-Contract :-
- a) All internal and external underground submain cabling and control / signal cabling.
 - b) All subswitchboards, Distribution Boards, Consumer Units splitter / tap off units inclusive of all control components and change over contractors.
 - c) All final subcircuits wiring for lighting and power points inclusive of terminations into fittings.
 - d) All internal and external light fittings and power points inclusive of all mounting accessories control gears and bulbs.
- 2.4 External and Internal Telephone distribution system consisting of the following :-
- a) All external telephone manholes, internal telephone pits and ducting inclusive of connection to existing TMB manhole.
 - b) All Main Distribution Boards, Tie DBs inclusive of mounting brackets, lightning protection blocks and tag blocks.
 - c) All cabling from Main DB to Tie DBs and final socket wiring inclusive of all cable trays, mounting brackets, trunking, underfloor ducting, junction boxes, socket outlets and cable terminations.
- 2.5 Master Antennae System comprising of coaxial cabling, splitter units and dual TV / FM outlets.

3 **INCOMING ELECTRICITY SUPPLY**

3.1 The incoming electricity supply to the Meter panel shall be from TNB LV supply.

3.2 The terminations of supply cables shall be undertaken by others, however, the Sub-Contractor shall provide and install on Meter Panel suitable terminal glands and bi-metal terminals (if necessary) to accommodate the incoming cables. Sub-Contractor is to liaise with TNB on the type and size of the incoming cables.

3.3 The incoming electricity supply to the building shall be 415/ 240V, 3-phase, 4-wire 50Hz, A.C earthed Neutral System. Possible fluctuation of the rated voltage (415V / 240V) is between +5% and -10%, therefore, all items of electrical equipment and accessories supplied and installed by the Sub-Contractor for the Sub-Contract Works shall be able to withstand the foregoing fluctuation of the rated voltage.

4 **MAIN L.V. SWITCHBOARD AND SUB-SWITCHBOARDS**

4.1 Main L.V. Switchboards and all sub-switchboards as detailed in the accompanying drawings shall be supplied, installed, connect-up, tested and commissioned into service by the Sub-Contractor including all incoming and outgoing cables connections.

4.2 **General Construction**

All the switchboards and all sub-switchboards as indicated on the relevant drawings shall be suitable for floor-mounting, free standing or wall mounting as the case may be, dead-fronted type, metalclad, cubicle board, fitted with the required number of circuit breakers, isolators, switch fuses, fuse-switches, necessary instrument, protection devices, indicating lamps, contactors, current transformers, busbars, internal interconnected wiring, cable end-boxes and all other items necessary to effect completion of the switchboards. The switchboards and sub-switchboards shall each consist of the required number of sheet steel enclosures for mounting all the items of electrical equipment and components as required. The structural work of the cubicles shall comprise welded m.s. angles with bolted frames provided at the rear to house and support busbars, cable boxes, cable glands, terminal blocks and other relevant items. Each cubicle shall be enclosed, on the front, sides, rear and top removable m.s. sheet panels of not thinner than following gauges :-

4.2.1 Front panel : No 12 SWG

4.2.2 Rear, side and top panels : No 14 SWG

4.2.3 The controlling circuit breaker or isolator each sub-switchboard or distribution fuse boards shall be mounted in its own separate cubicle which shall be completely isolated from the rest of the components on the switchboard and all incoming "live" terminals and conductors shall be fully insulated by means of insulated paneling, sleeving or other approved means in such a manner as to prevent accidental touch of the "live" metal parts or conductors of the incoming supply cable from its point of entry to the switchboard to the incoming terminals of the circuit breaker or controlling isolator.

4.3 Busbars

Busbars and busbar connections to switching devices in the switchboards shall comprise high-conductivity, tinned copper bars of current ratings and sufficient cross-sectional areas to cater for the current ratings stated on the relevant Drawings. The rupturing capacity of the busbars on the Main L.V. Switchboard shall be 31MVA, at 415V, 3-phase, 50Hz, A.C. (43.3kA., A.C. Symmetrical interrupting rating at 415V), whilst the busbars for the other Sub-Switchboards shall have minimum A.C. symmetrical interrupting ratings as stated on the Schematic Diagrams. The busbars shall also be of sufficient rupturing capacities to limit temperature rise as required by B.S. 158 : 1957 and busbar markings, clearances between busbars, other current carrying conductors and the structural frameworks of the switchboards shall be in accordance with the requirements of B.S. 158 : 1961, "Phase" and "Neutral" busbars shall be of similar cross-sectional areas in each case. Busbars supports shall be of the heavy duty type, fabricated from procelain or other non-hygroscopic insulating material of approved

type and of adequate mechanical strength. The busbars shall be so spaced within each switchboard so as to be installed in parallel or edge-to-edge disposition.

4.4 Internal Connections and Wiring

PVC-insulated cables of appropriate current ratings and voltage grades to suit the various circuits concerned, shall be utilised for interconnecting switching devices, instruments, relays and other relevant circuits within each switchboard. All such cables shall be neatly bound and cleated to frame supports by means of approved type PVC, binding strips or saddles, using non-corrosive type screws or bolts and nuts. Termination of PVC inter connecting cables shall be by means of soldered-type or compression-type copper lugs fitted to either end of each cable-run and these, in turn shall be fastened to busbars and terminals of switching devices, instrument and other items of electrical equipment by means of suitable brass bolts, brass washers, steel spring washers and brass nuts with lock-nuts.

Where the current ratings of inter-connecting circuits within the switchboards are to high to permit the use of PVC-insulated cables, copper busbars interconnections may be used in lieu of the cables provided that clearances between the framework and other busbars within each switchboard meet the requirements of B.S. 158 : 1961. Terminations of interconnecting busbars shall be well tinned before being connected in position.

4.5 Earth Continuity

Each switchboard shall be fitted with a built-in earth-continuity, tinned copper busbar of less than 1" x 5/8" cross-section and which shall extend throughout the full length of each switchboard. Each switchboard framework, main earthing lead, incoming and outgoing feeder earthing leads shall be securely bonded to its earthing busbars.

4.6 Terminations

All incoming and outgoing feeder cables to each switchboard shall be provided with appropriate cable end-boxes and / or brass terminal glands and terminal blocks, to suit the types and sizes of such cables as stated in the relevant Schematic Diagrams accompanying this document.

4.7 Labels

Black ivorine labels with white lettering engraved thereon (PVC, adhesive -type labels shall not be accepted) shall be provided and fixed immediately below or on panels of switching devices, stating details of the circuits controlled by such devices. In addition, a main label with 1" high lettering engraved thereon and stating the designation of the switchboard concerned shall be provided and fitted on the top panel of each switchboard.

4.8 Tropicalisation

Each switchboard with all its components shall be fully tropicalised and suitable for use in an ambient temperature of 90 deg. Fahrenheit under very humid, tropical conditions.

4.9 Painting

Each switchboard shall be well cleaned and derusted after which it shall be treated internally and externally with two (2) coats of an approved-type anti-corrosive paint. The switchboards shall be finished with two (2) coats of stove-enamelled paint in matt-finish, dark Grey. After each switchboard is delivered to the site and installed in position with the connections of all incoming and outgoing feeder cables completed, all scratched or chipped portions of paintwork shall be resprayed with same colour finish in such manner as to present a clean surface, free from patches or blemishes.

4.10 Manufacturer's Tests

Prior to the delivery of each switchboard to the site, the switchboard shall be tested at the Manufacturer's Workshop in accordance with the requirements of SuruhanJaya Tenaga (ST). The results of such tests shall be submitted by the Manufacturer to ST for registration. The Sub-Contractor is required to submit four (4) copies of the Manufacturer's Test Results, together with four (4) copies of the ST letter of registration of each switchboard, to the Consulting Engineer for distribution to the various parties concerned. It shall be the responsibility of the Sub-Contractor to ensure that each switchboard is properly registered and accepted by the ST before commissioning into service same and no claims for compensation from the Sub-Contractor resulting from modification works required by the ST on such switchboards before acceptance is given, shall be entertained.

5 **CIRCUIT BREAKERS, FUSEGEAR & ISOLATORS**

5.1 Air Circuit - Breakers (ACBs)

Wherever ACBs are specified on the Drawings for use on the Sub-Contractor Works, the Sub-Contractor shall supply and install ACBs conforming to the following requirements :-

- 5.1.1 Each ACB shall be a metalclad, T.P., manually-operated (unless where stated on the Drawings as being electrically operated type), withdrawable type, suitable for flush-mounting in switchboards, distribution boards or control panels.
- 5.1.2 A bolted-type solid 'Neutral' link shall be provided and fitted in the same compartment as its relevant ACB.
- 5.1.3 The ACBs shall match the current and voltage ratings stated on the relevant Schematic Diagrams and be manufactured in accordance with B.S. 862 : 1959 or B.S. 4752 : 1971. The rupturing capacities (in MVA) or symmetrical interrupting ratings (in kA) stated against each ACB on the relevant Schematic Diagrams shall be based on a 415V., 3-phase, 4-wire, 50Hz., A.C. supply rating and all ACBs, supplied for the Sub-contract Works shall be not less than the rupturing capacities or interrupting ratings stated on the said Diagrams.
- 5.1.4 Each ACB shall be fitted with a shunt-trip device and provided with C/T-operated, magnetic over-current trips on all 3-poles (i.e. on all 3 "Phase: of the electricity supply) and fitted with adjustable settings. Provision shall also be made for external connections to automatic or manual devices operating in conjunction with the ACB's shunt-trip device.
- 5.1.5 Every ACB shall be fitted with interlocking facilities to prevent closing of the ACB in its withdrawn position. A mechanical "ON/OFF" indicator shall be built-in with the mechanism of the ACB's operating handle and provision for padlocking the handle in the "OFF" position shall also be made.

5.2

Moulded Case Circuit Breaker (MCCBs) & Miniature Circuit Breakers (MCBs)

Where MCCBs and MCBs are required to be provided and installed for switchboards, control panels or distribution boards for the Sub-Contract Works, the Sub-Contractor shall supply and install all such MCCBs and MCBs which meet the following requirements :-

- 5.2.1 Each MCB and MCB shall be of the all-insulated, moulded, T.P. or D.P. or S.P. (where stated on the relevant Schematic Diagrams), non-withdrawable type, suitable for flush-mounting in the switchboards, distribution boards or control panels.
- 5.2.2 A bolted-type, solid 'Neutral' link shall be provided and fitted in the same compartment as its relevant MCCB or MCB.
- 5.2.3 The MCCBs and MCBs shall match the current and voltage ratings of the circuits they control and as stated on the relevant Schematic Diagrams. In addition, the MCCBs and MCBs shall be suitable for the symmetrical interrupting ratings as stated on the relevant Schematic Diagrams in kiloamperes (kA) at 415V, 50Hz., A.C.
- 5.2.4 MCCBs shall be manufactured in accordance with B.S. 3871 : part 2 : 1966 and MCBs shall comply with the requirements of B.S. 3871 : Part 1 : 1965. In addition, they shall be of makes approved for use in Peninsula Malaysia by the ST.
- 5.2.5 All MCCBs and MCBs shall each be fitted with a thermal-operated tripping device of fixed time / current characteristics, operating on all poles of the supply and suitable for the current rating stated on the relevant Schematic Diagram. The tripping device shall be so designed as to prevent "single-phasing" of the supply (in the case of D.P. and T.P. breakers only) should a fault occur on any one "phase" of the supply (in the case of D.P. and T.P. breakers only) should a fault occur on any one "phase" of the supply.
- 5.2.6 Where it is stated on the Schematic Diagrams that shunt-trips are required for certain MCCBs or MCBs, such devices shall be provided and built-in with the relevant breakers, with provision being made for connections to external automatic or manual "tripping" of the MCCBs or MCBs.
- 5.2.7 Every MCCB or MCB shall be provided with a mechanical 'ON/OFF' indicator operating in conjunction with the operating handle of the circuit breaker. A facility for padlocking the operating handle of the MCCB or MCB in the "OFF" position shall also be provided.

5.3 Fusegear Units (Fuse-switches & Switch-fuses)

Where it is required for fusegear units to be utilised on switchboards and elsewhere in this Sub-Contract Works, the Sub-Contractor shall supply and install such units which shall conform to the following requirements:-

- 5.3.1 Each fuse-switch or switch-fuse unit shall be of the S.P. & N, or D.P. or T.P. & N., metalclad type as stated on the relevant Schematic Diagrams. Where the units are required for installation in switchboards, distribution boards and control panels, they shall be suitable for flush-mounting in the boards or panels. Individual units installed on walls, framework of machines or equipment, or on brackets and stands, shall be housed in their own metalclad or cast-metal alloy casings which shall be of the dust and oil-tight type, with facilities for cable entries and exits. In outdoor locations, or in areas where water or dampness is always present, the casings of the units shall, in addition to being dust and oil-tight, be made weatherproof with facilities for the entry of incoming and outgoing cables.
- 5.3.2 The moving contacts of fusegear units shall be of the heavy-duty, silver-plated, quick-break/quick-make type, irrespective of the effort applied to the operating handle. Fixed contacts shall be of the operating handle. Fixed contacts shall be of the spring-loaded, self aligning, silver plated type, mounted on an insulating panel of high mechanical strength and with excellent electrical insulating properties. All fixed contacts shall be fully shrouded and all shrouds shall be moulded from material which possesses good electrical insulating and self-extinguishing properties, so that the shrouds give full protection from accidental touch during fuse replacement on maintenance and assist in ARC control to give longer contact life.
- 5.3.3 All fusegear units shall be manufactured in accordance with B.S. 3815 : 1959 and be of makes approved for use in Peninsula Malaysia by the ST.
- 5.3.4 Mechanical "ON/OFF" indicators shall be fitted to fusegear units for operation in conjunction with their respective operating handles. Operating handles shall be provided with facilities for padlocking the handles in their "OFF" position. In addition, fusegear units shall be provided with built-in interlocking arrangements whereby their respective covers or doors may not be opened when the operating handles are in the "ON" position.
- 5.3.5 HRC fure-links of current ratings stated in the relevant Schematic Diagram shall be provided for all fusegear units. All HRC-links shall conform to the requirements described under Clause 6 herein.

5.4 Isolators

Where isolators are required for installation on switchboards and elsewhere in the Sub-Contract Works, they shall be metalclad type S.P. & N., D.P. or T.P. & N. types as indicated on the schematic diagram. Units used for switchboards shall be of the flush-mounting type and suitable for mounting on cubicle-type switchboards. The units shall conform to B.S.S. 861 : Part I : 1955 and B.S.S. 861 : Part II : 1966 where applicable and shall be of the 'ON LOAD' type, fitted with heavy duty contacts, generally constructed in the same manner as for fusegear units described under Sub-Clause 5.3 above. Mechanical 'ON' and 'OFF' indicator shall be fitted to the units for operation in conjunction with their respective operating handles. Operating handles of all isolator units shall be fitted with facilities for padlocking their handles with 'OFF' position and the units shall be provided with interlocking arrangements whereby their respective unit covers may not be opened when the switch handles are in the 'ON' position.

6 **HRC FUSE-LINKS**

- 6.1. Wherever it is required for HRC fuse-links to be fitted to fusegear units, cut-outs, distribution fuse boards and other similar current protection devices to be installed for the Sub-Contract Works. The Sub-Contractor shall supply and install HRC fuse links affording close-excess current protection which shall enable them to operate within four (4) hours at 1.5 times the designed load currents for the circuits which they protect. Such HRC fuse-links shall be those complying with B.S 88 : Part 2 : 1975 and fitted with fuse-links marked to indicate a Class 'Q1' fusing factor.
- 6.2. HRC fuse-links used for 13A fused ply tops complying with B.S.S 1363 : 1967 shall be of 13A current rating and manufacturing to B.S.S 1362 : 1953.

7 **EARTH FAULT RELAYS**

7.1. Where earth fault (E/F) relays are to be provided for earth fault protection of electrical circuits and feeders as shown on the schematic diagrams, the Sub-Contrator shall supply and install such units conforming to the following requirements :-

7.1.1. The E/F relays shall operate in conjunction with circuit breakers controlling the electrical feeders or circuits concerned.

7.1.2. Each relay shall be of the solid slate digital type (unless otherwise, stated on the schematic diagrams) and be operated through a set of four (4) current transformers of current ratio, burden and class as stated in the Schematic Diagram.

7.1.3. The relay units shall be suitable for either flush-mounting or surface-mounting on switchboard or control board panels and manufactured in accordance with B.S. 142 : 1966.

7.1.4. Every E/F relay shall be fitted with a reset button / switch with flag indicator and provided with adjustable settings having a range of 10% to 40% of the secondary current rating of its relevant current transformers.

8 **CURRENT TRANSFORMERS**

8.1 Current transformers (C/Ts) supplied and fixed by the Sub-Contractor in switchboards or control panel for the operation of ammeters, power factor indicators, earth-fault relays and magnetic overcurrent tripping devices of circuit breakers, shall be of the ring type with appropriate current ratio, burdens and classes as indicated on the Schematic Diagrams.

8.2 All current transformers shall be of current dimensions for fixing in bushbars and shall be manufactures to B.S. 3938 : 1973.

9 **MEASURING INSTRUMENT**

9.1 Wherever instrument for measuring or indication are required to be incorporated in switchboards, control panels or distribution boards for the Sub-Contract Works, the Sub-Contractor shall provide such instrument conforming to the following requirements :-

9.1.1. All instrument shall be provided with square dials and be flush-mounted in their respective switchboards, distribution boards and control panels.

9.1.2 The instrument shall be manufactured to the relevant BS or other Standard approved by the BE. For the Main LTV. Switchboard, the instrument shall be fitted with 144mm x 144mm frames. In all other control boards and switchboards, dial frames of instrument mounted thereon shall be 96mm x 96mm size.

9.1.3 Voltmeters

Each Voltmeter shall be of the M.I.S.C type, be of suitable voltage range to suit the circuit concerned and of a high degree of accuracy. The Voltmeter shall be connected in circuit with a S-position selector switch and protective cut-outs fitted with HRC fuse-links.

9.1.4 Ammeters

Every Ammeter shall be of the M.I.S.C. type, be of suitable range to suit the current rating of the circuit it is meant to operate on through current transformers. It shall have a high degree of accuracy and be connected to three (3) busbar-connected current transformers of the type detailed under Clause 8 above and of the correct ratios, burden and class as stated on the relevant Schematic Diagram. The Ammeter shall also be connected in circuit with a 4-position, selector switch.

9.1.5 Power Factor Indicators

Each Power Factor Indicator shall be of the M.I.S.C type and be suitable for measurement of 3-phase, 4-wire, unbalanced loads through current transformers (for the voltage coil circuit protection, HRC fuse-links shall be used). The indicator shall be scaled to read from 0.5 capacitive to 1 and from 1 to 0.5 inductive circuits.

10 **INDICATOR LAMPS**

10.1 Where indicator lamps are shown on the Schematic Diagrams for installation on switchboards and control panels, the Contractor shall supply and install such lamps to meet the following requirements :-

10.1.1. All indicator lamps shall be of the transformer-operated type and be suitable for flush-mounting in their respective boards or panels.

10.1.2. Lenses for indicator lamps shall be of durable quality glass and coloured to suit the colours stated on the relevant Schematic Diagrams (for "phase" indication of the electricity supply, "Red", "Yellow", and "Blue" coloured lenses shall be used to indicated "red", "yellow" and "blue" Phases of the electricity supply respectively).

11 **CONTACTORS**

11.1. Where contactors are indicated in the Schematic Diagrams for use on the Sub-Contract Works, the Sub-Contractor shall provide and install such contactors to meet the following requirements :-

11.1.1. The Contactors shall be suitable for panel-mounting within the compartments of their respective switchboards, control panels and distribution boards.

11.1.2. The contactors shall be of the heavy-duty type, be suitable for operation on inductive or capacitive loads and be manufactured in accordance with B.S. 775 : Part 1 : 1969, or any other equivalent Specification for contactors approved for use in Peninsula Malaysia by the ST.

11.1.3. The operational life for the contactors shall not be less than nine million (9,000,000) operations and the mechanical duty of utilisation shall be Class IV, with a Making and Breaking Category of A4, as specified under B.S. 775 : Part 1 : 1969.

11.1.4. Contact surfaces shall be silver-plated and protected against dust and accidental contact of "live" parts. For larger current ratings, contact are preferred to be of the twin-break type, Auxiliary contacts, where required in the Schematic Diagrams, shall be fitted to the contactor units.

11.1.5. Contactor armatures shall be centrally located to ensure balance operation and equalised pressure. Armature bearings shall be of the self-cleaning type. Operating coils shall be of the voltages and frequencies stipulated in the Schematic Diagram for each contactor and means shall be provided for easy removals and replacements of the coils.

11.1.6. Where contactors are required to be installed outside switchboards or control panels, they shall be housed in dust-proof, pressed steel or cast-metal casings fitted with hinged, lockable doors and be suitable for wall-mounting or for installation on floor stands. Where contactors are exposed to weather conditions or to the constant of water or dampness, they shall be accommodated in cast-metal casings of weatherproof construction. All casings for contactor units shall have provision for the entry and exit of circuits cables wired in conduit or cables of the armoured multi-core type, as the case may be.

12 **TIME SWITCHES**

12.1 Where time switches are required in the Sub-Contract Works for the automatic time-controlled operation of lighting and other circuits, the Sub-Contractor shall provide and fix such switches in switchboards or control panels, or distribution boards (wherever as indicated on the Schematic Diagrams) to conform to the following requirements :-

12.1.1. The time switches shall be of the synchronous type, fitted with 36-hour spring reserves and 24-hour dial switches (switches to be provided with adjustable levers for two "ON" and two "OFF" operation).

12.1.2. The switches shall be suitable for flush-mounting on switchboard or control panel and be suitable for operation on a 240V., single-phase, 50Hz., A.C. supply.

12.1.3. The operating D.P. contacts of the time switches shall be rated at not less than 10A for operation in circuit with operating coils of switching contractors. Means shall also be provided for test or manual operation of the time switches.

13 **SUB-SWITCHBOARDS AND DISTRIBUTION FUSE BOARDS**

- 13.1 Sub-switchboards, Distribution fuse boards and consumer units indicated on the schematic diagram shall be supplied and installed by the Sub-Contractor at the various positions indicated on the layout drawings for lighting and power.
- 13.2 The Sub-switchboards and distribution fuse boards shall be of metal-clad, cubicle construction and suitable for installation on the walls or recessed in walls of the buildings. They shall be T.P. & N. and S.P.& N. types as indicated on the drawings and manufactured in accordance with B.S.S. 214 : 1959; wherever applicable. Consumer unit where specified to be used, shall be of metal enclosure complete with door made from electro-galvanised steel and finished with epoxy powder paint or moulded plastic enclosure made of self extinguishing, unbreakable plastic material with transparent hinge door. Consumer units shall be surface mounted complete with DIN mounting rail and neutral and earth terminals.
- 13.3 HRC fuse-links of types as indicated under Clause 6 of this section and of current ratings as shown on the schematic diagrams, shall be provided on porcelain or approved type moulded bases and carriers. Contacts shall be of copper with phosphor-bronze pressure clips and with fuse contacts fully shrouded. "Phase" barriers shall be fitted and all "Neutral" and "Earth" busbars install with the boards shall be provided with the same number of terminals as they are fuse-ways.
- 13.4 "Phase" identification discs and fuse-way labels for circuit identification shall be covered by clear plastic and provided for each distribution fuse board. On the outside face of each board's cover, a black perspex label with the number of the distribution board as indicated on the Schematic Diagram and engraved in white lettering, shall be provided and fixed thereon. For T.P. & N. type distribution boards, the Sub-Contractor shall supply and install an additional white perspex label on each board, bearing the letters : "DANGER, 415V; 3-PHASE SUPPLY", engraved in red colour thereon.
- 13.5 Each distribution fuse board's cubicle shall be provided with a separate door for its fuse compartment and its controlling isolator, respectively. The door for the controlling isolator shall be inter-locked with the isolator in such manner as to allow the door to be opened only when the isolator is switched "OFF" and all "live" metal parts of the board are de-energised of supply.

- 13.6 Isolators used for controlling distribution fuse boards shall be of appropriate current ratings as indicated on the Schematic Diagrams and shall be of the "ON LOAD" type with heavy-duty contacts and conform to the requirements stated under Sub-Clause 5.4 herein.
- 13.7 All distribution fuse boards shall be fitted with suitable means for terminating incoming and outgoing cables and final sub-circuit wiring.
- 13.8 Mild steel sheet used in the construction of distribution boards shall not be thinner than 14 SWG.
- 13.9 The painting and finishing of distribution fuse boards shall be carried out in the same manner as described for the Main L.V. Switchboard.

14 **CABLE-ENTRY DUCTS, ROAD CROSSING CABLE DUCTS & R.C. CABLE TRENCHES**

- 14.1 All underground cable-entry pipe ducts to and underground cable-distribution pipe ducts feeding from the buildings and reinforced concrete cable trenches within buildings shall be provided and installed by the Main Contractor.
- 14.2 Wherever it is stated on the accompanying layout drawings that road-crossing pipe cable ducts are to be provided by the "Electrical Contractor", the Sub-Contractor shall be required to supply and lay in position all such road-crossing pipe ducts and include for the cost of same in his Sub-Contract Sum. All other road-crossing pipe ducts for cables shall be provided and installed by the Main Contractor.
- 14.3 All road-crossing pipe cable ducts, cable-entry pipe ducts to and cable-distribution pipe ducts away from the buildings shall each be provided with a non-corrodable draw-wire for the easy drawing-in of cables.
- 14.4 All the cable-entry, cable distribution and cable road-crossing pipe ducts, whether provided by the Main Contractor or the Sub-Contractor, shall be effectively sealed by the Sub-Contractor (after all cables are laid in position) in such manner as to prevent the ingress of water, mud or dirt through the ducts.
- 14.5 The Sub-Contractor shall closely liaise with the Main Contractor in the laying of all cable-entry, cable distribution and road-crossing ducts so as to avoid any breaking-up of concrete walls, floors, aprons and completed road surfaces at a later date due to such items being installed or laid incorrectly or in wrong locations.

