SPECIFICATIONS

SECTION 1 PIPES AND FITTINGS

1.1 GENERAL

SCOPE

This specification refers to pipes and appurtenant fittings for water supply and distribution pipelines.

STANDARDS

All pipes and fittings, and waterworks materials shall conform to only one set of similar Standards (such as AWWA/ANSI/ASTM, or ISO/DIN, etc.) throughout the project. The materials shall be compatible and interchangeable with each other without the use of special adapters.

SUBMITTALS

Manufacturer's data shall be submitted for all materials specified in this section. The submittal shall be in accordance with the information below:

a) Submittals shall be submitted to the Project Manager for review and acceptance prior to construction in accordance with the General Conditions
b) Submit manufacturers recommended method for butt-fusing joints.
c) The polyethylene pipe manufacturer shall provide certification that stress regression testing has been performed on the specific product. Certification shall include a stress life curve per ASTM D2837.
d) The manufacturer's certification shall state that the pipe was manufactured from 1 specific resin in compliance with these Specifications. The certificate shall state the specific resin used, its source, and list its compliance to these specifications.
e) Submit certified lab data to verify specified physical properties. Certify that tests are representative of pipe supplied for this project.
f) Submit affidavit of compliance with referenced standards (e.g., AWWA C901, C906, etc.).
g) Submit qualification certificates for operators of heat fusion equipment.
h) Submit schedule for placement of and removal of test bulkheads.

1.2 MATERIALS

MATERIALS TESTING

Testing services by independent testing laboratories for manufactured goods shall be appointed by the Owner and test specimens may be selected by the Project Manager either at the place of manufacture or at the job site and shall be delivered to the testing laboratory by the Contractor. The number of pipes and fittings specimens to be tested shall not normally exceed 0.5% of the number of pieces to be supplied to the site. However, where initial testing indicates inadequacies in the materials additional testing may be required.

DELIVERY, STORAGE, AND HANDLING

a) On site pipe storage shall meet all manufacturers' requirements.

b) Transport individual pipe lengths to the job site on padded bunks with nylon tie-down straps or padded bonding to protect the pipe. Coiled HDPE pipe shall be stored in a manner to ensure safety. Protect the pipe from sharp objects. Anchor pipe securely to prevent slippage.
c) Store individual pipe lengths on earth berms or timber cradles in the numerical order of installation. Stack the heaviest series of pipe at the bottom. Do not stack pipe in excess of 20-rows high.
d) Protect the pipe from stones and sharp objects.
e) Store fittings in their original cartons.
f) Lift pipes with handling beams or wide belt slings near the middle of joints as recommended by the pipe manufacturer. Do not use cable slings, chains, or hooks.
g) Before installation, check pipe and fittings for cuts, scratches, gouges, buckling, kinking, or splitting. Remove any pipe section containing defects by cutting out the damaged section in a complete cylinder.

PIPE AND FITTINGS FOR SERVICE CONNECTIONS

HDPE pipes and fittings shall meet the requirements of BS 3284 and 5114 respectively. They shall be transported, laid, jointed and backfilled in accordance with the manufacturers written instructions.

For diameters up to and including 63 mm they can be supplied in coils of up to 100 m long. Coils of diameters greater than 63 mm shall be supplied with each layer bound separately to facilitate safe unwinding. For diameters from 125 mm upwards they shall be supplied in lengths not exceeding 12 m. For pipes of diameter 100mm and less HDPE connectors shall be used. For diameter 125mm and above fusion jointing shall be applied. Installation – including fusion jointing work on HDPE pipelines – must be directed and supervised by suitably qualified and experienced persons and the Contractor shall have demonstrated his ability to provide this in his Tender. All pipe diameters specified are internal diameters.

Pipes, fittings and coils shall be stored in such a way that they are completely protected from direct sunlight. When covered they must be well ventilated to avoid accumulation of heat and resultant deformation. Transparent coverings shall not be used. The storage location shall be flat and shall, for pipes, support the pipes throughout their length. Stones and sharp objects shall not be present. Pipes shall not be stacked to a height exceeding 1 m. The pipes must be secured at the sides to prevent them from rolling. Contact with harmful materials shall be avoided. As far as possible, coils shall be stored in a horizontal position. The area shall be free of stones and sharp objects. If stored upright they must be secured to avoid tilting.

NIPPLES AND FLANGED STUB ENDS

Short nipples and stub ends shall be of the same material as the HDPE pipe

FITTINGS

a. Fittings shall be made from material meeting the same requirements as the pipe. Fittings shall be fabricated by the manufacturer of the pipe.
b. Fittings shall meet the appropriate AWWA standard for the size involved (C901 or C906) and shall be Pressure Class 160 for water main and reclaimed water main and Pressure Class 100 for wastewater force main.
c. Molded fittings shall be manufactured in accordance with ASTM D3261 and shall be so marked.
d. Mechanical fittings, when used, shall be specifically designed for, or tested and found to be acceptable for use with HDPE pipe.
e. Fittings used to connect with dissimilar pipe materials shall be provided as per Section 15062 "Ductile Iron Pipe and Fittings."

JOINTS

a. Sections of polyethylene pipe shall be joined into continuous lengths on the job site above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. The butt fusion equipment used in the joining procedures shall be capable of meeting all conditions recommended by the pipe manufacturer.
b. Butt fusion joining shall result in joint weld strength equal to or greater than the tensile strength of the pipe. Socket fusion shall not be used. Extrusion welding or hot gas welding of HDPE shall not be used. Flanges, unions, grooved-couplers, transition fittings, and some mechanical couplers may be used to connect HDPE pipe mechanically without butt-fusion only where shown in the Drawings.
c. Ductile Iron to HDPE Connections
    i. Flanged connections between ductile iron pipe or fittings and HDPE pipe or fittings shall meet all requirements of "Ductile Iron Pipe and Fittings."
    ii. Mechanical joint connections between ductile iron pipe or fittings and HDPE pipe or fittings shall use ductile iron mechanical joint glands conforming to AWWA C111 and AWWA C153. Mechanical joints shall be fully thrust restrained. Gaskets, bolts, and hexagonal nuts shall be standard rubber gaskets conforming to AWWA C111. Follower gland shall match class 350 compact fittings.
    iii. HDPE pipe stiffeners shall be constructed of stainless steel and shall be flanged on one end to prevent over-insertion into the receiving pipe.

HEAT FUSION

a. Use fusion equipment specially designed for heat fusion of HDPE. The equipment utilized shall be regulated for the different melt strength materials. Compatibility fusion techniques shall be used when polyethylene of different melt indexes are fused together.
b. Use the following procedure to butt fused HDPE pipe. If a procedure noted below contradicts manufacturer's recommendations, follow the manufacturer's recommendation.
    i. Maintain the proper temperature of the heater plate as recommended by the pipe manufacturer. Check it with a tempilstik or pyrometer for correct surface temperature.
    ii. Clean pipe ends inside and outside with a clean cotton cloth to remove dirt, water, grease, and other foreign materials.
    iii. Square (face) the pipe ends using the facing tools on the fusion machine. Remove all burrs, chips, and fillings before joining pipe or fittings.
    iv. Check the line-up of pipe ends in the fusion machine to see that pipe ends meet squarely and completely over the entire surface to be fused. The clamps shall be tight so that the pipe does not slip during the fusion process.
    v. Insert the clean heater plate between the aligned ends and bring the ends firmly in contact with the plate but do not apply pressure while achieving the melt pattern. Allow the pipe ends to heat and soften. Softening depths shall be per the manufacturer's recommendation.
    vi. Carefully move the pipe ends away from the heater plate and remove the plate (if the softened material sticks to the heater plate, discontinue the joint, clean heater plate, square pipe ends, and start over).
    vii. The melted ends shall be connected rapidly but not slammed together. Apply enough pressure to form a double rollback bead to the body of the pipe around the entire circumference of the pipe about 1/8-inch (3.175-mm) to 3/16-inch (4.763-mm) wide. Pressure is necessary to cause the heated material to flow together.

viii. Allow the joint to cool and solidify properly. Remove the pipe from the clamps and inspect the joint appearance.

QUALIFICATION OF FUSION OPERATORS

Each operator performing fusion joining shall be qualified in the use of the manufacturer's recommended fusion procedure(s) by the following:

Appropriate training or experience in the use of the fusion procedure.

