

2- CIVIL ENGINEERING AND BUILDING WORKS
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1. CIVIL ENGINEERING AND BUILDING WORKS

1.1. General

1.1.1. Scope

This Specification includes clauses for materials and standards of workmanship required for permanent works of a civil engineering and building works nature.

1.1.2. Machinery Bases and Grouting-In

Bases to take machinery and associated pipework shall be constructed in fair-faced concrete to the required dimensions. The mounting surface of the base shall be steel floated to true line and level planes.

The structural concrete on which the bases are to be erected shall be prepared by “green cutting” and cleaning off. Bases shall be tied to the structural concrete with vertical reinforcement. Horizontal reinforcement shall be provided at the level of the pockets for the holding down bolts.

Bolt pockets and lead-ins for grout shall be formed by the Contractor Polystyrene formers will not be permitted. Where expanded metal is used as a former it shall be left in.

The completed bases shall be offered for inspection to the machinery supplier. When the machinery has been erected the bolt pockets shall be completely filled using an approved free-flowing non-shrinking grout which when hardened has resistance to fatigue caused by dynamic repetitive loading.

1.1.3. Tests for Water tightness of Structures

All water retaining structures shall be tested for water tightness. The description "water retaining" includes also for the retention of any other liquid or slurry.

The Contractor shall submit details of his proposed methods for testing (including details of test equipment) for approval and shall arrange for all tests to be witnessed by the Engineer and for the results to be reported to him in writing.

The Contractor shall provide all blank flanges, connections and other items necessary for carrying out testing and cleaning.

Each water retaining structure shall be filled and tested as soon as possible after completion of construction. Before starting the preliminaries of each test, the Contractor shall inform the Engineer and obtain his clearance for the test to proceed.

The Contractor shall remove all dirt, materials, tools and other foreign matter and shall brush and wash down with water the whole of the interior. The above procedure shall not relieve the Contractor of his responsibility to clean out again as necessary on completion of the Works.

The Contractor shall check that all valves are closed other than any needed for filling the structure with water and shall where necessary stop off and strut any open ends. The structure shall then be filled with clean water for a stabilising period and tested in accordance with the

requirements of BS 8007. During the stabilising period the Contractor shall frequently inspect the structure and any under drains thereto for visible signs of leakage.

In the case of tanks and similar structures, the Contractor shall supply an approved level measuring device such as a hook gauge. This shall be temporarily fixed at each structure to be tested. The water level shall then be dropped to a level 150 mm below that of any weir or sill over which spillage might occur due to wind action and left under test as specified in BS 8007.

All water tightness tests shall include inspection of under drains and walls for signs of concentrated leakage or damp patches; water retaining structures shall not, therefore, be backfilled before passing the water tightness test.

If a structure fails to pass the water tightness test, the Contractor shall locate the fault and shall uncover, repair and retest the structure as necessary until it passes the test.

The Contractor shall provide all water required for testing and cleaning water-retaining structures. The Contractor shall make all necessary arrangements for provision of the water including connections, pipes and pumps except as otherwise agreed and for disposal of the water after test, including any measures necessary for compliance with any applicable discharge consent conditions.

1.1.4. Materials in Contact with Potable Water

All materials which will come into contact with potable water or water to be used for potable supply shall be suitable for use with potable water and shall cause no deterioration of water quality and health hazards to humans. The Contractor shall submit manufacturer's certificates to the Engineer for all materials to demonstrate their suitability of materials in contact with potable water.

1.2. Site Clearance

1.2.1. Clearance of Sites

The Contractor shall clear the reservation widths for pipelines and the sites of structures free of all vegetation, including trees up to 0.50 m girth measured 1.00 m above ground level, and all superficial obstacles such as road surfaces, kerbs, bricks, rubbish and/or other objectionable matter.

Where required the Contractor shall also clear the sites of trees over 0.5 m girth, buildings and/or structures.

The extent of Contractor's clearing and grubbing operations shall be the minimum practicably necessary for the construction of the Works.

1.2.2. Protections

Trees and/or other vegetations designated for preservation shall be kept free from clearing operation and be protected from injury during execution of the Works.

1.2.3. Road Furniture

The Contractor shall re-install any road furniture (such as street lighting, traffic signs or traffic lights) that has to be removed during the progress of the Works.

Installation of the road furniture shall take place at its original location, in a condition at least equal to that prior to removal and as soon as practicable after completion of pipe laying at a particular location.

1.2.4. Disposals

Remnants of vegetation, including trees, stumps and roots, shall be disposed off site by the Contractor.

1.2.5. Blasting

No blasting shall be carried out without the written permission of the Engineer.

When necessary, blasting for clearing boulders and/or rock masses will be permitted only on written approval of the Engineer and when proper precautions are taken for the protection of all persons, the Works and public and private properties.

Blasting shall be carried out in a controlled manner and to the required depth, amount and extent necessary and only with explosives of such quantity and strength and in such locations as will not structurally damage the material to be blasted outside the prescribed limits. Any damage to the Works or properties arising from the blasting shall be repaired by the Contractor to conform to the condition existing prior to damage.

Before any blasting is carried out, the Contractor shall ensure that adequate measures that are necessary for the safety and protection of persons and property against injury or damage had been provided and warning signs and signals had been installed, all to the satisfaction of the Engineer and other authorities concerned with safety and public order.

Explosives and detonating caps shall be stored, handled and used in accordance with Statutory Regulations and national guidelines. Only qualified and authorized personnel shall handle and use explosives.

1.2.6. Notice of Commencement

The Contractor shall give to the Engineer written notice of blasting operations. The works shall not be commenced until written approval has been received from the Engineer.

1.3. Earthworks

1.3.1. General

1.3.1.1. Notice of Commencement

The Contractor shall give at least seven days written notice of his intention to commence earthworks on any part of the site and shall furnish the Engineer with all ground levels and other particulars he may require for the purpose of carrying out measurements. All levels shall be related to MSL (Mean Sea Level)

Earthworks shall not be commenced until written approval has been received by the Contractor from the Engineer.

1.3.1.2. Soil Investigation Reports

Deleted

1.3.1.3. Testing Facilities

The Contractor shall perform the tests required by the Contract, at his own expense, at the frequencies specified therein and he shall be responsible for his own quality control of the works. Three copies of the results of each test performed by the Contractor in a form approved by the Engineer shall be submitted to him. A fourth copy of the test results of each test shall be retained on Site for as long as the Engineer may require.

The Contractor shall provide on the site and maintain and remove when directed by the Engineer a laboratory including all necessary materials, equipment and tools needed for his own testing of materials. The laboratory shall be housed in a weatherproof building designed and used exclusively for that purpose. It should be suitably ventilated and be provided with water and electricity supplies.

The Contractor's site laboratory shall be provided with all equipment needed to carry out the testing required under this Contract. Testing that cannot be performed in the Contractor's site laboratory shall be carried out in other laboratories which shall meet the Engineer's approval.

The laboratory shall be adequately staffed and equipped so that no interruption to the progress of the Works shall occur as a result of the need to carry out tests required under the Contract. The laboratory staff shall include a qualified technician suitably qualified and experienced in the testing of soils, concrete and bituminous materials and a sufficient number of laboratory assistants and labourers.

Without relieving the Contractor of his responsibilities under the Contract, the Contractor shall perform any additional tests which the Engineer may require and/or repeat tests the results of which, in the opinion of the Engineer are not representative.

1.3.1.4. Earthworks to Lines and Levels

The whole of the earthworks for the Works shall be carried out to the required dimensions and levels.

For the purpose of the Specification, the term ground level shall refer to the ground surface before the start of earthwork operations, but after the operations of site clearance. The expression Formation Ground Level (FGL) where used in the Specification shall mean the final ground level of the site after the completion of the works.

1.3.1.5. Extent of Excavations

Earthworks shall comply with BS 6031.

The extent of excavations shall be the minimum necessary or practicable in the opinion of the Engineer for the construction of the Works.

The construction of open trenches shall, at any one time, be limited to lengths previously approved by the Engineer. Work on each approved length shall be completed to the satisfaction of the Engineer before work on any new length is commenced.

The maximum trench width shall be as per the specification. In the event of any trench for pipelines being excavated with battered or stepped sides that portion of the trench which extends from the formation to a point 300 mm above the crown of the pipe when laid in its correct position shall be formed with vertical sides to the required dimensions.

Excavations for all other structures, measured at blinding bottom level, shall be limited to the contour-line of the structure plus 1 m on all sides.

No excavations with battered sides will be permitted in public highways, private gardens or within 30 metres of any building or other structure.

1.3.1.6. Borrow Areas

It is the Contractor's responsibility to locate the borrow areas for all kinds of materials and obtaining, transporting and placing them when needed for the executions of the Works. The Contractor shall obtain the approval of the Engineer for the areas as well as for the materials he proposes to use.

Fill material for incorporation in the Works shall be obtained from approved borrow areas after the completion of any tests to confirm the suitability of the material.

On completion of excavation, the Contractor shall trim, grade and leave the borrow area in a tidy condition and shall carry out any further earthworks necessary to prevent accumulation of water in the area.

1.3.1.7. Filling Materials

Selected fill whether selected from locally excavated material or imported, shall consist of uniform readily compactable material, free from vegetable matter, building rubbish and frozen material, or materials susceptible to spontaneous combustion, and excluding clay of liquid limit greater than 80 and/or plastic limit greater than 55 and materials of excessively high moisture content. Clay lumps and stones retained on 75mm and 37.5mm sieves respectively shall be excluded from the fill material.

Materials proposed for use as selected fill shall be tested on site in accordance with the procedures as prescribed in BS 1377 to determine its characteristics and suitability.

Materials proposed for use as selected fill shall be subject to the approval of the Engineer.

1.3.1.8. Compaction of Fill

Compacted fill shall consist of approved material, spread and compacted in layers approximately horizontal and of uniform thickness with a slight outward slope and of a compacted depth not exceeding 0.20 metres before compaction.

Soil lumps larger than 0.10 metres in size shall be broken before compaction. The moisture content of the soil shall be carefully controlled either by natural drying or wetting with a fine spray.

Compaction shall be carried out by mechanical rollers, power rammers, vibro-tampers, vibrating plate compactors or other approved plant so as to produce a dry density not less than 95% of the proctor dry density as determined in accordance with BS 1377.

During compaction, the Engineer may order either in-situ or other tests to determine the dry density and nature of the fill material. Each layer shall be tested for the moisture content and to confirm it has reached the required dry density.

1.3.1.9. Excavation of Unsound Material

If any unsound material occurs in foundations of structures, the Contractor shall remove it and dispose of it. The Contractor shall fill the voids in the foundations so formed with Concrete Grade C10.

If any unsound material occurs in pipeline trenches, the Contractor shall remove it and dispose of it. The Contractor shall fill the voids in the pipeline trenches with approved fill material.

If the Contractor encounters any material which in his opinion may be unsound, he shall immediately inform the Engineer who will then instruct the Contractor as to whether or not the said material shall be treated as unsound.

The cost of dealing with the unsound material shall be borne by the Contractor if, in the opinion of the Engineer, the cause of unsoundness is due to failure of the Contractor to comply with the Specification, including keeping the excavation free from water.

1.3.1.10. Slips, Falls and Excess Excavation

Every precaution shall be taken by the Contractor to prevent slips and falls of earth and other material in the excavations. In the event of slips or falls occurring or in the event of excavation being made in excess of the minimum necessary or practicable for the construction of the Works the voids so formed shall be filled. In all cases where the voids so formed when backfilled would provide support for the permanent Works or adjacent structures and services then such voids shall be filled with concrete Grade C10. In all other cases the voids shall be packed with selected excavated material or approved fill material and thoroughly compacted.

In the event of any trench for pipelines exceeding the maximum allowable widths the trench width shall be restored or an alternative bedding material used or such other remedial action as is necessary.

1.3.1.11. Excavation to be Kept Free from Water

The Contractor shall keep excavations free from water whether caused by tides, floods storms or otherwise so that the Works shall be constructed in dry conditions. The Contractor shall keep the sub-soil or accumulated water at a level lower than the bottom of the Permanent Works for such a period as the Engineer shall direct.

In the event of the Contractor requiring drainage pipes channels or sub drains the Engineer may permit these to be constructed below the level of and within the width limits of the permanent Works provided he has approved the details of the Contractor's proposals. No sub-drainage pipes shall be left in unless they are filled with concrete Grade C10 or other approved material. Any sub-drainage that the Contractor constructs below the Permanent Works shall if left in place provide support at least equal to that which would have been available if the sub-drain was not present.

No water shall be discharged into any watercourse or sewer without the Contractor having first obtained all necessary consents and the permission of the Engineer. Such permission shall not be granted unless the Contractor shall have provided to the satisfaction of the Engineer an efficient settling basin or sand trap through which all such water shall pass before discharge into the said watercourse or sewer.

1.3.1.12. Excavation Method Statement

The Contractor shall prepare a method statement of his proposal for earthworks operation for each particular part of the Works to be constructed at any one time, detailing the location, programme of excavation, temporary supports and the placing and handling of the spoil.

The Contractor shall submit for the Engineer's approval his proposed method statement at least fourteen days (14) before his intended date to commence earthworks on each particular part of the Works.

1.3.1.13. Embankment and Site Grading

The material used in the formation of embankments and bunds and in filling low areas of the site shall be selected fill as specified in Clause 1.3.1.6.

The fill materials shall be obtained from excavations or be similar material obtained by the Contractor from sources approved by the Engineer.

In areas where foundations are to be constructed the selected fill shall be placed and compacted to the bottom level of the blinding concrete.

Special measures must be taken in compacting material laid immediately adjacent to a structure to ensure that the material is well compacted. Hand operated vibrating plate compactors, vibro-tampers or power rammers are to be used. In other, cases compaction shall be carried out by vibrating compactors, smooth wheel or pneumatic tyre rollers of types approved by the Engineer.

In trimming and forming bunds and embankments the Contractor shall make allowance in the height and width of these for consolidation and shrinkage.

1.3.1.14. Stripping of Topsoil

Topsoil shall be stripped from the whole or part of the Site to a depth of 250 millimetres and set aside for re-use as a separate operation prior to any further excavation which may be required.

Topsoil shall include any surface material capable of supporting vegetation and suitable for use in soiling areas to be grassed or cultivated.

The Contractor shall not dispose of surplus topsoil without the permission of the Engineer.

1.3.1.15. Trial holes

The Contractor shall excavate any trial holes he may require to determine the position of underground services, sub-soil drains or for any other reason.

The Contractor shall arrange for the refilling and reinstatement of trial holes to be carried out immediately the required information is obtained. The reinstatement of the surfaces of trial holes shall be carried out to the approval of the Engineer.

1.3.1.16. Inspection by the Engineer

When the specified levels or limits of any excavation are reached, the Engineer will inspect the ground exposed and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, selected excavated material or selected imported material.

Should the material forming the bottom or side of any excavation, while acceptable to the Engineer at the time of inspection, subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the Works, the Contractor shall remove such damaged, softened or loosened material and excavate further to a sound surface. Such further excavation shall be held to be Excess Excavation and material emanating there from shall be removed from the site.

1.3.1.17. Crossing Watercourses

Where the excavation crosses streams, ditches, culverts and other watercourses the Contractor shall be deemed to have allowed for all the additional measures necessary for the proper construction of the Works at these crossings including maintaining the full flow of water.

1.3.2. Structures

1.3.2.1. Dewatering

The Contractor shall keep the excavations clear of water during construction. The method of keeping excavations clear of water, dewatering and disposal of water, shall be subject to the approval of the Engineer.

Where a structure is subject to uplift the Contractor shall reduce the ground water pressures so that the structure is stable for the whole period of the construction.

The Contractor shall ensure that sufficient stand-by plant is available on site at all times to avoid any interruption to continuous dewatering.

1.3.2.2. Method of Excavation

Earthworks for structures shall comply with BS 8004.

1.3.2.3. Excavation to Alignment and Levels

Excavation shall be carried out to such dimensions as will permit adequate dewatering, proper support of the sides of the excavation, the erection of shuttering, placing of concrete and fill including compaction and any other construction operation.

Special care shall be taken not to disturb the blinding bottom level of any structural excavation.

1.3.2.4. Tests on Groundwater

Samples of the groundwater shall be taken for testing to ascertain the presence of substances aggressive to concrete or other materials used in the Works, if considered necessary by the Contractor or the Engineer. The testing shall be in accordance with BS 1377.

1.3.2.5. Tests on Blinding Bottom Level

On reaching the level for hand trimming as specified herein, the Engineer may order either in situ or other tests to determine the nature and bearing capacity of the soil strata.

1.3.2.6. Disposal of Surplus Excavated Material

The Contractor shall be responsible for negotiating and securing suitable areas for disposal of surplus excavated materials and shall pay any fees or other payments associated with such disposal.

In connection with the disposal of excess spoils, the Contractor shall be responsible for the following during the Contract period:

- (a) Upgrading the strength and the quality of the existing access road(s) and maintaining the same in good order and final reinstatement.
- (b) Dewatering of the tipping area(s) by means of porous concrete pipes laid at the bottom of the valleys or as agreed with the Engineer.
- (c) Unloading, spreading, levelling, placing the soil into embankments etc. as necessary, in order to keep the top(s) in good, safe and manageable order.
- (d) Keeping third parties from using the tipping area(s).
- (e) Keeping vehicles clean when leaving the tipping area(s) and to ensure they do not contaminate public roads.

1.3.2.7. Over Excavation

Any extra excavation beyond the limits specified or ordered shall be filled by the Contractor at his own expense with concrete Grade 10 or with approved fill material thoroughly compacted if the Engineer so directs.

1.3.2.8. Hand Trimming at Blinding Bottom Level

Where the Blinding Bottom Level of any excavation is to receive concrete or compacted fill, the final 0.15 metres of the excavation shall be trimmed by hand, after removal of any slurry and loose material and immediately before placing the concrete or fill.

The Blinding Bottom Level shall be carefully levelled or shaped as required.

1.3.2.9. Report to Engineer

The Contractor shall report to the Engineer when excavations are ready to receive pipes or concrete foundations and shall not proceed with pipe laying, concreting or other works until they have been passed and approved by the Engineer. Any pipe laying, concreting or other work carried out without prior approval of the Engineer shall be removed immediately at the Contractor's expense.

1.3.2.10. Filling not to Endanger Structure

The Contractor shall arrange the timing and rate of placing of backfilling or of filling to structures in such a way that no part of the Works is overstressed, weakened, damaged or endangered. The layers of material shall be so placed as to maintain adequate drainage and to prevent accumulation of water. In particular, the placing of material around concrete structures shall commence only after they have been completed and have attained their full specified strength. The material shall be placed so as to exert a uniform pressure around the structures.

Regardless of the method of backfilling adopted the Contractor shall ensure that backfilling to excavations is carried out to the satisfaction of the Engineer. The Contractor shall take all necessary precautions to ensure that no damage is caused to the Permanent Works or to adjacent structures.

1.3.2.11. Selection and Compaction of Backfill

Where backfilling below ground level and adjacent to structures is required, the material to be used shall be carefully selected and compacted as specified.

No backfilling work shall be carried out until it has been approved by the Engineer. Where backfilling is to be placed on two or more sides of the structure, it shall be placed simultaneously on the opposite sides so that the difference in level never exceeds 0.30 metres. The difference in level of backfilling on either sides of pipes shall not exceed a maximum of 0.20 m. Backfilling to structures shall generally be carried out as soon as practicable.

1.3.2.12. Levelling of Areas

Areas around or on top of structures shall be levelled to the required levels. The Contractor shall take due precautions to prevent any damage to the structures during the levelling. The

levelling of areas around structures shall be carried out by approved methods. Any damaged item shall be replaced or repaired at the Contractor's expense and to the satisfaction of the Engineer.

1.3.3. Support of Excavations

The Contractor shall be responsible for the design, installation, maintenance during construction, and where appropriate, removal of all support works needed for trenches and other excavations. The Contractor shall submit to the Engineer for approval, details of his proposals for excavation support which details shall include such drawings, calculations or other explanatory matter as the Engineer may require. No excavation work may proceed until the Engineer's approval has been given to the Contractor's proposals.

Excavation support shall be sufficient to prevent damage or overstressing to existing structures and other works. The contractor shall take special care in deciding the adequacy of the temporary supports to ensure that there is no lateral deflection along the excavated edge which can damage existing structures.

The Contractor shall not remove temporary works supporting the excavations until in the opinion of the Engineer the permanent work is sufficiently advanced to permit such removal.

Where the removal of excavation support works is considered by the Engineer to endanger existing structures thus making them liable to subsidence damage, the Contractor shall leave such support works in place, removing only the minimum necessary to allow the reinstatement of the surfaces.

1.3.4. Additional Site Investigation

1.3.4.1. General

The Contractor shall ascertain the subsoil conditions at the site by undertaking a programme of Additional Site Investigation, if considered necessary by the Contractor or the Engineer. This programme shall comprise fieldwork, laboratory work and reporting. Should the Engineer consider that the Additional Site Investigation undertaken by the Contractor remains insufficient for detailed design of any part of the Works, the Contractor shall undertake further work, and/or employ a specialist Site Investigation firm.

Additional site investigations, whether or not ordered by the Engineer shall be carried out in accordance with BS 5930 and BS 1377 unless otherwise specified.

The site investigation work shall be carried out using modern methods and equipment and by fully competent staff under the supervision of a qualified engineer. The methods and equipment employed shall be such as to provide the necessary data.

1.3.4.2. Boring Log and Report

The Contractor shall submit to the Engineer a Soils Investigation Report incorporating a record of all the investigation work carried out by him. The Report shall include boring logs, records of field and laboratory tests, records of water level observation and recommendations as to the bearing capacity of the soil and water inflow. Five copies of this Report shall be submitted to the Engineer within one month of completing the field work. Laboratory tests shall be carried out in a laboratory approved by the Engineer.

1.4. Road works

1.4.1. General

The road works in this Contract comprise mainly the construction of access and service roads at the Sites(s) and the reinstatement of existing surfaced public roads.

The roads and pedestrian access pavements to be reinstated may include the following types of surfacing:

- asphaltic concrete pavement
- natural cobblestones
- concrete pavements
- gravel roads and foot paths
- tiled pavements

Roads having an asphaltic concrete surface shall generally consist of one layer (surface course) of hot-mixed asphalt on a base constructed of the following compacted components:

- a bottom layer of subgrade material, only where necessary
- a sub-base of granular material or broken stones
- a base of cement bound granular material or concrete

Roadways within the project Sites shall be constructed with concrete pavements. Access roads shall have asphaltic concrete pavement.

For the precise details of materials to be used and thickness of construction, the Contractor shall refer to the highway authority or the local authority.

1.4.2. Granular Materials

Granular sub-base material shall be natural sands, gravels, crushed rock, crushed slag, crushed concrete or well burnt non-plastic shale. The material shall be well graded and lie within the following grading limits:

BS 410 Test Sieve	Percentage by Mass Passing	
	Type 1	Type 2
75mm	100	100
37.5mm	85-100	85-100
10mm	40-70	45-100
5mm	25-45	25-85
600µm	8-22	8-45
75µm	0-10	0-10

Where granular sub-base material is to be used within 450mm of the surface of any road, the Contractor shall supply to the Engineer a certificate confirming that the material has a heave not greater than 15mm when subjected to the frost test as specified in BS 812: Part 124.

Natural sands and gravels shall only be permitted in Type 2 material.

The particle size shall be determined by the washing and sieving method of BS 812: Part 103. The material passing a 425 µm BS sieve, when tested in accordance with BS 1377: Part 2, shall be non-plastic for Type 1 and have a Plasticity Index of less than 6 for Type 2.

With the exception of well burnt shale, the material shall have a 'ten per cent fines' value of 50 kN or more when tested in accordance with BS 812: Part 111.

1.4.3. Earthworks for Roads

The earthworks for roads shall generally be in accordance with Section 3 of the Specification. Fill shall be compacted in accordance with the Specification. Where the dry density of the natural ground within 0.5 m. depth of the blinding bottom level is below 95% of the maximum dry density as determined in accordance with BS 1377, the subgrade material shall be reworked and compacted as specified in Section 3 of the Specification. During wet weather conditions, particular attention shall be paid to the requirement that fill shall be compacted with a slight outward slope to ensure good run-off of surface water. Material excavated out of the road bed which is suitable for use in fill, shall be used for filling as far as this is practicable.

1.4.3.1. Filling of Excavations Beneath Site Roads

- (a) Excavations for pipelines laid under site roads shall be back filled with sand to BS 882: Grade C Sand.

Filling shall be built up evenly over the full width and compacted in layers not exceeding 300 mm in depth at the optimum moisture content. The moisture content of the sand may require adjustment to that required to attain maximum density. Sand which contains insufficient moisture to obtain the desired compaction will require the incorporation of additional water by the use of approved sprinklers and mixing.

Layers more than 300 mm below road formation shall be compacted to 90% of the maximum dry density determined according to BS 1377 Test 12 or 14. Layers less than 300 mm below road blinding bottom level shall be compacted to 95% of the maximum dry density determined according to the aforementioned standard method.

The Contractor shall ensure that the sand laid immediately adjacent to a structure concrete wall or thrust, block is well compacted. Hand operated vibrating plate compactors vibro-tampers or power rammers shall be used. In other cases compaction shall be carried out by vibrating compactors smooth wheel or pneumatic tyre rollers of types approved by the Engineer.

- (b) Excavations for pipelines laid otherwise and for all other structures beneath the carriageways shall be back filled with lean mix concrete. This concrete shall comprise proportions by weight of

1 part of cement
3 parts of sand
and 6 parts of aggregate with a maximum size of 40 mm.

The concrete and its placing shall otherwise conform to the Section 6 of the Specification.

1.4.4. Finish and Protection of Subgrade

When the subgrade has been compacted to the required degree, the surface shall have a formation parallel to the finished surface of the carriageway and to the correct levels and cross-section.

The finished surface of the subgrade shall be approved by the Engineer before any sub-base material is placed. The subgrade, once it has been finally compacted, shaped and approved, shall be protected and kept well drained.

Plant and materials shall not be stored or stockpiled on the formation. Contractor's traffic shall not be permitted to pass over the completed subgrade unless otherwise approved by the Engineer. The Contractor shall, at his own expense, repair any soft spots or damage caused to the subgrade.

1.4.5. Material and Construction of Sub-base

All material shall be placed, spread evenly and compacted, spreading shall be undertaken concurrently with placing. The material shall be spread in one or more layers so that after compaction the total thickness is as required. Compaction of the sub-base shall be to 98% of the maximum proctor dry density as determined in accordance with BS 1377 and shall be completed as soon as possible after material has been spread. Where compacting plant is of insufficient capacity, the sub-base shall be laid in two or more layers. During the construction period the sub-base shall be maintained in such a condition that it will be drained at all times. The outflow shall be diverted away from the construction at all times. The outflow shall be diverted away from the construction in order to prevent erosion.

1.4.6. Requirement for Compaction

Vibratory compacting plant may be used if approved by the Engineer. The number of passes to be made will be determined having regard to the characteristics of the plant to be employed and the material to be used.

If necessary, test specimens shall be taken to determine the optimum method of compaction. The surface of any layer of material shall, on completion of compaction, be well closed, free from movement under compaction plant and free from compaction planes.

All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompact.

1.4.7. Material and Construction of Base

1.4.7.1. Materials

The base shall comprise of cement bound granular material or concrete.

Concrete road bases shall be constructed in concrete grade C15.

In the case of roads constructed in cement bound granular material as base, the material to be used shall be naturally occurring gravel-sand, washed or processed granular material, crushed rock or any combination of these, provided that the sulphate content shall not exceed 1 percent. The material shall be sufficiently well graded to ensure a well closed surface finish.

The granular material shall be mixed with ordinary Portland cement to provide a crushing strength to the specified requirements. The material shall be mixed in a weight batch mixer or similar approved.

When batch mixers are used the mixing time per batch shall be not less than one minute, unless a shorter time is permitted by the Engineer after preliminary trial mixing. If continuous mixing is used, the rate of feed of materials shall be adjusted to give a consistent mixture.

If a water rose is used for adding the water into the mixer, the rate of flow shall be adjusted to give uniformity in moisture content throughout the mix. The moisture content of the mixed material shall not be more than 2 percent above the optimum.

At least 10 days prior to commencing the main work using cement bound granular material, the Contractor shall construct a 20 to 25 metre length of roadway as a preliminary trial bay at a location to be approved by the Engineer.

For constructing the trial bay the Contractor shall use the materials, mix proportions, mixing, laying, compaction plant and construction procedure proposed by him for the main work. If necessary, specimens shall be taken from the trial to determine the optimum method of compaction. The average crushing strength at 7 days for each batch of 5 specimens, made and tested according to the Specification Clauses for concrete shall not be less than 3.5 N/mm². If an area of cement-bound layer represented by 5 test specimens has an average strength less than the specified minimum values, the Contractor shall make good by replacing the defective areas with cement-bound material to the Specification.

1.4.7.2. Workmanship

The material shall be placed and spread evenly, spreading shall be undertaken concurrently with placing. Road base material shall preferably be spread in one layer using a paving machine or similar approved.

The material shall be spread so that after compaction, the total thickness is 250 mm as required. The Contractor shall organise the work in such a way that longitudinal joints against hardened material are avoided as far as possible. If this is not possible then before work proceeds against a longitudinal joint of hardened material, the edge compacted previously shall, if it had been exposed for more than an hour, be cut back vertically to produce a face equivalent to the specified thickness of the layer of properly compacted material.

Compaction of the road base to a minimum of 98% of the maximum proctor dry density shall be completed as soon as possible after the material has been spread. Compaction equipment shall not bear directly on hardened or partially hardened material previously laid other than what is necessary for achieving the specified compaction of the joint. Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse joints, and the Contractor shall use special small compactors in addition if necessary or instructed by the Engineer.

Any loose or poorly compacted material in the vicinity of construction joints shall be removed and replaced with fresh material. The surface of any layer of material shall on completion of compaction be well closed, free from movement under compaction plant and free from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-

compacted. If this cannot be done within 2 hours of mixing, the making good shall comprise the material being broken out to the full thickness of the layer, removed and replaced with freshly mixed material compacted in accordance with the Specification.

The base shall, immediately on completion or compaction, be cured for a period of at least 7 days, unless otherwise approved by the Engineer.

Curing shall be achieved either by covering with approved impermeable plastic sheeting adequately secured from being blown off the surface with joints overlapped at least 300 mm and set to prevent egress of moisture or in accordance with Clauses in the Specification dealing with concrete or by spraying with an approved curing compound.

1.4.7.3. Highway Authority or Local Authority Requirements

Notwithstanding the above the Contractor shall construct the road base in accordance with the requirements and specification of the relevant highway authority or local authority. The Specification included herein shall be adopted only in the absence of any particular requirements from these authorities.

1.4.8. Temporary Reinstatement of Public Highways

Temporary reinstatement of public highways shall be carried out as soon as is practical after completion of the Permanent Works and before the section of the road or pavement is reopened for public use. Temporary reinstatement shall be maintained by making good any subsidence, shrinkage, defect, imperfection or fault for a period as directed by the Engineer but of at least three months prior to final reinstatement.

Temporary reinstatement where not specifically required by the highway authority or the local authority shall comprise either an additional depth of road base material as instructed by the Engineer. Original surface materials shall be placed by hand with the wearing course upper most. The method of placing and compacting of temporary reinstatement shall be similar to that for road base construction, to the same surface tolerance, and to suit levels of the surrounding undisturbed road or pavement.

Only materials approved by the Engineer shall be used for making good any defects. Immediately prior to final reinstatement the temporary reinstatement shall be cut out and disposed of off Site and the road base cut out where found to be damaged or otherwise defective and replaced and compacted as specified.

1.4.9. Hot-mix Asphaltic Concrete

Asphaltic roads within the Site shall be surfaced in accordance with the following specifications.

The bituminous mixture for the surface source shall conform to the requirements of locally produced mixtures.

The composition of the mixture is generally as follows:

- 5 to 7% bitumen
- 70 to 75% grey or blue calcareous material
- 23 to 25% sand.

Bituminous mixture shall, as far as practicable, be obtained from an approved local mixing plant. No bituminous mixture shall be manufactured until a job-mix formula has been submitted by the Contractor and approved by the Engineer.

The formula shall indicate the exact percentage of each sieve fraction and the exact percentage of asphalt to be used in the mixtures, including the mix temperature. The job-mix formula shall be within the master range as specified and shall be in effect until modified in writing by the Engineer.

1.4.10. Weather limitations

Bituminous courses shall be constructed only when the base is dry and when the weather is not rainy. Such courses shall not be constructed when the atmospheric temperature is below 10°C and falling, but may be constructed when atmospheric temperature is at least 8°C and rising, unless otherwise directed by the Engineer.

1.4.11. Preparation, Delivery and Placing

1.4.11.1. Preparation

Immediately before applying the bituminous pavement, the surface of the underlying course shall be thoroughly cleaned of all loose or foreign material. The base shall be coated with tack-coat of the liquid asphalt rapid curing type. The tack coat to be used shall be to the Engineer's approval. The tack coat shall be applied just sufficiently in advance of the placement of the asphaltic concrete mixture so as to provide a thin adhesive film of bituminous cement to ensure a good bond.

The tack coat shall be uniformly applied by means of a pressure hand spray, in quantities of not less than 0.2 litre per square metre nor more than 0.3 litre per square metre of surface, unless otherwise directed by the Engineer.

Stakes for alignment control shall be furnished, set and maintained by the Contractor, subject to checking and correction by the Engineer, in order that the Works will conform to the design lines. The stakes shall be set in lines parallel with the centre line of the area to be paved, offset and spaced, as directed by the Engineer.

1.4.11.2. Delivery

All bituminous mixtures shall be transported from the mixing plant to the spreader in trucks having tight, clean, smooth beds which have been oiled with a minimum amount of approved thin oil to prevent adhesion of the mixtures to the trucks. Each load shall be covered with canvas, or other suitable material, to protect it from dust or rain, and to prevent the loss of heat. Deliveries shall be arranged so that spreading and rolling of all the mixtures prepared for a day's run can be completed during daylight, unless artificial light satisfactory to the Engineer is provided. Any loads excessively wet by rain will be rejected. Hauling over freshly laid material will not be permitted.

1.4.11.3. Construction

The temperature of each mixture when dumped into the spreader shall be as directed by the Engineer, plus or minus 10°C.

The spreader shall be adjusted and the speed regulated, so that the surface of the course will be smooth and of such depth that, when compacted, it will conform to the required cross section. The length of any lane laid before placing the adjacent lane shall be as directed by the Engineer. Where two spreading machines are operating in staggered position, no single lane shall be laid in advance of the adjoining lane further than will permit a satisfactory hot longitudinal joint between the lanes.

Where forming a hot longitudinal joint, the 15 cm strip along the edge against which additional material is to be laid shall not be rolled until such additional material is placed, except when the work is to be discontinued. After the first lane has been placed and rolled, the adjacent lane shall be placed while the unrolled 15 cm strip is hot and in a readily compactable condition. Rolling of the adjacent lane shall begin along the joint. Placing of the mixture shall be as continuous as possible.

In areas where the use of machine spreading is impractical, the mixture may be spread by hand and dressed with rakes. The loads shall not be dumped any faster than can be properly handled by the shovellers and rakers.

Contact surfaces of previously constructed pavement kerbs, man-holes, and similar structures shall be painted with a thin tack coat prior to placing the bituminous mixture.

1.4.12. Compaction of Mixture

1.4.12.1. Method

Compaction shall be effected by three-wheel rollers and tandem rollers.

Rolling of the mixture shall begin as soon after placing as the mixture will bear the roller without undue displacement. Delays in rolling freshly spread mixtures will not be permitted. Initial rolling shall be effected by tandem rollers, followed immediately by the three-wheel rollers. Rolling shall start at the extreme sides of the lanes and proceed toward the centre of the pavement, overlapping on successive strips by at least one-half the width of the rear wheel of the three-wheel roller. On the super-elevated curves, rolling shall begin at the low side and progress toward the high side. Alternative trips of the roller shall be slightly different lengths. Tests for conformity with the smoothness will be made immediately after initial compaction, any deviations in excess of the specified tolerances shall be corrected by loosening the hot surface with rakes and removing or adding material as directed before continuing the rolling.

Generally, rolling shall be executed in such a manner as to produce a smooth surface and shall be continued until a proctor density of at least 98 percent has been obtained.

During rolling, the wheels of the rollers shall be moistened to prevent adhesion of the mixture to the wheels, but an excess of water will not be permitted. The Contractor shall furnish additional and sufficient rollers if it is found that the pavement density specified is not obtained. In all spaces not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers weighing not less than 10 kilos, with a tamping face of not more than 300 square centimetres. Skin patching of an area that has been rolled will not be permitted.

Any mixture that becomes mixed with foreign material, or is in any way defective, shall be removed, replaced with fresh mixture and recompacted. The rollers shall not be permitted to stand on pavement which has not been fully compacted. Necessary precautions shall be taken

to prevent the dropping of oil, grease, petrol, or other foreign matter on the pavement, either when the rollers are in operation or standing. The Contractor shall provide competent workmen who are capable of performing all work incidental to the correction of all pavement irregularities.

1.4.12.2. Tolerances

The finished surface shall not vary more than 3 mm when tested with a 3.00 metre straight edge applied parallel with the centre line of the pavement. After completion of the final rolling, the smoothness of the course will be checked, and any irregularities that exceed the tolerance or that retain water on the surface, shall be corrected by removing the defective area and replacing with new pavement without additional payment. The completed bituminous pavement will be tested for thickness at such intervals as directed by the Engineer. Where the thickness proves to be more than 0.5 cm smaller than the specified pavement thickness, the deficient pavement shall be removed and replaced with satisfactory pavement with no additional payment.

1.4.12.3. Joints

All joints shall present the same texture, density and smoothness as other areas of the course. The joints between old and new lanes, or sections, shall be carefully made in such manner as to ensure a continuous bond between the old and new pavement. All trimmed contact surfaces of previously constructed pavement shall be painted with a thin, uniform tack coat before the fresh mixture is placed. When the edges of joints are irregular, honeycombed, or poorly compacted, all unsatisfactory sections of joint shall be trimmed to expose an even, vertical, or sharply sloping surface for the full thickness of the course. Fresh mixture shall be raked uniformly against the joint, followed by rolling. After final rolling, no vehicular traffic of any kind shall be permitted on the pavement for at least 24 hours.

1.4.13. Drainage

Surface water drainage to Site roads hard standings and access roads consists of a crossfall on the surface of the roads or paved areas draining to the adjoining ground.

Where surface water drainage is provided for roads it shall consist of piped drainage. Where practicable drainage work shall be completed before road works are commenced.

Trenches for piped drainage shall be excavated to the minimum dimensions necessary for the proper construction of the Works, and after pipes have been laid, tested and, where specified, surrounded with gravel or concrete, the trenches shall be back-filled with excavated material and compacted to a dry density equal to that of the adjacent ground. Surplus excavated material shall be disposed off Site.

Pipes shall be laid to the required lines and levels. Pipes shall be haunched or surrounded with concrete as necessary.

Porous pipes shall be laid dry-jointed and shall be surrounded with gravel. Brickwork manholes and gullies shall be constructed complete with cast iron covers or gully gratings.

1.4.14. Kerb Laying

Precast concrete kerbs shall be laid true to line and level and any kerb found to be more than 5 mm out of line or level at either end shall be lifted and relaid.

Where practicable kerbs shall be laid before paving. In reinstatement the original kerbs shall generally be re-used except where these are damaged. They shall be thoroughly cleaned before replacement and laid to suit the line and level of the undisturbed kerbs.

Kerbs laid on concrete pavement shall be bedded on a layer of 2:1 sand-cement mortar 13 mm thick and shall be backed with concrete, cast over and around steel dowels previously driven into the green pavement concrete and shaped up to the required cross-section.

Kerbs laid otherwise than on concrete pavement shall be bedded on a layer of 2:1 sand-cement mortar 13 mm thick laid on a concrete foundation and shall be backed with concrete shaped up to the required cross-section.

Specially cast circular kerbs shall be used on curves of 13 metre radius or less.

Kerbs shall be jointed with cement mortar except at expansion joints which shall be made with preformed joint filler 13mm thick. Expansion joints shall be carried through the concrete backing and foundation.

1.4.15. Footpaths

The formation and sub-grade for footpaths shall be prepared as specified for roads, except that proof-rolling will not be required.

Edging to footpaths shall be of precast concrete. It shall be bedded in concrete foundation shaped up as necessary.

No sub-base will be required for footpaths. The base shall be as specified for road base, laid and compacted to a minimum thickness of 75mm using a roller of not less than 2.5 tonne mass or other approved equipment giving equivalent compaction.

Where a flexible final surface is specified the base course shall be sealed with a coat of cut-back bitumen, 100 seconds grade sprayed on at the rate of 1.4 litres/m² and shall be covered by a surfacing of 6 mm nominal size medium textured wearing course macadam not less than 25 mm thick made and laid in accordance with BS 4987.

Where concrete flags are specified as the final surface, they shall be bedded on a layer of sand approximately 50 mm thick, laid on to the base course. Joints shall be made 3:1 sand-cement mortar. Paths surfaced with concrete flags will not normally have precast concrete edgings.

1.4.16. Road Markings

Where required, the Contractor shall paint markings on the completed road surfaces.

Before paint is applied, the road surface shall be thoroughly cleaned and dried to remove all dust and other deleterious matter.

Except where otherwise specified all lines shall be 100 mm wide. All lines shall be premarked with dots at approximately 3 metre centres on straight lines and 1 metre centres on curves. Lines on curves shall not be formed by a series of straight sections around the curve. The alignment shall not deviate more than 20 mm in 25 metres. The width of the lines shall not be varied more than plus or minus 6 mm from the specified width.

The paint shall be applied with due regard to the manufacturer's instructions. Lines and other road markings shall be applied uniformly and shall have sharply defined edges without runs or spatters.

1.4.17. Concrete Bollards

Concrete bollards shall be precast and sized 1000 long x 400 x 400 mm. Exposed surfaces shall be left smooth and fairface from the shutter. The top surface shall be weathered to falls. Surfaces below ground shall be left rough from the shutter or hacked to provide a key with the encasing concrete.

Bollards shall be set to project 550 mm above ground level and be vertical, true and plumb.

The base of each bollard shall be encased in mass concrete to a depth of 600 mm and all round to a thickness of 200 mm except where placed adjacent to building plinths or other structures. In such cases the concrete shall fill the gap between the structure and bollard.

A sample bollard shall be cast and be submitted to the Engineer for approval.

1.4.18. Testing

The Contractor shall carry out tests at such intervals as the Engineer may direct to demonstrate that the materials for the granular sub-base and road-base comply with the Specification and that the specified density for the sub grade, sub-base and road-base are being achieved.

The Contractor shall inspect and test each area of layer for compliance with surface level-accuracy.

1.5. Piling

1.5.1. General

The Contractor shall carry out detailed design of the piles in accordance with the Conditions of Contract and Specification and shall determine the type of pile and the optimum arrangement of piles required for supporting the structures to the approval of the Engineer.

Excavation, concrete, steel reinforcement, and steel casing where applicable shall conform to the relevant Sections of the Specification.

At least 14 days before the Contractor intends to commence piling work on the Site the Contractor shall submit for the Engineer's approval full details of his proposed piling system including the type and dimensions of piles, reinforcement details and full design for cast in-situ piles and design and driving calculations for driven piles. The details to be submitted shall include the Contractor's proposals for equipment, temporary works and construction methods.

No work on piling shall commence on the Site until the Engineer's approval to the Contractor's proposal has been received.

1.5.2. Types of Piles

Bearing piles shall be driven pre-cast concrete or cast in-situ concrete piles.

1.5.3. Design of Piles

Piles shall be generally designed in accordance with BS 8004. The materials and work shall conform to the requirements of the Specification. Where there may be any conflict of the requirements between the Specification and BS 8004 and the ICE Specification for Piling, the Specification shall take precedence for piling works. Piles shall be designed to sustain the specified loads with settlements not exceeding those specified. Allowance shall be made in the design for the incidence of negative skin friction where appropriate and for resisting the necessary tensile forces due to the swelling and heave of the clay stratum. Bearing piles shall be designed to have a factor of safety of at least 3.0 times the working load. The load depending on the type of structure can either be horizontal, Vertical or both vertical and horizontal.

The permissible loadings of bearing piles shall be modified where necessary to allow for particular conditions: piles in close proximity or in groups, soil strength, groundwater level, and other relevant factors.

The piles shall be of sufficient cross-section and length to sustain loads specified without settlement exceeding the following:

Working load	allowable settlement 8 mm
1.5 x Working load	allowable settlement 10 mm
2 x Working load	allowable settlement 12 mm

These settlements shall include both permanent and elastic deflections. Measurement of the settlement shall be made on first achieving the specified load. Measurement of the settlement shall be made at the point of application of the load.

Where piles in place are subjected to handling, stacking and pitching or bending moments and/or shear forces, these shall be combined with the vertical loads (either in compression or tension) to satisfy the design requirements of BS 8110.

The average compressive stress in the concrete of cast in-situ bearing piles under working load shall not exceed 25% of the characteristic cube strength at 28 days, calculated on the total cross sectional area of the pile shaft.

1.5.4. Preliminary Test Piles

Preliminary test piles shall be constructed according to the instructions of the Engineer. These shall be loaded to twice the working load to prove the design and system and to demonstrate that the safe load requirements can be achieved by the piling method proposed.

The total number of preliminary test piles shall not be less than one percent of the total number of piles. The preliminary test piles shall be located in places proposed by the

Contractor and approved by the Engineer. The Engineer shall be given at least 48 hours notice of commencement of construction of the preliminary pile which is to be test-loaded.

The preliminary test piles shall be constructed in a manner similar to that to be used for the construction of the working piles by the use of similar equipment and materials. Any variation will only be permitted with the prior approval of the Engineer.

For the preliminary piles which are to be test loaded a detailed record of the progress during construction shall be made and submitted to the Engineer daily. The pile shafts shall be terminated at the normal cut-off level or at some other level as required by the Engineer.

The pile shafts shall be extended where necessary above the cut-off level or working piles so that gauges and other apparatus to be used in the testing process will not be damaged by water or falling debris and to permit exposure of the reinforcement.

Where the pile shaft is extended above the cut-off level of the working piles in soils which would influence the load bearing capacity of the pile a sleeve shall be left in place during testing to eliminate friction which would not arise in working piles.

If the cut-off level is below ground level and the shaft is not extended and there is a risk of the borehole collapsing, a sleeve shall be left in place or inserted above the pile shaft or other means satisfactory to the Engineer shall be employed. Adequate clearance shall be given between the top of the pile shaft and the bottom of the sleeve to permit unrestricted movement of the pile.

For piles that are tested in compression the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile sufficiently large to accommodate the loading and settlement measuring equipment and shall be adequately reinforced or protected to prevent damage due to the concentrated application of load from the loading equipment.

The pile cap shall be concentric with the test pile and the joint between the cap and the pile shall have a structural strength equivalent to that of the pile.

A sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that at the maximum anticipated settlement load is not transmitted to the ground except through the pile.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide strength equal to the maximum load which is to be applied to the pile during the test with an appropriate factor of safety on the structural design.

If the preliminary test pile fails to meet the requirements of the Specification, the piling system proposed will be considered unsatisfactory. The Contractor shall then submit revised proposals and calculations for the approval of the Engineer. Unless otherwise agreed by the Engineer any test pile which has failed the preliminary test will be rejected and the Engineer may instruct the Contractor to provide one or more further test piles and tests to prove his modified system at no additional cost to the Employer.

1.5.5. Lengths and Tolerances

The Contractor shall determine the approximate lengths of bearing piles by examination of the available geotechnical information including information obtained from any additional

site investigations under the Contract and test piling. The final length of piles shall be decided by constructing the piles to a minimum depth on the basis of the geotechnical information.

Bearing piles shall be constructed within the following tolerances:-

- in plan, at the working level of the piling rig 75 mm in any direction from the designed position;
- 1 in 75 from the vertical for a vertical pile;

The cross-sectional dimensions of the pile shall not be less than those proposed by the Contractor nor should they exceed them by more than 6 mm. No face of a pre-cast pile shall deviate by more than 6 mm from a straight edge 3m long laid on the face and the centroid of any cross section of the pile shall not deviate by more than 12mm from the straight line connecting the centroids of the ends.

1.5.6. Sequence of Construction

The sequence of construction of piles shall be to the approval of the Engineer and shall be arranged so as to minimise the vertical and lateral displacement of piles already driven. Levels of the tops of adjacent piles or the structures founded upon them shall be measured at intervals while a pile is being driven. Piles driven which have risen, shall be re-driven or forced down to the original resistance.

1.5.7. Driving Piles

The Contractor shall submit for the Engineer's approval details regarding the suitability, efficiency and energy of his driving equipment.

