UNITED NATIONS OFFICE FOR PROJECT SERVICES (UNOPS)

URBAN WATER FOR DARFUR – UW4D

Design of El Fasher Piped Water Scheme –North Darfur

TECHNICAL SPECIFICATIONS

January 2019

TABLE OF CONTENTS

LIST OF TABLES

1. GENERAL BACKGROUND

1.0 General

Clauses refer to all parts of the works unless specified otherwise.

1.1 Location

El Fasher is located in North Darfur in Sudan. El Fasher pump stations, reservoir tanks are located in the peri-urban area. The water wells are located in the belt of Wadi Shagra also in the peri-urban area accessible by an all-weather murram roads.

1.2 Purpose of the Works

Extend piped water network to urban, peri-urban, installation of new pumps, installation of new reservoir tanks, construction of water kiosks in Eastern and Northern areas of El Fasher Town.

1.3 General Description of the Works

The construction contract consists of the following:

a) Pipe Works

Transmission and distribution pipe network comprises of supply and laying of the following quantities of pipes and scope;

S/N	Pipe Type	Diameter, OD(mm)	Pressure rating	Quantity (m)
1	HDPE	650	PN 10	**115**
2	HDPE	450	PN 10	**2055**
3	HDPE	315	PN 10	**3628**
4	HDPE	250	PN 10	**3733**
5	HDPE	200	PN 10	**10600**
6	HDPE	160	PN 10	**13729**
7	HDPE	110	PN 10	**21630**
8	HDPE	63	PN 10	**27149**

2.0 GENERAL SPECIFICATIONS

2.0 Design Life

All works constructed or placed shall be designed for long life and continuous operation during prolonged periods with minimum of maintenance and the contractor may be called upon to demonstrate this for any component either by the service records or similar equipment elsewhere by records of extensive type tests. Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel. The works have been designed over a design horizon of 10 years.

2.1 Regulations, Standards, Codes and Standard Specifications

Wherever reference is made in the Contract to specific standards and codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise stated in the contract. Where such standards are national or relate to a particular country or region, other authoritative standards which ensure a substantially equal or higher performance than the standards and codes specified will be accepted subject to the Project Manager's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Project Manager at least 28 days prior to the date when the Contractor desires the Project Manager's approval. In the event that the Project Manager determines that such proposed deviations do not ensure equal or higher quality, the Contractor shall comply with the standards specified in the documents.

All standards used will be the current version. A contractor proposing to use alternative versions of specified standards and codes shall submit the alternative version to the Project Manager for approval in accordance with the requirements outlined in the above paragraphs.

All materials and workmanship not fully specified herein or covered by an approved standard shall be such kind as is used in first class work and suitable to the climate in the project area. Where the requirements of any such standard specification or regulation conflict with the requirements of this specification or any item of the drawings, then the contractor should refer to the Project Manager for clarification before proceeding with that section of the works

Except where otherwise specified all materials and workmanship shall comply with current national standards provided that those standards are not stringent than the equivalent European Union, British Standards or Codes of Practice or provided that they comply with the requirements of the International Organization for Standardization (ISO) etc. as appropriate.

2.2 Drawings

The drawings comprise the following:

- Issued drawings
- Record drawings

The issued drawings are herein after described

- Engineer's Drawings
- The drawings issued from time to time by the Engineer
- Other drawings

2.3 Issued Drawings

These are drawings issued to the contractor with the Bid Documents for the purposes of preparing a bid.

2.4 Record Drawings

The contractor shall provide a set of as-built drawings for the works. He shall submit four hard copies and one electronic copy of the drawings. The electronic copy shall be readable by AutoCAD 2012.

2.5 Program

Before commencing the Works the contractor shall submit to the Project Manager for his approval a program showing the order in which he proposes to carry out the Works. The program shall be in form of a Bar chart, or any other form as may be agreed by the Project Manager, and shall be co-coordinated to take into account transportation and delivery times for the materials and for climatic and other conditions to provide for the completions of the works in accordance with the conditions of the Contract. The program shall clearly indicate the following:

- The sequence of each activity, the proposed start and completion dates of each activity, the rate of progress and the cumulative quantity of percentage of work expected to be achieved on each activity by the end of each month.

Dates by which major drawings requiring the Project Manager's approval will be submitted (a period of three weeks shall be allowed from date of receipt of these drawings for such approval). Time should be allocated for work by others, including those of the Employer and by utility undertakings. Sufficient space should be provided in the program for recording the actual progress against the programmed progress for each activity.

The program shall be submitted with details of the following:

a) A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled workers to be employed on the works;
b) A list and type details of major Construction Plant (including vehicles) which the contractor proposes to employ on the works;
c) Details of the contractors methods of working for all operations
d) A statement giving the proposals for location or locations and sizes of accommodation, offices, workshops and stores;
e) Details of the program for the works from the date of receipt of the Project Manager's order to commence the works including a complete resource allocation showing the number of units and allotted times for each unit of Constructional Plant, materials and labour allocated to each part of the works.

2.6 Progress Meetings and Reports

During the period of the Contract, the Contractor shall allow for all consultations with the Employer and the Project Manager and his staff in El-Fasher or elsewhere as necessary. From the commencement of the works on site, there will be a series of monthly site progress meetings to co-ordinate the civil and plant works.

Representatives of the contractor, approved by the Project Manager, shall attend monthly progress meetings on site or at the offices of the Employer. In addition, approved representatives of the Contractor shall attend further meetings in cases of emergencies or for other reasons when called upon by the Employer.

The Contractor shall submit to the Project Manager each month a report on his progress in the performance of the Contract. The report shall include a copy of the approved program with the current progress for each activity shown.

2.7 Commissioning

The contractor is required to provide suitable personnel, to be approved by the Project Manager, to operate each section of the Works during commissioning, i.e. the setting to work and testing of individual components of the works or the complete works.

This shall include tests on Completion as more fully defined in the "testing chapter". Commencing during the commissioning period the Contractor shall instruct the Employer's staff in the operation and maintenance of each section of the Works.

2.8 Water and Electricity

The contractor shall make his own arrangements for the supply of water and electricity for the purposes of the Works.

Water and wastewater derived from the construction, testing and completion of the works shall be disposed of to the satisfaction of the Project Manager so as to cause no damage or complaint.

2.9 Climatic Data

The contractor shall take account of the site climatic conditions at the site of the works both in the design and selection of all plant and equipment and the construction of the works.

2.10 Contamination of Water Supplies

Before any person is engaged on work involving a risk to the purity of potable water supplies or deemed to involve such a risk by the Project Manager, he shall be tested to indicate that he is not a carrier of typhoid, cholera or any other water borne disease and he shall be informed of the dangers of contamination. The contractor shall notify the Project Manager of any person suffering from an illness associated with looseness of the bowels, and no such person shall be employed on such work until the employer's medical adviser is satisfied that it is safe for him to be so employed.

The contractor shall comply with the provisions of "***Safeguards to be Adopted in the Operation and Management of Waterworks***" published by HMSO (UK).

2.11 Photographs

The contractor shall supply negatives of photographs and un-mounted positive prints not less than 250 x 200 mm of such portions of the works, in progress and completed, as may be directed by the Project Manager and specified herein. The negatives and prints shall not be retouched. The negative of each photograph shall be the property of the Employer and shall be delivered to the Project Manager with the prints. No prints of these negatives shall be supplied to any other person without the written permission of the Project Manager.

If so directed by the Project Manager, the contractor shall supply transparencies and colour prints in lieu of black and white negatives and prints. The photographs shall be of two categories:

a) Progress photographs
b) Record photographs

The categories of photographs shall be properly referenced to the approval of the Project Manager and on the back of each print shall be recorded the date of the photograph, the direction in which the camera was facing, an identifying description of the subject and the reference.

Photographs taken for record purposes as ordered by the Project Manager or as specified herein shall be supplied with three prints, having the reverse of one subscribed with the signatures of the contractor and the Project Manager (or their authorized representatives) for the purpose of attestation. If required, the Contractor may at his own cost have an additional print similarly attested for his retention.

The contractor shall supply one negative and three prints of each progress photograph selected by the Project Manager for incorporation in albums. He shall supply two sets of albums, mount the prints, and title the prints and albums all to the approval of the Project Manager.

The taking of photographs of the works by the contractor for any other purpose whether for use in Sudan or any other country shall not be carried out without written approval from the Project Manager.

2.12 Units of Measurement

All designs, drawings, specifications and manuals shall use SI (Kg m s) units and all measurements, dimensions and performance data shall be quoted in those units.

2.13 Language

All drawings, instructions, signs, notices, name-plates etc. for use in the operation and maintenance of the completed works shall be in English or in the local languages in case of warning signs and notices.

2.14 Safety Regulations on site

The contractor shall comply with all statutory and other regulations concerning the safety of his site staff, operatives, staff of the Employer and Project Manager and members of the public, as a result of his operations. He shall obtain copies of all regulations and shall make them available on site for inspection by the Project Manager.

