**Specifications**

The Specifications for this Tender shall be inserted in this Section.

# Specification
# General Specifications Part 1 – Civil and M&E

# 1. SITE PREPARATION

## 1.1 Site Clearance

This includes removing bushes and trees to allow access and undisturbed construction work. The Contractor shall prepare the site, or other areas were indicated on the drawings or ordered by the Supervisor's Representative by carrying out a general clearance of the ground and by moving trees to permit the proper execution of the works.

Stumps and major roots shall be grubbed out and all combustible material arising shall be gathered into windrows and burnt. The Contractor shall take precautions to prevent the spread of fire to adjacent land/property.

Extra payment shall only be given for removal of densely grown bush and for removal of trees includes their roots of a diameter exceeding 500mm.

For transmission lines only, clearing only up to a distance of 2 m to each side will be accepted.

## 1.2 Soil Testing

Soil sampling and testing shall be carried out to determine the compatibility and permeability of the soil at the site, and of any offsite material to be used in construction. Compaction and permeability tests shall be conducted according to the American Society of Testing Materials (ASTM) or British Standards Institution (BSI) standards or equivalent.

# 2.BOREHOLE DRILLING (Specify, if applicable)

## 2.1 Measurement for Drilling

Measurement for the drilling will be made of the actual depth of each borehole drilled, measured from the original ground surface. No measurement will be made for over-drilling necessitated because of caving ground, or Contractor's use in setting casing, for boreholes abandoned due to jammed tools, caving ground or negligence on the part of the Contractor or for boreholes not constructed in accordance with all the requirements of these specifications.

## 2.2 Drilling

### 2.2.1 Siting of boreholes

The location of boeholes shall be established in the field by the Employer's representative. If the borehole proves to be a failure it shall be backfilled and a new one drilled.

### 2.2.2 Drilling

The drilling method shall be suitable for the geological formation at the site. Air circulation shall be used as much as possible.

If a liquid circulation has to be chosen, clear water shall be used as long as the static water level is 3 m or more below ground level. If mud has to be used, care must be taken to remove the mud completely by back washing before any test pumping is started. When using water or mud circulation for drilling, during the drilling operation and until the placing of the filter material is complete, the Contractor shall maintain the circulation water/mud at an adequate head over the static water table and shall take all precautions as necessary to prevent caving in or collapse of the hole.

The circulation fluid pumps, or the annular air velocity in case of air drilling, must be able to provide adequate circulation return as observed by the ascending velocity of the cuttings conforming with good practice and related to the velocity and the maximum diameter of the drilled hole. The Contractor shall be entirely responsible for the control of artesian pressure if encountered. The storage of drilling water at site should be sufficient to meet the requirements

of the hole in operation and shall be constantly maintained adequately. The circulation should be effectively divided into two sections and so designed and operated that all cuttings are deposited in one section and the pump draws off fluid from the other.

### 2.2.3 Use of Temporary Casing

If unstable material is encountered which cannot be controlled by water circulation, the Contractor shall furnish and install temporary casing to hold the walls of the hole during drilling operations and until the gravel shrouding has been placed. All temporary casing shall be removed by the Contractor in short lengths as the gravel shrouding is placed. Where two diameters of temporary casings are required, the one designed as "outer" shall first be inserted: where it cannot be pushed down deep enough (due to excessive friction), a second temporary casing designed as "inner" shall be inserted through the "outer" one. When pulling out these temporary casings, the "inner" one shall be lifted first followed by the "outer".

### 2.2.4 Caving Zones

If caving is observed in producing zones, the Contractor shall take such measures to ensure that drilling can continue through the caving formation without causing any detrimental effect to the producing zone.

### 2.2.5 Alternative Drilling Fluid

In the event of any proposal by the Contractor to use a substitute for water or mud circulation, the composition of all such fluids shall comply with internationally accepted standards and ensure that no deleterious material is used, and in no case will chlorine or any petrochemical based additives be permitted.

### 2.2.6 Verticality

The walls shall be drilled sufficiently straight and plumb within limited deviation, which should not exceed 1 per cent of the depth.

### 2.2.7 Water for Drilling Works

The Contractor shall make all arrangements and procure water for drilling from local sources. The Contractor shall make his own arrangements to haul and transport sufficient water for the drilling works, civil works or for domestic purposes from any distance as the situation may demand.