1. Making a sample joint according to the procedure that passes the following inspections and tests:
   a. The joint shall be visually examined during and after joining and found to have the same appearance as a photograph or sample of an acceptable joint that was joined in accordance with the procedure; and
   b. The joint shall be tested or examined by 1 of the following methods:
      i. Pressure and tensile test as described in standards
      ii. Ultrasonic inspection and found to be free of flaws that would cause failure
      iii. Cut into at least 3 longitudinal straps, each of which is:
         1) Visually examined and found to be free of voids or unbonded areas on the cut surface of the joint, and
         2) Deformed bending, torque, or impact and if failure occurs, it must not initiate in the joint area.
2. Each operator shall be re-qualified under the procedure if during any 12-month period:
   a. Operator has not made any joints under the procedure; or
   b. Operator has 3 joints or 3% of the joints made, whichever is greater, that are found unacceptable by testing according to the above standards

POLYVINYL CHLORIDE (PVC) PRESSURE PIPE

Polyvinyl Chloride (PVC) Pressure Pipe for service connections shall be for a pressure of 1.0 MPa (PN 10) or as specified in the BOQ or elsewhere in the Contract and shall conform to the requirements for PVC and fittings stated in this section for PVC Pressure Pipe.

PVC pressure pipe shall conform to ISO 161, Wall thickness to ISO 4065, and PVC plastics to ISO R1965. The pipe shall also conform to the following supplementary data:

(a) Unless otherwise stated all pipe shall be rated for a minimum of 1.0 MPa (PN 10) potable cold water service. The wall thickness shall for PN 10 pipe be not less than ISO 4065 pipe series S=10. Where stated the pipe shall be rated for a minimum of 1.6 MPa (PN 16) potable cold water service. The wall thickness shall for PN 16 pipe be not less than ISO 4065 pipe series S=6.3.

(b) If requested by the Project Manager, the supplier shall submit an affidavit of compliance with the standard specifications and supplementary data as required for evaluation.

(c) Joints shall be integral-type bell and spigot, push-on, with a preformed synthetic rubber gasket.

(d) Couplings shall be of a class and strength equivalent to the pipe.

(e) Joints shall be capable of taking a 4 degree minimum deflection per joint.

(f) All pipes shall be of 6 m net laying length unless otherwise specified or approved by the Project Manager except for HDPE pipes, which shall be in rolls of 50-150m long.

(g) A sufficient quantity of lubricant, gaskets and application brushes shall be supplied with the pipe.

(h) All pipe diameters specified are internal diameters.

CAST IRON FITTINGS AND SPECIALS

Cast fittings and specials shall be grey iron or ductile iron with a rated working pressure of 1.0 MPa for pipe of pressure class PN 10, and with a related working pressure of 1.6 MPa for pipe of pressure class PN 16.

Mechanical seal joints on fittings to pipe shall be formed by a bell and preformed rubber gasket suitable for the pipe to which the joint is made.

Flanged joints on fittings shall be flat faced conforming in dimension and drilling to the standards specifications. One Standard shall be used throughout the contract.

FLANGES

Flanges shall be according to ISO 2084 and shall be for pressure greater or equal to that of the pipe. One Standard shall be used throughout the contract.

FLANGE GASKETS

Flange gaskets shall be manufactured from natural rubber and shall be 1.5 mm thick with a layer of cotton on both sides.

BOLTS

Flange bolts shall be stainless steel, machine bolts with square heads. Nuts shall be hexagon. Studs may be used where necessary. Bolt length shall be such that, after the joints are made up, bolts shall protrude through the nut, but not more than 12 mm.

All bolts and nuts shall be stainless steel.

Dissimilar metals shall not be used in pipe joints.

FLEXIBLE COUPLINGS

Flexible couplings shall be with ductile iron center sleeve and end rings finished with a corrosion resistant coating, rubber gaskets, stainless steel, bolts and nuts.

The coupling shall be capable of joining plain-end pipes of the same outside diameter, or the same nominal diameter but of varying actual outside diameters, or of different nominal diameters as indicated.

Flanged adapter couplings shall be with ductile iron body and end rings finished with a corrosion resistant coating, rubber gaskets, stainless steel, bolts and nuts. The coupling shall be capable of joining plain-end pipe to standard flanged fittings.

PIPE SADDLES FOR WATER SERVICE CONNECTIONS

Pipe saddles for use on HDPE/PVC pipes shall be as follows for the respective tapping size.

Tap Size	Nominal Pipe Size
19 mm - 25 mm	20 mm - 50 mm
32 mm - 50 mm	150 mm - 300 mm

Saddles shall be sized properly for the type and outside diameter of the pipe on which they are installed. Makes and models must be submitted for the prior approval of the Project Manager.

1.3 WORKMANSHIP

HANDLING

The Contractor shall use every precaution to prevent damages to the pipe. Any damage to the pipe from any cause during transport and before final acceptance by the Owner shall be repaired as directed by the Project Manager, by and at the expense of the Contractor. Material that cannot be repaired shall be removed and replaced at the Contractor's expense.

Pipe shall be loaded and unloaded without dropping, by hand or by using side boom tractors or other equipment approved by the Project Manager. The Contractor shall not roll or drop the pipe from any conveyance used for hauling.

Pipe and specials shall be handled using only wide canvas, leather, or rubber-padded slings. Use of bare cables, chains, hooks, pipe clamps, or other similar equipment will not be allowed. The width of belt slings shall be not less than one-half (1/2) the diameter of the pipe being handled.

Extreme care shall be exercised to prevent damage to pipe ends.

The Contractor shall ensure that all joints are made watertight to the satisfaction of the Project Manager. Items to be used for this work shall include hemp, thread tapes, WD-40, pipe jointing compound (Boss White), uPVC Solvent (Targit) among others.

1.4 PAYMENT

MEASUREMENT AND PAYMENT

Payment for the supply and handling of materials referred to in this section to the point of delivery, will be made as shown in the Tender Form of the Contract for the Supply of Pipes and Fittings.

SECTION 2 VALVES, STOPS AND HYDRANTS

2.1 GENERAL

SCOPE

This specification refers to valves, stops and hydrants for water supply and distribution pipelines.

STANDARDS

All pipes, fittings, valves, stops, hydrants and miscellaneous waterworks materials shall conform to only one set of similar standards (such as AWWA\ANSI\ASTM\CSA, or ISI\DIN, etc.) throughout the project. The materials shall be compatible and interchangeable with each other without the use of special adapters.

SUBMITTALS

Manufacturer's data shall be submitted for all materials specified in this section. The submittal shall be in accordance with Section 1.3 of this specification.

2.2 MATERIALS

AIR VALVES

Air valves shall be double orifice type to suit a maximum working pressure of 1.6 MPa and a hydrostatic test pressure of 2.4 MPa. Valves shall have a cast iron body with two chambers, each housing a ball, one chamber having a cast iron small orifice plate with bronze seat, the other having a cast iron large orifice plate with rubber seat. The valves shall be supplied with rubber gaskets and cast iron splash covers.

Double orifice valves shall incorporate the characteristics of both the small orifice and the large orifice valves. The valves shall exhaust small pockets of air when the line is under pressure, fully open the large orifice when the valve chamber is empty and fully close "drop-tight" when the chamber is full of water.

Small orifice (air release) valves shall be float actuated and be open when valve chamber is empty and closed "drop-tight" when the chamber is full of water. Internal levers, pins, screws, etc., shall be stainless steel or bronze.

Large orifice (vacuum breaking) valves shall have a ball sealed orifice, fully open when the valve chamber is empty and closed "drop-tight" when the chamber is full of water.

Surface boxes for air valves shall be of cast iron and suitable for installation in roads and of the following sizes:

(a) For 200 mm diameter air valves, 900 mm x 900 mm clear opening with two piece chained lid.

(b) For 150 mm diameter air valves, 900 x 900 mm clear opening with two piece chained lid.

(c) For 100 mm diameter air valves, 700 mm x 400 mm clear opening with one piece chained lid.

FLAP VALVES

Flap valves shall have cast iron frames and doors with non-ferrous metal facings. They are to be double hung with hinge pins and links of suitable non-ferrous materials.