Notwithstanding the above, the contractor shall ensure that the following primary safety rules are adhered to at all times;

a) All open excavations shall be fenced off with temporary fencing at all times, and shall be adequately lit at night.
b) Excavating and earth moving plant and equipment must not encroach on live carriage ways at any time. The contractor shall ensure that at all items of plant working adjacent to live carriageways is accompanied by a Banks man at all times.
c) Construction materials, bedding material and excavated material stored adjacent to the pipe trench must be safely and securely stored, and must not encroach onto the live

carriage ways, pedestrian foot paths, private or public access ways or water courses, unless prior approval is given by the Project Manager.

2.15 Protection of Existing Public and Private Services

The contractor shall notify all public authorities, utility companies and private owners of proposed works that will affect them not less than one week before commencing the Works.

The contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utilities, utility companies, private owners, or the Project Manager as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately carry out the following;

- Notify the Project Manager and appropriate public authority, utility company or private owner.
- Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility companies or private owners as appropriate. The contractor shall be liable for all for making good such damage.

The Project Manager may issue instructions or make other such arrangements as he deems necessary, to repair rapidly any essential services damaged during the execution of the contract. Such arrangements shall not affect any liability to pay for making good the damage.

2.16 Permits

The contractor shall be fully responsible for obtaining all necessary permits, licenses and permissions required for the execution of the Works, prior to the commencement of the Works.

2.17 Insurance

The contractor is required to maintain insurance for the works in accordance with the conditions of contract, including insurance of all steel tanks, fixtures, fittings, valves and meters etc. supplied by others, for which the contractor is solely responsible. In addition, the Contractor is required to maintain the value of his insurance cover and performance Security in respect of the rise and fall of costs, in accordance with the Conditions of contract.

2.18 Appurtenances and Accessories

The latest edition of the following Standards shall apply:

a) DIN 1952
b) DIN 3202
c) DIN 3230

d) DIN 3352
e) ISO 2441

2.19 Factory Tests and markings

All items shall be duly factory tested prior to deliver according to DIN 3230, Parts 3 and 4. Test certificates shall be submitted with each set of delivery. All items shall be duly marked as follows:

- Nominal diameter
- Nominal pressure
- Material of Body
- Manufacturer's trade mark
- Maximum temperature of liquid
- Permissible working pressure
- Quality control mark
- Serial number
- Year of manufacture

3.0 PARTICULAR SPECIFICATIONS

3.0 Preamble to Particular Specifications

The purpose of this chapter of the specifications is to detail some of the requirements particular to these works. It is to be read in conjunction with the General Specifications, but in the event of any conflict, this chapter will take precedence over the General Specifications. The same clause numbers as in the General Specifications have been used, with the letters "PS" added in front to identify clauses in this chapter.

3.1 Contract Period and Program

During the execution of the works, the contractor shall submit to the Engineer full and detailed particulars of any proposed amendments to the arrangements and methods presented in accordance with clauses of the General Specifications.

3.2 Survey levels

The levels indicated on the drawings are based on a Temporary Bench Mark (TBM) located in the project area.

3.3 Earthwork

3.3.1 Reinstatement of surfaces

The contractor shall keep a photographic record of surfaces to be reinstated, before the commencement of the works, and after completion of the reinstatement. Before the commencement of works that will damage surfaces, and will therefore need reinstatement, the contractor shall inform the Engineer in writing, one week in advance of date of carrying out the works, and the anticipated date of reinstatement.

3.4 Appurtenant Work

3.4.1 Welding

Welding shall be carried out only under the direction of an experienced and competent Supervisor. Welders shall be qualified in accordance with BS 4872 or BS 4871 as applicable. Metal Arc welding shall be submitted to the Engineer for approval detailing steel grades, joints design, and material thickness and welding process. The welding plant shall be capable of maintaining the voltage and current specified by the man of electrodes and the contractor shall provide instruments for verification accordingly.

3.5 Reports

3.5.1 General

The Contractor shall provide for preparation of reports and forms in duplicate during the entire duration of the Contract. Formats of these reports and forms shall be printed and shall be to the approval of the Engineer. Upon preparation, the Contractor's Representative shall sign both the copies and submit them to the Engineer's Representative for verification and his signature. After verifying and signing both copies, the Engineer's Representative shall retain the original and return the copy to the Contractor.

3.5.2 Daily Reports

This report shall give staff, work force and plant engaged, brief description of work done, weather, any loss of working time, and other such relevant information. The daily report shall be promptly submitted on the following morning of the day of report, starting with the first day of the Contract until its completion.

3.5.3 Work Approvals

When, in the Contractor's opinion, any work is ready for inspection by the Engineer, the Contractor shall prepare and submit this form to the Engineer's Representative, giving details of the work to be checked. The Engineer's Representative shall check the work as early as possible and shall endorse his approval or otherwise on the form, giving reasons if the work is not approved.

3.5.4 Day Work Report

This form shall be prepared separately for each day of the Day works. It shall record details of staff, work force, and plant engaged, materials used, details of the work done, and other such relevant information.

3.5.5 Concrete Testing

This report shall be prepared separately for each set of concrete cubes and shall give grade of the concrete, slump, location where that particular batch of concrete was placed, and subsequent test results.

4.0 PIPE WORK SPECIFICATIONS

4.0 General

The pipe-work shall be laid out and designed so as to facilitate its erection, painting in situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head.

All pipes, valves, fittings and other accessories shall be of the best quality available and shall be of the type and class required by the Specifications, Drawings or the direction of the Supervisor. The method of transportation and handling of pipe and fittings during transportation, loading and unloading shall be in accordance with the pipe manufacturer's recommendation. The pipe shall be examined after delivery to the Site and any damaged or defective pipes shall be rejected unless suitable lengths of pipe may be salvaged from the damaged or defective pipes. Pipes and fittings shall be stored and clearly marked as to type, size and class. The Contractor shall see that the pipe and fittings are handled with the utmost care and any damaged or defective pipe or fittings shall be replaced as soon as possible.

Pipes, valves and fittings shall be stored in accordance with the manufacturer's recommendation or as directed by the Supervisor. Pipes shall be stored in a manner that will prevent cross sectional and longitudinal deformation. Valves and fittings shall be stored on raised timber floors in locked weatherproof sheds and not delivered to site until immediately prior to fixing in the pipeline.

The end of the pipes shall be protected and when pipes are placed alongside the trench they shall be supported so that they are clear off the ground.

4.1 Pipe Materials

4.1.1 Steel or G.I. Pipes

All steel or G.I. pipes shall comply with B.S. 1387 imperial sized, pressure rating shall be 12 bars unless otherwise stated on the drawings. Galvanised iron pipes (GI) shall be the heavy-duty type, Class C and shall be given an additional coat of hot-dip galvanising internally and externally to B.S. 729. This additional coat shall be over and above the normal galvanising done at the time of manufacture. Evidence of such additional coat shall be handed over to the Supervisor prior to the pipes being utilised for construction.

Joints shall be screwed for socket jointing, with taper threads to BS 21. Sockets shall be provided with the pipe. Joints pressure rating to comply with those of the pipes.

4.2 Pipe Fittings

4.2.1 General

All fittings shall be of Cast Steel, Cast Iron, and Malleable iron or galvanised iron where applicable depending on operating pressures. Fittings shall be supplied from reputable manufacturers. The types of and materials used for fittings are indicative only. Alternative types and materials of equivalent quality may be supplied, subject to the approval of the Supervisor.

All pipeline fittings, valves, air valves, etc. shall be rated for normal maximum operating pressures of 16 bar. Additionally, where shown on the Drawings, fittings, etc. shall be for high pressure.

Fittings on the gravity main line shall be rated for normal maximum static pressures unless specified otherwise. Flanges on fittings shall, as stated on drawings, be to the required pressure, except for 'high pressure' fittings described above. Flanges to comply generally to BS 4504. Threaded joints to ANSI B 2.1 NPT.

The nominal pressure rating or class, Mark No. and other information as specified of all fittings, etc. shall be clearly and indelibly marked on the fitting, preferably by embossing or casting on at the time of manufacture. Adhesive or tied-on labels will not be accepted. Fittings not adequately marked will be rejected.

Fittings shall be purpose made in the factory. Only in exceptional circumstances, and at the discretion of the Supervisor, shall site fabrication be allowed.

4.2.2 Steel or G.I. Fittings

Steel or GI fittings shall conform to the specification for steel or GI pipes.
All steel or GI fittings shall be given two coats of red-oxide paint and two coats of bitumen paint after carrying out the fitting. These coats of paint and bitumen shall cover all scratched or marked sections of the fittings made due to spanners, tools and handling during jointing of the fitting. All such work shall be to the approval of Supervisor.

4.2.3 Special Steel and HDPE Steel Compatible Fittings

To join, provide flexibility, join pipes of different outside diameters and complete pipework in manholes special steel fittings and couplings shall be utilised. The following types of special fittings are recommended for use:-

- Flexible coupling - Flange Adapter Viking Johnson type or equivalent to suit N.P. 25 flanges to B.S. 4504. Adapter made from malleable Cast Iron to B.S. 310.