Pre-cast concrete piles shall not be driven until the concrete has achieved the specified characteristic strength.

Cast-in-situ piles with steel casing shall be bottom driven by using a casing which shall not distort or buckle during driving. Concrete casing shall be driven on the pile shoe using a mandrel.

The approved set shall be as determined by the Engineer following tests on the preliminary piles.

Each pile shall be driven continuously until the approved set and/or depth has been reached except that the Engineer may permit the suspension of driving if he is satisfied that the rate of penetration prior to cessation of driving will be substantially re-established on its resumption or if he is satisfied that the suspension of driving was beyond the control of the Contractor.

A follower (long dolly) shall not be used except with the approval of the Engineer who will then require the set to be revised to take into account the reduction in the effectiveness of the hammer blow.

The final set of each 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 25 mm. 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 if any 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 angles to the pile and hammer axis.

The Contractor shall give adequate notice and provide all facilities to enable the Engineer to check driving resistances. A set for purposes of the Contract shall only be taken in the presence of the Engineer unless otherwise agreed.

At the start of the work and in new areas or sections sets shall be taken at intervals during the last 5 m of driving to establish the behaviour of piles.

The Contractor shall inform the Engineer without delay if an unexpected change in driving characteristics is noted. A detailed record of driving resistance over the full length of the nearest available pile shall be taken.

Redrive checks if required shall be carried out by a procedure to be agreed by the Engineer.

Piles shall be driven in an approved sequence to minimise the detrimental effects of heave and lateral displacement of the ground.

Measurements shall be taken to determine the movement of ground or any pile resulting from the driving process when required by the Engineer.

Where piles have risen or moved out of plumb as a result of driving adjacent piles the Contractor shall submit to the Engineer his proposals for correcting such faults and their avoidance in subsequent work.

Where preboring is required in the Contract each pile shall be pitched into a hole prebored before driving to the required depth.

Jetting may be carried out only when approved by the Engineer and the Contractor shall submit detailed proposals and it shall not normally be undertaken over the last 5 m of penetration.

1.5.8. Repair and Lengthening of Piles

In preparation for repairing the head of a pile the concrete shall be cut off square at sound concrete to expose the reinforcement 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.

If the pile has been completely driven but the sound concrete is below cut-off level the pile shall be made good to cut-off level with concrete of a Grade not inferior to that of the concrete of the pile.

In preparation for lengthening a normal reinforced pile the concrete shall be cut off square to expose a sufficient length to ensure that the full strength of the bars will be developed across the joint.

Welded joints shall be made in accordance with BS 5135 and before welding the main longitudinal reinforcing bars in the head of the pile shall be exposed for at least 300 mm below the position of the weld.

For lap or splice joints sufficient link bars shall be provided to resist eccentric forces.

If the pile is to be subjected to further driving the additional length shall be of an approved grade of concrete.

Other methods of lengthening shall be subject to approval by the Engineer.

Repaired or lengthened piles shall not be driven until the added concrete has reached the specified characteristic strength of the concrete of the pile.

1.5.9. Reinforcement

Unless otherwise dictated by the design, cast in situ piles and pre-cast concrete piles shall be reinforced over the whole of their length. The minimum longitudinal reinforcement shall be 1.0% of the gross concrete area. in the full length of the pile. Helical reinforcement or reinforcement in the form of links shall be provided to maintain the alignment.

The reinforcement shall comply with the following minimum requirements:-

- area of longitudinal reinforcement of 16 mm diameter minimum shall be at least 1.0% of the gross concrete area (cast in-situ and pre-cast concrete piles) and shall extend to the full length of the pile.
- lateral reinforcement shall be in the form of hoops or links not less than 10 mm diameter. The lateral reinforcement shall be of diameter not less than 0.25x diameter of vertical reinforcement and the spacing shall be not greater than 12 x diameter of vertical reinforcement.

Piles of rectangular cross section shall have a minimum of 4 No. longitudinal reinforcement bars and piles of circular cross section shall have a minimum of 6 No. longitudinal reinforcement bars. Bars shall be 16 mm diameter minimum.

Hoops and links shall fit tightly against longitudinal bars and be bound to them by welding or soft iron wire with the free ends turned inwards. The longitudinal bars should be held apart by spreader forks not more than 1.5m apart.

The main longitudinal reinforcing bars in piles not exceeding 6 m in length shall be in one continuous length unless otherwise specified elsewhere. In piles exceeding 6 m in length joints will be permitted in main longitudinal bars at 6 m nominal intervals. Joints in adjacent bars shall be staggered at least 1 m apart along the length of the pile. Joints shall be such that the full strength of the bar is effective across the joint.

The cover to the outermost reinforcement, including binding wire shall not be less than 75 mm measured to the inside of the casing. Lap or splice joints shall be provided with sufficient link bars to resist eccentric forces. Laps shall have a minimum length of 42 times the diameter of the main longitudinal reinforcement.

Main longitudinal reinforcement shall project a minimum of fifty (50) times the bar diameter above the cut-off level of the pile. For pre-cast piles, compliance with this requirement will necessitate breaking down of the pile head after driving.

1.5.10. Pile Shoes

Driven piles shall be provided with a pointed co-axial shoes of cast iron.

Cast iron pile shoes shall be made from "chill hardened" iron of the grade used for making grey iron castings to BS 1452 grade 150. The chilled iron point shall be free from major blow holes and other surface defects.

Steel pile shoes shall be manufactured from steel to BS 7613 or BS 7668 grade 43A1.

1.5.11. Records

The Contractor shall maintain a complete record of all piling works which shall include the following where relevant:

- Contract
- Pile reference number (location)
- Pile type
- Nominal cross-sectional dimensions or diameter
- Nominal diameter of under ream/base
- Length of preformed pile
- Standing groundwater level from direct observation or given site investigation data
- Date and time of driving, red riving or boring
- Date of concreting
- Ground level at pile position at commencement of installation of pile (commencing surface)
- Working level on which piling base machine stands
- Depth from ground level at pile position to pile toe
- Toe level
- Pile head level as constructed
- Pile cut-off level
- Length of temporary casing
- Length of permanent casing
- Type, weight, drop and mechanical condition of hammer and equivalent information for other equipment
- Number and type of packings used and type and condition of dolly used during driving of the pile
- Set of pile or pile tube in millimetres per 10 blows or number of blows per 25 mm of penetration
- If required, the sets taken at intervals during the last 5m of driving
- If required, temporary compression of ground and pile from time of a marked increase in driving resistance until pile reached its final level
- If required, driving resistance taken at regular intervals over the last 3m of driving
- Soil samples taken and in situ tests carried out during pile formation or adjacent to pile position
- Length and details of reinforcement
- Concrete mix

- Volume of concrete supplied to pile where this can be measured in practice
- All information regarding obstructions delays and other interruptions to the sequence of work.

All records shall be accurately kept in duplicate as the work proceeds and one copy shall be handed to the Engineer at the completion of each day's work.

1.5.12. Pre-cast Reinforced Concrete Piles

1.5.12.1. General

Pre-cast reinforced concrete piles shall be designed cast and cured to develop the strength necessary to withstand the transporting, handling and driving stresses without damage. Square piles shall have chamfered corners. Manufacturing and curing shall be in accordance with BS 8004 and this Specification.

The pre-cast reinforced concrete piles of 300mmx300mm (minimum cross section) or 350mmx350mm manufactured by The State Development and construction Corporation of Sri Lanka or equivalent can be used subject to the Engineer's approval.

1.5.12.2. Compacting Concrete

Unless otherwise agreed by the Engineer, concrete shall be compacted with the assistance of vibrators. Internal vibrators shall be capable of producing not less than 150 Hz and external vibrators not less than 50 Hz. Internal vibrators shall operate not closer than 75 mm to shuttering.

Vibrators shall be operated in such a manner that neither segregation of the concrete mix constituents nor displacement of reinforcement occurs.

1.5.12.3. Protecting and Curing Concrete

Immediately after compaction, concrete shall be adequately protected from the harmful effects of the weather, including wind, rain, rapid temperature. It shall be protected from drying out by an approved method of curing.

Piles shall not be removed from formwork until a sufficient pile concrete strength has been achieved to allow the pile to be handled without damage.

When accelerated curing is used the curing procedure shall be approved. Four hours must elapse from the completion of placing concrete before the temperature is raised. The rise in temperature within any period of 30 minutes shall not exceed the rate of heating.

Bored Cast in-situ Pile

The bored cast in-situ piles can be formed either with temporary steel casing or with drilling fluid as temporary lining to support the surrounding soil.

The boring can either be with the help of auger or percussive.

1.5.13. Drilling Fluid

(a) Supply and Mixing

Drilling Fluid, Bentonite, if used shall be in accordance with specification DFCP 4 of the Oil Companies Materials Association or similar. A certificate shall be obtained by the Contractor from the manufacturer/supplier, and shall be forwarded to the Engineer.

Bentonite shall be mixed thoroughly with clean fresh water to make a suspension which will maintain the stability of the pile bore for the period necessary to place concrete and complete construction.

(b) Tests

Control tests shall be carried out on the bentonite suspension, using suitable apparatus. Density of freshly mixed bentonite suspension shall be checked daily. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite supplied to the pile bore. The results shall be within the range indicated below;

Property to be Measured	Range of Results at 20 ⁰ c	Test Method
Density	less than 1.10 g/ml	Mud density balance
Viscosity	30 -90s or lesser than 20 cp.	Marsh cone method Fann viscometer
Shear Strength (10 minute gel strength)	1.4 - 10 N/mm ² or 4 - 40 N/mm ²	Shearometer Fann viscometer
PH	9.5 - 12	pH indicator paper or electrical pH meter

The frequency of testing shall be as specified by the Engineer. When the results show consistent behaviour, the tests for shear strength and pH value may be discontinued with the approval of the Engineer.

1.5.13.1. Boring

(a) Boring Locations

Piles shall not be bored close to other piles which have recently been cast and which contain workable or unset concrete that a flow of concrete could be induced from or damage caused to any of the piles.

(b) Temporary Casings

Temporary casing of approved quality or an approved alternative method shall be used to maintain the stability of the pile bore which might otherwise collapse.

Temporary casing shall be free from significant distortion. They shall be of uniform cross section, and shall be free from internal projections or encrusted concrete.

The use of a vibrator to insert and withdraw temporary casing may be permitted by the Engineer subject to the limits of noise and disturbance, damage to adjacent structures and disturbance to the ground which would adversely affect the construction or capacity of piles.

Where piles are bored under water or bentonite suspension in an unlined state, the insertion of a full length loosely fitting casing to the bottom of the bore prior to placing concrete will not be permitted.

(c) Stability of Pile

Where boring takes place through unstable water-bearing strata, the process of excavation and the depth of temporary casing employed shall be such that soil from outside the area of the pile is not drawn into the pile section and cavities are not created outside the temporary casing as it is advanced.

If the drilling fluid is used for maintaining the stability of the bore, an adequate temporary casing shall be used in conjunction with the method so as to ensure stability of the strata near ground level until concrete has been placed. During construction, the level of drilling fluid in the pile excavation shall be maintained within the cased or stable bore so that it is not less than 1.0m above the level of external standing ground water at all times.

In the event of a rapid loss of drilling fluid from a pile excavation, the bore shall be backfilled without delay and instructions of the Engineer shall be obtained before boring at that location is resumed.

(d) Spillage and Disposal of Drilling Fluid

All reasonable steps shall be taken to prevent spillage of bentonite suspension on the site. Discarded bentonite shall be removed from the site without undue delay, and shall be disposed as approved by the Engineer and relevant Authorities, without causing an adverse environmental effect.

(e) Pumping from Pile Bores

Pumping from pile bores shall not be permitted unless the bore has been sealed against further water entry by casings or unless the soil is stable and will allow pumping to take place without ground disturbance below or around the pile.

(f) Inspection

Each pile bore which does not contain standing water or drilling fluid shall be inspected directly or indirectly prior to concrete being placed in it. The inspection shall be from ground surface. Torches or other approved means of lighting, measuring tapes and means of measuring vertically shall be provided.

(g) Cleanliness of Pile Bases

Any loose, disturbed or softened soil shall be removed from the bore before concreting. Large debris and / or accumulated sediment shall be removed using appropriate approved methods, which shall be designed to clean while at the same time minimising ground disturbance below pile bases. Where bore contains water or drilling fluid, it shall be maintained throughout and following the cleaning operation.

1.5.13.2. Reinforcement and Concrete

Special specifications applicable to piles cast in-situ are indicated below. Other general specifications also given in the relevant sections of this chapter shall be applicable here too.

(a) Reinforcement

The % of longitudinal reinforcement which shall be provided to the full length of the pile shall be not less than 0.8% of the cross sectional area of the pile. The minimum number of reinforcing bars shall be five and the minimum diameter of the bar size shall be 16 mm.

Lateral reinforcement shall be in the form of spiral links of diameter not less than 10 mm.

The number of joints in longitudinal steel bars shall be kept to a minimum. Joints in reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made so that there is no detrimental displacement of the reinforcement during the construction of the pile.

Reinforcement in the form of a cage shall be assembled with additional support such as spreader forks and lacings, necessary to form a cage which can be lifted and placed without permanent distortion. Intersecting bars shall be fixed together by approved means. Links shall fit closely around the main longitudinal bars and be bound to them by approved wire, the end of which shall be turned into the interior of the pile. Reinforcement shall be placed and maintained in position to provide an adequate projection of reinforcement above the final cut off level.

The cover to reinforcement shall be 50mm. The spacers shall be designed and manufactured using durable materials which will not lead to corrosion of the reinforcement or spalling of the concrete cover. If any welding is used, it shall be carried out in accordance with BS 5135 after getting Engineer's prior approval.

(b) Concrete

The concrete shall be grade 30 or more and placed without interruption as would allow the previously places batch to have hardened. The method of placing shall be approved. The cement content shall be at least 25% more than the allowed for the normal grade.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of concrete in a temporary casing. No soil, liquid or other foreign matter which would adversely affect the performance of the pile shall be permitted to contaminate the concrete.

Slump measured at the time of discharge into the pile bore shall be in accordance with the standards shown below;

Typical Conditions of Use	Slump	
	Min. (mm)	Range (mm)
Placed into water-free unlined bore, with reinforcements widely spaced	75	75 - 150
Where reinforcement is not spaced widely, and pile bore is water free	100	100 - 200
Where concrete is to be placed by tremie under water or drilling mud or by pumping	150	150 or more

Internal vibrators shall not be used to compact the concrete.

Measures shall be taken to ensure that the structural strength of the concrete placed is not impaired through grout loss, segregation or bleeding.

Concrete shall be directed vertically into the centre of each vertical pile so that grout is not lost from the initial discharges.

When concrete is placed under water or drilling fluid, Contractor shall ensure that there is no accumulation of loose material or debris at the base of the boring.

The Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the tremie pipe, has not accumulated at the bottom of the hole.

(c) Placing Concrete under Water / Drilling Fluid

Concrete to be placed under water or drilling fluid shall be placed by tremie and shall not be discharged freely into the water or drilling fluid. Pumping of concrete may be approved by the Engineer where appropriate.

A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.20 the placing of concrete shall not proceed. In the event, the Contractor shall modify or replace the bentonite as approved, to meet the specification.

The concrete shall be placed in such a manner that segregation does not occur.

(a) Placing Concrete - General

The method of placing and workability of the concrete shall be such that a continuous monolithic concrete shaft of the full cross-section is formed.

The concrete shall be placed without such interruption as would allow the previously placed batch to have hardened. The method of placing shall be approved.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a casing. No soil, liquid or other foreign matter shall be permitted to contaminate the concrete.

Piling mix workability	Slump Minimum mm	Range mm	Typical Conditions of use
A	75	75-150	Placed into water free permanently lined hole; reinforcement widely spaced, leaving ample room for free movement of concrete between bars.
B	100	100-200	Where concrete is placed into a water-free casing.
C	150	150 or more	Where concrete is to be placed by tremie under water.

Standards for concrete slump

(b) Workability of Concrete

Slump measured at the time of discharge into the pile casing shall be in accordance with the standards shown in the above table except that these standards shall not apply to piling systems which use semi-dry concrete and employ special means for its compaction. The concrete shall be of the workability approved when in its final position and until all construction procedures in forming the pile have been completed.

(c) Compaction

Internal vibrators shall not be used to compact concrete, excepting where approved within permanently lined piles.

(d) Placing Concrete within Casings which are Water-Free

Approved measures shall be taken as necessary in all piles to ensure that the structural strength of the placed concrete is not impaired through grout loss, segregation or bleeding.

(e) Placing Concrete under Water or in drilling fluid

Before placing concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the casing.

Concrete to be placed under water shall be placed by tremie and shall not be discharged freely into the water. Pumping of concrete may be approved where appropriate.

The hopper and pipe of the tremie shall be clean and watertight throughout. At the commencement of concrete placing the pipe shall extend to the base of the pile casing and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the tremie and the water or approved drilling fluid. The pipe shall at all times penetrate the concrete which has previously been placed and shall not be withdrawn from the concrete until completion of concreting. A sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water. The internal diameter of the tremie pipe shall be not less than 150 mm for concrete made with 20 mm aggregate and not less than 200 mm for concrete made with 40 mm aggregate. It shall be so designed that external projections are minimized, allowing the tremie to pass within reinforcing cages without causing damage. The internal face of the pipe of the tremie shall be free from projections.

1.5.14. Inspection and Testing

1.5.14.1. Pile Testing Definitions

(a) Allowable Load:

The load which may be safely applied to a pile after taking into account its ultimate bearing capacity, negative skin friction, pile spacing, overall bearing capacity of the ground below the piles and allowable settlement.

(b) Compression Pile:

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

(c) Kentledge:

The dead weight used in a load test.

(d) Maintained Load Test:

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

(e) Preliminary Pile:

A pile installed before the commencement of the main piling works or a specific part of the works for the purpose of establishing the suitability of the chosen type of pile and for confirming the design dimensions and bearing capacity.

(f) Integrity Testing of Piles:

Any test method used to check the integrity of the pile shaft after installation shall be dynamic methods.

(g) Proof Load:

A load applied to a selected working pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed 150% of the working load on the pile.

(h) Reaction System:

The arrangement of kentledge, piles, anchors or rafts that provide a resistance against which the pile is tested.

(i) Test Pile:

Any pile to which a test is or is to be applied.

(j) Ultimate Bearing Capacity:

The load at which the resistance of the soil becomes fully mobilised.

(k) Working Load:

The load which the pile is designed to carry.

(l) Working Pile:

One of the piles forming the foundations of the structure.

1.5.14.2. Safety Precautions Applicable to Pile Testing

When preparing for and conducting a pile test the Contractor shall carry out the requirement of the various Decrees, Orders, Regulations and other Statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparation for testing.

Where kentledge is used the Contractor shall construct the foundations for the kentledge and any crib-work beams or other supporting structure in such manner that there shall not be differential settlement bending or deflection of an amount that constitutes a safety hazard or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it falling apart or becoming unstable through deflection of the supports. The weight of kentledge shall be greater than the maximum test load and if the weight is estimated from the density and volume of the constituent materials an adequate factor of safety against error shall be allowed. The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit. The gauge shall be independently tested and certified prior to the commencement of piling operations and from time to time thereafter as the Engineer may require.

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head the whole system will be stable up to the maximum load applied. Means shall be provided to enable dial gauges to be read from a position clear of the kentledge stack or test frame if conditions are such that failure in any part of the system due to overloading buckling loss of hydraulic pressure etc. might constitute a hazard to personnel.

The hydraulic jack, pump hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum testing pressure without leakage.

1.5.14.3. Testing Working Pile

If a test is required on a working pile the Contractor shall cut down or otherwise prepare the pile for testing as required by the Engineer in accordance with the Specification.

1.5.14.4. Concrete Test Cubes for Piles

Six test cubes shall be made from the concrete used in each preliminary test pile and from the concrete used for building up a selected working pile. If a concrete pile cap is cast separately from a preliminary pile or a working pile a further six cubes shall be made and tested in accordance with the requirements of Section 6 of the Specification.

The pile test shall not be commenced until the strength of the cubes taken from the pile exceeds twice the average stress at any point in the cap under the same load. Variation of procedure will only be permitted if approved by the Engineer.

1.5.14.5. Reaction System

Testing of compression piles shall be carried out using two or more tension piles specially constructed anchorages or kentledge system. The contractor shall be not allowed to use working piles as tension piles.

Where kentledge is to be used it shall be supported on crib-work disposed around the pile head. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack. This Specification does not cover the use of kentledge carried directly on the pile head and this method of loading shall not be used except at the discretion of the Engineer.

The use of inclined reaction piles, anchors or rafts is not precluded and is subject to the approval of the Engineer.

In all cases the resultant force of the reaction system shall be coaxial with the test pile.

Working piles shall not be used as reaction piles without the written approval of the Engineer.

Where working piles are used as reaction piles their movement shall be measured to an accuracy of 0.5 mm or better.

The spacing of vertical reaction piles from a test pile including working piles used as reaction piles shall be not less than three times the diameter of the test pile or the reaction piles or 2m whichever is the larger measured centre to centre. Where a pile to be tested has an enlarged base this same criterion shall apply with regard to the pile shafts with the additional requirement that the surface of no reaction pile shall be closer than one half of the enlarged base diameter to the base of the test pile.

Where ground anchors are used to provide test reaction for loading in compression no part of the section of the anchor transferring load to the ground shall be closer to the test pile than three times the diameter of the test pile. Where the pile to be tested has an enlarged base this same criterion shall apply with regard to the pile shaft with the additional requirement that no section of the anchor transferring load to the ground shall be closer to the pile base than a distance equal to the base diameter.

Where kentledge is used for loading vertical piles in compression the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall not be less than 1.3m.

The size, length and number of the piles or anchors or the area of the rafts shall be adequate to transmit the maximum test load to the ground in a safe manner without excessive movement or influence on the test pile.

The method employed in installation of any reaction piles anchors or rafts shall be such as to prevent damage to any test pile or working pile.

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

1.5.14.6. Apparatus for Loading and Load Measurement on Piles

The apparatus used for applying load shall consist on one or more hydraulic rams or jacks. The total capacity of the jacks shall be at least equal to the required maximum load.

The jack or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. The complete system shall be capable of transferring the maximum load required for the purpose of the test.

The load shall be measured by a load measuring device and also by means of a calibrated pressure gauge included in the hydraulic system. Readings of both the load measuring device and of the pressure gauge shall be recorded. In interpreting the test data the values given by the load measuring device shall normally be used the pressure gauge readings being required as a check for gross error.

The load measuring device may consist of a proving ring load measuring column pressure cell or other appropriate system, a spherical seating shall be used in conjunction with any devices that are sensitive to eccentric loading and care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be short in axial length in order to have the best possible stability and the Contractor shall pay attention to details in order to ensure that axial loading is maintained.

The load measuring device shall be calibrated before and after each series of tests whenever adjustments are made to the device or at intervals appropriate to the type of apparatus. The pressure gauge and hydraulic jack shall be calibrated together. Certificates of calibration shall be supplied to the Engineer. The Engineer's agreement shall be obtained in writing before any modification of this procedure shall be used.

The apparatus 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 a maintained loading test.

1.5.14.7. Methods of Measuring the Movements of Piles

In a maintained load test movement of the pile head shall be measured by one of the methods (a) or (b).

- (a) Leveling method: By optical or other leveling method be reference to an external datum.

Where a level and staff are used the level and scale of the staff shall be chosen to enable readings to be made to an accuracy of 0.5 mm. A scale attached to the pile or pile cap may be used instead of a leveling staff.

At least two datum points shall be established on permanent objects or other well founded structures or deep datum points shall be installed. Each datum shall be situated so that only one setting up of the level is needed. No datum point shall be effected by the test loading or other operations on the site.

Where another method of leveling is proposed this shall be approved by the Engineer in writing.

- (b) Independent reference frame: By means of an independent reference frame which shall be set up to permit measurement of the movement of the pile. The supports for the reference frame shall be founded in such a manner and at such a distance from the test pile kentledge support cribs reaction piles anchorages or rafts that movements of the ground in the vicinity of the equipment do not cause movement of the reference frame during the test of an amount which will effect the required accuracy of the test. Check observations of any movements of the reference frame shall be made of the movement of the pile head relative to an external datum during the progress of the test. In no case shall the supports be less than 3 test pile diameters or 2m whichever is the greater from the centre of the test pile.

The measurement of movement shall be made by two or more dial gauges rigidly mounted on the reference frame that bear on 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 references frames. The dial gauges shall be placed in diametrically opposed positions and equidistant from the pile axis. The dial gauges shall be chosen to enable readings to be made to an accuracy of 0.1 mm. The reference frame shall be protected from sun and wind.

1.5.14.8. Protection of Pile Testing Apparatus and Supervision

Throughout the test period all load and settlement measuring apparatus shall be protected from the weather. Construction plant and persons who are not involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance of the measurement apparatus.

The Contractor shall provide a competent person or persons on the Site conversant with the apparatus and procedure for overall supervision of the test. The Engineer shall be given not less than 24 hours notice of intention to commence the test.

During the progress of the test the testing apparatus and all records of the test shall be available as required for inspection by the Engineer.

1.5.14.9. Test Procedure

The maximum load which shall be applied in preliminary tests on test piles and in proof tests on working piles is 2 times the working load and 1.5 times the working load respectively.

The loading and unloading shall be carried out in stages as shown below.

Following each application of an increment of load the load shall be maintained until the rate of settlement is less than 0.25 mm per hour and reducing and in no case for less than the period shown below. The rate of settlement shall be calculated from the slope of the curve obtained by plotting values of settlement versus time and drawing a smooth curve through the points.

Each stage of unloading shall proceed after the expiry of the period shown below.

Percentage of working load	Minimum time of holding load
25	1 hour
50	1 hour
75	1 hour
100	1 hour
75	10 minutes
50	10 minutes
25	10 minutes
0	1 hour
100	6 hours
125	1 hour
150	6 hours
175	1 hour)
200	6 hours) applicable
175	10 minutes) to tests on
200	10 minutes) preliminary
175	10 minutes) piles only
150	10 minutes
125	10 minutes
100	10 minutes
75	10 minutes
50	10 minutes
25	10 minutes
0	1 hour

1.5.14.10. Schedule of Recorded Data

As soon as possible after completion of testing and in any case within 48 hours the Contractor shall hand to the Engineer a schedule of recorded data for each pile tested. The schedule shall contain all the following information:-

General

- Site location
- Proposed structure
- Main Contractor
- Piling Contractor

- Engineer
- Client

Pile Details

- Pile identification (number and location)
- Pile position relative to adjacent piles
- Brief descriptions of location (e.g. in cofferdam in cutting over water etc.)
- Ground level at pile position
- Pile head level at which test load is applied
- Type of pile
- Vertical or raking compression or tension
- Shape and size of cross-section of pile position of change in cross-section
 - (a) Shoe or base details
 - (b) Head details
- Pile length in ground
 - Level of pile toe
 - Details of any permanent casing core
 - Concrete mix
 - Slump
 - Cube test results:
 - (a) Pile
 - (b) Cap
 - Date of casting of pre-cast pile
 - Reinforcement details

Installation Details

- Dates and times of driving of test pile and adjacent piles
- Unexpected circumstances and difficulties
- Date and time of casting concrete pile cap
- Method of support of pile and hammer (frame handing leaders suspended hammer or other method)
- Driven length of pile or temporary casing at final set
- Hammer type size or weight
- Dolly and packing: type and condition before and after driving
- Driving log (depth blows per 250 mm interruptions or breaks in driving)
- Final set in number of blows to produce penetration of 25 mm
- Details or redrive check:
 - (a) time interval
 - (b) set in number of blows to produce penetration of 25 mm
- Hammer stroke or drop at final set and at redrive set:
 - (a) for drop or single acting hammer the length of the drop or stroke
 - (b) for diesel hammer the length of the stroke and the blows per minute
 - (c) for double acting hammer the number of blows per minute
- Conditions of pile head or temporary casing after driving.
- Other details of relevance; use of a follower, of preboring, of jetting; any lengthening etc.

Test Procedure

- Weight of kentledge
- Plan of test arrangement showing position and distances of kentledge supports rafts or compression piles and reference frame to test pile.
- Jack capacity
- Method of load measurement
- Method(s) of penetration measurement
- Test method:
 - (a) Proof Test by maintained loading-details

Test results

- In tabular form
- In graphical form-load/settlement load with times
- Other information ground heave, effect on adjacent structure etc.

Site investigation information

- Relevant site investigation report number
- Relevant borehole reference

Other general details

- The time of the start and finish of each operation undertaken during the driving or installation of a pile and subsequent testing shall be recorded.
- All difficulties experienced in handling pitching and driving piles are to be described.
- All delays because of weather and other conditions are to be recorded.

1.5.15. Ground Treatment

Any ground treatment proposed by the Contractor to improve the bearing capacity and/or settlement characteristics of the soil must be supported by a full method statement and design calculations with a statement of the minimum performance to be achieved. Where directed by the Engineer the Contractor shall carry out a field trial of the proposed treatment to demonstrate that it meets the stated performance criteria.

1.5.16. Steel Sheet Piling

The Contractor shall submit drawings and calculations of his proposals for steel sheet piling in duplicate for the Engineer's approval, 14 days before commencing work on sheet piling for cofferdam or other works.

Piles shall have been rolled from mild steel complying with the BS 7613 or BS 7668 Grade 43A. The piles shall be delivered, pitched and driven in single lengths and shall be straight and true to section. Any piles which in the opinion of the Engineer are defective shall be rejected or replaced.

Steel sections used for walings, struts, hangers etc. shall comply with BS 7613 or BS 7668 Grade 43A.

The anchorage shall be fabricated from hot-dipped galvanised steel.

All anchor-bolts, assembly bolts, screws, nuts and other fasteners shall be of ample section to withstand the forces. Unless otherwise specified, all fixing bolts, screws and nuts shall be of hot-dip galvanised steel complying with the relevant standards.

1.6. Concrete

1.6.1. Organization of Concrete Production at the Site

At the commencement of the Contract the Contractor shall submit for the approval of the Engineer a Method Statement detailing with regard to the requirements of this Specification his proposals for organization of concreting activities at the site.

The Method Statement shall include the following items:-

1. Plant proposed.
2. Location and layout of concrete production facility.
3. Proposed method of organization of the concrete production facility.
4. Quality control procedures for concrete and concrete materials including any admixtures that will be used.
5. Transport and placing of concrete.
6. Details of formwork including striking times and procedure for temporary support of beams and slabs.
7. Protection and curing.

1.6.2. Ready Mixed Concrete

Concrete obtained from a single supplier of ready-mixed concrete may be used in the Works subject to the approval of the Engineer. Such approval will not be given until the Engineer is satisfied that the organization and control of the manufacture and delivery of all ready-mixed concrete is in accordance with the requirements of this Specification.

1.6.3. Materials and Testing

1.6.3.1. Type of Cement

The type of cement used in each of the various works shall be that specified herein or as otherwise ordered by the Engineer. High alumina cement shall be used only if directed and approved by the Engineer.

Ordinary Portland cement shall comply with BS 12. Sulphate resisting cement shall comply with BS 4027. The cement shall either be delivered in sealed bags marked with the manufacturer's name or in bulk consignments in a manner approved by the Engineer.

1.6.3.2. Tests of Cement

Before any cement is ordered in quantity or delivered to the Site, the Contractor shall submit to the Engineer for his approval a detailed list of the sources, country or countries of origin and manufacturer's brand names of the types of cement which he proposes to use.

The Contractor shall submit to the Engineer, test certificates relating to each consignment of cement. Each certificate shall show that a sample of the consignment has been tested by the manufacture or by an approved laboratory and that it complies in all respects with the requirements of the Specification.

When required by the Engineer, the Contractor shall supply samples of cement taken on delivery to Site, or during storage on the Site, for testing at a nominated laboratory at the Contractor's expense.

No cement from any consignment shall be used without the approval of the Engineer and the Contractor shall maintain a record of the locations of the concrete made from each consignment which record shall be available for inspection by the Engineer.

If for any reason the Contractor shall decide to vary the source of supply, country or manufacture in respect of any type of cement already approved by the Engineer at any time during the Contract, he shall give adequate notice of every such variation to the Engineer and shall carry out all the tests called for by the Engineer's written approval of such variation before ordering any material from the new source or supplier.

If cement has been stored on the site for more than 40 days or in the opinion of the Engineer is of doubtful quality, new tests may be required, at the Contractor's expense, to check whether the cement is still conforming to the requirements.

1.6.3.3. Delivery and Storage of Cement

All cement shall be delivered to the Site in properly and permanently marked, sound and sealed paper bags or other approved containers, unless written approval from the Engineer is obtained for the handling of cement in bulk.

Cement shall be delivered in quantities sufficient to ensure the proper progress of the Works and the quantities held in stock on site shall be to the approval of the Engineer. Such approval shall not in any way relieve the Contractor of his responsibilities for providing cement. Cement from abroad, shall be packed in sealed plastic bags and placed inside paper bags.

Cement when being conveyed to the Site in lorries or other vehicles, shall be adequately protected from the weather and from contamination by dust, sand or any organic materials. Any cement which shall prove to have been exposed to damage by water will be rejected upon delivery.

All cement shall be stored in a weatherproof, waterproof and reasonably airtight building provided solely to that purpose. The floors of the building shall be raised at least 300 mm above the ground level to prevent the absorption of moisture.

Storage of cement in the open may be permitted on small works on the written authority of the Engineer, in which case the cement shall be placed on a raised platform and amply protected by waterproof coverings to the approval of the Engineer. It is not permitted to store bags to a greater height than 2 metres. In the case of delivery of cement in bulk, the cement shall be stored in a properly designed silo. The silo shall be waterproof and must be provided with walls properly insulated against sunlight.

Where silos are used for the storage of cement each silo or compartment thereof shall be completely separate and fitted with a filter or an approved alternative method of dust control.

Each filter for dust control system shall be of sufficient size to allow delivery of cement to be maintained to prevent undue emission of dust and to prevent interference with weighing accuracy by build-up of pressure. The Engineer shall be furnished with the means of identifying the several consignments of cement delivered. Each consignment of cement shall be stored separately so as to provide easy access for inspection and testing.

After they have been approved by the Engineer, consignments shall be used in the order in which they were delivered. No cement shall be taken from the storage unless it is needed for immediate use.

1.6.3.4. Cement Measured by Weight

All cement used in the Works shall be measured by weight. Cement from partly filled or unsealed bags shall not be used.

1.6.3.5. Rejection of Cement

Notwithstanding the receipt of a test certificate the Engineer may reject any cement as a result of further tests. The Engineer may also reject cement which has deteriorated owing to inadequate protection or other causes, or in any other case where the cement is not to his satisfaction. The Contractor shall remove all rejected cement from the Site without delay and at the Contractor's expense.

1.6.3.6. Quality of Water

The water used for all purposes throughout the Works shall be potable clean fresh and free from objectionable quantities of silt, organic matters, alkali, salt or other impurities, and shall comply with the requirements of BS 3148.

The water used for mixing concrete and mortar, washing of aggregates and for curing the concrete, shall be from an approved source and shall contain no deleterious matter which significantly affects the reinforcement, setting time, strength or durability of the concrete or which has any effect on the appearance of the hardened concrete by discolouration or efflorescence.

The Contractor shall deliver to the Engineer, free of charge, samples of the water proposed for use on the Works for the Engineer to carry out such tests he may require to confirm its suitability. Samples will be delivered sufficiently in advance of the work for completion of the tests before the water is required for use and at such other times during the course of the Contract as the Engineer may direct.

If required by the Engineer, the Contractor shall at no extra cost to the Employer, treat the water taken from any other source to such a degree as may be necessary in order to render it suitable for mixing concrete and mortar.

1.6.3.7. Fine and Coarse Aggregates

Fine and coarse aggregates for concrete shall be obtained from sources approved by the Engineer. Fine aggregates shall consist of natural sand unless otherwise approved. The coarse aggregate shall be crushed granite.

Except as may be modified hereunder (fine and coarse) aggregates for all types of concrete shall comply in all respects with BS 882. They shall be hard, strong and durable and shall contain no harmful material of sufficient quantity to affect adversely the strength or durability of the concrete or, in the case of reinforced concrete, to attack the reinforcement.

Fine and coarse aggregate shall comply with the following physical requirements:-

- (i) The proportion of void forming hollow shells in fine aggregate and retained on a 2.36 mm BS sieve shall not exceed 3%.
- (ii) The clay, fine silt and dust content shall not exceed the following limits:-

Coarse aggregates	1% by weight
Natural sands	3% by weight
- (iii) The flakiness index and elongation index of coarse aggregates as measured in accordance with BS 812 shall not exceed 20% and 35% respectively.
- (iv) The absorption of fine and coarse aggregates as measured in accordance with BS 812 shall not exceed 3% by weight.
- (v) The aggregate impact value for coarse aggregates as measured in accordance with BS 812 shall not exceed 30%.
- (vi) Fine aggregates shall be clean, sharp, coarse naturally occurring sand and shall be within zones 2, 3 or 4 only of Table 2 of BS 882.
- (vii) Coarse aggregates shall be single sized aggregates obtained by mechanical crushing and screening.
- (viii) Fine and coarse aggregates when tested in accordance with BS 812 shall show a loss not greater than 10% or 12% respectively by weight.

Fine and coarse aggregates shall comply with the following chemical requirements:-

- (i) Fine and coarse aggregates shall not contain more than 0.10% and 0.05% respectively by weight of chlorides (as NaCl). If either material exceeds the above limits the material shall still be acceptable in this respect provided the total sodium chloride concentration in the mix complies with Clause 1.6.4.3.
- (ii) Fine and coarse aggregates shall not contain more than 0.40% by weight of acid soluble sulphates (as SO₃).
- (iii) Coarse aggregates shall be a minimum of 85% by weight calcium carbonate.
- (iv) fine and coarse aggregates shall not be potentially reactive with alkalis.

If this requirement cannot be met the Contractor shall adopt constituents for his concrete such that either:

- (a) The cementitious material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested in accordance with the method prescribed,

or

- (b) the total mass of reactive alkali in the concrete mix shall not exceed 3 kg per m³ of concrete when defined, tested and calculated in accordance with the method prescribed.

The Contractor shall notify the Engineer of his proposals for complying with this requirement at the time of tendering.

The methods prescribed for complying with (a) and (b) above shall be those set out in:

Alkali-Silica Reaction: Concrete Society Technical Report No 30, October 1987.

- For requirement (a) Clauses 16 and 17
(b) Clauses 16 and 18.

If, in the opinion of the Engineer, the aggregates fail to comply with, or if there are doubts as to the uniformity of their compliance with the specified purity requirements, he will order all aggregates to be washed before use in the Works. When washing is ordered, it shall be done by using water of the quality specified in 1.6.3.6 and using methods and plant approved in advance by the Engineer and all costs arising there from shall be borne by the Contractor.

1.6.3.8. Grading of Aggregates

The grading of aggregates shall comply with the requirements as given in Clause 1.6.3.7. The Contractor's attention is drawn to the fact that it may be necessary to combine two or more fine aggregates, or remove some fractions by hydraulic Gradification, in order to achieve the grading as specified.

The grading of coarse aggregates shall be within the limits given in BS 882 and the Contractor shall, if required by the Engineer, obtain the specified grading by combining single sized aggregates in proportions to give the specified grading.

The maximum size of aggregates required will not normally exceed 40 mm. At least four separate size ranges of aggregate are required as follows:-

- fine aggregate
- coarse aggregate, nominal size : 10 mm
- coarse aggregate, nominal size : 20 mm
- coarse aggregate, nominal size : 40 mm (Mass Concrete)

1.6.3.9. Storage of Aggregates

Each size of fine and coarse aggregate shall be stored in separate bins or on areas covered with steel plate, concrete or other hard and clean surface, which shall be self draining and protected from contamination by earth or other deleterious matter.

Fine and coarse aggregates shall be stored in such a way so as to avoid the two materials from becoming intermixed.

1.6.3.10. Preliminary Tests on Aggregates

The Contractor shall submit to the Engineer samples of the fine and coarse aggregates proposed for use in the Works. Sampling and testing shall be carried out in accordance with the methods described in Clauses 1.6.3.7 and 6.3.8 and BS 882. Samples shall be of a size

sufficient to carry out all preliminary tests specified which the Engineer may order in addition to the concrete tests specified in Clause 1.6.4.6 and to provide the 50kg sample for comparison purposes described below. The samples shall then be tested in the presence of the Engineer by the Contractor in accordance with the Specification or as the Engineer may direct.

If the source of aggregates is changed at the Contractor's request and with the approval of the Engineer at any time during the course of the Works, all sampling and testing described in the relevant Clauses shall be repeated at the Contractor's expense.

After approval has been given for any particular aggregate, a sample weighing at least 50kg of the approved aggregate shall be retained by the Engineer as a standard against which all future samples shall be compared.

1.6.3.11. Works Tests on Aggregates

During the course of the Contract, fine and coarse aggregates shall be tested at Site as often as required by the Engineer and at the Contractor's expense.

1.6.3.12. Delivery of Samples

Samples of cement, water and fine and coarse aggregates called for in the foregoing Clauses shall be delivered to the Engineer for testing by the Contractor before concreting is due to start so that the necessary tests on the materials and the preliminary concrete cube tests specified in Clause 1.6.4.4 can be completed before work is due to start.

1.6.4. Mixing and Testing

1.6.4.1. Concrete Grades

The grades of concrete to be used in the Works together with the 28 day characteristic strength, minimum cement content by weight, the nominal maximum aggregate size and application of each grade are shown on the Table of Designed Concrete Mixes.

Characteristic strength shall be defined as the value of the cube strength below which not more than 5 percent of the results of all possible cube strength measurements of the specified concrete are expected to fall.

1.6.4.2. Proportions of Materials

The proportions of cement, fine and coarse aggregates and water proposed by the Contractor for the use in the Works for each grade of concrete shall be approved by the Engineer as a result of satisfactory preliminary tests made in accordance with the Specification.

1.6.4.3. Concrete Mix Design

The various grades of concrete shown in the Table of Designed Concrete Mixes shall be designed by the Contractor with particular attention to durability, strength, workability and surface finish, and to satisfy the Engineer on these qualities. The water content of all concrete shall be rigidly controlled and kept to the minimum required to obtain a workable concrete suitable for the nature of the work to be executed.

The water cement ratio (kg of free water/kg of cement) shall not exceed 0.55 with the exception of Grade C35A for which the water cement ratio shall not exceed 0.50.

Each grade of concrete shall be designed in accordance with Clause 6.3 of BS 8110 : Part 1 and shall comply with the requirements of BS 5328. In addition grade C35A concrete shall comply with the requirements of BS 8007.

The addition of proprietary admixtures intended to change the flow characteristics cohesion or rate of setting of the concrete shall not be made without the approval of the Engineer. No admixture shall contain chloride ions.

Each Grade of concrete mix shall be designed to have a mean strength greater than the specified characteristic strength by at least an amount termed the Current Margin. Unless otherwise approved by the Engineer the Current Margin for the initial mix design shall be taken as 4.6 N/mm² for concrete Grade C10 and 15 N/mm² for all other grades of concrete specified in the Table of Designed Concrete Mixes. The Engineer may at his discretion approve a change in the Current Margin for the initial mix design if the Contractor produces evidence to show that he can satisfy the requirements for the determination of the mean 28 day compressive strength given in BS 5328.

No concrete shall be placed in the Works until the relevant mix has been approved by the Engineer. Approval will not be given to any concrete mix until it has been successfully subjected to Preliminary Mix and Trial Mix Tests.

The Contractor shall carry out Preliminary Mix Tests as specified hereinafter in order to determine for each grade of concrete shown in the Table of Designed Concrete Mixes the minimum practicable water/cement ratio and the required mix proportions of the fine and coarse aggregate, the necessary allowance being made for the moisture content of the aggregate. After the value of the water/cement ratio and the mix proportions have been approved by the Engineer Trial Mixes shall be carried out by the Contractor as specified hereinafter. The water/cement ratio and mix proportions which have been approved as a result of the Preliminary Mix Tests shall be used throughout the course of the Works and no amendment shall be made without the approval of the Engineer. Notwithstanding any such amendment the Contractor shall ensure that cube crushing strengths satisfy the compliance requirements specified hereinafter.

In concrete made with sulphate resisting cement the maximum total content of chlorides (as chloride ions) shall not exceed 0.2% by weight of cement and the total acid soluble sulphates (as sulphate ions) shall not exceed 4.0% by weight of cement.

Further tests shall be carried out if any feature of materials or mixes is changed during the course of the work.

1.6.4.4. Preliminary Mix Tests

The proportions of cement, aggregate and water determined by the Contractor in his mix designs shall be used in preliminary mixes of concrete made in the presence of the Engineer and tested for strength, workability and surface finish under laboratory conditions observing the appropriate requirements of Clause 1.6.4.6, and to satisfy the Engineer on these qualities. Preliminary mixes shall be repeated with adjusted proportions as necessary until concrete

mixes meeting the relevant requirements of 1.6.4.3 have been produced to the approval of the Engineer.

Concrete Cube Strength

Concrete Cube Strength, N/sq. mm		
Minimum Lab. Strength		
Strength	7 days	28 days
C40	28.0	40
C35A	23.2	35
C35	23.2	35
C25	16.5	25
C20	13.2	20
C15	10.0	15
C10	6.7	10

In no case, shall the resulting mix conflict with the values for maximum water-cement ratios and minimum cement contents as specified in Table in this section.

TABLE OF DESIGNED CONCRETE MIXES

Grade	Application
C40	Concrete exposed to a marine environment, Pre-cast concrete
C35	Pre-cast concrete; High grade in-situ concrete and slender sections; pre-stressed concrete
C25	Normal reinforced concrete structures. Pipeline protection; Benching in manholes and chambers
C35A	Concrete for water retaining structures
C20	Mass Concrete, Road kerb foundation or haunch, screed concrete for water retaining structures.
C15	Blinding concrete
C10	As a filler material in loose soil

Table of Concrete mix Proportions

Grade of Concrete	Minimum Characteristics Cube Strength at 28 day (N/sq.mm)	Maximum Water: Cement Ratio	Minimum Cement Content (kg/cu.m)	Maximum Cement Content (kg/cu.m)
C40	40	0.55	350	425
C35A	35	0.55	375	390
C35	35	0.55	330	360
C25	25	0.55	320	355
C20	20	0.55	300	325
C15	15	0.55	240	250
C10	10	0.55	210	220

These cement contents apply to "controlled" concrete subject to specific inspection.

1.6.4.5. Trial Mixes of Concrete

Trial mixes of concrete shall be prepared and tested at the Site by the Contractor in presence of the Engineer after Preliminary Mix Tests have been completed and when the Engineer has approved the Contractor's mix design for each grade of concrete. Trial mixes of concrete shall be mixed for the same time and handled by means of the same type of plant as the Contractor proposes to use in the Works. Sampling and testing of trial mixes shall be in accordance with Clause 1.6.4.6.

Three separate batches of concrete shall be made for each grade of concrete. Each batch shall comprise not less than 0.5 cubic metres of concrete unless otherwise approved by the Engineer. Three cubes shall be made from each batch of concrete. The average strength of the nine cubes made for each grade of concrete and tested after 28 days shall exceed the specified characteristic strength by at least the Current Margin minus 3.5 N/mm². The value of the Current Margin shall be that specified in Clause 1.6.4.3.

Unless otherwise approved by the Engineer the Contractor shall carry out practical tests on the site by filling trial moulds with Trial Mix concrete to confirm the suitability of each grade of concrete for the Works. Trial moulds shall be made for reinforced and plain concrete with dimensions typical of the Works. The formwork face to the trial mold/s for each grade of concrete shall be designed to display all the relevant surface finishes intended for use in the Works. In making transporting placing compacting and curing the Trial Mix concrete in the trial moulds the Contractor shall observe all the relevant requirements of this Specification. When curing has been completed the trial moulds shall be stripped and the concrete thus revealed shall be submitted for the approval of the Engineer.

When a proposed mix has been approved, no variation shall be made in the mix proportions, or in the type, size, grading zone or source of any of the constituents without the consent of the Engineer, who may require further trial mixes to be made.

Pre-cast concrete

The Contractor shall furnish all labour, materials and plant to perform all work necessary for the product design, fabrication and erection of such reinforced concrete components which by their definition are not normally constructed directly in their final location but elsewhere and installed thereafter as prefabricated units. This includes all inserts and all material for seating the pre-cast members. Grouting of joints, making connections and finishing the erected work is also included. All pre-cast concrete work shall be carried out as directed by the Engineer and as specified herein:

The work included consists of the following:

- Removable concrete covers
- Pre-cast concrete curbs
- Miscellaneous pre-cast concrete units

The Contractor shall submit to the Engineer for approval six (6) sets of detailed drawings and detailed calculations of all prefabricated elements and specifications outlining methods of fabrication, transportation, handling and sequence of erection. The shop drawings shall accurately locate and show dimensions of all necessary holds, embedded parts, inserts and other details as specified on the drawings.