CHECK VALVES

Check valves 65 mm and smaller shall be bronze, swing check type, with threaded inlet and outlet, Crane Model 37 or as approved.

Check valves 75 mm and larger shall be ductile iron body with stainless steel trim, resilient seating (Buna-N), with stainless steel spring, globe type, with flat face flanges compatible to those specified in Section 30800 and full face gaskets, Apcc Series 600, or as approved.

VALVE BOXES

Valve boxes shall be a sectional, telescoping construction, capable of withstanding surface traffic and impact loading without transmitting such loads to the valve. A top section or surface box shall be complete with a lid, which is secured in place and detectable with metal\magnetic-field locating equipment. A middle section or sleeve pipe shall be suitable for inserting a Valve operating key, have a minimum inside diameter of 100 mm, and a length suitable for the surface box and the required depth of burying the valve plus an adjustment of plus or minus 0.2 m.

Valve boxes shall be fabricated of corrosion resistant material or have corrosion resistant coatings on surfaces in contact with the soil.

Internal extension spindles where required shall be suitable for use with the valve box installed and consist of a bottom socket, rock shield and top-operating nut, and galvanized steel extension rod to suit the length of the valve box.

CORPORATION STOPS

Corporation stops shall be similar to Mueller H-15008 with inlet thread compatible with the pipe saddles specified in section 30837.

Compression joints shall be complete with stainless steel liners for inserting into plastic tubing.

FIRE HYDRANTS

Each hydrant shall be complete with one 90 degree flanged x spigot duck-foot bend, one flange extension (if necessary) for 1 m trench depth, surface box, one standpipe with instantaneous fire-hose couplings, and one operating key.

Hydrants shall be of the underground screw down type with a nominal diameter of 80mm, and shall conform to an internationally accepted standard, coated according to the manufacturer's recommendations.

2.3 SPARE PARTS

The Contractor shall submit in his Technical File detailed parts lists and drawings for all valves and hydrants, including a list of recommended spare parts and prices for each spare part. The Project Manager on the basis of the information submitted will determine the exact type and quantity of spare parts to be supplied.

2.4 WORKMANSHIP

HANDLING

The Contractor shall use every precaution to prevent damage to the materials supplied. Any damage from any cause during transport and before final acceptance by the Owner shall be repaired as directed by the Project Manager, by and at the expense of the Contractor. Materials that cannot be repaired shall be removed and replaced at the Contractor's expense.

Materials shall be loaded and unloaded without dropping, by hand or by using cranes or other equipment approved by the Project Manager. The Contractor shall not roll or drop the materials from any conveyance used for hauling.

2.5 PAYMENT

MEASUREMENT AND PAYMENT

Payment for the supply and handling of materials referred to in this section will be made for supply to the point of delivery as shown in the Tender Form of the Contract for the Supply of Pipes and Fittings.

PART 3 – CONCRETE

SECTION 3 – CONCRETE

3.1 SCOPE AND STANDARDS

This Section describes the quality of materials and workmanship of concrete and reinforced concrete works cast in situ in all parts of structures below or above ground.

The specification shall apply to concrete prepared on site as well as ready mixed concrete and small precast concrete elements. It is based on BS8110: 1997 in general, and on BS5337: 1976 in respect of exposure of concrete to water and moisture.

The standards and Codes of Practice, detailed below are by reference made part of this Specification.

BS: Part I	Structural use of Concrete
BS 4550	Portland Cement Methods of Sampling & Testing
BS 12	Portland cement (ordinary and rapid hardening)
BS 410	Test sieves
BS 812	Methods for sampling and testing of mineral aggregates, sands and filters
BS 882	Aggregates from natural sources for concrete
BS 1305	Batch type concrete mixers
BS 1370	Low heat Portland cement
BS 1881	Guide to use of non-destructive methods of test for hardened concrete
BS 3148	Tests for water for making concrete
BS 4449	Carbon steel bars for the reinforcement of concrete
BS 4466	Bending dimensions and scheduling of bars for the reinforcement of concrete
BS 4482	Steel wire for the reinforcement of concrete
BS 4483	Steel fabric for the reinforcement of concrete
BS 4550	Methods for testing cement
BS 5075	Concrete admixtures
BS 5135	Metal-arc welding of carbon and carbon manganese steel
BS 8007	Code of practice for the design of concrete structures for retaining aqueous liquids
BS 5606	Code of practice for Accuracy in Building
BS 4027	Sulphate Resisting Portland Cement
BS 8110	Structural use of concrete – parts 1-3

ASTM standard C309 Liquid membrane forming compound for curing concrete

ASTM standard C260 Air entraining admixtures for concrete

In case of discrepancy or contradiction, the requirements of this specification shall rule over any standard.

3.2 CLASSIFICATION OF CONCRETE

3.2.1 Normal Concrete

All normal concrete (i.e., other than mass concrete as specified below) to be used in reinforced and plain structure is classified in the contract documents according to required strength grade as per Table 1 and to (exposure) class as per Table 2.

Table 1: Grades of Concrete and Strength Requirements

Grade	Characteristic Strength N/mm2	Cube Strength at 28 days, in N/mm2		
		Work Cube [1]		Trial Mix [1]
		Average	Each Individual	Average
10	10	12.3	8.5	
15	15	20.0	12.8	21.5
20	20	27.5	17.0	31.5
25	25	32.5	21.3	36.5
30	30	37.5	25.5	41.5
40	40	47.5	34.0	51.5
50	50	57.5	42.5	61.5

[1] Note: Concrete may be accepted on the basis of 7 days cube strength, provided the average strength is at least 70% of the required 28 days strength.

Table 2: Minimum Cement Content (kg/m3) required for Classes of Exposure

Class	Reinforced Concrete					Plain Concrete				
	Max. Size of Aggregate, mm				Max. Free Water	Max. Size of Aggregate, mm				Max. Free Water
	40	20	14	10	Cement Ratio	40	20	14	10	Cement Ratio
E	320	360	390	410	0.45	270	310	330	360	0.50
Severe	(290)	(330)	(350)	(370)		(240)	(280)	(300)	(320)	
F	260	290	320	340	0.55	220	250	280	300	0.60
Moderate	(240)	(260)	(290)	(310)		(200)	(230)	(250)	(270)	
G	220	250	270	290	0.65	200	220	250	270	0.70
Mild	(200)	(230)	(250)	(260)		(180)	(200)	(220)	(240)	

Notes: The minimum cement content may be reduced, as given in brackets when:

1. Trial mixes have verified that a concrete with a maximum free water cement ratio not greater than that given for the particular concrete can be consistently produced and that it is suitable for the conditions of transporting placing and compaction.
2. The max. free water/cement ratio is strictly controlled by a site laboratory.

3.2.2 Cement Content

The cement content shall comply with requirements of Table 2. The actual amount of cement needed for each type of concrete in the various parts of the structures shall be determined by the tests as specified hereinafter, taking into consideration actual site conditions.

No change in the unit rates submitted for concrete will be allowed, if the actual quantity of cement used to obtain a specified concrete characteristic strength (grade) is greater than the minimum cement content specified in Table 2.

3.2.3 Concrete Designation

Concrete may be named on the Drawings and in the Bills of Quantities as follows:

Normal Concrete will be designated by three symbols: the first number stands for grade as to strength (Table 1), the middle letter stands for class of exposure (Table 2), the last figure stands for the maximum size of aggregate. Thus, for example, 20-f-40 designates a concrete having a characteristic strength of 20 N/mm2, class of exposure F, and maximum size of aggregate 40 mm.

3.3 CEMENT

3.3.1 Quality

All cement shall be Portland cement of approved manufacture. Unless otherwise specified, it shall be ordinary Portland cement complying with BS 12.

Cement shall be sulphate-resistant Portland cement complying with BS 4027 for the water treatment plant clarifiers and filters.

Rapid-hardening Portland cement shall not be used in mass concrete. Low-heat Portland cement complying with BS1370 may be used for mass concrete.

A certificate that the consignment complies in all respects with the approved standard shall be forwarded to the Project Manager with each consignment.

The Project Manager reserves the right subject the deliveries to independent tests and to reject without question such cement that fails to comply with the specification or fails to produce concrete

of the quality or of the rate of hardening specified. All such rejected cement shall forthwith be removed from the site of the works.