- Flexible coupling - For low-pressure connections, suitable screwed fittings may be used upon prior written approval of the Supervisor.
- Step Coupling - to suit outside diameter of steel pipes and HDPE pipes. Viking Johnson types compatible for HDPE and steel pipes or equivalent. Pressure rating to suit the position of the coupling as location on site.
- Special Step Coupling - to suit outside diameter Steel pipe and metric sized steel or HDPE pipes, as required.

All the metal couplings should be coated with approved protective bitumen paint or tape to prevent corrosion after completing the pipe joint. The tape should be wrapped so that no exposed surfaces of the coupling and joint are seen. The tape should be that supplied by Viking Johnson or equivalent, all to be approved by Supervisor before using.

4.2.4 Gate Valves

Flanged valves shall be double flanged inside screw, solid gate, metal or resilient seated, non-rising stem type cast iron gate valves for waterworks purposes, suitable for use in the tropics. They shall comply with B.S. 5163 or an equivalent Standard approved by the Supervisor. Flanged valves are for diameters greater than 80 mm unless otherwise stated. Screwed valves shall have similar specification as flanged valves and have BSP female threads. Screwed valve range from 12-80 mm diameter unless otherwise stated.

They shall be manufactured by a reputable manufacturer, and shall be clearly identified by integral casting on the valve body (or on a plate of durable material affixed to the body), showing the nominal size, nominal pressure rating, material designation, type of seat, manufacturer's name or trademark, the number of the applicable Standard and manufacturer's type identification as necessary for specifying spare parts, etc.

Valves on all pipelines and storage tank shall be rated for a maximum of 15-bar pressure depending on their location in the pipeline. Valves shall close clockwise, and be provided with caps, secured by hexagon headed set screws, for spindle or removable hand-wheel operation. Valves shall be suitable for use in pipelines in either an unsupported position, or supported and fixed at one end, and shall be subject to 'open end' works tests.

4.2.5 Ball Float Valves

Ball float valves shall be from Neptune Glenfield or other reputable manufacturers. The Supervisor prior to placing firm orders shall in every case, approve the manufacturer and type of ball float valve to be supplied in writing. The types of valves shown on the Drawings are indicative only and alternative types with equivalent performance characteristics may be proposed.

Valves shall be angular type with flanged inlets and outlets drilled to NP16 standard. They shall be nominally sized by the diameter of the inlet. They shall be suitable, preferably without special modifications, for use under the required conditions as specified in the drawings. All ball float valves shall have a pressure rating of 16 bars irrespective of the location of tanks.

4.2.6 Adapters

Suitable adapters shall be provided for making connections between the various types of pipe to be used. Adaptors shown on the Drawings are indicative only and alternative types may be used subject to the approval of the Supervisor. All adapters shall be strong and soundly constructed and shall be purpose made for the sizes of pipes to be joined.

4.2.7 Miscellaneous Fittings

Straight pieces in order to complete pipework in manholes and tanks are indicated on the drawings.

All straight pieces shall have spigot, flanged or threaded ends as required. The lengths of the straight pieces have not been determined as the required size shall be cut on site to suit the pipework.

Contractor shall provide for these straight pieces in his rates for the fittings and other pipework. Straight pieces shall be of GI or steel pipes and shall comply to Conditions stated elsewhere above. All the above straight pieces shall have prior approval in writing of Supervisor before manufacturing and fixing onto pipework.

4.3 Inspection of pipes and fittings

Before incorporation into the works each pipe shall be brushed out and carefully examined for soundless. Damaged pipes, which in the opinion of the engineers cannot be satisfactorily repaired, shall be rejected and removed from site. Damage to pipe coatings or linings shall be repaired to the satisfaction of the engineer.

4.4 Pipe Jointing

4.4.1 Jointing

All joints shall be made in strict accordance with the pipe manufacturer's instructions. Jointing details included in these Specifications are provided as a guide only.

Pipes and jointing materials shall be kept clean and be of a type provided or recommended by the manufacturer. Pipes shall be correctly aligned and centred within the tolerances allowed for the type of pipe and joint. Long radius curves may be negotiated by deflection of the joints or pipes within the pipe manufacturer's recommendations.

4.4.1.1 Flanged joints

All flanges shall be metric sized flanges to BS 4504, to NP16 standard. Flanges to any high-pressure requirements be made and drilled as recommended by manufacturers and to requirements.

Joints shall be made with a nut, bolt and two washers for each bolthole. One washer shall be placed under the nut and one under the bolt head.

Bolts, nuts and washers shall conform to BS 4190, 150 metric black hexagon bolts, screws and nuts - metric units; and BS 4320, Metal washers for general engineering purposes - metric series.

Bolts shall be of the sizes specified in BS 4504 for each particular size and type of flange in use. Their diameter shall generally be 2mm less than that of the bolthole, and their length sufficient to expose at least two threads beyond the nut after tightening. Nuts shall have a length equal to the diameter of the bolt. Bolts shall be tightened evenly by successively tightening diametrically opposed bolts to the recommended tension.

Flanges shall be fully faced at the mating surface and spot faced or fully faced on the rear to provide a true bearing surface for the bolt heads and nuts. Flanges shall be square with the pipe axis.

4.4.1.2 Screwed Joints

Screwed joints shall be made water tight with appropriate thread tape or sealing compound. The threads shall comply with BS 21 both internally and externally. Pressure rating of screwed fittings shall comply with a minimum of 15-bar pressure.

4.4.1.3 Flexible joints

Before assembly, spigot ends shall be wiped clean. The position and placing of the coupling on the pipe ends shall be checked to ensure proper alignment. The coupling is held in position and the bolts and nuts tightened. The Contractor shall ensure that the tension in bolts and nuts is as per torque required by manufacturers. A torque range shall be provided for checks to be made by the Supervisor. On no account shall force or hammering of the pipe be used to complete the joint.

Where long radius bends are to be negotiated by deflection of the joint, the joint shall first be assembled with the two pipe axes in a straight line, and the newly laid pipe shall then be deflected up to the required amount. After taking up the deflection the joint is tightened. Joints under this clause cover all couplings, Flange adaptors and flush and step couplings (Viking Johnson type).

4.4.1.4 Solvent joints

The pipes shall be cleaned at the spigot and socket end. Only the special solvent cements supplied for use with the pipes shall be used. Cement shall be checked before use to ensure that it is fresh,

clear and free running. Cement shall be of recent manufacture, and any which has, in the opinion of the Supervisor deteriorated, shall be removed from Site. Cement shall be marked with the date of its delivery to Site and be used in rotation.

The pipes to be joined shall be supported and aligned. Solvent cement shall be applied thinly and evenly to the inside of the socket and to the spigot using a stiff brush. The spigot shall, without delay, be forced into the socket up to the mark on the spigot, and twisted a quarter turn. The alignment of the pipes shall be checked and quickly adjusted as necessary before the cement has started to set, and the pipes shall then be anchored firmly to prevent subsequent disturbance or 'springing' of the joint. Backfill may be placed carefully over the middle of the pipe to assist in anchoring. Solvent jointing is mainly for PVC pipes.

4.4.2 Cutting Pipes

Pipes shall only be cut with the approval of the Supervisor. They shall be cut with a hacksaw, abrasive disc or pipe-cutting machine. They shall be cut cleanly at right angles to the pipe axis, and the edges subsequently cleaned of all irregularities. Where necessary, they shall be bevelled or rounded to match spigots on uncut pipes.

Care shall be taken only to cut pipes, which are sufficiently rounded and smooth on the outside to ensure that the resulting spigot will give a watertight joint. Vertically cast (as opposed to spun) iron pipes and pipes fabricated out of steel plate are unlikely to be sufficiently rounded.

Where the cutting of unsuitable pipes is unavoidable, they shall be further prepared by rounding, turning, and buffing flat of welds and suchlike. Such additional preparation shall be included in the price of cutting.

5.0 CONCRETE WORKS TECHNICAL SPECIFICATIONS

5.0 Introduction

This Part of the Specification refers to the requirements of in situ, mass and reinforced concrete including concrete ancillaries such as formwork, reinforcement, jointing and additives together with small precast concrete units and gunite. It is not intended that pre-stressed concrete works should lie within the scope of this Specification.

Concrete has been specified on the drawings and in this Specification in accordance with B.S.5328 "Methods for Specifying Concrete" Table 3 by compressive strength. Should the alphabetic suffix to the class of concrete shown on the Drawings be missing, the letter "C" is implied unless otherwise indicated.

The standards of material and of workmanship shall not be inferior to the recommendations contained in:

B.S.8100: The Structural Use of Concrete
B.S.8007: The Structural Use of Concrete for Retaining Aqueous Liquids.

The requirements of the above documents must be read in conjunction with this Specification and should any conflict exist between the above documents and this Specification, the requirements of this Specification shall prevail.