### 2.2.8 Drilling Log

The Contractor while drilling shall make a detailed record of each well drilled which shall include a description of materials encountered and their location in the well. The drilling log shall contain all relevant information and shall include, but not be limited to, a time /depth diagram. All observations regarding the physical condition of the rock, i.e. broken, decomposed, soft or hard and the prevailing hydrological characteristics of the ground shall be noted.

## 2.3 Installation and Shrouding

### 2.3.1 Installation of PVC Pipes and Slotted Strainers

Centralizers, spacers or other suitable devices shall be attached to the PVC pipes so that they will be centered in the drilled hole throughout its entire length and held in such position while it is being placed.

### 2.3.2 Bail Plug

The assembly of PVC pipes, plain and slotted shall contain at their bottom a bail plug 2m in length of the same material and diameter of the PVC pipes installed in the borehole.

### 2.3.3 Measurement for Installation

Measurement for installation of PVC pipes, plain and slotted will be made of the total length of each type actually installed in the well, including its coupling and joining and placing of centralizers. The cost of installation per meter shall include, but not be limited to, all handling, transportation, storing in Contractor's depot and its subsequent shifting to the borehole location.

### 2.3.4 Gravel Shrouding

The Contractor shall supply and place locally obtained gravel filter to be approved by the Engineer's representative to fill the annular space between the PVC slotted strainers and the borehole wall to a point not less than 5 m above the top-most screen, provided, it does not interfere with the grout plug on top. The annular space above the gravel filter shall be filled with the drill cutting material. The method adopted by the Contractor for placing the gravel filter shall prevent segregation of the gravel ingredients and dislodgement of the formation. The gravelling of the borehole shall be taken up immediately after the well has been installed with the PVC fixtures. Gravel shall be placed slowly and in small amounts.

### 2.3.5 Grain Size

The gravel shall consist preferably of rounded particles and between 2.0 to 5.0 mm, in a suitable grading.

### 2.3.6 Measurement of Shrouding

Payment for the gravel shrouding shall be made to the depth of borehole actually furnished and placed by the Contractor. Payment for furnishing and placing of gravel shrouding shall be made at the unit price per linear meter as stated in the Bill of Quantities.

### 2.3.7 Cement Plug

The upper-most section of the annular space between the borehole wall and the PVC pipes shall consist of a cement plug of 3.0m in depth shall be prepared from a mixture of Portland cement, Bentonite and water. The grout shall consist of a neat cement mixture with 3 per cent Bentonite (by volume) and not more than 700litres of water per cubic meter, thereby keeping shrinkage to the minimum. The mixture shall be poured down the space between the borehole wall and the PVC pipes. The cement plug shall be formed on top of a 200 mm sand layer.

### 2.3.8 Placing of Grout

To assure that the grout placed for the cement plug will provide a satisfactory seal, it shall be applied in one continuous operation and be entirely placed before the occurrence of the initial set. It is essential that the grout shall be placed through a 20mm diameter pipe, 2.0m long and allowed to flow continuously by gravity.

## 2.4 Well Head

The well head *shown in the contract drawing* shall be made of in situ concrete of a mixture of *concrete Class A* and finished with *cement-sand mortar (1:3)*. The top-most casing shall be of a steel pipe provided with mild steel rods welded laterally on to it externally to ensure proper bondage to the concrete to withstand the weight of the pump at all times, it shall extend from below the concrete slab to *850*mm above the top of the concrete slab, with the top end flanged.

## 2.5 Developing and Testing

### 2.5.1 Developing

The Contractor shall develop each well by airlift method. An air compressor with suitable capacity shall be connected to an air pipe in the well. The air pipe shall be enclosed in an outer discharge pipe. Both pipes should be capable of being shifted vertically by clamps. Development of the wells shall commence near the bottom of the well and shall proceed in an ascending manner.

To begin the development, the air pipe shall be closed and air pressure shall be built up to 7.5 to 10 $N/mm^2$ in a suitable air tank attached to the compressor where upon it shall be released suddenly into the well by means of a quick opening valve. Development shall continue for a minimum of 4 hours, the additional time utilized for the development of the well shall be paid according to rates in the Bill of Quantities.

### 2.5.2 Pump Test

After the completion of the development of the well, the Contractor shall conduct a pump test. The pump test shall be conducted with a suitably rated submersible pump with a foot valve.