15 **CABLES**

15.1 Except for the incoming electricity supply cables (supplied by others) to the Main L.V. Switchboards, all cables for the internal wiring of the buildings, including the external underground cable distribution sub-mains, shall be supplied and installed by the Sub-Contractor.

15.2 All electric cables supplied by the Sub-Contractor for the Sub-Contract Works shall be provided with high conductivity, multiple stranded annealed copper conductors (conductors of 1.5 sq mm cross-sectional area only, may be of single-strand conductor), manufactures to B.S. 6360 : 1969.

15.3 Electric cables installed throughout the Sub-Contract Works shall be of the following types :-

15.3.1. Where single-phase, final sub-circuit cables are installed in conduit or steel trunking, such cables are to be PVC- insulated (PVC) type, 600/1000V grade and manufactured to B.S.S 6004 : 1969 for metric sizes. For 3 phase, or 3-phase, 4 wire circuits, Metric-sized cables shall remain at 600/1000V grade.

15.3.2. For single-phase and 3 -phase or 3-phase, 4-wire, final sub-circuit wiring, PVC Insulated (PVC) cables of 600/1000V grade and manufactured to B.S. 6004 : 1969 shall be used. Where PVC cables area used for L.V single-phase or 3-phase, 4 wire sub-mains or rising mains installed on cable trays, such cables shall be of the PVC insulated and sheathed (PVC/PVC) type of the same voltage grade as specified above.

15.3.4. Wherever Mineral Insulated Copper covered and PVC Sheathed (MICC/PVC) cables or Mineral Insulated Copper Covered (MICC) cables are specified on the drawings for use in the Sub-Contract Works, such cables shall be of 600/1000V grade and manufactured to B.S.S. 6207 : Part I : 1969.

15.3.5. Wherever XLPE insulated, armoured cables are specified for use on this Sub-Contract, such cables shall be manufactured to B.S.S. 5467 : Part I : 1969 and of 600/ 1000V grade for all L.V. circuits.

- 15.3.6. Flexible cords used for the inspection of lamp-shades, connection of lighting fittings to their wiring points and for connection of electric appliances, shall be of the 3-core or 4-wire, or 5-core, PVC insulated type with white colour sheaths, of Metric Sizes (300/300V grade for single phase circuits and 300/500V grade for 3-phase or 3phase, 4-wire circuits) and manufactured to B.S.S. 6500 : 1969.
- 15.4 For the internal telephone wiring installation, cables used shall be of the multi-pair, PVC Insulated and Sheathed Type and manufactured in accordance with the requirements of the Suruhanjaya Komunikasi & Multimedia (SKM) where applicable.
- 16.0 **INTERNAL ELECTRICAL WIRING INSTALLATIONS & UNDERGROUND OR UNDERFLOOR CABLING**
- 16.1 Surface-Run Conduit Wiring
- Surface-run conduit wiring with PVC cables, wherever indicated on the Diagrams, shall be run on walls, steel structural work or on cable tray as the case may be.
- 16.1.1. Conduits utilised throughout the Sub-Contract Works shall be galvanised, heavy gauge, Class 'B' screwed steel type to B.S.S. 31. Or Rigid High Impact PVC conduct to BSEN 50086 = 1993, BS EN50086-2-1 = 1996 and to JBPM acceptance where specified.
- 16.1.2. Conduit fittings and accessories shall be galvanised type and manufactured in accordance with the relevant British Standard Specifications. All conduit bends, including solid non-inspection tees and elbows, shall be restricted in accordance with I.E.E Regulations (16th Edition).
- 16.1.3. Conduit ends and terminations shall be provided with approved type fittings of the same material as the conduits.
- 16.1.4. For cables manufactured to British Standard "inch" sizes, the minimum number of cables pulled shall comply with of the I.E.E. Regulations (16th Edition). For British Standard cables manufactured to Metric Sizes, the minimum number of cables through any conduit shall conform to the requirements of the I.E.E. Regulations (16th Edition).

- 16.1.5. Where conduits are installed directly on walls, and concrete work, they shall be fastened by means of galvanised, space-bar saddles and Rawlplugs at appropriate intervals in accordance with standard wiring practice. Rawlplugs shall be drilled into walls and concrete work and the use of hardwood plugs for installing spacer bar saddles shall not be permitted. Spacer-bar saddles shall be fastened by means of a round-head, brass screws and washers.
- 16.1.6. In the case where conduits are installed on perforated cable trays, they shall be fastened by means of suitable galvanised metal saddles, round-head brass bolts, nuts and washers.
- 16.1.7. The Sub-Contractor shall paint all surface-run conduits with two (2) coats of an approved type of paint after erection is completed. All conduits shall be painted orange colour.

16.2 Concealed Conduits Installation

Wherever conduit wiring is to be concealed in the plasterwork of walls or buried in floors, they shall be installed in cases of sufficient depth and width to suit the sizes of conduits and paralld runs involved. Cables used for concealed conduit runs shall be PVC insulated type, except where wiring runs are partially installed in conduit and partially run concealed directly in the plasterwork of walls, they shall be of the PVC / PVC type.

- 16.2.1. Where conduits are to be concealed in the plasterwork of brickwork walls, the Sub-Contractor is required to cut the necessary chases in the walls for the installation of the conduits. Initial plastering of chases shall be undertaken by the Sub-Contractor after conduits have been erected in position but the final plastering of chases shall be undertaken by the Main Contractor.
- 16.2.2. Where conduits is to be buried in concrete floors, fairfaced concrete walls and the underside of bare concrete ceilings, the conduit shall be cast in-site with the concrete and for this purpose, the Sub-Contractor is required to liaise very closely with the Main Contractor and arrange for all the conduits to be laid in position before the casting of any concrete floor or wall is carried of any concrete Contractor, throughout the progress of the building construction.

16.2.3. The methods employed for the installation of concealed conduit wiring shall generally be the same as for surface-run conduit wiring, outlined under Sub-Clause 16.1 of this section, except that conduits shall be held in position in their respective chases by means of normal, galvanized metal saddles and no painting of conduits before plastering or cementing is required, except where such conduits rise from floors or emerge from walls.

16.2.4. Rigid, concealed conduit risers shall terminate at a height of approximately 12" above finished floor levels under terminal boxes of motors or, where this is not possible, then as near as possible to machines on which the motors are installed. Flexible conduits with special adaptor sockets and of similar diameters as the rigid conduit shall then be connected to the rigid conduit terminations and continued to terminate in the terminal boxes of motors or control panels of machines. Where concealed conduit walls emerge from walls or floors to enter switchboards, control boards, distribution boards, termination boxes, lighting fittings and electrical accessories, the rigid conduit shall be brought directly to the equipment and terminated within the equipment. Where it is not possible for rigid conduit to terminate at equipment, then such conduit shall be connected to flexible conduit with special adaptors and the flexible conduit, in turn, shall terminate in the equipment.

Flexible conduits used throughout shall be of the liquid-tight type with bitumen infused paper between two flexible aluminium tube spirals and with electrical continuity being maintained throughout their entire lengths.

16.2.5. All exposed conduit shall be painted with 2 coats of approved orange colour paint.

16.2.6 All conduits shall be provided with suitable draw-wires.

16.3 Installation of PVC SWAPVC and PILCDSTA & S. Cables unless otherwise stated on the drawings, the foregoing cables may be installed in the following manner :-

16.3.1. PVC SWAPVC. Cables may either be installed direct in the ground, or on cable trays or directly cleated to walls or on cables racks or in concrete trenches.

XLPE/SWA/PVC Cables may be installed in the same manner as for PVC SWAPVC cables.

- 16.3.2. Where such cables are laid in pre-cast concrete trenches, the cables shall be neatly laid at the bottom of the trenches without crossing each other except where they rise from the trenches to their respective terminal boxes or cable end boxes. Cables laid in concrete trenches shall be spaced apart of each other in the manner prescribed under Clause 16.5 of this section. Where more than one layer of cables are to be laid in the same trench, then the upper layers shall be neatly spaced and held in position by purpose-made, hardwood cleats installed on m.s. brackets along the walls of the trench. The spacing of cables or brackets shall be in accordance with I.E.E. Regulations (16 Edition). For cables diameters exceeding 40mm. dia. (overall), reference shall be made to the Manufacturers of such cables for spacing of supports. In any case, however, the spacing of supports shall be such that there is no sag in the cables between supports.
- 16.3.3. Where such cables are laid on trays, they shall be held in position by means of purpose-made, non-corrodable, non-magnetic, metal saddles of appropriate sizes and mechanical strength. The cables shall be spaced apart in the manner prescribed under Sub-Clause 16.5 of this Section. Saddles shall be bolted to the trays by means of non-corrodable nuts, bolts and washers. Only one layer of cables may be installed on each tray and under no circumstances may two or more layers of cables be installed on a single cable tray.
- 16.3.4. PVC/SWA/PVC and XLPE/SWA/PVC cables pulled through ducts shall be separated from each other at not less than two (2) inches and such cables shall not be laid in parallel at a distance of 12 inches from gas, fresh or salt water pipes and pipes of various other services. The same distance apart shall also apply for L.V and H.T cables or cables of other services which are said in parallel to each other.
- 16.3.5. Where PVC/SWA/PVC or XLPE/SWA/PVC cables are laid direct in the ground, they shall be laid in trenches of sufficient width and depth to cater for the cables runs and cables voltage grades concerned. L.V cable shall be laid at a depth of not less than 2 ft below finished ground level, when measured from the top surfaces of the cables. Trenches of sufficient depth to meet the foregoing cable depth requirement shall therefore be dug. Prior to the laying of cables in trenches, a 2-inch layer of sifted sand shall be placed at the bottom of the trenches. The cables shall then be laid over this bedding without crossing each other and covered over with another 2-inch layer of sifted sand, over which interlocking type R.C cables slabs or UPVC cable slabs shall be laid in such a manner as to overlap the cables at 2 to 4 inches on both sides. The cables trenches shall then be filled-up with earth in layers of 6 inches each, every layer being properly tamped before another layer is placed over. The procedure shall continue until the trenches have been completely reinstated.

- 16.3.6. No straight-through or tee joints in PVCSWAPVC or XLPE/SWA/PVC, underground cable runs shall be permitted. Sufficient lengths of cables shall therefore be supplied to suit the various circuits indicated on the Drawings.
- 16.3.7. For cables laid directly in the ground, Regulation type reinforced concrete cable markers shall be planted into the ground at every change in direction of the cable route and at every 100 ft intervals along straight runs.
- 16.3.8. The sub-Contractor shall provide and connect up all necessary brass glands for the termination of PVCSWAPVC cables. In the case of XLPE/SWA/PVC cables, the Sub-Contractor shall provide the necessary cable end-boxes, black insulating compound for their respective cable end boxes and all such compound shall be suitable for the voltage grades of the cables to be terminated. All other jointing materials necessary to complete the termination of the cables shall also be provided by the Sub-Contractor.
- 16.3.9. PVCSWAPVC cables shall be terminated by means of compression type gunmetal or brass glands constructed to grip both the inner and outer PVC sheath of each cable and so designed that any strain on the cable is taken by the steel wire armouring which shall be effectively sealed between the gland itself and the outer cable sheath.
- 16.3.10. The type of gland that the Sub-Contractor proposes to use shall be approved by the Consulting Engineer before the termination is carried out.
- 16.3.11. All glands shall be weather and moisture proof complete with PVC shrouds.
- 16.3.12. Compounds shall be to the manufacturer's recommendations and the Consulting Engineer's approval.
- 16.3.13. Wherever a PVCSWAPVC cable is cut during the course of installation, the open ends shall be sealed immediately by means of a self adhesive non-hygroscopic tape in order to form an air-tight joint. A wax water seal shall be employed beneath the tapping to prevent the ingress of moisture between the cores.
- 16.3.14. Every outdoor cable end-box joint stated on a particular day shall be completed during the same day.

16.3.15. Crimped cable lugs shall be used throughout for the jointing of the conductors of PVC armoured cables. Lugs shall be affixed to the cable by means of a crimping tool as recommended by the manufacturers, using the correct pressures.

16.3.16. Where terminations are made at switchgear and other items of electrical equipment, wire armouring shall be bonded to the casing by means tinned copper conductors of cross sectional area not less than the appropriate size of earth conductor stated in the 16th edition of the I.E.E. Regulations.

16.3.17. The cable cores shall be taken direct into the equipment terminals; jointed tails shall not be permitted unless with the permission of the Consulting Engineer.

16.4 Cables in Conduit and Flexibles

16.4.1. Wiring cables and flexibles shall be insulated with PVC manufactured to the relevant British Standard and shall be delivered with the maker's seals intact, which shall be retained for inspection.

16.4.2. Flexible cables shall be kept to a maximum and shall comply with 16.4.4 below, where applicable.

16.4.4. Connections to apparatus which operate above 80°C shall be made using silicon coated cable with a non-hygroscopic fixed block connector.

16.5 Grouping of Cables on Trays and Cables laid in Closed Precast Concrete Trenches

When installing several circuits of cables on trays, or when laying several circuits of cables in pre-cast concrete trenches, the Sub-Contractor shall strictly adhere to the requirements stated below and install the cables accordingly. For this purpose, the word : 'circuits' used in single-core cable runs shall deem to mean pairs of cables for a single-phase, A.C. or D.C. circuit, or 3 cables per circuit for a 3-phase, 4 wire, A.C. circuit.

16.5.1. Or. PVC or PVC/PVC cables laid on trays, the horizontal clearance between circuits for single-core cables shall be :-

- a) not less than 6 times the overall diameter of an individual cable and not less than the overall width of an individual circuit, except that the horizontal clearance need not in any case exceed 150mm.,

- b) the vertical clearance between circuits is not less than 150mm and
- c) if the number of circuits exceed 4, they are installed in a horizontal plane.

16.5.2. For multi-core, PVC/PVC or PVC/SWAPVC or XLPE/SWA/PVC cables laid on trays, the horizontal clearance between cables shall be :-

- a) not less than 6 times the overall diameter of an individual cable, except that the horizontal clearance need not in any case exceed 150mm and
- b) If the number of cables exceeds 4, they are installed in a horizontal plane.

16.5.3. Where multi core cables of the types stated under 16.5.1 above and circuits of single-core cables stated under 16.5.2 above are installed in precast closed concrete trenches, the dispositions of the cables or circuits of single-core cables shall follow the requirements laid out in the I.E.E. Regulations and multi-runs of cables in trenches shall be de-rated in accordance with the Rating Factors stated in the I.E.E. Regulations (16th Edition).

16.5.4. The Sub-Contractor shall be required to provide cable trays of sufficient width, including sufficient tiers of cable trays, to meet the requirements of Sub-Clause 16.5.1 and 16.5.2.

17 **CABLE TRAYS**

17.1 Wherever cable trays are required for use in the Sub-Contract Works, the Sub-Contractor shall supply and install perforated type, galvanised or PVC-coated trays complete with all necessary bends, tee pieces and adaptors for changes in width of trays where required. The trays shall be constructed from sheet steel of 16 SWG for widths of up to and including 12 inches and 14 SWG for widths exceeding 12 inches. All PVC-coated trays, if used for the Sub-Contract Works, shall be coated with orange colour, PVC coating.

- 17.2 Cable trays may either be suspended from the underside of floor slabs of roof structural work, on column or wall supports, or installed on floor-mounted, m.s. angle structures as the case may be. All such suspension units, angle supports or structures shall be treated with 2 coats of an anti-corrosive paint and finished with two coats of an approved type paint (colour to be notified later by the Consulting Engineer). Galvanised trays, if used on the Sub-Contract Works, shall also be painted with 2 coats of an approved type orange colour paint after the erection of trays has been completed and prior to the installation of cable runs on the trays.
- 17.3 Cable-trays supports, hangers and structures shall be spaced adequately apart to cater for the weights of the cables and trays supported on them. In no case shall cable trays and cables be permitted to sag. In the event of a single layer of cable trays being insufficient to cater for the cables to be laid thereon, then the Sub-Contractor shall install two or more layers of cable trays on a common set of hangers, supports or structures shall be of sufficient robust construction to cater for the additional weights of the trays and cables.
- 17.4 Fixing clips or cleats for cables on trays shall be installed by means of non-corrosive metal screws (or bolts), washers and nuts.
- 17.5 All tees, intersection units and sets shall be purpose-made by the manufacturer. Where this is not possible these units may be made up on site only with the approval of the Consulting Engineer.
- 17.6 Cable trays shall be installed with the greater dimension in the horizontal position unless otherwise agreed with the Consulting Engineer.

18 **SURFACE-RUN STEEL TRUNKING**

- 18.1 Wherever it is found that several surface-run conduit cable runs are grouped together, thereby utilising extensive space on walls or steel structural work, the Sub-Contractor may, with the Consulting Engineers, Approval, use steel trunking in lieu of conduit for PVC cable runs.
- 18.2 The number of PVC cables to be installed in steel trunking shall be such that a space factor of 45% is not exceeded, as required in the I.E.E. Regulations (15th Edition). Under no circumstances shall circuit cables from different distribution boards be runs in the same trunking.

- 18.3 The trunking shall be manufactured from zinc-coated, mild sheet steel of 16SWG for cross section sizes of up to and including 12" x 4"/ For sizes exceeding 12" x 4", 14 SWG sheet steel may be used.
- 18.4 Steel trunking may be supplied in lengths of 6ft or 12ft, with each length being provided with a sleeve type coupling and external earth bonding link of copper. All trunking shall have a smooth interior with cover plates overlapping the sides of the trunking. In general, the trunking shall be designed for exception strength and rigidity with trunking lengths fitted with "butt-up" joints to form the necessary runs. Suitable adaptors shall be utilised for any change in cross section of trunking runs. All such adaptors, bends, tee pieces and stop bends used in the trunking installation shall be fabricated from the same materials as the trunking and fitted with sleeve-type couplings at each trunking connection point.
- 18.5 For every length of steel trunking run, a copper tape earth-continuity conductor (1" x 1/8" cross section) shall be provided throughout the full length of the trunking run and bonded to the trunking at every section.
- 18.6 In vertical trunking runs, insulated type cable support pins and retaining clips shall be fitted to support the weights of the cables.
- 18.7 Where conduit is tapped off trunking, suitable brass, smooth-bore bushes shall be fitted at all conduit terminations. The use of all insulated type, plastic, fibre or bakelite bushes for this purpose shall not be permitted.
- 18.8 Where vertical trunking runs pass through floors of the building, fire-resisting barriers with individual sleeve mouldings (manufactured from "Mycalex" or other non-tracking, inorganic insulating material of a mica and glass base approved by the Jabatan Bomba), shall be fitted in the trunking at individual floor levels. All such fire barriers shall have a minimum fire rating of 3 hours.
- 18.9 All trunking to be finished with two (2) coats of an approved type orange colour enamel paint.
- 19 **MAIN AIR-CONDITIONING SWITCHBOARD, SUBMERSIBLE PUMP SWITCHBOARD, LIFT SWITCHBOARD, CONTROL PANELS FOR COLD WATER PUMP,FUME CUPBOARD STARTER PANELS, HOSE REEL PUMPS AND COOLING TOWER, FAN AND PUMP PANELS**

19.1 The Sub-Contractor shall supply, install, connect at both ends and commission power sub-mains and riser main cables to the following Switchboards and Control Panels supplied by others and as listed below, including the provision of all necessary items of wiring accessories, cables glands and earth continuity conductors.

19.1.1. Main Air-Conditioning Switchboards

19.1.2. Submersible Pump Switchboards

19.1.3. Cold Water Pump Control Panels

19.2 All sub-main cables shall terminate at the incoming controlling switchgears, or isolators as may be provided on the switchgears or isolators as may be provided on the switchboards or control panels.

19.3 The sub-Contractor shall liaise closely with other service Sub-Contractor with regard to the locations of their various switchboards and control panels and shall provide adequate cable lengths for the terminations and connections of the sub-main cables into the switchboards or control panels.

20 **EXHAUST FANS FOR VENTILATION AND FUME HOODS / CUPBOARDS**

20.1 All exhaust fans for Ventilation and Fume Hoods / Cupboards shall be supplied by other services Sub-Contractors together with all necessary items of starting and control equipment as indicated on the relevant layout drawings and schematic diagrams.

However, the Sub-Contractor shall supply, install, connect up and commission all items of wiring accessories, switches and cables for all ventilation exhaust fans to effect their complete installation as listed under Sub-Clause 20.2 and 20.3 below.

20.2 Each of the surface-run conduit wiring points for the ventilation exhaust fans

shall terminate in a surface mounted, metal based flex-outlet plate, fitted with an all insulated, white or ivory finish cover plate ('MK' List No. 1090 WH1 plate mounted on a surface-mounted metal or approved equivalent). Connections between flex-outlet plates to the terminals boxes of the exhaust fans shall be carried out by means of suitably-rated, 3-cores, PVC flexible cords of the type described under Sub Clause 15.3.6 of this Section. Each of the conduit wiring points shall be controlled by a surface-mounted, 15A., S.P., metalclad switch ('MK' List No 4891 WH1 c/w MK 3631 WH1 cover plate or approved equivalent).

20.3 Each of the concealed wiring points for the exhaust fans stated above shall be terminated in a flush mounted flex-outlet plate. The flex-outlet plate shall be similar to the type described under Sub-Clause 20.2 above, except that it shall be installed in a recessed, metalclad box or ABS thermoplastic box. The 3-core, PVC flexible cord connection between the flex-outlet plate and the terminal box of the exhaust fan shall be the same as described under Sub-Clause 20.2 above. Each of the concealed wiring points shall be controlled by flush mounted 15A., S.P. switch fitted on all insulated, white or ivory finish cover plate ('MK' List No. 4891 WH1 c/w MK 3631 WH1 cover plate). The switches shall be installed in recessed, metalclad boxes or ABS thermoplastic box.

20.4 All exhaust fans and their wiring points shall be supplied, installed and commissioned into service by the Sub-Contractor under the requirements of their Sub-Contract.

21 **CEILING FANS**

21.1 All ceiling fans and their wiring points shall be supplied, installed and commissioned into service by the Sub-Contractor under the requirements of this Sub-Contract.

21.2 Ceiling fan points shall each comprise :-

21.2.1. PVC cables installed in surface-run or concealed G.I. Conduit wiring, wherever as stated on the relevant Schematic Diagrams;

21.2.2. A Flush mounted, metalclad board on which shall be installed a flush-mounted 5A., S.P., one-way, all insulated type control switch ("MK" List No. 4881 WH1 or other approved equivalent make) and the ceiling fan regulator mentioned under 21.3 below.

21.2.3. A fan hook, purpose-made to suit the beam on which it is fitted and a 3-way, connector for terminating the fan's wiring point.

21.3 Each ceiling fan shall be a 60" sweep, A.C capacitor type fan ("NEMC" or other approved make), supplied with matching speed regulator unit and downrod to suit the required mounting height. The cutting of downrods, or the provision of additional lengths of downwards to suit mounting heights shall be done at the expense of the Sub-Contractor.

21.4 Unless otherwise specified on the schematic diagram, all ceiling fans supplied and installed by the Sub-Contractor whereby the suspension heights for the ceiling fans are to be adjusted such that they are not lower than the surrounding lighting fittings. The Sub-Contractor are advised to confirm with the Consulting Engineer.

22 **INTERNAL & EXTERNAL SUB-MAINS**

22.1 All lighting and power internal sub-mains and riser mains wiring and cabling for the building, including all external underground sub-mains cables, as indicated on the accompanying layout drawings and schematic diagrams, shall be supplied, installed, connected up and commissioned into service by the Sub-Contractor.

22.2 The various methods of installing wiring and cabling for sub-mains and riser mains shall follow the methods detailed in the proceeding relevant clauses of this specification. The Sub-Contractor shall strictly adhere to the requirements prescribed therein.

23 **LIGHTING SWITCHES**

23.1 All control switches for lighting points shall be supplied and installed by the Sub-Contractor.

23.2 The positions of all lighting switches indicated on the layout drawings are approximate only. The Sub-Contractor shall therefore clarify the exact locations of all such switches with the Supervising Engineer before commencement of the wiring installation work or any of the rooms / floors of the buildings.

- 23.3 Lighting switches shall be rated for 5A (for circuits protected up to and including 5A) and 15A rating (for circuits protected above 5A ratings but not exceeding 15A). Except for weatherproof switches, all switches for the internal wiring of lighting points shall be rocker operated type, grid pattern, single pole. one way, two way or intermediate, as required on the layout drawings.
- 23.4 For concealed conduit wiring installations, lighting switches shall be flush mounted type, fitted with all insulated type cover plated in white colour finish and installed in recessed, metalclad or ABS thermoplastic boxes. The makes of flush mounted lighting switches are detailed in the Legend of the set of accompanying drawings.
- 23.5 For surface-run conduit wiring installations, lighting switches shall be installed in surface mounted aluminium colour finished, metalclad boxes and of 'MK' or other approved equivalent reputable make.
- 23.6 Where lighting switches are exposed to weather conditions or to the constant presence or moisture, such switches shall be of the galvanized, weatherproof type, which shall be surface mounted on walls and of 'CLIPSAL' or 'ML' or other approved, equivalent reputable make.
- 23.7 Where switches are connected to different 'Phases' of the supply and are also grouped together in one position, the switches shall be installed in a metalclad 'multiple phase' switch assembly unit, having built in 'phase' compartments or other approved equivalent.