3.3.2 Supply

The supply of cement to the site shall be made in whole and original bags, marked with the trade mark of an approved manufacture or in special closed bulk containers manufactured expressly for this purpose. Cement from torn bags or cement which has been split and swept up shall not be used.

The Contractor shall inform the Project Manager in writing at least 30 days before first shipments are required, concerning the mill or mills from which the cement is to be acquired and the purchase order number, contract number, or other designation that will identify the cement to be used by the Contractor.

3.3.3 Storage

In order that cement may not become unduly aged after delivery, the Contractor shall use cement in the chronological order in which it was delivered on the job. Each shipment shall be stored so that it may readily be distinguished from other shipments. The cement shall be free of lumps and shall be otherwise undamaged when used in concrete.

Sacked cement shall be stored in a watertight and weatherproof shed a floor raised at least 150mm from the ground. Stacking cement bags to a height exceeding ten layers will not be permitted. Any cement damage by water or otherwise defective and damage bags of cement will be rejected and shall be removed from the site immediately.

Bulk cement shall be stored in weatherproof bins or soils to be approved by the Project Manager. The bin shall be emptied and cleaned at regular intervals as directed by the Project Manager.

The use of sacked cement which has been stored for more than three months after delivery will not be permitted, except when it is proved by tests, to the satisfaction of the Project Manager that it complies with the requirements of the Specification.

3.3.4 Contractor's Responsibility

A suitable quantity of approved and certified cement shall always be available on site in order to ensure continuity in case of the rejection of a consignment by Project Manager.

If the Contractor has used cement for which no certificate of compliance with the standards was submitted as required in Sub-Clause 31.3.1 above or, where the Project Manager has ordered independent tests, before obtaining results of such tests, and the cement is later found defective in quality, the Project Manager shall have the right to reject that portion of the structure constructed with this cement and the Contractor shall be obliged to dismantle or demolish such

structure and reconstruct it at his own expense and with a cement complying with the requirements.

3.4 WATER

Water for mixing and for curing concrete mortar and grout shall be free from objectionable quantities of silt, organic matter, alkali salts, and other impurities. The source of the water to be used shall be subjected to the Project Manager's approval.

Where tests are required they shall be in accordance with BS 3148.

3.5 AGGREGATES

3.5.1 General

Aggregate for concrete (including for granolithic) shall be coarse aggregate and fine aggregate confirming in all respects to BS 882: 1983.

The grading shall be such as to produce a concrete with the specified properties, consistency, and one that will work readily in position without segregation and without the use of an excessive water content and can be readily compacted into a dense impervious mass.

Aggregate for concrete shall be furnished by the Contractor from approved sources, provided that they meet the requirements of the above standards. The approval of any sources by the Project Manager shall not be construed as constituting the approval of all materials taken from these sources and the Contractor will be held responsible for the specified quality of all such materials used in the works. Specimen samples of aggregates for concrete shall be submitted to the Project Manager for approval before any order is placed. Such approval will not relieve the Contractor of the responsibility of satisfying himself before placing an order that the aggregate will conform to BS882. All aggregate as delivered to the batching plant, shall have a uniform and stable moisture content.

The Contractor shall test all aggregates as ordered by the Project Manager, including tests sulphates and chlorides, and shall provide such facilities as may be necessary for procuring representative test samples. The Contractor shall prepare, for preliminary tests and approval, a representative sample of fine aggregate and of each size of coarse aggregate proposed for use in the works at least 30 days before the aggregates are required for use. The cost of all tests required under this Clause as well as the supply of representative samples shall be spread over the items for concrete work inserted in the Bill of Quantities.

During construction, the sizes of the coarse aggregates and grading of the fine aggregates shall be determined at least once for every 100 tonnes supplied, and at least once a week a check shall be made on supplies to ensure that the required grading is being maintained. If any aggregate or sand when so tested does not meet the requirements of the relevant Standard, the

Contractor shall forthwith cease to use that aggregate or sand and shall correct the quality and/or grading of the aggregate or sand without cost to the Employer.

If aggregates are bought to the site in separate loads containing aggregate of one size, they shall be stored in such a way as will prevent aggregates of different sizes being mixed together. Aggregates mixed either in transport or on site will be rejected. Unloading shall be done in such a way as to prevent excess segregation as directed by the Project Manager.

All aggregates, sand and stone intended for use in the works shall be stored on a concrete floor or a screeded and well drained surface to the approval of the Project Manager to prevent contamination by contact with ground.

A stock of aggregates permitting concreting operations for at least 5 days shall be available on the site.

All sand and coarse aggregate, when required by BS 882, shall be washed in clean fresh water at no extra cost to the Employer.

31.5.2 Sampling and testing of Fine & Course Aggregate

Sampling and testing of aggregate prior to the development of an aggregate source shall be in accordance with the following:

a Aggregate samples shall be taken in conformance with C.D3.201.

b A minimum of one (1) petrographic analysis for each source of supply shall be made in conformance with BS 812: Part I.

c A minimum of one (1) test for the sulphates (SO_3) content of the aggregate for each source of supply shall be made in conformance with BS 1074. The total of the sulphate content of the concrete mix shall not exceed 4% by mass of the cement.

d A minimum of one (1) test for chlorides content of the aggregate for each source of supply shall be made in conformance with BS 812: Part 4. The total chloride ion content shall not exceed the limit specified in BS 882, Table 8, and BS 5337.

e A minimum of one (1) sieve analysis of the fine and coarse aggregate for each source of supply shall be made in conformance with BS 812. The gradation shall comply with BS 812.

f A minimum of one (1) test for shell content for each source of supply shall be made in conformance with BS 812: Part 106. The results shall comply with BS 882 and BS 5337.

g A minimum of one (1) test for the 10% fines value for each source of supply shall be made in conformance with BS 812: Part 3. The results shall comply with BS 882: Table 3.

h A minimum of one (1) test for alkali-aggregate reaction for each source of supply shall be made in conformance with ASTM C289 for siliceous aggregates and ASTM C586 for carbonate aggregates.

i A minimum of one (1) test of absorption for each source of supply shall be made in conformance with BS 812. The result shall be less than 3%.

31.5.3 Fine Aggregate

Fine Aggregate shall consist of hard, dense, durable clean, uncoated fragments of natural sand, crushed stone, or other suitable materials approved by the Project Manager for use with the concrete specified and shall be free from clay, organic material or other deleterious substances.

The grading of the fine aggregate shall lie within one of the grading zones shown in Table 2 BS 882.

For reinforced concrete the grading of the fine aggregates shall be within either grading zones 1, 2, or 3.

31.5.4 Coarse Aggregate – General

Coarse aggregate shall be natural gravel or crushed stone or a mixture of natural gravel and crushed stone and shall consist of hard, dense, durable, clean, uncoated fragments.

31.5.5 Coarse Aggregate for Normal Concrete

The grading of coarse aggregate for normal reinforced and plain concrete, when analyzed in accordance with BS 812 shall be within the limits given in Table 1 of BS 882.

The nominal maximum sizes of the coarse aggregates are 40 mm or 20 mm.

The maximum size of coarse aggregate shall be, in general, as large as possible but in no case larger than:

a. One quarter of the minimum thickness of the member, or

b. 6 mm less than the distance between reinforcement bars or than the concrete cover over the reinforcement, provided that the concrete can be placed without difficulty so as to surround all reinforcements thoroughly and to fill the corners of the formwork. If the different sizes of coarse aggregates will be supplied separately, then the grading of the coarse aggregates shall be controlled by obtaining the course aggregate in two sizes for aggregate of 20 mm nominal maximum size and in three sizes for aggregate of 40 mm nominal size.

3.6 ADMIXTURES

3.6.1 General Requirements

Calcium chloride or other admixtures containing chlorides shall not be used. Other admixtures may only be used with the approval of the Project Manager.

All admixtures shall comply with the requirements hereinafter specified. The Contractor shall provide test certificates of an approved laboratory to show that the proposed admixtures comply with all the requirements of this specification and provide acceptable documentary evidence, that the proposed admixtures have been used successfully in major concrete projects.