5.1 Cement

5.1.1 General

All cement for the permanent works shall comply with the requirements of B.S 12 for Ordinary Portland cement unless otherwise specified by the Engineer. Sulphate resisting cement shall comply in all respects with the requirements of B.S. 12 and B.S. 4027 and all special conditions applicable to its use stipulated by the manufacturers shall be observed.

5.1.2 Supply of Cement

Cement shall be manufactured by a firm of cement manufacturers approved by the Engineer and shall be obtained either directly from the manufacturer or from a supplier approved by the Engineer. The supplier's arrangements for storing the cement shall be to the approval of the Engineer.

Cement in bulk shall be transported in totally enclosed watertight and sealed containers.

Bagged cement shall be delivered in 50 kilogram paper bags. Each bag shall be marked with the parcel number of the cement contained. Bagged cement shall be transported so that at no time is it exposed to damp or so that moisture can be absorbed from the atmosphere.

5.1.3 Storage of Cement

Facilities shall be provided at the Site for storing at least 14days supply of cement at peak consumption. The Contractor shall submit his proposals for storage of cement to the Engineer for approval.

Bins for storage of bulk cement shall be perfectly dry, well ventilated, and watertight and shall be self-clearing. Cement of different parcels shall be stored in separate bins.

Sheds for the storage of bagged cement shall be dry, well ventilated and watertight. The floors of cement sheds shall be of damp proof construction and raised above the surrounding ground. Cement of different parcels shall be kept separate.

Cement shall be used as soon as possible after delivery to the Site and in a suitable sequence so as to avoid any cement remaining unduly long in store.

5.1.4 Testing of Cement

Cement shall be tested by the manufacturer as specified in paragraph (b) of this Clause. The Engineer may require cement to be tested after its delivery to Site.

Any cement which has been in store at the Site for longer than one month shall, if ordered by the Engineer, be re-tested. The Engineer may take samples of cement as when and where he deems necessary.

In addition to the manufacturer's tests referred to in this Clause, the Engineer may require tests to be carried out as follows:-

a) The test for compressive strength on mortar cubes in accordance with Method 1 of Clause 6a of B.S. 12.
b) Test for soundness in accordance with Clause 9 of B.S. 12.

Cement which, in the opinion of the Engineer fails to meet the specified requirements shall be classified as rejected material.

5.2 Aggregates for Concrete

5.2.1 General

Aggregates for concrete shall be obtained from a source or sources approved by the Engineer. Aggregates shall be transported and stored in such a manner as shall prevent:

a) Contamination of the aggregates from the ground, rubbish, dust or other foreign material.
b) Segregation.
c) Intermixing of aggregates of different characteristics.

General tests on aggregates will be required as follows:-

1) Before aggregates are approved for use in the permanent Works, tests will be carried out on representative samples, submitted by the Contractor, to check that the aggregates comply with the requirements of the Specification.
2) During concreting operations, tests will be carried out to check that aggregates, delivered for use in the permanent Works, comply with the requirements of the Specification. Sampling and testing of aggregates for concrete will be carried out in accordance with the requirements of B.S. 812 except where described otherwise.

5.2.2 Fine Aggregates

Fine aggregates for making concrete shall be obtained from a source, or sources, approved by the Engineer and shall comply with the following requirements:

- The general requirements as specified in Clause 4.1 of B.S. 882.
- The grading shall be in accordance with Table 2 of B.S. 882 Grading Zone 2
- The percentage of material passing a 75 micron B.S. sieve shall not exceed 3 percent by weight
- Samples taken from the fine aggregate shall pass the colour test for organic impurities described in paragraph (d) of this Clause.

Tests on fine aggregates will be carried as required by the Engineer, on Site during operations as follows:-

1) Sieve analysis.

2) Moisture content. An approved "rapid" test may be used for this test.
3) Percentage of material passing 75 micron B.S. sieve by the Field Setting Test checked, when necessary, by the Decantation Method.
4) Test for organic impurities as described in paragraph (d) of this Clause.

The Contractor shall arrange to carry out the following tests when requested by the Engineer.

5) Specific gravity and water absorption.
6) Bulk density
7) Other tests described in B.S. 812.

5.2.3 Coarse Aggregates

Coarse aggregates for concrete shall be supplied as single sized aggregates of up to three nominal sizes as required for making the classed of concrete.

The nominal sizes shall be 40 mm. 20 mm and 10 mm. Coarse aggregate shall consist of crushed or natural igneous rock or rock of other origin to the approval of the Engineer. It shall be thoroughly washed and screened to the required nominal sizes and shall comply with the following requirements.

a. The general requirements as specified in Clause 4.1 of B.S. 882.
b. The "ten percent fines" value shall not be less than 100 kN and aggregate impact value shall not exceed 30 percent.
c. The grading of 40mm, 20mm and 10mm nominal size aggregates shall be within the appropriate limits given in Table 1 of B.S. 882.
d. The percentage of material passing a 75 micron B.S. sieve shall not exceed 1 percent by weight.
e. It shall have a low drying shrinkage and an absorption, as measure in accordance with B.S. 812 Part 4, not greater than 3 percent.
f. The flakiness index, when determined in accordance with Clause 15 of B.S. 812 shall not exceed 35, for aggregates of 20mm nominal and below, nor 40 for 40mm nominal aggregates.
g. Samples taken from the coarse aggregate shall pass the colour test for organic impurities described in paragraph (d) of this cause.

Tests on coarse aggregates shall be carried out as required by the engineer, on the site during concreting operations as follows:-

1) Sieve analysis.
2) Moisture content. An approved "rapid" test may be used for this test.
3) Percentage of material passing 75 micron B.S. sieve but the Field Settling Test checked when necessary by the Decantation Method.

4) Test for organic impurities as described in paragraph (d) of this Clause.

The Contractor shall arrange to carry out the following tests when requested by the Engineer:-

5) Determination of flakiness index
6) Specific gravity and water absorption.
7) Determination of "ten percent fines" value and aggregate impact value.
8) Other tests described in B.S. 812.

5.2.4 Test for Organic impurities

At the discretion of the engineer, aggregates will be tested for organic impurities by means of discoloration of a sodium hydroxide solution.

5.3 Mortar

Mortar shall generally consist of 1 part cement to 3 parts sand with such quantity of water to produce the minimum plasticity necessary for the work on which it is required and shall be used within one hour of mixing.

Ordinary Portland cement, sand and water shall be to the qualities as elsewhere specified, the sand shall be uniformly graded.

Mixing of material shall be by mechanical mortar or concrete mixer for not less than 2 or more than 5 minutes. The mortar is to be placed as soon as possible and not more than 45 minutes after mixing. Placing shall be by pneumatic means through an approved proprietary gun capable of discharging the mix at variable feed rates. At all times, care shall be exercised to avoid clogging of the gun and material hoses. The air supply shall be dry, free of oil and maintained at an adequate pressure and quantity to meet the demands of the gun.

5.4 Water for Concrete

The Contractor shall include in his rates for concrete, etc., for providing and conveying to the Works water for making concrete, mortar, and grout and for curing purposes. The water shall be taken from a source approved by the Engineer and shall be clean, fresh and free from matter in solution or suspension and shall comply in all respects with the Appendix to B.S. 3148 "Tests for Water for Making Concrete".

5.5 Contractor's equipment and construction procedure

The design, layout, installation and operation of equipment for processing, handling, transporting, storing and proportioning concrete ingredients and for mixing, transporting and placing concrete shall be to the satisfaction of the Engineer. Before the equipment is ordered

or delivered to Site, the Contractor shall submit drawings showing the proposed arrangements together with detailed descriptions of the equipment proposed.

5.6 Composition of concrete

Concrete shall be a homogeneous mixture of coarse aggregate, fine aggregate, water and Ordinary Portland cement, all as specified in the relevant Clauses of this Specification, together with any such admixture as the Engineer may specify or approve.

5.7 Concrete Mixes

Concrete mixes shall be "designed mixes" in accordance with the requirements of B.S. 5328 having the characteristics specified in Table 1 of this Part. Concrete for water retaining or water excluding structures shall comply with the requirements of B.S. 5337.

5.8 Trial Mixes

At least six weeks before starting to place any concrete in the Works, the Contractor shall prepare trial mixes for each class of concrete to be used in the Works. Three separate batches of concrete using the proposed mix proportions and materials, typical of the proposed supply, shall be made under full scale production conditions.

The workability of each of the trial batches shall be determined and six cubes made from each batch and cured under the conditions specified in B.S. 1991. Three cubes shall be tested at 7 days and three cubes shall be tested at 28 days.

The trail mix proportions shall be approved if the average strength of the nine cubes tested at 28 days exceeds the specified characteristic strength by $2N/mm^2$ or if nine tests at an earlier age indicate that it is likely to be exceeded by this amount.

To demonstrate that the maximum free water/cement ratio is not exceeded, two batches of concrete shall be made in a laboratory with cement and surface-dry aggregate known from past records of the suppliers of the material to be typical. The proposed mix proportions will not be accepted unless both batches have the cement content specified and free water-cement ratio below the maximum specified in Table 1 of this Part.