*Table: Pump Specification for Step Drawdown Test*

| Borehole PVC pipe | Pump capacity ($m^3/h$) | Depth of borehole (m) |
|---|---|---|
| 126/140 mm | 10 | 30 |
| 126/140 mm | 6 | 80 |
| 152/168mm | 30 | 30 |
| 152/168mm | 20 | 80 |

The contractor shall measure the water level by the use of an electric sounder and he shall measure the Yield by using 200 litre drums with the 200-litre level marked on it, and a chronometer. The results shall be recorded on a format to be approved by the Supervisor.

Each pumping test unit shall include a mobile diesel generator to operate the submersible pumps. The submersible pumps shall be installed in the bail plug.

The Contractor shall further prepare a record on the pump test containing all information regarding static water level, drawdown levels against corresponding yield, sand content in ppm, duration of test, etc. The test shall be of the Step drawdown type with a minimum of 5 pumping steps separated by 2 hours' recovery periods. The contractor shall adopt the method that will take into account the deepest dynamic water level and to ensure that the aquifer is not exhaustible at the end of the dry season.

The observation frequency for drawdown measurements during test pumping shall be as follows:

| Time since pumping started (time from shut down) | Time Intervals |
|---|---|
| 0 - 5 minutes | 1 minutes |
| 5 - 60 minutes | 5.0 minutes |
| 60 - 120 minutes | 20 minutes |
| 120 - shut down of the pump or change in pumping | 60 minutes |

The Contractor shall draw yield/drawdown curves for each borehole and shall compute aquifer and well loss coefficient for each borehole test-pumped.

The contractor shall also perform a one-step pumping test at maximum yield ($Q_{max}$) for at least 24 hours with 12 hours recovery period at the end of the test to ensure that the aquifer is spread enough and well recharged to deliver the yield throughout the year.

### 2.5.3 Pumping Tests and Treatment of Existing boreholes

The Supervisor's representative shall inform and show the locations of any existing boreholes that must be incorporated into the design to the contractors for pump testing. The pump test shall be carried out in accordance with that afore described. These boreholes shall be developed by airlift as described above.

### 2.5.4 Water samples and analysis

The Contractor shall take water samples on completion of the pumping test for water quality analysis. These samples shall be labeled with the borehole number and the date and time of sampling. The samples, minimum 1.0 litre (each), shall be delivered to the Engineer's representative for water quality analysis as per CWSA guidelines.

### 2.5.5 Disinfections

In the case of successful wells (both newly drilled and the existing boreholes), and after having taken the water samples, the wells shall be sterilized by introducing sufficient calcium hypo-chloride to maintain chlorine content of 10 ppm for 4 hours at least.

## 2.6 Borehole Pump and Rising Main

The borehole pump will be capable of pumping borehole water having sand and suspended particulate matter. The complete assembly shall comprise a wet type submersible motor, cable, pump with number of stages to suit duty, rising main and discharge bend.

Pump casings shall be of cast iron, aluminium bronze or stainless steel and shall incorporate pump bearings and integrally cast delivery guides vanes. The casings shall further be fitted with wearing rings.

### 2.6.1 Pump Characteristics

The pump shall have the following characteristics:

- Multistage centrifugal pump with integrated non-return valve
- Pump and submersible motor to have diameter compatible with borehole PVC Internal Diameter. A minimum of 10mm diameter is recommended.
- Stainless steel allowing good wear resistance and reduced risk of corrosion when pumping ordinary water with low chloride content
- Asynchronous, three-phase 380 V A/C motor
- Motor control panel or cubicle including a switch on/off circuit breaker and indicator light for operation
- Flat electrical power-supply cable and adapter sealed-waterproof connectors specially designed for use in boreholes

The pump suction cover shall have a spigoted flange at its lower end bolted to the driving motor. A cylindrical stainless-steel strainer shall screen water entering the pump. Pump impellers shall be manufactured from zinc-free bronze or stainless steel.

### 2.6.2 The Rising Main

The rising main shall comprise an assembly of screwed galvanized pipes, which shall locate the pump at the required depth. The sections shall be of such a length as to permit easy handling but shall not exceed 3m. All necessary jointing materials shall be provided.

The rising main shall be fixed to the top-most steel casing by a flange welded on the rising main. The flange must be of the same diameter as the flange of the steel casing and must bear openings for the power and control cables as well as an opening for insertion of a barometer.