24 **SWITCHED-SOCKET OUTLET**

- 24.1 All switches-socket outlets for lighting and power shall be supplied and installed by the Sub-Contractor for the Sub-Contract Works at the locations indicated on the layout drawings.
- 24.2 For portable lighting fittings, lighting switches socket outlets shall be 5A x 3-pin, type supplied complete with matching plug tops. The type of 5A x 3-pin, switches socket outlets to be supplied and installed for the Sub-Contractor Works shall be as follows :-

- 24.2.1. For concealed conduit wiring within the building, 5A x 3-pin switched socket outlets shall each be of the shuttered type, flush mounted in walls in a recessed metalclad or ABS thermoplastic box and fitted with an all insulated type, white colour finished cover plate. The units shall be 'MK' Cat. No. 2891 WH1 or other approved reputable make.
- 24.2.2. Where 5A x 3-pin switched socket outlets are installed for surface run conduit wiring, the units shall be of the shuttered, metalclad, aluminium colour finished type, surface mounted on walls.
- 24.2.2. Where 5A x 3-pin switches socket outlets are used for operating outdoor lighting fittings and are exposed to weather conditions, such units shall be of the galvanized, weatherproof, interlocking or shuttered type. These units shall be 'WALSALL' List no. 1150B/G or other approved reputable make.
- 24.3 For general purpose use on appliances, switches-socket outlets shall be one gang or two gang 13A x 3-pin type, as indicated in the layout drawings and supplied complete with fused matching plug-tops. Such switched-socket outlets shall be of the following types :-
- 24.3.1. For concealed conduit wiring, within the building, one gang or two gang 13A x 3 pin shuttered type, flush-mounted in walls in a recessed metalclad box and fitted with an all-insulated type, white colour finished cover plate. The unit shall be 'MK' Cat No. 2747 WH1 or No. 2757 or other approved reputable make.
- 24.4 For 240V., single phase, power appliances connected to switch-socket outlets, the switched-socket outlets shall be of the 15A x 3-pin shuttered type, supplied complete with matching plug-tops. Such units shall be of the following types :-
- 24.4.1. For concealed conduit wiring within the building, 15A x 3 -pin, switched-socket outlets shall each be flush-mounted in the wall in a recessed metal-clad box fitted with an all-insulated, white colour finished coverplate. The unit shall be "MK" Cat No. 2893 WH1 or other reputable approved make.
- 24.4.2. For surface-run conduit wiring in the building, 15A x 3-pin switched-socket

24.4.3. For 15A x 3-pin switched-socket outlets installed outside the building and exposed to weather conditions, such units shall be of the interlock, cast metal galvanized finished type. Such units shall be Clipsal cat no. 56S0313 or other approved reputable make.

24.5 Where laborator benches or other benches are located away from the walls, the Sub-Contractor shall provide, construct, lay and install all necessary underfloor, concealed wiring conduits and terminate same above ground on to suitable size metalclad termination boxes of approved make mounted inside the benches. The Sub-Contractor shall also provide and install all necessary interconnecting conduit wiring and wiring accessories between 13A Socket outlets required on the benches from the terminal box so as to effect complete installation.

All 13A socket outlets shall be recessed-mounted or pedestral-mounted on suitable metalclad or ABS thermoplastic boxes supplied by the Sub-Contractor on to benches as shown and specified on the relevant drawings.

Where Fume Hoods / Cupboards are mounted in to benches tops, all switch-socket outlets, lighting switches and exhaust fan controlling switches for the use of the fume hoods/cupboards shall be recessed mounted on to the supporting benches as indicated on the relevant drawings.

25 **POWER POINTS FOR MACHINES / EQUIPMENT**

25.1 All power points for machines or equipment in the Workshop and other areas of the main building as indicated on the relevant layout drawings, shall be supplied, installed, connected-up and commissioned into service by the Sub-Contractor.

25.2 Power points for machines or equipment shall each terminate in a metalclad S.P. & N or T.P. & N. isolator ("M.E.M." or other approved make) on the wall as indicated on the relevant schematic diagram and layout drawings.

25.3 Where machines are positioned at a distance from walls, the power points for all such machines shall terminate in isolators positioned adjacent to their respective machines. All such isolators shall be installed on m.s. floor stands which the Sub-Contractor shall supply and erect in position at the machines. Floor stands shall be treated with 2 coats of anti-corrosive paint and finished with 2 coats of an approved type enamel paint to match the colours of the machines near which they are located.

26 **LIGHTING & FITTINGS**

26.1 Light Fittings

All lighting fittings for the building shall, together with their wiring points, be supplied, installed, connected-up and commissioned into service by the Sub-Contractor. The various types of lighting fittings to be supplied are indicated in the Legend and the locations of same are shown on the accompanying layout drawings.

26.2 Supply Voltage Fluctuation

All lighting fittings and their components, incandescent lamps, fluorescent tubes and control gear supplied under this Sub-Contractor shall be suitable for operation on a rated voltage of 240. 5-Hz., A.C. Possible fluctuation of the supply is -10% and +5% of the rated voltage (240V); therefore all the foregoing lamps, tubes, components and control gear shall be manufactured to withstand this range of fluctuation of the electricity supply.

26.3 Incandescent Lamps

Incandescent lamp bulbs supplied for fittings shall be of the bi-pin, general lighting service (G.L.S.) type and shall not exceed the Wattages of the lamps specified by the manufacturers for the relevant lighting fittings in which they are to be utilised. For open-type or louvered lighting fittings and lampshades, " peral" type bulbs shall be fitted and in totally-enclosed type light fittings, " clear" glass bulbs shall be installed.

26.4 Fluorescent Tubes

Fluorescent tubes used for fluorescent lighting fittings shall be of the bi-pin type and of the bi-pin type and of White colour rendition (colour temperature of 4,300 deg. K), average turning life shall be 18,000 hours. The fluorescent tubes used for fittings shall generally conform to the following requirements :-

	18W <u>Tubes</u>	36W <u>Tubes</u>	58W <u>Tubes</u>
26.4.1. Average lumens at 20000 burning hours	1200	3000	4750
26.4.2. Length of tube	600mm	1200mm	1500mm
26.4.3. Diameter of tube	26mm	26mm	26mm

26.5 Ballasts for Fluorescent

Every fluorescent tube shall be fitted with its own low loss ballast and associated circuitry. Under no circumstances shall two or more fluorescent tubes be operated off a larger capacity ballast except with the prior approval of the Consulting Engineer. All ballast supplied under this Sub-Contractor shall be of the switch-start, polyester type and connected in circuit with power factor to 0.9 or better. The units shall be fitted with screw terminal blocks and be manufactured in accordance with the relevant SIRIM Standard or B.S. 2818 : 1973.

26.6 Wiring & Spacing Within Fluorescent Lighting Fittings

All fluorescent light fittings shall be so design as to allow a minimum clear air space of 1/2" all around ballasts and other heat-producing components within their respective metal casings. Wiring within fluorescent light fittings shall be carried out with an appropriate current-carrying capacity, colour coded heat-resistant cables or approved type. Colour coding of cables within fluorescent lighting fittings shall follow the colour code stated under CEI. Circular No. 2/70, viz : " Brown" Phase conductor, "Blue" Neutral conductor and striped "Green/Yellow" Earth conductor. All wiring within the casings of fittings shall be kept clear of ballasts and other heat-producing components when in operation, as required under CEI. Circular No. 4/70.

26.7 Installation of Lighting Fittings

Wherever pendent lighting fittings are to be installed on the Sub-Contract Works, The Sub-Contractor shall supply sufficient length of conduit downrods for such fittings, or flexible cables for lampshades, to suit mounting heights. The cuttings of conduit downrods or suspension gear rods and / or the provision of extended lengths of conduit downrods or suspension gear rods to suit mounting heights shall be undertaken by the Sub-Contractor. Where fluorescent lighting fittings are to be surface-mounted on the undersides of soft board or other types of suspended ceilings, the Sub-Contractor is required to provide and install suitable spacers which shall be inserted between the fittings bases and the undersides of the ceilings so as to allow a minimum clearance of 1/2" between fittings and the undersides of the ceiling panels. Where fluorescent fittings are to be recessed in false ceilings, all such fittings shall be of the recessed modular pattern and be suitable for recessing to Tee-bar modular ceilings of 2' x 4' pattern or 2' x 2' pattern.

The cutting of holes in false ceilings for the installation of recessed lighting fittings shall be undertaken by the Main Contractor; however, the Sub-Contractor shall supply the Main Contractor with the correct hole dimensions to be cut and it shall be the responsibility of the Sub-Contractor to ensure that all such holes are cut to the required dimensions and at the correct locations.

- 26.7.1 All conduit wiring shall terminate at the lighting fittings where it is not possible for rigid conduit to terminate at the lighting fitting, then such conduit shall be connected to flexible conduit with special adaptors and the flexible conduit, in turn, shall terminate in the lighting fitting. Flexible conduit used shall follow requirement as stated under Sub-Sub Clause 16.2.4.

26.8 Samples of Fluorescent Lighting Fittings

In the event of the Sub-Contractor offering fluorescent light fittings for the Sub-Contract Works, which are to be made in West Malaysia, The Sub-Contractor prior to placing his firm order with his Suppliers for such fittings, provide two (2) samples of each fitting for verification and approval by the Consulting Engineer. One sample of each type thus offered shall be forwarded to the office of the Consulting Engineer and the other sample of each type shall be sent to the site office. The Sub Contractor shall not confirm his orders with his Suppliers for such fluorescent light fittings until the Architect and / or the Consulting Engineer has, after examining the fittings and any necessary modifications thereof, given his written approval to the Sub-Contractor to proceed with the ordering of the fittings. Random checks shall be made by the Supervising Engineer on consignments of such fittings delivered to site, in order to ascertain that all the fittings are manufactured in accordance with the approval samples.

If it is found that a few fittings of any one consignment do not comply with the sample-fittings in any way whatsoever, then the Supervising Engineer shall have the right to reject such consignment of fittings and the Sub-Contractor shall then arrange to replace such consignment of fittings with a fresh consignment, having fittings complying in all respects with the sample-fittings, at no additional cost to the Employer. If the Sub-Contractor so desires, he may include the sample fittings as part of a consignment to be supplied under this Sub-Contract, in which case, the sample fittings shall be returned to the Sub-Contractor for installation after all the remaining fittings to be supplied under this Sub-Contract have been in position. Any costs to be incurred by the Sub-Contractor for providing samples of fluorescent fittings and for installing them later as required above, shall be included in his tender price and no additional payment of costs shall be made to the Sub-Contractor should he fail to included for any such costs in his tender price for this purpose.

26.9 Alternative Light Fittings

In the event of the Sub Contractor offering other makes and types of lighting fittings in lieu of those specified, the Sub-Contractor is reminded that such alternative fittings shall not only be of equivalent reputable quality and of similar shapes and sizes to the types specified, but such fittings and all their internal and external components shall conform to the requirements as set out under Sub-Clauses 26.2 to 26.7 above, where applicable and shall also approved for use in West Malaysia by the CEI. If there is any doubt as to the suitability of an alternative fitting offered by the Sub-Contractor, the Consulting Engineer reserves the right to request the Sub-Contractor to submit a copy of a letter from the CEI stating that such fitting is acceptable for use in West Malaysia. In the event the Sub-Contractor failing to submit the required written proof from the CEI, then such alternative fitting shall be at no additional cost to the Employer.

27 **"KELUAR" SIGN FITTINGS**

- 27.1 The Sub-Contractor shall install, connect-up and commission all self-contained 'KELUAR' sign fittings supplied by the Sub-Contractor and as indicated in the accompanying drawings. All such fittings shall meet the requirements and be certified approved for use by the Jabatan Bomba Malaysia and the JPE.
- 27.2 All 'KELUAR' sign fittings shall be lighted by not less than two electric lamps and shall be powered by Nickel Cadmium batteries for not less than 3 hours duration and capable of not less than 50% of the duration after 12 hours charging and full duration after 24 hours charging.
- 27.3 All 'KELUAR' sign wordings shall be in plain letters of not less than 6 inches high with the principal strokes of the letters not less than 3/4 inches wide.
- 27.4 All self-contained 'KELUAR' sign fittings shall operated on a normal 240V, 50Hz., A.C. single phase mains supply under normal conditions and powered by sealed Nickel Cadmium batteries when the mains supply is not available. Lamps used in each sign lettering and also provide even illumination level for the sign lettering and also provide downward illumination for the space immediately below the sign.
- 27.5 All 'KELUAR' sign fittings shall be provided with the following features :-

- 27.5.1 Each sign shall have an A.C. mains indicator which is illuminated and clearly visible when the A.C. mains supply is available.
- 27.5.2 Each sign shall be provided with an easily accessible test switch for transfer of operation from A.C. mains to internal battery source, which shall also extinguish the mains indicator.
- 27.5.3 Each sign shall be provided with a concealed switch, not normally accessible to the public, for isolating the internal battery supply from the lamps when necessary.
- 27.6 Each 'KELUAR SIGN' shall be illuminated by incandescent lamps or fluorescent lamps. The illumination level shall be sufficient for the sign to be clearly visible at a distance of 80ft in a room / space having standard illuminations of about 30 lumens. The sign illumination shall be maintained approximately constant under both mains and internal battery operation.
- 27.7 'KELUAR SIGN' using incandescent lamps shall have a minimum of 3 lamps for each sign and each lamps shall have an average life of not less than 1,000 hours continuous operation.
- 27.8 Signs using fluorescent lamps shall have a minimum of 2 lamps. For safety and maintenance purpose it is highly desirable that all lamps operate at low voltage and not at the A.C. mains supply voltage of 240V., 50Hz., A.C. Further it is required that the failure of any one lamp shall not render any of the other lamps non-operative.
- 27.9 'KELUAR' signs shall be protected against lightning. The lightning single arrestor shall be fitted at a point of the mains connection of the 'KELUAR SIGN'.

28 **EMERGENCY LIGHTING**

- 28.1 All emergency light fittings shall be supplied and delivered to the site by the Sub-Contractor which is required to install and connect up same to their respective wiring points. All wiring points for installed by the Sub-Contractor.

28.2 All self-contained type emergency light fittings shall be switches into use automatically upon failure of the normal mains supply system. The duration of emergency illumination shall not be less than three (3) hours. Upon restoration of mains supply, the units shall automatically switch off with the Nickel Cadmium batteries being immediately put on charge automatically.

28.3 All self-contained emergency lighting fittings shall operate on a normal 240V., 50Hz., A.C. single-phase main supply under normal conditions and powered by sealed Nickel Cadmium batteries when the mains supply is not available.

28.4 All emergency light fittings shall be provided with the following features :-

28.4.1 Each fittings shall have an A.C. mains "on".

28.4.2 A test switch to stimulate mains failure.

28.4.3 Interior switch to disconnect lamp when required, e.g. during transportation and installation.

29 **EXTERIOR PERIMETER BUILDING SPOTLIGHTING**

29.1 All exterior perimeter building spotlightings, together with all their relevant wiring points cable connections and switches shall be supplied, installed, connected-up and commissioned into service by the Sub-Contractor.

29.2 The types of spot lighting fittings to be supplied are indicated in the Legend of the accompanying set of Drawings.

30 **LIGHTNING PROTECTION SYSTEM**

30.1 The Air Termination type of network lightning protection system complete with the copper or galvanised steel rods Air Terminals lighting preventor, and an earth electrode system, shall be supplied and installed by the Sub-Contractor on top of the roof of the Building at the positions indicated on the relevant drawing.

30.2 The Air Terminals shall be manufactured to BS 665. The height of the copper taper pointed air rods shall be minimum 300mm and 8.0mm diameter.

30.3 The earth download from the air terminals shall comprise 20 x 2.5mm cross-section, high conductivity copper or Aluminium tape which shall be securely fixed on the roof and walls of the building by means of suitable D.C. cleats and brought down along the wall to a height of 1520mm, above the building's concrete apron and terminated in a brass or copper earth test clamp ("FURSE" or approved equivalent, make). From the test clamp, the earth conductor shall be installed in G.I. conduit which shall be buried in the ground to a depth of 450mm below finished ground level and connected to the earth electrode system.

30.4 The earth electrode system shall generally be the same as described under Sub-Clause 32.7 to 32.10 of this Section, except that the resistance of the earth electrode system to the general mass of earth shall not exceed 5 Ohms. The minimum number of electrodes used for the earth electrode system shall be two (2), but in any case, the Sub-Contractor shall provide more insufficient at no extra cost, if two electrodes are insufficient to meet the minimum earth resistance requirements as stated above.

31 **EARTHING**

31.1 The earth connection of all 3-pin, switch socket outlets, fans, lighting fittings, metal parts of all switchgears and fuse boards, control boards, starter panels, conduits, electrical appliance and all metalwork liable to become "alive" in the event of the installation becoming defective, shall be effectively earthed by means of earth continuity conductors of sizes given in the I.E.E. Regulations (16th Edition); but in any case, the minimum size of earth continuity conductor used for the Sub-Contract Works shall be 2.5 sq mm size.

31.2 Earth continuity conductors and earthing leads shall be of high conductivity copper, continuous throughout their whole lengths and without joints, except by means of approved mechanical clamps. Where connections are made at switchgear and such items of electrical equipment, the conductors shall terminate in soldered sockets. in the case of MICC/PVC. cables, the copper outer sheaths of the cables may be utilised as earth continuity conductors, provided that at the termination of each cable run, the copper sheaths (or sheaths in the case of single-core, multiple runs of MICC/PVC cables) shall be effectively bonded to earth.

31.4 Every conduit off a switchboard, distribution board, control board, tap-off unit and splitter switch-fuse shall be provided with its own earth-continuity conductor.

- 31.5 The electrical resistance of any earth continuity conductor or earthing lead measured from its connection with the main earth electrode system of a building to any other position in the complete installation in the building shall not exceed one (1) Ohm.
- 31.6 The main earthing lead of an installation shall be taken from the earth connection of the Main Switchboard or Sub-Switchboard as directly as possible without looping into any accessory or equipment to the earth electrodes. Such earthing lead shall be mechanically protected by means of conduit or similar means, which shall be surface-run on walls and buried in the ground at a depth of not less than 1' - 6' below finished ground level.
- 31.7 Separate earth electrode systems shall be supplied and installed by the Sub-Contractor for the following equipment :-
- 31.7.1 A main earth electrode system for the Main L.V. Switchboard's frame earth and cable glands at the Switchboard.
- 31.8 For each electrode system, electrodes shall comprise 14mm dia., 3.66m long, extensible-type, copper/ steel rods ("Copperweld" or approved equivalent make), or hard-drawn copper rods ("B.I.C.C." or equivalent make), driven into the ground at intervals of at least twice the driven length of any two electrodes. Electrodes shall be driven into the ground by means of a "KANGO" or similar type electric or pneumatic hammer. Every connection clamp shall be provided with a Regulation type concrete inspection chamber and cover.
- 31.9 All electrical equipment, etc., shall be bonded and earthed in accordance with the I.E.E. Regulations and British Standard Code of Practice CP. 1013.
- 31.10 The number of earth electrodes to be driven into the ground for each earth electrode system will entirely depend on the soil condition in the vicinity where the electrodes are installed. The resistance of each electrode system to the general mass of earth shall, however, be low enough to permit the passage of current to earth of not less than three (3) times the rating of the largest main fuse protecting the whole installation, or not less than 1+ times the current rating necessary to operate the overload trip coil of the circuit breaker protecting the circuits of the installation which has become defective. The Sub-contractor shall therefore provide sufficient earth electrodes to obtain the above mentioned requirement and no claims for additional earth electrodes to meet this requirement will be allowed.

The Sub-Contractor may, at his own discretion, increase the length of earth electrodes to obtain the required earth resistance value; nevertheless, the minimum number of electrodes installed for each earthing system shall be two (2) and the minimum length of each earth electrode shall be 3.66m.

- 31.11 Interconnecting earth-continuity conductors between electrodes shall comprise cables installed in conduit and buried in the ground to a depth of not less than 1ft 6 ins below finished ground level. Such cables shall be of sizes to suit the main earthing leads to each electrode system, in which case the earth-continuity conductors between electrodes shall be in accordance with the I.E.E. regulations (16th Edition). In the case of the earth electrode system for the Main L.V. switchboard and the Sub-switchboards requiring electrode systems, interconnecting conductors between earth electrodes and the main earthing leads shall comprise 1" x 1/8" cross-section, high-conductivity copper tape, enclosed in conduit and buried in the ground to a depth of 450mm below finished ground level.

33 **SUB-CONTRACTOR'S WORKING DRAWINGS**

33.1 The Sub-Contractor shall submit the following Working Drawings to the Consulting Engineer for approval :-

33.1.1 The Main L.V. Switchboard with internal Schematic Diagram of connections.

33.1.2 All L.V. Sub-Switchboards with internal Schematic Diagram of connections.

33.1.3 All distribution fuse boards with internal Schematic Diagram of connections.

33.2 The Sub-Contractor shall allow in his Sub-Contract Sum for the preparation of all the above Working Drawings which shall be of professional standard and include all necessary dimensions, weights, plans, sections and fixing methods, for proper assessment to be made by the Consulting Engineer.

34 **COMMISSIONING TESTS**

34.1 After the Sub-Contract Works have been completed and before the Certificate of Practical Completion is issued, the entire electrical installation and telephone wiring installation covered under this Sub-contract shall pass all tests as the Supervising Engineer may deem necessary to ensure that the Sub-Contract Works comply with the requirements of the Specification and Drawings. In addition, the Sub-contractor shall furnish proof that the electrical and telephone wiring installations have passed the acceptance tests required by the LLN and the TMB, respectively and that the electricity supply has been turned-on by the TNB.

34.2 The Sub-Contractor shall arrange to forward four (4) copies of test results of all tests carried to the Consulting Engineer for distribution to the various parties concerned. Any charges incurred by the Sub-contractor in connection with undertaking the production of photo copies of the required copies of test results, shall be allowed for by the Sub-Contractor in this sub-Contract Sum.

34.3 The sub-contractor shall undertake the site tests as detailed below and which tests shall be considered as the minimum requirement :-

- 34.3.1 Insulation tests on resistance to earth between "Phases" and between "Phases" to "Neutral", for all lighting, power and control cables to permit compliance with the I.E.E. Regulations (16th Edition) and the requirements of the TNB.
- 34.3.2 Earth continuity tests for each circuit of the installation to ensure that the impedance of the earth fault loop is such as to permit compliance with the requirements of the I.E.E. Regulations (16th Edition). A suitable instrument to be used for this purpose is a "Ferranti" Phase-Earth loop Impedance Tester (Model 8) and the Sub-Contractor shall employ such an instrument or other approved equal type.
- 34.3.3 Earth electrode resistance tests to the general mass of earth for the main and auxiliary earthing systems of the electrical and lightning preventor installations, to permit compliance with the relevant I.E.E. Regulations (16th Edition) and the requirements of the TNB.
- 34.3.4 Polarity tests for all single-pole switches and switch socket outlets to determine compliance with the relevant I.E.E. Regulations (16th Edition).
- 34.3.5 Operational tests for starting and tripping of all electric motors and starting equipment installed for the sub-contract Works. Such tests shall also include starting and tripping of motors from float-switch equipment and / or other automatic switching devices and push button stations where installed. Where sequence tripping and starting of motors are required, such tests shall also be conducted to ensure that their operation complies with the specified requirements.
- 34.3.6 Arrange with T.N.B. or other Test Authority or firm approved by the T.N.B to conduct calibration tests for all air-circuit breakers and protective relays installed on the Main L.V. Switchboard.
- 34.3.7 Arrange to carry out all necessary tests as may be prescribed by TMB for the telephone wiring installation.

34.4 The Consulting Engineer reserves the right to present at all tests. The Sub-contractor shall therefore give at least ten (10) days' notice writing to the Consulting Engineer for this purpose.

TT DISTRIBUTION SYSTEMS

Abstract - This paper examines the need for main switchboard surge protection and presents typical specifications for surge protection devices suitable for TT distribution systems where the neutral conductor is not earthed at the switchboard. These specifications are suitable for high to very high exposure sites against transient overvoltages.

a) INTRODUCTION

Shunt Surge Diverters are shunt connected devices generally comprising metal oxide varistor components. These components have a non-linear $V \sim I$ characteristic and are able to absorb high-energy impulse type disturbances.

In a TT distribution system induced voltages due to lightning and other transient disturbances will appear on all phases and the neutral conductor. For this reason all mode protection is essential. All mode protection means protection between all phases and neutral, all phases and earth and neutral and earth. The same applies at distribution boards further “downstream” from the main switchboard.

b) STANDARDS

The following standards provide details of the likely voltages, currents and waveforms that may be encountered in a typical LV distribution network.

Australian Standard	AS1768-1991
British Standard	BS6651-1999, Annex C
American Standard	ANSI/IEEE C62.41:1991
American Standard	UL 1449
International Electrotechnical Committee	IEC 1000-4-5: 1995
Singaporean Standard	CP33-1996

Shunt Surge Diverters shall provide all mode protection by use of a combination of MOV based surge diverters and a high energy gas filled arrester. This design results in excellent all mode performance and means that earth leakage current is negligible. Where it is not possible to install surge protection prior to earth leakage relays, the minimal earth leakage current will have no effect upon ELCB operation. However it is highly recommended that surge protection always be installed upstream of ELCBs to minimize nuisance tripping.