5.9 Adjustment to mix design

No change in the mix design approved, following completion of trial mixes, will be permitted unless the Contractor carries out further trials on the proposed modified mix design to show that compliance with the Specification is maintained. Approval from the Engineer in writing must be obtained before any modified mix design is used on the Works.

The proportions of concrete materials in the various concrete mixes shall be given below for nominal volume-based mixes. As a temporary expedient while trials of the nominal mixes are being prepared and tested, corresponding standard mixes may be used, but volume-based mixes shall replace standard mixes once these have been tried and approved. Standard mixes shall be in accordance with B.S. Code of Practice CP 114.

The Supervisor reserves the right to vary from time to time without extra charges the proportions of coarse aggregate to fine aggregate to obtain satisfactory mixes. The aggregate: cement ratio will remain unchanged. All mixes shall be to the satisfaction of the Supervisor.

Table 1: Classes of Concrete

CLASS*	Characteristic Comprehensive Strength (N/mm^2)	Maximum Aggregate size (mm)	Maximum free Water/ Cement Ratio	Minimum Cement Content (Kg/m^3)	Maximum cement Content (Kg/m^3)
C25/10	25	10	0.55	360	400
C25/20	25	20	0.55	360	400
C25/20	25	20	0.55	290	400
C25/20	25	20		240	540
C20/20	20	20	0.55	290	400
C20/40	20	40	0.55	260	400
C20/40	20	40		220	540
C15/40	15	40		180	540
C15/20	15	20		180	450
C10/40	10	40		150	540

* Code indicator: - Compressive Strength (N/mm2)/Aggregate size (mm)

Table 2: Mix Design

Class	**Portland cement, kg**	**Fine Aggregates, m^3**	**Coarse Aggregates, m^3**	**Nominal Mix proportions**
25	50	0.05	0.10	1:1.5:3
20	50	0.07	0.14	1:2:4
15	50	0.085	0.17	1:2.5:5
10	50	0.10	0.20	1:3:6
Lean Mix	50	0.05	0.10	1:18

For lean mix an 'all in' aggregate may be used. The Supervisor may direct that it be mixed and placed dry.

Corresponding standard mixes shall be as given in Table 5 of CP 114 for concrete of 19-mm maximum size and medium workability, with a slump not exceeding 50-mm. Mix proportions shall then be shown below:

Table 3: Mix Proportions

Class of Concrete	**Weight of aggregate in kg per 50kg of Cement**	
	Dry Sand	**Coarse Aggregate**
25	80	135
20	90	155

The above mixes are based on the use of fine aggregate complying with Zone 2, Table 2 of B.S. 882. Fine aggregate complying with Zones 1 or 3 may be used but the proportion of coarse aggregate to fine aggregate will be subject to alteration. The aggregate: cement ratio will remain unchanged. Such alterations in the proportion of coarse aggregate to fine aggregate shall not constitute a variation to the Contract and no extra charge will be allowed on this account.

5.10 Compliance with specified requirements

Concrete shall comply with the following requirements:-

5.10.1 Sampling and Testing

All concrete shall be sampled and tested in accordance with the requirements of B.S. 1881 unless otherwise stated in this Specification.

The Contractor shall allow for the provision of all equipment necessary for sampling and testing, including straight edges, slump test apparatus, 150mm steel cube moulds and tamping rod to B.S. 1881.

5.10.2 Strength

To show compliance with the specified requirements, a sample shall be taken from a randomly selected batch of concrete by taking a number of increments in accordance with B.S. 1991. The

samples, wherever practicable shall be taken at the point of discharge of the mixer, or in the case of ready mixed concrete, the point of discharge from the delivery vehicle.

Two test cubes shall be prepared from the sample and shall be cured as follows:-

1) For 28 days
2) By any other regime, approved by the Engineer, that is capable of predicting the strength at 28 days (e.g. 7 days normal curing or accelerated curing at an elevated temperature).

On completion of curing, the two samples shall be tested and provided the difference between the two results does not exceed 14% of the mean of the two results, the mean shall be taken as the test result. Where the difference between the two results exceeds 14% of their means, the lower of the two results shall be taken as the test result.

Compliance with the specified strength may be assumed if the conditions given in both 1 and 2 below are satisfied:-

1. The average strength determined from any one group of four consecutive 28 days test results exceeds the specified characteristic strength by not less than 3 N/mm^2 for C20 grades and above, not less than 2 N/mm^2 for C15 grades and below.
2. Each individual 28 days test result is greater than the specified characteristic strength minus 3 N/mm2 for C20 grades and above, or 2 N/mm2 for C15 grades and below.

The rate of sampling shall be as directed by the Engineer but shall not be less than one sample per $15m^3$ of concrete or 15 batches whichever is the lesser volume. The estimated quantities and the rate of payment are as entered in the Bills of Quantities.

If only one test result fails to meet the second requirement, then that result may be considered to represent only the particular batch of concrete from which the cubes were taken, provided the average strength of the group satisfies the first requirement.

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

from which samples were taken to produce the first and the last results in the group of four, together with all the intervening batches.

5.10.3 Workability

The workability of the concrete shall be measured as required by the Engineer by slump tests or compacting factor tests and shall be within the following limits:-

Slump: +/- 25mm
Or +/- one third of required value whichever is greater

Compacting factor: +/- 0.03 where required value is 0.90 or greater
+/- 0.04 where required value is less than 0.90 but more than 0.80
+/- 0.05 where required value is 0.80 or less

The required value shall be that which has been accepted under Clause 312 of this Specification.

5.11 Non-compliance with specified requirements

If the specified requirements have not been fulfilled, the Contractor shall take such remedial action as the Engineer may order and the Contractor shall, before proceeding with the placing of concrete, submit in good time to the Engineer, his proposals to ensure that concrete will comply with the specified requirements.

Where, in the opinion of the Engineer, remedial action is unacceptable, the batches of concrete represented by the tests shall be classified as defective work.

Non-destructive tests, or tests on core samples, shall not nullify the establishment of non-compliance provided that non-compliance was based on valid test results.

5.12 Weighing, Batching and Mixing

The proportions of materials used in the work shall follow the proportions found to be acceptable in the trial mixes. The concrete shall be prepared under the control of a competent person, and close control kept over quantities and water content, care being taken to make due allowance for variations in the moisture content of the materials. Regular testing of the moisture content of the aggregates shall be carried out.

The arrangements made shall be to the approval of the Engineer and shall be such that all operations can be viewed from a single point and thus be capable of being fully inspected and checked by one inspector.

The concrete mixing plant shall be installed in a suitable position of the Site to the approval of the Engineer and as near as possible to the place of deposit. Weighing of the cement is permitted to be non-automatic if the amounts of coarse aggregate and sand in each batch are so arranged that one or more full bags of cement are used per batch. No subdividing of cement in bags will be permitted.

Unless otherwise agreed by the Engineer, concrete shall be mixed in a batch mixer manufactured in accordance with B.S. 1305 or in a batch type mixer, a specimen of which has been tested in accordance with B.S. 3963, or equivalent and having a mixing performance within limits of Table 5 of B.S. 1305. Truck mounted mixers shall be to the approval of the Engineer.

Where appropriate, the batch capacity, method of loading, mixing time and drum speed shall conform to the details furnished in accordance with the requirements of B.S. 3963, or equivalent, for the mix which corresponds most closely to the mix proportions being used.

These methods of mixing used shall be such as to produce a dense homogeneous concrete and the order in which the concrete materials are to be fed into the mixer shall be subject to the approval of the Engineer
The means of adding water to the materials shall be adjustable to compensate for the varying weight of moisture contained in the aggregate and for any change of mix proportions. The batching plant shall be capable of controlling the delivery of material so that the combined inaccuracies in feeding and measuring during normal operation will not exceed 3 percent.

The equipment for weighing the water to be used in a mix shall be provided with a safety working load used on the most heavily loaded scale, and other auxiliary equipment required for checking the satisfactory operation of each scale or other measuring device. Tests shall be made by the Contractor at intervals, to be determined by the Engineer, and shall be carried out in his presence and to his approval.

The Contractor shall furnish the Engineer with copies of the complete results of all check tests and shall make such adjustments, repairs or replacements as the Engineer may consider necessary to ensure satisfactory performance.

The mixers shall be completely emptied before receiving the materials for the succeeding batch and shall be kept clean and washed out after stopping work and at the end of each shift.

Neither volume batching of materials nor hand mixing of concrete shall normally be allowed. They may, however, be permitted, at the Engineer's discretion, at isolated points where the total volume of concrete is small. Hand mixing of concrete shall be done on a clean close-boarded platform. The material shall be turned over no less than three times dry, water shall then be sprayed on through a hose and the materials turned over in a wet condition and worked together until a mixture of uniform consistency is obtained.