Material and Fabrication

If the fabrication of the pre-cast members is not carried out on the job site, the Contractor shall notify the Engineer at least three (3) weeks ahead of the time of commencement of such work so that the Engineer can arrange for the necessary supervision, inspection and testing of materials and work.

The concrete shall conform in general to the Concrete Section of these specifications. The maximum size of coarse aggregate shall be 20 mm.

The pre-cast units, if not cast on the site by the Contractor, shall be manufactured by a manufacturer of pre-cast concrete products approved by the Engineer. All pre-cast units shall be poured in accurately made forms with a concrete slump of not more than 5 cm and shall be vibrated into place in a manner that will give a smooth even surface. All wires, strands or bars shall be free from oil, lubricants, loose rust scale. Tolerances on all pre-cast and pre-stressed concrete work shall be in accordance with the ACI Standard 347. Reinforcing steel in pre-cast concrete shall conform to the specifications.

All welding required for the anchorage of component parts shall be in accordance with the General Requirements of these specifications.

The forms shall be of substantial construction and shall produce a uniformly smooth surface on all formed sides. A minimum concrete cover of 50 mm over all reinforcing steel shall be maintained with the use of spreaders or by bundling in areas adjacent to openings or inserts. Ties shall also have a minimum cover of 50 mm at these locations.

Void forms shall be held in place against uplift or lateral displacement during the placing and vibrating of the concrete by wire ties or other satisfactory means.

The concrete shall be vibrated internally or externally, or both. The vibrating shall be done with care and in such a manner as to avoid displacement of reinforcing steel, void forms, or other components. There shall be no interruption in the concrete placement for any one of the elements. Concrete shall be carefully placed in the forms and vibrated sufficiently to produce a surface free from imperfections such as honeycomb, segregation, cracking, or checking. Any deficiency noted, such as honeycomb or segregation, may be a cause for rejection.

The topside surface of the element shall be given a uniformly smooth trowel finish to match the finished surface of the formed sides.

Side forms carrying no load may be removed after 24 hours with the permission of the Engineer.

No patching or finishing of the completed elements will be allowed unless permitted by the Engineer. The Contractor's proposal for methods and materials to be used in the patching or finishing operation shall be submitted to the Engineer for his approval. Projecting fins and surface imperfections shall be removed from the elements in a workmanlike manner.

Inspection and Testing

The material and workmanship of all pre-cast concrete elements shall, at all times, be subject to inspection by the Engineer. The Contractor or his subcontractors shall co-operate with the Engineer in permitting access for inspection at all times and to all places where work is being done. No pre-cast concrete member shall be shipped from the manufacturer's plant until approved.

The Contractor shall design and submit for approval by the Engineer, a concrete mix meeting the requirements of this specification.

The Contractor shall keep accurate records of the concrete mix, concrete strengths, and details of curing. The Contractor shall also provide certification of the steel for reinforcing bars or wire. The certification shall in no way limit or prevent the Engineer from testing samples of reinforcing steel to determine conformity with the shop drawings and specifications. The costs of these tests shall be borne by the Contractor.

Where the Contractor intends to purchase factory-made precast concrete units, trial mixes may be dispensed with, provided that evidence is given to satisfy the Engineer that the factory regularly produces concrete which complies with the Specification. The evidence shall include details of mix proportions, water/cement ratio, workability and strengths obtained at 28 days.

Erection and Installation

Pre-cast concrete elements shall be installed as approved by the Engineer.

No-fines concrete

1.No-fines concrete, No-fines concrete shall be made using natural aggregate conforming to BS 882 and cement to BS 12. Fine aggregate shall not be used. The grading of the coarse aggregate shall be

Not less than 95% by weight passing a 20 mm BS sieve;

Not more than 5% by weight passing 10 mm BS sieve.

The proportion of aggregate, cement and water shall be determined by trial mixes by the Contractor starting cement: aggregate ratio of one to eight by volume. The trial mix shall be considered suitable when all the aggregate particles are coated with a film of cement grout. The water content shall be just adequate to ensure that the cement paste completely coats the aggregate. The concrete when placed shall contain no layer of laitance. No fines concrete shall not be mixed by hand.

Vibration shall not be used to compact the no-fines concrete. Three test cubes of no-fines concrete shall be made of each preliminary mix. The minimum crushing strength of the mix shall be 15 N/sq. mm at 28 days.

Porosity be such that water will pass through a slab 300 mm thick at the rate of not less than 7 litres/sec/m² of slab with a constant 100 mm depth of water on slab.

Non-Shrink Grout

To aid strength and bonding of multiple layer application of grout the Engineer may order the use of non-shrink additive as follows:

Proportions		
Material	Volume	Weight
Cement	1.0	
Coarse Aggregate	0.15	0.25
Fine Aggregate	1.5	1.5
Additives	As recommended by the manufacturer	

Non-shrink grout shall comprise of prepared, size-graded aggregate combined with a catalysing agent and water reducing agent. When used in the proportioning of grout, mortar and concrete mixes, shrinkage shall be counter-acted and basic qualities improved. The Contractor shall demonstrate to the Engineer that the product has successfully been utilised on similar projects for a minimum of five (5) years. Preparation of surfaces, mix proportions, application procedures, and precautions shall be followed in strict compliance with the manufacturer's directions.

For very heavy (generally formed) applications, the Engineer may order the addition of pea gravel, passing a 3/8" screen but retained on a 1/4" screen, to the mixture with the proportions modified as follows:

Proportions		
Material	Volume	Weight
Cement	1.0	1.0
Coarse Aggregate	0.2	0.33
Fine Aggregate	1.0	1.0
Pea Gravel	1.5	1.5
Additives	As recommended by the manufacturer	

In case where coarse aggregate is employed in multiple layers on exposed faces, the final 1.2 cm shall be composed of the 1:1.5 grout without coarse aggregate.

1.6.4.6. Concrete Testing

The Contractor shall make all necessary arrangements for the sampling and testing of fresh and hardened concrete in accordance with the provisions of BS 1881 and shall supply all necessary apparatus, labour, materials and transport.

Slump tests shall be carried out at such times and places as the Engineer may direct and shall be used as a guide to the consistency of each grade of mix. The degree of slump will be decided by the Engineer following Trial Mix Tests and the figure given shall be adhered to thereafter.

Crushing tests shall be carried out on concrete cubes formed in 150 mm moulds.

Prior to the commencement of construction of the Works concrete test cubes shall be taken and tested in accordance with the requirements of the Clauses herein entitled "Preliminary Mix Tests" and "Trial Mixes of Concrete".

During the course of construction of the Works concrete test cubes in sets of four shall be made at such times and places as the Engineer may direct and in any case at not less than the average rate of one set of cubes per 20 cubic metres of concrete. Two cubes from each set shall be tested at an early age (normally 3 and/or 7 days) and two cubes shall be tested at 28 days or as approved by the Engineer and the results so obtained shall constitute part of the Contractor's quality control procedure. The remaining two cubes from each set shall be tested after 28 days and the average of these two results shall be taken as the Test Result for use in judging compliance with the characteristic strength requirements of this Specification. Particular care must be taken to ensure that the test cubes are stored under uniform conditions throughout the year, including a complete covering of damp thick hessian sheet or similar approved material constantly sprayed with water whilst in the moulds and during any transit between site and laboratory, and also including subsequent storage in water kept strictly within the specified temperature range.

If the cubes fail to attain the required compressive strength as specified, the concrete which they represent shall be cut out, removed and replaced with concrete complying with the Specification, to the satisfaction of the Engineer at no extra cost.

The cost of sampling, making and curing Works test cubes together with the provision of moulds, all other necessary equipment and apparatus and the packing and transport to the laboratory, shall be included in the rates for concrete.

All cubes shall be marked at the time of casting, with the date, the grade of concrete and other necessary markings to identify the part of the Works, from which they were taken.

1.6.4.7. Compliance Requirements for Concrete

During the course of the Works and after satisfactory completion of Preliminary and Trial Mix tests the compliance of concrete mixes with the requirements specified in the Table of Designed Concrete Mixes shall be determined as detailed below.

Compliance with the cement content requirements shall be satisfied if the conditions given in

(a) or (b) below are met:

- (a) Where compliance is determined by observation of the batching or from autographic records the cement content shall not be less than 95% or more than 105% of the value approved by the Engineer for each concrete mix.
- (b) Where compliance is assessed from the results of analysis tests on fresh concrete the cement content shall not be less than 90% or more than 110% of the value approved by the Engineer for each concrete mix.

The Contractor shall provide facilities as required by the Engineer to enable the latter to check compliance with the cement content requirements.

Compliance with the maximum values of free water/cement ratio approved by the Engineer for each Grade of concrete mix shall be assessed by means of slump tests. Following the approval by the Engineer of slump values for each Grade of concrete mix the tolerance which shall subsequently apply to test results shall be $\pm 1/3$ of the approved slump.

Compliance with the characteristic strength requirements shall be based on cube test results determined in accordance with the relevant requirements of Clause 1.6.4.6 and shall be assumed if the conditions given in both (c) and (d) below are met:

- (c) The average strength determined from any group of four consecutive test results exceeds the specified characteristic strength by 3 N/mm² for all grades of concrete.
- (d) The strength determined from any test result is not less than the specified characteristic strength minus 3 N/mm² for all grades of concrete.

The quantity of concrete represented by any group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

When a test result fails to comply with requirement (d) above only the particular batch from which the sample was taken shall be at risk.

Should cube test results fail to satisfy either or both of requirements (c) and (d) above the Contractor shall remove the concrete represented by the non-complying cubes or execute such other measures as the Engineer may direct.

The Engineer may require that additional testing by one or more of the methods detailed in BS 6089 be carried out by the Contractor upon concrete represented by non-complying cubes. The results of any such additional tests shall not nullify the previous establishment of non-compliance with this Clause.

If requirement (c) above is not satisfied the Contractor shall unless otherwise directed by the Engineer immediately cease production of the particular grade of concrete mix represented by non-complying cube test results and shall repeat for that grade all the stages specified in Clause 1.6.4.3.

All costs consequent upon non-compliance with the specified requirements for concrete shall be borne by the Contractor.

1.6.4.8. Mixes Not Approved

Approval of a mix may be withheld or withdrawn under the following circumstances:

- (a) The grading of the aggregate changes such that the fraction of aggregate retained on any sieve differs from the corresponding fraction of aggregate in the approved mix by more than 2% of the total quantity of fine and coarse aggregates.
- (b) The source of supply of aggregate or cement is changed.

In the event that approval of a mix for any grade of concrete is withdrawn for any reason the Contractor shall carry out such further trials and tests in order to achieve a satisfactory mix for that particular grade of concrete.

1.6.4.9. Testing of Concrete Cores

If the results for the compressive strength of the concrete used in the Works do not fulfill the requirements in Clause 1.6.4.6, or if defects of workmanship during construction give rise to doubt as to the strength, durability and/or safety of the structure or of part thereof, supplementary testing may be required to be performed.

At least six concrete cores shall, where ordered by the Engineer, be drilled or cut perpendicular to the face of the hardened concrete and tested in accordance with BS 1881.

The cores shall be approximately 150 mm. in diameter and, where possible, have a height/diameter ratio of two. Where it is not possible to take a core of height/diameter ratio, the appropriate correction factor shall be applied to give the equivalent strength of a cylinder having a height/diameter ratio of two.

If the compressive strength of the cores, adjusted for height/diameter ratio and age, fails to attain the specified characteristic strength at 28 days, the suspected part of the concrete shall be cut out, removed and replaced with concrete to the satisfaction of the Engineer at no extra cost.

1.6.4.10. Water Content and Slump Tests

A check on the moisture content of the aggregate shall be made before concreting is commenced. For the purpose of assessing the amount of free water to be added at the mixer, the Contractor shall provide himself with a chart, a copy of which shall be given to the Engineer for approval, relating moisture content in the aggregate to water to be added at the mixer for all grades of concrete in use.

The amount of water introduced into the mix shall be strictly controlled and shall be the minimum amount consistent with complete compaction. The device for measuring water shall show accurately the quantity and be so designed that the water supply will be automatically cut off while water is being discharged into the mix.

Frequent slump tests shall be carried out in accordance with BS 1881 on samples of concrete taken immediately before placing, to determine the consistency of concrete. The slumps of the trial mixes shall be recorded for identification purposes and for subsequent use as a rough routine check on quality. However, slump test shall not be used as an officially acceptable measure of the workability of any concrete.

1.6.4.11. Weigh Batching and Mixing

Concrete shall be mixed in a batch type mixer manufactured in accordance with BS 1305 and the plant proposed shall be to the approval of the Engineer. Volume batching shall not be permitted except for the concrete grades C15 and C10.

All plant and equipment used for batching and mixing concrete and concrete materials shall be painted white and shall be provided with the means to permit quick and accurate checks on calibration. Sun shades shall be provided over stock piles of aggregates, cement and mixing water tanks.

Materials for all grades of concrete shall be proportioned by weight in an approved weigh batch and shall be thoroughly mixed in a batch mixer of an approved size and type so as to ensure a uniform distribution of the materials throughout the concrete.

The type of the mixer shall be in accordance with the maximum nominal size of the aggregate. The materials shall be mixed for a period and at a drum speed specified by the manufacturer of the mixer. Mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed for the specified minimum time.

The accuracy of such equipment shall be maintained within the tolerance described in BS 1305 and checked against accurate weights and volumes as and when required by the Engineer.

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 weigh dials shall be easily visible from the place at which filling and emptying of the hoppers is controlled.

Cement used in the production of concrete may be measured by making the size of each batch of concrete such as to require an integral number of complete bags or drums of cement. The maximum size of the batch shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and as stamped on the mixer.

Weigh batching equipment shall be kept clean and maintained in good order. If any mixer is out of operation for more than 20 minutes it shall be thoroughly cleaned, together with all the handling plant, before any further mixing of concrete shall commence. All mixing and handling plant shall also be thoroughly cleaned in case of using a different type of cement. Under no circumstances shall concrete be mixed with more than one type of cement in any one batch.

The weights of the fine and coarse aggregates shall be adjusted as appropriate to allow either for free-water contained in the aggregates or for aggregate absorption. The quantity of water to be added to each concrete mix shall as appropriate be either reduced by the amounts of free-water contained in the fine and coarse aggregates or increased to allow for aggregate absorption. The values of either free water content or of absorption for the fine and coarse aggregates shall be determined by the Contractor by a method approved by the Engineer immediately before mixing begins and at such further intervals as the Engineer may require.

Every concrete mixing machine shall be fitted with a device to measure added water by weight or volume and shall be so constructed that the water inlet and outlet valves are interlocked so that neither one of them can be opened unless the other is fully closed. The device shall be 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. The entire water system shall be maintained free of leaks at all times and the measuring device shall be fitted with a drain pipe which allows the full quantity of water being measured to be drained off for checking the measurement. The outlet arrangement of the measuring device shall be such that between five and ten percent of the water enters the mixer before the other materials and a further five to ten percent of the water enters the mixer after the other materials. The remainder of the water shall be added at a uniform rate with the other materials. The water measuring device shall be readily adjustable so that the quantity of water added to the mixer can, if necessary, be varied for each batch.

Any admixtures which may be used shall be measured separately in calibrated dispensers. The accuracy of calibration of any weighing plant, water measuring device and admixture dispenser shall be checked before carrying out trial mixes, before the first mixing of concrete for inclusion in the Works, after each service or adjustment to the mixing plant, and in any case at least once per month.

Unless approved by the Engineer in writing, no admixtures shall be used.

Admixtures shall conform to ASTM C 494 or BS 5075 – Part 1. The Contractor may also be required to use a retarding, or water reducing and retarding admixture conforming to ASTM C494 and as approved by the Engineer, under conditions contributing to early set of concrete, or when the temperature of concrete is 30°C or above, or when the time between introduction of cement to the aggregate and placing of concrete exceeds 45 minutes. If admixtures are used, it will be at the Contractor's option and at no additional cost to the Employer.

Compatibility of all proposed admixtures shall be tested for compatibility with proposed cement and aggregate in accordance with ASTM C494.

The amounts and types of additives used shall be as directed or approved by the Engineer and may be varied by him according to the location of the work or for other reasons.

Before the commencement of concreting operations for any particular section of the Works, the Contractor shall satisfy the Engineer that sufficient plant is in working order, including adequate stand-by equipment, in order to ensure the proper mixing of the concrete required during the period of placing.

The first batch of concrete materials placed in the mixer shall contain sufficient amount of excess cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned. Mixing for each batch shall continue until there is uniform distribution of the materials and uniformity of colour and consistency of the concrete. Admixtures for which approval in writing has been given by the Engineer shall be introduced into concrete by means of automatic dosing equipment. Such equipment shall feed a fixed quantity of admixture into the mixing water before the latter is discharged into the mixer and shall be subject to the approval of the Engineer.

The Contractor shall take particular care to ensure that no residual materials remain in the mixer after depositing each batch of concrete and he shall wash and clean out of the mixer drum immediately following the completion of each concreting operation or when changing to a mix using a different type of cement.

The Engineer may, at his discretion, forbid the mixing or placing of any concrete if he considers the ambient temperature too high. The Contractor may also be required by the Engineer to carry out frequent cleaning of equipment to remove deposits of hardened or dried concrete which accrete rapidly at high air temperatures.

Under certain conditions the Engineer may sanction hand mixing of grade C15 and C10 concrete in which case the concrete shall be made on a flat impervious platform of suitable area. The cement and aggregates shall be spread in thin layers and mixed dry until a uniform colour is attained. Water shall then be added and the mixture turned over at least three times or until the concrete is of uniform colour and consistency throughout.

Hand mixed concrete shall contain 10 percent more cement than the quantities determined by the preliminary and trial mix tests. Materials other than cement for hand mixed concrete may be proportioned by volume.

Maximum volume of concrete permitted by hand mixing at any one operation shall be that made from one 50 kg bag of cement.

1.6.4.12. Transporting Concrete

Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by means which will prevent the segregation or loss of any ingredient.

Wherever practicable concrete shall be emptied from a mixer directly into a skip which shall then be transported to the place of final deposit and the concrete shall be discharged as close as possible to its final position to avoid re-handling or flowing.

Should the Contractor propose to use concrete pumps for the transporting and placing of concrete he shall submit full details of the equipment and operating techniques he proposes to use for the approval of the Engineer.

Where concrete is conveyed by chuting or pumping the plant used shall be designed to ensure continuous and unimpeded flow in the chute or pipe. The delivery end of the chute or pump shall be thoroughly flushed with water before and after each working period and shall be kept clean. Water used for this purpose shall be discharged away from any permanent works.

1.6.4.13. Granolithic Concrete

Granolithic concrete for screed shall be mixed using one part by weight of Portland Cement to two parts of clean granite chippings in accordance with BS 882 and clean water sufficient to form a stiff but workable mix and provide a dense concrete.

1.6.4.14. Sand-Cement Mortar

Sand-cement mortar shall be composed of Portland Cement and sand. The proportions of these materials determined by the Contractor in his mix design shall be used in preliminary mixes of mortar made and tested for strength and workability under laboratory conditions.

Trial mixes of mortar shall be prepared and tested by the Contractor in the presence of the Engineer after preliminary mix tests have been completed. Trial mixes of mortar shall be mixed for the same time and handled by means of the same plant as the Contractor proposes to use in the Works.

Three separate batches of mortar shall be made. Each batch shall comprise not less than 0.5 cu.m. of mortar. Six 150 mm cubes shall be made from each trial batch of mortar. Three shall be tested after 7 days and three shall be tested after 28 days. The average strength of the nine cubes of mortar tested after 28 days shall be 10 N/mm². Cubes which lie outside the range 8 N/mm² to 12 N/mm² shall be deemed to have failed. If any of the cubes from the trial batches of mortar fail the mix shall be re-designed.

Where re-design of any mortar mix becomes necessary the making and testing of the trial mixes shall be repeated until the trial mix satisfies the above requirements.

When the mortar is being poured six test cubes shall be made from every 50 m³ batched. Three shall be tested after 7 days and three shall be tested after 28 days. The Contractor shall keep detailed records of the position of each pour and the relation to test cubes taken. Should the 28-day test results indicate that the specified strengths are not being achieved the Contractor shall check and modify his mix details to the Engineer's approval before further pours of mortar take place.

1.6.5. Placing and Compaction of Concrete

1.6.5.1. Preparatory Work

The Engineer's approval in writing shall always be obtained before any concrete is placed in the Works. All constructional plant and materials required, or which may be required during the concreting work and for curing shall be on site and the Contractor shall be fully prepared for the work. The Engineer's approval to place concrete will only be given after such preparations and other relevant requirements of the Specification have been carried out and complied with.

If necessary and/or directed by the Engineer, the Contractor shall cool any shuttering that has become overheated or exceptionally dry through prolonged exposure to the sun. The Contractor shall ensure that all shuttering retains a sufficient amount of humidity and has not become shrunk or warped. All soaking or spraying of shuttering shall be done with potable water.

When concreting in hot weather the requirements of Clause 1.6.5.5 shall be complied with. The Engineer may forbid altogether the placing of concrete in any shuttering which he believes has become too hot and/or dry and the condition of which could harm the quality and strength of concrete. No extra payment for cooling or soaking of shuttering shall be claimed and costs incurred by the Contractor, due to shuttering becoming too hot or dry, shall be deemed to be included in the rates.

All shuttering, area of deposition, reinforcement and exposed surfaces of adjoining concrete surface shall be thoroughly cleaned and free from dust, debris, oil or any other substance that may be harmful to fresh concrete.

Recommended slump

Portion of Structure	Slump in mm.	Recommended Range
Pavement and slabs on ground	50	25 - 75
Plain footings, gravity walls, slabs and beams	50	25 - 75
Heavily reinforced foundations, walls and footings, cast in situ piles (concreting in dry condition)	75	50 - 100
Thin reinforced walls and columns	75	50 – 100
Concrete placed by pumping	100	100-125
Concreting under water	150	125 - 180

Concrete shall be of such consistency and mix composition that it can be readily worked into the corners and angles of the forms and around the reinforcement, inserts, embedded items and wall castings without permitting materials to segregate or free water to collect on the surface, due consideration being given to the methods of placing and compacting.

No excessively wet concrete will be permitted and, if at any time, concrete of consistency beyond the limits of Table 5.1 is delivered to the job, the Engineer may reject the concrete. No additional water shall be added at any time (eg. While in transit) except that established for the design. Failure to comply with this requirement shall be justification for rejecting the concrete.

1.6.5.2. Depositing in Work

The methods of conveying and depositing concrete shall be such as to prevent segregation of the materials and shall be approved by the Engineer before concreting begins. The placing and compaction of concrete shall be carried out under the direct supervision of a competent member of the Contractor's staff.

Concrete shall be deposited directly in the Works as soon as possible without the need for rehandling and not more than 20 minutes after mixing and in any case, before the initial set has taken place. If any delay has occurred after mixing and the concrete has begun to set, it shall not be used in the Works and shall be removed from the site. Unless otherwise agreed by the Engineer on the basis of satisfactory site trials concrete shall not be dropped into place from a height exceeding 2 metres.

Concreting of any section or unit shall be carried out in one continuous operation to construction joints and no interruption of the concreting will be allowed without the approval of the Engineer. Where deposition of concrete has to be interrupted, precautions shall be taken to ensure satisfactory adhesion of later batches of concrete to that previously placed.

Where delays of more than one hour have occurred between successive concreting operations in one section or unit of work, concreting shall only be resumed when, in the opinion of the Engineer, the previously placed concrete has had ample time to harden and the resulting joint shall be treated as a Construction Joint within the meaning and description of Clause 1.6.5.11 hereafter. At all times when concrete is being placed, a competent steel fixer shall be in

continuous attendance to adjust and correct the position of any reinforcement which may become displaced.

Transportation of concrete directly over fixed reinforcement steel during concreting shall not be allowed unless proper provisions are made to avoid displacing or damage to the reinforcement.

1.6.5.3. Depositing in Layers

Concrete shall be deposited in approved quantities and in horizontal layers of such depth as to permit thorough incorporation with the layers below by vibration, spading, ramming and working. If, for unforeseen reasons, it is necessary to stop concreting before completion of a lift, then construction joints as specified shall be formed and further concreting shall be suspended for at least 24 hours.

1.6.5.4. Concrete Placed in Water

Concrete shall not be placed under water without the written approval of the Engineer. The Contractor shall submit to and obtain the approval of the Engineer his detailed proposals of the plant and method for underwater concreting.

The quantity of cement in any concrete placed in water shall if necessary be increased so that the free water/cement ratio is not more than 0.47. The method of placing concrete in or under water shall be such as to keep as much as possible of the concrete being placed out of direct contact with the water so as to avoid any rapid movement or agitation of exposed surfaces. The work shall where possible be carried out in one operation. Where this is impracticable, laitance, washed out aggregate or foreign matter which may have accumulated on the previously placed concrete shall be completely removed prior to additional concrete being placed. This concrete shall then be placed directly on the cleaned surface. Tremie pipes shall be smooth bored, water-tight and fitted with quick release joints and have an adequate cross-section for the size of aggregate to be used. Bottom opening skips shall be straight sided, perfectly smooth, and fitted with externally operated bottom opening double doors and overlapping canvas flaps. Toggle bags shall be used only for small pours and for depositing small discrete quantities of concrete. Bagged concrete shall not be used for permanent work.

During and after concreting underwater, pumping or dewatering operations in the immediate vicinity shall be suspended until the Engineer permits them to be continued.

1.6.5.5. Concreting in Hot Weather

The Contractor's methods shall comply with the recommendations in ACI 305 entitled "Hot Weather Concreting" as modified and supplemented below.

The Contractor shall take great care during hot weather to prevent the cracking or crazing of concrete. The Contractor shall arrange for concrete to be placed in the early morning or late evening as directed by the Engineer.

The Contractor shall have particular regard to the requirements specified herein for curing.

Formwork shall be shaded from direct exposure to the sun both prior to placing of the concrete and during its setting. The Contractor shall take appropriate measures to ensure that

reinforcement in and projecting from the section to be concreted is maintained at the lowest temperature practicable.

Concrete at placing shall have a temperature of not more than 30°C. If the temperature of concrete is in excess of 30°C. at the time of placing the entire load of concrete shall be rejected. If necessary the Contractor shall cool the aggregates and mixing water by adding ice or chilled water as approved by the Engineer.

Where necessary the Contractor shall design, install and operate a cooling system by which cooling water is pumped through a piping system in order to decrease the heat of hydration during concreting. The proposal for such a cooling system shall be submitted to the Engineer for his approval well in advance of the concreting operations.

The temperatures of ambient air, concrete at various levels and intervals not exceeding 5 metres and cooling water where applicable shall be measured by means of thermocouples and recorded with a Philips type PR 3210 A/00 recorder or similar approved.

1.6.5.6. Concreting in Unfavorable Weather

Concreting will not be permitted during heavy rain or when the concrete temperature rises above 32°C.

1.6.5.7. Concrete in Large Pours

A large pour is defined as a pour where the least dimension is greater than 1.5 metres.

Subject to the requirements for construction and movement joint locations and the requirements for the test blocks detailed in the following clause, the Contractor will not be limited as to the size of a large pour, provided that adequate measures are taken to control temperature differentials. Such measures will be evaluated with reference to the following:

(a) Temperatures:

The difference in temperature between thermometers in the concrete near any concrete face and the interior of the concrete at a distance of 1 m from that face shall not exceed 20°C at any stage after placing.

(b) Monitoring of Temperature Changes:

Sets of thermometers for recording concrete temperatures shall be placed at positions in the concrete near to each exposed face at spacing not exceeding 5 m. Further sets shall be placed at corresponding positions within the concrete at a distance of 1 m from each face. The concrete temperatures shall be recorded at intervals not exceeding 6 hours, or such other intervals as may be required by the Engineer, for a period of at least 7 days.

Where the minimum dimension of a pour is between 1.5 m and 2.0 m the internal temperatures shall be recorded by thermometers placed at mid depth of the least thickness.

(c) Insulation and Protection of Concrete Surfaces:

Formwork shall be plywood 19 mm thick, or such other combination of materials having an equivalent insulation value. The formwork shall remain in position for a sufficient time to ensure that the temperature control requirement specified above can be maintained after its removal.

Unformed surfaces shall be protected, as soon as practicable after the initial set has taken place, by either of the following means:

- by ponding the surface with at least 100 mm depth of water;
- by covering the surface with a layer of polythene sheet upon which shall be placed a layer of sand of at least 50 mm thickness.

When the latter method of protection is adopted, the Contractor shall take appropriate steps to ensure that no loss of sand is suffered through the action of wind; the thickness of the sand layers shall be maintained at the specified minimum of 50 mm at all times.

Whichever method of protection is adopted, the protection itself shall be kept shaded from direct sunlight.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to protect the concrete from the effects of temperature build-up and with details of the methods he proposes to use to assess the correct timing at which protection may be removed. No concreting in large pours shall be put in hand until the proposed measures have been approved by the Engineer.

1.6.5.8. Test Blocks

Before commencing any large pour (as defined in the preceding clause) for a particular mix of concrete, the Contractor shall construct three test blocks 2.0 m cube in size. The temperature of the concrete at the time of casting the blocks shall not exceed 30°C except under hot conditions, when the requirements of Clause 1.6.5.5 will apply. The materials used in making concrete for the test blocks, together with the reinforcement, formwork and materials used for protecting the top surfaces, shall be of the same type and from the same source as those intended for the large pour.

Two of the blocks shall be reinforced on two opposing sides and on the top face by 32 mm diameter high yield reinforcing bars at 250 mm spacing in each direction. The cover to the outer bars shall be 60 mm.

The Contractor shall ascertain the thermal characteristics of the cement and aggregates to be used, from which he shall calculate the likely maximum rise in temperature of the concrete. The data used shall be clearly indicated in the calculations which the Contractor shall give to the Engineer before casting the blocks.

Thermometers shall be installed in the concrete near to the surface at the centre of each face, with one placed centrally in the block. Temperatures shall be recorded at 6 hourly intervals for a period of at least 7 days for each of the blocks.

Six 150 mm test cubes shall be taken during placement of concrete for each block, two for testing at 7 days and four for testing at 28 days.

The test blocks shall be considered satisfactory if, for each of the blocks, all the following conditions are met:

- (i) The average strength of the four 28 day test cubes exceeds the specified 28 day characteristic strength by at least 7.5 N/mm²;
- (ii) The rise in temperature during hydration does not exceed 45°C and the difference in temperature between any face and the centre of the block does not at any stage exceed 20°C;
- (iii) The nature of any cracks appearing is such that, in the opinion of the Engineer, the cracks would not constitute a potential source of harm if they were to occur in the Permanent Works.

If condition (i) above is not fulfilled the Contractor shall redesign the concrete mix, construct further test blocks, and repeat the testing as specified.

If condition (ii) is not fulfilled or if under (iii) the Engineer is of the opinion that the cracks as noted are potentially harmful, the Contractor may proceed with the casting of a large pour only if he incorporates one or more of the following procedures in the concreting operation:-

- cool the mixing water/aggregates as set out in Clause 1.6.5.5;
- replace the 19 mm thick plywood formwork to formed faces with material having better insulating properties;
- increase the surface protection to unformed faces.

If the Engineer so requires, the Contractor shall construct further test blocks to demonstrate the efficacy of the measures which are being incorporated in the casting of the large pour.

1.6.5.9. Compaction of Concrete

The Contractor shall regard the compacting of the concrete as work of fundamental importance the object of which shall be to produce a watertight concrete of maximum density and strength.

Concrete shall be thoroughly compacted during the operation of placing and shall be thoroughly worked around the reinforcement and embedded fixtures and into corners of the formwork and moulds.

Mechanical vibrators shall be of the immersion type with a frequency of not less than 6000 vibrations per minute and design approved by the Engineer. A sufficient number of vibrators shall be used to handle the maximum rate of concrete production with a 50% allowance for stand-by units during any period of concreting. All operators handling vibrators shall be trained in their operation.

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. Vibrators shall be withdrawn slowly from the mass of concrete 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.

Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the formwork over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the formwork or shuttering.

Every care shall be taken to see that reinforcement and fittings attached to the shuttering are not disturbed, and that no damage is caused to concrete that has already set or to the internal face of the shuttering by using immersion type vibrators. In areas of congested reinforcement, it may be necessary to use small diameter pokers and the Contractor shall supply suitable sizes of pokers for each part of the work. Vibration of concrete by hammering the shuttering with hand tools shall not be permitted.

When placing concrete against horizontal or inclined elements of waterstops they shall be lifted and the concrete placed and compacted to a level slightly higher than the underside of the waterstop before releasing the waterstop to ensure complete compaction of the concrete around the waterstop.

The duration of vibration shall be limited to that required to produce satisfactory compaction without causing segregation. Vibration shall not be continued after water or excess grout has appeared on the surface.

Concrete shall not be disturbed after compaction and placing in its final position. Concrete that has partially set before final placing shall not be used and shall be removed from the Site.

1.6.5.10. Construction Joints

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 any relative movement.

The contractor is advised that in water retaining structures, water stops are necessary in a properly formed construction joint. The Contractor shall install water stops in construction joints to satisfy the requirements of these Specifications and all costs shall be borne by the Contractor.

The Contractor shall submit to the Engineer for his approval, as soon as practicable after the commencement of the Work and not less than one week before the commencement of concreting, shop drawings showing his proposals for placing concrete on which the position and form of all construction joints 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 structural strength of the completed structure. The position of construction joints and size of formwork panels shall be so co-ordinated 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. Rebates, keys or notches shall be formed, and water stops inserts as required.

Concrete placed to form the face of a construction joint shall have all laitance removed and the coarse aggregate exposed prior to the placing of fresh concrete. Form retarder may be used to achieve easy removal of the surface concrete with the prior approval of the Engineer. The laitance shall be removed and the coarse aggregate is exposed by “green cutting” - spraying the concrete surface with water under pressure and brushing while it is still green. The process shall not disturb the hardened coarse aggregate in concrete. With the Engineer’s prior approval in writing while the concrete is still green the whole of the concrete surface forming part of the joint shall be hacked to expose the coarse 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 thoroughly cleaned by the brushing, air blasting or washing, and the surface to which the fresh concrete is applied shall be clean and damp.

Construction joints shall generally be located as follows:

Columns: Joints in columns shall be made at the underside of floor members and at floor levels. Haunches and column capitals shall be considered as part of and continuous with the floor or roof.

Suspended floors & roofs Joints in the system shall be located at or near the middle of the spans in slabs, beams or girders, unless otherwise instructed.

Walls: Vertical joints shall be away from corners. Horizontal joints shall be above splays or openings. Construction joints shall be placed at intervals not exceeding 5.0 metres.

Ground slabs. Construction joints shall be placed at intervals not exceeding 5.0 metres.

An order of casting slabs and walls that gives free edges in two directions as right angles shall be followed as far as possible to reduce restraint to free contraction of the immature concrete. The proposed sequence of casting shall be submitted for Engineer’s approval before commencement of concreting.

Concreting of large floors walls and roof slabs in reservoirs where prevention of shrinkage cracking is essential shall be cast in an order that gives free edges in two direction as right angles as far as possible. The length of single pour shall be limited to 5.0 m in any direction. In the case of walls at construction joints to facilitate visual inspection of mother concrete surface and concrete compaction, the pour height shall be limited to 2.5 m and maximum free fall allowed shall be 500 mm. The new panels shall not be cast until the adjacent panels are at least one week old after casting. Each wall panel shall be cast within one week of the casting of the kicker to which it is monolithic. Subsequent lifts within the panel shall be cast when the previous lift not more than one week old. There is no restriction on the timing of the casting of adjacent wall panels separated by expansion joints.

1.6.5.11. Placing Concrete on Previously Executed Work

Where concrete is to be deposited against or on top of previously executed work the surface of the previously executed work which is already “green cut” and cleaned, shall be

thoroughly wire brushed cleaned with water and air under pressure to expose the surface of the aggregate and to remove all laitance.

Special care shall be taken to ensure that the new concrete is thoroughly compacted and rammed against the old. In certain cases, depending on the Grade of concrete in use, the elapsed time between successive concreting operations and the weather conditions at the time of recommencing concreting, the Engineer may require the old concrete to be treated differently, including the use of "wash-off" and "dry-bond" techniques, wire brushing, etc.

1.6.5.12. Protection and Curing of Concrete

Concrete shall be protected from damage by climatic conditions (direct sunlight, rain), running water or mechanical damage during curing. All methods to be used for curing and protection of freshly placed concrete shall be subject to the prior approval of the Engineer.

The maximum and minimum ambient temperatures and humidity shall be measured and recorded each day by the Contractor. The records shall be made available for the Engineer's inspection.

All exposed surfaces shall as finishing proceeds be covered with a wet hessian sheet followed by a reflective polythene sheet. These shall be securely fastened around the edges and supported in order not to damage the finished concrete surface. As soon as practicable the hessian and polythene shall be lowered into close contact with the concrete and securely weighted or fastened down to prevent wind blowing underneath. The hessian sheet shall be maintained in a moist condition at all times and shall be inspected at intervals not exceeding 6 hours. Concrete shall be kept moist on exposed surfaces for a period of not less than 10 days or as approved by the Engineer.

Alternative methods of protecting and curing concrete may be approved by the Engineer. In any case liquid curing membranes shall not be used on exposed surfaces or where laitance is to be removed and aggregate exposed to provide satisfactory bond for placing further concrete or mortar screeds. Liquid curing membranes shall not be used where mortar, resin mortar, or joint sealant is to be applied.

Sufficient methods to afford full protection to a concrete pour shall be available at the place of work prior to the commencement of concreting.

During very hot weather conditions, the Contractor may be required to cool formwork containing concrete by spraying with water and this shall be carried out where directed notwithstanding and whatever other measures the Contractor may have employed for the curing of the concrete. All materials, spray equipment and an ample supply of water for curing shall be ready on site before any concreting starts.

1.6.5.13. Record of Concreting

The Contractor shall keep on site a complete record of the works showing the time and date when concrete was placed in each part of the Works. The record shall be available at all times for inspection by the Engineer.

1.6.5.14. Faulty Work

Any portion of the work which is honeycombed or otherwise inferior shall, on the written instruction of the Engineer, be immediately cut out and reconstructed in an approved manner without extra charge. Plastering of defective work will not be permitted. Any leaks or cracks shall be sealed by injection with a synthetic resin or other appropriate methods approved by the Engineer.

1.6.5.15. Blinding Concrete

A blinding layer of minimum 75 mm. concrete grade 15/20 shall be placed under all foundations and ground slabs ordered by the Engineer. The blinding layer shall be allowed to harden before the structural concrete for the foundation is placed. A layer of polythene of thickness not less than 0.2 mm and of approved colour shall be placed prior to laying structural concrete. The polythene sheets shall be lapped not less than 300 mm.

1.6.5.16. Loading of Concrete Structures

No external load of any kind shall be applied to any part of a concrete structure until the concrete has matured for at least 7 days and then only with the approval of the Engineer and after confirmation that 7 day cube strengths as agreed by the Engineer have been met.

The full design load shall not be applied until confirmation that the specified 28 day strength has been reached.

The Contractor shall not fill around any structure incorporating a ground or floor slab before confirmation that the slab has reached its specified 28 day strength.

1.6.6. Contraction and Expansion Joints in Structures

1.6.6.1. Design

All movement joints shall be provided with a waterstop and sealant. Expansion joints shall be provided with joint filler whereas discontinuity at contraction joints shall be provided by painting one face of the concrete with two coats of bituminous paint. At contraction joints, the sealant shall be set in a caulking groove formed in the concrete.

1.6.6.2. Waterstops

Water Stops

All vertical and horizontal expansion joints in concrete slabs and peripheral walls of structures and conduits conveying or containing liquid shall have water-stops this requirement shall apply to construction joints also.

Suppliers

All concrete jointing elements herein specified shall be furnished by a supplier that can give satisfactory evidence to the Engineer that they are capable of supplying the quantities for the schedule required and has an organization that is knowledgeable in the installation of these systems. A competent representative of the supplier shall instruct in the installation of these systems.

Materials

Samples of all materials to be furnished under this Section shall be submitted to the Engineer for approval.

Materials shall be sourced and supplied by a single manufacturer with a minimum of ten years experience.

Manufacturer shall operate a quality system which is registered to ISO 9001 or approved equal.

Technical back-up service during installation shall be provided by the manufacturer at no additional cost to the Employer.

- (a) Unless otherwise specified all water-stops shall be extruded from a high grade electrometric polyvinyl chloride compound as basic resin and manufactured from virgin materials necessary to meet the performance requirements of this specification.
- (b) Comply with the requirements of BS 2782 or US Corps of Engineers specification CRD C572-74.
- (c) Suitable for storage, handling, installation and service within a range of 15° C to 50° C.
- (d) Shall be dumbbells type both for internal and external rear guard as specified. The water-stops shall have dumb bells 250 mm width with a centre bulb, minimum web thickness of 9.5 mm. The centre bulb shall have a minimum inside diameter of 20 mm & minimum outside diameter of 40 mm. The edge rib shall have a dumb bell of minimum of 25 mm diameter. The external or rear guard water stop shall be 250 mm wide with three bulbs. The centre bulb shall be a box section 25 mm wide which is flat to accept a filler board. To prevent the water-stops folding during concreting & assist in keeping firmly in position all water stops shall be provided with steel chips along both edge ribs at spacing not more than 500 mm. The water stop shall be held firmly to the reinforcement steel to the satisfaction of the Engineer with wire of No.12 gauge.
- (e) Intersection & Transition pieces shall be performed factory moulded type and or factory prefabricated type.
 - Site jointing shall be limited to butt joints and shall be strictly in accordance with the manufacturer's instructions.
 - Joints shall be heat sealed.

(f) Physical Properties:

Property	Test Method	Minimum Requirements
Tensile Strength	ASTM D 638	14.5 N/mm ²
Ultimate Elongation	ASTM D 638	370%
Tear Resistance	ASTM D 624	50 kN/m
Stiffness in Flexure	ASTM D 747	4.14 N/mm ²
Hardness, shore A/15	ASTM D 2240	70 to 80
Water Absorption	ASTM D 570	max 0.3%

Property	Test Method	Minimum Requirements
Tensile Strength after accelerated extraction	CRD – C 572	13.5 N/mm ²
Elongation after accelerated extraction	CRD – C 572	300%
Specific Gravity	ASTM D 792	max 1.4
Low Temperature Brittleness	ASTM D 746	No failure at - 37°C
Volatile Loss	ASTM D 1203	Max 0.5%
Effect on Alkali after 7 days: Weight Charge	CRD – C 572	Max + 0.25% - 0.10%
Hardness Change		Max ± 5%

Testing shall be carried out in accordance with BS 2782 or US Corps Engineers specification CRD C572-74.

Bond Breaker

Forced, non-absorbent polyethylene backing strip or equals as recommended by sealant manufacturer to prevent adherence of sealant to backup material.

Slip Membrane

- Pre-formed low friction bearing strip to form a thin sliding joint minimum bearing capacity of 0.7 N/mm²
- Extruded from specially formulated polyethylene to form a durable lamina, resistant to most chemicals, solvents and weathering.
- Applied in two layers with bottom layer bonded to substrate with high quality solvent borne adhesive based on polychloroprene rubber.
- Thickness 1.5 mm
- Coefficient of friction 0.15
- Operating temperature upto 500C.

Sealing Strip Membrane

Expansion joints shall be sealed with a sealing strip system. The joints shall be pre-sealed using sealant prior to laying sealing strip membrane. Sealing strip system shall comprise of hypalon high-polymer flexible sheeting bonded to the concrete surfaces on either side of joint using suitable epoxy resin adhesive. The system proposed shall have high performance allow for considerable movement in more than one direction while maintaining a high quality seal. Width of flexible membrane shall be 250 mm. Minimum thickness shall be 3.0 mm. Minimum un-bonded width shall be 50 mm centre on the joint to allow for greater movement potentials. Final sealing strip system shall be able to accommodate movement, which results in the de-bonded area being extended up to 100% of the de-bonded width.

Performance properties shall be as follows:

- Density : 1.65 kg/litre (adhesive) 1.50 kg/m² (hypalon Lmm)
- Service Temperature : -300C to + 700C
- Bond strength to concrete: Dry or Damp = -4N/mm² (concrete failure)
- Tensile Strength : -6N/mm²
- Peel Strength : -4.5 N/mm²
- Elongation : > 400%

Waterproof Membrane

Waterproof membrane shall be self-adhering sheet membrane consisting of rubber modified asphalt compound such as Bituthene 1000 coated to one side of a polyethylene film. The membrane shall have a minimum overall thickness of 1.5 millimetres and a tensile strength of 140 kN/sq. cm and shall in all respects comply with the requirements of BS 102.

Primer: Special compound provided by the self-adhering manufacturer, formulated for its intended use.

Installation: The reservoir roofs and sump roofs shall be protected with self-adhering water proofing membrane.

Over the cleaned concrete surface the Contractor shall apply primer in manner and using quantities in accordance with the membrane manufacturer's printed instructions. After the primer has dried, the Contractor shall apply the self-adhering membrane to the concrete without stretching, with polyethylene face out. It shall be smoothed down with a small roller.

The contractor shall apply the membrane sheets with 120 mm overlaps at edges and ends, rolled down firmly and completely.

Bearing Pads

The bearing pads shall have bearing core of 450 x 220 x 25 mm made out of Elastomeric neoprene confirming to BS 2752 and Standard Specification for Highway Bridges adopted by the American Association of State Highway Transportation Officials or to BS 5400.

Performance properties shall be as follows:

Safe load capacity = 225 kN per pad

Overall displacement = + or - 17.5 mm

The bearing area shall be surrounded with expanded closed cell polystyrene (water absorption less than 0.02 mg/cu.cm after 72 hours) to facilitate insitu poring of superstructure concrete. An adhesive shall be used (non solvent type) to fix the bearing pad to the base concrete. The spacing of bearing pads shall be as such that, there is no single bearing pad which exceeds the safe load carrying capacity.

Where the lateral movements can not be assessed accurately and does not conform to the above requirements bearing pads of 'free type shall be provided. The sliding surface shall be stainless steel plates sliding on PTFE (polytetrafluoroethylene) sheet.

Installation

Water stops for all joints shall be continuous around all corners and intersections. Splices shall be made in accordance with the manufacturer's recommendations, subject to the approval of the Engineer.

Particular care shall be taken to correctly position the water-stop during installation and prevent it being moved or distorted by the concrete placement. The water-stops shall be thoroughly cleaned immediately prior to placing concrete. Adequate provision shall be made to support the water-stop during the progress of the work and to ensure proper embodiment, symmetrical about the joint. When PVC water stops are to be left for future connections they shall be protected by wood covers.

Joint filler shall be installed at the locations.

Joint sealers shall be placed to the width and depth as specifications. Surfaces in contact with sealers shall be clean, dry and firm with all traces of form oil or other coatings removed. Preparation of surfaces, priming, and the handling and preparation of materials shall be in complete compliance with the manufacturer's instructions.

1.6.6.3. Joint Filler

Joint Filler Board

Non-absorbent, semi rigid, cross-linked closed cell, heat laminated polyethylene filler board.

Non-tainting and rot proof in accordance with BS 6920

Fully compatible with the surface sealant and if elastometric sealant are used the joint filler shall act as a bond breaker.

Sheet form in one layer. The thickness shall be specified in the Drawings.

Performance Properties:

- Recovery : greater than 98% after 50% compression
- Water Absorption : < 0.05% by volume
- Compressive Strength : min 0.15 N/mm²
- Density : 100kg/m³ ± 5kg/m³
- Extrusion : Nil (three edges restrained & sample compressed by 50%)

Joint Filler shall be preformed compressible cellular and resilient and shall not become brittle in cold weather. It shall be granulated cork bound with bitumen.

Where low compression filler is required this shall be low density closed cell polythene.

1.6.6.4. Joint Sealer

Joint Sealant

Two part polysulphide complying with BS4254 or FS TT-S-00227E, Type II, Grade A.

- Must in all cases be carefully selected as appropriate for their climatic and environmental exposure.
- Hardness Shore A : min 25
- Movement Accommodation Factor : min 25%
- Polymer Content : min 25% (for normal grade)

- Resistance to weathering, ozone, ultra-violet light, chemicals and biodegradation
- Ability to withstand repeated cycles of compression and expansion over a wide temperature range

Joint Sealer shall be non-degradable and shall be suitable for use in hot climates. Joint sealer shall be elastoplastic and shall possess a movement accommodation factor of at least $\pm 25\%$

For movement joints in water retaining structures the physical properties of the sealer shall not be inferior to those of polysulphide based sealers complying with BS 4254 and the sealer shall have a minimum life expectancy of 25 years.