Shunt Surge Diverters may be installed on the line side of the main switch but like any other load it is recommended that they be fused or otherwise protected with circuit breakers. For surge protector install at the Main Switch Board 63A HRC fuses are recommended however for installation at Sub Switch Board 32A HRC fuses are recommended.

c) **COMMISSIONING PROCEDURES**

The manufacturer or local authorized agent shall provide testing & commissioning procedures to ensure proper testing & commissioning.

d) **MANUFACTURING DEFECT WARRANTY**

A two-year warranty certificate shall be obtained from local authorized agent.

36

Shunt Surge Diverters (SSD)

Main Switchboard/Sub-Switchboard Shunt Surge Diverters [40kA (8/20us) per phase]

a) General

Supply and install SSD on each phase and neutral of the distribution board. The SSD shall provide protection against multiple impulses caused by lightning or other transient disturbances. The SSD shall be connected between each phase, neutral and earth so that effective all mode protection is obtained.

b) Product

The SSD shall provide a minimum of 40 kA per phase (8/20us) (Novaris SD3-40N or eg).

c) Standards

The SSD shall be rated at 8/20us of 40kA per phase suitable to withstand multiple impulses as defined by location category C, high exposure in AS1768: 1991, BS6651: 1999 Annex C or ANSI/IEEE C62.41.

d) Construction

The SSD shall be based upon metal oxide varistor (MOV) technology and housed in metal enclosures to UL 1449 requirement. The configuration of the SSD shall allow for protection between line-neutral, line-earth and neutral-earth (all mode).

e) Alarms

A voltage free changeover contact shall be incorporated in each diverter. This shall provide a common alarm indicating any phase failure. The contact shall be isolated to 4kV to any active circuitry. Should the SSD be subject to a prolonged overvoltage and the MOVs reach a high temperature a thermal sensor will trigger the alarm.

d) Performance

Each surge diverter shall be rated for a nominal operating voltage of 240Vrms and a maximum operating voltage of 280Vrms. Let through voltage when subject to 6kV 1.2/50us, 3kA 8/20us impulse shall be less than 600V between any phase to neutral and phase to earth. Let through voltage between neutral and earth shall be less than 200V. These measurements shall be made at the SSD terminals.

Earth leakage current from any phase or neutral to earth shall be less than 10 microamperes.

37 Sub-Switchboard/ Distribution Board Shunt Surge Diverters [40kA (8/20us) per phase]

a) General

Supply and install SSD on each phase and neutral of the distribution board. The SSD shall provide protection against multiple impulses caused by lightning or other transient disturbances. The SSD shall be connected between each phase, neutral and earth so that effective all mode protection is obtained.

b) Product

The SSD shall provide a minimum of 40 kA per phase (8/20us) [Novaris SD3-40DIN/3 (three phase)/ SD1-40DIN/3 (single phase) or eg].

c) Standards

The SSD shall be rated at 8/20us of 40 kA per phase suitable to withstand multiple impulses as defined by location category C and B in AS1768: 1991, BS6651: 1999 Annex C or ANSI/IEEE C62.41: 1991.

d) Construction

The SSD shall be based upon metal oxide varistor (MOV) technology and housed in metal enclosures to UL 1449 requirement. The configuration of the SSD shall allow for protection between line-neutral, line-earth and neutral-earth (all mode).

Each MOV shall be individually fused and alarmed with a suitable electronic display showing MOV integrity.

e) Performance

Each surge diverter shall be rated for a nominal operating voltage of 240Vrms and a maximum operating voltage of 280Vrms per phase. Let through voltage when subject to 6kV 1.2/50us, 3kA 8/20us impulse shall be less than 900V between any phase to neutral, phase earth and neutral to earth. These measurements shall be made at the SSD terminals.

Earth leakage current from any phase or neutral to earth shall be less than 10 microamperes.

38 Sub-Switchboard/ Distribution Board Shunt Surge Diverters [25kA 98/20us) per phase]

a) General

Supply and install SSD on each phase and neutral of the distribution board. The SSD shall provide protection against multiple impulses caused by lightning or other transient disturbances. The SSD shall be connected between each phase, neutral and earth so that effective all mode protection is obtained.

b) Product

The SSD shall provide a minimum of 25 kA per phase (8/20us) [Novaris SD3-25DIN/3 (three phase)/ SD1-25DIN/3 (single phase) or eg].

c) Standards

The SSD shall be rated at 8/20us of 25kA per phase suitable to withstand multiple impulses as defined by location category B in AS1768: 1991, BS6651: 1999 Annex C or ANSI/IEEE C62.41: 1991.

d) Construction

The SSD shall be based upon metal oxide varistor (MOV) technology and housed in metal enclosures to UL 1449 requirement. The configuration of the SSD shall allow for protection between line-neutral, line-earth and neutral-earth (all mode).

Each MOV shall be individually fused and alarmed with a suitable electronic display showing MOV integrity.

e) Performance

Each surge diverter shall be rated for a nominal operating voltage of 350Vrms and a maximum operating voltage of 480Vrms. Let through voltage when subject to 6kV 1.2/50us, 3kA 8/20us impulse shall be less than 900V between any phase to neutral, phase to earth and neutral to earth less than 250V. These measurements shall be made at the SSD terminals.

Earth leakage current from any phase or neutral to earth shall be less than 10 microamperes.

Requirement of Technical Specification for Transient Surge Protection System

	Description	Tender Requirement
4.1	Three Phase Shunt Surge Diverter for Sub-Switchboard / Distribution Board	
4.1.1	Standards of Compliance :	1) ANSI/IEEE C62.4 : 1991, Cat. C and B 2) AS1768 : 1991, Cat. C and B 3) BS6651 : 1999, Annex C, Cat. C and B
4.1.2	Nominal Voltage per phase :	240 V AC
4.1.3	Maximum Voltage per phase :	280 V AC
4.1.4	Surge Rating per phase (8/20 μ s)	40 kA
4.1.5	Let Through Voltage, when - 3 kA (8/20 μ s) Cat B I. Line to earth II. Line to Neutral III. Neutral to Earth - 6 kA (8/20 μ s) Cat C I. Line to earth II. Line to Neutral III. Neutral to Earth - 20 kA (8/20 μ s) Cat C-High I. Line to earth II. Line to Neutral III. Neutral to Earth	600 V 600 V 200 V 750 V 750 V 250 V 950 V 950 V 350 V
4.1.6	Status LED Indicator	YES
4.1.7	Auxiliary Contact (volt free)	YES
4.1.8	Total leakage current to earth	Less than 10 μ A
4.1.9	Enclosure according to UL1449	Metal enclosure
4.1.10	Manufacturing defect warranty	2 years

	Description	Tender Requirement
4.2	SSD FOR Subswitchboard / Distribution Boards	
4.2.1	Standards of Compliance :	1) ANSI/IEEE C62.4 : 1991, Cat. C and B 2) AS1768 : 1991, Cat. C and B 3) BS6651 : 1999, Annex C, Cat. C and B
4.2.2	Nominal Voltage per phase :	346 V AC
4.2.3	Maximum Voltage per phase :	484 V AC
4.2.4	Surge Rating per phase (8/20µs)	80 kA
4.2.5	Let Through Voltage, when - 3 kA (8/20µs) Cat B IV. Line to earth V. Line to Neutral VI. Neutral to Earth	< 900 V < 900 V < 900 V
4.2.6	Status LED Indicator	LED
4.2.7	Total leakage current to earth	Less than 10 µA
4.2.8	Enclosure according to UL1449	Metal enclosure
4.2.9	Manufacturing defect warranty	2 years

1

TELEPHONE WIRING INSTALLATION

- 1.1 The entire telephone wiring installation including telecommunication manholes, interlinking cable ductings, underfloor trunking, conduits and terminal units, as shown on the relevant drawings accompanying this document, shall be supplied, installed and commissioned by the Contractor who shall also be a Registered Contractor with the Suruhanjaya Komunikasi dan Multimedia (SKM). If the Contractor is not a Registered Contractor, he shall then obtain the services of Registered Contractor and submit the name of such Contractor to the Consulting Engineer for approval prior to engaging the services of the said Contractor. In the event of the Contractor engaging the services of an approved Registered Contractor, he shall be fully responsible for all works undertaken by such Registered Contractor, including all terms and conditions stated under this Sub-Contract.
- 1.2 The telephone underfloor trunking installation shall be carried out in concealed, rigid PVC underfloor trunking of gauges and type approved by the (SKM). The trunking runs shall be laid in floor screed below floor finishes. The Contractor shall therefore closely liaise with the Main Contractor and arrange for chases of suitable depths and widths to be cast in the floor screed to accommodate the trunking; the final concreting of cases shall be undertaken by the Main Contractor.
- 1.3 Telephone floor trunking shall, as far as possible, be supplied in lengths to suit the trunking runs. Where joints are unavoidable, the joints shall be coated with an approved jointing compound during assembly and be made watertight. All joints shall be so constructed that cables can be conveniently drawn through without damage. Each run of trunking shall be completed with draw in wires.

- 1.4 Wherever telephone underfloor conduit installation is required, it shall be carried out in concealed, rigid PVC conduit of the heavy gauge type manufactured in accordance with B.S. 4607 : Part I : 1970 (for Metric sizes) or B.S. 4607 : Part II : 1970 (for Imperial sizes) and laid in floor screeds below floor finishes. The Contractor shall therefore arrange to provide chases of suitable depths and widths in floor screeds to accommodate the conduits and the final concreting of chases shall be undertaken by the Main Contractor.
- 1.5 Telephone outlet and junction boxes shall be fabricated in galvanised mild steel and manufactured in accordance with relevant B.S. or SIRIM and approved for use by SKM. The boxes shall be recessed in the floors and provided with removable mildsteel covers (covers to be flush with floor finishes).
- 1.6 A gasket shall be provided around the end of each junction box to seepage of water into the box when the cover has been screwed in position. The screws used shall be of brass and counter-sunk so that their heads do not protrude above the finished floor levels when installed.
- 1.7 The junction boxes are to be supplied in terminal through way, tee-off or intersection patterns as required on the drawings. The opening where trunking enters each boxes shall be filed smooth so that the PVC sheath of the telephone cables will not be damaged during installation.
- 1.8 Distribution boxes shall be constructed from polycarbonate or ABS thermoplastic material and shall be to the requirements of the SKM and approved by them.
- 1.9 Cable terminal units shall be of the approved type and shall be of the type to allow conductors to be easily isolated without disconnecting or unsoldering wires.
- 1.10 Cables terminal unites used for telephone earthing and power cabling shall be provided for each distribution box.
- 1.11 All necessary cable trays and metalclad trunking used for risers shall be of the galvanised type and generally conform to the requirements of SKM.

- 1.12 All materials used for wiring must be approved by the SKMt. Internal telephone cables shall comprise tinned, annealed copper conductors, PVC. Insulated and PVC sheathed with Grey / Black colour code of conductors according to SKM.
- 1.13 All external JC9C manholes, interconnecting underground pipe ducts between manholes and the incoming underground G.I. pipe ducts for incoming cables as indicated on the relevant Drawings, shall be supplied and laid / constructed by the Contractor. The Contractor shall, however, ensure that all such manholes and ducts are constructed to the approval of the SKM or the service provider requirements and for such purpose, the Contractor shall arrange with the service provider to supervise the construction work of the manholes when undertaking such work.
- 1.14 Ducts seals for underground cable ducts shall be supplied and installed by the Contractor on the inner side walls of manhole and where the ducts enter the building. The ducts seals shall be of appropriate sizes and types and shall be to the service provider requirements.
- 1.15 The entire telephone wiring installation shall also include all accessories necessary for the completion of the works in every respect and to the satisfaction of the SKM, whether such be mentioned in this Specification and the Drawings or not.
- 1.16 For the internal telephone, wiring installation, cables used shall be of the multi-pair, PVC insulated and sheathed type and manufactured in accordance with the requirements of the SKM specification.

2 MASTER ANTENNA TELEVISION SYSTEM

2.1 General

The specification covers the supply of all materials labour, cartage, tolls, equipment and appliances necessary for the construction and completion of the MATV system.

2.2

Suitable television antennas shall be installed for all the existing television channel / radio RM channel in Malaysia. The positioning of these antennas shall be decided in relation to the locations of the respective transmitting stations.

If the building is in fringe reception area, the special allowance for the use of narrow band high gain antenna mast head amplifiers and such other devices as may be necessary to ensure the best possible signal reception shall be provided.

2.3 Distribution Amplifiers

Separate channel amplifiers shall be provided for VHF and UHF signal from Malaysia. The channel amplifiers shall be selected to amplify the required TV / Radio channel signals. All channel amplifiers shall have low-loss, low-noise and variable gain characteristics.

The main amplifier shall have a gain capable of maintaining a minimum signal level of 63 dBuV at the most distant outlet (i.e. the outlet at the end of a circuit having maximum loss of signal level). The frequency response of the amplifiers shall be compatible with radio Television Malaysia transmitted frequencies in the selected area.

The amplifiers along with remainder of the system shall be capable of use without modification for distribution of colour monochrome signals to the respective Bonds.

The equipment shall be fully tropicalised with low power consumption designed to remain switched on and unattached at all times. Lightning arrestors should be fitted at the input stage to make the unit electrically safe and fire proof.

The amplifier shall be housed in a locable cadmium plated ventilated steel cabinet to be wall mounted with suitable steel brackets at the position shown on the drawing or as directed by the Consulting Engineers at site.

2.4 The Signal Distribution System

The system shall be such that each TV / Radio outlet shall produce a signal at a standard system level of at least 63 dBuV. The final box of each series of outlets must be terminated with a 75 ohm resistance prevent reflection.

The system shall be so designed that the isolation between outlets shall be greater than 60 : 1 (36 dB) over the band to ensure that the use of any outlets will not affect the other outlets.

Outlets shall be capacitor isolated to ensure that a faulty receiver cannot feed a high potential onto the main line.

The cover plate shall be of ivory mould plate suitable for flush mounting. Equivalent to MK types.

2.5 Cabling

All cables shall be lowloss coaxial type having a characteristics impedance of 75 ohms. The cables loss per 100 yds at 200 MHz shall not exceed 10 dB. All cabling shall be in concealed PVC conduit.

2.6 Calculation and Working Drawings

The Contractor prior commencement of work shall submit a full set of calculations based on manufacturer's equipment to achieve the required signal level. Upon approval by the Consulting Engineer, a set of working drawings shall be submitted for approval.

2.7 Testing & Commissioning

On completion of the installation the output signal level at each Television outlet shall be measured. All test results shall be submitted to the Consulting Engineers.

3 **STRUCTURED CABLING SYSTEM FOR VOICE & DATA**

3.1 GENERAL

The objectives of the structured cabling system are :

- 3.1.1 Support any data transmission technology exceeding 100 Mbps.
- 3.1.2 The cabling system complies to IEEE, EIA/TIA 568 and ESTI guidelines / standards.
- 3.1.3 The structured cabling system constitutes of the MDF, DDF, Backbone cable, Horizontal distribution frame, Horizontal cabling and Wall outlet.

3.2 DDF

- 3.2.1 The DDF is the main data cable distribution point for the backbone cable and the active component.
- 3.2.2 The DDF must be a 19" rack mounted in a lockable 23" cabinet or enclosure equipped with cooling fan and minimum 5 nos. power outlets.
- 3.2.3 The heights of the cabinet or enclosure should not be less than 37U.
- 3.2.4 It must be accessible from all sides by unlocking and lifting the sides or doors.
- 3.2.5 The front side or door must be transparent so that all the signal lights and patch cords are visible from outside.

3.3 Backbone Cable

- 3.3.1 The Backbone cable links the DDF to the Horizontal distribution frame at every floor.
- 3.3.2 The Backbone cable must be of the tight buffered fiber optic 62.5/125 um MM or 9/125 um SM.
- 3.3.3 It must have minimum 6 cores and it must be individually insulated and reinforced with aramide yarn strength member under a PVC flame retardant outer jacket.
- 3.3.4 The fibre optic cable must be able to support IEEE and ESTI standards.
- 3.3.5 The maximum fiber loss must be less than 3.76 db/km for MM or 1 db/km for SM.
- 3.3.6 The minimum bandwidth 160 m MHz for MM and 500 m MHz for SM.
- 3.3.7 The minimum bending radius allowable is 10 times the cable diameter.

3.4 Horizontal Distribution Frame (HDF)

- 3.4.1 The Horizontal distribution frame housed the line interface unit (LIU) for the backbone cable termination, the active components HUB : Concentrator / Bridges / Meters, etc, the horizontal cable patch panel, the patch cords and wire guide.
- 3.4.2 Horizontal Distribution Frame can be either floor or wall mounted equipped with cooling fan and minimum 3 power outlets.
- 3.4.3 The heights of the HDF minimum 12 U and it must be transparent from the front.

3.5 Line Interface Unit (LIU)

The Line interface unit shall provide facilities to splice or terminate 6, 12 or 42 cores backbone fibres complete with ST/FC/SC adapter or coupler.

3.5.1 The LIU shall be 19" rack mount minimum height IU.

3.6 Horizontal Patch Panel

The Horizontal patch panel must be of the RJ45, 24 ports category 5.

3.6.1 The Horizontal patch panel shall be 1 U height mounted inside the enclosure 19" HDF rack.

3.6.2 The patch panel horizontal wiring configuration must be in accordance to TIA 568A or B.

3.6.3 Each port must be clearly marked and labelled for easy identification.

3.7 Patch Cords UTP / STP

The patch cords is to interconnect the horizontal patch panel port to the HUB port or active component.

3.7.1 The patch cord can be UTP or STP cable with RJ 45 Connectors at both ends.

3.7.2 The patch cord must be of Category 5 and variable length of 1, 2, 3, 5 or 6 meters in order to ensure the right length to be used for the inter connection between the RJ 45 Horizontal patch panel to the HUB.

3.8 Fiber Patch Cord

The fiber patch cord is to interconnect the backbone cable from the LIU to the HUB or the active component.

3.8.1 The fiber patch cord must be tight buffered 62.5 / 125 um or 9/125 um.

3.8.2 The patch cord must be equipped with the right connectors ST/FC/SC at both ends for the right interconnection at the LIU and HUB.

3.8.3 The patch cord must be variable in length of 1, 2, 3, 5 or 6 meters in order to ensure only the right length to be used for the interconnection.

3.9 Horizontal Cable

The horizontal cable is used to connect the RJ 45 Horizontal Patch panel at the horizontal distribution frame to the Work Station RJ 45 wall outlet. The cable can be unshielded twisted pair or shielded twisted pair.

3.9.1 The cable must be 4 pairs 24 AWG category 5 and meeting or exceed UL/CSA/ETL standards.

3.9.2 The cable should be able to support ATM transmission at 155 Mbps.

3.10 Wire Guide

It is used to guide patch cords to the right port at the RJ 45 patch panel and HUB for easy identification.

3.10.1 The height of the wire guide must be iU and it is installed and spaced at every 48 ports of the patch panel or HUB.

3.11 Telephony Outlet RJ 45

The work station wall outlet is the point of connection of the horizontal cable and the work station PC.

3.11.1 The wall outlet must be of the RJ 45 single or double outlet and should be able to accept 22 to 26 AWG SOLID WIRE TERMINATION.

3.11.2 The RJ 45 wall outlet must meet or exceed UL, CSA or FCC part 68 standards.

3.11.3 The RJ 45 wall outlet must be of the IDC type and preferably with shutter.

3.12 **PRODUCTS WARRANTY**

The products supplied must meet the TIA/EIA 568 standards and carry a 12 months warranty from manufacturing defects.

3.13 **SYSTEM COMMISSIONING**

The complete data cabling system must be tested to meet the EIA/TIA 568 Category 5 100 Mbps requirement. Every wall outlet and every ports at the patch panel must be tested from both ends for wire mapping, wire length, near end crosstalk (NEXT) and signal

3.14 Wire Mapping test is to ensure :

- a) Proper pin termination at each end
- b) Continuity from wall outlet to the patch panel
- c) To detect shorts between any two or more conductors
- d) To detect crossed pairs, reversed pairs, split pairs or other miss wires.

3.15 Wire length test is to ensure that the UTP cable length which is the link from the wall outlet to the patch panel does not excess 90 meters.

3.16 Near end cross talk is to measure the signal coupling from one pair to the other within the UTP cable length.

3.16.1 The measurement must be better than the reading in Table A.

3.17 Attenuation is to measure the signal loss in the UTP cable length and the patch cord up to permissible level.

3.17.1 The measurement must be better than the reading in Table B.

Table A

Frequency MHz	Category 5 (dB)	Measured	Pass or Fail
1	60.3		
4	50.6		
8	45.6		
10	44		
16	40.6		
20	39		
25	37.4		
31.25	35.7		
62.5	30.6		
100	27.1		

Table A

Frequency MHz	Category 5 (dB)	Measured	Pass or Fail
1	2.5		
4	4.5		
8	6.3		
10	7		
16	9.2		
20	10.3		
25	11.4		
31.25	12.8		
62.5	18.5		
100	24		

3.18 **PERFORMANCE WARRANTY**

The complete Category 5 data and voice cabling system must be able to provide performance warranty for a minimum of 10 years from the date of commission.

3.19 **MAIN DISTRIBUTION FRAME (VOICE)**

the main distribution frame (MDF) and connector used to connect Telekom Malaysia incoming cables must be of Telecoms approved type. This MDF is the demarcation point between the incoming cable and the in-house voice and data cabling system. It must be on

3.20 **OPTION - CAMPUS ENVIRONMENT**

Campus environment is where the interconnection has to be done from one site to another site nearby. The recommend cable for this interconnection is fiber optic 62.5/125 um MM or SM.

3.21 **ENHANCED CAT 5 CABLE**

The cat 5e cable shall be constructed with 4 pairs of solid and insulated copper conductors with UL CMR fine rating. It shall be designed for use in horizontal cabling and comes in a 305m pull out box.

It shall be available in Grey and Blue sheath colours, colour coded fo 4 pairs, PE insulated for the outer jacket.

It shall comply to UL 444; TIA/EIA 568 - B.2 (April 2001), ISO/IEC 11801.

Technical specification shall comply to the following standards.

Table 1

@100 Mhz	Category Se Standard
Attenuation (-dB)	22
Crosstalk (-dB)	35.3
PSNEXT (-dB)	32.3
ELFEXT (-dB)	23.8
PSELFEXT (-dB)	20.8
Return Loss (-dB)	20.1

Table 2

Cable	Category Se Standard
Gauge	24 AWG copper wire
Pair Count	4 pair individually colour coded
Rated temperature	60 Celsius, 75 Celsius

3.22 ALARM WIRING SYSTEM

- 3.22.1 The alarm system wiring shall comply to the telephone wiring specifications strictly.
- 3.22.2 The type of wiring employed shall be 2 pair 10lbs Grey telephone wiring or multipair communication cables (approved by the S.O) concealed in conduit.
- 3.22.3 All wiring shall be tested for continuity after installation and results shall be tabulated for the SO. approval.
- 3.22.4 All wiring shall be left coiled with 300mm extra length at the sensor points and 1m length at the location of alarm panel end.

SPECIFICATION

SCOPE OF WORKS FOR COLDWATER & SANITARY PLUMBING

- 1 The extent of work to be provided under this sub-contract include the supply, delivery, installation, testng, commissioning and eighteen months maintenance and guarantee of the installation. In general, this shall include arrangements with various authorities for testing and approval of the installation including payment of relevant fees.
- 2 All work carried out shall be by competent personnel in compliance with specifications and conform as closely as practicable with the best engineering practice.
- 3 The whole of the sanitary works shallbe executed strictly in accordance with the relevant by-laws of the Local Authority and allowance to be made in the tender for any such by-law which may not be specifically mentioned in the specification or on the drawings.
- 4 The plumbing work shall be executed by a contractor who is registered under the appropriate class with the Jabatan Kerja Raya Malaysia, Jabatan Perkhidmatan Pembentungan Malaysia and Syarikat Bekalan Air Selangor Sdn Bhd.
- 5 Pipes and fittings shall be manufactured complying with the current British Standards & Malaysian Standards and shall be of the type and class as specified.
- 6 Supplied materials shall be factory marked with manufacturer's name or identification mark. Any unmarked material shall be rejected.
- 7 The contractor shall provide every assistance to relevant authority's representative or representatives who may be present to inspect the plumbing and testing operation.
- 8 The contractor shall maintain records of pipes, fittings, joints, valves laid by him.
- 9 The manufacturer's names or trade names hereinafter given are used to indicate general design only and are not restrictive. Items by other manufacturers of similar design and of equal overall quality may be submitted for approval.

10 The work is summarised under the following main headings:-

- i) Water Supply
 - a) Water is piped from the SYABAS's main to the roof domestic tank where gravity feed is employed to supply to the fittings.
 - b) Hot water system excluded in this Contract.
- ii) Sanitary Plumbing
 - a) The installation shall be as shown on the drawings and as specified in this Contract.
 - b) Excavation, trenching and making of manholes shall be by this contractor.
 - c) Sewerage pumps and associated works also by this contractor.
 - d) All surface water drainage submissile pumps and associated works also by others.

11 Regulations, Code and Standards

All works covered in this specification shall be implemented and completed in strict compliance with all relevant statutory regulations, By-laws and Orders of the Local Authorities. Where the Local Regulations and Rules do not exist, the appropriate British Standards and Malaysian Standards shall be adhered to.

12 Testing

Before the issuing of the letter of acceptance by the Engineer, the installation shall be tested and adjusted in accordance to SYABAS's regulations and Local Authorities' requirements.