For hand mixing concrete, the specified quantities of cement shall be increased by 10 percent and not more than one half of a cubic metre shall be mixed at one time. Any concrete mixed by hand will be paid for at the appropriate rates for the class of concrete inserted in the Bills of Quantities and no claim will be considered in respect of any extra cost of hand mixing by reason of the additional cement or otherwise.

Continuous mixing machines shall be used only with the written permission of the Engineer. When a concrete mixer has been out of use for more than 20 minutes, or when the type of cement is changed, the mixer shall be thoroughly cleaned before a fresh batch of concrete is made in it.

5.13 Concrete production records

Records, in a form approved by the Engineer, shall be kept by the Contractor of the details of every pour of concrete placed in the Works. These records shall include class of concrete, location of pour, date of pour, temperature, slump, moisture content of aggregates, weights of aggregates, number of batches, tests undertaken and cement parcel number. The Contractor shall supply to the Engineer four copies of these records each week covering the concrete work carried out in the preceding week.

5.14 Preparation of rock surfaces to receive concrete

Immediately before concrete is placed on or against a rock surface, the rock shall be given a final cleaning with the aid of high pressure air. The foundation shall be properly drained and dewatered so that no water runs over or stands on a surface on which concrete is being placed. If required by the Engineer, drains provided through or beneath concrete for the temporary conveyance of water shall afterwards be completely sealed to the engineer's approval.

5.15 Transporting and placing of concrete

5.15.1 General

No concrete shall be placed until the Engineer has approved the formwork and reinforcement. The Contractor shall provide all facilities for inspection.

The Contractor shall give at least 48 hours' notice to the Engineer of the times he proposed to concrete and no concreting shall take place until either the Engineer or his representative is present.

Concrete shall be transported in water tight containers in such a manner that will avoid the segregation of the constituent materials. The time elapsing between the initial mixing of the concrete and finally placing it in the works shall not exceed weight minutes when Ordinary Portland cement is used. Where other cements are used, the Engineer will stipulate the maximum time allowed. Concrete remaining unplaced at the end of the period shall not be placed in the work, but shall be removed from the site and disposed of at the Contractor's expense.

Concrete shall not be dropped through a height exceeding 1.5m. For lowering concrete through heights in excess of 1.5m, special methods shall be used, such as **chutes, tremies, bottom dumping hampers, or bagged placing**, and then only with the approval of the Engineer. All containers, troughs, chutes and apparatus, through and in which concrete is passed, shall be kept clean and entirely free from hardened concrete or cement and free from contamination by extraneous material.

The concrete shall be placed in position in lifts not exceeding the thickness to be agreed by the Engineer, and excessive heights which may cause segregation of the aggregate at the working face shall be avoided.

Concreting of any unit or section of the work shall be carried out in one continuous operation, and no interruption will be allowed without the approval of the Engineer.

A competent steel fixer shall be in attendance the whole time concrete is being cast around reinforcement. Proper bridging arrangements for traffic over reinforcement shall be provided so that the reinforcement is not distorted, damaged or displaced.

Where approval is obtained for concrete to be conveyed by chutes, these shall have a slope (not exceeding 1 vertical to 2 horizontal) such as to ensure a continuous flow of concrete. Additional water shall not be introduced to assist the flow if deposition is to be intermittent the chutes shall be arranged to discharge into a storage hopper. In no case will a clear fall of more than 1.0m be permitted at the discharge end of the chute.

When approval is obtained for pumping the concrete, the pump manufacturer's recommendations shall be followed. The pumps used shall be of adequate capacity and power

to ensure delivery of a continuous supply. The Contractor shall ensure adequate alternative arrangement for transporting the concrete in case of a breakdown of the pumping equipment.

Whenever transport of concrete is interrupted for any length of time (periods of 30 minutes shall be treated as such), the chutes, pumps, pipes and any means of distribution shall be thoroughly flushed out and cleaned. These shall be flushed out immediately prior to resumption of concreting and shall be kept free from hardened concrete.

All wash water used shall be discharged outside the shuttering and clear of the freshly placed concrete.

5.15.2 Placing of Concrete in Foundations

Before placing concrete in foundations, the bottom shall be thoroughly rammed and cleaned up to a neat horizontal plane, or such profile as is shown on the Drawings. No steps or batters will be permitted unless shown on the drawings or approved by the Engineer.

Where shown on the Drawings, or ordered by the Engineer, that the concrete shall be cast against the existing ground, without using shuttering, the faces of the ground shall be trimmed neat and true to line. Where such a hole is over-excavated, the void shall be filled with concrete, of the same class as specified for the foundation, at the Contractor's expense.

When pumping from the foundation is necessary, pumps and drains shall be provided outside of the area to be concreted. Where it is likely that there will be standing water in the foundation after excavation, the final 0.1 to 0.15m of the soil shall not be excavated until immediately before concreting. Where, in the opinion of the Engineer, the bottom of the excavation has become unsuitable for bearing, due to the Contractor's method of working, the soft materials shall be excavated to such level as the Engineer may direct, and replaced with concrete Class 15 at the Contractor's expense.

No concrete shall be placed in the foundation until the excavation has been approved by the Engineer.

5.16 Compaction of concrete

All concrete shall be compacted mechanically, except when agreed by the Engineer that small areas may be otherwise compacted.

Vibrators shall be of a type and size adequate for the portion placed. Vibrators shall operate at a frequency of between 7,000 and 10,000 impulses per minute. All vibrators shall be of a type approved by the Engineer.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, a stand-by vibrator shall be available for instant use at each concreting locality. The length and diameter of the vibrating element of immersion vibrators shall be sufficient to penetrate through the layer of concrete being placed and re-vibrate the upper portion of the underlying layer of concrete.

Mould vibrators shall not be used for in situ concrete work and may only be used for the manufacture of small precast units, with the approval of the Engineer. Vibrators shall not be attached to the reinforcement and care shall be taken to avoid contact with it.

Concrete shall be placed to uniform levels in layers not exceeding 450 mm deep in such manner as to avoid segregation, and each layer shall be compacted by means of approved vibrators to form a dense material free from honey-combing and other blemishes. Special care shall be taken to ensure that the concrete around the reinforcement, adjacent to the forms and waterstops is free from voids.

Vibration time, the effective radius and other vibration characteristics shall be in accordance with the vibrator manufacturer's recommendations. Internal vibrators shall be withdrawn immediately water or thin film of mortar begins to appear on the surface of the concrete. Withdrawal shall be carried out slowly to avoid cavitation. If shuttering vibrators are used, the shuttering shall be strong enough to withstand the forces of vibration.
Concrete shall not be compacted to such an extent that segregation takes place, and any concrete which, in the opinion of the Engineer, has been over-compacted, shall be removed, carted from the Site and replaced, all at the Contractor's expanse.

5.17 Hot weather concreting

Concreting shall not be permitted if its temperature at placing is in excess of 38 deg.C. In order to maintain the temperature of the concrete below this value the following precautions shall be taken wholly or in part as instructed by the Engineer:-

- All aggregates stockpiles, water lines and tanks as well as the mixer shall be protected from the direct rays of the sun;
- Coarse aggregate shall be cooled by constant watering where possible;
- Mixing water shall be cooled by the addition of ice to the storage tanks where necessary;
- Rapid hardening cement shall not be used;
- Where the above precautions are inadequate, concreting shall be carried out during the cooler parts of the day, or during the night, as may be directed by the Engineer.

When the air temperature is above 20 deg. C loss of mixing water by evaporation shall be considered in arriving at the amount of water to be added to the mix.

The maximum water/cement ratios may be increased, with the Engineer's permission by 0.05 during mixing, but on no account shall water be added to concrete directly or indirectly once it has left the mixer.

In order to reduce premature drying of the concrete during transporting and placing all chutes, shuttering and reinforcement shall be cooled by watering when possible, or shall otherwise be protected from the direct rays of the sun. Any water so used shall be removed by jetting with compressed air before placing the concrete in close contact.

As soon as possible after concreting the shuttering shall be stripped and the surface of the concrete shall be kept moist for a period of 7 days by covering with wetted hessian or sand, or shall otherwise be treated with an approved curing membrane.

Where drying winds are encountered, with shields shall be positioned, as directed by the Engineer, to protect exposed surfaces of the curing concrete.

5.18 Wet weather concreting

Concreting during periods of constant rain shall not be permitted unless aggregate stockpiles, mixers and transporting equipment and the areas to be concreted are adequately covered. During showery weather, the Contractor shall ensure that work can be concluded at short notice by the provision of stop ends. On no account shall work be terminated before each section, between one stop end and another, is completed. Adequate covering shall be provided to protect newly placed concrete from the rain.

5.19 Protection and curing of concrete

Immediately after placing, the surface of the concrete shall be protected from the harmful effects of the sun, drying winds, rain, running of surface water and shocks. It shall be cured by keeping it covered with damp material for a minimum period of seven days after placing. The formwork shall also be kept damp, and if struck earlier than seven days, shall be replaced for the remaining period with some other approved damp material. On horizontal surfaces, the curing membrane shall be applied immediately after placing the concrete and, on vertical surfaces, immediately after removing the shuttering.