For horizontal joints in non-water retaining structures or pavements the sealer shall be a type A1 rubberized bituminous compound to BS 2499 and shall have a minimum life expectancy of 10 years.

In other situations the sealer shall be synthetic rubber based on polysulphide to BS 4254 or BS 5215 or based on polyurethane or silicone to the approval of the Engineer and shall have a minimum life expectancy of 25 years.

Where the joint sealer is to be in contact with a protective coating the Contractor shall satisfy the Engineer that the sealer and the protective coating are compatible.

The sealer shall be stored in accordance with the manufacturer's instructions and no sealer shall be used after its shelf life has elapsed.

To ensure non-adhesion to the back of the joint cavity a bond breaker is to be fixed where this is specified by the manufacturer of the sealer.

Primer shall be obtained from the same manufacturer as the sealer.

1.6.7. Admixtures for Concrete

Admixture 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.

Admixtures shall be used only if the Engineer has given his prior approval in writing, and with due regard to the manufacturer's instructions. Both the amount added and the method of use shall be to the approval of the Engineer who shall also be provided with the following information:

- (i) The typical amount added and the detrimental effects, if any, of an increase or decrease in this amount.
- (ii) The chemical name(s) of the main active ingredient(s) in the admixture.
- (iii) Whether or not the admixture leads to the entrainment of air when used at the amount the manufacturer recommends.

Any approved admixture shall conform to whichever of the following standards is appropriate:

- Water reducing admixtures BS 5075 Part 1

1.6.8. Connections to Concrete Structures, Temporary Holes and Openings

1.6.8.1. General

All steel constructions and other items to be cast in, such as anchor bolts, steel frames, sockets, pipes, strips, waterstops, etc. shall be fixed and cast in by the Contractor in accordance with the approved working drawings.

The Contractor shall also provide templates and other supplementary means for the correct positioning of the constructions and items as mentioned above.

The Contractor is to ensure that all of the constructions and items as mentioned above are on site in time in order to avoid interruptions during the execution of concrete works. If recesses are provided, these shall be sufficiently larger in size than the dimensions of the construction or items to be cast in.

1.6.8.2. Building-in Pipes and Other Items

Pipes and other items passing through concrete structures shall wherever practicable be built into the structure as work proceeds, having been installed and connected to the remainder of the system to ensure proper fit prior to the start of any concreting.

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 the holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without prior approval of the Engineer in writing.

When that procedure cannot be adopted, holes or openings of suitable dimensions shall be formed for such items to allow them to be built in later along with or after installation of the remainder of the system. Such holes or opening shall be of size and shape sufficient to permit proper placing and compaction of concrete or grout. The surfaces of the holes or openings shall be treated as construction joints.

All items to be built in shall be securely supported in their correct position to prevent movement or damage during building in. In particular, any pipe with flanged joints shall not be concreted in until its accurate fit with other pipework has been checked and it has been secured in position.

Concrete used for building in shall be of the same grade as the surrounding concrete, except that the mix shall also incorporate an approved expanding additive used with due regard to the manufacturer's instructions.

Cement sand mortar or cement grout used for this purpose shall also incorporate an expanding additive. Concrete, mortar and grout shall be placed and compacted by methods which will avoid moving or damaging built in items.

1.6.8.3. Cutting or Displacement of Reinforcement

Reinforcement shall not be cut bent or displaced to facilitate building in without the Engineer's approval.

Where reinforcement is cut or displaced to facilitate the formation of holes or openings, the Contractor shall provide and fix additional reinforcement steel as required and approved by the Engineer to transfer the stresses from one side of the hole, opening or recess to the other.

Cutting or displacement of reinforcement shall only be permitted after the approval and inspection by the Engineer.

1.6.8.4. Cleaning

Before filling or grouting, the holes and openings shall be roughed and cleaned to remove dust or other impurities. The openings and holes shall be moistened with clean water before filling or grouting. The threads of anchor bolts and other items shall be cleaned and greased immediately after filling or grouting.

1.6.8.5. Grouting in Narrow Spaces

In the event of the space between the fixture or unit to be cast in and the adjacent concrete being less than or equal to 25 mm, the grouting shall compose of one part cement and two parts of sand with an approved expanding additive.

1.6.8.6. Joint between Old and New Concrete

Where new concrete is joined with old or existing concrete, the Contractor shall cut the old concrete to form a straight surface. The joint shall be considered as a construction joint and treated with an approved epoxy resin compound, prior to placing the new concrete. The exposed surface of the joint between old and new concrete shall be formed with a timber insert 20 mm x 25 mm. After the concrete has fully hardened, the timber insert shall be removed and the space filled with an approved epoxy sealer.

1.6.8.7. Grouting Under Hand-Railings

The grouting under hand-railings shall be executed with a synthetic resin mortar based on epoxy and to be approved by the Engineer.

1.7. Shuttering and Concrete Finishes and Coatings

1.7.1. General

Shuttering shall include all temporary moulds for forming the concrete together with all temporary constructions required to support such moulds.

1.7.2. Drawings and Calculations

The Contractor shall submit detailed method statements with drawings and calculations showing details of the shuttering he intends to use for the approval of the Engineer. The drawings shall show the materials proposed and indicate details of construction such as size of members, spacing and position of walings, struts, bolts and wedges. Shuttering shall not be constructed until the drawings and calculations have been approved by the Engineer. Such approval shall not relieve the Contractor of his responsibility for the adequacy and performance of the shuttering. Any changes or modifications to the shuttering required by the Engineer shall be carried out at no extra cost to the Employer.

Shuttering shall be of suitable design and adequate construction to carry the loads without excessive bulging, distortion or deflection. Shuttering shall be constructed so as to prevent loss of water or grout from the concrete. Special attention shall be paid to shuttering where poker or shutter vibrators are used for compacting the concrete.

1.7.3. Materials for Shuttering

Shuttering shall be made from good quality timber, free from loose knots, shakes and warped surfaces. Timber for shuttering shall not be less than 30 mm. in thickness, and the board faces in contact with concrete and the board edges shall be planed smooth and joints shall be tongued and grooved. Alternatively, with the approval of the Engineer, shuttering may be made from either (a) metal with accurately aligned and close fitting joints, or (b) plywood or hardboard 5 mm. in thickness supported by close boarded timber, 20 mm in thickness, or (c) plywood not less than 16.0 mm in thickness. The plywood or hardboard shall be resistant to deterioration by water, and shall be fixed and jointed in such a manner as to give a perfectly smooth and even finish to the concrete.

1.7.4. Fixing of Shuttering

Shuttering shall be fixed to perfect line and level and be truly plane with no crevices at joints, and shall be securely braced, supported and wedged so as to retain its position without displacement or deflection during the placing and compaction of the concrete. Joints in shuttering shall be made so that no leakage of grout from the concrete can occur.

All joints shall be either horizontal or vertical, unless the form of the finished concrete requires them to be otherwise.

1.7.5. Back Shuttering

Back shuttering shall be used to form concrete surfaces which are designed to be concealed by earth backfill or further construction, and shall comply with the specified requirements of shuttering except insofar as the board faces are not required to be planed.

1.7.6. Internal Ties

No internal wall ties shall be used in the construction of the Works except with the approval of the Engineer.

1.7.7. Coating to Prevent Adhesion

All shuttering in contact with concrete shall be treated with an approved mould oil or solution before usage to prevent the adhesion of the concrete. Such oil or solution shall be carefully applied in such a manner that there is no contamination of the reinforcement or previously placed concrete by the oil or solution. Any material which will adhere to or discolour the concrete shall not be used.

1.7.8. Access Holes

Adequate access holes shall be left for the purpose of cleaning the shutters and for placing the compacting the concrete.

1.7.9. Cleaning and Re-using of Shuttering

Before any concrete is placed, the shutters shall be properly cleaned and washed out with water and air under pressure to remove sawdust, shavings and all other foreign matter. All water shall then be drained and mopped out from the shutter.

In no case shall concrete be placed in shuttering until the shuttering has been approved by the Engineer. If shutters or moulds are to be reused, all surfaces shall be cleaned and shall be completely free from remnants of concrete or mortar. If, in the opinion of the Engineer, shutters or moulds are not acceptable for reuse, they shall be either properly repaired or substituted with new shutters or moulds.

1.7.10. Removal of Shutters

Shutters shall be removed only with the permission of the Engineer and under skilled supervision of a competent foreman and in such a manner as will not cause any damage to the concrete. Shutters shall not be removed before the concrete is sufficiently set and hardened. The minimum periods which shall elapse between the placing of the concrete and the removal of the shutters for the various parts of the structures cast insitu are given in the table below, but compliance with these requirements shall not relieve the Contractor of his obligation to delay the removal of the forms if the concrete has not sufficiently set or reached the required strength. Should there be variations in site temperature and depending on the curing conditions, the Engineer may, at his discretion, vary the period shown in the table below and the period shall be held to cover such a contingency.

The period of time elapsing between the placing of concrete and the striking of form work shall be approved by the Engineer after consideration of the loads likely to be imposed on the concrete, and shall in no case be less than the period shown below:

Type of formwork	Minimum period before stripping (times are exclusive of the day of concrete placement)
Props to beams and slabs	14
Beams and slabs without props	14
Beam and slab Soffits (props left under but not re-propping)	7
Beam sides walls and columns	1

At all times the Contractor shall delay the removal of the shutter if in the opinion of the Engineer the concrete contained therein has not attained sufficient strength.

Stripping of formwork within the time limits listed above does not relieve the Contractor from his responsibility for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

Alternatively, the removal of shutters shall be determined by the demanded compressive strength of the concrete at the time of removing. In this case, the demanded strength shall be in accordance with Clause 1.6.4.3.

Any damage to the concrete, which may occur by removal of the shutters or by overloading, shall be made good at the Contractor's expense and to the satisfaction of the Engineer.

1.7.11. Finish to Concrete Surfaces

The following requirements for the finish to concrete surfaces shall apply as appropriate unless otherwise specified.

(a) Formed surfaces

Grade F1:

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

Grade F2:

- All surfaces permanently exposed to view, except where Grade F3 is required.
- Surfaces either permanently or periodically in contact with stored, retained or flowing liquids.

Grade F3:

- Surfaces prominently exposed to public view where good appearance is of special importance. Grade F3 is also known as 'fairfaced' finish.
- Any surface in contact with fast flowing water.

(b) Un-formed surfaces

Grade U1:

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

Grade U2:

- All surfaces permanently exposed to view, except where Grade 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.

Grade U3:

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

(c) Concrete road and hardstanding surfaces:

Concrete road and hardstanding surfaces shall have the surface finish obtained by the conventional use of a hand tamper or vibrating beam.

(d) Rendered or surfaced areas:

Areas to be subsequently rendered or to receive a surfacing shall be adequately scored to provide an effective key.

(e) Exposed arises:

Exposed arises shall be formed with a chamfer 20 mm by 20 mm.

(f) Textured Concrete:

The Contractor shall construct a sample of 1m² for the Engineers' approval prior to constructing textured concrete in the permanent works.

(g) All surfaces:

All surfaces shall be free from cracks, sand runs, honeycombing, porosity and grout/matrix loss.

For partly buried surfaces the exposed surface quality shall extend to 500 mm below final ground level.

1.7.12. Dimensions and Surfaces of Finished Concrete

Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surfaces being perfectly compacted, smooth and with no irregularities. Concrete surfaces for the various finishes shall not exceed the maximum permitted tolerances stated in the table below.

Surface irregularities shall be Gradeified as 'abrupt' or 'gradual'. Abrupt irregularities include, but shall not be limited to offsets and fins caused by displaced or misplaced formwork, loose knots or other defects in formwork materials, and shall be tested by direct measurement. Gradual irregularities shall be tested 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.

Maximum tolerance (mm) in:

Grade of Finish	Line and Level	Abrupt Irregularity	Gradual Irregularity	Dimension
U1	+/- 12	6	+/- 6	-
U2	+/- 6	3	+/- 3	-
U3	+/- 6	3	+/- 3	-
F1	+/- 12	6	+/- 6	+12, -6
F2	+/- 6	6	+/- 6	+12, -6
F3	+/- 3	3	+/- 3	+/- 6

1.7.13. Unformed Surfaces - Grade of Finish

Finishes to unformed surfaces of concrete shall be Gradeified as U1, U2, U3, 'spaded' or 'bonded concrete' or such other special finish as may be particularly specified. Where the Grade of finish is not specified, the concrete shall be finished to Grade U1.

Grade U1 finish is the first stage for Grade U2 and U3 finishes and for a bonded concrete surface. Grade U1 finish shall be a levelled and screeded, uniform plain or ridged finish,

which (unless it is being converted to Grade 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 Grade 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.

Grade 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 surface free from screedmarks.

Grade U3 finish shall be a hard smooth steel-trowelled finish. Trowelled shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked into the surface. The surface shall be trowelled under firm pressure and left free from trowel marks.

The addition of dry cement, mortar or water will not be permitted during any of the above operations.

Exposed aggregate finish shall be achieved by exposure of the coarse aggregate using a method approved by the Engineer. The average depth of exposure shall be 6mm for concrete with a maximum aggregate size of 20 mm and between 6mm and 12mm for concrete with a maximum aggregate size of 40 mm.

The Contractor shall prepare sample panels 1000 mm x 500 mm of concrete with an exposed aggregate finish for inspection and approval by the Engineer at the Site.

1.7.14. Formed Surfaces - Grade of Finish

Finishes to formed surfaces of concrete shall be Gradeified as F1, F2 or F3. Where the Grade of finish is not specified the concrete shall be finished to Grade F1.

Formwork for Grade F3 finish shall be lined with as large panels as possible of non-staining material with a smooth unblemished surface such as resin bonded, sanded plywood or hard compressed fibre board, arranged in a uniform approved pattern and fixed to back formwork by oval nails. Unfaced wrought boarding shall not be permitted.

Formwork for Grade F2 finish shall be wrought timber or steel arranged in a uniform approved pattern free from defects likely to detract from the appearance of the surface.

Formwork for Grade F1 finish shall be constructed of timber, steel or any suitable materials which will prevent loss of grout when the concrete is vibrated. Surfaces subsequently to be rendered plastered or tiled shall be adequately scabbled or hacked 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.

For Grades F2 and F3 all surface blemishes shall be repaired as described in Clause 1.7.15.

1.7.15. Remedial Treatment of Concrete Surfaces

Any remedial treatment to concrete surfaces shall be agreed with the Engineer following inspection immediately after the stripping of formwork and shall be carried out without delay.

Any concrete the surface of which is found to have been treated before inspection by the Engineer shall be rejected.

Any minor surface blemishes shall be repaired to the satisfaction of the Engineer immediately after completion of curing. Remedial measures may include, but shall not be limited to, the following:

- (a) Holes left for 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.
- (b) Fins, pinhole bubbles, surface discoloration and minor defects may be rubbed down with sacking and cement immediately the formwork is removed.
- (c) Abrupt and gradual irregularities may be rubbed down with carborundum and water after the concrete has been fully cured.
- (d) Small defects and minor honeycombing shall be chipped out perpendicular to the face of the concrete to a depth of at least 25 mm. and filled with dry-pack mortar as specified.

All other defects will be regarded as too extensive to permit satisfactory repair and the concrete containing the defect shall be broken out and replaced.

1.7.16. 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 fine aggregate passing a 1 mm. sieve and an expanding agent approved by the Engineer. Additives to improve workability may be added to the approval of the Engineer. 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 material shall be placed and packed in layers 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 area 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. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

1.7.17. Coatings on Concrete Surfaces

1.7.17.1. General

Bituminous coatings shall be applied to concrete structures in order to protect the concrete against aggressive effects of saline groundwater or other unwanted matters. Generally, protective coatings shall be applied to surfaces of concrete structures which are underground and/or in contact with groundwater.

The Contractor shall supply, deliver and apply all paints protective coatings. The type of coating to be used shall be a bituminous paint product approved by the Engineer.

All priming-coats and undercoats shall be obtained from the same manufacturer and shall be the type of primer and undercoat recommended by the manufacturer for that particular paint or bitumen.

All paints and bituminous coatings shall be applied strictly according to the instructions of the manufacturer. All the paints shall be delivered to the site(s) in sealed containers with the manufacturer's name clearly shown. All coatings shall be applied by skilled labour under supervision of a competent foreman and to the satisfaction of the Engineer. No bituminous coatings shall be applied until the concrete has been cured as specified and prior approval of the Engineer has been obtained.

1.7.17.2. Preparation of Surface

Before the application of any coating or primer, the surface of the concrete shall be thoroughly cleaned of all dirt, curing compound, dust and loose material and, where necessary, the surface shall be made good so that it is smooth and free from air or water holes. The surfaces of the concrete shall be dry before application of the first priming coat. No bituminous coating shall be applied until the Engineer has approved the preparatory work. The Contractor shall ensure that the required quantity of paints and coatings are on Site prior to commencing work so as to avoid interruptions during the execution of the work.

1.7.17.3. Application

No paint, bituminous coating or primer shall be applied until the surface to be treated has been approved by the Engineer. After the application of a particular coat, the surface shall be approved by the Engineer before the next coat is applied.

(a) Priming Coat:

The priming coat shall be applied and well brushed into the concrete and allowed to dry.

(b) First Coat:

A heavy brush coat shall be applied in one direction and allowed to dry.

(c) Second and Subsequent Coats:

A heavy brush coat shall be applied at right angle to the previous coat and allowed to dry.

(d) Number of coats:

A minimum of two coats of bitumen excluding the priming coat shall be applied to concrete and other surfaces unless otherwise ordered by the Engineer.

(e) Holidays or Skips:

The applying of any layer or coating shall be done in such a manner that no holidays or skips shall occur on any treated surface.

(f) Quantity and Curing:

The application rate for the primer and subsequent coats shall be not less than 0.5 kg per square metre of surface. Each coat shall be thoroughly dry before applying a subsequent coat and shall be considered as dry when no staining occurs on a wet finger which is rubbed vigorously over the coating. No coating shall be immersed in water for at least seven days after it had been applied on the surface.

1.7.17.4. Coating Underside of Structures

The underside of concrete structures in water logged ground shall be protected by the application of bituminous coating to a layer of cement sand mortar of minimum thickness 20 millimetres.

The cement sand mortar shall be constructed on top of the blinding concrete and when it has been properly cured and hardened; the bituminous coating shall be applied prior to laying the structural concrete.

1.8. Steel Reinforcement

1.8.1. Types, Quality and Storage

Steel reinforcement for concrete shall consist of steel bars or steel wire fabric, except where otherwise shown. Steel bars shall consist of deformed and/or mild plain round steel bars in accordance with BS 4449. Steel wire fabric reinforcement shall be in accordance with BS 4483. All steel wire fabric shall be delivered in flat sheets.

All bar reinforcement shall be hot rolled deformed bars except for column ties, beam stirrups, ligatures or other minor items which may be from plain bars.

If requested the Contractor shall prepare test specimens of steel reinforcement to be used in the Works. Test specimens shall be taken in the presence of the Engineer and shall be of a size sufficient to carry out the tests as described below. They shall be tested in an approved laboratory and the certified copies of the results of the tests shall be submitted to the Engineer. The specimens shall be tested for bending and tensile properties and the wire fabric also for weld shear strength. The methods and requirements for testing shall be carried out in accordance with BS 4449 and BS 4483. No steel reinforcement shall be used in the Works until the testing results have been approved by the Engineer. If ordered by the Engineer, test procedures shall be repeated at the Contractor's expense for any new supply of reinforcement during the course of the Works.

Strength of Reinforcement bars

- Hot rolled mild steel round bars – complying with BS 4449 - characteristic strength 250 N/mm²
- High yield steel (hot rolled or cold worked deformed bar type 2) complying with BS 4449 or BS 4482 –characteristic strength 460 N/mm²

Welded Steel Wire Fabric shall conform to BS 4483.

The Tie Wire shall conform to BS 4482 – 1.6 mm black annealed mild steel

Representative samples of all reinforcing steel that the contractor proposes to use in the Works must be submitted, before the work commenced, to the Engineer for his written approval. Manufacturer’s certificates which shall be submitted shall clearly state Place of manufacture, All relevant details of composition, manufacture, strength and other qualities of steel.

Frequency of sampling and method of quality control shall be in accordance with Appendix C of BS 4449.

Welding if approved by the Engineer in writing shall conform to AWS D 1.4 or BS 5135.

Bar Size Table

Nominal Diameter (mm)	Weight (kg/m)
6	0.222 Round (Plain)
8	0.395 Round (Plain)
10	0.617 Deformed
12	0.888 Deformed
16	1.579 Deformed
20	2.466 Deformed
25	3.854 Deformed
32	6.313 Deformed

Reinforcing bars will be rejected if the weight of a bundle of one size of bars as delivered is underweight by 3.5 percent or more. An individual bar will be rejected if it is underweight by 6.0 percent or more.

Storage of reinforcement shall be on racks or supports clear of the ground. Different types and sizes of reinforcement shall be kept separate.

1.8.2. Bending and Cutting Schedules

Cutting and bending of reinforcement shall be in accordance with BS 4466.

The Contractor shall prepare for his own use bar bending schedules and bar lists, cutting schedules and sheet lists for wire fabrics for each individual structure and shall be responsible for ensuring that correct information is given when ordering reinforcement. If requested copies of these schedules, lists and orders shall be submitted to the Engineer for his approval. Steel bar supports shall be included in the bending schedules.

1.8.3. Protection and Cleaning

Reinforcement shall be protected at all times from damage, and when placed in the structure shall be free from dirt, loose mill scale, rust scale, paint, oil, or other foreign substance. All reinforcing steel shall be carefully cleaned of all set or partially set concrete, shutter oil or paint which may have been deposited during the construction of adjacent works.

1.8.4. Bending of Bars

Steel reinforcement shall be cut from straight bars free from kinks and bends or other damage and shall be bent cold by experienced competent workmen. Bars shall be bent in a bending machine designed for the purpose and approved by the Engineer. Any reinforcing bar that had already been bent shall not be re-bent at the place of the previous bend.

1.8.5. Cutting of Wire Fabrics

Wire fabric reinforcement shall be cut straight from the sheets. Cutting of sheets shall be done in such a way as to limit the loss of material. The use of off-cuts in the Works will not be permitted.

1.8.6. Lapping of Bars and Wire Fabrics

Unless otherwise specified, lap length of bars shall be at least forty two (42) times the diameter of the larger bar, and laps shall be positioned in a staggered pattern.

Laps on adjacent sections of wire fabrics shall generally be carried out as follows:

- End to End by lapping the two pieces one full mesh (measured from the ends of the longitudinal wires in the other piece) and securing the two pieces together with wire ties placed at intervals of about 450 mm.
- Side by Side by placing the two selvage wires (the longitudinal wires at the edges of the fabric) one alongside and lapping the other, and by securing the two pieces together with wire ties placed at intervals of about 900 mm.

No welding of reinforcement shall be carried out unless authorised by the Engineer. All welding procedures shall be subject to prior approval of the Engineer in writing.

1.8.7. Fixing of Reinforcement

All reinforcing steel shall be accurately placed and fixed in position and retained in that position during the placing of the concrete.

Correct positioning will be achieved with the use of steel bar supports, blocks, ties, hangers or other approved supports. Spacer blocks for holding the reinforcement from contact with the forms, or adjacent reinforcement, shall be of dense precast concrete blocks of approved shapes and dimensions. The blocks shall be fitted with a semi-circular hollowing and double bent poured-in binding wires. The water-tightness of these blocks must be at least similar to the concrete into which they are concreted. The use of pebbles, pieces of broken stone or brick or other materials will not be permitted. Steel shall be bound and tied in its correct position using steel wire. Apart from any other requirement, the reinforcing steel shall be fixed in such a manner that it will support its own weight and any loads which may be

imposed upon it during construction without displacement, deflection, or movement of any kind.

In slabs provided with two or more layers of reinforcement the parallel layers of steel bars shall be supported in position by the use of steel chairs (eg steel bar supports). Spacer blocks shall be placed at each chair to support the layers of reinforcement from the blinding concrete or shuttering.

Concrete cover to the nearest reinforcement shall be exclusive of plaster or other decorative finish and blinding concrete.

The distance between any two parallel bars except at laps shall not be less than 5 mm greater than the nominal aggregate size or 25 mm or the diameter of the larger bar whichever is the greater.

All reinforcement projecting from construction joints or likely to be exposed to the weather for long periods before concreting is commenced, shall be covered with polythene, blinding tape, or cement grout in order to prevent excessive rusting or staining of the surrounding concrete. Should in spite of these precautions rust staining occurs on any permanently visible surfaces, it shall be removed at once to the satisfaction of the Engineer.

Reinforcement shall be installed with clearance for concrete coverage in millimetres as follows:

Foundation bottoms cast against a layer of blinding concrete	75 mm
Formed surfaces in contact with soil or exposed to the weather or water	50 mm
Columns, beams and walls	40 mm
Top and Bottom steel of interior slabs	25 mm
Top and Bottom steel of internal Stairs	25 mm
Top steel in reservoir slabs	50 mm
Bottom steel in reservoir slabs	50 mm
Columns and beams in reservoir interior	50 mm
Interior face of walls in reservoirs	50 mm

All slab reinforcing shall be supported on concrete cubes or wafers of the correct height. Wafers shall contain soft steel wires embedded therein for fastening to reinforcing. Wafers shall have a minimum compressive strength equal to that of the concrete in which they are to be placed, and shall have been cured as specified for concrete. Masonry units will not be permitted for supporting steel in bottom mats or elsewhere. For supporting the top steel in slabs, the Contractor shall furnish extra steel supports such as channels if required and shall construct blocks of concrete having the same quality as specified for the structure for use in supporting both top and bottom mat steel. Wood blocks, stones, brick ships, cinder blocks, or concrete building blocks will not be allowed. Alternate methods for supporting top steel in slabs, such as vertical reinforcing fastened to bottom and top mats, may be used if approved.

Alternate methods of supporting bottom reinforcement for slabs and beams not exposed to the weather (such as plastic chairs, but not plastic tipped wire) may be used only if specifically approved by the Engineer.

Reinforcement for vertical surfaces (beams, columns, walls) shall be properly and firmly positioned away from the forms at all points by approved means.

1.8.8. Approval before Concreting

All reinforcement, after having been fixed in position, shall be inspected and approved by the Engineer before any concrete is placed. Any concrete placed contrary to this requirement shall, if ordered by the Engineer, be removed together with the reinforcement and replaced by the Contractor at his own expense.

1.9. Pre-cast Concrete Units

1.9.1. General

The Contractor shall submit drawings and calculations to the Engineer for approval.

Precast concrete units shall be manufactured either on the site or in a concrete factory approved by the Engineer.

All precast concrete units shall have the date of casting and identification number engraved on them before the concrete is fully hardened. Any undated units shall be rejected by the Engineer. The Contractor shall cure and protect the units after fabrication.

Transportation of the units to the site shall be permitted only on one of the following conditions:

- 28 days after fabrication, or
- after the required compressive strength specified in the Table of Designed Concrete Mixes has been reached.

Where the installation of precast concrete units in any particular structure is such that the faces of the units are to be left exposed either internally or externally, the exposed surfaces of the units as finished shall be uniform in colour and in texture. All cement, aggregates and other materials used in the manufacture of the units shall be obtained from the same approved sources throughout the period of manufacture.

Concrete for precast units shall be placed and compacted by methods approved by the Engineer.

1.9.2. Concrete Quality and Tests on Concrete

The concrete used in the manufacture of precast concrete units shall comply in every respect with the concrete Specification and the Grade of Concrete required shall be in accordance with the requirements in the Table of Designed Concrete Mixes.

The design, mixing, testing, curing and quality control of the concrete used in precast units shall be in accordance with Section 1.6 of the Specification.

Shuttering and concrete finishes shall comply with Section 1.7 of the Specification.

1.9.3. Cast-in Parts

The cast-in parts, such as lifting lugs, fasteners, jointing materials supporting structures, etc. shall be fixed in position. Cast-in parts shall be free from rust, dirt or grease and shall be properly stored before using.

1.9.4. Transport, Storage and Erection

Precast units shall be adequately protected to preserve all permanently exposed surfaces and arises. The protection shall not mark or otherwise disfigure the concrete.

Transportation, storage and erection of the precast concrete units shall be done carefully and in such way as to avoid any damage and to keep the surfaces of the units free from dirt or other unwanted marks. Loading and unloading, storage and erection of the precast concrete units at the site shall be carried out by skilled labour and under supervision of a competent supervisor.

Any precast concrete unit which is found to be cracked, damaged or otherwise inferior in quality either before or after erection shall be rejected and shall be replaced by the Contractor.

1.9.5. Installation of Precast Concrete

All precast concrete units shall be laid, bedded, jointed and fixed in accordance with the required lines, levels and other details.

Dry-pack mortar where necessary shall be used for jointing or packing. The mortar shall be placed and packed in stages where possible from both sides of the space being filled using a hardwood stick hammered until the mortar is thoroughly compacted.

1.9.6. Manufacturing in a Factory

Precast concrete units may be manufactured in a factory approved by the Engineer and which is off the site. If the units are to be made in a concrete factory, then the Contractor shall give the Engineer full information, in advance concerning the name and address of the factory, details of the probable date of commencement of manufacture. The Contractor shall make the necessary arrangements for the Engineer to inspect the factory during working hours.

1.9.7. Work Programme and Method Statement

The Contractor shall submit to the Engineer for his approval, the Work Programme and Method Statement giving full details of his proposed method of carrying out all operations connected with the manufacture and erection of precast concrete units, which shall include the following:

- period required to produce the drawings and detailed calculations;
- dates of commencement of manufacturing of the concrete units;
- dates of delivery to site with the Specification for erection;
- sequence of erection and the period required for site erection works;
- a description of the types of casting bed, mould and shuttering for the various types of members;
- procedure for concrete casting and method of curing the concrete;

- procedure for transporting, handling, hoisting and placing of each type of precast concrete unit; and
- particulars of temporary supports as deemed necessary to ensure adequate stability during erection and to sustain the effects of construction loads, wind loads or other transient loads.

No commencement of works shall be permitted until the programme and method statement have been approved by the Engineer.

1.10. Pipe Materials

1.10.1. General

1.10.1.1. Scope of Work

The Contractor shall furnish all pipes, fittings, adaptors, valves, hydrants and other materials of the various sizes and diameters, complete with jointing materials in accordance with these specifications.

All pipes fittings and valves shall be in every respect suitable for storage, installation, use and operation in the condition of temperature and humidity appertaining in Sri Lanka. The temperature of the water to flow in pipelines will be about 30 °C.

Pipes and pipeline components, including their protective coatings and joint materials, that will or may come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discoloration of the water and shall be approved by a recognised certifying authority as being suitable for use in portable water supply schemes.

The materials to be furnished under this Contract shall be the product of a manufacturer who has designed and manufactured similar materials having a record of successful operation. The Contractor may be required to submit the evidence to this effect together with a representative list of overseas supply consignments of the manufacturer.

All pipes, fittings, valves, hydrants and accessories furnished shall be new and from a current manufacturer. A certificate from the manufacturer stating that the materials furnished are new and out of a current manufacture shall be furnished to the Engineer.

1.10.1.2. Affidavit of Compliance

The Contractor shall provide the Employer with an affidavit in quadruplicate from the manufacturer that the pipes, valves, fittings, meters and any other products or materials furnished under the Contract comply with all applicable provisions of these specifications.

The Contractor shall also produce the certificates to the effect that the items supplied comply with the relevant BS/BS EN ISO 9000 series of quality standards.

1.10.1.3. Rejection

Material that fails to conform to the requirements of the specifications will be rejected and the Contractor will be notified accordingly by the Engineer.

1.10.1.4. Shop Coating and Lining

The Contractor shall supply all labour, material and equipment for the preparation of surfaces and the shop application of protective coatings and linings specified under each section. The Contractor shall furnish a manufacturer's certificate of compliance for each coating or lining material prior to its use in the work. The certificate shall include material identification, quantity, batch number, and date of manufacture.

Coating, where not specified will be selected by the Engineer from manufacturer's samples submitted by the Contractor.

1.10.1.5. Marking

Each pipe and fitting shall be legibly and durably marked with the following:

- Name of the Employer as “NWSDB”
- Material of pipe indicated as “DI”
- Nominal Diameter or size
- Year of Manufacture
- Class designation
- Reference Standards such as BS, AWWA, DIN or ISO
- Manufacturer's identification mark – Brand Name
- Pressure rating of flange
- Angle of bends in degrees
- Socket penetration lines of each pipe with push-in joints

All markings shall be of a permanent nature.

The manufacturer's name or identification marks shall be engraved embossed/cast on the socket/flanges of all Ductile Iron and Steel pipes, fittings and accessories.

In addition to what is specified in Standards, all pipes, specials and fittings shall be legibly and indelibly with details as follows.

Item	Diameter (mm)	Details required	Height of Lettering (mm)
Pipe Lengths (at intervals not more than 3 m)	above 350	“NWSDB”; Pipes standard (SLS or other); Class type; Nominal dia.	50
	150 to 350 (both inclusive)	as above	25
	50 to 150	as above	10
	below 50	as above (except “NWSDB”) “NWSDB”	05 10
Fittings & Specials	above 350	“NWSDB”; Pipes standard; Class type, Nominal dia.	25
	150 to 350	as above (except “NWSDB”) “NWSDB”	10 25
	50 to 150	as above	10
	below 50	as above (except “NWSDB”) “NWSDB”	05

Item	Diameter (mm)	Details required	Height of Lettering (mm)
Manhole Covers	All sizes	“NWSDB” Standard; Class type; Size	50
Surface Boxes	All sizes	as for manhole covers	20

1.10.1.6. Packing

All pipes and fittings, valves and specials and all other products shall be packed in such a manner as to prevent damage in ordinary handling and transportation. Each box, bundle or crate shall be legibly marked identifying the contents, and giving the name and address of manufacturer, name of the project **consignee "NATIONAL WATER SUPPLY & DRAINAGE BOARD, SRI LANKA"**, and date of dispatch.

Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100 Kg. Gross weight. Joint rings and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket. Each box and package therein shall be clearly labelled stating the number, size and description of the contents.

1.10.1.7. Transporting and Handling

The Contractor shall provide protection, to the approval of the Engineer, for the ends of all pipes and fittings prior to the pipes and fittings leaving the place of manufacture in order to guard effectively against damage during transit and storage and the ingress of foreign matter inside the pipes and fittings.

In handling pipes and fittings every care shall be taken to avoid distortion, flattening, denting, scouring or other damage. Pipes and fittings shall not be allowed to drop or strike objects and shall be lifted or lowered from one level to another by means of approval equipment only.

When required pipe and fittings shall be lifted by means of a mechanical forklift, or similar equipment, belt slings shall be applied at the correct lifting points along the length of the pipe section, with tackle suitably padded to prevent damage to the coating.

Pipes and fittings that is damaged during transportation, handling or stockpiling shall be satisfactorily repaired. If the damage to any pipe or fitting is serious or beyond the capability of repair in the field, the contractor shall replace it with new one.

1.10.1.8. Storage and Security

All pipes, fittings, valves, hydrants and appurtenances shall be stored at sites in or around Project Area approved by the Engineer in accordance with the manufacturer's recommendations until they are incorporated in pipe laying work. The Contractor shall be responsible for providing security including fencing, watching and lighting for the materials at his own cost.

Pipe shall be stockpiled on timber cradles on level ground, in such a manner as will prevent damage to any part of the pipe. During stacking and removal operations, safe access to the top of the stack is essential. Stacking types and the maximum stacking height shall be in accordance with manufacturer's recommendation or comply to BS 8010 Section 2.

1.10.1.9. Submittal

The Contractor shall submit to the Engineer and obtain approval before starting the works the manual for handling, storage, installation, maintenance and repair, test report on materials to be used for manufacture and shop drawings giving complete dimensions of all pipes and fittings.

1.10.1.10. Material Reconciliation Schedule

Upon completion of the work the Contractor shall submit to the Engineer a materials reconciliation schedule in respect of the materials supplied under Supply Bills. The schedule shall give the following detailed for each item:

- (a) Quantity ordered – According to each and every supply bill items
- (b) Quantity Delivered - According to each and every supply bill items
- (c) Where used – According to each and every installation bill item
- (d) Quantity surplus and in good condition
- (e) Quantity surplus but partially complete cut or damaged and in repairable condition
- (f) Quantity surplus but damaged beyond repair
- (g) Quantity missing or lost

The Contractor shall collect and transport the surplus materials in (d) and (e) to a central location for inspection by the Engineer's Representative. Materials in group (d) shall be stacked separately. All material shall be in a reasonably clean state and each piece shall be marked with its item number for easy identification.

The Employer may accept some or all of the surplus materials for maintenance purposes. The Contractor shall load the materials to be taken into stock and transport and off-load them at the Employer's stockyards.

The Contractor will be paid under Supply Bills for all materials installed in the permanent works and those surpluses in good condition taken into stock.

1.10.2. Pipe Material

1.10.2.1. Ductile Iron (DI) Pipes and Fittings

(1). General

(i) Scope of Work

The Contractor shall supply ductile iron pipes and fittings in accordance with the specified herein, including all jointing materials.

(ii) Standard Specification Reference

The following standards are referred to:

BS/ BSEN

ISO 9000 Series Quality Assurance Standards

ISO 2531 Ductile Iron Pipes, Fittings, and accessories for Pressure Pipelines

ISO 4179 Ductile Iron Pipes for Pressure and Non-Pressure Pipelines -
Centrifugal Cement Mortar Lining General Requirements

ISO 6600	Ductile iron pipes centrifugal cement mortar lining (composition controls for freshly applied mortar)
ISO7005 (Part 1&2)	Metallic Flanges
ISO 8179	Ductile Iron Pipes - External Zinc Coating
BS EN 545	Ductile Iron Pipes, Fittings, accessories and their joints for water pipelines. Requirements and test methods.
BS EN 1563	Founding Spheroidal graphite cast iron
BS EN 1564	Founding Austempered ductile cast iron
BS 3063	Specification for Dimensions of Gaskets for Pipe Flanges
BS 4504 (Part 1)	Circular Flanges for Pipes, Valves, and Fittings
BS EN 1092	Flanges and their joints, circular flanges and accessories
BS 2494	Elastometric seals for joints in pipe work and pipelines.
ISO 4633/BS EN 681-1	Elastometric seals. Material requirements for pipe joints seals used in water and drainage applications
BS 3416.1991	Bitumen based coating for cold application.
DIN30674/BS 4164	Bitumen based hot applied coating materials for protecting iron and steel.
BS 4865	Dimensions of non-metallic gaskets for pressures upto 64 bar.
BS 8010	Part 1 Code of practice for pipelines on land: General
Part 2	Design, construction and installation
Part 2	Section 2.1 Ductile Iron.
BS 6076.1996	Polymeric film for used as a protective sleeving for buried iron pipes and fittings
BS 970	Wrought steel for mechanical and allied engineering purpose.
BS 1706	Method for specifying electroplated coatings of zinc and cadmium on iron and steel
AWWA C151	Ductile Iron Pipe, Centrifugally Cast in Metal Moulds or Sand-Lined Moulds, for Water or Other Liquids
AWWA C110	Ductile Iron and Grey Iron Fittings. 3 inch through 48 inch for Water and Other Liquids
AWWA C104	Cement Mortar Lining For Ductile Iron Pipe and Fittings for Water
AWWA C213	Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipeline.
BS GN 545	Ductile Iron Pipes, Fittings, accessories and joints for water pipelines.

Note: *The above Standard Specification or equivalent DIN Standards are applicable.*

(2) Manufacture

(i) General

Ductile iron shall conform to the material specification given in one or more of the standards listed in Clause 1(ii) except for the requirements stipulated herein. The pipe and fittings shall be manufactured in accordance with one or more standards listed in Clause 1. (ii) or any other national standard which is equivalent or superior to those quoted above except as stipulated herein.

(ii) Mechanical Properties

The mechanical properties of pipes and fittings shall be as follows:

Minimum Tensile Strength	420 N/sq. mm
Minimum Bending Strength	590 N/sq. mm
Modulus of Elasticity	14 to 18 x 10 ⁴ N/sq. mm

(iii) Hydrostatic Pressure Test

Ductile iron pipes and fittings shall have working pressure of 16 bar and shall be in accordance with ISO 2531 or with BS EN 545. The standard classes of pipes and fittings shall be as follows unless otherwise stated.

Socket & Spigot Pipes	K	9
Flanged Pipes & all other fittings except tees	K	12
Tees	K	14
Flanges	PN	16

Each pipe and fitting shall withstand the working hydrostatic test pressure given below:

Nominal Diameter (mm)	Hydrostatic Test Pressure (bar)	
	Pipe	Fitting
80 to 300	50	25
350 to 600	40	16
700 to 1000	32	10
1100 to 1200	25	10

(iv) Fitting Compatibility

The Contractor shall supply the fittings manufactured by the same manufacturer of pipes, using the same kind of material and compatible standards.

The Contractor shall also ensure the dimension compatibility of pipes, fittings and couplings.

(v) Joints

Joint types shall be meet the following requirements.

- Flexible Joint (Push-In Joints)

Except where flanged joints are required, standard pipes and fittings for pipelines of ductile iron shall be supplied with push-in socket and spigot joints similar to joint type A.1 illustrated in BS 8010: Part 2 : Section 2. The material of the joint rings use shall be in accordance with the requirement of BS 2494:1990 type W.

Where pipes and fittings are not available with this type of joint, they shall be supplied with mechanical type flexible joints of the bolted gland type. Glands, bolts, and nuts for mechanical joint shall be of ductile iron having the same mechanical properties as the fittings.

- Flange Joint

PN 16 pressure rated flanges shall be raised faced and shall conform to the requirements of BS 4504 Part 1 (or to ISO 2531 or BS EN 1092 or equivalent DIN standards which are compatible with BS 4504 Part 1 for the same nominal diameters)

The flanges of all fittings including Tees shall be integrally casted with the fitting. The flanges of Flanged pipes may be screwed, welded or integrally cast with the pipe unless otherwise stated. "Welded" means that the flanges should be welded to the pipes at the point of manufacture under factory conditions, with inspection agency certification.

All bolts to be supplied with flanges shall be of high tensile steel to the approval of the Engineer. Flanged joints shall be complete with all nuts, bolts, gaskets and two washers per bolt. Protection of all bolts, nuts, washers etc. and the joint as a whole shall be covered with Denso or equivalent paste, primer, mastic, tape and PVC or polyethylene outer wrapping.

Gaskets for flanges shall be inside bolt circle type, with dimensions complying with BS 4865 Part I, and be manufactured from material complying with BS EN 1514, BS 2494 : 1990 Type W listed in the Directory of the Water Research Centre, UK or equivalent.

The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, including where connections are required to pipe work and valves associated with pumping plant and inlet/outlet pipe work at service reservoirs or other structures.

- Restrained Self Anchoring Joints

The design of restrained joints shall comply with ISO 10804.

- Slip-on Coupling and Flange Adaptor

Bolted sleeve type couplings, stepped couplings and flange adaptors may be used for connecting plain ended steel, ductile iron, grey iron, uPVC and other rigid or semi-rigid pipe materials, subject to approval of each type by the Engineer. Couplings, etc. shall be designed and manufactured in accordance with AWWA C219 "Bolted, Sleeve-type Couplings for Plain-end Pipe" except that elastomeric gaskets shall comply with BS EN 681-1.

Couplings included in this section will effect a connection between two pipes of either the same pipe materials, or of two different pipe materials, at the same nominal bore. Couplings and flange adaptors shall be manufactured from one of the following materials:

Carbon steel :	BS EN10025 Grade Fe 430A, or equivalent DIN Standard or ASTM A283 grade C
Malleable Cast Iron	BSEN 1562:Grade B35-12, or equivalent DIN Standard or ASTM A47 grade 32510 or 35018
Ductile Iron	BS 2789 Grade 420/12, or equivalent DIN Standard or ASTM A536 65-45-12

Gaskets shall be of elastometric conforming with the requirements of BS 2494 Type W. Gasket shall have a hardness rating of 80IRHD to prevent gasket extrusion at the bottom tolerance of the fitting. All gaskets shall have identification to detail size range, mould number compound and year and quarter of manufacture.

Nuts, bolts and tee bolts for fasteners shall be manufactured from alloy or carbon steel conforming to BS 970 Part 1 grade 070 M20.

Bolts shall be restrained against rotation by means of "D" shaped necks, which will locate in similar "D" shaped holes in the end rings to facilitate single spanner operation. Washers shall be provided to prevent damage to the coating of the fittings.

Centre sleeves, end rings and flange adaptors bodies shall be coated with Rilsan Nylon 11 coating, to a uniform minimum thickness of 250-300 microns, having been shot blasted and suitably primed prior to application of coating, maintaining the minimum thickness throughout the fitting. Holding points shall be touched in with the appropriate Rilsan repair coating.

Fasteners shall be electroplated to BS 1706 grade Zn10 or equivalent followed by a suitable primer and then with a coating of Rilsan Nylon 11 to a uniform thickness of 60 - 120 microns.

Flange adaptors for jointing flanged specials to plain-ended pipes shall conform to the foregoing contents of this clause. Prior to the commencement of the manufacture the Contractor shall submit to the Engineer for approval detailed drawings of all couplings and flange adaptors.

When harness is specified with coupling or flange adaptor, the harnessing shall be provided as recommended by the manufacturer of couplings or flange adaptors. Harness joint shall be designed and manufactured to withstand for the pull-out force caused by the internal pressure of 16 bar at the joint.

(vi) Length of Straight Pipes

Length of straight pipes shall conform to the requirements in ISO, BS, or AWWA to be applied. Pipes longer than specified may be used in accordance with the recommendation of the manufacturer. However, it shall be the sole responsibility of the Contractor to examine the difficulties he is likely to face in transporting, storing, handling and installing such longer length pipe. While ordering the pipes the Contractor shall ensure the possibility of negotiating the horizontal and vertical bends as shown in the drawing.

Three percent of all straight pipes shall have applicable external diameter to the joints for full length of barrel and shall be suitable for usage by cutting at sites. Such pipes shall be clearly marked.

(3) Coating and Lining

(i) External Coating

Pipes and fittings shall be externally coated with metallic zinc and bitumen paint conforming to BS EN 545 or ISO 8179, which shall not contain any constituent soluble in water or any ingredient liable to leach in water after drying. The coating shall have good adherence to the pipe and fittings and not scale off. Thickness of the coating shall not be less than 70 microns.

(ii) Internal Lining

Internal surface protection shall be either of:

- (a) Cement mortar lining, or
- (b) Fusion-bonded epoxy coating

(a) Cement Mortar Lining

Pipes and fittings shall be internally lined with cement mortar using ordinary Portland cement conforming to BS12 or Sulphate resisting cement confirming to BS 4072. The thickness of lining shall be as follows:

Pipe Nominal Diameter (mm)	Thickness of Lining (mm)	
	Nominal	Minimum
80 to 250	4	3
300 to 600	6	5
700 to 900	8	6
1000 to 1200	10	7

Inside of socket shall be free of cement mortar lining and shall be coated with the material used for external coating. Internal lining shall be done in accordance with BS EN 545, ISO4179, AWWA C104, or equivalent.

(b) Fusion-bonded Epoxy Coating

Fusion-bonded epoxy coating for ductile iron pipes shall conform to AWWA C213 or equivalent.

Material shall consist of a one-component powdered fusion-bonded material composing of epoxy resin, hardener, and fillers. Composition of epoxy resin hardener shall not be less than 55 percent in weight. The standard film thickness shall not be less than 300 microns except for the socket portion where the minimum film thickness shall be 100 microns.

The physical properties of coating shall satisfy the requirements of ANSI/AWWA C213 or equivalent. ANSI/AWWA requirements are shown below:

Item	Requirement	Test Method	
i.	Impact	Min. 1.1 kg-m	AWWA C213
ii.	Bendability	Pass	AWWA C213
iii.	Appearance	Pass	AWWA C213
iv.	Shear adhesion	Min. 210 kgf/sq. cm	ASTM D1002
v.	Penetration	Less than 10 %	ASTM G17
vi.	Abrasion resistance (5000 cycles-gm loos)	Max. 0.3	ASTM D1044
vii.	Cathodic disbondment area	Max. 9.7 sq. cm	ASTM G8
viii.	Hot water resistance	Pass	AWWA C213
ix.	Water extractable	Max.0.078 mg/sq. cm	AWWA C213
x.	Taste and odour	Pass	AWWA C213

Should the coating fail to satisfy the requirements of the tests or the coating be damaged, the defective or damaged area shall be repaired by using a two-component liquid type epoxy paint.

(4) Special Protections

(i) Polythene Sleeving for Aggressive Soil Conditions

The Polythene sleeving supplied shall conform to BS EN 545 or BS 6076 specifications by the manufacturer for the particular DI pipe. The Contractor shall furnish all the relevant technical specifications of the sleeving he intends to use in the works to the Engineer for approval, before the sleeves are used.