The Rising Flexible Tube (between pump head and the BH head) shall have the following characteristics:

Fit for potable water supply and the selected diameter shall conform to the pump flows below:

| Internal Diameter | Pump Flows (m3/h) |
|---|---|
| 1 1/4" | < 4 |
| 2 1/2" | 4 < pump flows < 14 |
| 3" | 14 < pump flows < 27 |
| 4" | > 27 |

Resistant to corrosion
Working pressure:
Continuous pumping: 25 bars
Peak pumping: 35 bars
Non-bursting pressure: 70 bars
Average Elongation < 3%
Shall have built-on clips to carry electric cables and probes.

### 2.6.3 Discharge Bend

A 90$^{o}$ discharge flanged bend shall be provided for fitting to the top of the rising main. A straight-flanged steel pipe shall follow this with sockets welded on it to provide seating for the air-release valve.
If the borehole is controlled from a pump house, the rising main shall lead below ground level to the control room (see contract drawing.)
If the borehole is controlled from a free-standing cubicle, a pressure gauge and pressure switch shall be mounted on to the above-mentioned steel pipe and the fittings specified in the appropriate contract drawing must be included in the rising main.

## 3.EARTHWORKS

### 3.1 General

### 3.1.1 Description and Scope

Earthworks shall consist of performing all operations necessary to excavate earth and rock, regardless of character and sub-surface conditions; to excavate all materials of whatever nature, necessary for the construction of foundations for structures and other aspects of the works; to excavate selected materials and borrow material for use as specified; to construct embankments including the placing of selected material in connection therewith as specified; to backfill for structures, to backfill trenches and depressions resulting from the removal of obstructions; to backfill holes, pits and other depressions (within the area of the works); to remove, dispose and replace unsuitable material; to excavate and grade road approaches; all labour, materials tools, equipment, including timbering, pumps, removal of water, fencing, lighting, batching, reinstatement and maintenance of surfaces and every other expenses entailed in complying with the specifications.

### 3.1.2 Definition of Earthworks Materials

In the Contract, the following words and expressions shall have the meanings hereby assigned to them except where the Contract otherwise requires:

i) ‘original surfaces’ means the surface of the ground before any work has been carried out.

ii) ‘stripped ground level’ means the surface of the ground after the completion of clearing operations and removal of topsoil.

iii) ‘formation level’ shall mean the level at the completion of earthworks for road works prior to the laying of the pavement.

iv) ‘top soil’ shall mean the top layer of soil that can support vegetation

v) ‘suitable material’ shall comprise all that material which arises from excavations within the sites and which is approved by the Supervisor’s Representative as acceptable for use in the works.

vi) ‘Selected fill’ shall be material having liquid limit below 50% and not more than 30% passing the B. S. 75 microns sieve.

vii) ‘soft’ material shall mean all material other than that defined as rock hereunder.

viii) ‘rock’ shall mean those geological strata or deposits as described in the contract and any hard natural or artificial material requiring the use of blasting or approved pneumatic tools for its removal bit excluding individual masses less than 0.20 m3.

### 3.1.3 Surface Levels

After the area of any section of the works has been cleared and after trees have been felled and stumps removed to the satisfaction of the Supervisor's Representative, but before any other work is commenced, surface levels of the ground shall be taken. The levels shall be taken at spacing agreed with the Supervisor's Representative and shall be used as a basis for submitting the "as-built" drawings on completion of the project.

### 3.1.4 Removal of the Topsoil

Before commencing any excavation or other work in any area of the works, including rights-of-way for pipelines, the topsoil shall be removed in accordance with areas indicated on the plans. All grass, topsoil and other surface materials shall carefully be separated, should they be required to be re-used on the contract.

The contractor shall take all necessary precautions for the protection of those trees that the Supervisor's Representative wishes to maintain in those areas where the topsoil is to be removed. This requirement shall apply to the areas of the permanent works as well as temporary ones.

## 3.2 Excavation

### 3.2.1 Ground Levels and Measurement of Excavation

After having completed the removal of the topsoil and before commencing any other excavation or refilling, the contractor shall take levels at frequent intervals and agree upon them with the Supervisor's Representative or his representative.

The depth of excavations shall be taken as the depth from the ground surface to the levels designated on the drawings, except that if the Supervisor's Representative orders additional excavation below the required formation level the extra depth shall be added to the direct measurement.