The Contractor shall submit for the approval of the Engineer, the method he proposes to use for protecting and curing the concrete.

No traffic or constructional loads shall be permitted on newly placed concrete unit it has hardened sufficiently to take such traffic or load without surface damage or deformation.

If directed by the Engineer, the concrete shall be fenced in such a manner as to prevent the access of traffic, unauthorised persons, or animals, on the surface of the newly laid concrete.

After removal of shuttering any concrete surface which might be damaged, or discoloured, during further construction of the works, such as arises and treads of stairways, shall be adequately protected.

No concrete structures shall be loaded until the concrete is at least 21 days old and only then with the approval of the Engineer, and subject to such conditions as he may lay down.

5.20 Treatment and making good of cast concrete

No treatment or making well, other than that required for curing, shall be applied to the concrete faces until they have been inspected by the Engineer. The Contractor shall submit to the Engineer his method for making good any defects and shall only proceed when the Engineer's written approval is received.

Honeycombing or damaged surfaces of concrete which, in the opinion of the Engineer, are not such as to warrant cutting out and replacement of the concrete shall be made good as soon as possible after removal of the shuttering as follows:- 1:1.5 Portland cement and sand mixture shall be worked into the pores over the whole surface, with a fine carborundum float, in such a manner that no more material is left on the concrete face than in necessary to fill the pores completely so that a uniformly smooth and dense surface of uniform colour is finally presented.

5.21 Removal and replacement of unsatisfactory concrete

The Contractor shall on the Engineer's instruction so to do, replace any concrete in any part of the structure if in the Engineer's opinion:-

a) The concrete does not conform to the Specifications; or
b) Deleterious materials, or materials which are likely to produce harmful effects, have been included in the concrete; or
c) The honeycombed or damaged surfaces are too extensive; or
d) The finished concrete sizes are not in accordance with the Drawings, within permissible tolerances; or
e) The setting-out is incorrect; or
f) Reinforcement cover has not been maintained; or
g) The protection, including curing of concrete during construction was inadequate, resulting in damage; or
h) The work of making good, or other remedial measures the Engineer may indicate, are not carried out to his satisfaction; or
i) Undue deformation of or damage to the work has taken place due to inadequate shuttering, or to premature traffic and loading; or
j) Any combination of the above points has taken place resulting in unsatisfactory work.

5.22 Rates for concrete

The prices inserted in the Bills of Quantities include for all labour, appliances and materials, including water, for weighing, gauging, mixing, conveying, placing, spreading, compacting, vibrating, finishing, and, except where otherwise provided for in the Bills of Quantities, for joints with existing work or recently deposited concrete, for shuttering to construction

joints, skew-backs, stop ends, steppings, bonding chases and the like, for constructing the work under the alternate bay system, for curing the surface finish as specified in Clause 325, for the cost of strengthening and stiffening the shuttering to resist vibration and for handling the concrete at the specified water/cement ratio.

Unless items for shuttering are included in the Bills of Quantities, the prices for all mass concrete shall include for any shuttering, side forms, and timber work. Unless otherwise specified, separate items are included in the Bills of Quantities for moulds and shuttering for reinforced and other graded cast-in-place concrete and for finishing concrete to a very smooth surface.

5.23 Loading tests

The Engineer may direct that a loading test be made on the work or any part thereof if he deems such test to be necessary for one or more of the following reasons:-

- failure of "Works cubes" to attain the specified minimum strength requirements;
- premature removal of shuttering;
- overloading of the structure during construction;
- Any other circumstances attributable to alleged negligence on the part of the Contractor which, in the opinion of the Engineer, may result in the structure being of less than the required strength.

If the loading test be ordered for reason (d), the Contractor shall be reimbursed for the cost of the test if the result is satisfactory. Loading tests shall be carried out in accordance with B.S.8110 as required.

If the results of the test are not satisfactory, the Engineer will direct that part of the work concerned be taken down or removed and reconstructed to comply with the Specification, or that such other remedial measures as he may think fit be taken to make the work acceptable and the Contractor shall carry out such work at his own cost.

The Engineer may also instruct the Contractor, before a loading test takes place, to take out cylindrical core specimens from the structures concerned and have them tested. The cutting equipment and the method of doing the work shall be to the Engineer's approval. The specimens shall be dealt with in accordance with B.S. 1881. Prior to testing, the specimens shall be made available for examination by the Engineer.

5.24 Site books and B.S. to be kept on site

A triplicate book shall be provided especially by the Contractor wherein all instructions on concrete work given by the Engineer shall be entered. This book shall be kept on the Site and one copy of all entries shall be forwarded to the Engineer.

In addition to the concrete production records, a continuous entry diary shall be kept permanently on Site by the Contractor wherein he shall record details of shuttering construction, placing of reinforcement, concreting and curing operations, striking of shuttering, making good, daily temperature and weather conditions. The diary shall always be available for the Engineer's inspection.

The Contractor shall provide and keep permanently on site the following British Standards:-

- B.S.812, B.S. 1881, B.S. 4466, B.S.8007 and B.S.8100

5.25 Forms, Falsework or Centering

5.25.1 Definitions

"Forms, Formwork or Shuttering" shall include all temporary moulds forming the concrete to the required shape together with any special lining that may be required to produce the concrete finish specified.

"Falsework or Centering" shall consist of furnishing, placing and removal of all temporary construction such as framing, props and struts required to support the forms.

5.25.2 Materials

All timber used for forms, falsework and centering shall be sound wood, well-seasoned and free from loose knots, shakes, cracks, warping and other defects. Before use on the work, it shall be properly stacked and protected from injury from any sources.

Any timber which becomes badly warped or cracked, prior to the placing of concrete, shall be rejected. All shuttering for visible surfaces above final ground shall be either tongued and grooved or provided with a suitable lining to produce a smooth surface finish.

If the Contractor proposed to use steel shuttering, he shall submit to the Engineer dimensioned drawings of all the component parts, and give details of the manner in which it is proposed to assemble or use them. Steel shuttering will only be permitted if it is sturdy in construction and if the manner of its use is approved by the Engineer.

Struts and props shall, where required by the Engineer, be fitted with double hardwood wedges or other approved devices so that the moulds may be adjusted and eased gradually when required. Wedges shall be spiked into position and any adjusting device locked before the concrete is cast.

5.25.3 Forms

All forms shall be of wood or metal and shall be built grout-tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incidental to construction operations. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage of the timber.

The forms shall be substantial, unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The design of the forms shall take into account the effect of vibration of concrete as it is placed.

All formwork shall be approved by the Engineer before concrete is placed within it. The Contractor shall, if required by the Engineer, provide copies of his calculations of the strength and stability of the formwork, or falsework but, notwithstanding the Engineer's approval of these calculations, nothing shall relieve the Contractor of his responsibilities for the safety and adequacy of the formwork.

5.25.4 Falsework and Centering

Detailed plans for falsework or centering shall be supplied by the Contractor to the Engineer at least 14 days in advance of the time the Contractor begins construction of the falsework. Notwithstanding the approval of the Engineer of any designs for falsework submitted by the Contractor, the Contractor shall be solely responsible for the strength, safety and adequacy of the falsework or centering.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads from the weight of green concrete, shuttering and incidental construction loads.

Falsework or centering shall be founded upon a solid footing safe against undermining and protected from softening. Falsework which cannot be founded on satisfactory footings shall be supported on pilling which shall be spaced, driven and removed in a manner approved by the Engineer. The Engineer may require the Contractor to employ screw jacks, or hard wood wedges, to take up any settlement in the formwork either before or during the placing of concrete.

Falsework shall be set to give the finished structure the required grade and camber shown on the Drawings.

5.26 STEEL REINFORCEMENT

5.26.1 Materials

Steel reinforcement shall conform to the following requirements:-

- Unless otherwise directed or shown on the Drawings, hot rolled high yield reinforcement shall be used throughout the Works.
- All mild steel shall conform to the Impact Test Specification laid down in B.S. 4360 steel Grade NDI Class B. This is based on the ***Charpy Impact Test***. The Contractor shall, when called upon by the Engineer, provide representative sample pieces for Charpy testing. Mild steel reinforcement, medium tensile steel reinforcement, cold

twisted steel reinforcement and high tensile steel reinforcement shall comply with B.S. 4449. Steel fabric reinforcement shall comply with B.S. 4483.

- All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit a test certificate of the rollings. The Contractor shall, when requested by the Engineer, provide sample pieces one metre long for testing.
- All reinforcement shall be free from scale, rust, grease, paint or other substances likely to reduce the bond between the steel and the concrete.

5.26.2 Cleaning

When placed in the work, reinforcement shall be free from coatings or dirt, detrimental scale, paint, oil or other foreign substances. When steel has on its surface rust, loose scale, and dust which is easily removable, it may be cleaned by a satisfactory method, if approved by the Engineer.