To facilitate approval, the Contractor shall provide the following information:

a) the trade name of the admixture, its source, and the manufacturer's recommended method of use;

b) typical dosage rates and possible detrimental effects of under-dosage and over-dosage;

c) whether compounds (such as those containing chloride in any form as an active ingredient) likely to cause corrosion of the reinforcing steel or deterioration of the concrete are present, if so, the chloride content (expressed as chloride ions or as equivalent anhydrous chloride) by mass of admixture;

d) the average expected air content of freshly mixed concrete containing an admixture which causes air to be entrained when used at the manufacturer recommended rate of dosage.

Each consignment of admixture shall be supplied in sealed waterproof containers. A certificate showing that the consignment complies in all respects with this specification shall be forwarded to the Project Manager with each consignment. The Project Manager reserves the right to subject the deliveries to independent tests, and to reject without question and admixture which fails to comply with the specification, or is not compatible with any of the other ingredients of the concrete as shown by preliminary tests with the proposed concrete mixes. All prices for concrete include the admixtures of the types and quantities as specified hereinafter.

Different admixtures shall not be allowed to mix prior to charging the mixers, and they shall be added to separate ingredients of each batch. When dispensing systems are used separate dispensers shall be used for each admixture.

3.6.2 Air Entraining Admixtures

If ordered by the Project Manager, an air entraining admixture, complying with the requirements of ASTM C260 shall be used in Tremie or Mass Concrete. The amount of air entraining admixture to be used for entraining the required amount of air shall be determined by preliminary laboratory tests and adjusted in the field to meet the specification requirements. The actual amount of entrained air shall be continuously controlled on site. If the air-entraining admixture is to be used together with another admixture, it shall be proved by preliminary tests that both admixtures are compatible and the concrete has no undesirable properties. Laboratory and field procedures shall be subject to approval by the Project Manager.

The Contractor shall provide equipment to permit on-site measurement of the percentage of air entrained in the concrete and the density of concrete.

The air-entraining admixture shall be added in the mixer to each batch together with the water.

3.6.3 Water Reducing, Set Retarding Admixture

All mass concrete and concrete in such structures or parts thereof, as will be determined by the Project Manager, shall include an approved water reducing, set retarding admixture complying with BS 5075, thoroughly tested in conjunction with the particular brand of cement used in the given structure.

The quantities of the admixture used and the method of use will depend on the composition of the concrete, prevailing temperature, desired setting time, the manufacturer's instructions and the results of trial tests. The use of any admixture shall require the prior approval of the Project Manager.

3.7 DESIGNED MIXES

3.7.1 General

The Contractor shall fix the grading of the aggregate and proportions of the mix, on condition that he can prove by advance testing that they are suitable, comply with all the requirements of this specification, such as strength, density, impermeability, durability, etc. and that they are workable and can be transported, placed and compacted by the methods and equipment used on the site, without segregation, without the use of excessive water content and that they can be readily compacted into dense impervious mass. He shall supply the Project Manager, at least 14 days before the commencement of casting, with the results of trial mixes, for each class and grade of concrete, for each maximum nominal size aggregates and each consistency required.

Three separate batches of concrete shall be made using materials likely to be typical of the proposed supply and preferably under full scale production conditions. If circumstances make this inconvenient, the batches may be mixed in an approved laboratory. Sampling and testing shall be in accordance with BS 1881.

The workability of each of the trial batches shall be determined and three cubes made from each batch for test at 28 days. A further three cubes from each batch shall be made for test at 7 days if required.

The test results shall contain the following details:

a. Cement content

b. Tests of the quality of the aggregates, their contents and grading, and the quality of cement and admixtures used

c. The proposed mix proportions including cement, admixture and water, expressed in kg/m^3 or fresh compacted concrete based on saturated surface dry aggregates.

d. The consistency of the fresh concrete, as measured by the slump tests according to BS 1881.

e. The compressive strength of at least 18 standard concrete cubes in compression made from 3 batches of which 9 shall be tested at 7 days and 9 tested 28 days old.

3.7.2 Approval of Mix Proportions

Without detracting from the aforesaid, the Project Manager's prior approval of the proposed mix is to be obtained. This approval will be given based on the results of the above tests and on condition that it can be proved to the Project Manager's satisfaction that:

a. All materials comply with the requirements for quality as demanded, including aggregate sizes and grading;

b. Cement content complies with requirements of Table 2 (sub-clause 31.2.1);

c. The consistency of the fresh concrete is suitable for the conditions of transport, placing and compaction in the forms as required in the specifications and in accordance with the equipment and systems of work which are intended to be used;

d. The average compressive strength of 9 standard cured cubes at 28 days age shall be equal to or greater that the average strength required for preliminary tests in Table 1;

e. The concrete is impermeable to water for those part of the structures which will be subjected to standing or running water or water under pressure (Classes E, F and M2).

3.7.3 Contractor's Responsibility

In all cases and under all circumstances, the Contractor shall be solely responsible for the quality of the concrete, including its impermeability to water where required in the structure.

Approval of mix proportions by the Project Manager shall be binding upon the Contractor as follows:

a. To use materials only of the same origin and quality as used in preliminary tests.

b. To use the above mentioned mix proportion without any changes, except for slight changes due to different grading of aggregate within approved limits, and due to different moisture content of aggregates, and climatic conditions, as approved by the Project Manager.

The Contractor may propose alternations in source of supply, mix proportions and gradings of aggregates, provided that he complies with the requirements of the specification, and provided the proposed change does not interfere with the progress of the work.

Changes by the Project Manager in proportions or materials, or both, may be made as necessary, without any additional payment to the Contractor, to secure the required properties during progress of work, should it be found impracticable to obtain concrete of required workability, strength, density, and/or impermeability with materials and transporting, handling and compacting equipment approved by the Project Manager and furnished by the Contractor.

3.8 NOMINAL MIXES

On less important concrete structures or elements, the Project Manager may allow the Contractor to use nominal mixes without preliminary trial mixes for ordinary structural concrete of class G exposure under the following conditions:

a. The concrete mixes shall be produced to comply with all requirements of the specification, including requirements of Tables 1 and 2.

b. The materials comply with all the requirements of the specification.

c. No admixtures are used or required

d. Evidence can be provided to the satisfaction of Project Manager that with the materials and workmanship available in the particular locality a concrete of required standard can readily be obtained.

e. The Project Manager shall be informed of the nature and source of each material to be used and subsequently whenever a change is made.

Table 4 shows the cement contents for the nominal mixes, which together with the total weight of dry aggregate produce approximately one cubic metre of concrete. Depending on specific gravity of the aggregate slight adjustment may be required to the quantity of aggregates to produce this volume of concrete having the required workability, strength and cement content.

Where single size coarse aggregates are used, the proportions should be chosen to produce a combined grading within limits of BS 882 for graded coarse aggregate of appropriate size.

The actual batch weights should be calculated to suit the size of the mixer from the values of Table 4. Allowance should be made for a moisture content typical of the aggregates being used.

Table 4: Nominal Mixes for Ordinary Structural Concrete

Concrete Grade	Nominal Max. Size of Aggregate, mm	Medium Workability				High Workability			
		40	20	14	10	40	20	14	10
	Limits to slump that may be expected, mm	50-100	25-75	10-50	10-25	100-150	75-125	50-100	25-50
C-10	Cement, kg	210	240			230	260		
	Total Agg., kg	1,900	1,850			1,850	1,800		
	Fine Agg., %	30-45	35-50			40-45	35-50		
C-15	Cement, kg	250	280			270	310		
	Total Agg., kg	1,850	1,800			1,800	1,750		
	Fine Agg., %	30-45	35-50			30-45	35-50		
C-20	Cement, kg	300	320	340	360	320	350	380	410
	Total Agg., kg	1,850	1,800	1,750	1,750	1,750	1,750	1,700	1,650
	Sand [1] Zone 1	35	40	45	50	40	45	50	55
	Zone 2	30	35	40	45	35	40	45	50
	Zone 3	30	30	35	40	30	35	40	45

C-25	Cement, kg	340	360	380	400	360	390	420	450
	Total Agg., kg	1,800	1,760	1,700	1,700	1,750	1,700	1,650	1,600
	Sand [1] Zone 1	35	40	45	50	40	45	50	55
	Zone 2	30	35	40	45	35	40	45	50
	Zone 3	30	30	35	40	30	35	40	45

[1] Sand is fine aggregate resulting from natural disintegration of rock. Zone numbers refer to BS 882 Table 2.