The Contractor shall supply all materials, apparatus, instrument, water and labour required for the tests. All tests shall be carried out in the presence of and certified by the relevant authority's appointed representative. Test results shall be submitted to the Engineer. Test results shall be submitted to the Engineer in duplicated for approval and shall include a brief description of test method and instrumentation used.

13 Sewers

No sewer, laterals, junctions and other work shall be covered up until they have been checked and approved by the Engineer. The test should apply before the pipes backfilling the trenches. Should the pipes become damaged and lose water from any cause after backfilling, the Contractor at his own expense shall have the pipes uncovered and rectified and the pipe re-tested.

14 Soil, Waste, Ventilating and Anti-Siphonage Pipes

Smoke test shall be applied to soil, waste and anti-siphonage pipes. The Contractor shall supply all the necessary equipment for tests. Pipe joint shall not be painted prior to the satisfactory completion of test. Care should be taken to ensure that the system is filled with smoke before sealing with plugs.

15 Performance Guarantee

The Contractor shall guarantee the installation against any defects weakness, deterioration, defective materials or workmanship, for a minimum period of 12 months from the date of handing over.

16 failure to Achieve Guaranteed Performance

Should the whole or any part of the installation be unable to produce on test the performance guaranteed in the Tender, the Consulting Engineer may at his discretion permit the Contractor to carry out at his own cost such modifications to the installation as he may propose to improve its performance and allow such time as they consider to be reasonable for the execution of such modifications. Such permission will not be granted if the Consulting Engineer considers the carry out of the modification proposed by the Contractor to be not in the best interest of the Employers.

Notwithstanding the above, should the installation be unable to produce on test (or re-test approved modification) the performance guaranteed in the Tender, the Consulting Engineer may reject the whole or any part of

The Contractor shall at his own cost dismantle and remove from site the whole or any part of the work which has been rejected and at the discretion of the Consulting Engineer will be required to replace it with an approved alternative or to reimburse the employer for the cost of such replacement carried out by others provided that the total amount of such reimbursements shall not exceed the original Tender Price.

17 Work By Others

The following is a general guide only and the details will be finalised by the Main Contractor and the various specialist contractors during the formulation of their respective contract.

18 Main Contractor

- i) Base plinths for Booster pumpsets and water storage tanks.
- ii) Riser duct cabinets and doors on each floor.
- iii) Provision of structural openings through R.C. walls, beams and floor.

19 Electrical Contractor

Sub-mian to all coldwater Booster Pumpsets and sewage pumpsets control panels.

20 The condition above does not release the Contractor from his responsibilities to comply to specification and drawing to provide all necessary openings and base plinths and liaison with other specialist contractor for such provisions.

21 Clearing, Cleaning And Making Good On Completion

The contractor shall gather up and clean away all rubbish as it accumulates during the progress of the works and leave the site clean and tidy upon completion. The Contractor whall also remove all debris arising from the construction work form the site.

22 Electrical Works

All electrical associated with cold water and sanitary plumbing services are to be included in this tender unless otherwise stated.

23 Submission Of Shop Drawings, Catalogue/Samples

To submit for approval a schedule of shop drawings submission and shop drawing for approval also to summit ctalogue and sample for approval prior to starting works.

WATER SUPPLY SYSTEM

1.1 Water Main Connection

The Contractor shall make application to the water supply department before connecting up the main to water supply main with tap off valve.

All pipes, valves and fittings supplied and installed shall meet with the B.S. specification and SYABAS's approval

The Contractor shall be responsible for all necessary excavations, trenching laying pipes and set in concrete blocks, backfilling, ramming and making good.

1.2 Materials of Pipes

All installation shall be done according to the drawings. Special care shall be taken in the arrangement of piping to ensure a neat finishing and alignment.

All pipes and fittings shall be thoroughly cleaned and free from burrs, scale and obstructions before erection. Clean sharp pipe cutters not hacksaws, shall be used to cut metal pipes. Threads shall be cut with clean sharp die.

Connections shall be as direct and as feww as possible. Valves and fittings shall be grouped where this will not affect their operation, to reduce the number of joints to a minimum.

All necessary isolating valves, check valves and other fittings as required and as shown on the drawings for proper valving of the whole installation. Every section of major branch supply piping shall be controleld by a stop valve at the point of connection to the supply.

Pipe connections of 2+" and above connect to equipment shall be flanged joints and pipe connections below 2+" diameter shall be screwed unions to permit removal for maintenance without disturbing other pipes.'

All pipeworks other than in pump rooms and where stated shall be run in false ceillings, ducts or chase in wall.

1.3 Pipe joints

The number of demountable joints, e.g. flanges, unions etc., shall be kept to a minimum.

All screwed joints shall be made by using Teflon tape or approved jointing compound. Machine flanges shall be used for flanged joints.

True alignment is important. Flange gasket shall be of asbestos composition or cotton duck reinforced rubber gaskets suitable for the temperature and pressure of the particular system.

1.4 Pipe Supports

The Contractor shall supply and install all necessary pipe supports, hangers anchors, guides or required for proper support.

Riser shall be supported at each floor with mild steel riser clamps.

Horizontal pipe runs shall be supported on hangers of split ring or clavis type.

Where practical, supports and hangers shall be located immediately adjacent to any change in direction and at valves and heavy equipment.

Where pipe lines run in a common group they shall be supported from a common hanger bar fabricated from mild steel sections.

Pipe supports and hangers shall be spaced at interval not exceeding the followings:-

<u>Nominal Pipe Diameter</u>	<u>Hanger Rod Diameter</u>	<u>Horizontal Spacing</u>
Up to 3/4"	1/4"	6
1" to 1 1/4"	1/4"	6
1 1/2" to 2 1/2 "	3/8"	10
Above 2 1/2"	1/2"	12

Vertical pipes shall be supported at least at the top and bottom of each riser, at each floor level and at each isolating valve. In addition, a further support shall be provided between floor levels for pipes smaller than 1 1/4".

1.6 Sleeve and Cover Plate

The Contractor shall supply and install sleeves where pipes penetrate through walls, floor etc. All exposed piping within occupied rooms shall be heavily chrome plated. Cover flanges shall be installed at the point of penetration by pipes or fittings at walls or ceiling where exposed to view.

1.7 Valves and fittings

All valves and fittings necessary for the correct control, operation and maintenance of all services shall be provided and installed to the satisfaction of the S.O. Samples shall be submitted for S.O.'s approval before installation. Valves shall be installed where they are easily accessible for maintenance and operating purposes.

Each valve shall be of the same nominal size as the line in which it is installed, except for control, pressure reducing and similar valves which shall be correctly sized for the duty concerned.

Valves shall be of replaceable components, valve bodies up to 2" shall be of bronze construction with screw connection and cast iron or steel construction with flanged connections for valves 3" and above.

Before installation, every valve shall be blow out with air to remove any foreign matter lodged in the valve.

All valves shall be of approved manufacture and generally constructed in accordance with relevant British Standard Specifications. All valves shall be suitable for operating pressure up to 150 p.s.i.

a) Gate Valves

Gate valves shall be used at connections to pumps, water mains, tanks, main risers etc., where indicated on the drawing.

The valve shall have hand-wheel with externally screwed bronze or stainless steel spindle.

b) Stop Cocks

Stop Cocks shall be used to isolate fixtures for maintenance purposes.

- c) Strainers
Y Type with removable stainless steel or bronze mesh basket strainer shall be supplied and installed where shown in the drawings.
- d) Pressure Gauges
4" diameter dial type with 3-way gauge cock shall be supplied and installed where indicated in the drawings
- e) Water Meter
Suitable water meter of approved manufacturers(Kents or equivalent) shall be supplied and installed as required.
- f) Float Ball Valves
Pressure operated ball valves shall be supplied and installed to the make up tank. Installation shall be carried strictly to the manufacturer's recommendation.

1.8 Storage Tanks

- a) Tanks
The overall sizes of the tanks are as shown in the drawings and they shall be of approved quality.
- b) Galvanised Pressed Steel Tank
Pressed Steel sectional tanks made of 4'-0" square pressed steel sectional plates shall conform to B.S. 1564. For 3' 3/4" (1 meter) square pressed steel plates, they shall be of approved manufacture and similar to "Braithwaite". The tank shall be constructed with external flanges, complete with internal bracings, nuts, bolts, perforation for pipes, pads, 1/8" thick mild

All tanks bracings, nut and bolts etc., and other accessories shall be galvanised by the hot dipping process. The zinc coating shall be smooth, uniform, continuous and tough. It shall be able to withstand light blows from a 1/2 lb hammer without peeling or deformation.

The minimum thickness of steel plates for various sizes of tank shall be as follows:-

- i) tank sections where tank does not exceed 8 ft. depth 3/16" thick.

- ii) tank sections where it exceeds 12 ft depth. 3/16" for section not more than 8 ft from top of tank.
- iii) Angle-iron stays, cleats and other similar members shall adequately provided and of sizes calculated to withstand expected forces and corrosion. These sizes shall be to manufacturers' recommendation and in no cases shall the members be less than 1/4" thick.
- c) Jointing Material
The jointing material shall be of the best quality, non-toxic, non-contaminating and does not melt or deteriorate at an ambient temperature of 170°F.
- d) Painting
The tank shall be sand blasted and painted internally with "ICI Delux Protective Primer (F580-PJ-0455)" and then with 2 coats of Epoxy Tank coating (F431-166) or equivalent and externally with 2 coats of chromate primer and 2 coats of "ICI" aluminium paint or equivalent to be approved by S.O.
- e) Fibre-Reinforced Polyester (FRP) Sectional Tank
Where FRP sectional tank is used it shall be complied to SYABAS's requirement and approval.
- f) Polyethylene Water Tank
The tank shall be complied to SYABAS's requirement and approval.
- g) Testing
The tank shall be filled to a maximum operating capacity level with water from an approved source. The tank shall be considered to have passed the test if after a period of 48 hours, there is no measurable reduction in water level and no sign of leakage from any part of the tank.

2.0 DOMESTIC WATER PRESSURE SYSTEMS

General

The system shall include booster pumpsets, wirings valves, vibration pads, orifice plates, flow switches, flow meters, power and control panels, emergency controls, sensing devices such as electrodes and float switches, pipework and accessories as required for a complete system.

2.1 Valves and fittings

All valves and fittings shall conform to the relevant British or Malaysian Standards.

All bends in pipework shall be long radius bends with turning radii not less than five times the pipe diameters. If this cannot be achieved, alternative bends of approved type shall be used. Square elbows shall not be allowed.

Reductions in the diameter of through-flow pipes shall be by means of reduction sockets. Eccentric reducing sockets shall be used on horizontal pipes and concentric reducing sockets on vertical pipes only.

Except for control valves, pressure reducing valves and similar valves which have been specifically sized for the duty concerned, all valves shall be of nominal size as the pipeline. Valves shall be installed in accessible positions, located as near as possible to supports and equipment. The connection between each valve and adjacent equipment or piping shall be of screwed connections.

Valves shall be installed in strict compliance with the manufacturer's recommendations. Every valve shall be blow out before installation to remove any foreign matter lodged in the valve.

- a) Isolating valves sized up to and including 2 in. 50mm shall be of the gate type to BS 1952 with bronze body, bronze solid wedge, rising stem and screwed bonnet being flanged to BS 10 Table E or screwed to BS 21 as applicable. Valves shall be complete with a locking facility.

- b) Balancing valves shall be globe or ball valves of approved pattern and manufacturer. They shall be of bronze body for valve sizes up to 2 in. (50mm) and of cast iron or steel for sizes above. Valves shall have bronze or brass spindles, replaceable seats and steel handwheels.
- c) Non-return valves sized up to and including 1 1/2" (40mm) shall be of the swing check type to BS 1953 with bronze bodies cscrowed bonnet and bronze metal to metal seat. The connections shall be flanged to BS 10 Table E or screwed as applicable.
- d) Non-return valves sized at 2" (50mm) and over shall be of the swing check the to BS 4090 with cast iron body, cover plate and bronze metal to metal seat. The connections shall be flanged to BS 10 Table E. A vent cock shall be incorporated in the cover.
- e) Strainers of sizes up to 2" (50mm) diameter shall be bronze body strainers. Sizes 2'(50 mm) and larger shall be cast iron body type fitted with removable bronze screens.
- f) Flexible Pipe Connections

When required at all motor operated equipment, provide flexible piping connections as hereinafter specified.

- i) Flexible connections for steel piping shall be **Annonda** Co., or equal, corrugated steel with galvaanised wire braid, or shall be corrugated stainless steel with stainless steel wire braid.
- ii) Designation and length shall be as recommended by the equipment manufacturer for conditions applicable during the system's test and under the most adverse operating pressures and temperatures.
- iii) Automatic air release valves shall be installed on all high points of piping whether shown on the drawings or not. They shall be of bronze body with brass ball, and stainless steel valve and seat.
- iv) Drain valves shall be fitted at the base of pipe risers, headers and all low points of the piping system. The valves shall be brass bib cocks with hose connections.

- v) Pressure gauges shall conform to B.S. 1780 and shall be minimum 4 in (100mm) diameter dial type of approved pattern and manufacture. The scale value shall be calibrated up to 150% of the maximum known pressure. Gauge connections shall be complete with an isolating gauge cock as well as anti-vibration cock snubbers.
- vi) Pressure switches shall be of the electrically operated type and shall be selected to suit the system installed.

2.2 Pipework Installation

All piping shall be run as directly as is practicable from one point to another, and with a few ells and bends as conditions permit. Piping shall be well supported and protected against damage. Overhead lines shall be securely fastened to structural members of adequate strength and supported with approved type brackets and hangers at suitable intervals. Supports, brackets and hangers shall allow for pipe adjustments to be made for securing proper grade and alignment.

Provision shall be made in the piping system to compensate for expansion, contraction, settling and vibration. Supports shall be provided at each change of direction.

All piping shall be graded to ensure venting and all piping and fittings arranged so that the complete system can be thoroughly drained. Separate drain valves or drain plugs shall be installed for all piping that cannot be drained back to the piping main. Air locking shall be prevented by the use of air cocks fitted where necessary located for convenient operation.

All services shall be installed in an approved manner to meet the Structural and Architectural Conditions and to avoid interference as far as possible with the work of other trades.

Where pipework passes through building structures G.I. Pipe sleeve shall be provided, sized to give a minimum of 1/2" (15mm) gap full around the pipe. The length of sleeve is to suit the thickness of the structure. Where the pipe pass through steel beams a 1"(25mm) spacer shall be allowed between the sleeve and the reinforcing plate around the hole. This sleeve shall be packed with asbestos fire proofing compound in an approved manner.

All pipes passing vertically through floor shall have sleeves extending 1" (25mm) above the floor. All sleeves shall be supplied and handed to the Building Contractor, together with detailed drawings showing exact locations required in sufficient time to avoid building delay.

Buried pipes shall be laid at least 18" (450mm) below the ground.

Pipe supports and hangers shall be spaced at intervals not exceeding the following. The means of supporting and anchoring of hangers and brackets shall be approved by the Engineer before installation.

<u>Nominal Pipe size (Diameter)</u>	<u>Hanger Rod Size</u>	<u>Maximum Span</u>
Up to 3/4"(20mm)	1/4"(6.4mm)	6 ft. (1.8m)
1"(25mm) to 1 1/4"(32mm)	1/4"(6.4mm)	6 ft. (1.8m)
1 1/2"(40mm) to 2 1/2 "(50mm)	3/8"(9.5mm)	10 ft. (3m)
Above 2 1/2"(65mm)	1/2"(12.5mm)	12 ft. (3.6m)

Vertical pipes shall be supported at least at the top and bottom of each riser, at each floor level and at each isolating valve. In addition, a further support shall be provided between floor levels for pipes smaller than diameter 1" (25mm).

A minimum of 2" (50mm) clearance shall be maintained between the pipe and the nearest wall or ceiling surface.

2.3 Booster Pumpsets

The water supply system shall be provided with water booster pumps as shown in the drawings. These shall comprise two numbers electrically driven pumpsets for duty and standby operation.

Pumps provided shall generally be centrifugal end suction type pumps. The pumps shall operate at constant speed with the pump motor coupled directly to the pump and the whole mounted on a common base plated bolted onto a concrete plinth. The plinth shall raise the pumps to at least 6 in. (150mm) above the known flood level of the pumpset location. Mounting of the pumpsets on the plinth shall be complete with adequate padding or vibration absorbers.

The pumps shall be selected to suit the type of service encountered. End covers, body rings, bearing housing and casing shall generally be of cast iron construction. Impellers shall be of bronze or gun metal and shafts of stainless steel. Case sealing rings, intermediate bushes and water -lubricated journal bearings shall be of phosphor bronze material.

Each pump shall be fitted with an air valve grease lubricator water shaft seal connection, copper gland drain fitting and tappings in the pump head casing for discharge pressure gauge. Proper drainage shall be provided for all points around the pump set mounting.

Suitable approved type flexible connections, splash guards, strainers, check valves, gate valves and pressure gauges shall be furnished with each pump set installation.

The capacities and performance requirements of the pump sets shall not be less than the minimum indicated in the schedules and drawings.

2.4 Electric Motor for Pump

The electric motor for the pump shall be a totally enclosed fan cooled squirrel cage-induction motor, of sufficient capacity to efficiently fulfil the pump horsepower requirements. The continuous maximum motor rating shall be to BS 2613 and shall have a minimum overload factor of 15% in excess of the power requirements at maximum pump discharge and minimum total head condition.

The pump motor shall generally be flanged motor and suitable for horizontal operation. Stator frames, end shields and terminal box and cover shall be cast iron or other approved material. Fan and fan bowl shall be corrosion protected material.

The motor shall be suitable for 415V, 3 phase, 50Hz power supply. All electrical works pertaining to the motor installation shall be provided. The motor shall be suitably earthed and provided with overload trip protection.

All supply cabling shall be PVC insulated cable run in conduit or trunking of PVC SWA PVC type.

The motor shall be provided with all the necessary thermal and overload protection.

The motor shall comply to TNB's requirements and suitable for the local power supply. The starters for the pump motors shall be DOL for motor less than 3 HP and star delta for motor 3 to 10 HP.

Capacitors shall be incorporated where necessary to maintain the power factor of all motor to 0.85 or higher. The contractor shall be responsible to arrange for testing on site to show that the P.F. is above 0.85 when motor are running at full load. Overload trip protection shall be provided.

Electrical works include the supply, installation, testing and setting to work of all motors, switchboards, starter, level regulators and other necessary work for the proper functioning of the system. All electrical works shall comply to the requirement of Nasional Electricity Board , Malaysia.

2.5 Automatic Control for the Pumps

All the pumps shall be wired for automatic operation, the controls shall be as shown and described in the drawings. The control wires shall run in conduit along with the water pipe.

The switchboard for all pumps shall have an ON, OFF indicator lights. Pumps failure warning light, high water level warning light and storage tank low water level warning light, auto manual switch, etc., as specified. The Contractor shall submit switchboard drawings for approval before construction.

All alarm signals shall be duplicated with the second set of signal at 24 volt installed on a space provided on the monitoring console. The light shall be similar to other securities light on the monitoring console. Details of the type of light required shall be supplied to the Contractor

2.6 Testing and Balancing

Upon completion of installation the contractor shall notify the Engineer and proceed to undertake the balancing, testing, cablibration and setting of all equipment and controls. Prior notification shall be not less than 48 hours in advance of any testing to be done.

All components shall be systematically tested for correct operation to ensure an approved installation as follows:-

- a) All pumps shall be checked for flow rates, pressure head and r.p.m.

- b) All pipework shall be hydrostatically tested to 150 psi to 1 + times the working pressure whichever is greater. This shall be maintained for a period of not less than 24 hours.
- c) Hose Reel Tanks shall be tested for leaks.
- d) All pressure and flow switches shall be set and tested to the satisfaction of the Engineer.
- e) All control board circuitry, indicators and alarms shall be checked for correct setting and operation.
- f) The two highest or most hydraulically remote hose reels shall be discharged simultaneously and checked for discharge rates and cut-in and cut-off limits of the duty pumpset :-

If as a result of these tests any defects are found, these shall be remedied as necessary and a retest of the system shall be carried out, until satisfactory performance is achieved.

2.7 Automatic Control

All pumps shall be automatically controlled. Three water level shall be used. The lowest level controller cuts off the pumps. Then the water level reaches the second level, the duty pump will be called into operation. If the water level further increases the next pump will be called into operation.

The switchboard for all the pumps shall have an ON, OFF indicator lights. Audio and visual device shall be incorporated and they will be actuated, once the water level reaches the third level controller. All for approval before construction.

1) Pump

The pump shall be a single or double stage centrifugal pump. The heavy section cast iron casing generously shall exceed the pressure and pipe loads imposed upon the system. All switchboard details shall be submitted to the engineer for approval before construction.

2) Pressure Tank

The tank outer sheel shall be of at least 3 mm steel, and protected internally with an anti-corrosive paint and the external sureface is additional quoted with a high quality enamel finish. The heavy section cast base is sealed by the 'O' ring portion of the Butyl rubber convoluted diaphragm. Again the internal surfaces of the base are additionally protected by corrosion resistant paint. The system shall be bolted down using the 4 nos. diameter mounting holes. Tank pressure rating shall exceed maximum pump working pressure.

3 Pressure Switch

The pressure switch which controls the pump's operation shall be factory set at to the right pressure. It shall be of heavy duty type with a power rating to cope well with the requirements of the pump.

2.8 Painting and Corrosions Protection

In general, all items of equipment, piping, sheathing, hangers supports shall be painted and protected against corrosion. Painting shall generally comprise of one coat of suitable primer, one undercoat and two finishing coats of high glass enamel. Only the best and approved type primers and paints shall be used. All surfaces shall be suitable for the relevant surface.

Each coat of paint shall be supplied by brush and when thoroughly dry, be smoothed with suitable abrasive paper or cloth before the next coats is applied. Painting shall be done only dureing suitable weather.

All final coatings shall be to the approval of the Engineer.

All hot dipped galvanised iron pressed steel water tanks, tailor made galvanised iron tanks, must be painted internally with a coat of non-toxic paint and externally with one coat of suitable under water and two finishing coats of high gloss enamel light blue color.

All M.S. Bolts and Nuts must be painted aluminium colour.

All M.S. Bracket support must be painted with one coat of undercoat before installation.

3.0 SANITARY SERVICES

3.1 Internal Pipework

All pipes shall be run in accordance with layout and sizes shown on the drawings.

Soil and main waste pipes above ground shall be of cast iron (B.S. 416) heavy grade or unplasticised P.V.C. to B.S. 4514 : 1983/MS978:1985

Main vent pipes shall be of cast iron (B.S. 416) (medium grade) or unpasticised P.V.C. to B.S. 4514 : 1983.

Branch vent pipes shall be cast iron (B.S. 416) (medium grade) and galvanised steel (B.S. 1387) for wastes or unplasticised to B.S. 4514 :1983/MS978: 1985

Main soil, waste and vent pipes shall be carried up the root level and completed with vent cowl.

Cleaning eyes or access shall be provided at all bends and branches of soil and waste pipes. "Long Bend" shall be used for all bends, Pipe gradients other than that stated in the drawings shall be as follows:-

2" pipe	-	1 : 20
3" pipe	-	1 : 30
6" pipe	-	1 : 60

Glazed Ware Pipes

- 3.2 All joints of glazed ware pipes shall be made by wrapping one lap of tarred gaskin round the spigot of the pipe and placing it into the socket of the pipe previously laid. After fixed in its correct position the gaskin caulked lightly home but not so as to occupy more than one quarter of the socket depth. The socket shall then be completely filled with cement mortar (1:1) and a fillet shall be formed round the joint, with a trowel forming an angle of 45 degrees with the barrel of the pipe.

Cast Iron Pipes and Steel Pipes

- 3.3 All joints shall be made lightly caulking in sufficient turns of tarred yarn or lead strip as will leave the unfilled the required depth of socket as set out in BS Code of Practicae 301. Molten pig lead shall be then poured in to fill the remainder of the socket and shall be solidly caulked right round the joint with neat finishing.

Pipes installation

- 3.4 All pipes shall be installed at least 1+" clear of walls with hinged holderbats or other approved fisings. Where pipes run horizontally shall be suspended from the underside of the floors slabs with approved hangers.

Anti-Syphonage Pipes

- 3.5 An anti-syphonage arm shall be installed where shown in the drawings. Anti-syphonage pipe shall be connected from each fixture to branch or main vent pipe above the level of such fixtures. Except in special cases and with the approval of local Authorities, anti-syphonage pipes shall be connected to the waste, soil or combined pipes on the opposite side of the water seal to the fisture at a point not less than 3" or not more than 12" from the highest point of the traps. No fixture shall be connected to the soil, waste or combined pipe at any point of the anti-syphonage pipe.

SANITARY FITTINGS

General

- 4 All sanitary fittings and appliances shall be manufactured in accordance with
- 4.1 British Standards or as approved by Local Authority. All such fittings shall be supplied by others. However, they shall be installed by this Contractor under this Contractor.

Workmanship

- 4.2 Sanitary fittings and appliance have to be fixed in good workmanship and to the satisfaction and in accordance with the regulations of the Local Authority as specified or as directed by Engineer.

Rates must include for all making good, sundry items essential for the installation such as plugging walls, providing nails, screws, etc.

The whole of the work is to be tested at the Contractor's expense, at such time and in such manner as the Engineer may direct and to his satisfaction. Discharge tests should be made from all appliances, singly and collectively. Any defects revealed by the test should be made good and tests repeated until a satisfactory result is obtained.