Where measurements are based on volumes, whether for excavation in open trench, back-filling excavations with concrete or other approved material, or for any other purpose, the dimensions

of excavation shall, for the purpose of measurement and payment, be taken as the elevation dimensions except otherwise specified. The contractor should in his rate make due allowance for working space.

### 3.2.2 Nature of Ground

The Contractor shall satisfy himself of the nature of the ground to be excavated and his prices are to include for excavating in whatever soil that may be met with exception of concrete, block work, masonry and rock, which shall be measured and paid for separately.
Turf, topsoil to a depth not exceeding 200mm and any artificial paving or surfaces of any kind shall be excavated separately from the sub-soil and kept separately for re-use in reinstatement or to cover excavations, embankments or tips as directed by the Supervisor's Representative.

The Supervisor's Representative will order the diversion of an existing services if it would obstruct the permanent works. The Supervisor's Representative will also order the permanent or temporary diversion of services when in his opinion it is reasonable that this should be done for carrying out the works. The diversion referred to above shall be paid for under the contract, but other diversion requested by the contractor shall be at his own expense.
No service diversion shall be made without the approval of the Supervisor's Representative and the responsible authority.

### 3.2.3 Excavation – General

Excavation shall be carried out in such a manner and in such climatic conditions as to avoid damage to or deterioration of suitable material that is designated for incorporation in the works. Where excavation reveals a combination of suitable and unsuitable materials the contractor shall, wherever the Supervisor's Representative considers it practicable, carry out the excavation in such a manner that the suitable material is excavated separately for use in the works without contamination by the unsuitable material.

Suitable material that is rendered unsuitable by the operations of the contractor due to non-compliance with the specification shall be run to spoil and replaced by an equal quantity of excavation from the works. The excavation shall proceed with such portions at one time as the Supervisor's Representative may direct.

No concrete shall be placed, no pipes laid, and no permanent works of any kind begun upon the surfaces prepared by excavation without the permission of the Supervisor's Representative.

### 3.2.4 Mechanical Excavation

Mechanical Excavator shall only be used where the soil condition so permits or it is possible to install temporary supports so that the trenches or other excavations are sufficiently stable. When mechanical excavators are used a layer of material of sufficient thickness shall be left at the bottom of the excavations in order to be sure that the soil at foundation level is not damaged or disturbed. The excavations shall be completed to the final levels by hand.

### 3.2.5 Extent of Excavation

All excavation shall be carried out to the required limits, inclinations and curvatures as shown in the drawings or as may be necessary for the construction of the works in whatever material that may be found and the surplus soil shall be disposed off as specified. The bottoms of excavations shall be levelled and trimmed to full width to the required lines and levels and where under foundations, shall be well watered and rammed before placing of concrete.

Before commencing any building or earth-filling work, all shattered and loose material must be removed by hand, the excavation being performed in such manner as to ensure that the work sits on an absolutely solid and clean foundation or abuts tightly against solid ground.

Foundations in earth upon which concrete will be placed is to be brought to proper moisture content by sprinkling water as required, and thoroughly compacted. No boulders shall be left projecting within the minimum excavation lines shown on the drawing. Foundations of concrete on bedrock shall be trimmed to the prescribed lines, thoroughly cleaned of mud and debris, and moistened in advance of placing concrete. All foundation surfaces shall be free of pools of water at the time of placing concrete.

### 3.2.6 Excavated Materials

All excavated material shall be deposited so that it will cause no damage or inconvenience to the public.

If required by Supervisor's Representative, different classes of material shall be deposited and kept separately. The contractor shall arrange for handling different classes of material and for re-handling all excavated material as often as may be necessary.

If in the opinion of the Supervisor's Representative the excavation has deteriorated before the placing of concrete or other materials through the fault of the contractor, the unsatisfactory soil shall be removed and replaced by selected granular fill approved and compacted to the level of the original formation or filled with concrete class B.

### 3.2.7 Excavation for the Installation of the Pipeline

The width of any trench for pipework of whatever diameter shall be the minimum required for the installation of the pipe and for the installation of temporary supports, should they be necessary. The dimension of the trench shall be as shown on the Laying Instructions in the relevant contract drawing but shall generally be not less than 600mm from ground level to the top of the pipe for a single pipe in a trench. For a trench with more than one pipe, the diameters of the pipes should be added to the prescribed width for excavation. After laying the pipe, the space between the adjacent pipes and pipe and excavation walls shall not be less than 200mm. The Supervisor's Representative shall approve the width and depth of the trench.