3.8.1 General

Except as otherwise provided hereinafter, the amounts of sand, bulk cement, and each size of coarse aggregate entering each batch of concrete shall be determined by weighing, and the amount of water shall be determined weighing or volumetric measurement. Where sacked cement is used, the amount of cement entering the mixtures shall be determined on the basis of integral sacks of cement of known weight.

For concretes of grades 10 and 15, class ‘G’ the Project Manager may, in exceptional cases, permit volumetric measurement of aggregates.

The Contractor shall provide equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. Moreover, the Contractor shall be able to ensure timely calibration of the compressive test machine from recognized standardizing organization.

3.8.2 Weighing Equipment

A separate weighing device shall be provided for the cement. All weighing equipment shall be subject to the Project Manager approval. An accuracy to within 0.5 percent of the scale capacity will be satisfactory, and the equipment shall be capable of ready adjustment to compensate for the varying weight of any moisture contained in the aggregate and to effect changes in concrete mix proportions.

The accuracy of the measuring equipment shall be within +/- 3% of the quantity of cement, water and total aggregate being measured, and within +/- 5% of the quantity of any admixture used. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device and shall make periodic tests over the ranges of measurements involved in the batching operations. The tests shall be made in the presence of the Project Manager’s Representative and shall be adequate to prove the accuracy of the measuring devices. Unless otherwise directed, tests of equipment in operation shall be made at least once in two weeks.

The Contractor shall make adjustments, repairs, or replacements as may be necessary to meet the specified requirements for accuracy of measurement. The operating mechanism in the water measuring device shall be such that leaking will not occur when the valves are closed. Water tanks on portable mixers shall be constructed so that the indicating device will register, within the specified limits of accuracy, the quantity of water discharge, regardless of the inclination of the

mixer setting. Where the batching plant involves the use of storage bins and weighing hoppers, each weighing unit shall include a visible springless dial which will register the scale load at any stage of the weighing operations from zero to full capacity or shall include an over-and-under indicator which will show the scale in balance with no load or when loaded at any desired beam setting. The weighing hoppers shall be constructed so as to permit the convenient removal of overweigh material in excess of the prescribed tolerances.

Each dial or over-and-under indicator and each water-measuring device shall be in full view of the operator.

3.8.3 Batching by Volume

Where batching by volume is permitted by the Project Manager (see sub-clause 31.9.1), only precisely dimensioned gauge boxes approved by the Project Manager shall be used for the sand and different sizes of aggregates. After filling the box the aggregate shall be struck-off level with the brim. The mix proportions by volume shall be based on the actual unit weight of the aggregates in measuring boxes including their moisture content. All gauge boxes shall bear marks in red oil paint showing the kind and size of aggregate for which each box is to be used. No boxes similar in shape and appearance but different in volume from the approved gauge boxes shall be kept on the site.

3.9 MIXING

The concrete ingredients shall be mixed in sufficient number of approved batch mixers of adequate capacity complying with BS 1305. The number of mixers employed shall be regulated to suit the requirements of the concrete placing operations. In addition, sufficient reserve capacity shall be available at all times.

The concreting capacity of mixers will be subject to the approval of the Project Manager, who will prohibit concreting, should the capacity in his opinion be inadequate. Any mixer that at any time produces unsatisfactory results shall be tested according to BS 1305 and shall be repaired promptly and effectively or shall be replaced. Mixers shall not be loaded in excess of their rated capacity unless specifically authorized.

The mixing shall continue until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall the mixing be less than 1 minute for batches of up to 0.50m^3 and 1½ minutes for larger batches after all the ingredients, including the full amount of water, are in the mixer.

The Project Manager may permit, subject to preliminary tests, to reduce the above mixing times for high-speed pan type mixers by half a minute.

The Project Manager shall have right to increase the above minimum mixing time when the charge and mixing operations fail to produce a concrete batch throughout which the ingredients are uniformly distributed and the consistency is uniform. The concrete shall also be uniform from batch to batch, except where changes in composition and consistency are required.

Water shall be added prior to, during and following the mixer-charging operations. Excessive over mixing requiring the addition of water to preserve the required concrete consistency will not be permitted.

No dry materials shall be introduced into the mixer until all material from the previous batch has been removed.

Incrustations of concrete or mortar shall not be allowed to accumulate on the interior surface of the mixing drum. Re mixing of concrete, or addition of water in an attempt to improve the consistency of a mixture which has already begun to set or which is otherwise unsuitable for casting, shall not be permitted and such concrete shall be wasted.

Where small quantities (not exceeding 3 cumecs) are involved, the Project Manager's Representative may in exceptional cases permit hand mixing of lean and other non-reinforced concrete. No hand mixing shall be done unless authorized in writing by the Project Manager's Representative. The batches in hand mixing shall not exceed 0.25m^3. Hand mixed concrete shall not be used until the mixing of the whole colour and consistency. Hand mixing shall be done twice on dry aggregate, and at least twice wet, on a clean and even surface, which will prevent the loss of water during mixing. The water added shall be measured in order to prevent the use of an excessive quantity water.

When mixing by hand, the quantity of cement shall be increased by 10%, above that specified in Table 2.

3.10 TRANSPORTING OF CONCRETE

The methods and equipment used and the speed required for transporting of concrete on site shall be such that concrete having the required composition and consistency will be delivered into the work, without objectionable segregation, loss of slump or delay. No more than 30 minutes shall elapse between the first wetting of all concrete ingredients and composition of placing the concrete in the work.

3.11 READY MIXED CONCRETE

3.11.1 General

The use of ready mixed concrete brought to the site from a central off-site batching plant requires the Project Manager's approval. Approval shall be granted only if the following conditions are fulfilled:

a. The location of the plant permits delivery under normal transport conditions within one hour after batching.

b. Mixers shall conform to approved national standards.

c. The plant has sufficient capacity and transportation equipment to deliver the concrete at the desired rate.

d. The concrete mix will contain set-retarding admixtures at no extra cost if required by the Project Manager.

e. The Project Manager can check at all times the manufacturing process, the quality of the concrete ingredients, the accuracy of the measuring devices, the mixers and all other equipment used.

f. All materials and mixes used comply with all requirements of specification,

Every consignment shall be accompanied by a bill of lading including at least the following information:

a. Concrete Designation
b. Nominal maximum size of coarse aggregate
c. Slump
d. Minimum (or if required maximum) cement content
e. Time of adding water to mix
f. Pumpability, if required
g. Chemical admixtures
h. Maximum permissible addition of water

Retempering (addition of water on site) will not be allowed, except for the amount stated in bill of lading.

Concrete which has lost slump and which cannot be returned to the required slump with the amount of water stated above shall not be accepted.

3.11.2 Approval of Mixes from Operating Concrete Plants

The Project Manager may approve standard mixes from operating concrete plants without preliminary trial mixes subject to the following conditions:

a. Existing data as evidence of satisfactory previous performance of proposed mix, including impermeability to water where required.

b. Results of current quality control tests of materials to be used to prove compliance with specifications.

The proposed mixes will be accepted by the Project Manager if they comply:

a. With required minimum cement contents as per Table 2 or 3.

b. With strength requirements of Table 1 or 3.

3.12 CONSISTENCY OF CONCRETE

Uniformity in concrete consistency from batch to batch will be required.

The slump as measured according to BS 1881 shall be within the following limits:

$\pm$ 25 mm or $\pm$ 1/3 of the approval value, whichever is greater.

3.13 PREPARATION OF FOUNDATIONS

All earth surface against which concrete is to be placed shall be leveled, wetted and rammed to required lines and grades, the cost of such work being deemed included in rates for earthwork and/or concrete.

On the rock surfaces prepared as under Clause 22.6.2, a 15 mm layer of 1:3 cement mortar shall be spread immediately prior to placing concrete and shall be well immediately prior to placing concrete and shall be well worked into the surface with the aid of brushes. Care shall be taken that the mortar does in no case set before concrete is placed on it. The cost of such mortar and its spreading shall be held to be included in the rates for concrete.