Painting and Identification

All pipeworks equipment, valve, etc., shall be clearly identified as specified below and subject to the approval of the Engineer.

a) Pipework

All piping installed under this Contract shall be identified in accordance with the following table and BS 2660 'Colours of Building and Decorative Paints'.

<u>Nature of Pipe</u>	<u>Colour</u>	<u>Supplementary Colour</u>
Main Water	6.071 Light Green	0.012 mid blue
Drains, Waste & Soil	Black	-
Hot Water Ablution	0.012 mid blue	4.055 yellow
Electrical Conduit	0.004 orange	-
Pipes & Other items exposed to weather	Aluminium	-

b) Labels for Valves and Controls

All control valves, relays, switches and instrumentation shall be identified by black or white engraved laminated plastic labels, securely attached to the item of equipment, or where such equipment is installed on or within panels or cubicles the labels shall be located immediately below the equipment. Where valves are normally opened the hand-wheels shall be painted green and if normally closed the hand wheels shall be painted red.

Directional arrows shall be painted on the pipework in the plant rooms and vertical risers.

Manhole

All materials not otherwise specified are to be in accordance with the Specifications of the British Institution or its equivalent, in so far as those Specifications apply.

Concrete

Concrete shall be quality A, B, C, F or G as provided by this Specification, or when the quality is not specified, as required by the Consulting Engineer, and the proportions of the ingredients shall be as follows:-

Concrete Mixture	Parts by Measures			Uses
	Cement	Sand	Aggregate	
Quality A	1	2	4	All jointing chambers plinth place between two sets of plant if separation clearance is 6" or less
Quality B	1	2	7	
			a	
			n	
			o	
			l	
Quality C	1	3	9	For supporting, protection or filling in purposes.
			I	
			t	
			h	
			i	
			c	
Quality F	1	2	3	Concrete Troughs
Quality G	1	1 1/2	3	Filling in covers Manhole 3E & 7E
Cement	1	4	3	Encasement of Conduits
Mortar	1	3	-	Plastering, sealing Dummy ducts in Jointing Chamber, Repairing damaged or split ducts.

Concrete for Encasing Conduits

The concrete used for encasing conduits shall relatively be dry having the consistency of wet sand. In no circumstances shall the water content be increased appreciably as this will result in a weak concrete. Rapid-hardening cement shall be used.

Quality

The jointing chambers shall be constructed throughout of Quality A concrete and concrete troughs of Quality F concrete.

When a coarse concrete is required for supporting or protecting other service mains, or for filling in purposes, Quality C concrete shall be used, unless otherwise specified.

Waterproofing

If the contractor desires to use a waterproofing material he shall obtain the consent of the Consulting Engineer before using it but no extra payment will be allowed for the use of waterproofing material.

Mixing

Concrete mixing may be done manually or by machine. When mixed manually the ingredients shall be sand, cement and aggregate repeatedly turned over and mixed in a dry state on mixing boards, after which water from the rose of a watering can shall be added, and the material shall then again be turned over sufficiently to ensure thorough mixing.

The mixing boards shall be sufficiently large to give ample room for turning over the ingredients entirely from one place to another and shall be so arranged or constructed that liquid cement shall not escape through the joints.

When mixed by machine the ingredients shall be put into the machine dry without prior mixing. The water shall be poured in first. Such machine shall, however, be used only so long as they ensure thorough mixing and are maintained in clean condition. They shall be of the "batch" type.

Water

The standard of cleanliness of water for mixing is that it shall be fit for drinking. The quantity used shall be sufficient, but not more than sufficient, to effect the proper hydration of cement to obtain a plastic mixture. The Consulting Engineer may reject concrete which is, in his opinion, so overwatered that it would be deficient in ultimate strength.

Compaction of Concrete

The concrete shall be deposited carefully in its intended position as quickly as possible after being mixed, and all concrete footings and foundations shall be tamped and carefully levelled. All concrete shall be compacted by the use of a poker type vibrator until a dense solid mass without voids is obtained. Under no circumstances must the vibrator be used longer than is necessary to obtain compaction nor left unattended in the concrete, otherwise segregation of the mixture will occur.

Rejection

Concrete which has become hard, dry, dirty or not placed within 30 minutes after being mixed shall not be used, and if any earth fall on the top of any concrete after laying and before the work is completed it shall be carefully removed.

Cleanliness

Cleanliness shall be observed in all operations and in relation to all materials.

Cement

All cement used shall be of the best Malaysian or other approved manufacture and shall comply with all the requirements of B.S. No. 12. The cement shall be fresh, fine, smooth, loose and warm when tested by hand, and the Consulting Engineer may order that any bag of cement, a portion of the contents of which was hardened, or found unsatisfactory by the hand sampling test be removed from the site forthwith.

High Alumina Cement

Before work with high alumina cement commences, all tools and plant shall be cleaned of all other types of cement residue and at no stage of the work shall any other type of cement be mixed or allowed to come into contact with high alumina cement, HIGH ALUMINA CEMENT MUST NOT BE USED WITH PVC DUCT.

Rapid-Hardening or High Alumina Cement

The Contractor may employ generally rapid-hardening Portland cement or high alumina cement in lieu of ordinary Portland cement for his own convenience and acceleration of progress. No extra payment for rapid hardening or high alumina cement will be made except when its use is authorised by the Consulting Engineers.

Protection

The Contractor shall ensure that all cement is protected adequately against moisture while being transported and stored.

Cement Aids

The use of cement aids where an additive is added to ordinary Portland Cement to render it rapid-hardening is not recommended and permission for its use shall first be obtained from the Consulting Engineer who shall also determine the amount of additive to be used.

Sand

All sand shall be clean, sharp, gritty, river sand, free from loam or earth or other impurities and from an approved source, If upon test by washing a sample, the sand is found to contain more than 5 percent by volume of silt, the sand shall not be used. The sand used shall be of coarse, the grains graded in size to 3/16 inch.

Aggregate

The aggregate for concrete shall be cleaned screened river ballast, gravel, stone or other material as approved of the nature of cubes, not of flakes, graded in size, free from dirt, flinty stones, dust, loam or earth or any other impurities, No clinker, brick sandstone, or other porous stone shall be used.

Size of Aggregate

The maximum size of aggregate for each of the qualities of mix shall be as follows:-

A... 3/4 inch, B ... 1 1/2 inches, C... any size suitable for work, F & G ... 3/8 inch, for encasement of conduits ..., inch. Any portion which will pass a 3/16 inch mesh may be used as sand.

Bricks

The bricks used shall be best quality hard burned common bricks, either wire cut or plastic pressed, or selected hard hand-made stock bricks or other hard or overburned hand-made bricks of comparable quality. They shall be of good shape, free from visible partivulars or lime and from serious cracks, and shall not absorb more than 12 percent of their weight when immersed inwater for 24 hours. (5 bricks from each batch delivered on site shall be tested and all shall be required to pass the test). The dimensions of bricks described as types 2 and 3 in BS 657 shall be regarded as standard.

Cement Mortar

The cement mortar shall consist of :-

One measure of cement ; Three measures of sand

The materials after being gauged shall be thoroughly mixed in a dry state, and then thoroughly mixed with sufficient water form a stiff mortar.

On no account shall water be added after mortar has once been mixed, and mortar after has once begun to set shall not be used or mixed other cement and sand.

An excess of water shall in no case be used for mixing and if more water than is necessary be used, such mortar after it is once begun to set shall not be mixed with further quantity of sand and cement, but the whole shall be condemned.

Steel

All steel shall be in accordance with British Standard Specification No. 15 for structural steel. All invoices for steel shall be open to inspection by the Consulting Engineer or his representative.

If the Contractor cannot procure such reinforcing steel in the Imperial Size as described in the Drawings in sufficient time to avoid delay in the performance of his obligations under the Contract but can obtain such steel in the metric sizes to the dimensions approximating to those described in Drawings in accordance with the following table, then the Contractor shall forthwith give notice to the Consulting Engineer of these facts stating the dimensions to which such steel are procurable in the metric sizes.

Imperial sizes (ins.)	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1	11/8	11/2
Metric Size (mm)	6	8	10	12	16	20	22	25	28	40

As soon as practicable after receipt of any such notice the Consulting Engineer shall give an order to the Contractor which shall either :-

- a) direct the Contractor to supply the steel to the dimensions stated in his said notice to be procurable instead of to the dimensions described in the Drawings provided that (a) the quality of the steel comply with requirements of BS 4449 and that (b) any extra cost so arising in the variation is absorbed by the Contractor; or
- b) direct the Contractor to make some other variations where by the need to supply such steel to the dimensions described in the Drawings will be avoided.

Ironwork

Bolts, nuts, rivets and other accessories shall be in accordance with the relative BSS. All bolts, nuts and screws shall be withworth Standard. All invoices for iron shall be open to inspection by the Consulting Engineer or his representative.

Hardcore

All hardcore shall consist of hard brick, concrete or stone graded down to a minimum of 3 inches.

Note: When provided for use in trenches sufficient hardcore material under 3 inches shall be added to fill voids and aid consolidation.

Excavation

General

- 2 The Contractor shall not start work until he has produced all warning notices, barricades, barrier ropes, red warning lamps, etc., as may be considered necessary by the Consulting Engineer. The delay so caused shall not alter the date of completion of the Contract work.

Road

The Contractor shall keep open all roads and footways with the maximum interference to traffic and pedestrians. Not more than half a road may be closed to traffic at once, and the Contractor must comply with requirements of the Police Department, the Public Works Department or the Municipality or any Local Authority. On no account shall any materials be placed beyond 2 feet of edge of any excavation.

Barricades, Signs & Blinkers

Barricades and work signs shall be used by the Contractor at site at all hours from the commencement of works and blinkers between 6 pm till the roads are considered safe for use for traffic. This shall be determined by the Consulting Engineer who shall advise the Contractor in writing.

The barricades, road signs and blinkers shall be spaced at reasonable distance and shall conform with Part VI of the "PLACING AND HEIGHT OF ROAD SIGNS" Rules of the Road Traffic Ordinance 1958, which require that :-

- 1) The signs shall be placed on the traffic side of the roads appropriate to the direction of the traffic concerned. They may be repeated on the other side of the road.

- 2) The signs shall be placed at not less than 450 ft. And not more than 750 ft. From the hazard unless it is impractical on accounts of local conditions. In such exceptional cases the signs shall be erected at less than 450 ft. but as far as possible from the hazard.
- 3) The height of signs shall be not more than 7 ft. and outside built up areas not less than 2 ft.
- 4) The signs shall be so placed as not to be obscured or cause an obstruction to pedestrians.

Should it be found that the above have not been observed the Consulting Engineer reserves the right to install the barricades, work signs and blinkers without prior notice to the Contractor and charge the Contractor at cost plus 25% . This shall be deducted from the amount due to the Contractor for executing the work. The above action shall not absolve the Contractor from being responsible for any accidents incurred for non-observance of the requirements. The custody of the barricades, work signs and blinkers at site shall be the sole responsibility of the Contractor.

Protection of Excavated Material.

The Contractor shall excavate in carriageway or footway in positions as he may be directed by the Consulting Engineer, carefully segregating the surface and foundation materials from the sub-soil. Sub-soil shall be protected, whilst above ground, from weathering action which would cause a damaging increase or decrease in the natural moisture content of the soil leading to the formation of voids and/or settlement after backfilling. Normally a certain amount of sub-soil roughly equivalent to the volume of duct being laid is thrown surplus and carted to tip. Sub-soil which is damaged shall be selected for cartage to tip and undamaged brought from newly excavated length to replace the sub-soil carted away. Except where otherwise provided, the excavation shall include

Mechanical Excavators

Timber base support or platform shall be placed under the feet of the excavating machine as protection to prevent the carriageway surface being marked with scars and blemishes when the machine is in operation.

Silencer

Where pneumatic drills or other power driven road breaking appliances are used, they shall be fitted with efficient silencing devices and the compressor machine shall be maintained in an efficient condition so as to avoid undue noise.

Pilot Holes

The Contractor must obtain the prior approval of the Consulting Engineer to dig pilot holes. Pilot holes shall be dug at positions selected by the Consulting Engineer, normally, one per sectional length to ascertain the most suitable positions for the work.

Timbering Excavations

The Contractor shall be responsible for the stability of the excavation at all times. Timber supports for excavations shall be so designed and placed as to permit wherever possible withdrawal of such timber and consolidation of the space it occupied. The prior agreement of the Consulting Engineer must be obtained supporting timber is considered to constitute a greater danger to the surrounding property than the subsequent void produced by rotting timber.

Width of Trench

In no case shall the width of trench excavated be greater than is necessary for satisfactory execution of the work. The line of the excavated trench shall be as straight as possible and any bends or curves must be of the maximum radius possible. The line of trench will be marked out. Lines enclosing a suitable width of trench will be marked by the aid of a chalked cord. Where ducts are to be encased in concrete the width of trench is dependent upon the number of conduits to be laid in a horizontal direction. In unstable ground timbering may be necessary to support the trench and to act as a former for the concrete. To avoid excessive use of concrete the width of the trench shall be no greater than is reasonably necessary for the satisfactory execution of the work.

Depth of Trench

The dept of trenches shall be such that the average dept below the surface be according to the respective specification and required by the Consulting Engineer. The floor of the trench must be level and not follow surface irrregularities. The bottom of every trench shall be normally levelled with 2 inches of sand and rammed.

Change of Level

In passing from footway to carriageway and vice versa or where ducts enter jointing chambers below standard depth or in any other circumstance where it is necessary to change level, the bottom of the trench shall rise or fall gradually s the Supervising Officer may direct.

Dewatering

The Contractor shall deal with the disposal of water so as to prevent any risk of the ducts, cables and other materials to be laid in the trenches being detrimentally affected. He shall provide all pumps and appliances required and shall carry out the necessary pumping and bailing.

5.0 Pipes Laying

Line of Pipes

The line of ducts shall be kept as straight as possible.

Supervision

On no account shall any duct laying be done in the absence of the Consulting Engineer, and the Supervising Officer's directions and instructions shall be closely followed.

Clearance from Other Services

All ducts, whether asbestos-cement, plastic, iron or steel laid direct in the ground shall be kept well clear of water mains and service pipe, sewers and subways and manholes and joint boxes belonging to other undertakers. In order to permit the use of "Tapping" machines on water mains at least 6 inches clearance shall be given wherever possible. This clearance shall also be given, if practicable, to the other classes of plant mentioned above. In no case shall the clearance be less than 1 inch; where the two sets of plant cross each other the minimum vertical clearance shall be 2 inches, provided the approval has been obtained from the authority concerned.

Obstructions

When any water or electric supply main, drain or other plant which has seemingly been abandoned, constitutes an obstruction to the works, all efforts must be made to ascertain who are the owner with a view to consulting them before obstruction is disturbed in any way. In no circumstances must electric supply mains be interfered without the sanction of the owners concerned.

Clearance from Electricity Supplies

As much clearance as is practicable shall be given to the bases of electric lamp standards, electricity supply pillars, traffic signal posts, etc. Where it is impossible to provide a clearance of more than 6 inches, a layer of concrete Quality B, not less than 2 inches thick, shall be placed between the two sets of plant.

In the case of electricity supply cables, the following minimum separating distance between the two sets of plant shall be provided:-

High-Voltage Single-Core Cables (exceeding 650 volts)

Standard minimum clearance = 18 inches
No exception to this requirement will be permitted.

High-Voltage Multi-Core Cables (exceeding 650 volts)

Standard minimum clearance = 12 inches, in difficult cases a reduced clearance will be permitted.

Where it is impossible to provide a greater clearance than 6 inches, a layer of concrete Quality B, not less than 2 inches thick and of a width to overlap the power plant by 2 inches on each side, shall be placed between the two sets of plant. Where the two sets of plants cross each other, the length of the layer of concrete shall not be less than the width of the Telecoms plants.

Low and Medium Voltage Cable (not exceeding 650 volts)

Standard minimum clearance = 2 inches

Clearance from Electrical Supplies

Where the two sets of plant cross each other, no exception to this requirement will be permitted. At other points a clearance down to 1 inch may be allowed in difficult cases. Whatever the clearance is 2 inches or less, the space between the two sets of plant shall be filled with a layer of concrete Quality B.

In all cases the concrete must overlap the power plant by 2 inches on each side, and at crossings the length of the layer of concrete shall be not less than the width of the Telecoms Plant.

Concrete necessitated by the proximity of other undertaker's plant will be paid for at the relevant rates tendered in Schedule B, Schedule of Rates.

Variation of Ducts

In any case in which the Consulting Engineer so directs, the character of the duct to be laid shall be varied to suit special requirements.

Cutting, Bending of Ducts

The Contractor shall do any necessary cutting of ducts and bending of steel or iron ducts, according to the requirements of the work. Inside edges of cut ducts, etc., shall be thoroughly rounded off or so dressed before being put into position that there can be no possibility of damage to cables from the edges.

Trench Bottom

The trench bottom shall be filled with a layer of sand 2" thick and holes shall be taken out of the bottom of the trench at all points where sockets occur so that the barrels of the ducts rest on solid ground.

Rocky Soils

In rocky soils, sand shall be spread over the trench bottom and rammed to afford a bedding 3 inches thick on which to lay the ducts.

Cleaning & Testing

On completion of the duct line between any two jointing chamber or sites thereof a cylindrical brush connected to the following end of a mandrel shall be passed twice through each "way" to clean the duct and to remove any foreign matter which may have entered. The Contractor shall supply the labour needed for the testing operations.

All tests shall be carried out in the presence of Consulting Engineer, and if any obstruction or other defect be discovered it shall be rectified forthwith to his satisfaction.

Plugs

A hardwood plug shall be inserted at the ends of each "way" in a line of ducts until length has been tested and passed.

Draw Rope

A draw rope shall be threaded through and left in any "way" that may be specified by the Consulting Engineer.

Alignment Test for Disturbed Duct

When jointing chambers are provided on an existing duct route or when any disturbance takes place which may effect the alignment of the ducts, a test mandrel of appropriate dimensions shall be drawn through each of the spare "ways".

Protection of Paving

The Contractor shall take all reasonable steps to prevent damage to pavings by his plant and to protect pavings from contamination by fuel and/or oil from his equipment.

6.0 Cast Iron Ducts

Laying

When two or more layers of cast iron ducts occupy one trench, sand shall be well rmed to a thickness of 3 " between the layers, care being taken not to fracture the ducts.

Cut Pipe

When a cut pipe must be used, it should be inserted a length or two away from the end of the section , so that a smooth spigot may project into the jointing chambers. The inside edges of cut pipes should be rounded with a

Joints

Joints shall be made with tarred hemp pipe-yarn and new pig lead wool well packed and caulked, the lead or lead wool to be 1 1/2 inches deep for 4 inch duct.

Bonding

The end of every cast iron entering a jointing chamber shall project 1 1/2 inches beyond the face of the wall to allow a bonding clip to be fitted.

Cleaning & Testing

The test mandrel to be used for testing shall be 18 inches in length an inch less than the nominal diameter of the duct. The cylindrical cleaning brush shall be 4 1/2 inches diameter.

7.0 Asbestos Cement Ducts

General

A "Vee" shaped rubber ring is used for the joint to prevent the entry of water or dirt. Asbestos cement ducts will be supplied in lengths of 13 feet. Care should be taken in loading and unloading of these pipes to avoid damage by severe impact with other objects, or pipes.

Trench Bottom

The trench shall be scooped out at all points where the sockets rest, so that the body of the duct lies upon rammed sand.

Laying

Where one line of ducts is laid over another in the same trench sand shall be filled in over the lower line of ducts and carefully rammed to form a bedding 2 inch in thickness for the top ducts. Sand shall also be rammed between the ducts laid side by side in the same trench. The ducts shall break joint by approximately half the duct length in alternate lines, horizontally and vertically.

Deflection

It is necessary to deflect from a straight line or to vary the depth, sets may be given to the joints but deflections shall not be greater than 1/2 inch per 2 foot run of the single ducts. At the direction of Supervising Officer short ducts not less than 2 feet in the required deviation, but the deflection must not be greater than will admit of the tests hereinafter specified being

Cutting

Ducts shall be cut when necessary, at right angles to the bore only, preferably with a saw in a simple cutting guide, the inside edges being afterwards so trimmed that there can be no possibility of damages to cables from the edges.

Jointing

The spigot and coupling linings of the ducts shall be wiped clean and the vee-shaped rubber ring fitted pointing upwards, The lubricant shall be applied to the spigot back to the positioning groove. The lubricated end of the conduit shall be positioned to the coupling and pressure applied by hand to the new piece to be jointed and pushed home. The coupling should be checked to ensure that it lines up with the witness groove on the end of the conduit. In no circumstances shall dirt or grit be allowed to enter the joints.

Alignment Test

To ensure the alignment of the ducts a working mandrel 18" in length and 3 3/4" in diameter shall be drawn through as the ducts are laid.

Jointing Chamber Deferred

When the building of a jointing chamber is deferred until after the completion of a section of duct included in the work, the last joint of each duct shall be tested on completion of the jointing chamber by means of the working mandrel mentioned above.

Testing

The test mandrel used for testing shall be 18 inches in length and 3 3/4 inch in diameter, the cylindrical brush shall be 4 inches in diameter.

8.0 P.V.C. Ducts

General

These ducts are supplied in 20 feet lengths. These ducts should be stored away from the direct rays of the sun, as they tend to deteriorate and go out of shape. A solvent cement is used for the joint.

Encasing in Concrete

Method

The method of encasing conduits in concrete is the layer by layer method where each conduit is completely surrounded by concrete.

Installation in Straight Runs.

- i) Open trench to required length. Minimum opening is approximately 1 1/2 times length of conduits being used.
- ii) Place a 2" thick bed of concrete on the trench floor.

- iii) In unstable ground or locations where high security is required, place a wire mesh vertically on either side of nest of ducts. The concrete when poured should fully cover the reinforcement which shall be 6" x 6" welded mesh.
- iv) Install a layer of conduits along the trench keeping them evenly spaced by using wooden combs at intervals of 5".
- v) Place a layer of concrete over the conduits and compact in so as to fill the spaces between the conduits by using an approximate 2" covering above the conduits to form a bed for the second layer.
- vi) Repeat the process for the next and subsequent layer of conduits, raising the spacing comb as each layer is completed.
- vii) Remove spacing comb and wash in a suitable cleaning agent.
- viii) Concurrently with the conduit laying in the first section of the trench excavate the second section so tht sufficient trench is opened to conduit laying on completion of the first section.
- ix) UNDER NO CIRCUMSTANCES shall any batch of concrete be off-loaded from wheel barrow, bucket, dumpe, chute or similar equipment, directly onto the assembled duct nest. It should first be off-loaded onto suitable boards prior to placing around the ducts. Spades or shovels used for placing must not be puched into the placed concrete.
- x) To assist in the placing of subsequent rows of spacers and ducts, and concrete, a "walkway" shall be used when access within the trench or form the surface is restricted, UNDER NO CIRCUMSTANCES MUST THE DUCT ALREADY LAID BE USED AS A WALKWAY.

Installation Around Curves

- i) Rigid PVC conduit may be bent to avoid obstacles or to negotiate curves. The conduit may be cold bend around stakes for radii above 35 feet. To provide favourable cable hauling conditions the bend radii should be as large as possible. Cold bending in situ to the curve required is achieved by provision of stakes to form the conduit to the required shape. The stake must be spaced at intervals not greater in length than 1/20th of the raadius of curvature or alternatively as indicated in the Table below. Failure to observe this maximum dimation for support sparing will result in the kinking on the conduit with consequent loss of cross section are of the duct at the bend.

Bend Radius	35-40'	40-50'	50-60'	60-70'	70-80'	80-90'	90-100'
Support spacing	1'-9"	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"

Concrete cover above the top conduit of a completed tier is to be a minimum of 2 inches.

- (ii) After the initial set of the concrete has occurred and before it sets hard, withdraw all stakes by applying a lifting and turning action to the stakes. Where additional conduits are to be installed above the first nest, withdraw the stakes until approximately 12" remain embedded.
- (iii) Immediately on completion the withdrawal of all stakes, wash traces of concrete from all the tools.

Fixing Ducts to Bridges

Methods

- Two methods shall be used (i)fixing to steel R.S. Js. Or fabricated beams.
(ii) fixing to reinforced concrete bridge beams and masonry walls. Pipes shall be fixed in accordance with the drawing supplied.

Care

It should be noted that extra care shall be taken when it is necessary to make holes for fixing bolts in existing bridge beams. Before any holes are made the Supervising Officer will indicate where they are to be located. All bridge fittings shall be thoroughly cleaned and painted with one coat bituminous paint.

Through Abutment Walls

Where it is necessary for pipes to pass through abutment wall, the masonry or brickwork shall be arched over the pipe, the diameter of the hole thus formed being at least 1/2" more than the external diameter of the pipe. The space between the masonry or brickwork and the pipe shall then be filled with bitumen to provide a cushion of bitumen to the perimeter of the pipe at least 1/2" thick.

Slewing And/Or lowering or Raising Duct

Excavation

The size of the excavation for slewing and/or lowering or raising a duct line shall be as directed by Consulting Engineer.

Where lowering only is necessary the duct line shall be suspended and the required excavation taken out down the side and under the duct line. When this method is impracticable the duct line shall be slewed and raised or lowered temporarily as required by the Consulting Engineer for a distance which is just sufficient to allow access for carrying out the excavation.

With the exception of making slight adjustments to the duct line after smoved in any way without adequate reinforcement in the form of a strongback being firmly lashed to it.

Strongback

The strongback shall be lashed to the duct line, with both ends ducts firmly held, using separate lashings or a continuous rope. The lashings shall be tightened, by driving wedges between the ducts and the strongback, or otherwise, to the satisfaction of the Consulting Engineer.