The sleeves supplied shall include necessary adhesive tapes and any other material that may be required for the purpose.

(ii) Tape Wrapping for Highly Aggressive Soil Conditions

The tape wrap shall be self adhesive bituminous rubber compound providing self sealing joints at over laps and shall be high resistance to cathodic disbondment. Site application shall be conforming to the recommendations of the manufacturer. The Contractor shall furnish all the relevant technical specifications of the tape wrap he intends to use in the works to the Engineer for approval, before use.

1.10.2.2. Un-elasticised Polyvinyl Chloride (uPVC) Pipe and Fittings

(1) General

(i) Scope of Work

The Contractor shall supply polyvinyl chloride pipes and fittings in accordance with the specified herein.

(ii) Standard Specification References

The following standards are referred to:

SLS 147:1983 Specification for Rigid Unplasticized Polyvinyl Chloride Pipes for Potable Cold Water Supplies

BS 3505:1986/	Specification for Unplasticized Polyvinyl Chloride pressure pipes for EN 1452 – 2 cold portable water
BS 4346	Joint and fittings for use with Unplasticized PVC pressure pipes
EN1452-3	
BS 2494	Materials for Elastomeric Joint Rings for Pipe work and Pipelines
EN 681-1	
BS 4504	Circular Flanges for Pipes, Valves, and Fittings
ASTM F 477	Specification for Elastomeric Seals for Joining Plastic Pipe
ASTM K 138	Rigid PVC Pipe for Pressure and Non-pressure Applications
JISK6353 (or equivalent)	Rubber Goods for Waterworks
JISK 6380 (or equivalent)	Rubber Packing Material for Industrial Use
JIS K 6720 (or equivalent)	Polyvinyl Chloride
JISK 6741(or equivalent)	Unplasticised Polyvinyl Chloride Pipes for General Use
JISK 6742 (or equivalent)	Unplasticised Polyvinyl Chloride Pipes for Waterworks
JISK 6743 (or equivalent)	Unplasticised Polyvinyl Chloride Pipe fittings for Waterworks

(2) Materials

Unless otherwise specified, pipes shall be rigid, unplasticised polyvinyl chloride conforming to SLS 147:1983, or DIN/EN 1452 - 1.

Pipes shall be furnished in standard laying lengths of 6m and shall be grey in colour.

Pipes shall be designed for a minimum working pressure of not less than 6 kgf/sq. cm or 6 bars for type 600 pipe, and 10kgf/sq.cm or 10 bars for type 1000 pipes at a temperature of 29 °C. All fittings shall have the same characteristics and strength as the connecting pipes. Fittings shall be confirm to BS 4346 Part 1 and Part 2.

Fittings made of polyvinyl chloride shall be manufactured by a heat injection moulding machine or extruded machine. Fittings fabricated by heat-fusion or solvent-cement technique are not acceptable.

(3) Joint

Unless otherwise specified, joints for underground pipe 110 mm and larger shall be push-in type using rubber gaskets.

Unless otherwise specified, joints for underground pipe and bends of 90 mm and 63 mm shall be welded using solvent cement. Other fittings of 90 mm and 63 mm shall be push-on type using rubber gaskets.

Unless otherwise specified, joints for all exposed pipes and for pipes smaller than 63 mm shall be welded using solvent cement.

All joints shall be designed to have the same characteristics and strength as the connecting pipe.

(i) Push-in Type

The pipe ends shall be integral bell-end type at one end and plain end at the other end. The bell-end section shall be designed by the manufacturer.

One neoprene gasket shall be furnished with each standard length of pipe and fitting.

The neoprene rubber gasket shall be manufactured in conformity with BS2494, or ASTM F477, or DIN/EN 681 – 1.

(ii) Welding Type

The bell-end section shall be designed by the manufacturer.

Solvent cement shall be confirm to BS 4346 Part 3 or SLS 935, 1991. Solvent cement shall be mixed in strict accordance with the manufacturer's instructions. Any impurities in the cement shall be a cause for rejection. Data on the pot life of the solvent cement shall be approved by the Engineer.

(iii) Flanged Joint

Flange joint shall be flange adapters as to confirm to BS 4346 Part 2:1970 or DIN/EN 1452 - 3.

(4) Coating

Fitting made of cast iron shall be coated internally with non-toxic epoxy resin of not less than 100 microns (4 mils) and externally with coal tar epoxy of not less than 200 microns (8 mils) after the hydrostatic test has been carried out.

(5) Testing

Pipe and fittings shall be tested in accordance with DIN/EN 714, or DIN/EN 715 or equivalent.

Each standard length of pipe and each fittings shall be tested under an internal hydrostatic pressure of not less than 12 kgf/sq. cm for the duration of 60 seconds.

The Contractor shall furnish copies of certificates of tests carried out for quality control during manufacture of the pipe in accordance with Section 7.2 of SLS 147:1983 and Appendices A to E of BS 3505:1986 and shall if required by the Engineer undertake such additional tests as he considers necessary.

1.10.2.3. Steel Pipe (SP) and Fittings

(1) General

(i) Scope of Work

The Contractor shall supply steel pipes and fittings in accordance with the details specified herein, including gaskets and other jointing materials and pipe adapters necessary for connections to Ductile Iron piping. All pipes shall be designed for maximum working pressure of 16 kg/cm² unless otherwise specified. Where specified, prior to completion of the work the Contractor shall supply additional materials for maintenance by the Employer as specified in the Bill of Quantities.

(ii) Standard Specification References

The following standards are referred to.

BS 4504	Circular Flanges for Pipes, Valves, and Fittings
BS 534-1990	Steel pipes, joints and specials for water and sewage.
BS 4515	Welding of steel pipelines on land and off shore
AWWA C104	Cement Mortar Lining for cast-iron and Ductile-Iron Pipe and Fittings
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
AWWA C205	Cement-Mortar Lining for Steel Water Pipeline
AWWA C206	Field Welding of Steel Water Pipe Joints
AWWA C208	Dimensions for Steel Water Pipe Fittings
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C602	Cement Mortar Lining of Water Pipelines 4 inch (100 mm) and larger - In Place
AWWA Manual	Steel Pipe Design and Installation M11
ASTM A185	Welded Steel Wire Fabric for concrete Reinforcement
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality
ASTM 307	Carbon Steel Externally Threaded Standard Fasteners
ASTM A570	Hot-rolled Carbon Steel Sheet and Strip, Structural Quality
DIN 17100	Rolled Steel for General Structures
DIN 2444	Fittings of Coating Steel Pipe for Water Service
DIN 2458	Arc Welded Carbon Steel Pipes
JWWA A109	Mortar-Lining of Steel Pipes for Water Works

(2) Materials and Fabrication

(i) Pipes

Steel pipes shall be fabricated from steel sheets or plates and shall be arc welded or electric – resistance welded, shop fabricated, tested and cleaned. Steel sheets or plates shall have a minimum yield point not less than 2,300 kgf/cm² (226 N/mm²) and shall conform to the following standards.

DIN 1700
DIN 2444
DIN 2458
ASTM A 283, Grade D
Or ASTM A 570, Grade 33

The Fabrication of Steel pipe shall be in accordance with AWWA C 200 or BS 534. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means except that with the approval of the Engineer, manual welding by a qualified procedure and welder may be used.

All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt-welded. The maximum allowable number of shop seams shall be one longitudinal seam and three girth seams per length of pipe. The length of pipe shall be six (6) metres or smaller unless otherwise specified.

The longitudinal shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe.

All pipe ends shall conform to the requirements specified in the Para 4 (Joints and Pipe Ends) of Section 1.10.2.3

(3) Dimensions

(i) Pipe Dimensions

The nominal pipe diameters shall be of the following outside diameters and minimum wall thickness before lining and coating.

TABLE 4.1 Dimension of Steel Pipe

Nominal Pipe Dia	Diameter	Outside Wall Thickness Unit (mm) (as minimum)
150	168.3 ± 1.6	3.5
200	219.1 ± 1.6	4.0
250	273.0 ± 1.6	4.8
300	323.9 ± 1.6	4.8
400	406.4 ± 1.6	5.2
500	508.0 ± 1.6	6.4
600	610.0 ± 1.6	7.1
700	711.0 ± 1.6	7.1
800	813.0 ± 1.6	7.1
900	914.0 ± 1.6	7.1
1000	1016.0 ± 1.6	8.7
	11001118.0 ± 1.6	9.5
1200	1219.0 ± 1.6	9.5

(ii) Fitting Dimensions

All steel fittings shall be of the same materials and fabrication, strength, outside diameter and wall thickness as that of pipes, and shall be provided with reinforcing rings and saddles on the exterior when and where required in accordance with AWWA Manual M11 to meet the specially high pressure.

The minimum wall thickness and outside diameter of fittings shall conform to the following standards or requirements specified in para (2) (a) above.

The dimensions of fittings shall conform to either AWWA C 208 (Table 1 and Fig. 1, and Table 2 A to 2 D and Fig. 2).

All steel fittings except bends having a deflection angle less than 5 degrees shall be shop fabricated. Bends having a deflection angle less than 5 degrees may be field fabricated from shop fabricated steel pipe by means of field cutting and welding.

Bends having a deflection angle of 22.5 degrees and smaller shall be two- piece bends. Bends having a deflection angle of over 22.5 degrees and up to 45 degrees shall be fabricated using three pieces. Bends having a deflection angle of over 45 degrees shall be four – piece bends.

(4) Joints and Pipe Ends

(i) General

All steel pipes and fittings shall be furnished with bevelled ends for welding unless otherwise specified. Steel pipe end (s) where specified shall be standard flange joint or plain end for sleeve coupling or others. All joints shall be designed to have the same characteristics and strength as the connecting pipe.

(ii) Flanged Joints

Pipes and fittings to be jointed by flexible coupling shall have the plain end.

Flanged joints shall be provided, where necessary. Flanges shall be made as seamless forging or cut and fabricated from steel plates and shall conform to BS 4504. Class of flange shall be PN16 unless otherwise specified.

Material for flanges, bolts and nuts shall be the same steel used for fabrication of steel pipes and fittings. Flanges shall be steel welding neck flanges, having a raised face attached to pipes or fittings by means of single butt-weld. All flanges shall be raised faced with bolt holes straddling the vertical axis of the pipes or fittings, and all gaskets shall be of at least 3.0 mm thick asbestos or neoprene, full face with bolt holes correctly sized and spaced. Flanges shall be supplied complete with the required size, quantity and quality bolts, nuts and gaskets. Unless otherwise particularly specified, all plate and neck flanges shall, in mating dimensions and drilling, conform to BS4504.

(iii) Bevelled end for Welding

Pipe ends for welded joints shall have bevelled ends. Ends for pipes in sizes 700 mm and under shall have bevelled ends to permit a “single-welded butt joint” from the outside of the pipe.

Ends for pipes in sizes 800 mm and over with a wall thickness of 15 mm and thinner shall have bevelled ends to permit a “single-welded butt joint” from inside of the pipe. Ends for pipes in sizes 800 mm and over with a wall thickness of 16 mm and thicker shall have bevelled ends to permit a “double-welded butt joint” from both the outside and inside of the pipe. Shape of the bevelled end shall be for ACE welding and in accordance with the manufacturer’s standard approved by the Engineer.

(5) Lining

Unless specifically noted otherwise, all steel pipe and fittings shall be epoxy or coal tar epoxy lined on the inside in accordance with AWWA C210.

The lining systems such as epoxy or coal tar epoxy shall be shop applied. They shall consist of the following:

(a) Epoxy System

- One (1) coat of liquid two-part chemically cured rust-inhibitive epoxy primer
- One (1) or more coats of a liquid two-part epoxy finish coat which contains no coal tar

(b) Coal Tar Epoxy System

- One (1) coat of liquid two-part chemically cured rust-inhibitive epoxy primer
- Two (2) coats of a two-part coal-tar epoxy finish coat

Primer and finish coat(s) shall be from the same manufacturer.

The epoxy lining system may alternatively consist of two or more coats of the same epoxy coating without the use of a separate primer. This alternative system shall conform to requirements of AWWA C210 and the first coat of this alternative system shall be considered as the primer.

The total dry film thickness of both coating systems shall not be less than 400 microns nor more than 600 microns.

(6) Coating

The outside coating for all pipes and fittings, excluding sleeve pipes, to be placed underground, shall be shop-coated and conforming to the followings:

(i) AWWA C203: "Coal Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot-applied" which shall consist of but not limited to, the followings:

- Coal-tar primer
- Coal-tar enamel 0.8 mm. Thick minimum
- Bonded asbestos-felt wrap or fibrous glass mat
- Coal-tar enamel 0.8 mm. Thick minimum
- Bonded asbestos-felt wrap
- Water-resistance white wash or Craft-paper finished coat.

or

(ii) BS534: "Specification for Steel Pipes, Fittings and Specials for Water, Gas and Sewage" which shall consist of but not limited to, the followings:

- Coal-tar primer
- Coal-tar enamel 0.8 mm. thick
- Glass tissue inner wrap
- Coal-tar enamel 0.8 mm. thick
- Coal-tar impregnated reinforced glass tissue outer wrap
- Water-resistance white wash or Craft-paper finished coat.

The above-ground pipe and fittings shall be shop-coated with one or more coats of non-breeding type coal tar epoxy followed by additional two or more coats of epoxy-resins Micaceous Iron Oxide (MIO) paint. The total uniform dry film thickness of non-breeding type coal tar epoxy coating shall not be less than 0.15 mm. while that of the MIO point shall be at least 0.06 mm. The method of surface preparation and coating shall conform to the manufacturer's standards and recommendations.

The exterior of sleeve pipe shall be coated with non-breeding type coal tar epoxy at the total uniform dry film thickness of at least 200 microns.

(7) Lining and Coating at Pipe Ends

(i) Bevelled Ends

Where shop lining is applied, at bevelled ends of pipe and fittings 600 mm and larger in diameter, both shop lining and coating shall have a cutback of 200 mm to facilitate field welding.

At bevelled ends of pipe and fittings smaller than 600 mm in diameter, only coating shall have a cutback of 200 mm, and lining shall be extended to the pipe ends.

All interior surface left as cutback at the bevelled ends shall be given Cement-Mortar lining conforming to AWWA C205 or JWWA A109 or equivalent DIN standards after jointing the pipe. All exterior surfaces left as cutback at bevelled ends shall be given:

- one shop coat of Type B coal tar primer conforming to AWWA C205 for underground buried pipe and fittings, or
- one shop coat of epoxy primer conforming to the paint manufacturer's standards for above-ground exposed pipe and fittings.

(ii) Plain Ends

At all plain-ends and shouldered-ends specially prepared for sleeve couplings and other flexible or expansion joints, only the coatings except primer shall have a cutback of required length for replacing the coupling or joint. The exterior area, which may contact with handling liquid, shall have the same coating as the pipe lining specified after removing the said primer completely. After setting couplings or joints, the remaining area, which has only the said primer and the exterior of couplings or joints, shall be finished with petrolatum corrosion protective tape, which will be specified hereinafter. The lining shall be extended to the pipe ends.

(iii) Flanged Ends

At all flanged ends, no cutback of lining and coating shall be provided.

For underground-buried pipe and fittings including those installed in concrete valve chambers, coal tar epoxy lining shall be extended to the entire flange surface.

For aboveground exposed pipe and fittings, coating system consisting of non-bleeding type coal tar epoxy and MIO paint as specified for aboveground exposed pipe and fittings shall be extended to the entire flange surface.

(8) Manufacturer's Mark

Each pipe and fitting shall bear the mark of the manufacturer; the nominal diameter; wall thickness; year of manufacture; the wordings "Steel Pipe" or "SP", and the owner's name "NWSDB". The marking shall be conspicuously painted in non-toxic paint on the inside of each section of pipe and each fitting.

(9) Shop Testing

(i) Pipe

Shop testing and inspection of the pipe shall be conducted in accordance with AWWA C200 in the presence of the representative of the Engineer. The minimum hydrostatic test pressure for straight pipe shall be determined in accordance with Section 3.4 of AWWA C200 using the design stress equal to 75 percent of the minimum yield point of the steel used. When approved by the Engineer, the hydrostatic test may be replaced by other appropriate non-destructive testing methods such as ultrasonic and/or radiographic testing methods.

During pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Pipes that show any leakage under test shall be re-welded at the points of leakage and subjected to further hydrostatic tests until satisfactory results are obtained.

(ii) Fittings

Upon completion of welding, but before lining and coating, each fitting shall be bulk headed and tested under the same hydrostatic pressure as for the pipe. Provided, however, that if fittings are fabricated from previously tested straight pipe, only those welding seams that were not previously tested in the straight pipe may be tested by means of ultrasonic or radiography method or other methods as approved by the Engineer, with no further hydrostatic test.

Any leakage and porous welds, which may be revealed by the test, shall be chipped out and re-welded and the fitting be re-tested until satisfactory results are obtained.

(10) Flexible Coupling

Flexible couplings to join the plain-ended pipes shall conform to the requirements as specified for couplings and flange adaptors for Ductile Iron Pipes in this specification.

(11) Harness Joint

The harness joint shall be provided where shown on the drawing. Steel plate for lugs shall have the same properties as the pipe. Tie rods shall be made of steel conforming to ASTM A307 "Carbon Steel Externally and Internally Threaded Standard Fasteners, Grade B" and shall be hot-dipped galvanised.

The dimensions of nut shall conform to BS4140 "British Standard Specification for ISO Metric Black Hexagon Bolts, Screws, and Nuts Normal thickness Nut Type".

1.10.3. Valves, Appurtenance and Equipment

1.10.3.1. Standard Specification References

The following standards are referred to:

ISO 9000 Series Quality Assurance Standards

AWWA C500	Gate Valves -3-Inch through 48-Inch for Water and Other Liquids
AWWA C504	Rubber Seated Butterfly Valves
AWWA C509	Resilient-Seated Gate Valves 3 through 12 NPS, for Water and Sewerage System
ASTM A108	Steel Bars, Carbon, Cold-Finished, Standard, Quality
ASTM A126	Grey Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A276	Stainless and Hot-Resisting Steel Bars and Shapes
ASTM A307	Carbon Steel Externally Thread Standard Fasteners
ASTM A320	Alloy-Steel Bolting Materials for Low Temperature Service
ASTM B62	Composition Bronze or Ounce Metal Castings
BS 750:1984	Underground Fire Hydrant and surface box frames and covers
BS 5150	Cast Iron Gate valves.
BS 5153	Cast Iron check valves
BS 5155	Butterfly Valves
BS 5163	Pre Dominantly key operated Cast Iron Gate Valves for Water Works Purposes
BS 4504	Circular Flanges for Pipes, Valves, and Fittings
BS 21	Pipe treads for tube and fittings where pressure type joints are made
BS 5728	Measurement of flow of cold portable water in closed conduits
BS 3100:1991	Steel casting for general engineering purpose
BS 970	Wrought steel for mechanical and allied engineering purpose
BS EN 1561	Grey cast iron
BS EN 1563	Founding. Spheroidal graphite cast iron
BS EN 1564	Founding. Austempered ductile cast iron
BS EN 124:1994	Gully tops and manhole tops for vehicular and pedestrian areas

1.10.3.2. Materials and Manufacture

All valves shall be from one manufacturer, unless approved by the Engineer in exceptional circumstances.

(1) Valves Ends

Valve ends shall be of flanged ends. Where flanged ends are used, mating dimensions and drilling shall be in accordance with BS4504. Class of flange shall be PN16 unless otherwise specified. Bolts and nuts shall be galvanised mild steel.

(2) Valve Marking

All valves shall have the direction arrow for opening; the name or mark of the manufacturer; the name of the Employer "NWSDB"; the valve size; year of manufacture; number of turns to open, and the working pressure for which they are designed cast in raised letters upon an appropriate part of the body. In addition, valves designed for one-way flow only shall have a direction arrow cast on the body.

(3) Interior Parts in Valves

All interior parts of valves manufactured of bronze (except valve stems) shall conform to the requirements of ASTM B62 or approved equivalent standards unless otherwise stated.

(4) Protective Interior Coating for all Valves

Ferrous surfaces in the water passages of the valves excluding those surfaces manufactured of corrosion resistant material) shall be non-toxic epoxy resin. The minimum coating thickness shall not be less than 100 microns.

(5) Protective Exterior Coating for Buried Valves

All buried valves shall be provided with an exterior protective coating against corrosive soil in accordance with JWWA or equivalent DIN standards K115 or BS 5163: 1974 or approved equivalent standard. The minimum coating thickness shall not be less than 200 microns.

(6) Valve Stem

The valve stem shall be stainless steel grade AISI 304.

(7) Direction to Closure

The valve shall be so constructed as to be closed by clockwise turning of the wrench nuts and valve operators and opened by counter clockwise turning.

(8) Underground Valves

All underground valves shall be furnished with surface boxes unless otherwise specified.

All underground valves shall be coated completely including flanges, all bolts and nuts except stem with Denso paste and primer, Denso mastic, Denso tape and PVC or Polyethylene outer wrapping.

(9) Spool Pieces

Testing and operation of the work is not to be delayed due to late delivery of valves. Contractor shall provide and install if required spool or spacer pieces equivalent in length and pressure rating to the valves to be installed in the work. The valves shall then be installed on arrival.

(10) Submittals

The Contractor shall submit manufacturer's certified drawings showing the principal dimensions, construction details and materials used for all parts of the valve and full details of valve stem extensions, including material, dimensions, fabrication, torque limits, method of connection to the valve and valve box and stem guides when required to avoid buckling.

(11) Maintenance Materials

The Contractor shall supply the following materials for use of the Employer as replacement parts for the valves furnished under this Contract in quantities of:

1) For every five (5) gate valves of the same size and type or fraction thereof:

- 1 set stem seal
- 1 pc stuffing box gasket with O-Ring
- 1 pc bonnet gasket with O-Ring
- 1 pc stem
- 1 pc operating nut

2) For every five (5) butterfly valves of the same size and type or fraction thereof:

- 1 pc shaft seal
- 1 pc rubber-sealing ring
- 1 pc thrust bearing
- 1 pc operating nut

3) For every five (5) fire hydrants of the same size and type or fraction thereof:

- 1 pc shaft seal
- 1 pc rubber-sealing ring
- 1 pc thrust bearing
- 1 pc operating nut
- 1 pc outlet stand pipe (1m high)

When each type of valve to be installed is less than five (5) sets, each one (1) set of the materials specified above shall be provided.

Costs of these maintenance materials shall be deemed to be included in the rate of each type of valve.

(12) Tee-Handle Valve Keys, Extension Spindles and Lifting Keys

The Contractor shall supply twenty four (24) tee-handle valve keys of sufficient length (inclusive extension spindles where required) for the operation of buried/below ground valves. The length of the key shafts shall vary according to the valve depths but shall project approximately one meter (1m) above ground level. Tee-Handle shall be of galvanised mild steel. The Contractor shall obtain Engineers prior approval before ordering these materials.

The Contractor shall also supply twenty four (24) lifting keys suitable for manhole covers and surface boxes.

1.10.3.3. Gate Valves (Resilient Seat Type)

(1) General

Valves 300 mm and smaller in diameter shall be gate valves (sluice valves) unless specified otherwise.

Gate valve shall conform to AWWA C500, BS5163, AWWA C509 or Equipment DIN Standards. Gate valves shall be cast iron or ductile iron body, non-rising stem with solid wedge designed for a minimum working pressure of 16 kgf/sqcm.

Gate valves specified as PN16 shall conform to BS5163 PN16 designed for a minimum working pressure of 16 bar.

(2) Materials and Construction

In general, the underground type valve and the aboveground type valve shall be of the same construction with the stem collar made integral with the stem and the hand wheel shall be

used instead of the wrench nut in case that the valve is the aboveground type. The valve shall be designed to be opened by counter clockwise turning and the arrow marks indicating the open and close directions shall be cast on the hand wheel or operating nut. Stem sealing shall be in accordance with BS5163.

Resilient seat shall be bonded to either the gate or valve body. If the resilient seat is rubber material, the method used for bonding or vulcanising shall be proved by ASTM D429 "Tests for Rubber Property-Adhesion to Rigid Substrates-Method A or Method B". For Method A, the minimum strength shall not be less than 11.0 kgf/sq. cm and when Method B is applicable the peel strength shall not be less than 5.3 kgf/sq. cm.

(3) Specific Requirements

The maximum effort required to operate the valve against the maximum unbalanced head, applied at the circumstance of the hand wheel or end of the tee-key shall not exceed 26 kg.

(4) Testing

Each gate valve shall be subjected to operation, hydrostatic and proof-of-design tests at the manufacturer's plant as specified in the standard of BS or AWWA as applied at the appropriate test pressure.

1.10.3.4. Butterfly Valve (Resilient Seated Type)

Standard butterfly valves shall conform to BS 5155 for PN 16 pressure rating or equivalent DIN Standards and shall give tight closure against unbalanced water pressure in either direction. The unbalanced water pressure shall be the design pressure rating of the valve.

The manufacturer's preferred direction of flow for the valve shall be clearly marked on it.

Valve shall be double flange cast iron or ductile iron resilient seated and shall be suitable for maximum velocity of 3 m/sec and for throttling service.

Valve body shall be designed to with stand the maximum working pressure specified and the maximum differential pressure of 0.6 Mpa. Minimum thickness of valve body shall be calculated with out exceeding a working stress equivalent to 20% of the tensile strength of the material used.

Valves shall be fitted with sleeve type bearings contained in the hub of the valve body and shall be equipped with either one or two trust bearings, which shall hold the valve disc securely in the centre of the valve. Sleeve and other bearings fitted in to the valve body proper shall be made of self lubricated material that do not have a harmful effect on potable water or resilient material.

Shaft shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs. If of "stub" construction, each stub shaft shall be inserted in to the valve disc hubs for a distance of at least 1.5 times the shaft diameter. Valve shaft shall be of high yield strength mantensitic series stainless steel such as type 403, 420, 431, and others and valve shafts made by precipitation series stainless steel also maybe acceptable. Allowable torsional sheer stress, not exceeding 25% of yield strength of material used shall be applied for design of valve shaft diameter.

A shaft seal shall be provided where shafts project through the valve bodies for actuator connection. Shaft seal shall be designed for the use standard V-Type packing; O-ring seals; O-ring loaded U-cup seals; or a pull-down packing. If O-rings are used, they shall be contained in a stainless steel or bronze removable recesses. If stuffing box and pull-down packing are used, the design of the valve and stuffing box assembly shall permit adjustment or complete replacement of packing without disturbing any part of the valve or actuator assembly except packing gland follower. Gland or gland assemblies shall be made of stainless steel or bronze. Packing shall be made of resilient, non-metallic material suitable for potable water service, which shall not contain asbestos.

The valve seat shall be replaceable and be formed of approved resilient material. Seats shall be of a design that permits removal and replacement at the site of installation. The valve seat shall be securely clamped into a machined groove in the valve body or to the edge of the disc by seat retention members or other equivalent retention device, in such a manner as to prevent leakage of water under the seats and to hold the seat securely in position during opening and closing of the valve disc. The seat retention members shall be of stainless steel and shall be securely fastened to the body or disc with stainless steel fasteners. When all the seat retention members are in place, the finished edges shall fit closely and the surface shall be smooth with all fastenings set flush in the water passage so as to offer the least resistance possible to the flow of water through the valve.

Valve seats which extend over the face of the flanges to secure the seat in place, or which require surface grinding and/or hand fittings of the disc; or designs which require the adjoining pipe flange to retain the seat in place and resist line pressure, shall not be supplied.

Valve disc shall be made of cast iron or ductile iron or stainless steel casting and shall be of design with no external ribs transverse to the flow. The design of disc shall with-stand full differential pressure across the closed valve disc without exceeding the working stress, equivalent to 20% of tensile strength of the material used. Disc edges shall be machined with rounded corners and shall be polished to a smooth finish. The valve disc shall rotate through an angle of 90 degrees from the fully opened to the fully closed position and the seat shall be of such design as to allow the valve disc to seat at an angle normal to the axis of the pipe when the disc is in the fully closed position. Adjustable mechanical stops shall be provided in the valve body to prevent over-travel of the valve disc in both the open and closed positions.

Operating gear for butterfly valves shall be of the fully enclosed type. Valves shall be suitable for operation by one man at all pressure conditions that can apply. A valve position indicator shall be provided for butterfly valves in chambers. Where a hand wheel is used for operating such a valve, the indicator shall be clearly visible from the hand wheel operating position. Where a containing chamber is not shown, butterfly valves shall be specially adapted for buried use. In line valves shall be operated by means of a hand wheel or tee key and be provided with gearing to prevent rapid closure of the valve. Gear ratios shall be at least 20:1. The valve bodies shall be protected by a bitumen coating and the valve discs by a Nylon Coating similar.

All butterfly valves shall be tested at the manufacturer's works in accordance with BS 5155 and under 'open-end' conditions. The seat test shall be for tight closure under maximum unbalanced water test pressure in either direction. The maximum permissible leakage for each valve shall be 0:05 litre per hour per 100 mm nominal diameter of the valve.

The word "CLOSE" or its abbreviation and the arrow mark indicating the direction of rotation to close the valve shall also be cast on the cover or the body.

The minimum size of letters shall be 25 mm and 3 mm raised from the surface.

1.10.3.5. Air Valve

Air valves shall be designed and manufactured in accordance with fitness for purpose requirement and appropriate verification tests EN 1074 Part 4, or equivalent. Air valves shall meet the working pressure of 16 kgf/sq. cm respectively.

The valves shall be iron bodied, float actuated air valves.

Valve bodies, covers, bonnets and stuffing boxes shall be of cast-iron conforming to ASTM A48 Class 35, or BS1452 Class 220, or equivalent DIN standards.

Stainless steel conforming to AISI 304 may be used for stem, stud, bolts and nuts and main valve retaining units and plugs.

Air valves shall be of the following type and size depending on the size of pipeline in which they are installed.

Type & Size of Pipe (mm)	Nominal Size of Air Valve (mm)		Type of Air Valve
	Body size	Flange size	
upto 225 PVC	25	Saddle	Single Orifice with an isolating cock, 1 inch BSP Threaded Male ferrule.
250 - 300 DI	60	80	Double Orifice with flanged inlet and an isolating Gate valve.
400 – 600 DI	100	100	Double Orifice with flanged inlet and an isolating Gate valve.
800 - 1200	150	150	Double Orifice with flange inlet and an isolating gate valve.

(1) Single Orifice Type

Single orifice type air valves shall be designed to automatically operate so that they will exhaust accumulated air under pressure while the pipe is flowing full of water.

(2) Double Orifice Air Valve

Double orifice air valves shall be designed to automatically operate so that they will:

- Positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;
- Exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;
- Not blow shut under high velocity air discharge; and
- Exhaust accumulated air under pressure while the pipe is flowing full of water.

Air valves are performance tested to ISO 5208 at the shop.

Seat test 1.1 x working pressure.

Body test 1.5 x working pressure.

No leakage shall be allowed.

Coating of air valve shall be same as coating for gate valve.

(3) High Speed Air Valve (Quick Type)

Where shown on the drawing, high speed (quick type) air valve conforming to JIS B2063 Class 4, or equivalent DIN standards shall be used. The valve shall have flanged end and to meet the maximum operating pressure of 16 kgf/sq. cm. Dimension of flange shall conform to the requirement of the pipe flange.

The valve shall be a float actuated air valve with their inlets flanged. Valve bodies, covers, bonnets and stuffing boxes shall be of ductile iron conforming to ASTM A536 65-45-12, or BS2789 500/7, or equivalent.

1.10.3.6. Flap Valves

Flaps and frames shall be ductile iron conforming to BS 2789. Mating surfaces of flaps and frames shall be of non-ferrous metal (excluding aluminium) accurately machined to ensure a watertight fit in the closed position.

Hinge pins shall be of tamper proof austenitic stainless steel; all flaps shall be double hung and seat off the vertical. Flanges shall be PN 16 conform to BS 4504. Coated in either fusion bonded epoxy, minimum thickness 150 microns, or cold applied black bitumen.

1.10.3.7. Tilting Disc Check Valves

Tilting disc check valves shall be cast iron or ductile cast iron body and disc, and bronze or stainless steel seating. Valves shall be designed for a working pressure of 14.0 kg/cm² and shall be suitable for operation in a horizontal pipeline.

Body shall be two (2) piece construction bolted together. Seat rings shall be mounted on both valve body and disc and shall be made of bronze casting conforming to JIS H5111 Class 6 or equivalent DIN standards or type 304, 403, 420 or equivalent or other stainless steel. Mating surfaces of body seat and disc seats shall be machine finished. Hinge pin shall be of stainless steel specified above. Bushing of hinge pin shall be bronze casting specified above or aluminium bronze casting conforming to JIS H5114, Class 2 or 3 or equivalent DIN standards.

Body shall be provided with suitable holes for cleaning and by-pass pipe with valve. Pivot pin housing shall be fitted with ball check grease fittings.

Dash pots shall be furnished with valves and designed to have valve opening and closing speed control devices. Dash post shall be approved by the Engineer.

1.10.3.8. Mechanical Couplings and Flange Adaptors

Couplings for jointing plain-ended pieced shall be of the Dresser Viking Johnson or similar type approved by the Engineer and may be steel or ductile iron at the option of the Contractor. They shall be designed to withstand a maximum working pressure of 16 bars.

Flexible couplings shall have a Rilsan Nylon II coating fully bonded to the surface. The thickness of the coating shall be 250-350 microns, applied by the fluidised bed process.

Bolts and nuts shall be carbon steel to BS 970 Part 1 : 1986 Grade 070 M20 or equal and nuts shall be zinc plated to grade Zn 3 primed and electro-statically sprayed with Rilsan Nylon II powder, giving a dry film thickness of 100 microns. Washers shall be hot dipped galvanized in accordance with BS 729 1971. All couplings and flanged adaptors shall be provided with a transit protection coat. Gaskets shall be of EPDM to BS 2494 : 1986 type W (potable water).

The flexible couplings shall be designed for a safe allowable angular deflection of 6 degrees without leakage.

Flexible couplings for each size of pipe shall also be capable of withstanding a shear force corresponding to the weight of a 4m length of pipe of that diameter full of water applied by the coupled pipes.

Prior to the commencement of the manufacturer the Contractor shall submit to the Engineer for approval detailed drawings of all mechanical couplings.

All mechanical couplings and flange adaptors shall comply with the BS/ BSEN ISO 9000 series quality system. Quality Assurance Certification should be from an organization accredited to issue such certification. Documentary evidence regarding accreditation together with the scope of certification shall be provide.

1.10.3.9. Fire Hydrants

Fire hydrants shall be supplied and installed at the necessary locations of Distribution Pipelines. The exact locations of the fire hydrants shall be identified at site in the presence of the Engineer's Representative and approved by the Engineer. Fire hydrants shall be wedge gate type in accordance with BS 750:1984. The fire hydrant shall consist of a screwed outlet 60 mm diameter round head.

The fire hydrants shall have a rated working pressure of 16 bars and flanges shall be drilled according to BS 4504 PN16. All the fire hydrants shall be supplied complete with pipes and specials required to connect the tee and the fire hydrants, manhole covers and frames etc. as per details given in the standard drawing, as specified under relevant item.

1.10.3.10. Manhole Cover and Frames

Manhole covers and frames shall be of ductile iron conform to EN 124-1994 Class D400 or to the approval of the Engineer. They shall be with circular opening of 600 mm, with captive hinge arrangement to deter vandals and with suitable watertight arrangement to prevent ingress of surface water into the manhole.

Fire hydrants – to comply with requirements of fire authority.

Air valves – ventilated type

Sluice valves – water tight

Washouts – ventilated type

The man hole covers shall have letter or words in English to indicate the function of the fitting, “FH, WO, SV, METER” and also the marking “NWSDB – WATER - 2009” in suitable size, cast in raised letters.

1.10.3.11. Surface Boxes

Surface boxes shall be of ductile iron, confirm to BS 5834:1983 Grade A or to the Engineer's approval, with the following minimum clear opening of 120mm, unless otherwise specified.

They shall be with captive hinge arrangement to deter vandals and with suitable watertight arrangement to prevent ingress of surface water into the keyhole.

Surface boxes shall be painted before installation with two coats of bituminous paint.

The lids or covers of surface boxes shall have letters or words in English to indicate the function of the fitting “FH, WO, SV, METER” and also the marking “NWSDB – WATER - 2009” in suitable size, cast in raised letters.

1.10.3.12. Water Meters (in Distribution System)

(1) General

All types of water meters and waste meters for the distribution system will be supplied and installed by the Contractor. Under this Contract provision shall be made with necessary fittings for the installation of meters.

1.10.3.13. Water Meters (for service connections) to Domestic, Commercial and Industrial Premises

The meters shall conform to BS 5728 or ISO 4064/1, class D. It shall be of positive displacement type and of dry dial construction and also conform to BS/ BSEN ISO 9000 series for quality assessment standards.

The body shall be of an alloy of metal of adequate strength and durability to withstand corrosion and wear and tear.

The cover lids shall be so designed and manufactured that they cannot be easily broken or detached from the meters.

Service meters shall be robust, have a high degree of accuracy of measurement at low flows replaceable working parts and cyclometer counters.

The meters shall be calibrated to read in cubic metres and liters, with a return to zero at not less than:

<u>Size of meter</u>	<u>Integrated quantity</u>
Up to and including 80mm	99,999 m ³
Larger than 80mm	999,000 m ³

The head losses caused by installing meters in service pipes should not exceed the following at the maximum continuous flow rates quoted.

Size of Meter (mm)	Max. Continuous flow rate (cubic metres/hr)	Approx. head loss (metres)
15	1.5	2.5
20	2.5	2.5
25	3.5	2.5
40	6.5	1.0
50	8.0	0.75
80	13.0	0.70
100	25.0	0.4
150	42.0	0.4

The contractor shall state in the Schedule of Particulars the head losses which will occur in the meters he proposes to supply at the maximum continuous flow rates quoted.

For sizes up to and including 40mm each meter shall have union connections to enable the body to be removed from the service pipe. A male connection screwed B.S.P. shall be provided for connecting to a stop valve on the upstream side of the meter, and a similar male connection shall be provided on the downstream side of the meter.

For sizes 50, 80, 100, 150 and 200mm the meters shall be flanged to Table 16/11 BS 4504. Tenderers shall state the length of straight pipe required, if any on each side of the meter for accurate measurement of flow.

Direction of flow arrows shall be integral with the body metal.

The meters shall have strainers in the body of the meter on the upstream side of the mechanism.

All meters shall be suitable for horizontal or vertical installation.

The contractor shall state the percentage minimum accurate registration in liters per hour for sizes up to 50 mm and in cubic metres for larger sizes, the recommended maximum continuous rate of flow, and the recommended maximum daily and monthly flows.

Accuracy of the meter reading shall be within the range of +2% when tested at flows ranging from 150 liters/hr. to the maximum flows stated in clause stated in above table.

The meter shall be calibrated to read in cubic meters and liters.

The meters supplied shall include all the necessary washers, nuts, connecting pieces as recommended by the manufacturer.

The Contractor shall furnish all the particulars of the water meters offered, for the approval of the Engineer prior to placing the order.

(a) Electromagnetic Bulk Flow Meters

The flow meters shall be of electro magnetic type conforming to following specifications.

- The meter shall have bi-directional capabilities.
- The metering tube shall be made of stainless steel and lined with a suitable thermoplastic material suitable for potable water.
- Electrodes shall be made of stainless steel.
- The flanges shall be of steel and must be compatible with BS 4504, 16 bar flanges.
- The enclosure shall be made of weatherproof material suitable for buried conditions.
- Electronic enclosure shall be of epoxy coated steel.
- Battery pack shall be a single sealed unit having a minimum life span of one year.
- The entire flow meter unit shall be manufactured to meet IP68 submersible to one meter depth.
- Ambient temperature : 50 °C
- Minimum accuracy : $\pm 2\%$ actual flow on ± 2 mm/s whichever is greater.
- Flow velocity range : 0 to ± 10 m/s.

The meter shall be complete with all accessories to make it fully operational and it shall be compatible with common data loggers and data logging programs.

1.10.3.14. Materials for House Connections

The Contractor shall furnish all the specifications and relevant particulars for the materials for house connection he intend to supply, together with samples of the items to the Engineer for his approval, prior to placing the order.

(1) Brass Swivel Ferrules

Ferrules shall be standard screw down pattern brass ferrule with female BSP screwed single outlet for PVC pipes to BS 21 parallel thread. It shall have a main stem with 360° swivel outlet at 90° with control of water flow via a threaded inner plug. The inlet shall be male, with taper thread to BS 21 or ISO 7/1.

The ferrule shall be designed for underground installation, and to handle potable water with temperature upto 35° C, and also to withstand a working pressure of 15 - 20 bars.

“O” rings for drill spindle, ferrule spindle and piston shall be of Nitrile Rubber in conformity to BS 2494 Type W and that for spindle buffers shall be of Nitrile or EPDM rubber in conformity to BS 2494 Type W.

The machine body shall be of Malleable Cast Iron in accordance with BS 6681: 1986 or Ductile Iron in accordance with BS 2789 grade 420/12 or equivalent or superior.

Bearings shall be of Stainless Steel in accordance with ASNI 420.

Rotating Table shall be of wear resistant Cast Iron in accordance with BS 1542 : 1977 (ISO/R 185).

The fixing shall be capable of withstanding a minimum load of 4000kg.

Each machine and its accessories shall be supplied in a robust lock up case.

Each machine shall be supplied with a set of spare parts recommended by the manufacturer for a minimum of 5 year normal operation.

In addition to that Contractor shall supply following cutter and spindles Tungsten drill bits.

12mm (1/2”) cutters and spindles (Tungsten drill bits)	16 Nos.
20mm (3/4”) cutters and spindles (Tungsten drill bits)	16 Nos.
25mm (1”) cutters and spindles (Tungsten drill bits)	16 Nos.
50mm (2”) cutters and spindles (Tungsten drill bits)	16 Nos.

1.10.3.16. Under Pressure Drilling Machine (for Asbestos and PVC)

The drilling machine shall be capable of drilling PVC pipes and Asbestos cement pipes of different diameters, and connecting ferrules to the water main through a saddle strap. (Clamp saddle). The machine shall be capable of doing this operation while the pipe is under pressure as well as under dry conditions. Saddle strap will be used with conventional swivel ferrules/service valves for service connections, and this combination shall be well suited with the equipment supplied.

The drilling machine shall be of two sizes, based on the size of the tapping;

Size	Size of the Tapping
1	1/2” (12mm), 3/4” (20mm), 1” (25mm)
2	1 1/4” (30mm), 1 1/2” (40mm), 2” (50mm)

The machine shall be capable of quickly adaptation for either PVC or AC pipes, and for different types of drilling, by inserting the appropriate size and type of cutter/integral spindle and correct ferrule adaptors.

The “T” bar assembly, head works, inner sleeve, inner sleeve retaining screws, square plug adopter, spindles, ferrule adopter, ferrule keys shall be of high quality steel in accordance with BS 970 Part I : 1993 (ISO 683/1) or equivalent.

“O” Ring seals for spindle, inner sleeve and gate valve, shall be of Nitrile Rubber in accordance with BS 2494 Type W.

The gate valve shall be of gun metal in accordance with BS 5154 or bronze to BS 1400 LG2 DIN 1705.

Each machine and its accessories shall be supplied in a robust lock up case.

Each machine shall be supplied with a set of spare parts recommended by the manufacturer for a minimum of 5 years normal operation.

In addition to that Contractor shall supply following cutter and spindles Tungsten drill bits.

12mm (1/2") cutters and spindles (Tungsten drill bits)	16 Nos.
20mm (3/4") cutters and spindles (Tungsten drill bits)	16 Nos.
25mm (1") cutters and spindles (Tungsten drill bits)	16 Nos.
50mm (2") cutters and spindles (Tungsten drill bits)	16 Nos.

1.10.4. Pipe Laying and Testing

1.10.4.1. Pipe Laying

The Contractor shall furnish all labour, materials, equipment and incidentals required to install, test and disinfect water pipelines.

1.10.4.2. General Requirements

All pipes shall be laid to lines and grades to comply with BS 8010 Section 2 “pipe lines on lands: Design Construction and Installation”. The type of bedding and minimum clear cover to the pipes shall be as shown in the Standard Drawings but not limited to what is shown therein. Only pipes, fittings and accessories which are as specified in Section 1.10.2 “Pipe Material” shall be used in this work. Loading, transporting and handling shall be done very carefully as described in Section 1.10.1. “General”, or in conformance with the manufacturer’s recommendations.

Pipe end covers and other transit protections fixed by the pipe shall be retain in place except for taking over inspections until the pipes are finally inspected shortly before they are laid.

All pipes, fittings and accessories shall be examined, and no piece, which is found to be defective, shall be installed.

When pipes and fittings etc are strung adjacent to the pipe trench prior to laying they shall be supported clear of the ground on suitable approved support to prevent damage to their external coating.

Excavation, bedding, backfill shall be done as specified in this section, all to the satisfaction of the Engineer.

The open ends of the installed pipes shall be plugged with a watertight plug, or other approved means, after the Contractor has finished the installation on each day/night, or when

there is no pipe laying in progress. The plug shall be taken off whenever the Contractor is ready for joining pipes. The Engineer reserves the right to order the Contractor to remove any pipe length, which has not been plugged as required to clean the inside of the pipe. Material to be used for plugging shall be approved type that shall adequately protect the pipe from damage, and prevent dirt, debris and water from entering the pipe. The Contractor shall prevent trench water, mud, sand or sewage from entering the pipe during installation.

The type of joint required for each material shall be in accordance with Section 1.10.1 “Pipe Material”.

All rubber joint rings and gaskets must be stored in a cool damp location in black polythene sacks and shall not be distributed to the trench side until immediately prior to assembly thereof. Rubber gaskets shall be well lubricated prior to fitting.

Care shall be taken during joining the pipes. All pipe fittings shall be checked for defects and cleaned before joining.

Any field cutting of the pipe shall be done only with the approval of the Engineer. The Contractor shall submit to the Engineer for prior approval details of his cutting method, along with types and sizes of pipes to be cut. Any damage to the coating and/or lining shall be immediately repaired. Where cut pipe has been installed without the above prior approval of the Engineer, and the work is found not to conform to the specifications, the Engineer has the right to order the Contractor to remove that pipe length for rectification. All expenses involved shall be borne by the Contractor.

Each pipe and fitting shall be laid true to alignment, curve and gradient in accordance with the drawing or as directed by the Engineer. The minimum cover and the minimum gradient shall unless otherwise stated not be less than one metre and 1:400 respectively.

The pipes shall be laid to even gradients and sight rails shall be provided for this purpose at intervals not exceeding 50 metres and at changes of direction and grade.

Pipes and fittings suppose to view at culvert or bridge crossings and in manholes or chambers shall be painted in accordance with Section 1.10

The following standards are referred to:

ISO 4482	Asbestos-Cement Coating – Guide for laying
AWWA C203	Coal-Tar Protective Coating and Lining for Steel Water Pipeline – Enamel and Tape-Hot-Applied
AWWA C206	Field Welding of Steel Water Pipe Joints
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C600	Standard Specifications for the Installation of Gray and Ductile Cast-Iron Water Mains and Appurtenances
AWWA C603	Standard Specification for the Installation of Asbestos-Cement Pressure Pipe
AWWA Manual M11	Steel Pipe Design and Installation

1.10.4.3. Installation of Pipe and Fittings

(1) Installation of Ductile Iron (DI) Pipe and Fittings

All pipes and fittings to be used in this work shall be in accordance with Section 1.10.2 “Pipe Material”.

All pipes shall be carefully inspected for defects before installation. No pipe or fittings, which show defects excluded by the specification, shall be used. Any injury to protective coating of the pipe or fittings shall carefully be repaired before installation.

The Contractor shall, after excavating the trench and preparing the bed for the pipes, furnish all necessary facilities for properly lowering and placing the section of the pipe in trench without damage and shall properly install the pipe. The section of the pipe shall be fitted together correctly and shall be laid true to line and grade in accordance with the benchmark established by the Contractor. The full length of the barrel of the pipe except the socket (bell) or flange shall have a uniform bearing upon the bed of the trench. Suitable excavation shall be made to receive the socket (bell) or flange, which shall not bear on the sub-grade.

As far as possible, pipe shall be lowered into trench using cranes. No pipe shall be rolled into place for lowering into the trench except over suitable timber planking free from roughness likely to damage any coatings. If the prepared bed is damaged for any reason, the pipe shall be raised and the bed made good before pipe laying is continued.

Whenever the work ceases for any reason, the unfinished end of the pipeline shall be securely closed with a tight fitting plug or cover. The interior of each pipe after being laid shall be thoroughly cleaned. Any pipe, which is not in true alignment both vertical and horizontal, or shows any undue settlement after laying shall be taken up and re-laid correctly by the Contractor at his own expenses when so ordered by the Engineer.