3.14 PLACING OF CONCRETE

3.14.1 General

No concrete shall be placed until formwork installation of parts to be embedded and preparation of surfaces involved in the placing have been approved by the Project Manager. All surfaces of forms, reinforcement bars and other embedded materials that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.

Concrete shall be placed only in the presence of the Project Manager or his Representative, unless written permission is given for placing concrete in their absence.

The Contractor shall give the Project Manager at least twenty-four hours' notice of his intention to cast concrete in any structure or major part thereof, stating the exact hour at which concreting is to commence, to enable the Project Manager or his Representative to be present or to grant permission to place concrete in their absence, which permission shall, in such event, not be unreasonably delayed or withheld.

Concrete shall be deposited in all cases as nearly as practicable directly in its final position and shall not be caused to flow in a manner to permit or cause segregation.

Excessive separation of coarse aggregate from the concrete caused by allowing the concrete to fall freely from too great a height or at too great an angle from the vertical or to strike the forms of reinforcement steel will not be permitted. Where such separation would otherwise occur, the Contractor shall provide suitable drop chutes and baffles to confine and control the falling concrete. Except as intersected by joints all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which shall be from 30 to 60 cm and in lifts not exceeding 1.80 m in height, unless specified otherwise.

The Contractor shall make such arrangements and shall time his operations in such a manner that no layer of concrete will being setting before the neat layer is placed on top of it. In no case shall the delay between the placing of any two layers be such that the vibrating unit will not readily penetrate of its own weight the concrete placed before the delay.

Concreting should be carried out continuously between and up to joints, the position and arrangement of which shall be predetermined and approved by the Project Manager in writing. The surface of all concrete during deposition shall be maintained reasonably level between planes of stoppage formed by vertical stopping-off boards or other vertical faces.

In the event of unavoidable stoppage in position not predetermined, the concrete shall be terminated on horizontal planes and against vertical surfaces in the manner before described. Where it becomes necessary or desirable, to allow concrete to stand so long that it may set before the work is renewed, keyways shall be formed in the surfaces as shown on the drawings or as directed by the Project Manager.

Retempering of concrete will not be permitted. Any concrete which has become so stiff that proper placing cannot be assured shall be wasted.

Where the concrete abuts against earth or any other material liable to become loose, the greatest possible care shall be taken by cutting away or otherwise removing, the timber shoring (if any) in small depths and lengths at a time, and otherwise, to avoid falls or runs of such or other materials upon the surface of the concrete. If any such falls or runs occur, the surface of the work soiled thereby shall be removed until a new and clean surface shall have been obtained. All spaces left of such falls or runs beyond the prescribed width of the work, or caused by negligence of or for the convenience of the Contractor, shall be built up with concrete at the discretion of the Project Manager.

The additional cost so incurred shall be held to be included in the Contractor’s rates in the Bill of Quantities for work within the original contract limits.

Special precautions approved by the Project Manager shall be provided to protect the fresh concrete, immediately after casting, from quick drying and plastic shrinkage cracking and from being washed away due to rain.

3.14.1 Placing Concrete in Wet Ground

Wherever concrete is to be placed in wet ground, shallow drains shall be excavated below the ground formation, filled with broken stone, and connected to suitably placed sumps.

A concrete carpet, the top of which will form the foundation level for the structural concrete, shall then be laid.

3.14.2 Placing Concrete Below Water Level

No Concrete (unless expressly permitted by the Project Manager in writing), shall be placed in or under water. In all cases where concrete is to be placed below water level, the water table level is to be lowered by pumping in such a way that the sub-base shall not be disturbed. The method of lowering the water table shall be subject to approval by the Project Manager. The lowering of the water table shall continue after the concrete has been placed, and permission to stop pumping must be obtained from the Project Manager. During the whole period, standby pumping equipment shall be kept on site. The concrete shall be placed only after the Project Manager has approved the arrangements which have been made for the pumping equipment and the method of ground water lowering.

All concrete placed below water level, where expressly permitted by the Project Manager, shall contain additional cement at a rate of 10% above the cement content as defined in Table 2 for class ‘E’ exposure.

3.14.3 Special Requirements

a. <u>Machine Foundations</u>

Machine Foundations shall have all holes for anchor bolts formed in them to the exact requirements of the equipment manufacturer. All such holes shall be accurately positioned by the use of templates supplied by or prepared to the intersections of the plant manufacturer. The machine foundation blocks shall be separated from the adjacent floors and the gaps shall be filled with approved compressible joint filler such as Flexcell or similar.

b. <u>Concrete Floors</u>

Concrete Floors supported on grade shall be cast in alternative bays of not more than 2.40 m square and shall be finished as shown on the Drawings or as directed by the Project Manager.

SECTION 4 CONCRETE GROUND LEVEL RESERVOIRS (GLR)

4.1 GENERAL

The Reservoirs shall be constructed of reinforced concrete with all appurtenant pipework for water supply and drainage, metalwork and valve chambers, all as shown on the Drawings and Site Works.

The pipe works for the reservoirs shall be performed in accordance with the relevant Works in Section 73.

4.2 SITE WORKS

All site works near and around the reservoirs, such as site formation, access roads, fences and gates, drains, etc., shall be carried out in accordance with the relevant clauses of the Specification.

4.3 EXCAVATION

4.3.1 Ground Level Reservoirs

The Contractor shall excavate to formation levels for the blinding layer under the floors of reservoirs including wall and columns foundations in accordance with Section 22 of the Specification and the excavated material shall be stored for subsequent re-use as backfilling. Excavation of sumps, column footings, pipe blocks and the like shall be performed below the general level of the floor subgrade to the lines and levels shown on the Drawings.

The final subgrade on which the blinding layer is to be placed shall be finished to the exact lines and slopes and shall be watered and rammed to obtain a firm base for the blinding concrete in accordance with Clauses 22.9 and 22.10.

4.4 PREPARATION OF GLR FOUNDATIONS

4.4.1 In Excavation

When excavation for the G.L. reservoirs in accordance with Clause 32.3 has reached formation levels, the subgrade shall be prepared by one of the methods specified below depending on the nature of the soil encountered. The Project Manager will in each case decide as to which method of foundation preparation is to be employed, and the Contractor shall request the Project Manager's decision as soon as excavation has reached formation level. The Contractor shall not proceed with the work unless he has asked for and obtained the Project Manager's decision.

a) When the subgrade is suitable stable soil, it shall be compacted to an effective depth of 30 cm to a density of 100 percent of the maximum dry density at optimum moisture content as obtained from Test No. 12 described in BS 1377: (hereinafter " Standard Proctor Density").

b) Where the subgrade is in sound rock, no special preparation is required at formation level except for cleaning and draining rock surfaces as specified.

c) Where the subgrade has irregular rock outcrops or is otherwise unsuitable as a reservoir foundation, it shall be excavated to not less than 0.6m below the required grade, unless otherwise shown on the Drawings or instructed by the Project Manager, and backfilled to the proper level with approved compacted granular backfill.

d) The area on which compacted fill is to be placed shall be prepared by watering, harrowing and compacting with the equipment used for compacting earthfill as described above.

No stones having a maximum dimension of more than 50 mm shall be placed in the fill. The material shall be placed in continuous, approximately horizontal layers having a thickness after compaction of not more than 150mm if the material is laterite or clayey sandy soil, and not more than 200mm in the case of sand or gravel.

The material shall be compacted at the optimum moisture content. The moisture content shall be maintained throughout placing and compacting operations.

When each layer of material has been conditioned to the best practicable moisture for compaction purposes, it shall be compacted to the required density by tamping rollers, rubber tired rollers, vibrating rollers, or other approved compacting equipment, according to the nature of the fill material, and no subsequent layers shall be spread until the previous layer has been fully consolidated. The exact type and weight of the roller to be used shall be determined by the Project Manager on the basis of compaction tests made on the materials to be compacted.

Final grading of the backfill shall be done in accordance with Clause 32.3

4.4.2 In Fill

Where the designed floor underside is wholly or partly above the natural ground level, the ground surface shall be stripped and if necessary excavated to at least 60 cm below said designed level, and compacted backfill shall be placed in accordance with Sub clause (d) above. Such backfill shall extend beyond the perimeter of the reservoir to be finished with a berm 3 m wide and which shall not be less than 1 m above reservoir floor, and a slope of 1:2.