Any forces which is necessary to apply to the duct line to move it in any wall shall be applied not directly to the duct line but to the strongback lashed to it. Such forces shall be applied at points whose spacing is sufficiently close to keep the bending of the duct line and strongback between the points to a negligible amount.

Slewing Only

When the duct line is to be slewed only, it may be moved without suspending it, provided that :-

- i) The surface across which the duct line is to be slid shall be reasonably level and regular, made so if necessary by setting boards on the surface.
- ii) Grooves shall be cut across the surface in positions to allow the socket of each duct to remain in a groove throughout its movement.
- iii) The strongback shall be firmly lashed to the side of the duct line.
- iv) The moving force shall be applied to the strongback by rope, jack or other method to allow the duct line to be moved smoothly and without jerking.
- v) In the final position of the duct line the holes for the duct sockets shall be made large enough to allow access to the underside of each joint for the purpose of making seal. Such holes shall be subsequently filled with soft cement mortar.

Movement

The slewing and/or lowering of the duct line shall be carried out by making a succession on very small movements of the duct line, each made progressively along the affected length. The curvature of the duct line at any intermediate stage between the initial and final positions shall not exceed the deviation limits laid down for laying new duct of the same type.

Trench Bottom

Prior to final placing the duct, the trench bottom shall be prepared in the same way as is specified for duct laying.

Irregularities

After the duct line has been finally lowered into its required position and the strongback has been removed, any slight irregularities in the general line of the ducts shall be corrected at the direction of the Consulting Engineer.

Repairing Ducts

A.C./P.V.C. Ducts - Empty damaged ducts shall be replaced by similar good ducts or split ducts, and cabled damaged ducts shall be replaced with split ducts. If so directed by the Consulting Engineer minor damage to ducts may be repaired, in situ with a mixture of cement. Split ducts shall be surrounded with 2 inches of cement mortar, carried over the joints and held in position by forms. The entry of mortar into the ducts shall be prevented by the use of building paper or similar effective means.

Pulled Joints

Where, following slewing and/or lowering or raising operations, a duct joint or joints have pulled apart short lengths of ordinary or split duct may be inserted in the duct line and satisfactory joints effected as directed by the Consulting Engineer.

Inspection

After all operations are completed, the joints of all ducts shall be inspected to ensure that they are forming an effective seal. Any defects shall be made good to the satisfaction of the Consulting Engineer.

Testing

All spare bores of the duct line shall be cleaned and tested as specified for the particular duct concerned.

Dummy Duct

Method

A short length of PVC 4" duct that will occupy the thickness of a jointing chamber wall shall be split to envelope another duct of similar length to form a dummy set, which is then positioned in the wall of the chamber above the row of ducts terminated at a jointing chamber.

Later on when it is necessary to increase the number of ways, the entry hole into the chamber can be made available by breaking the mortar seal and knocking out the inner duct of the dummy set previously set in position when the ducts and chamber were constructed.

9.0 JOINTING CHAMBERS

Waterproof Construction

All jointing chambers shall be of waterproof construction, whether built of bricks or reinforced concrete.

Standard Depts Varied

Where the standard dept of jointing chamber is exceeded, the Contractor may charge for the excavation below standard depth at the "Extension" rate (which include carting away) in Schedule B, Schedule of Rates. Likewise, if the standard depth be not reached, the Contractor shall give credit at the same rates for any excation not required.

Obstruction

If the site selected for a jointing chamber be encroached upon by any obstruction as for instance a pipe mian, the Contractor shall arch the walls round such obstruction or make such other arrangement as may required by the Consulting Engineer.

Clearance Around Conduit

Conduits shall enter manholes at such a depth to ensure a clearance of at least 1 ft. 6 ins. Between the top of the barrel of the uppermost conduits and the underside of the roof of the manhole. Except where a duct seal is provided, when a clearance of 8 ins. is required, clearance of 6 ins. depending on type of manhole, shall be given between the outside of the barrel of the conduits and the adjacent wall, and a minimum clearance of 1 ft. 6 ins. between the underside of the barrel of the lowest conduit and the floor.

Space for Duct Growth

Where the duct capacity of any proposed manhole is not fully utilised the space shall be fitted with dummy dcts for future duct growth by laying initially at atandard depth. The dummy ducts shall be sealed with 1/2" cement mortar inside the chamber wall.

Duct Terminations

To ensure that cables can easily housed in manholes with a minimum of bending, the conduits should be displayed over the last length to enter the manhole equally on either side.

Materials

Materials to be employed shall conform to the specification laid down in the schedule.

A. Construction of R1/R2 Type Manholes (Reinforced)

1 Excavation

The ground shall first be excavated to the required dimensions, the sides of the excavation being supported by poling boards or by other means if there is any likelihood of the earth falling-in. The foundations shall then be levelled and rammed. Soft places shall be dug out, filled in with hardcore and consolidated.

2 Templates

Two light wooden templates, slotted (not drilled) to receive the reinforcing bars, shall now be set up. The lower template shall be fitted about 1 ft. above the foundation and shall be supported on four small pegs at its corners. The upper templates shall be fixed to correspond with the lower template, but 1 ft. below the position at which the roof of the manhole will be.

3 Erection of Floor

Shuttering for the sump hole shall now be set up and concrete laid over the foundation to the thickness of 1 1/2". The mixing and placing of the concrete shall be done in accordance with Section A5 of this Schedule. The end and side-wall-to-floor corner-reinforcement shall be placed so that horizontal portion shall only be covered by the concrete. The vertical portions shall pass through the slots in the lower template and be set so as to obtain 3/4" cover from the outside faces of the walls when these are erected. Additional concrete shall next be laid until the level is 3/4" less than the concrete level for the floor. This shall be done as soon as possible after placing the first layer of concrete, so that the two layers unite thoroughly. Anchor ions shall not be set in the floor in accordance with the relative drawings.

The interior wall-reinforcement shall now be placed with the horizontal portions flush with the surface of the concrete in the floor and the vertical portions passing through the slots of both templates so as to obtain 3/4" cover from the interior face of the walls when these are erected. The remaining 3/4" layer of concrete is then laid to reach specified floor level.

4 Erection of Walls

When the floor has been left for at least 12 hours, the erection of the walls shall commence. The portion of the floor on which the walls will be erected shall be cleaned and rendered with, inch thickness of neat cement, well trowelled and placed in position, just before wall concreting is commenced. The wall shall, as far as possible be erected continuously to their full height, but if during erection a break of 2 hours or more is unavoidable, the existing work shall be cleaned and rendered as previously described before proceeding reinforcement shall be placed as walls are built up. It is necessary to wire up this reinforcement, since there is no tendency for these bars to move once placed, "Steps, Manhole" and "BoltsZZ", "Cable Bearers", shall be set in the walls. The templates shall be removed when the work reaches such a stage that they impede the placing of the concrete.

5 Erection of Roof

When the walls have been built to the requisite height, shuttering for the roof shall be set up, the boards being arranged to form a recess at the position of the laid throughout the roof area, including the recess for the beams. The beam reinforcement-which have been previously assembled by threading and wiring of the stirrups to the bars - may now be laid at one movement, the main reinforcing bars being set to obtain 1" cover. The remainder of the roof reinforcement shall be laid and, to give the correct cover of 3/4", the rods shall alternate bent bars may be conveniently supported by a single wired fixing at the point where they enter the beam reinforcement. The concrete in the roof shall then be made up to the necessary thickness, and finally the roof to wall corner-reinforcement embedded.

The correct cover of 3/4" to the roof can be checked by a wood spike and when correct at each end of the horizontal part of the rod, will ensure that the vertical portion has the correct cover throughout its length. The upper face of the beams shall be spade-finished, and the roof given a slight slope to the sides to avoid accumulation of water on the roof.

6 Striking of Shuttering

Finally, after the lapse of time the shuttering shall be struck and the floor give a 3/4" rendering of cement mortar, with a fall to the sump-hole on all sides and the manhole frame fitted in accordance with Table of this section.

7 Concrete Curing Times for Jointing Chamber

The period required shall conform to the Specification laid below:-

MANHOLES BUILT IN THE CARRIAGEWAY FOOTWAY
TABLE 3

Type of cement used	Minimum period from completion of Concreting		
	a) to removal of shuttering	b) before commencing reinstatement	c) before allowing passage of traffic
Portland Cement or its local equivalent.	5 days/ 5 days	7 days/ 5 days	7 days/ 5 days
Rapid hardening cement	2 days/ 2 days	3 days/ 2 days	3 days/ 3 days
High Alumina Cement	10 days/ 11 days	24 hrs/ 24 hrs	24 hrs/ 24 hrs

Note:

Because high alumina cement generates heat, the striking of the shuttering shall commence before the expiration of 12 hours and the concrete prevented from becoming dry at any time within 24 hours of mixing, by watering it.

8 Jointing Chamber fittings

All iron and steel supplied by the Contractor shall be free from mill scale and shall be painted with one coat of red lead and iron after delivery and two coats of approved bituminous paint after fixing, except when the iron or steel is to be embedded in concrete. In the later case all loose rust particles shall be removed by the use of wire brush.

- a) Grating for sumphole shall be fitted to the sumpholes of all manholes.
- b) Anchor irons shall be fitted in accordance with the relative drawing.
- c) Steps, Manhole shall be used in the RO and R1 types of manholes, in the position shown in the relative drawings for the manholes. The steps shall also be used in entrance shafts for all manholes.

- d) Ladders. Steel ladders shall be used in the R2-R15 and RT types and in Standard Manholes. The ladders shall be fixed in accordance with the relative drawings to suit the different heights of the manholes.
 - e) Bolts, Hot dip Galvanised for the attachment of Cable Bearers, Wall Type shall normally be fitted in the walls of all manholes during construction. In the R type of manhole, the bolts required for the walls shall be fixed temporarily in the shuttering during the construction of the manhole, to ensure that they will remain in their correct position while the concrete is setting. The positions for holes in the shuttering shall be obtained by using the cable bearer as a template. If it is impossible to foresee the requirements for bearers when the manhole is being constructed, the galvanised bolts may be omitted and expansion bolts fitted afterwards. The provision shall be 2 per cable bearer.
 - f) Cable Bearers, Wall Type The bearers shall be provided by the Contractor and are fixed to the walls as described in (e).
 - g) Bracket, Cable Bearers shall be provided and the initial provision shall be 2 per cable bearer, e..g. in R2A type manhole, where the cable bearers are fitted 3 to a wall making a total of 6 cable bearers, the number of brackets provided shall be 12.
 - h) Pins, Locking, Cable Bearer are designed to facilitate the removal of brackets.
- 9 Fitting of Manhole Covers
Manholes cover number 3 E shall be fitted in all classes of manholes in accordance with the relative drawings. Manholes covers No. 7E may be fitted where so specified by the Consultant Engineering.
- a) Where the manhole is to be set at the minimum depth (as shown on the standard manhole drawings) one course of brickwork shall be laid between the manhole roof and frame.
 - b) Where due to anticipated alterations in level, the manhole is to be set at an increased depth, one or more additional course of brickwork shall be laid. This is particularly important in the case of manholes built in the footway where there is possibility of the frames and covers being installed to carriageway level at a later date. Cement mortar shall be used both for setting brickwork and for bedding the manhole frame.

- c) 24 hours must lapse after the building of a jointing chamber and before the frame and cover are installed. The water used in the concrete shall not exceed 4 gallons per cubic foot of cement.

The frame shall be positioned accurately in relation to the cover before being filled so that the cover is flush and level with the surrounding carriageway. Two methods of filling and setting may be employed.

- i) In-situ Filling - The frame shall be embedded on a layer of stiff cement mortar, care being taken to ensure that the frame is fully supported along all four sides. The level of the frame shall be adjusted to the level of the surrounding road surface by pieces of mild-steel packing approximately 6" x 2" and of appropriate thickness. The cover shall then be placed in the frame. When the cover is correctly suited, the edges of the frame and the cover shall be at the same level, if any irregularity can be felt, by running the finger along the joint, or if the cover rocks, the frame shall be packed up until the edges are at the same level and the cover is free from rock. The cover and frame shall then be filled with concrete quality G, or an asphalt and granide mixture.

Great care shall be taken when filling the frame to ensure that no voids are left, the concrete in each pocket shall be thoroughly tamped with a reinforcing rod. Finishing shall be done with a trowel, the concrete in the cover compartments being left slightly proud but not more than 1/8" at the edge to 1/4" crown in the centre of the cover to allow for shrinkage, wear and to prevent concrete adhering to the floor. The levelling of the frame and cover, and the concrete filling shall then be done as described in method (1). The frames and covers must be left undisturbed for a minimum of 3 days. When the frame is installed, it shall be bedded on stiff 1 : 3 cement mortar.

Concrete Curing Times for Manhole Covers.

The minimum period which shall elapse :-

- a) Before disturbing the frame or cover where in-situ filling is not employed.
- b) Before removing the cover or covers from the frame after the complete installation including cement mortar bedding.

	A	B	C
	Before disturbing	Before removing	Before allowing the
Portland Cement or its local equivalent.	5 days	3 days	7 days
Rapid hardening cement	3 days	2 days	3 days
High Alumina Cement	10 hours	24 hrs	24 hrs

B. Construction of Joint Boxes

1 Excavation

The ground shall first be excavated to the required dimensions, the sides of the excavation being timbered if necessary. The foundations shall then be levelled and rammed.

2 Erection

Concrete of quality A for the floor shall next be laid level to the required thickness. Iron, Anchor reinforcing bars shall be inserted where specified on the relative drawings. The fall of one inch shown in the drawings for the floor can be achieved by rendering with cement mortar with a smooth finish.

3 Erection of Walls

Brickwork for the walls shall be laid in cement mortar, and flush pointed. The bricks shall be dipped in water before they are laid. Brackets for joint box shall be fitted as the walls are erected.

4 Erection of Roof

Roof shuttering shall be set up. Concrete of quality A for the roof shall be laid to a depth of one inch and reinforcement set to give the correct cover. Additional concrete shall then be placed to the specified thickness for the roof.

5 Striking of Shuttering

Shuttering shall be struck as follows:-

- I) For carriageway joint boxes, after the lapse of time given in table 3.
- ii) For footway, joint boxes after 24 hours, irrespective of the type of cement used. A 3/4" cement mortar rendering shall be applied to level the floors or they shall be built up to give the 1" drainage fall where required.

6 Fitting of Frames & Covers to Joint Boxes

Manhole cover No. 7 E shall take such measures, as directed by the Consulting Engineering to protect cables and associated equipment during the cutting of duct entries into existing structures or the demolition and rebuilding of jointing chambers, Such measures may include any or all of the following:-

- a) All movement of cables will be carried out under the direction of the Consulting Engineer.
- b) A ladder must be provided by the Contractor for access in and out of manhole excavations. Under no circumstances may cables, joints and associated equipment be used for climbing, standing or sitting on.
- c) Sufficient pumping capacity shall be made available and operated to ensure that when cables are removed from their bearers they shall not be immersed in water at any time.
- d) All cables shall be protected at duct entries by packing with foam rubber to act as a cushion when an movement occurs.
- e) During demolition of the roof of a manhole the Contractor shall erect a deck of timber between the cables and the roof of the manhole to protect Telecoms Plant from falling debris in the following manner:-

- i) A minimum of three 9" x 3" timber upright shall be evenly spaced against each long wall of the manhole with the 9" side against the wall. The length of the upright shall be such that they terminate approximately midway between the upper most cables and the roof. Further lengths of 9" x 3" timber shall be placed horizontally on top of the uprights and secured and between the uprights at the bottom; all positions to be wedged and blocked to the satisfaction of the Consulting Engineer. Lengths of poling boards or other similar timber shall then be placed on top of horizontal supports.
- ii) When the manhole roof and walls have been demolished down to the level of the timber decking and all debris and decking removed, the cables and other associated equipment shall be suspended from beams on the surface of the ground to the satisfaction of the Consulting Engineer.
- iii) Cables and joints and other equipment shall be protected by wrapping (not tying) with several layers of sacking while timber decking is being erected or dismantled.

C. Plinth for A.P.O Cabinet

1 Site

The plinth shall be construed on a suitable site specified by the S.O. where it shall not (1) be an obstruction to pedestrians (ii) be damaged by vehicles (iii) spoil the appearance of the surroundings.

2 Construction

The foundation of the plinth is dug to the dimension given in respective drawing and the PVC 30" radius bend is located as shown in the Drawing. 30" radius bends are necessary to obtain variations in depths of cover and to accommodate the number of tail cable associated with the Cabinet to be installed. The top of the bend may be shortened where necessary. The top of the bend may be shortened where necessary. The concrete shall be Quality A mix. Normally Portland cement is used, but if it is necessary to accelerate the hardening of concrete rapid hardening cement may be used.

3 Template

A simple 1/8" thickness aluminium or any other metal template made locally must be used to ensure correct setting of the bend and bolts in the concrete foundation. Place a 10" diameter gasket with 6 1/2" diameter centre hole and appropriate bolt holes over the concrete footings.

4 Bonding at Jointing Chambers for Earthing Facilities

Method

Where metal pipes are laid and terminated at jointing chambers the break in continuity shall be made good by embedding 2" x 1/8" G.I. Strips of required lengths in the walls of the jointing chamber during construction, and welding the ends to the pipes.

D. Filling - In, Restoration & Permanent Reinstatement of Roads

1 Interim Restoration

The Contractor shall execute interim restoration of all trenches dug.

2 Bedding & Cover

The operation of filling in shall not commence until the work to be covered thereby has been approved by the Consulting Engineer. A layer of sand shall first be laid on the bed of the trench as stated in Section E, E5.1

3 Backfilling Around Jointing Chamber

The spaces outside the walls of jointing chambers and surrounding area dug up shall be completely filled with sand free from stones in 9" layers and rammed, care being taken that the ramming does not disturb any recently completed work.

4 Backfilling of Trenching

All materials shall be replaced in 6 " layers in the reverse order to which they were excavated and the remaining 1'0" top of the trench back-filled with good quality red earth and the block metal previously excavated placed on the top and the gaps filled with quarry dust and thoroughly compacted. Mechanical rammers shall normally be used though hand ramming is allowed.

5 Backfilling at Road Crossing

For all road crossing on carriage way, the backfilling shall be done with nothing else except sand or quarry dust in layers each layer to be not more than 9" in thickness and well rammed with mechanical rammers or watered down before the next layer is laid. The top 12" shall be backfilled with quarry dust only. This shall be done in two layers, one layer to be well rammed with mechanical rammers before the next layer is laid. The top layer shall be rammed with mechanical rammers until it is flushed with the road surface.

6 Compacting Test

Back-filled excavations shall be tested by applying a power frog rammer repeatedly over one half a square yard area for a period of 3 minutes and shall be performed by the Contractor as instructed by the Consulting Engineer at intervals as he considers necessary.

The compactness shall be considered satisfactory providing the test shows no measureable change in level - measurable change in level being a depression which cannot be rectified by re-shaping the tested area and consequently requires additional imported material to level. Should any measureable change in level occur then the area of faulty compaction as defined by the results of this and further tests shall be rectified by the Contractor.

7 Maintenance Period

The reinstatement portions of unpaved-footway or other excavations shall be maintained by the Contractor and he shall ensure that they are level and the turfing is replaced where affected to the satisfaction of the Municipality, PWD or any Local Authority, for a period of three months after completion. Any subsidence of other defects arising during this period shall be made good by the Contractor.

8 Reinstatement by Contractor

Permanent reinstatement shall be undertaken by the Contractor for trenches dug on private road or roads not yet taken over by the Municipality, P.W.D. or any Local Authority where applicable.

- a) Permanent reinstatement shall commence only after the backfilling and interim restoration has been allowed to settle well for at least two weeks and that there is no measurable change in level.
- b) The reinstatement shall be carried out by removing the back filled material from the trench to a depth of 10" which shall then be filled with a 6" course of fresh metal not less than 2" in size and the voids between the metal filled with quarry dust to serve as a bind.

A base course of metal pre-mix 2" thick pre mix and the reinstated trench shall be gone over with a heavy road roller or a suitable mechanical tamper.

9 Obligations

Should the standard of the reinstatement measures be not to the satisfaction of the Municipality, P.W.D or any Local Authority, the Department reserves the right to carry such remedial measures as are necessary and charge the Contractor at cost plus 25%.

10 Cartage of Surplus Material

Should the standard of the reinstatement measures be not to the satisfaction of the Municipality, P.W.D or any Local Authority, the Department reserves the right to carry such remedial measures as are necessary and charge the Contractor at cost plus 25%.

5 **PIPING, FITTINGS AND VALVES**

5 SCOPE OF WORK - PIPING LAYOUT AND INSTALLATION PROCEDURES

- 5.1 This section covers the supply, delivery and installation of all piping, fitting and valves and sets out the desired standards of workmanship for the installation. In general, the entire piping installation shall be carried out in a neat and workmanlike manner, with all line alignments and grades maintained strictly so as to avoid interference with the work of other trades or building treatment and reinstated to the satisfaction pipework shall be removed and reinstated to the satisfaction of the Consulting Engineer, at the expense of the Contractor, if it is determined that it had been improperly installed in the first instance.
- 5.1.1 The location and sized of the various pipework shown on the accompanying drawings shall be adhered to strictly unless site condition disapproved otherwise. In this case, the Superintendent Officer shall be notified and written variation/decision shall be required before the work can proceed. Generally, pipe route shall be shortest and simplest possible, consistent with the flexibility and clearance required. A minimum clearance of 2" between the outer surface of the pipe or fitting and the nearest wall, ceiling or other structure or obstruction shall be maintained to permit painting and removal of flanges, unions fittings and
- 5.1.2 All pipe sizes indicated on the Drawings or Specified herein shall not be altered under any circumstances and unless otherwise noted, all valves strainers expansion/flexible joints, etc. shall be of the same as the line.
- 5.1.3 The Contractor shall supply and install only one approved brand of valve, strainers, vibration isolators, expansion joints and other pipe fittings for the whole installation for standardization purposes.
- 5.1.4 Upon installation of the pipelines, all openings shall be capped or plugged to prevent the ingress of foreign substances that can obstruct the lines. The plastic caps or wooden plugs shall be left in place until the final stage of the installation where their removal is necessary for completion of the pipework. All piping shall be flushed or blown clean and strainers and traps cleared of all foreign substances prior to

- 5.1.5 The outer surfaces all steel pipes and fittings shall be wire brushed to remove mill scale and rust and a coat of red oxide or yellow zinc chromates primer applied. Any steel pipes found installed without undergoing the above mentioned treatment, shall be rejected. For galvanized iron pipes, only deep scrated to the zinc coating shall be suitably treated to prevent corrosion.
- 5.1.6 For installation required oil-free air, the oil coating inside the piping shall be removed by immersing the pipes in a hot phosphoric bath, maintained at 160-17-F for 3-5 minutes,. Furthermore, the compressor intake piping shall be thoroughly cleaned to prevent scoring of the pistons and cylinders during subsequent operation.
- 5.1.7 All piping installed shall slope towards the drain points which are indicated on the accompanying drawings. In cases where two sections of a piping with differing slopes terminate at a valve or fittings, care shall be taken to ensure the valve or fitting is not unduly stressed and hence, special gradual bends shall be fitted to achieve the desired slopes or grades. For air compressor, the supply pipe shall be pitched such that condensate do not flow backwards into the compressor. Liquid lines shall be pitched such that air pocketing is avoided.
- 5.1.8 Valves in regular or emergency use shall be conveniently located as follows:-
- | | |
|-------------------------------------|--------------------------------|
| Horizontal spindle valve hand wheel | - 5 feet above floor level |
| Vertical spindle valve hand wheel | - 3 1/2 ft, above floor level |
| Small horizontal valve hand wheel | - up to 7ft, above floor level |
- All valves installed higher than specified shall be chain operated. A minimum of six (6) inches clearance shall be needed to clear the operator's hands. Similarly, all instruments mount on piping to be read by operators shall be located five (5) feet above the finished floor level.
- 5.1.9 All piping shall be suitably installed so as to avoid excessive stresses being generated in the pipes, valves, fittings and other accessories. This is particularly so in cases due to contraction and expansion effects and hence, suitable expansion joints or loops shall be installed to relieve the stresses.
- 5.1.10 Provision shall be made for periodic flushing of the piping system and suitable vent and drain points shall be fitted on pipes which are frequently tested hydrostatically or dismantled for cleaning.
- 5.1.11 The Contractor shall submit copies of shop drawings for the entire

piping installation, including the piping layout within the plant room, to the Superintendent Officer for approval prior to installation. For repetitive type of equipment in the system such as air handling units, pumps, compressor, coolers, etc., the Contractor is allowed to proceed with the rest of the equipment. Failure to comply with these procedures shall result in the modification of the piping layout to the satisfaction of the Superintendent Officer at the expense of the Contractor.

- 5.1.12 All pipes, fittings and valves to be supplied and installed under this contractor shall be of approved manufacture conforming to the relevant British Standard or other standards of institution of international repute and to the approval of J.K.R. Malaysia.

5.2 Types of piping

Unless otherwise stated, the following types of pipes shall be used for the corresponding applications.

5.3 Condenser/Cooling Water Piping

The pipes shall be seamless heavy gauge class 'C' galvanized steel to B.S. 1387.

5.4 Refrigerant Piping

- i) Up to and including 2" diameter, pipes shall be of copper to B.S. 659
- ii) For 2 1/4" diameter and above, pipes shall be of heavy gauge class 'C' seamless black steel to B.S. 1387

5.5 Drain Piping

The pipes shall be of medium gauge class 'E' unplasticized PVC to B.S. 3505.