When subsoil water is encountered, it shall be kept below the sockets when joining by pumping or other means. In no case shall pipes and/or fittings be jointed before being lowered into position.

If any damage should occur to any pipes through failure of the Contractor to comply with these conditions, the damage shall be made good at the Contractor’s expenses.

When the pipes are specified to be installed with the polyethylene sleeves or tape wrap, the Contractor shall take the necessary care to do it strictly in accordance with the specifications of the manufacturer, using the recommended material, tools and equipment and methods.

If, in the opinion of the Engineer, the sleeves or tap wrap fails to provide the protection to the pipe as intended due to improper material, tools or methods used by the Contractor, he shall replace the sleeves or tape wrap in the affected area as directed by the Engineer, at his own cost.

(i) Concrete Protection of Pipe

When ordered by the Engineer, pipe shall be encased in concrete as specifications. Such concrete shall not be placed until the joints at each end of the pipe have been completed. Each pipe to be encased shall be supported on at least two purpose made precast concrete blocks of same grade of encasement concrete which shall be left in place and the full width and depth of concrete encasement shall be placed and carefully tamped beneath the pipe followed at once by the addition of the encasing concrete.

(ii) Push in Joints and Restrained (Self Anchored) Joints

Installation shall be in accordance with the manufacturer's recommendations. Sockets and spigots shall be thoroughly cleaned prior to making the joint. Only lubricant recommended by the manufacturer shall be used and it shall be non-toxic. The completed joint shall have a uniform contract by the gasket between the outer surface of the spigot and the rubber ring seat of the socket.

(iii) Flanged Joints

Joints shall be made up square with even pressure upon the gasket and shall be properly watertight. Gaskets shall fit the inside dimension of the pipe accurately so that no surface material projects out into the flow area. The completed joint shall be perfectly aligned. Flanged joints shall be coated including all bolts and nuts with Denso paste and primer, Denso mastic, Denso tape and PVC or polyethylene outer wrapping.

(iv) Slip-on Coupling and Flange Adaptors

Coupling and flange adaptors which are as specified in Section 1.10.3 shall be used when approved by the Engineer. Installation shall be accordance with the manufacturer's recommendations. Gasket seats and gaskets shall thoroughly cleaned before assembly. The completed joint shall have uniform contract by the gasket between the outer surface of the spigot and the gasket seat at the socket. Coupling and flange adaptors shall be coated including all bolts and nuts with Denso paste and primer, Denso mastic, Denso tape and PVC or polyethylene outer wrapping.

(v) Deflection of Pipeline

Minor changes in direction of pipeline both vertically and horizontally shall be made through deflections at the joints. Such deflections shall not exceed the values given below.

Nominal Diameter (mm)	Maximum Allowable Deflection (degree)	
	Push-on Joint	Mechanical Joint
80 to 200	5.0	5.0
250 to 350	4.0	4.0
400 to 600	3.0	2.5
700 to 900	2.5	2.0
1000 to 1200	2.0	1.5

Joints with deflection shall be installed in accordance with the manufacturer's instruction.

(vi) Cutting of Pipes

Pipe shall be cut using power driven abrasive wheel cutting machine. Acetylene torch and chisel methods will not be permitted in any circumstances. Cut spigot ends shall be beveled to the same dimensions as the normal spigot ended pipe. The edges of the cutter shall be given

two coats of approved paint and the internal coating shall be repaired if damaged. The Contractor shall ensure that the diameter at the point of cutting will match the pipe to which it is to be jointed.

(vii) Welding

No site welding work on ductile iron pipe and fittings shall be undertaken without the approval of the Engineer. Where approved, welding work shall be undertaken in accordance with the manufacturer's recommendations.

(viii) Protection of Joints

All buried flange joints, and any un-coated mechanical coupling shall be protected by wrapping with "Denso Paste", "Densyl Mastic", "Densyl Tape" and "PVC Outerwrap" manufactured by Winn and Coales Limited, Denso House, Chapel Road, London, S.E.27 or similar approved materials.

The joints shall be thoroughly cleaned to remove all loose rust and extraneous matter and thoroughly coated with "Denso Paste" over the whole of the joint. A liberal amount of paste should be left around all bolt heads, narrow cavities, etc.

"Densyl Mastic" shall then be applied to cover all bolt heads and nuts to form a triangular fillet against flanges and to fill all gaps and abrupt changes in contour to provide an even contour for wrapping.

"Densyl Tape" shall be applied circumferentially, care being taken to smooth and eliminate any air pockets and to form the tape well into all angles and changes in contour. The tape should be applied with an overlap of at least 25 mm and should extend at least 50 mm on either side of the joint.

Finally an outer wrapping of "PVC Outerwrap" shall be applied with minimum lap of 25 mm to completely cover the "Densyl Tape".

Contractor shall use any equivalent joint protection materials with the approval of the Engineer.

(2) Installation of Steel Pipe (SP) and Fittings

All pipes and fittings to be used in this work shall be in accordance with Section 1.10.2 "Pipe Material".

All pipes and fittings shall be handled and installed in accordance with the applicable section of AWWA Manual M11 and the requirements described herein.

At crossings over canals and ditches, the exposed steel pipes and fittings shall be painted with two coats of synthetic red lead primer and one coat of Aluminum paint. The underground steel pipe shall be tied around with synthetic asbestos cloth. Steel sleeve pipe shall be painted with two coats of coal-tar epoxy.

The ends of the pipe shall have wooden stiffeners installed inside of the pipe at quarters points and at both ends of the pipe. This blocking shall remain inside the pipe until the pipe has been installed.

When field cutting or metering of the pipe is required the cutting shall be done by the acceptable cutting machine, leaving a smooth cut at right angles to the axis of the pipe or deflection angle. Cut ends of the pipe shall be bevelled with a special tool made for the purpose, and the bevelled end shall be exactly the same as the plain end of the pipe as manufactured at the factory.

Steel pipe with plain ends shall be joined together with a flexible coupling as specified in Section 1.10.1. The Contractor shall make excavation of sufficient width and depth to provide the suitable room for joining the pipes and fittings. The bedding at the joint shall be installed and compacted after the joining has been completed. Where fittings such as bends, tees and blanks are used, all fittings shall be joined with single butt welded joints.

Any damage to the exterior coating and interior lining shall be repaired in accordance with the manufacturer's recommendations. If, in the opinion of the Engineer, the damage is not properly repaired by the field methods, the Engineer reserves the right to order the Contractor to use the method of repairing that is the same as the manufacturer's procedure. The expenses of repairs shall be borne by the Contractor.

Welded joints shall be butt and weld and in full conformance with AWWA C206. Welders in charge shall have the qualification stipulated in JIS Z3801 or equivalent.

The Contractor shall submit the qualification of the proposed welders for the steel pipe jointing for the approval of the Engineer. The Engineer may request the Contractor to conduct the testing for examination of the capability of the welders. The Contractor shall, when requested by the Engineer make the necessary arrangement for such testing for joint welding at his own cost.

After all field welded joints have been made, and inspected and approved by the Engineer, the joints shall receive the protective coating and lining as specified below.

(i) Coal Tar Enamel Coating (Underground Buried pipe)

All field welded joints in the underground buried pipeline shall be field-coated with coal tar enamel and bonded with double asbestos felt wrap in accordance with BS534, or Appendix A Section A1.2 of AWWA203. The coating system shall be equivalent to the shop-applied coating of the pipe section and shall be applied across around the outside of the joints. The joints protective coating shall overlap the main body of the shop coating on each side of the field joint to form continuous coating free from defects. The overlapping length shall be at least 200 mm on each side of the joint.

(ii) Epoxy Painting (Above-ground Exposed Pipe)

All field welded joints in the above-ground exposed pipeline shall be field coated with at least two (2) coats of epoxy resin paint. The first and second coats shall be of minimum coating thickness not less than 40 and 30 microns, respectively. The colour of epoxy paint shall be determined by the Engineer from the sample submitted by the Contractor. The method of field painting shall conform to the paint manufacturer's instruction and recommendations.

Unless otherwise permitted by the Engineer, shop coating and field-painting materials shall be from the same manufacturer.

(iii) Cement Mortar Lining

All field welded joints shall receive field applied cement mortar lining in accordance with AWWA C602. The lining system shall be equivalent to the shop applied lining and shall be applied across the inside of the joints.

Bolts and nuts for mechanical joints, flanged joints and blank flanges shall be given a coat of bituminous paint after the jointing has been completed.

(3). Installation of Un-plasticised Polyvinyl Chloride (uPVC) Pipe and Fittings

Careful consideration must be given to the handling and storage of polyvinyl chloride pipe and fittings. The pipe must be stored out of any direct sunlight. Extreme care must be made to prevent any scarring or nicking of the pipe from bearing on sharp objects. Any pipe, which has any cut or bruise deeper than 10% of the wall thickness will be rejected and shall not be used in the work. The section of pipe with such a cut shall be reject in its entirety. The pipe shall be stored in such a manner that no direct sunlight is on the pipe but ventilation is provided. Covering the pipe with a tarpaulin shall not be allowed. Stacking shall not exceed 600 mm in height.

In normal ground, pipe shall be bedded in 150 mm depth of granular material as specified. The same material shall be placed alongside the pipe and compacted in 200 mm layers upto the crown of the pipe. Same material shall be placed over the pipe and compacted in two layers, upto a depth of 300 mm.

In other types of ground, additional bedding types shall be used, as shown in relevant typical drawing.

Where uPVC pipes passed under or at the side of culverts they shall be protected by Sleeve pipes as shown on the drawing.

The joints shall be of the push-in type. The socket and spigot of the pipe shall be carefully cleaned before the rubber ring is set in place. The spigot shall then be covered with an approved lubricant and the pipe pushed into the socket. Pushing the pipe into the socket shall be done by barring against the opposite end of the pipe being installed. A wooden block or other suitable device shall be used to prevent any damage to the socket against which the bar is being pressed. No blocking will be allowed under the pipe and it shall bear evenly along its entire length on the bedding material.

Cutting of the pipe shall be kept to a minimum. When cuts are necessary they shall be perpendicular to the axis of the pipe and smooth. Cuts shall be made with tools in conformance with the pipe manufacturer's recommendations. Cut ends shall then be tapered and beveled with a special tool made for that purpose and the bevelled end shall be exactly the same as the spigot end of the pipe as manufactured at the factory.

Solvent weld joints for pipes of diameters 90 mm shall be made in strict accordance with the manufacturer's recommendations and utilise only solvents furnished by the manufacturer. In addition it will be necessary to snake the pipe so that on offset from true horizontal alignment

of 30 centimetres in 30 meters of laying length will be provided. Care shall be taken to insure that the temperature of both sections of pipe being jointed are the same.

For any diameters other than 90 mm, solvent joints shall be used only after written approval by the Engineer.

For the uPVC pipes of diameters 110 mm and above, caution tapes (warning tapes) shall be installed in the pipe trench, 500 mm above the crest of the pipe.

At uPVC fittings when forming the trust block and anchor blocks a polythene film or equally suitable material membrane to the satisfaction of the Engineer of minimum thickness 2 mm shall be provided to separate the fitting from the concrete of the trust or anchor block.

The warning tape shall be of polythene, and should have performance details applicable to the 100 micron material of “Boddingtons underground warning tapes”, or equivalent.

- Minimum ultimate tensile strength at break (longitudinal and transverse) shall be 10MN/m² as determined by BS 2782 method 301E.
- Minimum Elongation shall be 300% (Longitudinal) and 350% (Transverse)
- Shall be resistant to chemical attack from the ground conditions with pH ranging from 3.0 to 9.0.

The width of the tape shall be 100mm. Tape shall be blue colour, with the words printed “WATER PIPE LINE BELOW – CAUTION” on upper side of the tape in black letters, printed in two rows, at an interval of 1m.

(4) Installation of Galvanized Steel (GS) Pipe and Fittings

Only pipes, fittings and accessories, which are in accordance with the requirement described in Section 1.10 “Pipe Material”, shall be used in this work. Installation of pipes, fittings and accessories shall be in conformance with the manufacturer’s recommendations, or as directed by the Engineer. Gibault or flange joints may be used if necessary.

All threads for screw joints shall be clean, machine cut, and all pipe shall be reamed before erection. Each length of pipes as erected shall be up-ended and rapped to dislodge dirt and scale.

Screwed joint shall be made up with good quality thread compound and applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned, and new compound applied.

No close right and left hand nipples shall be used. All nipples shall be of such length that the correct size of pipe wrench can be used on them when in place. At crossing over canals or ditches, the pipe shall be laid in accordance with the details and/or construction method as directed by the Engineer.

Pipe laid under ditches, shall be as specifications and as directed by the Engineer. Pipe bedding shall be compacted for the entire length of the pipe good alignment shall be preserved and fittings may be used where necessary.

1.10.4.4. Exposed Piping

The Contractor shall furnish and install sleeves or wall casting for all pipes passing through masonry walls and concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Contractor shall check all and figures which have a direct bearing on his pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.

Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed that no stress or strain is created in the lines and associated equipment due to forcing parts into position.

Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.

Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken in placing piping to prevent damage to the pipelining or pipe coating or to adjacent structures or equipment. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.

Flange piping shall have a sufficient number of couplers and adaptors to allow convenient removal of piping.

The Contractor shall furnish and place all inserts for the support of piping installed under this section in masonry and in concrete forms before concrete is placed, unless otherwise permitted.

Systems shall be arranged with low points and drains to arranged with unions or union connections at low points to permit draining. Fill connections shall also be provided on closed systems where required.

Adequate air vents shall be provided at high points in all liquid carrying pipes. All exposed piping shall be rigidly supported by pipe hangers and supports specified hereinafter.

All pipes shall be sound and clean before installation.

In case interference develops between piping and appurtenances, the Engineer will decide which work is to be relocated regardless of which was first installed.

Upon completion of installation and testing, the Contractor shall paint all exposed piping in accordance with the specified. Where the pipe passes through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer. Sealing compounds shall be applied in accordance with the manufacturer's instructions.

1.10.4.5. Canal or River Crossing and Culvert Crossings

The Contractor shall furnish all labour, equipment and materials and perform all incidental work required to install canal or river crossings and culvert crossings as specified or as

otherwise directed by the Engineer. For canal or river crossings using existing bridges the Contractor shall follow the requirements.

(1) General Conditions

The Contractor shall dig test pits, before the pipe crossing the canal is installed, near the bridge and/or the bank of the canal. If it appears that underground structures and/or utilities are not in the same locations, which may cause changes in the pipe routing and position of form of pipe support structures and other related work, then the Contractor shall prepare drawings showing details of the change and submit them to the Engineer for approval. The Contractor shall follow the directions of the Engineer without argument. Any damage resulting from not following the said direction, including the costs in changing the method of construction of the approach pipe laying, shall be borne by the Contractor.

Welding of steel pipe shall conform to AWWA C206 and the requirements as specified in Section 1.10.2.3

Steel used for pipe supports and incidental works of canal crossing shall be of structural steel as specified in Section 1.11.6 “Structural Steelwork”.

Concrete thrust blocks shall be constructed at fittings or bends as directed by the Engineer.

(2) Construction

The Contractor shall submit to the Engineer for approval his proposed method and details of the construction. Approval of such details shall not relieve the contractor from the responsibilities under the Contract.

The Contractor shall take extreme care to protect bridges, surrounding structures and utilities from damage. Vehicular and pedestrian traffic shall be maintained at all times, as well as utility services. Costs or charges resulting from damage thereto shall be borne by the Contractor.

Where pipe trenching is not practical or where pipes are to be installed in the swampy areas, the Contractor shall support these pipes with proper concrete structures. The installed pipe shall be levelled and an air valve shall be installed at the highest point of the pipe, or at the end point of the pipe or at the tail water end.

Where crossings at outside of the culvert under the invert level, necessary trench cut off walls and Rubble pitching shall be provided as shown in the drawing.

1.10.5. Connections to Existing Mains

1.10.5.1. General

(1) Scope of Work

The Contractor shall supply all labour, material, tools and equipment to connect the proposed new pipes to the existing pipes which have been constructed in other contract in accordance with specifications, and as may be directed by the Engineer.

(2) Submittals

At the point connecting to existing pipe, the Contractor shall excavate and inspect the pipe or valves to determine the material type and make measurements. Following measurements the hole shall be backfilled and the surface temporarily restored with asphalt pavement.

Based on the field data the Contractor shall prepare and submit shop drawings showing the method proposed for making the connection. Field data shall be clearly indicated on the shop drawings.

Generally the connections will be made dry unless a wet tap is specified. The Contractor shall co-ordinate his pipe laying and testing work with the connection work so that interruption of service to consumers is minimized.

As a part of the shop drawings the Contractor shall submit a plan for shutting down existing pipe so that connections can be made dry. The Contractor shall determine the locations of all valves required to be shut down and check the valves to be sure that they are operational. The Engineer will provide assistance in developing this plan.

(3) Materials

All material including pipe adaptor used to make the required connections shall be in accordance with the applicable sections of this Specifications.

1.10.5.2. Execution

Connection to the existing pipe shall be made by means as specified or as directed by the Engineer. The Contractor shall clean up the inside of the existing pipe prior to the connection work. The Contractor shall be fully responsible for testing and disinfection of this existing pipe from the point of connection to the extent, which has been affected by the connection work as, instructed by the Engineer.

Prior to any connection work, the Contractor shall notify the Engineer of his intention to commence the particular work. No connection work shall be commenced unless an approval by the Engineer has been given in writing.

The work program of the Constructor has to be approved by the Engineer before starting.

1.10.5.3. Testing

All connections to existing mains or valves shall be installed prior to the hydrostatic test of the water main, and they shall be tested with the pressure of the water main.

1.10.6. Installation of Valves, Fire Hydrants & Markers

1.10.6.1. General

(1) Scope of Work

The Contractor shall supply all labour, equipment and material required to install valves, fire hydrants and market posts, and construct valve chamber and surface boxes, as specified herein. This work includes: surface breaking; excavation and backfill; sheeting and bracing; on site forming; supply and installation of pipes, fittings, valves, fire hydrants and appurtenances; supply and installation of miscellaneous metalwork, surface restoration and other work needed to complete the valve boxes.

Most of the components of work for above works are specified in other parts of this Specification. This section consolidates a description of the work required for above works in particular. The Contractor shall consult other parts for further details.

(2) Submittals

The Contractor shall prepare and submit a shop drawing for each installation. The shop drawings shall include the dimensions of piping, appurtenances and other equipment to be installed and shall extend to the limits limit of special pipe construction. All supports, clearances and materials to be installed shall be shown.

1.10.6.2. Materials

Cement, aggregate, water, admixture, reinforcing steel, concrete, form work, shall be in accordance with the provision of Section 1.6 “Concrete”, and the valves, fire hydrants, man holes, surface boxes and appurtenances shall be in accordance with the specifications of Section 1.10 “Pipe Materials”.

1.10.6.3. Location of Installation

(1) Fire Hydrants

The location of the fire hydrants shall be either under the pedestrian walkway or under the shoulder of the road, but shall not be under the carriageway. The location shall be approved by the Engineer before installation.

(2) Valves

The location of the valves shall be a sufficient distance away from the road junctions, so that the installation is not adversely affected by future road widening or surfacing by the road maintenance authorities. The Contractor shall obtain the approval of the Engineer before installation.

1.10.6.4. Execution

(1) Underground Utilities Interference

When underground utilities are anticipated to exist near the proposed location of the installation, the Contractor shall excavate test pits to make sure that the existing underground utilities will not interfere with the construction of the structure. On the other hand, if underground utilities are found to actually exist, proper precautions shall be instituted so as not to disrupt service to the general public.

(2) Manhole Frame and Cover

Manhole frame shall be set with the top conforming to the grade of the pavement or finished ground surface as directed by the Engineer. Frames shall be set in full bed of mortar.

(3) Valve Box

Valve boxes shall be constructed with the top of cover lower by 0.2 m from the grade of the pavement or finished ground surface, or as directed by the Engineer. The manhole frame and cover shall be raised with its top conforming to the grade of the pavement or finished ground surface.

1.10.6.5. Installation of Marker Posts

Marker Posts shall be installed at the locations of all valves and meters of the distribution pipe lines and transmission mains and at the location of fire hydrants. The type depth location and diameter of the main shall indicate as specified in the relevant drawing, for the specified sizes of valves and pipe lines. Contractor shall obtain the approval of the engineer regarding the location of marker posts, and also obtain the permission from the relevant authorities for the installation of the marker posts.

1.10.7. Testing and Disinfection

1.10.7.1. General

(1) Scope of Work

The Contractor shall furnish all labour, equipment, materials and metering device required for the pressure and leakage testing and the disinfection of the finished pipelines. The finished pipeline includes the pipes, fittings, valves, fire hydrants and all other appurtenances that are constructed under this Contract. The Contractor shall provide the facilities necessary to convey the water from its sources, as designated by the Engineer, to the place where it is required, and shall install the metering device.

All testing and disinfecting operations shall be done in the presence of the Engineer.

Late delivery of valves will not be allowed to delay testing and commissioning of a pipeline. In such cases the Contractor shall supply and install spool or make up pieces so that testing may proceed. The Contractor shall install valves later in a manner acceptable to the Engineer.

(2) Standard Specification References

The following standard are referred to

AWWA C600 Standard for Installation of Ductile-Iron Water Mains and their Appurtenances

AWWA C601 Standard for Disinfecting Water Mains

(3) Submittals

The Contractor shall submit, as part of his shop drawings, a sketch for each section of pipe to be tested. The sketch shall show the section schematically in profile and shall contain a sequence of operation to be followed during the test such as observations and closing of air-valves, blow-offs and other appurtenances; shall show point of filling, point of pressure observation and test pressure.

1.10.7.2. Colouring Tests for Welding

The colouring test shall be performed at each welding joint on 100 percent in length of joint, and examination on defects or incompleteness shall be executed in accordance with JIS Z2343 or equivalent. When any defect or pinhole is detected by the colouring test, the Contractor shall repair it to the satisfaction of the Engineer and shall repeat the colouring test to confirm that the repair work has been satisfactorily done.

All such tests shall be carried out by the Contractor in the presence of the Engineer. Where necessary, welds shall be repaired in accordance with instruction of the Engineer, at the Contractor's own expense.

The Contractor shall nominate a qualified chief supervisor for field tests of the steel pipe who has the responsibility to perform and to supervise the field tests of steel pipe.

All expenses for the said testing including expenses for equipment, tools, materials, labours, reporting, and any other works related shall be deemed to be included in the rates of pay items for installation of steel pipes.

1.10.7.3. Field Hydrostatic Pressure Test

Hydrostatic pressure test procedure for the pipeline shall be as specified in Section 1.10.7 of AWWA C600, which shall be not less than 1.5 x the maximum working pressure.

For all pipe sizes, the working pressure shall be of water column based on the elevation of the lowest point in the pipeline under tests, and corrected to the elevation of the test gauge.

All tests shall be conducted on the pipelines in sections after the trench is backfilled, but before pavement restoration. Joints shall be exposed during the test wherever possible.

Before a length of pipeline is tested, each pipeline securely anchored, all trust and anchor block shall have been constructed.

Maximum length of pressure testing shall be 1 km.

All pipeline shall be thoroughly flushed out with water prior to testing. The pipeline shall be prepared for testing by closing all valves and hydrants; placing substantial stops and bulkheads at openings, opening air valve assemblies and fitting air release taps at all other high points along the pipeline. These taps shall later be removed after completion of the testing and disinfection and, unless otherwise specified, replaced with permanent plugs.

The pipeline shall be slowly filled with water, allowing all air pockets to be released, until the pipe is completely filled and under working pressure at which condition it should be allowed to stand for 24hours. Any apparent defects in the pipeline at this stage shall be rectified by the Contractor. To demonstrate that air has been removed the Contractor add a measured amount of water at filling point and measure outflow at remote points of pipe being tested. If remote points of pipeline do not contain convenient points to measure outflow the Contractor shall install taps.

The hydrostatic pressure shall be raised to the test pressure. The duration of the pressure test shall be for a period of two (2) hours. Any defective pipe, fittings, joint, valve or hydrant shall be removed and replaced and the test shall be repeated until satisfactory to the Engineer.

1.10.7.4. Field Leakage Test

Leakage tests procedure for the pipeline shall be as specified in Section 1.10.7 AWWA C600. The leakage test shall be conducted after the pressure test has been satisfactorily completed. The duration of each leakage test shall be two(2) hours, and during the test the pipeline shall be subjected to the same test pressure stated in the preceding paragraph. The pipeline leakage

shall be taken as the amount of water, as measured by the metering device, needed to be injected into the line to maintain the test pressure for the two (2) hour leakage test period.

The allowable pipeline leakage shall be less than 2.3 litres per 24 hours per mm-pipe diameter per km-length as presented by the formula below:

$$\frac{Q}{D \times L \times H \times T} \times 24 < 2.3$$

Where:

- Q : Amount of leakage in litres
- D : Diameter of pipe in millimetres
- L : Length of pipeline in kilometres
- H : Duration of leakage test in hours
- T : Test pressure in bars

Should any test of pipe laid disclose a leakage greater than the specified above, the Contractor shall locate and repair or replace the defective materials or joint, to the satisfaction of the Engineer. The test shall be repeated until any leakage falls within the permitted allowance.

1.10.7.5. Disinfection

(1) Swabbing

After the pipelines have been completed and pressure tested satisfactorily in accordance with the relevant Clause then the Contractor shall on the instructions of the Engineer prove any length of pipeline to be free from obstruction.

Proving shall be carried out by means of passing through the pipelines a polyurethane foam swab of approved grade in accordance with the following procedure.

Pipelines shall be proved in sections between entry and exit points. Temporary swabbing points shall be provided in the distribution system by insertion of tees and valves, which shall be removed after proving and replaced by short lengths of straight pipe.

At the start of the operation the swab shall be introduced at the entry point at the upstream end of the section by means of the tee provided and the isolating valves on branch mains closed.

The isolating valves on either side of the entry point shall be opened sufficiently to flood the entry tee containing the swab and the sluice valve on the entry tee shall then be closed.

By opening the isolating valves on either side of the entry point the swab will be free to travel along the pipeline towards the downstream exit point.

The theoretical loss of head between the entry point and the exit point and either end of the section will previously have been determined by the Engineer for a flow of water which will cause the swab to travel through the section at a suitable predetermined velocity. This flow and the corresponding required velocity of the swab will be controlled by throttling of valves at the exit point or at hydrants or washouts.

Washouts or hydrants downstream of swabs shall be controlled so that any rubbish, silt, debris or other extraneous matter may be discharged during the passage of the swab along the pipeline.

Proving of any section shall be repeated as required by the Engineer in the event of the initial or any subsequent operation not being to his satisfaction.

The Contractor shall provide all transport and labour required to prove a pipeline free from obstructions.

Diameters 300 mm and greater:

Visible dirt and debris should have been removed either manually or by the use of cleaning pigs before testing.

After the pipelines have been completed and pressure tested satisfactorily as herein specified the Contractor shall flush out and cleanse the pipelines.

Pipelines shall be cleansed in sections and this shall be carried out by passing polyurethane foam swabs through the pipeline. The swabs shall be to the approval of the Engineer. Water for passing swabs will be made available by the Employer.

Diameters less than 300 mm.

Pipelines shall be cleansed in sections by flushing with portable water, provided by the Employer, for a period of time shall be decided by the Engineer's representative.

Cleansing of any section shall be repeated as required by the Engineer's Representative in the event of the initial or subsequent operation not being to his satisfaction.

The Contractor shall supply all necessary equipment for the cleansing and sterilizing operations, including sufficient swab and swab detectors.

Swabs shall be suitable grade and dimensions appropriate to the pipelines being cleansed and to the approval of the Engineer.

Swabs shall be passed through pipelines at speeds of between 0.2 and 0.4 metres per second to obtain the best cleaning result with the minimum number of passes. Should it be apparent from the debris collected by the swab that damage to the lining has occurred; the Contractor shall be wholly responsible for repairing the lining to the satisfaction of the Engineer's Representative.

The cost of the initial sampling analyses and preparing reports on the bacteriological quality of water shall be borne by the Employer but, in the case of the initial reports being unsatisfactory the cost of any subsequent sampling analyses and preparing reports shall be borne by the Contractor.

(2) Disinfection

Before being placed into service or before certification of completion by the Engineer whichever occurs earlier, all new pipelines which will convey the filtered water shall be disinfected with chlorine, and a satisfactory bacteriological analysis of the water certified in accordance with AWWA C601 shall be submitted to the Engineer.

The amount and concentration of chlorine solution applied shall be such as to provide a dosage of not less than 50 mg per litre, introduced into the lines as directed by the Engineer. After a contact period of 24 hours, the chlorine residual at the end of pipeline shall not be less than 25 mg per litre. The system shall then be flushed with clean water until the residual chlorine is not greater than 0.75 mg per litre but not less than 0.25 mg per litre.

The point of application of the chlorination agent is normally at the beginning of the pipeline through a corporation stop insertion on the top of the laid pipe, and the point of withdrawal (normally by blow-off) is at the opposite end of the line.

Should the initial treatment fail to result in the conditions stipulated above, the chlorination procedure shall be repeated until satisfactory results are obtained.

The Contractor shall dispose of the water used in the pipeline testing and disinfecting operations without causing damage to adjacent property.

1.10.8. Pipe Jacking for Railway Crossing

1.10.8.1. Scope of Work

The Contractor shall furnish labour, materials, equipment and incidentals to install the encasement pipe by pipe jacking for railway crossing as specified herein.

The work shall include supply of driving pipe with jointing materials, and construction of driving and arrival shafts, pipe driving, and incidentals to complete placing of the encasement pipe under the utilities.

1.10.8.2. General Requirements

Construction method applicable to the pipe driving under this contract shall be open type. Excavation may be done either by manual or by mechanical methods.

Special measures for pipe driving such as ground treatment and/or use of intermediate jacks may be incorporated in the driving work by the Contractor. The Contractor's attention is directed to the fact that there will be a large thrusting force required for the pipe driving operation and that the earth behind the driving shaft must safely withstand the thrusting force during the operation. The Contractor shall be responsible to there in force the original soil to obtain sufficient bearing capacity for the jacking force if required, and for this purpose, the Contractor shall carry out additional subsoil investigation as necessary. All expenses due to this improvement shall be the Contractor's responsibility.

Prior to the construction work, the Contractor shall investigate existing subsurface structure as, and utilities located in and around the construction site so as not to damage those facilities during all stages of construction. Before, during and after the driving operation, the Contractor shall make a continuous measurement and record of the level of the existing ground, road surface and railway line.

When the Contractor intends to change his construction method during driving operations, the Engineer's approval shall be required.

The Contractor shall liaise with the Railway Authority \throughout the pipe jacking work under the railway lines and comply with all the requirements of the Railway Authority.

1.10.8.3. Driving Pipe

Driving pipe (encasement pipe) shall be steel or ductile iron pipe and the pipe material component and fabrication shall comply with the Specifications in Section 1.10. Lining and exterior coating will not be required.

1.10.8.4. Driving and Arrival Shaft

Driving shafts shall be sized so that all equipment needed for the driving operation can be reasonably accommodated in the shaft and that placing and jointing of pipe and other works in the shafts can be safely done. Each driving shaft at the bottom shall be provided with dewatering sumps and pumps to maintain the shaft dry throughout the driving operation. Each driving shaft shall also be equipped with a crane for unloading of pipe and driving equipment and for removal of excavated soil.

Arrival shafts shall be sized so that removal of cutting edges and pipe connections in the shafts can be satisfactorily accomplished. Unless otherwise directed by the Engineer, construction of arrival shafts shall be delayed until driving operation has been nearly finished.

1.10.8.5. Cutting Edges

Irrespective of the construction methods to be used by the Contractor, cutting edges shall be designed to withstand against the required driving force and anticipated earth pressure. Each cutting edge shall be designed to integrate a reasonable number of jacks of controlling of pipe alignment and grade during driving operation.

Cutting edges shall have the same outside diameter as that of the steel-encasing cylinder of pipe for driving.

1.10.8.6. In-Pit-Based Jacks

The total number of in-pit-based jacks shall be determined on the basis of jack output equal to 70 percent of the rated jack pressure. The rated pressure of the jack shall not be less than 400-kg/sq.cm and jacking stroke shall not be less than 500 mm.

1.10.8.7. Installation of Pipe

The Contractor shall take all necessary steps to ensure that the casing pipe is driven to the proper alignment and grade.

For steel pipe, method of field welding shall be same as that used for field welding of steel pipe and fittings as specified in Section 1.10.2. After the welded joints have been inspected and approved by the Engineer, coating equivalent to the shop applied coating shall be applied across the joints. The ductile iron pipe shall be jointed as specifications.

The pipes shall be jacked progressively as they are jointed and properly positioned. Thereafter the space between the pipeline and the casing pipe shall be filled with rammed sand or very weak grout that could be removed later if necessary.

1.10.8.8. Submittal of Shop Drawings and Reports

Prior to construction work, the Contractor shall submit to the Engineer shop drawings containing at least the following:

- Results and analyses of soil investigation.
- Construction method and sequence in detail.
- Design calculations to determine the wall thickness of the steel casing pipe.
- Drawings showing full details for dimensions of steel casing pipe for driving including pipe joint and cutting edge.
- Drawings showing full details of driving and arrival shafts.
- List of equipment to be used.

The shop drawings shall be submitted for each railway crossing work. No construction work shall be commenced by the Contractor until the shop drawings have been approved by the Engineer.

1.11. Steelwork

1.11.1. General

For all fabricated steel works the Contractor shall submit fabrication details, and drawings and calculations for the approval of the Engineer prior to the manufacturer of any of the items.

Miscellaneous steelwork comprises the following main items:

- open mesh flooring and gratings including framework and supports;
- manhole covers;
- bar screens and accessories in overflow chambers and outfalls;
- cylinders for steel cylinders type pipes;
- flanges and bolted connections;
- anchoring;
- step irons, ladders and pipes
- staircases, landings and platform

Structural steelworks comprises the fabrication and erection of the following:

- columns and beams
- gratings, including frameworks
- hatches, including frameworks
- angles for protection of edges, including anchors
- ladders
- staircases, landing and platforms
- other structural steelwork associated with the specified mechanical and electrical plant.

1.11.2. Quality and Testing of Materials

All materials, including operating appurtenances and fasteners, shall conform to the requirements of the relevant specifications for alloy, grade type or Grade of material.

At least two weeks before ordering materials, the Contractor shall send a written notice to the Engineer giving the following details:

- type, quality and quantities to be ordered from a steel mill;
- type, quality and quantities to be ordered from available (local or non-local) stocks.

If requested test certificates from the steel manufacturers shall be submitted to the Engineer for the materials ordered. Material obtained from stocks shall be checked by the Engineer for exterior defects either in the workshop or at the Site.

1.11.3. Submissions by Contractor

1.11.3.1. General

Prior to any steel fabrication work the supplier shall submit full details of his proposed procedure, qualification and methods of fabrication to the Engineer for approval.

This information shall include (but not be limited to) the following details where they are relevant:-

- The method of plate forming
- Joint design
- Proposed welding procedure and proof of competence of welders
- Method of straightening, sizing and hydrostatic testing.
- Quality control and inspection procedures.

1.11.3.2. Drawings

Before commencing fabrication, the Contractor shall submit to the Engineer for his approval working drawings of the steelworks in accordance with the relevant Clauses of the Specification. Each component shall be clearly marked.

1.11.3.3. Calculations

The Contractor shall submit to the Engineer for his approval calculations of the following items:

- structural calculations where applicable or required by the Engineer;
- mounting plates;
- stiffening parts;
- welded seams;
- anchors and bolts

The calculations shall be in accordance with the relevant Clauses of the Specifications.

In the event of unavailability of certain materials and steel sections, deviations from the original design can be made provided they are approved by the Engineer. In such cases the Contractor shall submit to the Engineer his calculations for the proposed design. Such calculations shall be submitted to the Engineer for approval in two copies together with two copies of corresponding working drawings.

If requested the Contractor shall submit to the Engineer for his approval calculations of weights of all relevant steel structural components. The basis for the calculations shall be the measurements of items as indicated on the approved working drawings multiplied by their number and the specific weight of steel (= 7850 kilograms/cubic metre) or specific weight per metre and/or square metre. These calculations shall be submitted in two copies together with two copies of corresponding working drawings.

1.11.4. Manufacturing and Workmanship

All works shall wherever possible be carried out in covered and well equipped workshops. Where work has to be carried out on site the Contractor shall take adequate measures to protect work against damp, draughts and extremes of temperature. The Contractor's proposed measures shall be submitted to the Engineer for approval before site welding commences.

1.11.5. Ladders (Steel)

Steel ladders shall generally comply with BS 4211 except where otherwise specified. Ladders shall be fabricated of solid mild steel sections. Bolts, nuts and washers shall be cadmium plated. The stringers shall be flat section not less than 65 mm x 13 mm spaced 380 mm apart and shall be flanged and drilled for wall fixing at both ends. The stringers shall be radiused over the top where they shall be not less than 600 mm apart. Ladders over 3 metres long shall have additional intermediate stays at not more than 2.5 metre centres.

Rungs shall be 25 mm diameter solid equally spaced at 250 mm centres, shouldered at each end and securely riveted into countersunk holes. Rungs shall be not less than 225 mm from the wall. All ladders rising more than 2.50 metres from lower platform or ground level to the top rung shall have safety cages which shall be constructed of three flat verticals supported by flat hoops with a diameter of 750 mm. The hoops shall be approximately 700 mm centres and the first hoop shall be 2.4 metres above ground or platform level.

Where the rise exceeds 6.2 metres an intermediate landing shall be provided.

Steel ladders shall be galvanised and coated with an approved coating.

1.11.6. Structural Steelwork

1.11.6.1. General

Structural steel sections shall comply with the relevant provisions of the following standards:

Structural steel sections	BS 4: Part 1
Cold rolled steel sections	BS 2994
Weldable structural steels	BS 7613 and BS 7668
Hot-rolled structural steel sections	BS 4848: Parts 2 and 4
Steel tubes for general purposes	BS 6323: Parts 2 - 7

In addition structural steelwork shall comply with BS 449.

Where the use of proprietary designs of prefabricated building frames is proposed, the standards to which they are manufactured shall be no less rigorous than those stated above.

1.11.6.2. Bolts and Nuts

Steel bolts and nuts for structural steelwork shall be high strength friction grip bolts conforming to BS 4395 or black bolts conforming to BS 4190. Washers shall conform to BS 4320.

High strength friction grip bolts shall be used in conjunction with approved proprietary load indicating washers.

1.11.6.3. Welding Consumables

All welding consumables (electrodes, wire, filler rods, flux, shielding gas and the like) shall comply with the requirements of BS 5135.

1.11.6.4. Welding

All welding carried out during fabrication or erection shall be in accordance with the requirements of BS 5135. Details of the proposed weld procedures shall be submitted to the Engineer for approval. All connections shall be welded in such a manner as to make the finished connections neat and smooth in appearance and suitable for painting. All slag shall be removed and any sharp projections shall be ground smooth.

Before welding is commenced either in the fabrication shop or on site, weld procedure tests shall be carried out in accordance with BS 4870 where directed by the Engineer.

All welders employed either in the fabrication shop or on site shall pass qualification tests relevant to the weld procedures in use in accordance with BS 4871. Welders shall have satisfactory evidence of having been engaged in welding for at least 9 months in the preceding 12 month period. If the work of any welders employed on the Contract is unsatisfactory, the Contractor shall carry out such further welder qualification tests as are necessary to demonstrate that the welders are proficient.

If requested welds shall be subjected to non-destructive testing by processes which may include but shall not necessarily be limited to radiographic, ultrasonic, magnetic particle, or dye penetrant methods, depending on the type of weld and its position in the structure. The standards of acceptance shall be as defined in BS 5500: Table 5.7, unless otherwise agreed with the Engineer.

If any work shows defects or fails to comply with the specified requirements it shall be repaired or rejected, even though it may have been carried out by qualified welders using approved procedures.

1.11.6.5. Fabrication Tolerances

The general tolerance on all dimensions shall be ± 2 mm. Holes shall be aligned such that fasteners can be freely inserted through the members at right angles to the contact face. Where holes in members cannot be aligned without damaging or distorting the structure or (unless the Engineer shall permit) reaming the holes, the member or members shall be rejected.

A structural member shall not deviate from straightness (or from the specified shape) by more than:

1/1000 of the lengths between lateral restraints in the case of compression members and beams, or

1/500 of the overall lengths (maximum 25 m) in the case of other members.

A structural member shall not deviate from its intended length by more than:

± 1 mm in the case of compression members faced at both ends for bearing, or

+ 0 mm to - 4 mm in the case of other members.

Lengths of components shall be such that cumulative variations do not prejudice the accurate alignment of the completed structure.

Where two steel surfaces are required to be in contact to effect a bearing or frictional contact, the surfaces shall be prepared so that at least 90% of the area is touching before any clamping force is applied.

1.11.6.6. Dissimilar Metals

Where metals dissimilar to those specified are used in close proximity to structural steel members or their connections, contact between such metals and the steel shall be avoided unless the Contractor can demonstrate to the satisfaction of the Engineer that contact between the dissimilar metals will not lead to galvanic corrosion.

Contact between aluminium or aluminium alloy and galvanised mild steel will be permitted. For fixing aluminium to steel structures, bolts, nuts, washers and screws shall be galvanised or cadmium plated.

Where galvanised parts might otherwise become sacrificial anodes to the main structure, or where the electrolytic potential difference exceeds 250 mV, the parts shall be separated by an insulating medium of adequate strength.

1.11.7. Protective Treatment

1.11.7.1. General

Protective treatment materials shall be stored in a clean, dry area which is protected from extreme temperatures, and used in order of delivery, in accordance with the manufacturer's recommendations and within the advised shelf life.

Materials shall be prepared, and coatings applied to surfaces, in accordance with the manufacturer's recommendations.

The procedures for handling and storage shall be so arranged that the protected surface is unlikely to be damaged.

1.11.7.2. Surface Preparation

Surfaces which are not to be blast cleaned, but are to be coated, shall be wire-brushed to remove loose mill scale, and cleaned to remove dust, oil and grease.

Surfaces which are to be blast cleaned shall comply with the following:

- (i) The standard of blast cleaning specified shall be in accordance with BS 7079 Part A1.
- (ii) The methods used shall be capable of cleaning all surfaces of the component
- (iii) The surface roughness shall be compatible with that recommended for the coating to be supplied.
- (iv) The cleanliness levels specified shall be those existing at the time of the application of coating.
- (v) When abrasives are recycled in the blast cleaning system, the equipment shall be fitted with a dust removal system to remove fines and contaminants.

1.11.7.3. Galvanising

Galvanising shall be performed in accordance with BS 729.

Small areas which are within 10mm of intact galvanised coating may be touched up in accordance with Appendix D of BS 729.

If so required by the Engineer vent holes in hollow members, necessary during the galvanising process, shall be sealed after galvanising with a plug of approved material.

All exterior steelwork shall be galvanised unless specified otherwise.

1.11.7.4. Paint Finishes

Steelwork shall be dry and cleaned to the surface cleanliness specified in clause 1.11.7.2

Steel surface to be embedded in concrete shall be left unpainted and need not be blast cleaned unless required by the Engineer.

All paint products shall be used within the manufacturer's recommendation pot life.

Where two or more coats of a product are to be applied, a different colour shade shall be used for each coat.

Additional stripe coats of primer or undercoat shall be applied in the following circumstances:

- (a) to welded surfaces where a weld-through primer has been used;
- (b) to steelwork which will be exposed externally in the finished works, applied to all edges and corners, and to seal gaps between adjacent component such as shop and site bolted connections.

Storage and handling procedures shall ensure that damage to the protective system is minimised.

Work shall not proceed when the steel surfaces are wet or the ambient temperature, or dew point, is below that recommended by the paint manufacturers.

All protruding portions of bolt assemblies and site weld surfaces shall be cleaned to remove traces of all, welding flux etc.

An approved paint system shall be applied to ensure similar properties compatibility with the surface treatment system being used as the surrounding surfaces.

Bolt assemblies which are supplied with a protective treatment need not be painted except when the Engineer requires it.

All internal steelwork shall be given one coat of an approved zinc phosphate steel primer and two finish coats of an emulsion latex paint unless specified otherwise.

1.12. Fencing

1.12.1. Fencing Materials

Chain link fencing shall comply with BS 1722 Part 1 and shall be hung on concrete posts. The chain link and the line wire shall be plastic coated galvanised wire and tying wire to Table 2 Grade A Type PLC 180A, and the stirrup wire and tying wire to BS 4102 Grade A. The bottom of the fence shall be fixed down with staples to a continuous concrete sill (225x225 mm reinforced with 4-y10 and r6 -200 c/c links) placed on 300 wide rubble wall with foundation depth not less than 600 mm.

Galvanized barbed wire fencing.

Gates.

Steel posts shall be galvanised in accordance with the specification.

Access gates shall be both single and double entrance gates shall be fabricated tubular steel and galvanised after manufacture. They shall comply with BS 1722 Part 1 Supplement No. 1 Sockets for casting into the roadway shall also be provided. The sockets shall be designed to provide secure and robust support for drop bolts when gates are in both open and closed positions.

Each gate shall be supplied with a padlock and three keys all to the Engineer's approval.

1.12.2. Erection

Fencing shall be constructed to details approved by the Engineer.

In areas where the ground has not already been graded during other earthworks operations, the fence shall generally follow the existing ground line. Minor irregularities shall be removed or filled by grading 600 mm on each side of the fence.

Spacing of straining posts shall not exceed 66 metres in straight lengths of fence.

All fence post and strut holes shall be filled with concrete grade C25 to a level of 150 millimetres below finished ground level. The holes shall be vertically sides and shall be backfilled to give a minimum concrete surround thickness of 150 millimetres. Concrete shall be cured for a minimum of 72 hours before any further work is done on the posts.

1.12.3. Temporary Fences and Barriers

All boundaries of the Contractor's offices, work-yards, workshops, depots and stores shall be agreed with the Engineer. A proper fencing, including lockable gate, shall be provided by the Contractor along the agreed boundaries. The Contractor shall erect similar fences around all

construction Sites before commencing work, and dismantle them after the Works have been completed.

The fencing shall be in close-boarded timber aluminium or steel corrugated sheets 2400 mm high fixed on timber, concrete or steel posts. All fenced areas shall be provided with lockable gates. In some of the areas agreed with the Engineer, the Contractor may provide chain link fencing or galvanised wire netting.

Barriers shall be fixed around trenches in streets and pedestrian area and properly sign posted. All barriers on roads and pedestrian area shall be lit with warning lights during night time or when there is poor visibility.

1.13. Landscaping

1.13.1. Submissions

Prior to commencement of any landscaping work, the Contractor shall submit to the Engineer for approval his detailed proposals for landscaping including the proposed species of grass, trees and shrubs.

1.13.2. Materials

1.13.2.1. Top Soil

Existing top soil stripped from the site and stored in heaps adjacent to the works may be reused provided it has not become contaminated and is free of rubble and debris.

Where insufficient site top soil is available additional humus shall be imported from an approved source. Samples shall be submitted to and be approved by the Engineer before landscaping work is commenced.

1.13.2.2. Sweet Sand

Sweet sand for use on the site shall be obtained from an approved source. Samples shall be submitted to and be approved by the Engineer before landscaping work is commenced.

1.13.2.3. Manure

Animal manure for mixing with sweet sand shall be of good quality and be obtained from an approved source.

1.13.2.4. Grasses

Grasses shall be Bermuda Grass - *Cynodon Dactylon* or any alternative species proposed by the Contractor and approved by the Engineer.

1.13.2.5. Trees and Shrubs

Trees and shrubs shall be of the species proposed by the Contractor and approved by the Engineer and shall be of the best quality and free from disease. They shall be young stock or in the case of shrubs may be established seedlings or cuttings. All must be sufficiently mature to survive transplanting from the supply nursery.

The root systems of all plants shall be maintained intact in the soil in which they have been grown and may be supplied in containers.

1.13.2.6. Gravel

Gravel for use on the site for landscaping shall comply with BS 882 and be of 28 mm nominal size.

1.13.2.7. Irrigation Water

Water for irrigation shall be taken from the potable water supply main.

1.13.2.8. Wire and Pegs

Wire for supporting climbing plants shall be black plastic covered stout wire and pegs for fixing same to brickwork shall be galvanised mild steel tapered pegs 75mm long with single hole to carry wire suitable for driving into brick joints.

1.13.3. Landscaping

1.13.3.1. Tree Felling

Existing trees and shrubs where directed by the Engineer shall be cut down and all stumps and main roots shall be grubbed up. All planting thus dealt with shall be either burnt in situ or removed from the Site.

1.13.3.2. Inspection of Retained Trees

All trees and shrubs to be retained shall be inspected jointly by the Engineer and the Contractor at the commencement of the Contract and a list of trees to be retained shall be agreed. Any tree found to be diseased, dead, dying or unsafe shall be felled and uprooted subject to the prior approval of the Engineer.