4.5 BLINDING LAYER

4.5.1 Where required a blinding layer in concrete Class 15-G-10 of a thickness as shown on the Drawings or as directed by the Project Manager shall be cast on the finished subgrade. The blinding layer shall be levelled with a straight edge to obtain a flat surface to receive the concrete foundations and floors of reservoirs.

4.6 FOUNDATIONS AND FLOORS

Floors, foundation to columns sumps and concrete in surrounds to inlet and outlet pipes below the floors in ground level reservoirs shall be of reinforced concrete Class 30-E-20.

Reservoir floors shall first be cast to a truly horizontal surface, which shall be left rough to provide a good bond with the finishing layer. The final slopes of the reservoir floor shall be formed in Class 15-G-10 concrete. The finished floor surface shall be trowelled in accordance with Clause 31.20, with the addition of 1.5kg of cement per square metre of surface.

4.7 WALLS OF R.C. RESERVOIRS

The walls of reservoirs, including the tower of the Elevated Tank, shall be of reinforced concrete Class 30-E- 20 cast in lifts not exceeding 1.80 m in height. Construction joints shall be prepared as specified in Clause 31.18. Absolute water-tightness of such joints is essential.

Wrot formwork shall be used on internal and external surfaces. The parts in contact with earth may be cast against unwrot forms. Core holes and recesses shall be formed where shown on the Drawings and where ordered by the Project Manager for ladder stays, cleats and brackets, and grouted or concreted after fixing. Alternatively, subject to permission of the Project Manager, the Contractor may embed anchor plates in walls during concreting and weld on fixing brackets and cleats later.

4.8 COLUMNS

Columns and baffles in the reservoir shall be of reinforced concrete Class 30-E-20. Columns shall have a circular cross sections and shall be cast in one continuous operation integrally with their heads.

Care shall be taken to ensure that the columns are truly vertical. Columns shall preferably be cast in one continuous operation with the roof.

4.9 ROOFS

The roofs shall be of flat slab construction with a raised rim cast in concrete Class 30-E-20 and shall have a slight slope from the center towards the rainwater spouts. The roof of the reinforced concrete reservoir shall be separated from the wall top by 2 layers of an approved preformed plastic sheet to provide a sliding joint between roof and wall top and filled with joint sealing compound as specified below (Clause 32.11).

4.10 VALVE AND DRAIN CHAMBERS

Walls of valve chambers shall be of 150mm thick solid concrete blocks, covers shall be of precast concrete class 30-E-20 with C.I. surface boxes.

Drain chambers shall be of reinforced concrete Class 30-E-20. Floors shall be cast on a 50 mm thick blinding layer of concrete class 15-G-10. Covers shall be of precast concrete.

4.11 JOINTS

Joints at the wall footings and column bases shall have rubber or PVC waterstops of approved type and make incorporated in them as shown on the Drawings and in accordance with the requirements of Clause 3.32

Care shall be taken to ensure that the joint surfaces are truly horizontal or vertical and plane and to this end all shuttering shall be rigidly supported and the top surface of the wall footing shall be carefully finished.

At the joints between the floor and column bases, the surfaces of concrete members first cast shall be painted with two coats of bitumastic paint to prevent adhesion of the concrete subsequently cast against them.

A rectangular caulking groove shall be formed along these joints and filled with joint sealing compound.

Prior to placing the reservoir wall, the surface of the wall footing shall be covered with two layers of plastic sheet as specified above for the top of the wall. The vertical groove between the wall and footing shall be filled with an approved compressible performed joint filler and sealed at the top with joint sealing compound.

The joint sealing compound shall be of the two-component, poly-sulphide based type, and of approved make. It shall be suitable to withstand tropical climatic conditions without deteriorating. The manufacturer’s instructions as to preparation and cleaning of caulking grooves and mixing and placing of joint sealer shall be strictly adhered to.

Sealing compounds of suitable viscosity shall be used on horizontal and vertical surfaces respectively.

4.12 PIPES AND FITTINGS

The Contractor shall install all pipes, valves fittings, and other accessories for the inlet and outlet, drain and overflow pipes, complete as required for the proper operation of the reservoirs, all in accordance with the Drawings and the Project Manager’s instructions.

All pipes, valves fittings, etc., as well as the workmanship employed in their installation shall be in accordance with the applicable clauses of the Specification dealing with pipelines, Division 7.

4.13 METALWORK

The Contractor shall supply, build-in, fix and paint all required metalwork as shown on the Drawings, such as ladders, climbing steps, covers and vents on roofs, including fly screens, water level indicators, etc., all in accordance with Section 51 of the Specification.

4.14 DITCHES AND TRENCHES

Pipe trenches shall be excavated to the lines and grades as shown on the Drawings or, as directed by the Project Manager in accordance with Section 72 of the Specification.

Overflow ditches with flat bottoms and sides cut to 1.5:1 slopes shall be excavated to the required lines and gradients, from the outlets of the drain and overflow pipes to the nearby natural drain.

4.15 SURFACES IN CONTACT WITH EARTH

The exterior surfaces of concrete of water retaining structures which are to be in contact with earth shall be given two coats of an approved bituminous paint.

4.16 TESTING OF RESERVOIRS

As soon as possible after completion of each reservoir and before backfilling (if any), the Contractor shall clean and remove all dirt from walls, columns and floors and fill the reservoir with clean water to the intended working level.

The structure shall be checked for leakage three days after filling has been completed. At the end of the period, the exact water level shall be determined by the Project Manager.

If after a further period of 14 days the drop in the so determined water level shall not exceed the due allowance made by the Project Manager for evaporation losses, the structure will be considered watertight and accepted by the Project Manager.

Evaporation losses shall be measured in a separate watertight container suspended in the water in the tank being tested. Should the drop in the water level exceed evaporation losses, the Project Manager shall carefully examine all external surfaces of the structure, and shall mark all visible wet spots and leaks. Such visible wet spots and leaks shall be kept under the Project Manager's observation for an additional period of 30 days.

If, after this additional period, leaks are still in existence and/or the drop in the water level exceeds evaporation losses, the Contractor shall repair and make good all defects by cutting and renewing or otherwise as directed by the Project Manager, without further payment.

No reservoir shall be deemed to have been completed and delivered to or accepted by the Project Manager until the repairs shall have been proved perfectly watertight to the satisfaction of the Project Manager.

After having been proved watertight on completion of remedial works, reservoirs shall be kept filled with water until chlorination, where such is required.

Lump sum items have been inserted in the Bill of Quantities to cover the Contractor's expenses for testing reservoirs.

The prices shall include for cleaning and removing dirt, filling with water as many times as may be required to prove water tightness, and making good all defects and leakages to the satisfaction of the Project Manager.

4.17 DISINFECTION OF RESERVOIRS

Where required, reservoirs shall be disinfected by chlorination.

Before disinfection, the reservoirs shall be entirely emptied and perfectly cleaned. All walls are to be scraped to remove all dirt, silt, sand and other impurities.

Disinfection will be carried out by painting (preferably spraying) the floor, walls, columns, baffles, ceiling, pipes, etc. with a solution containing 250 ppm chlorine.

The solution may be prepared by dissolving calcium chloride (bleaching powder), which shall have an available chlorine content not less than 25%, in water. The actual chlorine content of the bleaching powder shall be ascertained before use. After the solution is prepared, the lime is allowed to settle and the clear water is used for painting the walls.

After a minimum of 6 hours for drying, the reservoir shall be filled with water.

Precautions to be taken during painting of the walls include the following:

1) The reservoir is to be continuously ventilated at the time of painting
2) Not less than two workmen shall be in the reservoir while disinfection is being carried out, with a third man outside at the access point into the reservoir.
3) Men working in the reservoir shall wear protective eye goggles and a self-contained breathing apparatus or a face mask combined with a canister containing a suitable absorbent.
4) The men employed in spraying shall wear rain-boots previously sterilized and shall never them outside the structures until the spraying is completed.

4.18 PLACING GRAVEL

Flat reservoir roofs shall be covered with a layer of gravel to a thickness of 10 cm or as shown on Drawings.

The covering of roof slabs with gravel shall be permitted only after a minimum lapse of 14 days after concreting.

No stacking of gravel on the roofs shall be permitted.