5.26.3 Fabrication

Bar reinforcement shall be bent to shapes shown on the Drawings and bending schedules. All bars be bent cold, unless otherwise permitted by the Engineer. All hooks, bends, etc., unless otherwise shown on the Drawings, shall be to B.S. 4466. The Contractor shall satisfy himself as to, and be responsible for, the accuracy of any bar bending schedules supplied and shall provide all reinforcement in accordance with the Drawings. Bar reinforcement shall be bundled and each bundle of steel shall be tagged, with weather proof identifying tags, showing the size and mark of the bar.

5.26.4 Fixing Reinforcement

All reinforcing bars and fabric shall be fixed in the positions shown on the Drawings within the tolerances specified in B.S. 4466. In no case shall the cover specified on the Drawings be reduced by more than 5mm.

Displacement of reinforcement beyond the specified tolerance shall be prevented by supporting the bars sufficiently and securely fixing them together at intersections where necessary.

Spacers shall be used to maintain the cover to steel and shall be made from dense cement mortar unless other materials are approved by the Engineer. Spacers shall not be used on water retaining faces. Chairs, stools, etc., shall be used to maintain clearance between two or more layers of reinforcement. These, in addition to all tying wire, must be provided by the Contractor and included in the rates for reinforcement. Steel support to top reinforcement shall however be measured as reinforcement.

The fixing of reinforcement shall be checked before and during concreting, and particular attention shall be given to the position of top steel in cantilever sections.

During concrete placing, a competent steel fixer shall be in attendance to adjust and correct the position of any reinforcement which may be displaced.

5.27 WATER RETAINING STRUCTURES

5.27.1 General

All work intended to exclude water or by which water is to be conveyed or retained, shall be made watertight. All leaks which may appear on test or may develop during the Defects Liability Period through whatever cause arising, shall be made good by the Contractor at his own expense and to the satisfaction of the Engineer.

5.27.2 Forced Ventilation

The Contractor shall provide, operate and maintain such cowls, fans, or other devices necessary to force a steady flow of air through covered tanks and reservoirs after the roofs have been completed so that the joints may be thoroughly dried before priming and all fumes, arising from the making of the joints, are removed from the tanks to the satisfaction of the Engineer.

5.27.3 Lighting

The Contractor shall provide and maintain at the Site a supply of electricity to provide adequate lighting to enable work to be carried out and inspection made in tanks, reservoirs and pumps which have been roofed over.

5.27.4 Cleaning

On completion of the construction of all reservoirs, tanks, sumps and channels, but before testing, the Contractor shall clear away from them all internal rubbish and shall brush down first day and then with water, all concrete surfaces. Sufficient water shall be used so that all matter collected in the washout and drainage channels is carried to the outfalls without silting the drains. The Contractor shall provide all necessary apparatus for cleaning purposes and shall ensure that the joint seals are not damaged during cleaning operations.

5.27.5 Testing Water Reservoirs

All concrete and steel water reservoir structures shall be tested by the Contractor after completion for water-tightness. Such testing shall not begin until the structure has been fully completed and all concrete has reached its specified strength. The Contractor shall make preparations to begin testing as soon as possible after each main structure has been completed.

After cleaning to the satisfaction of the Engineer, the structure shall be filled, at an approximately uniform rate of increase of water level of not more than 2m in 24 hours, to the intended top water level. The water shall be allowed to stand in the structure for a period of 7 days after which time the level shall be recorded and further measurements made at intervals of 24 hours for 7 days. The structure may be deemed to be watertight if

the total drop in surface level does not exceed 10mm in 7 days, taking into account the losses by evaporation and recharge through rainfall, the Contractor shall install an evaporation pan and a rain gauge of specification acceptable to the local meteorological authorities at the site of the structure to be tested. The cost of these shall be included in the Contractor's rates. If the total loss is greater than 10mm, the Contractor shall at once investigate the cause, and shall determine the point or points of leakage, the water level being lowered in stages as required. The level measurements shall be carried out using a hook gauge. The Contractor shall carry out any further remedial work necessary to stop such leakage in a manner directed by the Engineer. The structure shall subsequently be re-cleaned and testing repeated. All investigation, remedial, re-cleaning and retesting work shall be at the Contractor's expense.

If the structure does not satisfy the conditions of the test, and the daily drop in water level is decreasing, the period of test may be extended for a further 7 days and, if the specified limit is then not exceeded, the structure may be considered as satisfactory. Where internal division walls occur in the structure, each compartment shall be, individually similarly tested.

The structures will not be accepted by the Employer until they have been ascertained to be in a perfectly usable and watertight condition.

No claim for extra payment to the Contractor shall be allowed if for any reason the Engineer is unable to allow filling or emptying to be carried out at the time requested by the Contractor.

5.27.6 Disinfection

On completion of the test for water-tightness, the Contractor shall thoroughly clean the interior of the reservoir or tank by hosing down the roof, walls, columns, baffle walls and floor, as applicable, with clean, potable water from an approved source and remove all debris, soil, silt or other material.

After the reservoir or tank has been cleaned as described, the Contractor shall, when instructed by the Engineer and under his direction, disinfect the reservoir or tank by chlorination as described below.

The Contractor shall provide a suitable chlorinator (including the provision of the chlorine), which shall be capable of injecting the required concentration of chlorine solution at a steady rate into the reservoir or tank.

The Contractor shall introduce at least 30 parts per million of free chlorine whilst filling the reservoir or tank to a minimum depth of 100mm. The Contractor shall then spray all surface

areas to the underside of the roof, walls, columns and water-tightness with the heavily chlorinated water by means of a stirrup pump or similar appliance. No pump which requires petrol or fuel oil for its prime mover shall be used inside the reservoir or tank, but at the Engineer's discretion an electrically driven pump may be used.

On completion of the spraying to the Engineer's satisfaction, the heavily chlorinated water shall be drained out of the reservoir or tank and each compartment shall be filled with potable water, from an approved source, to a minimum depth of 200mm. This water shall then be drained out and the reservoir or tank filled with potable water to overflow level.

Samples shall be taken as directed by the Engineer after the reservoir or tank has been full for a period of at least two hours and shall be sent to a qualified bacteriologist for analysis. If the results of the tests show that the water contains any presumptive or typical coliform organisms in a 100 ml water sample then disinfection shall be repeated until the tests show that all pollution has been eliminated. If it proves necessary to repeat the disinfection procedure, the cost of water and bacteriological examination of water shall be at the Contractor's expense.

On completion of disinfection the Contractor shall close off access to the reservoir or tank to all personnel, and no further work shall be permitted in areas allowing direct access to the interior of the reservoir. Should any unauthorised access occur, and if the Engineer rules that contamination may have resulted, the Contractor shall carry out at his own expense such tests, as the Engineer may require, to determine the extent of the contamination, and shall also carry out and bear the cost of any additional disinfection measures required by the Engineer.

The safe disposal of the heavily chlorinated water shall be included in the rates for disinfection.

5.28 Concrete Tanks Water-proof Sealing

- **Bituminous Surfacing - General**

The grades and spraying temperatures for approved bitumen used for surfacing shall be:-
Prime coat:

- Cutback M.C.30: - 20 to 60 ^{o}C

Seal coats:

- Straight run: - 120 to 150 ^{o}C, 80 -100 penetration

Heaters used for bitumen shall conform to BS1676 and the heated bitumen shall be applied by self-propelled pressure distributors with spray bars complying with BS1707 or BS3136. Where different grades of bitumen are used, heaters and distributors shall be thoroughly cleaned before the grade of bitumen is changed. Flushings from heaters and distributors shall be drained to disposal pits and not discharged into drains, ditches or watercourses.

Any bitumen heated above the maximum specified temperate shall be removed from the Site and replaced at the Contractor's expense.

Where spraying is commenced or stopped, metal sheets or building paper shall be spread across the width of area to be sprayed to produce a clean sharp edge to the area. The sheets shall be cleaned daily and the building paper destroyed after use.

During spraying, all other surfaces shall be protected from bitumen splashing. Any such features accidentally marred shall be cleaned immediately.

During the course of the work only essential construction equipment shall be allowed into the area and not allowed to stand on completed work.

- **Bituminous Prime Coat**

Immediately before applying the bituminous material, the surfaces to be treated shall have all loose dirt and other objectionable material removed by power brooms. If so ordered by the Engineer, a light application of water shall be made just before the bitumen is sprayed.

MC-30 grade cutback bitumen shall then be applied to the surface at the rate of 1.0l/m^2 or as otherwise directed by the Engineer.

- **Bituminous Surface Dressings**

Binder for surface dressing shall only be applied upon completion of the priming and when any defects to the primed surfaces have been repaired. No binder shall be applied until the primed surfaces have been approved by the Engineer.

Bitumen binder shall be straight run 80/100 penetration grade bitumen and the first seal coat shall consist of bitumen sprayed at the rate of 1.2 l/m^2 of surface area. The second seal coat shall consist of bitumen sprayed at the rate of 1.2 l/m^2 of surface area.