1.13.3.3. Protection of Retained Trees

Existing trees and shrubs that are to be retained shall be adequately protected by the Contractor during the course of the Contract from all operations and from goats and other animals.

Small trees and shrubs generally shall be surrounded by adequate temporary fencing to safeguard trunks and foliage.

Large trees shall have suitable screening round trunks, and low branches shall be protected by temporary fencing or barriers to prevent damage from building plant and equipment.

Construction materials shall not be stored close to or within the branch spread of any tree or shrub. Existing ground levels shall be maintained.

1.13.3.4. Maintenance of Retained Trees

Retained trees and shrubs shall be maintained during the Contract and pruned at completion having due regard to the appropriate time of year for such work to be carried out.

Maintenance shall include removing snags, dead wood and fronds, sealing cavities and irrigating as required to ensure the continued health of existing planting.

1.13.3.5. Replacement of Damaged Trees

Should any retained tree or shrub be damaged or killed as a result of the building operations then it shall be replaced by the Contractor by an equivalent mature tree or shrub of the same variety.

1.13.3.6. Preparation of Ground

Where so required landscaping of the Site shall be undertaken after the Contractor has completed all other earthworks apart from replacing top soil. The areas to be landscaped shall be brought to final ground levels less the depth required for top soil or other surfacing and all surplus material shall be disposed of off site.

All areas of the Site which are to be finished with gravel shall be excavated to a level of 150 mm below final ground level. After excavation is complete the area shall be filled to final ground level with compacted gravel.

All areas of the Site which are to be finished with sand shall be excavated to a level of 400 mm below final ground level. After excavation is complete the area shall be filled to final ground level with lightly compacted sweet sand. In this filling the Contractor shall make allowance for any consolidation and shrinkage which may subsequently occur.

1.13.3.7. Cultivation of Ground

The Contractor shall, prior to commencing work, excavate to a depth of 250 mm below existing ground level over all areas which are to be regarded to remove topsoil. This top soil shall be retained for re-use. After construction is complete relevant areas shall be filled and reinstated to a level of 250 mm below final ground level with lightly compacted approved material. In this filling the Contractor shall make allowance for any consolidation and shrinkage which may subsequently occur. The Contractor shall then relay the 250 mm thick top soil. Any deficiency in the top soil shall be made up with imported top soil.

Prior to replacing topsoil areas of the Site which are to be prepared for grass planting shall be thoroughly broken up by deep raking and cross raking to a depth of 450mm. Retained top soil may be used as fill to final ground level subject to the approval of the Engineer being first obtained. Imported top soil shall be used if the existing top soil is insufficient or unsuitable.

Where new and replacement trees or shrubs are to be planted by the Contractor in positions in agreement with the Engineer, holes 1000 mm deep below final ground level and 1000 mm square shall be excavated in each case. These shall be filled with sweet sand topped with 250 mm of top soil. Sand filling shall be thoroughly mixed with 10 kg manure before placing.

1.13.3.8. Time for Planting

In programming the planting work the Contractor shall take due regard of the accepted seasons for planting. Should the time for completion be such that landscaping works would be carried out at a time when planting is inadvisable then the Contractor may apply to the Engineer for permission to postpone the planting until a more suitable time of year.

Should this delay mean that the planting has to be carried out after the date of completion of the Works then the Contractor shall give satisfactory undertakings to carry out the outstanding landscaping during the Period of Maintenance.

1.13.3.9. Leaching

Immediately prior to planting and at the direction of the Engineer the Contractor shall irrigate areas for planting to leach out remaining traces of salt. Irrigation water shall be applied uniformly over the ground for 7 consecutive days at a rate of not less than 15 litres/m² per day.

1.13.3.10. Top Soil Dressing

Top soil ready to receive planting shall be given a dressing of manure at a rate of 5 kg/m². After spreading uniformly on the surface the manure shall be thoroughly mixed into the top soil.

1.13.3.11. Supply of Plants

All trees, shrubs, grasses and other plants shall be supplied by a nursery approved by the Engineer.

1.13.3.12. Planting of Trees and Shrubs

Prior to planting holes for trees and shrubs shall be prepared and filled twice with water. Plants shall be watered in their containers so that the soil and the roots are kept in a moist condition. Plants shall then be removed from their containers and their root ball complete with soil set in place and the holes backfilled and the plants firmly trodden in.

Soil shall not be allowed to rise above the original container level and the ground level around the trunk or stem shall be set below adjacent ground to retain irrigation water.

All species of tree and shrubs where required shall be provided with supports during planting. These shall take the form of timber stakes of adequate strength driven into the ground adjacent to the trunk or stem without damage to roots. Wide hessian strips shall be used to tie the plant securely but not tightly to the support.

Where shrubs are to be planted in groups to provide ground cover, individual plants shall be spaced as follows:

Size	Height when grown	Spacing
Small	less than 1m	500 - 600 mm
Medium	1 - 2 m	900 - 1200 mm
Large	over 2 m	1800 mm

1.13.3.13. Grassing

Areas to be grassed shall be drilled 50 to 100 mm deep at 150 mm centres in each direction. Each drill shall be filled with grass or sedge rhizomes and a soil covering provided so that 40 mm only of the upper foliage remains above ground level.

The different species of grasses and sedge shall be planted as directed by the Engineer. After planting, the areas shall be rolled and trodden over.

1.13.3.14. Support for Climbing Plants

Training wires shall be pegged to brickwork walling where required to support climbing plants. Wires shall be horizontal fixed to every 4 courses of brickwork with pegs at 1500 mm maximum centres.

Climbing plants shall be secured to wires with sisal string as required.

1.13.3.15. Irrigation

After planting of native tree and shrub species they shall only be irrigated twice and thereafter only as required. Non-indigenous species shall be irrigated regularly until handover to the Engineer.

Grassed areas shall be irrigated immediately after planting and regularly thereafter until handover. Watering of grass shall preferably be by night time sprinkler system. If watering is carried out during the daytime the area should be flooded.

Irrigation shall be from overhead in all cases.

1.13.3.16. Maintenance

All new plants and grassing shall be maintained for not less than 12 months after planting. This shall take the form of irrigation, restaking, pruning, weeding, tilling, etc to ensure sufficient growth is achieved by all plants up to handover to the satisfaction of the Engineer.

Once grassed areas are sufficiently established they shall be kept cut or mown to provide a uniform depth of growth. Edges of grassed areas shall be trimmed as necessary.

All new plants and grassed areas shall be protected to prevent damage from workmen, builder's plant and equipment, goats and other animals, but the use of temporary fencing or other suitable means.

1.13.3.17. Replacement

Any trees, shrubs or areas of grass which fail to show satisfactory growth or wither and die shall be replaced by the Contractor.

The responsibility for the irrigation and maintenance of these replacement plants shall remain with the Contractor until such time as they exhibit satisfactory growth.

1.13.3.18. Soil Testing

If so required by the Engineer the Contractor shall arrange for samples of existing and/or imported top soils and sweet sand to be tested by an independent laboratory to assess salinity levels.

These tests shall be carried out prior to leaching.

1.14. Building Trades

1.14.1. General

Works in this section consists of furnishing of all labour, materials, apparatus and appurtenant work in connection with building trade work.

In general, all building trade work shall comply with the “Specification for Building Works - Sri Lanka (Volume I) -1985”, (ICTAD publication No. SCA/4 - Volume I) and for sanitary installation, the same specification Volume II - 1989 or their subsequent revisions if any.

1.14.1.1. Work Included

The work includes, but is not limited to the following:

- Brick Masonry Construction
- Roof Construction
- Floor and Wall Finishes
- Glass and Glazing
- Miscellaneous Metal
- Carpentry
- Ceiling

Any other Work specified herein.

1.14.1.2. Related Work not Include in this Section:

- (a) Miscellaneous Structural Work.
- (b) Field Painting.

1.14.1.3. Co-ordination and Co-operation

Work of this section shall be fully co-ordinated with related work of other trades. Particular attention is required for items embedded in concrete or masonry.

1.14.1.4. Submittals

Shop drawings shall be submitted prior to fabrication of any work. Shop drawings shall be based on the Drawings, specification, and field measurements and shall present complete information as to fabrication, installation and proper fitting with other construction.

1.14.1.5. Sample Panels

Prior to commencing construction, a sample panel shall be erected, 1 metre square showing brick, bonding, jointing and mortar. Materials intended for use in the construction shall be displayed and method demonstrated and Engineer's approval shall be obtained. Completed work shall uniformly match selected and approved sample. Samples of the following work for approval of the Engineer shall also be submitted.

- Plastering
- Flooring
- Joinery
- Tiling

- Door & window where requested
- Painting

1.14.2. Materials for building Trades

1.14.2.1. Delivery and Protection of Materials

The Contractor shall deliver all materials to the job site in manufacturer's original containers, properly labelled for identification. The Contractor shall provide raised platform and waterproof covers to protect the materials from the weather and from contamination from loose dirt, and debits.

1.14.2.2. Roofing

All roofing shall be erected using clay flat tiles (calicut pattern) conforming to Sri Lankan ICTAD standards.

1.14.2.3. Bricks and Cement Blocks

First quality properly pressed bricks, and regular and uniform to colour. Brick dimensions shall conform with BS.3921 Part. 2 and shall be of nominal depth 60 mm. Samples shall be submitted to the Engineer for his approval.

Common bricks of the internal quality shall be the solid type. Facing bricks shall be selected special quality bricks of the solid type. Independent Tests shall be carried out on samples of bricks. The Sampling Procedure and Testing Methods shall be in accordance with the requirements of BS 3921 Part 3.

Cement blocks shall be to the following standards:

- BS6073 “Pre-Cast Concrete Masonry Units (Concrete Blocks);”
- Sri Lankan ICTAD standard;
- Sri Lankan Standard 855 Parts 1 & 2.

1.14.2.4. Cement

Cement shall be Portland Cement BS 12. Cement brand shall be subject to the approval of the Engineer.

1.14.2.5. Fine Aggregate and Course Aggregate

For Concrete Works

As specified in Section 1.6.3 in this specification.

For Building Works

The sand may be naturally occurring like river sand or pit sand. It shall generally conform to BS 1198, BS 1193 and BS 1200. It shall be hard, durable, clean and free from adherent coatings such as clay. It shall not contain harmful materials like pyrites, salts, coal or other

organic impurities mica, shale or similar laminated materials, or flaky or elongated particles in such a form or in sufficient quantity to affect adversely the hardening, strength or durability of the mortar. In addition to the above, the sand when used for reinforced brickwork shall not contain any material, which may attack the reinforcement.

The quantity of clay, silt and dust shall not exceed the following unless there is satisfactory evidence to the contrary.

In natural sand - 3% by mass when determined by the decantation method given in BS 812.

Sand for brickwork/stone work/block work and external plastering shall pass completely through a sieve of 2.36 mm sand for second and third coats of plastering, pointing and fine work shall completely pass through a 1.18 mm test sieve.

1.14.2.6. Water

Potable water.

1.14.2.7. Reinforcement

As specified in Section 1.8 of this specification.

1.14.2.8. Steel for Hollow Metal Doors and Frames

Cold rolled stretcher levelled carbon steel with hot-dip galvanised G-90 type zinc coating conforming to ASTM A525.

1.14.3. Fabrication and Erection

1.14.3.1. Brick Masonry Erection

(1) General

Except as herein specified, brickwork shall conform to the requirements of C.P. 121:101 and various Standards referred to herein. All materials for brickwork shall be handled and stored on site in such a manner as to avoid damage or contamination. Bricks straight from the kiln shall not be used in walling and brick deliveries shall be arranged to ensure that natural weathering takes place for a minimum period of 4 weeks before use.

(2) Mortar

Mortar shall be composed of cement and sand and the constituents shall be mixed in small batches in a mechanical mixer and used fresh. Cement shall be ordinary Portland Cement stored and handled as described in these Specifications. Mortar mixes for brick joints shall be measured by volume and be composed of 1 part of Portland Cement to 5 parts of sand, for brickwork laid above the level of damp-proof course. Prior approval shall be obtained from the Engineer to the use of any admixture in mortar. Mortar shall be used within an hour of adding water to the mix and no softening or reviving of the mortar will be allowed in any circumstances.

(3) Brickwork

Brickwork shall be jointed and pointed with mortar unless otherwise instructed by the Engineer. All brickwork is to be built with horizontal courses and vertical perpend and in

vertical planes. The finished surface must be true to line and level. Window and door openings are to be furnished accurately to size, and finished solid against metal or wood frames. Unless the sides of the brickwork are to be plastered or rendered, the brickwork is to have fair-faced sides. Walls with fair face both sides shall have a Weathered Joint externally and a Flush Joint internally both as shown in C.P.121. 101, Page 144, Figure 2. All jointing shall be completed with pointing as the brick laying proceeds. External wall faces or other wall faces, which are to be rendered or plastered respectively, shall have their joints raked out as the brick laying proceeds. The cross joints in any course shall not be less than a quarter of a brick from those of the course below; or in the case of stretcher bond, half a brick. Expansion joints where required shall be of expanded Polystyrene. Joints shall be painted with approved polysulphide filler. Brickwork of 230 mm and 115 mm (9 inches and 4 1/2 inches) thick shall be built in English and Stretcher Bond respectively. Snap headers will not be permitted, and bats shall be used only as closers to obtain a true bond. Particular care shall be taken to ensure that the vertical joints of the header courses are completely filled with mortar.

(4) Miscellaneous

All bricks shall be kept damp during building and shall be and carefully bedded on mortar and all vertical and horizontal joints being completely filled with mortar. The brickwork shall be built approximately in courses of 1 metre to the approval of the Engineer. Every third course shall be truly levelled and laid fair and level by line and all quoins, perpendiculars etc., kept true and square. The whole of the work shall be built straight and plumb and properly bonded together and neatly pointed, all to the satisfaction of the Engineer. No one section being raised more than 1 metre above another at one time. Facework shall not be built overhand. All unfinished brickwork shall be left toothed and projecting headers to form a bond with succeeding work. The Contractor is to cut all holes, form all chases for service pipes and conduits for all other trades as required. No wall shall be built up more than 1.5 metres in height on any working day.

(5) Protection

Architectural features and finished surfaces shall be protected against damage during the progress of the works. Newly laid brickwork shall be protected from the harmful effects of sunshine, rain, drying wind, running and surface water and shocks. Any work that is damaged shall be taken down and re-built or the joints raked out and pointed as directed by the Engineer. Any cost incurred in carrying out such remedial work shall be borne by the Contractor.

(6) Damp-Proof Course

The damp-proof course shall be 20 mm thick cement mortar (1:3 mix) and shall be continuous throughout and stepped down where floor level changes.

(7) Cleaning

The whole of the exposed faces of brickwork shall on completion be cleaned of all mortar drops and other markings and left in a perfect condition, and shall be properly protected against possible damage during execution of the works, all to the satisfaction of the Engineer.

1.14.3.2. Roofing

Install corrugated asbestos cement roof sheets to all roof surfaces of buildings. The Asbestos cement sheets shall be of the best quality, compressed, of Sri Lankan manufacture, complying

in every respect with the latest BS's. The Asbestos cement sheets shall be 72 mm corrugations with thickness not less than 5.6 mm.

The Asbestos cement sheets shall be fixed with galvanized hook bolts of 6.0 mm diameter, Impet washers shall be not less than 3.0 mm thick and additional bitumen washer, to purling spaced not more than 900 mm. Sheets shall overlap at least 250 mm down the slope of the roof and adjoining sheets shall be laid with a lap of 1½ corrugations. All AC roof panels shall be securely fastened to the hardwood bearers by drilling and self-taping coach screw along the ridges of the corrugated sheets. Eaves shall overhang the fascia by 50 mm.

The ridge of roof shall be sealed with standard asbestos cement ridge cap sections laid with at-least 150 mm overlap. They shall be of the adjustable type to fit closely with slopes of the roof. The details of Valance and bargeboard and methods of fixing shall be approved by the Engineer.

Flashing

Unless otherwise specified, the junction of all sloping roofs and walls shall be flashed with no. 22 BWG. (0.71 mm) Aluminium sheets. One edge shall be dressed over the roof to a width not less than 300 mm and the other edge turned up to a height not less than 150 mm and tucked into a chased cut in the wall and pointed in cement sand mortar 1:2.

1.14.3.3. Floor and Wall Finishes

(1) General

In general erection of all Plant and Equipment shall have priority over all the finishing work of every description and inclusive of plastering, painting, cement finish, floor tiles, ceilings etc. Prices quoted in the Bills of Quantities are to include for all difficulties, delays and inconveniences encountered and for any interference that may be caused by other Contractors at no additional cost to the Employer.

(2) Cement Finishes

Steel Trowel

Screed interior slabs shall be steel trowelled. Tamp with grid tamper enough to rise a bed of mortar to surface. No "dusting" on wet surface will be permitted. Level and compact with motor-driven disk type compactor float. Immediately thereafter the surface shall be further levelled and compacted with motor-driven trowel with flat-pitched blades. Final troweling shall be done with steel hand trowels after surfaces become hard enough to produce a hard, dense, smooth burnished finish. Provide for exposed interior concrete flat-work, except as otherwise indicated or specified.

Steel Float

Same as steel trowel, except that final burnishing shall be omitted. Provide where resilient flooring is indicated or scheduled.

Curing

- (a) Water Curing, maintain all concrete including slabs, in continuously wet condition for not less than seven (7) consecutive days after pouring, except where membrane curing is permitted.

Fabric Covering: Cover flat surfaces immediately after finish has hardened enough so that it will not be marred. Use Sisalkraft curing paper or approved equal polyethylene curing-and-protective tape-seal joints as recommended by manufacturer; also seal edges.

Sprayed Membrane: May be used for both flat and vertical surfaces of concrete, except where paint or other incompatible finish is to be subsequently applied. Apply with a power sprayer with nozzle equipped with a wind guard. Apply in conformance with manufacturer's printed directions. Protect surfaces that have been membrane cured during entire curing period from all forms of abrasion.

Weather Conditions: If weather conditions are severe enough to unduly dry out concrete surface, the surface shall be kept moist with a fine fog spray until protected by one of the above-specified cures.

1.14.4. Plastering

1.14.4.1. Material

(1) Cement

Cement shall be or ordinary Portland cement complying to BS 12. Blended cement can be used only with the approval of the Engineer.

(2) Fine Aggregate

Fine aggregate shall be natural sand clean, sharp, suitably graded and free from all deleterious and impure materials.

The grading of sand for plaster works for internal and external walls and ceiling works shall be as follows.

Sieve Designation	Percentage passing
10 mm	100
4.75 mm	95-100
2.36 mm	95-100
1.18 mm	90-100
600 micron	80-100
300 micron	20-65
150 micron	0-50

(3) Mortar Plasticizer

The air entraining (Plasticising) admixtures shall comply to BS 4887 Part 1. It shall not give adverse effects if over dosed.

(4) Filler Coat

The filler coat for concrete block or burnt clay brick masonry shall be cementitious type filler approved by the Engineer.

(5) Levelling coat

Levelling coat shall be Modified acrylic or vinyl type cement plaster approved by the Engineer.

1.14.4.2. Mortar

(1) Cement Sand Mortar

The mortar shall consist of Ordinary Portland Cement (OPC) or blended cement (with the approval of the Engineer) mixed with graded sand, each complying with the respective standards and mixed in the proportions specified.

The cement and sand shall be mixed only in sufficient quantities for a day's requirement. It can be mixed dry three times on an approved platform of masonry, stone or wood, and then sprinkled with necessary quantity of water and mixed in a mortar mill. Approved liquid or solid plasticiser conforming to BS 5750 shall be added in approved quantities. Water may be added during the mixing process, care being taken not to add more water than will bring the mixed materials to the consistency of a stiff paste. The sides of the mill shall be maintained in good order. A satisfactory method of counting the revolutions shall be followed.

All mortar shall be used as soon as possible after grinding. As a rule it shall be used on the day on which it is made, but in no case shall mortar made 72 hours previously be permitted to be used or remain at the site of the work except mortar, which is to be ground a second time for plastering work (see below). In all cases, the mortar shall be kept damp and on no account be allowed to dry. It shall always be protected from the sun and rain. All mortar more than 72 hours old or mortar hardened or set before being used shall be removed from the work site within 24 hours or order to do so, and no second mixing will be permitted.

The Cement sand mix (with approved quantity of Plastizers) shall be mixed in the proportions specified below.

	Item of work	Cement Sand
Mortar for load bearing brick work	1	3
Mortar for masonry	1	5
Mortar for plastering	1	3
Mortar for pointing	1	3
Mortar for floor screeds	1	3

The Portland cement shall be measured by weight, a bag weighing 50 kg. Being taken as 0.035 cum and the sand in suitable measuring boxes. Where gauge boxes are used for measurement of cement by volume the gauge box shall be 400 mm x 350 mm x 290 mm high while the gauge box for sand shall be 400 mm x 350 mm x 250 mm high. The sand shall be measured on the basis of its dry volume. In the case of damp sand, its quantity shall be increased suitably to allow for bulking.

The mixing of mortar shall be done in mechanical mixers unless the Engineer permits hand mixing taking into account the nature magnitude and location of the work.

Machine Mixing

The cement and sand shall be fed into the mixer in the specified proportions and shall be mixed dry. Water shall then be added gradually and wet mixing continued for at least one minute. Care shall be taken not to add more water than will bring the mortar to the consistency of a wet paste. Mixing shall be restricted to such quantities as could be utilised on the work within 30 minutes of mixing.

Hand Mixing

In the case of hand mixing, the measured quantity of sand shall be spread level on a clean dry platform and the cement spread over it. The cement and sand shall be mixed dry three times over. Water shall be added to the mixture only when to mortar is required for use and then only in sufficient quantity to bring the mortar to the consistency of a stiff past.

Cement mortars shall be used on the works within two hours after mixing. Mortar remaining unused for more than two hours shall be rejected and removed from the work site.

1.14.4.3. Types

(1) Cement Sand Plaster -15 mm thick

The plaster shall not exceed 15mm total thickness. This shall consist of a single coat of cement sand mortar including where necessary the setting coat of vinyl based air drying compound of approved colour.

Surface Preparation

New brickwork or stone masonry shall have been finished with recessed joints to receive plastering. In the case of stone masonry, the bushings on the wall to be plastered, shall be removed to within 12 mm projection.

Where so specified for dense and smooth surfaces a suitable bonding treatment shall be applied to manufacturers' instructions before plastering.

All soft joints in old stone masonry or brickwork shall be raked out to a depth of not less than 12 mm. The walls shall be brushed clean of all dust, thoroughly wetted and surface dried before plaster is applied.

Application

Plastering of walls commence after completion of ceiling plastering if any. The plastering shall be started from the top and worked down towards the floor. All put-log holes (i.e. holes left for scaffolding) shall be properly filled in advance of the plastering.

To ensure an even thickness and a true surface, gauges of plaster 15 mm x 15 mm, or broken clay tiles set in mortar shall be first established on the entire surface at about 2 meter intervals both vertically and horizontally.

The thickness of the plaster over any portion of the surface shall not vary from the specified thickness by more than 3 mm.

Mortar shall be applied between the gauges to slightly more than the required thickness i.e. slightly proud of the gauges. The plaster shall be well pressed into the joints, levelled and

brought to a true surface by working a wooden straight edge reaching across the gauges, with small upward and sideways movement. Finally the surface shall be finished true with a wood float or trowel according to the type of finish required.

If a sandy granular texture is needed, the surface shall be wood floated. If a smooth finish is needed, towelling shall be done to the extent required. During this process the Filler coat and setting coat of vinyl based air drying compound shall be applied on the surface to facilities finishing.

All moulded work, apart from the coves shall be formed and run in approved cement sand mortar. All ornaments mitres etc. neatly formed. These shall be finished with approved vinyl based air drying compound.

All arises shall be plastered in cement sand mortar and finished filler coat and levelling coat of vinyl based air drying compound coat for widths of not less than 25mm along each face of the arise.

All necessary dubbing behind, rounding of corners at the junctions of the walls plastering of cornices etc. shall be done.

In suspending work at the end of the day, the plaster shall be left cut clean to line both horizontally and vertically. When recommending the plastering, the edge of the old work shall be scraped, cleaned and wetted filler coat before plaster is applied to the adjacent areas, to enable the two to be properly jointed together. Plastering work shall be closed at the end of the day on the body of the wall and not nearer than 150mm to any corners or arises. It shall not be closed on the body of features such as plaster bands and cornices, nor at corners or arises.

Horizontal joints in plasterwork shall not be formed on parapet tops and copings, as these invariably lead to leakage.

No portion of the surface shall be left out initially to be patched up later on.

Any cracks, which appear on the surface, and all portions, which sound hollow when, tapped, or are found to be soft or otherwise defective shall be cut out in rectangular shapes and redone as directed by the Engineer.

Finish

The plaster shall be finished a true and plumb surface and to the degree of smoothness required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5m long and with plumb bobs. The gap between the straight edge and any point on the plastered surface shall not exceed 3 mm. All horizontal lines and surface shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

Curing

Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of seven days. During this period it shall be suitably protected from all damages, at the contractor's expense by such means as the Engineer may approve.

Surface finish

Unless otherwise specified all surface of cement sand plaster for external rendering shall be wood floated; internal plastering shall be trowelled and finished with a setting coat of vinyl based air drying compound of approved colour.

(2) 15mm Thick Cement Plaster on Masonry / Brick Work

The plaster shall not exceed 15mm total thickness comprising a single coat of cement mortar and the setting coat of neat cement slurry.

Materials

The cement mortar 1:3 or other specified proportion conforming to the requirements of Clause 1.6.4.14.

Surface Preparation and Application

The surface preparation, application and curing shall be similar to the procedures specified in Clause 1.6.5.12 taking account of the following details:

The setting coat of neat cement slurry shall be applied within an hour of the completion of plastering.

It shall be trowelled smooth without showing signs of trowel marks of waviness or folds. Where a smooth finish is not specified, the surface shall be finished off with a rough wood float to the texture approved by the Engineer.

(3) 18mm Thick Coloured Cement Plaster - 2 Coat Work

This shall consist of 2 coats. The base coat shall be cement mortar 12mm thick with a surface coat of coloured cement mortar 6mm thick.

Materials

Cement mortar 1:3 other specified proportion conforming to the requirement of Clause 1.6.4.14.

An approved water-proofing additive shall be used where specified.

Surface Preparation and Application

Surface preparation, application and curing shall be similar to the procedures in Clause 1.6.5.12 taking account of the following details.

The base coat of cement mortar shall where specified include 3% by weight of an approved water proof additive. The base coat shall be left roughened with a wire brush to provide a key for the surface coat. The surface coat shall consist of a mortar of coloured cement and sand mix as specified applied to a thickness of 6mm. It shall be applied not earlier than 24 hours of applying the base coat. It shall be finished with a rough texture to accord with the approval sample area or as directed by the Engineer.

(4) Cement Plaster on Concrete Surface

Cement plaster for concrete surface shall be of cement mortar of minimum thickness 6mm in the case of single coat work and of maximum thickness 10mm in the case of 2 coat work.

The thickness of the plaster on the soffit of suspended floor shall be the minimum possible.

Materials

Cement mortar 1:3 or other specified proportion conforming to the requirements of Clause 1.6.4.14.

Surface Preparation

Projecting burrs of formed surfaces shall be removed and the surface scrubbed clean with a wire brush. The surface shall then be prepared as follows:-

- (a) A first coat of spatter dash shall be applied over smooth clean concrete surfaces if so directed by the Engineer. The dashing shall consist of 1 part of cement and 2 parts of clean fairly coarse sand mixed to thick slurry and kept well stirred. It shall be applied using a strong whipping motion normal to the face of wall. On setting and hardening, the spatter dash shall give a good key for the subsequent coat to be applied.
- (b) Where directed by the Engineer, the surface shall be hacked with a pointed tool at spacing of not more than 50mm, the hacks being not less than 3mm deep. The surface shall then be cleaned of all mould oil, grease etc. by scrubbing with water containing detergent and washing off with plenty of clean water. The surface shall be allowed to dry before application of plaster.

Application

- (a) Soft Plaster

Floor rendering and finishing of a suspended floor shall have been completed before commencing plaster its soffit. In the case of flat roofs, the weather proofing and other work shall have been completed so that the soffits plaster is not disturbed by subsequent operations on the floor or the roof. The concrete surfaces shall be wetted in advance and allowed to dry before application of plaster. To ensure an even thickness and a true surface, suitable gauges shall be established at about 1.5 metre intervals in both directions as described in Clause 1.14.3.3 and the plaster applied and finished smooth as described therein with a floating coat of vinyl based air drying compound. The finished soffit shall not show trowel marks, waves or folds and shall be true and plane. The mortar shall be used within an hour of adding water to the dry mix.

- (b) In the case of concrete surface other than soffits of suspended floors, the plaster shall be finished to a true and plumb surface and to the proper degree of smoothness required. All horizontal surfaces shall be tested with a levelling instrument and all jambs and corners with a plumb bob as the work proceeds. All internal surfaces shall be finished smooth with a floating coat of vinyl based air drying compound and external surfaces wood floated rough to the texture desired, all to the satisfaction of the Engineer.

1.14.5. Glass and Glazing

The Contractor shall furnish all labour, materials, and equipment to complete the glass and glazing work as specified herein.

1.14.5.1. Workmanship

Experienced glaziers shall be used to perform glazing. Glass shall be set tight and true with metal and/or extruded glazing beds, on glazing compound, as required. All excess compound shall be struck flush and neat, to leave work clean. All glazing shall be performed in strict accordance with applicable provisions of C.P. 152 and as herein specified.

1.14.5.2. Materials

Glass shall be labelled and labels shall not be removed until so directed by the Engineer. Thicknesses of glass are nominal with a permissible tolerance of plus-or-minus 0.8 mm. Actual glass sizes shall be obtained at job site or from manufacturers of windows. Conform to C.P. 152 and applicable Code requirements for maximum glass size and thickness required to meet a wind pressure of 950 Pa. Types of glass to be used are defined as follows:

(1) Tempered Glass

Pittsburgh Plate Glass Company 6.4 mm tempered plate glass or approved equal.

(2) Clear Sheet Glass

Pittsburgh Pennvernon Sheet Glass B quality 5.6 mm thickness or approved equal.

(3) Clear Plate

Pittsburgh 6.4 mm Polished Plate Glass (wire where indicated) or approved equal.

1.14.5.3. Protection and Replacement

All glass shall be protected against damage. At completion of work, all cracked, broken or imperfect glass and glass which cannot be properly cleaned shall be replaced. Immediately prior to final acceptance of the project, all glass shall be thoroughly cleaned.

1.14.6. Miscellaneous Metals

The Contractor shall provide all labour and materials to complete the miscellaneous metals work as specified herein, but not limited to the following:

- Miscellaneous Metal Work.
- Metal Corner Guards and Sills.
- Steel Supports for Crane and Hoists.

1.14.6.1. General

The Contractor shall verify all dimensions in the field; report all discrepancies for correction to the Engineer before fabricating work. Shop drawings shall be submitted to the Engineer for approval.

1.14.6.2. Welding

All welding shall be performed in a licensed shop by certified welders.

Materials

- Miscellaneous Steel ASTM A7, ASTM A 36

- Machine Bolts and Nuts ASTM A 307
- Galvanising Hot-dip process, ASTM A 123
- Metal Primer Red lead; Federal Specifications TT-P-86, Type I or II; or zinc chromate Military Specifications MIL-P-8585, 85 percent zinc quality.

1.14.6.3. General Requirements

(1) Workmanship

Contractor shall conform to accepted shop practice. Formwork shall be true to detail, with clean straight, sharply defined profiles. Unless otherwise shown or specified, exposed metal surfaces shall be finished smooth and face of exposed welds shall be made flush and smooth.

(2) Provisions for Attachment to Structure

Miscellaneous metal items shall be furnished complete with supports, anchors, and other devices shown, specified or necessary for reinforcement and proper, secure setting or attachment to building construction.

(3) Painting

After fabrication, all exposed steel items shall be thoroughly cleaned and given a coat of specified metal primer. All aluminium surfaces placed in contact with concrete, plaster, masonry or dissimilar metals shall be given two heavy coats of the specified protective paint.

1.14.6.4. Installation

(1) Embedded Items

Embedded items shall be delivered with setting drawings or instructions to other trades for setting. Contractor shall verify grade and line position of items so set; report errors or deviations in order that corrective adjustment may be made before placement of concrete or masonry.

1.14.7. Carpentry

Contractor shall provide all labour, material, equipment and appliances to complete the carpentry work as specified herein, including but not limited to the following:

- Rough Carpentry, including Rough Hardware.
- Millwork
- Wood Furring and Grounds
- Roof Framing
- Installation of Hardware
- Door & window

1.14.7.1. Materials

(1) Timber

General

Timber for constructional purposes shall be of the specified species and of the best quality, thoroughly well seasoned, sawn square, and free from sap, shakes, cracks and waney edges. It shall be free from decay and insect attack. It shall not contain loose or dead knots and other

defects. Sound knots if they exist, shall be of such size and location as will be permissible for the relevant structural or joinery work.

Where a choice of more than one species is allowed, only one variety shall be used for any particular Grade of work.

The density of timber used for building purposes should not, in general, be less than 640 kg/m³ (40 lb/ft³) at 12% moisture content.

In general, the quality of building timber shall conform to SLS 263. The size of structural and non-structural timber components shall be as specified.

Any timber brought to the site, which in the opinion of the Engineer does not conform to the required standard shall be rejected and shall then be removed from the site by the Contractor at his own cost within 24 hours of notice to do so.

Tolerances

The tolerance for dimensions of timber both sawn (unplanned) and finished (planed) shall conform to Clause 4 of SLS 263 (1974) which is reproduced below:-

Sawn (unplanned)

Nominal dimension mm	Maximum permissible	
	variation	mm
	Up to 25	-0 +2
	Over 25 to 50	-2 +3
	Over 50 to 150	-3 +6
	Over 150	-6 +6

Finished (planed)

Nominal dimension mm	Maximum permissible	
	variation	mm
	Up to 25	-0 +1
	Over 25 to 50	-1 +2
	Over 50 to 150	-2 +3
	Over 150	-3 +3

Grain Slope

In structural timber, the slope of the grain shall not exceed 1 in 8. Slope shall be measured over the worst face and over a distance of not less than 200mm.

For timer to be used for door and window frames and shutters, the slopes shall not exceed 1 In 8. In panelling however, sloping grain may be permitted to any extent.

(2) Moisture Content and Seasoning of Timber

Timber seasoned under controlled conditions shall be used, as green timber is liable to shrinkage and warping and is easily affected by wood destroying and sap-staining fungi. The moisture content of the timber at the time of fabrication shall be within 3% of the moisture content likely to be attained by the timber in service.

Seasoning of green timber in air, kiln or both, shall conform in all respects to CS 159. Seasoning techniques shall be such that seasoning defects like end splits, surface cracks warping etc. are minimised. The moisture content of air seasoned timber shall be not more than 15% and that kiln seasoned timber not more than 12%.

(3) **Preservative Treatment**

Special Preservative treatment such as Pressure Diffusion, vacuum or immersion treatment shall be carried out where necessary in consultation with the Forest Department. Guidance may be obtained from BS 5628: Part 5 for structural timbers and BS 5589 for joinery work.

Unless otherwise specified, all parts of wood work resting on or set in masonry, shall be painted with two coats of hot tar which shall be applied without disfiguring exposed faces. 40mm wide recesses shall be left for free circulation of air around the ends of all beams, and the recesses protected with perforated zinc sheet.

Timber buried in the ground shall be tarred. No timber shall be tarred, oiled or painted before inspection and approval by the Engineer.

Adhesives

- Adhesives used for joinery work shall conform to one of the following:
- B.S. 745 Animal glues for wood
- B.S. 1444 cold setting casein glue for wood
- B.S. 1203 synthetic resin adhesive (Phenolic and Amino plastic) for plywood
- B.S. 1204 Synthetic resin adhesive (Phenolic and Amino/plastic) for wood

For structural gluing one of the latter three glues shall be used as specified.

Regarding storage, mixing and use of adhesive, the instructions of the manufacturer shall be followed.

Fasteners

Wire Nails

Wire nails (oval, chequered head, lost head, round or panel pins) shall conform to the following standards.

- Steel nails CS 8
- Copper nails BS 120% Part II

Where not specified, the gauge of the nails shall be suited to the woods being used and their length shall give a sound and secure fixing. Nails or screws used with reactive timbers shall be of non-ferrous metal.

Nails used in woodwork likely to be subjected to moist conditions (as in the case of external work) shall have the specified protective coating.

Wood Screws

These shall be made of steel wire or brass wire and shall conform to CS 6 or BS 1210. The finish whether oxidised, anodised, galvanised etc., shall be specified.

Coach Screws

These shall conform to BS 1494 Part 2. The finish shall be as specified.

Black Bolts, Screws and Nuts

These shall conform to CS 97 with the specified finish.

Washers

These shall be made of steel or brass and shall conform to CS 238 or BS 4320.

Steel Gussets

These shall be made from steel plates conforming to BS 4360. Thickness of plates and the finish shall be as specified.

Mild Steel Connectors

These shall conform to BS 1579.

Other Fixing Devices

Expanding bolts and nuts, joist hangers, framing anchors, tie down straps, anchor bolts etc. shall be as specified in respect of materials, size, gauges and the finish.

Plugs

These shall be of durable timber like teak of specified sizes.

Dowels

These shall be Mild Steel rods of 16mm diameter and of adequate length.

Holdfasts

These shall be of Mild Steel flats 25mm x 6mm x 250mm long, turned up and with 2 Nos. 3mm holes drilled one end, and finish tailed at the other end.

Plywood, Hard Board, Block Board, Chip Board, etc.

These shall conform to the relevant Sri Lanka or British standards as noted below.

- | | | |
|----|-----------------------------|--------------------|
| 1. | Plywood for general purpose | - SLS 261 |
| 2. | Plywood for exterior use | - BS 1455 bonding |
| | W.B.P. Grade 1 | - where varnished, |
| | Grade 2 | - where painted, |
| | Grade 3 | - where hidden. |
| 3. | Block Board | - BS 3444 |
| 4. | Wood chipboard | - BS 5669 |
| | Hard Board | - BS 1142 |

1.14.7.2. Structural Timber and Timber Roof Work

General

Structural timber and timber roof work shall be fabricated in accordance with standard practice adopted in Sri Lanka and detailed drawings and shall generally conform to BSCP 112: Part 2 in regard to workmanship. The detailed drawings shall be approved by the Engineer prior to the works.

The Contractor shall provide details of the work as necessary to help ensure co-ordination with related building elements and services. He shall provide fabrication/installation drawings and obtain approval before starting fabrication. Where directed, he shall provide samples for intended connection before commencing actual fabrication.

Proprietary products shall be used to manufacturers recommendations.

Fabrication

The size of timber sections unless otherwise stated are basic (nominal) sizes. Tolerance on sizes shall be as per Clause 1.14.7.1.

All timber shall be sawn, planed, drilled or otherwise machined to the correct size and shape in accordance with specifications. Pieces damaged by splitting or bruising shall be rejected.

Mating and bearing surfaces shall be finished to ensure close contact over the whole area. These surfaces shall have a good sawn or planed finish and treated with the specified preservative. Bearing surfaces of notches and other cuttings shall be true and smooth and in appropriate relation to the other surfaces of the piece.

1.14.7.3. Joints

(1) Nailed Joints

Wire nails shall be at least 20mm longer than the full thickness of the assembly to be secured. Gauge shall be as per the specifications. The projecting portion shall be clinched over at right angles to the grain to resist withdrawal. All nails shall be soaked in hot boiled linseed oil and allowed to drain immediately before fitting. All nails shall be driven, unless the nails are of large gauge or the timbers are likely to be split in which case holes shall be drilled in one operation through all the members held in position. The holes shall be approximately 20 percent smaller in diameter than the nails.

(2) Screwed Joints

Lead holes shall be used in making screwed joints; the diameter of the hole for the shank shall be equal to the diameter of the shank; for the threaded portion, the diameter of the hole shall not exceeding 0.9 of the diameter of the root of the screw thread adjacent to the shank. Care shall be taken to avoid placing screws in an end split.

(3) Bolted Joints

Boltholes shall be drilled to diameters as close as possible to the nominal diameter of the bolt but not more than 1.6mm larger than the bolt diameter. Care shall be taken to avoid placing a bolt in an end split. At least one complete thread shall protrude from the nut. A washer shall be fitted under the head of each bolt and under each nut. The minimum sizes of washers are given in the table 8.1 below.

Diameter of bolt	Minimum thickness of washer	Minimum side of square washed or dia of washer
MM	MM	MM
(9.5)		
(12.7)	3	51
(15.9)		
(19.0)	5	64
(22.2)		
(25.4)		
(28.6)		
(31.8)	6	76

Structural connections using steel plates split rings etc. shall be as per BS CP 112: Part 2.

Note - Laminated Roof Trusses

Unless otherwise specified all members of laminated roof trusses shall be connected with wire nails with a washer at each end of the nails.

Preservative Treatment of Cut Surfaces

Cutting of timber after preservative treatment shall be avoided. However, when it is unavoidable, a liberal application of preservative shall be made to the cut surfaces.

Assembly of Structural Units

Assembly of structural units shall be done on a level bed and in such a way as to avoid damage to any of the members. The finished structural units shall conform to specifications. Twisted or damaged members shall be replaced before erection on the site.

Before proceeding with bulk production, a complete assembly of each type of framed truss or other structural unit shall be checked for accuracy. A similar check shall be carried out from time to time to control the wear and tear on templates and gauges.

Timber members of built up units shall be marked in accordance with a marking diagram.

Storage

Timber components shall not be exposed to high humidity and all materials and assemblies shall be protected against exposure to the weather, wetting, damage, decay and insect attack.

Painting

Where painting of the timber is specified, all parts of assemblies or individual pieces shall be protected with a priming paint complying with BS 2521 or BS 2522 and one undercoat before leaving the factory.

Steel components other than bolts, connectors and washers shall be thoroughly cleaned to remove all loose scale and rust and painted with one coat of genuine red lead paint before despatch to site.

Transport

All materials and assemblies shall be protected from the weather, and suitable measures shall be taken to protect the surfaces during hoisting and fixing.

Handling Hoisting and Fixing

The over-stressing of members during handling shall be avoided. In the case of framed arches, portal frames, trusses etc., special care shall be taken to avoid distortion in hoisting from the horizontal to the vertical position. Where lifting points or methods of lifting are not indicated on the drawing guidance shall be sought from the Engineer. On completion of erection, all joints shall be inspected and care taken to ensure that all bolts are tightened without crushing the wood under the washers.

Testing and Acceptance

When testing of a timber structure or component becomes necessary due to doubt about the adequacy in design, quality of material, etc., the test and acceptance criteria shall be as per Clause 6 of BS CP 112 Part 2.

1.14.7.4. Joinery

General

Joinery work shall consist of the manufacture, delivery to the site and fixing in the building of all joinery described in the specification including the supply and fixing of;

- (a) Metal straps, lugs and dowels
- (b) Priming and application of preservative
- (c) All iron mongery specified or shown in the drawing

The joinery work shall be of the best workmanship conforming generally to BS 1186: Part 2. The joinery work shall be completed ready for the respective finishes.

Dimensions

All wrot timber is to be sawn, planed, drilled or otherwise machined or worked to the correct sizes and shapes as specified. Tolerance on timber sizes shall be as per Clause 1.14.7.1.

Exposed Faces

All timber that is to be exposed in the finished surfaces of joinery works shall be wrot on the appropriate faces unless otherwise specified.

Natural Finish

When natural finish or finish for staining, clear polishing, or varnishing is specified, the timber in adjacent pieces shall be matched for colour and grain. The surface finish shall be as specified.

Shrinkage

The arrangement, jointing and fixing of joinery works shall be such that shrinkage in any part and in any direction shall not impair the strength and appearance of the finished work, and shall not cause damage to contiguous materials or structures.

Fabrication

All necessary mortising, tenoning, grooving, matching, tonguing, housing, rebating, and all other works necessary for correction jointing, shall be in conformity with BS 1186. All metal plates, screws, nails and other fixing that may be directed by the Engineer or that may be necessary for the proper execution of the joinery works specified shall be the responsibility of the Contractor. All works necessary for the proper construction of all framing, linings, etc. and for their support and fixing in the building shall be carried out to approval.

Joints

The joinery shall be constructed as per specifications or as directed by the Engineer. Where joints are not specifically indicated they shall be the recognised forms of joints for each position. The joints shall be made so as to comply with BS 1186; Part 2.

Glued joints shall be used where provision need not be made for shrinkage or other movements in the connections, and where sealed joints are required. All glued joints shall be cross-tongued or otherwise reinforced. All nails, springs, etc. shall be punched and puttied. Surfaces in contact shall have a good sawn or planed finish. All cutting edges of tools shall be shape to avoid burnishing. The surface of plywood to be glued shall be lightly dressed with sand or glass paper. The sand or glass paper must not be allowed to clog and cause burnishing.

Members to be joined by gluing are to be of similar conversion. All surfaces to be glued shall be kept clean, free from dirt, dust, sawdust, oil and any other contamination. Adequate pressure shall be applied and maintained whilst the glue is setting.

Moulding

All moulded work shall be accurately worked to the full size. All mouldings shall be worked on the solid timber except where otherwise stated.

Bent Work

Where bending is specified, it shall be built up with an appropriate number of pieces out to the required shapes. The pieces shall be put together in two (or three) thickness so that they break joint, and shall be secured with hardwood keys and wedges or with hardwood pins (whichever is more appropriate).

Circular Work

When circular work is specified, it shall be built up with an appropriate number of pieces out to the required shapes. The pieces shall be put together in two (or three) thickness so that they break joint, and shall be secured with hardwood keys and wedges or with hardwood pins (whichever is more appropriate).

Veneering

This shall be carried out in an approved manner, and to the entire satisfaction of the Engineer.

Scribing

All skirting, architrave, plates and other joinery works shall be accurately scribed to fit the contour of any irregular surface against which they may be required to form a close but connection.

Weathering

All weathering surfaces, throatings, grooves and joints, etc., and all open connections in external joinery works shall be properly executed so as to provide a reasonable degree of weather resistance.

All reasonable measures shall be taken to check or prevent capillary penetration of water in the joints and open connections of external joinery works, and in all other positions where joinery works may be exposed to water.

1.14.7.5. Door and Window Frames (wooden)

General

The frames shall be wrote, framed and fixed in position. The scantling of specified timber shall be planed smooth and accurate to the dimensions. Rebates, rounding, and mouldings shall be made before assembly. Patching or plugging of any kind shall not be permitted except as specified. Tolerance on sectional dimensions of timber shall conform to Clause 1.14.7.1

In general joinery work shall conform to requirements of Clause 1.14.7.4.

Joints

These shall be of mortice and tenon type, simple neat and strong. Tenons shall be formed on the posts of frames. Mortice and tenon joints shall fit in fully and accurately without wedging or fitting. The joints shall be glad and the frames put together and kept pressed in position by mean of a press pinned with hardwood pins of at least 10mm dia.

Surface Treatment

Woodwork shall not be painted, oiled or otherwise treated before it has been approved by the Engineer. All portions of timber abutting against masonry or concrete or embedded in ground shall be painted with approved wood primer or preservative.

Fixing in Position

Before fixing, the backs and ends of frames shall be coated with 2 coats of good quality wood preservative. When frames are to be built into masonry these shall be braced and protected as necessary to prevent distortion and damage during construction of the brick-work.

The frame shall be positioned accurately plumbed, levelled and aligned as necessary. The timber frames unless otherwise specified shall be fixed at centres not exceeding 600mm with at least one fixing located 150mm from each end of jambs and one adjacent to each hanging point of doors/window shutters. Generally at least 3 fixing per side of each doorframe and 2 fixing per side of each window frame shall be provided. The fixing device shall consist of a hold fast as described in Clause 1.14.7.1 embedded in concrete, or stout steel screws driven into hard wood plugs embedded in the walls, or other approved clamps of a suitable design

The feet of all doorframes and posts shall not be buried into the concrete floor but shall be fitted to specially cast cement spur block projecting above the floor. 16mm dia iron dowels shall be provided connecting the spur stone and the frame. The spur stone shall be such that the architraves if any and the coved floor finishes shall be accommodated producing a neat clean finish with no corners, which can hold dust or vermin.

1.14.7.6. Sashes for Doors, Windows, Fanlights etc. (wooden)

General

The specified timber shall be planed smooth and accurate to the full dimensions rebates, roundings mouldings shall be made before assembly. Patching or plugging of any kind shall not be permitted except as specified.

The sashes shall be wrot, framed and fixed in position as per detailed drawing and as directed by the Engineer.