5.6 Fabrication of pipe works

Any material damaged or found to have defects shall not be used in fabrication except where minor surface marks may be dressed providing the nominal wall or minimum wall thickness is not inroached upon after considering the manufacturing tolerances defined in the appropriate material specification. All matters is market and subject to the approval of the authorities and the Consulting Engineers.

- 5.6.1 Cutting of pipes and tubings shall be done by a power bucksaw or a circular cutting machine using an abrasive wheel or in a square and sawing vise by means of a hand hacksaw. No pipe shall be cut with a metallic wheel cutter of any sort. All pipes shall have the rough edges or burrs removed so that smooth and unobstructed flow will be obtained.

- 5.6.2 Bends shall be free of wrinkles, bulges, kinks and twists.

- 5.6.3 All pipings and tubing shall be cut accurately to measurements obtained at the site and shall be installed without spring or forcing.

- 5.6.4 Sections of pipe shall not be welded together for lengths less than 10 feet and the number of welds shall be kept to a minimum for longer lengths. During welding, sections of pipe shall be adequately supported so that joints are relieved of any strain.

- 5.6.5 Use of backing rings in welding shall not be permitted, small tack welds used for 'fit-up'. If free from cracks, may be included in the first pass provided they have been made up by qualified welders to the same procedures as required for the first pass. The use of chill-rings for butt welds in piping is generally recommended and shall be mandatory in cases where specified in order to prevent welding beads from getting into the pipe.

- 5.6.6 Competency Certificates of all the welders involved shall be available upon request by the Superintendent Officer & all welding shall be supervised and record maintained to ensure each welding can be subsequently identified with the individual welder concerned.

5.7 Joints

5.7.1 Screwed Connections

Up to including 2 1/2" diameter on galvanized steel piping shall be made by means of screwed connections.

All pipe threads for screwed connections shall comply with B.S. 21. All threads shall be cut with standard thread dies ends shall be reamed prior to assembly.

For sealing the threaded joints, a thin paste of lithrge and glycerine applied to the male threads only shall be used. No `plumber's tape' nor paint shall be used to fill improperly threads. `Teflon' sealing tapes shall be permitted in cases where the services pressures encountered are

5.7.2 Flanged Connections

Where welded joints are impractical or where required for erection purposes or at connections to fittings on steel pipes 3" diameter and above and at all flanged valves, flanges shall be fitted and welded on to pipes to approval.

Flanges shall be of mild steel materials to comply with B.S. 450 (metric sizes) while all black bolts and nuts uses shall comply with B.S. 916

All flanges faces shall be flat, parallel and posses similar gasket facing finishes complying with B.S. 1560, Part 2. Convoy width of flange face.

The space between flanges prior to assembly shall not be too excessive. The available bolt load shall be to compress the gasket only and not to pull the flange faces together.

Bolts shall be tightened in uniform fashion and in small degree using sequence of opposed bolts.

The gasket material used shall be compatible to the service temperature, nature of fluid, surface finish of jointing face and available seating load.

5.7.3 Copper Pipes Jointing

All copper joints shall be brazed using a hard solder which is silver brazing alloy with melting temperature over 1000F . For pipes 2 1/2" and over, flanged joints of the tongue and grove type shall be used. For soft temper copper tubes up to 1/4" approved type of flared compression fitting of approved type of flared compression fitting of forged brass may be used. For tubes of greater diameter and for hard temper copper, sweat fittings of wrought copper or forged brass together with solder shall be used for joints.

The silver used shall not contain less than 15% silver. Suitable non-crossive soldering flux may be used and after tied joint are made, they shall be thoroughly cleaned and washed to remove all traces of flux before assembly.

When flanges are required, bronze flanges to B.S. 4504 (Metric Sizes) shall be used and these shall be brazed to the copper pipes using hard silver solder.

5.7.4 Bends.

In all piping, bends shall have radius of not less than five times the diameter, If this radius cannot be obtained, alternative bends of approved types shall be used.

5.7.5 Tees

l) Copper Piping

Tees in copper pipes shall be completely brazed, bronze welded or silver soldered. Tees in copper pipe 1/4' and 1/2" may also be made using approved capillary fittings together with silver solder.

5.7.6 For ease of dismantling, all equipment and valves shall be fitted with unions for pipes up to and including 2 1/2" diameter while for larger pipes, flanges shall be fitted. Similarly, facilitate

5.8 Pipe Hangers and Brackets

The sub-contractor shall supply and install sufficient hanger, brackets, clamps, mounts, supports and other accessories necessary to support all piping individually and shall allow for removal of equipment, valves and fittings without requires additional temporary supports whilst the removed piece is out of the pipework.

- 5.8.1 Hangers, supports and brackets shall be able to carry the pipe under all operating conditions allowing for free expansion and contraction and preventing excessive stress from transferred weight being introduced into the pipe or connected equipment. They shall have smooth flat bearingsurfaces, free from burrs or other sharp projections which can wear or cut the pipe.
- 5.8.2 Unless otherwise stated, all pipe hangers, brackets, clamps, supports, etc. shall be of galvanized steel with minimum 2 oz. Sq. ft. of zink coating to B.S. 729. For those fabricated of ordinary mild steel be applied before they are painted with final gloss finish to approved colours.
- 5.8.3 All pipes shall be supported with factory fabricated rigid or flexible hangers and roller guides, the latter two shall be used when vertical and horizontal of the piping are envisaged respectively. The spans between pipe supports , the following schedule shall be adhere to for steel and copper piping.

<u>Pipes Size</u>	<u>Rod Diameter (Minimum)</u>	<u>Maximum Span Between Hangers or Supporters (ft)</u>
1/8" - 1/2"	1/4"	4
1/4" - 1"	3/8"	6
1 1/4" - 6"	1/2"	8
6" and above	3/4"	10

Notwithstanding, the above schedule does not apply where concentrated loads exist such as heavy connasted equipment, valve and fittings and also it does not allow for changes in directing of piping between hangers. Pipe hangers shall be placed not more than 24" from each change or direction of pipe, preferably on the side with the longest run, preferebly on span between hangers or supports shall be such that the deflection of the fully loaded pipe is less that 0.1" under all operating conduits.

5.9 Refrigrant

Approved refrigerant shall be used. The Contractor/Sub Contractor shall fully charge the systems and he shall be responsible for any change lost during the maintenance charge period. Refrigerant circuits shall be completely factory assembled, tested and dehydrated

9 INSULATION

9.1 GENERAL

Unless otherwise noted the following shall apply:-

All insulation work shall be carried out by skilled craftsmen. Samples of material and workmanship shall be submitted for approval, before proceeding with the installation. Manufacturer's application instructions shall be rigidly followed. Insulation on ducts shall be finished so that edges are square, level and plumb. All finishes shall be smooth and even after painting.

9.1.1 Where insulation is subjected to mechanical abuse and where exposed pipe covering terminates, such as floors, walls around pumps, etc., this Sub-Contractor shall provide 20 gauge steel insulation protectors, as directed by the Engineers.

9.1.2 In the case of cold lines, special attention shall be paid to the final coating of insulation that will be on view. All plain surfaces shall be trowelled to a truly smooth surface and all pipe insulation shall be finished using purpose made metal or hard wood formers as necessary for a clean, smooth unlined surface to approval of the Engineer.

9.1.3 Rangers that support piping with chilled water etc., shall be supported wholly on the outside of the insulation. This Contractor shall provide suitable material to support the pipe below the hanger so that the insulation is not crushed. Number 16 gauge steel insulation protectors to suitable length shall be used to spread the load. Shield and hanger spacing shall be designed to limit the compressive strength between hanger and insulation to 35 p.s.i.

9.1.4 All insulation for cold pipes, ducts and equipment shall be provided with approved type exterior vapour barrier.

In general pipe fittings, valves etc., shall be boxed in and insulated with an equivalent thickness of insulation as the adjacent piping. Where flanges and unions occur, insulation shall be stopped on the pipe. Flanges and unions shall be boxed in so that they can be dismantled without disturbing the adjacent insulation.

In the case of cold lines, the vapour barrier shall be continuous and at valves, flanges, etc., the barrier shall be stopped and sealed to the pipe.

- 9.1.5 Performed pipe insulation shall be applied with joints staggered and shall be applied with all joints fitted to eliminate voids. Large voids shall not be filled with vapour seal coating, but eliminated by refitting or replacing insulation. Any round corners on the insulation shall be deleted before application.

The void between the insulation covers and the fittings shall be filled with suitable fitting such as brine putty or chlorinated wax compound.

Protruding metal parts such as valve stems shall be thoroughly sealed.

- 9.16 Where expansion joints occur, insulated shields shall be provided to permit free movement of the joints.

- 9.17 Before finishing, the asphaltic material shall be sealed with asphalt sealer to prevent bleeding through.

- 9.18 Note that all insulation must be applied to be clear of and to provide access to all instruments, dampers, controls and linkages etc.,

9.2 Refrigerant Piping Insulation

Liquid and suction refrigerant lines shall be insulated with minimum 2" thick "Armaflex" flexible expanded rubber compound or approved equivalent.

9.3 Chilled Water Pipe Insulation

- 9.3.1 Chilled water piping in all areas inclusive of buried underground ones shall be insulated as described below. They shall be insulated using an approved non-combustible material to a thickness as specified below and vapour sealed with double-sided fire-resisting aluminum foil.

9.4 Type of Insulation Material

Insulation shall be fiberglass of the general properties as indicated below and all manufacturer's recommendations shall be strictly adhered to for maximum effectiveness.

Specification Data:

- (a) Material: long, extremely fine, flame-attenuated glass fibers bonded with a thermosetting resin and shall be strictly asbestos-free.
- (b) Maximum Temperature : 350 deg. F
- (c) Moisture Absorption : Less than 0.2% by volume
- (d) Alkalinity : less than 0.6% expresses as Na₂O
- (e) Corrosively (with steel, copper or aluminum): does not accelerate
- (f) Odour : none
- (g) Capillarity (after 24 hours): negligible
- (h) Shrinkage : none
- (i) Resistance to fungi, vermin and bacteria : does not breed or promote.
- (j) Fire Hazard Classification : BS 746 Class 'O' and to satisfaction of C.I.F.S. Malaysia.
- (k) Thermal Conductivity: 0.25 BTU/sq. ft.-hr-deg.F per inch for density of 2.00 lb/cu ft, at mean temperature of 75 deg. F.

The sub-Contractor shall strictly conform to any statutory regulations issued in connection with the handling of such fibers glass insulating material.

9.5 Thickness of Insulation

- (a) All chilled water piping shall be insulated to the thickness as listed in the schedule below:-

<u>Pipe Size</u>	<u>Insulating Thickness</u>
Up to 1"	1"
1 1/2" to 2 1/2"	1 1/2"
3" to 4"	2"
15" to 18"	2 1/2"
19" and above	3"

9.6 Chilled Water Piping

All chilled water pipe shall be of factory preinstalled type. This Sub-Contractor shall be fully responsible to check on site to ensure the out jacket of the preinstalled pipe will be suitable for the condition of site where the portion of the whole piping system located.

The factory preinstalled pipe shall be considered of the following

- a) Service Pipe Material
 - i) All pipe up to and including 150mm. Diameter shall be heavy gauge seamless black steel to BS 1387.
 - ii) All pipe above 150mm. Shall be seamless black steel to BS 806 Class C.
- b) Insulation for Pipe

The insulation of the pipe shall be rigid fire retardant polyurethane. The insulation shall be factory injected into annular space between the service pipe and the jacket. The service pipe shall be preheated prior to the injection of the insulation. The insulation shall be not less than 37 mm thick for pipe size up to 100mm. diameter and 50mm. thick for 125mm. diameter and above

The properties of the rigid fire retardant close cell polyethylene shall be as follows:-

Density	50 Kg/m
Compression Strength	1.69 Kg/cm ²
Tensile Strength	2.51 Kg/cm ²
Thermal Conductivity K factor at 22.80C	0.022-0.024 Kcal/M.H. deg.C
Service Temperature	-184 deg.C to 100 deg.C
Water Absorption & by Volume after 24 hours	Less than 5%

9.7 Indoor Unexposed Insulated Pipework

All indoor unexposed insulated pipework shall be finished with 8 oz. Canvas glued on neatly to the aluminum foil with Flintcote Emulsion or approved equivalent. Overlap at the seams of the canvas shall not be less than 1 1/2 inches.

9.8 Outdoor Exposed Insulated Pipework

All outdoor pipework exposed to weather shall be wrapped with Densel tape or approved equivalent with 1" overlap. The Densel tape shall be heated with blow-torch to soften the bituminous compound sufficiently to facilitate a proper water proof seal. Extreme care shall be taken to ensure that the Densely tape is not overheat. The size of the pipe shall determine the width of Densely used. Pipes up to 3: N.B. shall be wrapped the 6" wide tapes.

9.10 Underground Insulation Pipework

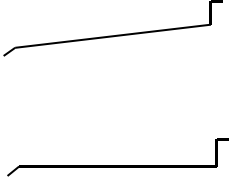
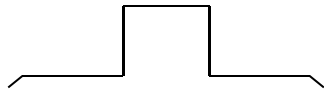
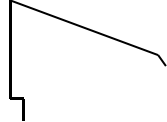


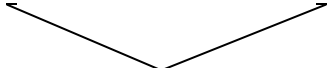


- (a) All underground insulated pipework shall be primed over the insulation with one coat of Denso Paste of approved equivalent of 6"width shall then be used to wrap spirally round the insulation with 8" overlap. A final overwrap of Denselt tape of 6" width shall then be applied with 1" overlap. The Denselt tape shall be applied as described for outdoor pipework exposed to weather.
- (b) Where piping is buried, after the insulation and finishing has dried, the insulated piping shall be carefully laid on the trench bottom which shall be relatively smooth and free of rocks and other debris.
- (b) Where piping is buried, after the insulation and finishing has dried, the insulated piping shall be carefully laid on the trench bottom which shall be relatively smooth and free of rocks and other debris. On rocky or poor subsoil, the trench shall be excavated at least a foot below bottom of pipe and filled with a carefully compacted suitable bedding material. On normal subsoil, the minimum bedding depth shall be 4".
- (c) The most suitable material for side filling and backfiring shall be gravel or coarse sand with maximum particle size not exceeding 1/2'. An excess of fine particles shall be avoided as it causes difficulty in compaction when wet.

- (d) Initially backfilling with sand around and over the pipe to a minimum depth of 4 inches. The next layer of backfill, to a minimum depth of 12 inches shall be a layer carefully compacted granular material free of rocks and other debris. The remainder of the trench shall be filled with excavated earth or other approved material and compacted in stages, each consisting of a layer not greater than 12" in depth. Heavy mechanical compactors shall not be used until the fill has reached a depth of at least 36" above the top of the pipe.

9.11 Drain Piping Insulation

Drain pipes discharging chilled water condensation from drain pan, etc. shall be insulated with 1" thick flexible expanded rubber compound or approved equivalent.

TABLE 1 : RAINWATER GOODS - FLASHING & GUTTER

Description	Below 5 storey	At or above 5 storey & High end	Above 5 storey	Girth	Lap	Profile
	Gauge	Gauge	Gauge	mm	mm	
1 Wall flashing Roof fall away from wall	26	24	24	300	100	
	26	24	24	300	50	
2 Capping	26	24	24	1200	50	
3 Upper eaves flashing	26	24	24	400	100	
4 Gable Eaves flashing	NA	NA	26	400	50	
5 Vent pipe flashing Pipe dia =<100mm	26	26	26	450x475	NA	
	26	26	26	600x600	NA	
6 Valley gutter End on Roof	24	24	24	600	100	
	24	22	22	600	100	
7 Perimeter gutter	22	22	22	450 to 600	50	
8 Concealed gutter	22	22	22	450 Variable	50	

Note : High end denotes Semi-D and Bungalow

Table 3. Strength groups of timber

S.G. 1	S.G. 2	S.G. 3	S.G. 4	S.G. 5	S.G. 6	S.G. 7
A) Naturally Durable						
Balau	Belian	Bekak	Giam	Teak		
Bitis	Mata ulat	Delek	Malabera	Tembusu		
Chengal	Kekotong	KerANJI	Merbau			
Penaga			Resak			
B) Requiring Treatment						
	Dedaru	Agoho	Berangan	Alan bunga	Bayur	Ara
	Kempas	Balau, red	Dedali	Babai	Damar Minyak	Batai
	Merbatu	Kelat	Derum	Balek angin bopeng	Durian	Geronggang
	Mertas	Kembang semangkok	Kapur	Bintangor	Jelutong	Laran
		Kulim	Kasai	Brazil nut	Jenitri	Pelajau
		Pauh kijang	Keruntum	Gerutu	Jongkong	Pulai
		Penyau	Mempening	Kayu kundur	Kasah	Sesendok
		Perah	Meransi	Kedondong	Machang	Terentang
		Petaling	Meranti bakau	Keledang	Medang	
		Ranggu	Merawan	Keruing	Melantai/Kawang	
		Durian batu	Merpauh	Ketapang	Meranti, light red	
		Tualang	Nyalin	Kungkur	Meranti, yellow	
			Perupok	Melunak	Mersawa	
			Punah	Mempisang	Terap	
			Rengas	Mengkulang		
			Simpoh	Meranti, dark red		
				Meranti, white		
				Nyatoh		
				Penarahan		
				Petai		
				Ramin		
				Rubberwood		
				Sengkuang		
				Sepetir		

NOTES:

1. For naturally durable timbers, sapwood should be excluded. If sapwood is included, preservative treatment is necessary. (Source: MS360, 1986)
2. For timber requiring treatment, they should be amenable to preservative treatment.

**Table 4. Wet and dry grade stresses for various strength groups of timber
(Stresses and modull expressed in N/mm²)**

Strength groups	Condition ¹⁾	Bending parallel to grain			Tension parallel to grain			Compression parallel to grain			Compression perpendicular to grain ²⁾				Shear parallel to grain			Modulus of elasticity for all grades	
		Sel	Std	Com ³⁾	Sel	Std	Com	Sel	Std	Com	Basic	Sel	Std	Com	Sel	Std	Com	Mean	Minimum
SG 1	Wet	29.2	23.0	18.2	17.5	13.8	10.9	26.8	21.1	16.8	4.59	3.90	3.67	3.44	2.54	1.98	1.59	17000	13300
	Dry	33.6	26.5	21.0	20.2	15.9	12.6	28.5	22.5	17.8	4.67	3.97	3.74	3.50	2.94	2.28	1.84	18800	14000
SG 2	Wet	20.7	16.3	13.0	12.4	9.8	7.8	18.8	14.8	11.7	3.50	2.97	2.80	2.62	2.24	1.74	1.40	15700	11700
	Dry	23.3	18.3	14.6	14.0	11.0	8.8	23.4	18.5	14.7	3.82	3.25	3.05	2.86	2.51	1.95	1.57	16800	12600
SG 3	Wet	18.1	14.2	11.3	10.9	8.5	6.8	15.3	12.0	9.5	2.38	2.02	1.90	1.78	1.84	1.43	1.15	13300	9800
	Dry	20.2	15.9	12.6	12.1	9.5	7.6	17.8	14.1	11.1	2.61	2.22	2.09	1.96	2.07	1.61	1.3	14300	10300
SG 4	Wet	14.2	11.2	8.8	8.5	6.7	5.3	12.1	9.5	7.6	1.83	1.55	1.46	1.37	1.53	1.19	0.96	10700	7400
	Dry	16.8	13.2	10.5	10.1	7.9	6.3	14.1	11.1	8.8	2.06	1.75	1.65	1.54	1.58	1.23	0.99	11000	7600
SG 5	Wet	11.0	8.6	6.8	6.6	5.2	4.1	9.1	7.2	5.7	1.12	0.95	0.90	0.84	1.21	0.95	0.76	8800	6100
	Dry	12.1	9.5	7.5	7.3	5.7	4.5	10.8	8.5	6.7	1.42	1.21	1.14	1.06	1.37	1.07	0.86	9100	6300
SG 6	Wet	9.4	7.4	5.9	5.6	4.4	3.5	7.9	6.2	5.0	1.02	0.87	0.82	0.76	1.05	0.82	0.66	6700	4900
	Dry	11.3	8.9	7.1	6.8	5.3	4.3	8.8	6.9	5.5	1.28	1.09	1.02	0.96	1.11	0.86	0.69	7300	5200
SG 7	Wet	6.6	5.2	4.2	4.0	3.1	2.5	5.3	4.2	3.3	0.62	0.53	0.50	0.46	0.91	0.71	0.57	5700	3000
	Dry	8.2	6.5	5.1	4.9	3.9	3.1	6.9	5.4	4.3	0.77	0.65	0.62	0.58	0.98	0.76	0.61	6600	3400

¹⁾ Moisture content for Wet >19%, for dry ≤ 19%

²⁾ When there is no wane at the bearing area, the basic stress figures may be used for all grades.

³⁾ Sel, Std and Com stand for select structural, standard structural and common building grades respectively as defined in the Malaysian Grading Rules (MGR)(see Appendix C).

MALAYSIAN WOOD - A GUIDE TO THEIR USES

Usage	Construction			Furniture			Flooring			Plywood/Veneer		Paneling & Partitioning	Railway Sleeper	Joinery	Piling	Door & Window frames
	Heavy	Medium	Light	Decorative	Heavy duty	Utility	Parquet	Heavy duty	Utility	Decorative	Utility					
HEAVY HARDWOODS																
Balau/Selangan Batu	x				x			x					x		x	x
Balau Red / Selangan Batu Merah	x	x			x			x					x			x
Belain	x							x							x	
Bitis	x						x	x					x		x	
Chengal	x							x								
Giam	x							x					x			
Kekatang	x	x					x	x				x				x
Keranji	x						x	x				x				
Malagangai	x															
Merbau				x	x		x			x		x		x		x
Penaga	x				x		x						x			
Penyau	x				x			x								
Resak	x							x		x			x	x	x	x
Tembusu	x				x		x	x				x				
MEDIUM HARDWOODS																
Alan Batu	x	x				x			x			x		x		
Bekak		x	x				x	x								
Derum	x	x				x	x		x							x
Entapuluh						x										
Geriting/teruntum				x					x			x			x	x
Kandis	x								x							
Kapur	x	x				x		x								x
Kasai						x		x		x	x					x
Kayu Malam				x						x	x	x				
Kedang Belum / Tualang Daing		x		x			x		x			x				
Kelat																x
Keledang				x			x					x		x		x
Kempas	x				x		x					x	x		x	
Keruing	x						x	x	x				x			
Keruntum	x								x		x	x				
Kulim		x						x					x		x	x
Mata Ulat	x				x		x									x
Mempening	x	x		x			x			x		x				
Mengkulang/Kembang						x	x		x	x	x	x		x		x
Meransi	x	x		x			x			x	x	x				
Merawan/Gagil						x			x	x	x			x		x

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Usage	Construction			Furniture			Flooring			Plywood/Veneer		Paneling & Partitioning	Railway Sleeper	Joinery	Piling	Door & Window frames
	Heavy	Medium	Light	Decorative	Heavy duty	Utility	Parquet	Heavy duty	Utility	Decorative	Utility					
Merbatu	x	x					x									
Merpauh		x	x	x					x		x	x	x	x		
Mertas	x	x					x	x								
Nyalin		x					x			x	x	x	x			
Pauh Kijang	x				x		x				x	x	x			
Perah	x	x					x						x			
Petaling	x	x			x				x						x	
Punah	x				x								x			x
Ranggu						x			x					x		
Rengas							x			x	x	x				
Semayur		x						x								
Senumpul												x				x
Simpoh						x			x	x			x			x
Tampoi		x														
Tualang	x				x		x					x				
LIGHT HARDWOODS																
Alan Bunga						x					x	x		x		
Ara											x					
Babai			x													
Bayur			x			x			x							
Berangan	x	x				x						x				
Bintangor			x	x		x	x		x	x	x			x		
Binuang			x								x					
Dedali		x									x					
Durian			x			x			x		x	x				x
Geronggan/Serungan						x				x	x	x		x		
Gerutu		x	x			x			x		x	x				
Jelutong											x					
Jongkang						x			x			x			x	x
Kedondong						x					x					
Kelumpang			x								x					
Kembang Semangkok				x						x		x				
Ketapang				x		x			x		x	x				
Kungkur						x			x		x	x		x		
Laran											x					
Machang			x	x		x			x	x	x	x		x		
Mahang																
Medang		x	x	x						x		x			x	
Melantai/Kawang						x					x	x		x		
Melunak			x			x	x		x	x	x	x		x		

MALAYSIAN WOOD - A GUIDE TO THEIR USES

Usage	Construction			Furniture			Flooring		Plywood/Veneer		Panelling & Partitioning	Railway Sleeper	Joinery	Piling	Door & Window frames
	Heavy	Medium	Light	Decorative	Heavy duty	Utility	Parquet	Heavy duty	Utility	Decorative					
Mempisang/karai Meranti Bakau Meranti, Dark Red/ Obar Suluk			x			x	x		x	x	x			x	
Meranti, Light Red / Red Seraya Meranti, White/Melapi Meranti, Yellow/Yellow Seraya		x	x			x			x	x	x		x		
Merbulan Mersawa Nyatoh			x												x
Pelajau Penarahan Perupok									x		x	x			
Petai Pulai Ramin											x				
Rubberwood Sengkuang Sentang				x			x				x				
Sepitir Sesendok Terap			x	x					x	x	x	x		x	
Terentang White Seraya						x					x			x	
SOFTWOODS Damar Minyak Podo Sempilor				x						x				x	
				x					x	x	x			x	
				x						x	x			x	

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