Note: Joinery work for doors and windows etc. shall be started immediately after commencement of the building work. The components shall be stored clear off the floor in a dry and covered area allowing for free circulation of air. Pressing and securing of joints shall be carried out at the time of fixing frames or shutters.

(a) Joinery Work

All members of the door sashes shall be straight without any warp or bow, and shall have smooth well-planed faces at right angles to each other.

The corners and edges of panels shall be finished for the satisfaction to the Engineer and these shall be feather tongued into stiles and rails. Sash bars shall have mitred joints with the stiles. Stiles and rails shall be properly and accurately mortised and tenoned. Rails, which are more than 180mm in width, shall have to tenons. The thickness of each tenon shall be approximately one third the finished thickness of the members and the width of each tenon shall not exceed five time its thickness. The tenons shall pass through stiles for at least 3/4th of the width of the stile. Muntins and glazing bars shall be stubtenoned to the maximum depth, which the size of the member would permit or to a depth of 25mm, whichever is less. When assembling a leaf, stiles shall be left projecting as horn. The stiles and rails shall have 12mm grooves in the panelled portion for the panel to fit in.

The depth of rebate in the frames for housing the sashes shall in all cases be 12.5 mm; the rebate in the sashes, for closing in double sash doors or windows shall be less than 20mm. In the case of double leaved sashes the meeting of the stiles shall be rebated 20mm and the rabate shall be splayed.

In general, the joinery work shall conform to the requirements of Clause 1.14.7.4.

The joinery work shall be assembled and approved by the Engineer before the joints are pressed, and secured by hard wood or bamboo pins of about 6 - 10mm diameter. The horns of stiles shall be sawn off.

(b) Gluing of Joints

The contact surfaces of tenon and mortice joints shall be treated before putting together with bulk type synthetic resin adhesive of a make approved by the Engineer. Sashes shall not be pained, oiled or otherwise treated before they are fixed in position and approved by the Engineer.

(c) Beading

Timber, plywood, hard board and particleboard panels shall be fixed only with grooves but additional beading may be provided either on one side or on both sides. In so far as glass panels are concerned, beading shall always be provided without grooves. Where beading is provided without grooves, the beading shall be only on one side, the other side being supported by a rebate from the stiles.

For external doors and windows beading shall be fixed on the outside.

(d) Fittings

Fittings shall conform to the requirements of elsewhere. Details of fittings shall be as specified.

(e) Wooden Cleats and Blocks

Wooden cleats and blocks shall be fixed to doors and windows as specified or as directed by the Engineer. The size and shape of cleats and blocks shall be as approved by the Engineer.

(f) Tolerance

A "tolerance of ± 1.5 mm shall be allowed on heights and widths of sashes.

Ledge, Braced and Battened Sashes

The thickness of the doors shall be the thickness of the battens only and not the combined thickness of battens and braces. Planks for battens shall be 75mm to 100mm wide and 20mm thick unless otherwise specified. These shall be planed smooth and provided with rebated joints rebated at least 12mm. The tolerance on sized of battens, ledges and braces shall conform to Clause 1.14.7.1.

Ledges and Braces

The battens shall be fixed together by 25mm thick ledges and braces fixed to the inside face of the door shutters with screws. The ledge shall be 175mm wide and brace 125mm wide unless otherwise specified. The braces shall incline downwards towards the side on which the door is hung. Edges and ends of ledges and braces shall be chamfered. Tee hinges shall be provided for these doors.

Wooden cleats, blocks and fittings shall be as specified.

Panelled, Glazed or Panelled and Glazed Sashes - Panelling

The following types of panelling shall be used for door/window sashes as specified.

- (a) Plywood
- (b) Hardboard
- (c) Block board
- (d) Sheet glass

These shall conform to the relevant SLS/BS.

The panels shall be framed into grooves to the full depth of the groove, leaving an air space of 1.5mm and the faces shall be closely fitted to the sides of the groove. Mouldings to the edges of panel openings shall be scribed at the joints.

1.14.7.7. Shelving (Timber)

All shelving shall be of the widths and thickness specified. Timber shelving shall normally consist of 25mm thick boarding screwed to 100 x 50mm timber brackets fixed to the wall at approximately 1.2m centre.

1.14.7.8. Trellis Work (Timber)

(1) Plain Trellis

The shall consist of wooden strips or laths 35 x 10mm section unless otherwise specified, planed and nailed together at every alternate crossing. The strips shall be spaced 35mm apart so as to form 35 x 35mm openings, or as shown in the drawing. These shall be fixed with nails to the frame. To cover the ends of strips, 50 x 12mm beading shall be fixed to the frame with screws. Finished work with a tolerance of ± 1 mm may be accepted.

(2) Trellis Door and Window Sashes

The sash frame shall consist of two styles and the top, lock and bottom rails, each of section 75 x 35mm unless otherwise specified. The styles and rails shall be properly mortised and tenoned. The tenons shall pass through the styles for at least 3/4th of the width of the style. The sash and frame shall be assembled and passed by the Engineer before jointing. The joints shall be pressed and secured by hard wood pins of about 6mm diameter. To this frame, plain trelliswork as described in Clause 1.14.7.8 shall be fixed as directed by the Engineer; wooden cleats and blocks shall be provided as specified.

1.14.7.9. Pelmet (Timber)

The sides, front and top of the pelmets shall be of 12mm thick, planks or boards of specified width unless otherwise stated.

These shall project from the wall face by 150mm or as specified, and shall be securely fixed to walls with wood screws by means of wooden plugs and 100mm long x 25 x 3mm mild steel flats bent in the form of an angle or by any other device approved by the Engineer. The pelmets shall be provided with curtain rods and brackets or curtain rails with rollers, stop ends and brackets as specified. Intermediate wooden brackets shall be provided if the front length of pelmets exceeds 1.5 metres.

1.14.7.10. Mild Steel Bars or Grills in Wooden Frames

These shall be of the pattern and details specified.

(1) Fixing of Mild Steel Bars in Wooden Frames

Through holes shall be drilled in one frame, and 50mm deep in the other frame. The bars shall be passed into the frame from one side and shall be of the correct length to fit in at one end and to end flush with outside of the fame at the other side.

Where there are mild steel flats provided along with the bars, these shall be fixed to the wooden frame with wood screws. Holes for passing M.S. bars shall be punched in the flats at proper positions.

(2) Fixing of Steel Grills

The grills shall be fabricated as per design and fixed to the frame using round screw nails.

1.14.8. Sheet Metal

Provide all labour, material, equipment and appliances to complete the sheet metal work as indicated herein including but not limited to the following:

- A. Sheet Metal Flashings
- B. Gravel Stops and Scuppers
Louvers and Frames

1.14.8.1. General Requirements

Submit shop drawings for approval showing materials, profiles, layout, jointing, and method of attachment to adjacent construction. Take such field measurements as may be required for fabrication of work.

1.14.8.2. Materials

(1) Galvanised Iron or Sheet Metal

ASTM 193 "Commercial" coating. Where gauge is not shown or specified, use gauge suitable for specific use, but in no case lighter than 24-gauge (or metric equivalent).

(2) Bolts, Screws, Nails, Rivets, Clips and Accessories

Iron or steel, galvanised, sherardized or cadmium-plated.

(3) Solder

ASTM B32, 50 percent pig lead and 70 percent block tin (new metals).

(4) Soldering Flux

Non-corrosive type, which will not discolour metal.

(5) Caulking Compound

Polysulfide Sealant. See Caulking paragraph.

(6) Plastic Cement

As recommended by roof material manufacturer.

(7) White Lead Paste

Basic lead carbonate, ASTM D81, and eight percent boiled linseed oil, mixed into smooth paste of putty-like consistency.

- (8) Hot-dip Galvanising
ASTM A 123
- (9) Flashing and Counter flashings
Shall be as manufactured by Fry Reglet Corporation or Lane-Air Manufacturing Corp. Metcoa Company types as detailed on the plans or approved equal.

1.14.8.3. Fabrication

- (1) Workmanship
Work shall conform to first Grade commercial practice. Work shall be neat, strong, weather tight and serviceable with adequate provisions for expansion and contraction.
- (2) Seams and Joints
Unless other type joints are shown, specified or approved for particular conditions, soldered lock seams shall be used where subject to stress and soldered lap seams shall be used where not subject to stress. Where soldered seams are impracticable, lock seams caulked with white lead past shall be used. Where necessary for strength or stiffness, parts shall be joined with rivets or sheet metal screws.
- (3) Tinning and Soldering
Both sides of all sheet metal to be soldered shall be tinned with pure tin or solder; use specified soldering flux. Soldering shall be performed slowly, thoroughly heating seams and completely sweating solder through full width of seams.
- (4) Exposed Edges
Unless otherwise approved, sheet shall be doubled back 12 mm to conceal and stiffen raw edges.
- (5) Provisions for Attachment to Structure
Sheet metal items shall be complete with anchors and other devices shown, specified or necessary for reinforcement and proper, secure, attachment to building construction.

1.14.8.4. Installation

- (1) Items to be installed by others
Sheet metal items which are to be installed by others shall be delivered to other trades as required in sufficient time to avoid delays to construction progress.
- (2) General
Surfaces to which sheet metal is to be applied shall be thoroughly clean and dry, smooth, free of projections and depressions, and shall be properly prepared.
- (3) Attachment
Except as otherwise shown or specified, nails, rivets, or screws shall be used at spacing not to exceed 200 mm. Lead washers shall be used where exposed to weather. Barbed roofing nails 11-gauge, 6 mm long shall be used for attachment to masonry or concrete.

(4) Expansion and Contraction

Work shall be installed with adequate provisions to prevent distortion and over stressing from expansion and contraction. Expansion joints shall be constructed to be weather tight with specified sealing compound.

1.14.8.5. Special Requirements

(1) Flashing and Counter flashings

Counter flashing shall be furnished for flashings at vertical surfaces. Counter flashing shall be installed by securely fastening upper portion in accordance with approved manufacturer's directions. Transverse joints shall be 75 mm and laps cemented with plastic cement. Open ends shall be completely filled and made weather tight with specified sealing compound.

1.14.8.6. Painting

All surfaces of all galvanised sheet metal work concealed after installation shall be cleaned and primed with one coat of a good quality priming paint approved by the Engineer. Priming of exposed surfaces and finish coats is provided under Painting Specifications.

1.14.9. Painting

Contractor shall furnish all labour, materials, equipment, and appliances to complete the painting work as specified elsewhere in these specifications and as specified in this section including all exterior and interior faces of the buildings except as specifically excluded. Any work not specified in detail shall be given customary finish for such work.

1.14.9.1. Preparation of Surfaces

(1) General

All dirt, dust, loose plaster, and other deleterious matter, which would prevent good paint adhesion, shall be removed. All holes, cracks, and depressions shall be filled with patching plaster, mixed and applied to properly key with and match existing plaster. Patches shall be sand papered when dry so that flush, smooth, and properly sealed surface is available before applying prime coat. After priming surfaces, suction spots shall be touched up again with additional prime coat material until entire surfaces evidence uniform coating. For enamel finishes on smooth plaster, all undercoats shall be sand papered by hand with No.00 sandpaper and dusted clean before applying succeeding coat.

(2) Metal

All dirt, scale, and rust shall be removed by scraping, wire brushing and/or sanding as required. Oil, grease shall be removed with mineral spirits or appropriate solvent. Before painting, ferrous metal surfaces, including galvanised ferrous metal surfaces shall be pre-treated with approved phosphoric acid etching cleaner, in accordance with manufacture's directions, to produce chemically clean surfaces to ensure good paint adhesion. Unless already properly performed in accordance with specifications of other sections, touch up abraded and bare spots in shop primed coatings with metal primer matching shop coating. For enamel finishes, sandpaper smooth by hand (with No.00 sandpaper) all undercoats. When dry, dust clean before applying succeeding coat.

(3) Hardware

Remove all hardware including plated butts before painting doors.

(4) Woodwork

Unless already properly hand-sanded and woodwork shall be sand papered smooth by hand and dusted clean. Before priming surfaces, thoroughly clean knots, pitch pockets and sap steaks therein of residue, and touch up with shellac varnish coating. After priming surfaces neatly fill nail holes, cracks, and depressions therein with putty or other approved filler coloured to match required finish. When dry sand paper flush, smooth.

(5) Masonry and Concrete

Remove dirt, dust, oil, grease, efflorescence and other deleterious matter and roughen when necessary to ensure good paint adhesion: method of surface preparation will be left to discretion of the Contractor, provided results obtained are satisfactory to the Engineer. Before application of resin emulsion paint, prepare surfaces in accordance with manufacturer's directions. Before application of oil-base, test surfaces for presence of alkali. If alkali is present, neutralise as recommended by the manufacturer of the materials to be applied.

1.14.10. Caulking

The Contractor shall provide all materials, labour, equipment and appliances to complete the caulking work as specified herein.

1.14.10.1. General

This Specification is intended to be general in scope as to location of caulking. The Contractor shall examine all details, thoroughly familiarise himself with the extent of the caulking and sealing involved. Only a complete and absolutely watertight and weather tight job will be accepted.

Additional Information pertaining to sealing and/or caulking will be found in the various specific trade sections and shall be co-ordinated with the work of this section.

1.14.10.2. Submittals

Submit for approval a list of sealants and priming materials, with colour selection for each condition prior to application of sealant.

1.14.10.3. Materials

(1) Sealant

Sealant shall conform to or exceed the applicable requirements of Federal Specification TT-S-227b, Sealing Compound; Rubber base, Two Component (for Caulking, Sealing and Glazing in Building Construction) or an equivalent or superior sealing materials approved by the Engineer. Oil-based caulking compounds shall be used. The following construction sealants are acceptable to the Engineer for this project.

1. Chem Seal 2400 synthetic rubber compound manufactured by Chem Seal Corporation of America, Los Angeles, California.

2. Dow Corning 780 Building Sealant, manufactured by Dow Corning Corporation, Midland, Michigan.
3. G-E Silicone Construction Sealant, manufactured by Silicone Products Department, General Electric Company, Waterford, New York.
4. Hornflex Thiokol LP-32 Sealant, manufactured by Grace Construction Materials of W.R. Grace and Company, Cambridge, Massachusetts.
5. Lasto-Metric or Mono-Lasto-Metric, manufactured by the Tremco Manufacturing Company, Cleveland, Ohio.
6. Rubber Caulk 150 Sealant, Rubber Caulk 210 Sealant, Rubber Caulk 220 Sealant, Rubber Caulk 250 Sealant or Rubber Caulk 5000 Sealant, manufactured by Products Research and Chemical Corporation, Burbank, California.
7. Sonolastic Sealant as manufactured by Sonneborn Building Products, Inc. Des Planies, Illinois.

(2) Joint Filler

Joint filler used as a backing for the caulking compound may be vinyl tubing of a slightly greater diameter than the width of the joint to be caulked, a soft glass fibre rope or strip, an open-cell polyurethane rod or a closed-cell neoprene or butyl rod. The compressible joint filler shall be of a type acceptable to the manufacturer of the weather sealing compound being used on this project.

1.14.10.4. Application

The Joints to be caulked or customarily required to be caulked or required by the Engineer to be caulked shall be thoroughly cleaned of dust, dirt, scale, corrosion, grease or anything that might interfere with the adhesion of the sealant, Non-porous surfaces such as metal or glass may be cleaned either mechanically or chemically. When solvent is used to clean non-porous surfaces, the solvent shall be wiped off with clean cloths before it dries and re-deposits the contaminants.

If the Joints are deeper than 10 mm. they shall be packed to within 10 mm of the face surface with one of the compressible joint fillers specified; the final 10 mm shall be filled with the sealing compound. If possible, the joints to be caulked shall be built up or be cut square down the sides so as not to be vee shaped.

The Surfaces to be caulked shall be primed with the primer recommended by the manufacturer of the sealant being used in accordance with the sealant manufacturer's application instructions with respect to the various types of materials to which the sealant is to be applied.

The Joint Filler, the primer or any other material used in conjunction with the sealant shall be of such composition that will not cause staining of the sealant or the materials to which it is applied.

The Sealant shall be applied before the final coat of paint is applied to adjacent work. The sealing compound shall be applied with a hand gun with the gun nozzle of the proper size to fit the joints. The materials shall be driven in with sufficient pressure to solidly fill the joints: superficial pointing of the joints with a skin bead will not be acceptable. The finish of the weather sealing on flush surfaces shall be neatly pointed flush or be tooled with a beading tool. Excess material shall be removed according to the job conditions or as directed. The Weather sealing materials shall be applied by experienced workmen in meticulous accordance with the sealant manufacturer's recommendations.

1.14.10.5. Quality Control

The weather sealing shall be uniformly smooth, free of wrinkles, flush with adjacent surfaces and absolutely watertight. Adjacent surfaces, which have been soiled by the application of the sealing compound, shall be wiped clean and be left neat. The work will be adjudged defective due to the sealant's hardening, cracking, crumbling, melting, shrinking, leaking or running.

1.14.11. Ceiling

1.14.11.1. Framing

Framing for ceiling shall be constructed with medium hardwood. Ceiling joints shall be of 100 mm by 50 mm size at 1200 mm centres and spacers shall be 50 mm by 50 mm size at 600 mm centres. The joists shall be hung by metal straps secured to the reinforced concrete beams and shall be set out to enable ceiling sheets to be fixed symmetrically from the centre of the ceiling.

1.14.11.2. Ceiling Boards Generally

Plain Asbestos cement sheets for ceiling shall comply with Sri lankan standard CS9 and shall not be less than 5.0 mm thick. The finished surface shall be painted with two coats of paint, the colour of which shall be approved by the Engineer.

Timber ceilings shall be of 20mm thick, 125mm wide timber planks of approved type in appropriate lengths. The planks shall have decorative grooves of approved design, and shall have a smooth surface. The timberwork shall be applied with an approved wood preservative before installation. The underside of the ceiling shall be applied with an approved colour wood stain in order to obtain a uniform colour, and finished with two coats of varnish.

1.14.12. Plumbing and Sanitary Fittings

1.14.12.1. General

Plumbing installations shall be carried out in accordance with best modern practice and shall be in all respect to the satisfaction of the Engineer. The Contractor shall submit all plumbing details to the Engineer for approval prior to commencing any installation. Plumbing installations shall be complete with all necessary appurtenances, whether detailed or otherwise which are requisite for the proper functioning of the system.

Each sanitary fitting shall be supplied by a separate feed pipe and unions shall be inserted to facilitate the disconnection and removal of each sanitary fitting. Unions shall also be inserted on each branch pipe where this joins a principal pipe.

1.14.12.2. Water Service

All pipe work for internal potable cold water supply shall be uPVC to SLS 147 with solvent joints. Joints and fittings for uPVC pressure pipes shall be to SLS 659.

Stop valves are to be screw down type gate valves and shall conform to BS. 1010.

Unless otherwise specified or instructed by the Engineer, in case of pipelines taken along the walls of buildings, all pipe work of diameter 32mm and below shall be embedded within the walls, and all pipe work of diameter 40mm and above shall be mounted externally to finishes and shall be supported by means of brackets, at intervals not exceeding 1.5 meters.

Pipelines when laid along the floor, shall be installed sufficiently under the surface of the floor. Contractor shall make necessary provisions in floor slabs, concrete members, and foundation etc. For laying necessary pipelines, in order to avoid any subsequent breakages.

The whole of the water service plumbing installation shall be tested prior to any embedding at a pressure of 5 bar for a period of not less than 2 hours in the presence of the Engineer's Representative. Any defect noted shall be made good and the test repeated to the satisfaction of the Engineer. The Contractor shall be responsible for the provision of all necessary equipment, appliances and labour for the testing of plumbing installations. Upon completion the Contractor shall leave all in perfect working order.

Kitchen Sink

The living quarters, offices, and labour rest room shall be provided with a stainless steel kitchen sink of size 1.0m x 0.5m approximately, conforming to BS 1244, complete with a drain board, chromium plated sink tap, 32mm detachable siphon trap (bottle trap) and necessary piping, all of approved quality and make. The sink shall be mounted on a wooden pantry cupboard of 0.5m wide, 0.85m high and length as indicated made of approved Grade I timber complete with cupboards with shelves and drawers. Pantry cupboards shall have formica exterior surface, and all necessary fittings.

The Contractor shall obtain the prior approval for the design and materials he intends to use for the work before commencement and the work shall be completed to the satisfaction of the Engineer.

Domestic Water Storage Tank

Each living quarters shall have an overhead water storage facility (a tank or a compartment of a tank), to which the supply from the public water service shall be connected. The inlet pipe shall be provided with a stop valve, and a high pressure ball valve of appropriate size. The tank shall be provided with an outlet pipe with stop valve of appropriate size, an overflow pipe and a washout pipe with a stop valve, connected to a suitable drainage.

The tank shall be provided with an asbestos sheet roof on timber frame with provision for easy access to the tank for inspection and cleaning, and wire mesh, screen or other approved protection against insects and rodents.

All the pipe work for the water supply to the quarters shall be connected to the respective water storage tank, or to the compartment of the tank as appropriate.

1.14.12.3. Soil and Waste Plumbing

Soil and waste plumbing work shall comprise all internal and external soil and waste pipe work, as necessary, to the buildings. Adequate access doors and cleaning eyes shall be provided. All parts of the work shall meet the requirements of the local regulations in every respect.

Building drains running to first or nearest manholes shall be uPVC of type 600, conforming to SLS 147:1993 or equivalent. The pipes shall be 90 mm diameter, with approved bedding. All lines shall have approved solvent cement joints.

Contractor shall make necessary provisions in floor slabs, concrete members, foundations etc. for installing necessary pipes, in order to avoid any subsequent breakages.

1.14.12.4. Rainwater Drainage

Approved uPVC guttering shall be supplied and fixed as directed by the Engineer. uPVC supports shall be provided at spacing not exceeding 1.2 metres. The guttering shall be fixed so that it falls at a gradient not less than 1 in 100 to the nearest down pipe.

Rainwater down pipes, fittings and fixings shall be of an approved manufacture in uPVC and shall be fixed in the locations and to the dimensions as directed by the Engineer. Down pipes shall discharge into a channel in in-situ concrete around the buildings.

1.14.12.5. Sanitary Fittings

All sanitary fittings, washbasins, urinals, commodes sets, squatting pans etc. shall be of the best quality and shall be obtained from a manufacturer to the approval of the Engineer and supplied complete with all flush pipes, taps, valves, siphons, brackets, waste plugs and chains, etc. of approved patterns.

Commode sets to approved colour shall be of vitreous china complying with BS 5503 with "S" trap and shall include a low level vitreous china cistern to BS 1125 close mounted to the pan and incorporating a siphonic flushing system with 1/2" low pressure ball valve complying with BS 1212. Commode set shall be provided with plastic seat and cover.

Each commode set shall have a porcelain toilet paper holder fixed within the wall and adjacent to it.

Each squatting pan set shall be of vitreous china complying with BS 5503 with "S" trap, and shall include a high level cistern of vitreous china, complete with siphonic flushing system with 1/2" low pressure ball valve complying with BS 1212, all to the approval of the Engineer.

The inlet to each cistern shall be fitted with a 1/2" stop valve complying with BS 1010.

Washbasins shall be of vitreous china complying with BS 1188 and fixed to the wall by means of two steel brackets. Washbasins shall be supplied with chromium plated drains complete with rubber stopper and chromed metallic chain. Each basin shall be fitted with a 32 mm diameter detachable siphon trap (bottle trap), which shall be connected to the nearest floor drain, gully trap, or drainage pipe by a 50 mm diameter galvanised pipe. Each basin shall be fitted complete with chromium-plated tap for cold water. Each washbasin shall be

supplied with vitreous china soap tray, towel rack with chromium plated bar and clothes hanger of quality and make approved by the Engineer. Colours shall be approved by the Engineer.

All taps, mixers, stop valves and the like shall be chromium plated with metal handles.

All sanitary fittings shall be set level and true and shall drain away completely on emptying. They shall be fixed securely to floors and walls as appropriate and all protective paper shall be removed from concealed edges before fixing. All fittings shall be tested and adjusted to the satisfaction of the Engineer on completion.

1.14.13. Masonry

Masonry shall be constructed from approved hard durable stone laid to bond. The stones shall be rough dressed so that the beds and sides are roughly perpendicular to the exposed face of the wall. The joints shall be 12 mm thick on the average and completely filled with mortar. The face of the work shall be true to profile and the joints shall be neatly pointed in mortar.

Where the walls are to be rendered the joints shall be raked out to a depth of 12 mm to form a key.

1.14.14. Drainage

1.14.14.1. General

Foul drains and sewers shall be constructed of uPVC or asbestos cement pipes unless otherwise stated.

Surface water and overflow drains shall be constructed of pre-cast concrete pipes unless otherwise stated.

1.14.14.2. uPVC Pipes and Fittings

Unplasticised Polyvinyl Chloride (uPVC) pipes and fittings for sewerage and drainage shall comply generally with SLS 147, Type 600 or equivalent and shall be obtained from an approved manufacturer. Joints shall comply with SLS 659 or equivalent.

1.14.14.3. Pipe Bedding

Pipes shall be laid on bedding similar to those specified for water pipes under similar ground conditions.

Above the bedding the trench shall be backfilled with suitable material similar to that specified for water pipes, under similar ground conditions.

1.14.14.4. Laying Pipes for Drainage

Pipes shall be laid straight and at constant gradient between manholes and chambers.

The width of the trench at the crown of the pipe shall not exceed the outside diameter of the pipe plus 300 mm.

1.14.14.5. Construction of Chambers and Headwalls

Chambers and Headwalls shall be constructed as directed by the Engineer. Benching shall be provided with channels to conduct flow between the incoming and out going pipes.

1.14.14.6. Testing Drains, Chambers etc.

All drains and chambers shall be watertight and clean throughout. Drains shall be tested by the Contractor under a minimum head of 1 m in the presence of the Engineer's Representative. Should the pressure fall during a test the Contractor shall locate the leaks and make them good after which the pressure shall be reapplied and the process shall be repeated until the drains are satisfactory.

No drain or other work shall be covered up until it has been seen and approved by the Engineer.

In every case the water used for testing the pipes shall be left in the pipes until they are covered with earth to the top of the trench or a depth of at least 1.2 m over the top of the pipes and until permission is given by the Engineer for the water to be released. If after the Engineer has approved the pipes and has given permission for the trenches to be refilled the pipes become damaged and loose water from any cause and/or admit subsoil water the pipes shall be uncovered and the defect made good and the pipe re-tested as before to the satisfaction of the Engineer.

1.14.14.7. Covers and Surface Boxes

Chambers shall be completed with access covers and frames. All chamber covers shall be set in cement mortar or built into concrete slabs to the correct levels, cambers or falls.

1.14.14.8. Septic Tanks

Septic tanks shall be constructed in concrete with reinforced concrete roof slab as directed by the Engineer.

Paths and Paved Areas

Paths and paved areas shall comprise pre-cast concrete paving slabs bedded in 1:5 cement/sand mortar and laid on a 150 mm layer of compacted hard-core.

Paving slabs shall be 600 mm square and 50 mm thick, joints shall be grouted up with cement mortar.

The Contractor shall lift and relay at his own expense any slabs, which have sunk as a result of consolidation of the underlying fill or sub-base.

1.14.15. Insulation to Reservoir Roofs

Insulation to reservoir roofs shall be pebbles or gravel, which have been washed and screened so as to eliminate all dust and particles which will pass through a 6 mm (1/4 in) sieve.

The material shall be distributed evenly and raked true to falls and to a uniform finished thickness of 150 mm (6 in.) Under no circumstances will dumpers or other mechanical plant be permitted on the roof to place, distribute or spread the material.

1.14.16. Waterproof to Reservoir Roofs

Waterproofing membrane shall be Bitu-Thene 1200 HC as manufactured by Servicised Ltd. of London, England or equivalent self-adhesive waterproof sheeting.

The Contractor shall apply waterproofing in strict accordance with the manufacturer's instructions and recommendations. Waterproof roof slabs shall be tested for water tightness as specified for water retaining structures elsewhere in the specification.

The Engineer's approval to the use of any waterproofing materials shall not relieve the Contractor of his responsibilities as to the watertight performance of any roof slab. Any defects detected in waterproofed roofs shall be repaired and made good to the satisfaction of the Engineer at the Contractor's sole expense.

The discontinuity of concrete channels at expansion joints between two structures should be treated with a special surface water sealing system as directed by the Engineer.

The surface should be at least 28 days old and thoroughly cleaned of any debris, dirt or sediment and should be mechanically scrubbed by grinding; needle gunning or any other approved blast-cleaning technique.

The epoxy adhesive should be a Thixotropic adhesive in two components and is damp tolerant. Application temperature should be 4 °C to 35 °C with curing time of approximately 2 days at 5 °C. The pot life shall be 30 minutes at 20 °C.

The water proofing membrane shall comprise of a durable non-absorbent electrometric sheet membrane, which can be effectively bonded onto prepared concrete surfaces. The membrane shall have elongation characteristic capable of absorbing three way movements. The membrane shall have following characteristics.

- Density – (ASTM) not less than 1.7
- Tensile strength (Machine direction) not less than 7.5 n/mm²
- (across machine) not less than 6.5 N/mm²
- Elongation at break (ASTM 412) not less than 350%
- Manufacturer's recommended movement not less than 18 ±both transverse and shear.

1.14.17. Doors & Windows (Aluminium)

1.14.17.1. Material (Alloys)

All extrusions shall be of AlMgSi, designation 6060, or 6063, temper T5, heat treatable, and shall be in accordance with BS 1474 : 1987.

Panels, if not extruded and sheets, plate and strip shall conform to BS 1470 : 1987, shall be of AlMgSi designation 5005, 5050 or 3003; temper and condition to suit conditions of environment and use.

The average roughness of the surface shall not exceed Ra = 5 microns.

The radius of corners shall be 1.5 mm minimum.

1.14.17.2. Anodizing

Prior to anodizing, the extrusions, panels and sheets shall be etched or pickled in an even manner, to achieve a chemical satin finish.

Bronze anodizing, in an Anolok color to be selected by the Architect, shall be carried out preferably by means of the Sulphuric Acid direct current method, but otherwise in accordance with BS 3987 with an average film thickness of not less than 20 microns (Grade AA25 as set out in BS 1615)

Said average implies the mean film thickness of 10 Nos. measurements with an eddy-current film thickness meter taken over the total surface, all in accordance with ISO 2360; no measurement shall show less than 80% of the specified film thickness.

The surface shall then be sealed. Sealed is to be in compliance with testing through the “admittance measuring” method of ISO 2931/2 or the solvent-method of ISO 3210; “admittance” shall be a maximum of 20 micro Siemens, and with the solvent-method the maximum permitted weight loss shall be 30 mg/sq.cm.

1.14.17.3. Aluminium Windows

The windows shall be delivered to site complete with all fittings. Care shall be taken to protect all units during handling, storing and fixing in.

All windows and their components shall conform to B.S.4873 and shall be designed to resist the severe (b) exposure test pressure of 2800 N/m² when tested in accordance with B.S.4315: 4315: Part 1, and test certificates shall be submitted to the supervising Engineer confirming this requirements.

All frames and casements shall be fully weather stripped with continuous neoprene strips and shall be designed for internal glazing with snap-on Aluminium beads. Those windows shall open inwards and shall be secured in the closed position by means of budget locks.

All aluminium surfaces in contact with steel, concrete, masonry or mortar shall be protected by painting with bituminous paint or taping with PVC before fixing in position.

The windows shall be fixed-in with stainless steel lugs, or with screws supplied by the manufacturer, in accordance with the specifications.

After fixing, the frames shall be pointed in polysulphide or equal and approved non-hardening pointing sealant recommended by the window manufacturer.

1.14.17.4. Aluminium Doors and Screens

The Aluminium doors and partitions are to be constructed of box section aluminium as detailed, with single action floor closers.

Meeting stiles and the back edges of stiles adjoining the frame of double doors shall be fitted with woven pile or neoprene draught strip.

Each outer pair of double doors shall have fitted in one leaf a flush bolt top and bottom, and in the other a mortice deadlock, mastered with the other locks in the part of the building, which it serves.

1.14.17.5. Aluminium Louvers

The louvers shall be of 18-gauge Aluminium, of fixed pitch at 45o, complete with frames, sills, and mullions as directed by the Engineer. The louvers shall be preformed for site assembly, and shall be anodized to match the windows in accordance with B.S 3987. The back of the louvers shall be fitted with bird mesh screens or blank sheet Aluminium panels as directed by the Engineer.

Care shall be taken to protect the louvers during handling, storing and fixing. All Aluminium surfaces in contact with steel, concrete, masonry or mortar shall be protected by painting with bituminous paint or taping with PVC before fixing.

1.14.17.6. Appearance and Detailing

The details of anodized Aluminium windows, certain types of sections, which have not been calculated for strength, together with the relevant vertical and horizontal connections to builders work. The Contractor may submit alternative sections, which he proposes to use with his Tender, for approval by the Architect, although a box-section is preferred and the width of 50 mm for external window frames should be adhered to.

1.14.17.7. Execution of the Works

(1) General

The works shall be executed in a first Grade workmanlike manner including all work and materials in accordance with this Specification referred to therein and the shop drawings, to be prepared by or on behalf of the Contractor and approved by the Engineer.

In all cases where a component or part of the installation is referred to in the singular, it is intended that such reference shall apply to as many such items as are required to complete the whole installation.

(2) Responsibility of the Contractor

It is the responsibility of the Contractor to calculate and provide on the basis of approved calculations, sections and glazing of material, strengths and thicknesses suitable and adequate for their purposes and locations in the building;

1.14.17.8. Installation

The Contractor shall be responsible for setting all units straight, plumb and level, and for their satisfactory operation after fixing is complete.

The Contractor shall ensure that he has sufficient support on site from the manufacturer and/or supplier to guarantee a first Grade installation procedure and flawless operation of the units installed.

All units shall be fixed into prepared openings. Frames shall not be forced into openings, which are out of square or too small. The openings must show at least 2.5 mm tolerance all

round. The frames shall be secured at head, jambs and sill; care should be taken to ensure that the frames are not distorted when screwing up lugs or fixing screws, etc.

All external doors, doorframes, windows and window frames when installed, shall be completely watertight.

All opening lights, pivoted or sliding, and all doors shall open as directed by the Engineer.

All windows and door units shall be protected from damage by being wrapped in plastic film or by other approved means until shortly before handling over of the building.

All glass shall be as specified in Section 1.6.14.5 of the Specification.

All glass shall be sized, cut, finished and fixed in accordance with specifications and requirements of the manufacturer.

1.14.17.9. Shop Drawings

Fully detailed shop drawings shall be submitted within 14 days after the commencement of the works, showing complete scale elevations and full-size details of all doors, windows, etc. required; the relations of all the sections to the exterior and interior work, the points to which all dimensions are taken and the locations of all ventilators and opening light.

The type and positioning of all fixing devices shall be shown, the work to be done by other trades shall be indicated, and the size, type and thicknesses of glass and all infill panels, doors, hatches etc. shall be shown.

Shop drawings must be approved by the Engineer before any of the required units are manufactured or assembled; in programming the works, the Contractor shall allow adequate time for the Engineer to inspect and approve these drawings

1.14.18. Ceramic Floor & Wall Tiling

1.14.18.1. Ceramic / Floor Tiles

Tiles shall be 200 x 200mm or 300 x 300mm fully vitrified ceramic tiles of approved make. The tiles shall conform to EN 87(BS 6431 PG1) and shall have water absorption not exceeding 3-6%.

Tiles shall be installed with straight joints 4 mm wide, and shall be bedded in an approved floor tile adhesive, in strict accordance with the manufacturer's instructions. Against wall tiles shall be cut to the proper size in order to obtain joints no wider than the regular joints. The installed tile work shall give a full sound when tested with a hammer.

Tile joints shall be filled with Bal-Grout Flooring or equal and approved grouting applied in strict accordance with the manufacturer's instructions.

1.14.18.2. Ceramic Tile Skirting

Ceramic tile skirting shall be 200 x 100 mm with a bullnosed top to plastered walls, the skirting standing 5mm proud of the walls finish and with a square top to tiled walls, the

skirting finishing flush with the tiling, the cove radius not less than 15mm. The bases shall be of the same quality as the above-specified ceramic tiles.

1.14.18.3. Wall Tiles (Internal)

The tiles shall be eggshell ceramic glazed tiles nominally 150 x 150 mm as supplied by an approved manufacturer. Tiles shall conform to EN 87 and shall have water absorption not exceeding 3 – 10%.

1.14.18.4. Application of Wall Tiles

The walling shall be plastered in cement and sand to give a true and level surface, which before hardening shall be combed and scratched. Tiles shall not be laid until 24 hours after application of the render backing.

Wall tiling is to be carried out in accordance with the recommendation of BS 5385 and BS 6431, the tiles spaced at least 1.5mm apart and the overall thickness of plaster and tiling not exceeding 20mm.

The tiles shall be soaked in clean water before use and shall be straight jointed and set in an approved tiling adhesive and pointed in white grouting compound both. Proprietary adhesives shall be used in strict accordance with the manufacturer's instructions.

The areas to be tiled shall be set out to avoid unnecessary cutting and the whole work shall be carried out to the Supervising Engineer's satisfaction.

On all walls tile work shall be checked for deviation from the plumb line, which shall not exceed 0.3 mm per meter of height.

1.15. Site works

1.15.1. Manholes and Chambers

1.15.1.1. General

Manholes and chambers shall be constructed on pipelines, sewers and drains at the required positions and levels. They shall be constructed in either precast or cast-in-situ concrete made with sulphate resisting cement and shall be watertight.

Manholes shall be positioned on sewer pipelines at all changes in alignment and levels, and connections with existing sewers.

1.15.1.2. Construction Details

Bases for manholes and chambers shall be constructed in reinforced concrete grade C25. Access shafts, walls, and cover slabs shall be constructed either in cast-in-situ concrete grade C35 reinforced or in precast construction using units made of concrete grade C35. Benching shall be in concrete grade C25 and carefully formed to the required shapes and forms. The benching shall be sloped towards the channel at a gradient of 1 in 40.

All pipes entering and leaving manholes and chambers shall be laid soffit to soffit.

1.15.1.3. Manhole Accessories

Manholes and chambers shall be provided with heavy duty manhole covers having clear openings of 750 mm by 750 mm for sewers and drains 1500 mm internal diameter and above and clear opening of 600 mm by 600 mm for sewers of internal diameter 1200 mm and below; access shafts; platform at a level above the crown of the sewer pipe with minimum head room of 2000 mm. Galvanised mild steel handrails (solid) and chains. 2 No. stainless steel hooks made of rods of minimum diameter 12 mm and each capable of sustaining a pull out force of 7 kN shall be fixed across the outlet pipe and provided with stainless steel safety chains of sufficient length to form a loop across the outlet. One end of the chain shall be permanently fixed to the hook and the other end detachable. Safety chains shall be provided for all sewers greater than 600 mm diameter.

Manhole covers and frames shall be constructed flush with the final ground level on roads and pavements, but they shall be 75 mm above final ground level elsewhere.

1.15.1.4. Bricks

Bricks for manhole chambers and brickwork below ground level shall conform to BS 3921 Grade B (Engineering Bricks).

Samples of all bricks intended for use in the Works shall be submitted to the Engineer for his approval. Bricks incorporated in the permanent Works shall be at least equal in quality to the approved samples.

1.15.1.5. Manhole and Access Covers and Frames

Manhole and access covers and frames shall have minimum clear openings of 750 x 750 millimetres and shall comply with BS 497 : Part 1, heavy duty Grade A. Covers located in roads shall preferably be double triangular loosely coupled with bolts complying with BS 497 : Part 1.

All manhole and access covers and frames shall incorporate a suitably secured gas tight GRP and ABS sealing plate to the approval of the Engineer. A heavy grease seal is to be formed between the cover and frame to prevent the ingress of sand.

Keyways in manhole covers shall be closed.

1.15.2. Surface Boxes

Cast iron surface boxes shall comply with the relevant requirements of BS 5834 and shall be Heavy Duty Grade A. Surface boxes shall have a nominal clear opening of 150 mm square and those located in roads have non-rocking covers.

1.15.3. Step Irons

Step irons shall comply with BS 1247 and be of the general purpose or precast concrete manhole pattern as appropriate.

Step irons of the general purpose pattern shall have 230 mm tails.

Step irons of the precast concrete manhole pattern shall have 50 mm tails.

1.15.4. Site Roads

Site Roads shall be laid out as directed by the Engineer and shall be constructed generally as specified. Road surfaces shall be flush with finished floor levels at entries to buildings where operating vehicles are required to enter.

1.15.5. Paving

Paving flags shall be unreinforced precast concrete of 50 mm minimum thickness and shall be natural colour unless otherwise specified and shall comply with BS 1474.

Pedestrian areas shall be paved with precast concrete paving flags, to the approval of the Engineer laid in a 25 mm sand bed over 100 mm of good quality clean hardcore which has been spread, levelled and compacted.

After laying the paving flags in a truly square and level fashion, joints between the flags shall be grouted up with cement mortar tinted as appropriate to match the colour of the flags. The paved area shall be well brushed and cleaned after grouting is complete.

1.15.6. Kerbs and Drains

Precast concrete kerbs shall comply with BS 7263.

Precast concrete kerbs and drains shall be supplied and laid along the roadways to be constructed.

1.15.7. Lifebuoys

Lifebuoys shall be canvas covered cork complying with the requirements of the UK merchant shipping (life-saving) Rules 1965.

Each lifebuoy shall be attached to a 30m length of buoyant lifeline knotted at every 3 metres.

Each lifebuoy shall be mounted on a galvanised mild steel support frame suitable for grouting into or bolting onto a horizontal concrete surface. The frames shall be such that the centre of the lifebuoys shall be approximately 1.5m above the horizontal concrete surface. The locations for lifebuoys shall be advised by the Engineer.

1.15.8. Hydrants

Hydrants shall be wet barrel pillar-type fire hydrants complying with the requirements of relevant British Standard. Nozzles and Couplings shall also conform to relevant British Standards.

The Contractor shall ensure that the hydrant valves proposed are suitable for use in the prevailing climate, soils, conveyed liquid and groundwater conditions.

1.15.9. Stoplogs

Stoplogs wherever ordered shall be of grade C25 concrete, and no individual stoplog shall exceed 1.5 tonnes in weight. When in use they shall be slotted into guides. Both the stoplogs

and the guides shall have 25 mm chamfers, and there shall be sufficient clearance to prevent jamming of stoplogs as they are lowered or raised.

1.15.10. Subsoil Drainage

Trenching and excavation for subsoil drainage pipework shall be as specified under Earthworks. Soakaways shall be tested by subjecting them to an overflow equivalent in volume to the design rainfall intensity for a time of 15 minutes on the area draining to the soakaway. The soakaway shall not back up during the test.

1.15.11. Precast Concrete Drain

1.15.11.1. General

All precast concrete drains shall be made of concrete Grade 20 with 12mm maximum aggregate and be a dense, impermeable texture, free from air holes and other defects. The concrete shall be cured for 7 days before being laid. The sections shall be in 60 mm lengths. Sections that have been rendered on the inside faces to give a smooth finish shall be rejected.

Any precast concrete drains which show scouring of their inverts shall be replaced by the Contractor at his own expense.

1.15.11.2. Laying Precast Drain Inverts

Precast concrete drain inverts shall be properly bedded with even support throughout their length. They shall be laid true to line and level and shall be properly jointed in 1:3 cement sand mortar with 6mm wide joints.

Where heavy rain has washed out the formation for drainage channels, the washed out sections shall be refilled with sand and well compacted all at the Contractor's expense.

The Contractor shall ensure that the back filling beside all drainage channels is well compacted and any scour taking place in this area shall be refilled and compacted by the Contractor at his expense.

1.15.12. Hardcore

Hardcore shall be hard inert material either broken stone or rock from excavations broken to pass a 75mm sieve and must be free from clay silt soil and vegetable matter and shall not deteriorate in the presence of water.

Hardcore shall be placed in layers not exceeding 150 mm thick and each layer shall be thoroughly compacted by mechanical means. The final surface of hardcore shall be blinded with fine crushed stone and thoroughly compacted.

1.15.13. Stone for Pitching and Rip-Rap

The material used in the formation of revetments pitching and rip-rap shall be obtained by the Contractor from sources approved by the Engineer.

Stone shall be sound durable and hard natural rock. It shall be free from laminations weak cleavages and undesirable weathering and shall be of such character that it will not disintegrate from the action of air sea water or sewage.

No stone for pitching and rip-rap shall be less than 0.015 m³ in volume. The least dimension which shall be not less than 150 mm.

The density shall be not less than 22kN/m³ (solid volume without voids).

1.15.14. Filter Fabric

Filter fabric shall be a thermally bonded or woven sheet of polypropylene polyethylene or similar synthetic material. It shall be non-biodegradable resistant to bacteriological and fungal attack and to all naturally occurring soil acids and alkalis and be suitable for use in tropical conditions. It shall be capable of sustaining a load of 230 Newtons when tested in accordance with BS 4768. It shall be laid and jointed as recommended by the manufacturer after due consideration of the soil conditions and application on the Site.

1.15.15. Reinforced Concrete Pipes

1.15.15.1. Precast Concrete Pipes

Unreinforced and reinforced concrete pipes and fittings with flexible or oge joints shall comply with BS 5911.

They shall be obtained from an approved manufacturer.

1.15.15.2. Pipe Laying

Concrete pipes as specified above shall be laid true to line and level, each pipe being separately boned between sight rails. The ends of the pipes shall be butted and the collar centred about the joint using wedges or other approved means. The annular gap shall then be filled with 1:3 cement sand 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 see that any excess of cement mortar, etc is neatly cleaned off while each joint is being made and any earth, cement or other material thoroughly cleaned out of the pipes by drawing a tight fitting wad through them as the work proceeds, or by other approved means.

1.15.15.3. Haunching and Surround

Bedding and haunching of pipes shall be of Grade 20 concrete. The Contractor shall pack the concrete under and around the pipes to ensure even bedding. The concrete shall not be thrown directly on to the pipes. The upper surface of the concrete shall be struck off with a wooden screed or template and neatly finished off.

Concrete surround shall be 150 mm a minimum in thickness all round the barrel of the pipe.

1.15.16. Subsoil Pipes

Porous pipes shall be high frequency vibrated concrete pipes complying with BS 5911. They shall be straight in bore, circular in cross-section with straight sides perpendicular to the axis and free from cracks and other flaws and well burnt.

1.15.17. Vitrified Clay Pipe

Vitrified clay pipes shall comply with BS 65 and shall in addition be capable of complying with the tests described below.

The pipes shall be “Extra Strength” as specified in Table 3 of BS 65 and shall be supplied with flexible ring joints.

Pipelines with a nominal bore of 300mm or less shall be subjected to a water test in accordance with the requirements of BS 8005. The test shall be conducted when they have been bedded and jointed and before any concrete surround or backfill is placed. A further check for defects shall be carried out when any concrete surround has been completed and when backfill has been placed and compacted to a depth of 300mm above the crown of the pipelines.

For the purpose of this test, clear water shall be used. Smoke testing of pipelines will not be permitted.

Whenever possible, testing should be carried out from manhole to manhole. All manholes shall also be tested for watertightness.

APPENDICES TO EMPLOYER'S REQUIREMENTS

APPENDIX A : GENERAL ABBREVIATIONS

APPENDIX B : NOT USED

APPENDIX C: WATER QUALITY DATA

APPENDIX A

GENERAL ABBREVIATIONS

bar	atmospheric pressure
°C	degrees Centigrade
cm	centimetre
cm ²	square centimetres
d	day
db	dry bulb (humidity)
dB	decibel
gm	gram
GRP	Glass Reinforced Plastic
g/s	grams per second
hr	hour
Hz	hertz
kg	kilogram
kg/cm ²	kilograms per square centimetre
kg/hr	kilograms per hour
kg/m ²	kilograms per square metre
km	kilometre
l	litre
l/hr	litres per hour
l/s	litres per second
l/sec	litres per second
m	metre
m ²	square metre (area)
m ³	cubic metre (volume)
m ³ /d	cubic metres per day
mg	milligrams
mg/l	milligrams per litre
min	minute
mm	millimetres
mm ²	square millimetres
m/s	metres per second
m/sec	metres per second
N/m ²	Newtons per square metre
N/mm ²	Newtons per square millimetre
No.	Number
N.P.S.H.	Net Positive Suction Head
Nr	Number
ppm	parts per million
PVC	Poly-Vinyl Chloride
RH	Relative Humidity
rpm, r.p.m.	revolutions per minute

s	second(time)
sec	second(time)
SS	Suspended Solids
S/S	(Electrical) Sub-Station
t	tonne (1000kg)
TWL	Top Water Level
wb	wet bulb (humidity)
w x d x h	width times depth times height
WL	Water Level
°C	degree Centigrade
%	per cent

APPENDIX B

NOT USED

APPENDIX C
WATER QUALITY DATA