The trench bottom shall be even and smooth so as to provide a proper support for the pipe over its entire length, and shall be free from stones, lumps, roots and other hard objects that may damage the pipe or coating. Holes shall be dug in the trench bottom to accommodate couplings, if any, to ensure continuous contact between the trench bottom and the pipe between coupling holes.

The bottoms of the trenches shall be maintained level and uniform and free of stones and other obstructions, where pipes are to be installed without a granular or concrete bed. Holes made for the joints shall be of a minimum size and the pipework shall be supported uniformly over its full length.

Trenches shall generally have vertical sides but where approved by the Supervisor's Representative the Contractor may excavate trenches having vertical sides below and sloping sides above the top of the pipe. The cost of sloping sides will be borne by the contractor.

Wherever necessary to prevent caving-in, trench excavations in soils such as sand, shall be adequately sheeted and braced. Where sheeting and braces are used, the net trench width shall not be less than that specified above.

Materials taken from the trenches will be placed at the side of the trench except when in the opinion of the Supervisor's Representative, the materials will obstruct the passing of traffic or pedestrians. In such a case, the contractor shall excavate the trench in short lengths approved by the Supervisor's Representative and shall keep the excavated material at a convenient distance.

The length of trench to be excavated in advance of pipe laying shall not exceed 300 metres or a day's work out-put approved by the Supervisor's Representative or whichever is less. If in the opinion of the Supervisor's Representative and through the fault of the contractor the excavation has deteriorated before the installation of pipework all unsatisfactory material shall be removed and replaced by selected, compacted fill to the level of the original formation, all at the expense of the contractor.

The contractor shall not proceed with pipe laying until the trench has been inspected and approved by the Supervisor's Representative.

### 3.2.8 Protection of Trenches

The contractor shall provide caution tapes to ward off any intruders from the trenches and prevent any accidents occurring, once the trenches have been excavated and not yet laid. No trench shall be left unattended to overnight.

### 3.2.9 Excavations in Excess

If any trench or foundation is excavated by mistake, deeper or wider than necessary the excess excavation shall be refilled with concrete class B or selected granular fill approved and compacted to the original formation level, all at the expense of the contractor.

### 3.2.10 Excavation of Rock or Hard Material

For the purpose of payment under this Contract, rock is defined as natural material which is so hard that, in the opinion of the Supervisor's Representative, it cannot be removed by the ordinary methods of hand or machine excavation without undue difficulty or the solid surface or layer of material that cannot be removed without the systematic use of explosives or barring and wedging, boulders and pieces of rock of more than 0.20 cubic metres in volume.

No excavation of material that can be made with pick and shovel will be considered as rock for the purpose of payment.

If any dispute should arise as to whether or not the material or any excavation is to be classified rock the dispute shall be referred to an independent Arbitrator to be agreed upon between the parties, the decision of such Arbitrator to be final and binding upon the parties.

### 3.2.11 Padding Trench Bottom

The contractor shall provide sand to be approved by the Supervisor's Representative for padding of the excavated trench bottom as shown on the drawings and covering the crown up to height shown on the drawings.

### 3.2.12 Excavation for Chambers and Thrust Blocks

Excavation for chambers and thrust blocks etc. as far as it extends outside the regular trench profile, shall be measured for payment to the outside dimensions of the relevant structure as shown on the drawing with no addition for working space.

### 3.2.13 Backfilling

All excavations shall be backfilled to the levels of the original ground surfaces, unless otherwise shown on the drawings or ordered by the Supervisor's Representative.

The cost of backfilling shall be included in the rate for excavation. The additional cost of backfilling trenches in roads to the satisfaction of the authorities responsible for maintenance of roads will be paid to the contractor as extra charge of the rates for excavation contained in the Bill of Quantities.

### 3.2.14 Placing of Fill Materials

Fill materials shall be placed, spread and levelled in layers of loose depth not exceeding 250mm of general fill or 450 mm of rock fill and compacted. Notwithstanding the foregoing, where rock fill is placed below water level there shall be no restriction on the depth of layers.

The materials of each layer, of whatever type, shall be uniform throughout the layer. Each layer of materials shall extend over the full width of the filling. No layer of fill materials shall be placed until the Supervisor's Representative or his representative is satisfied that the underlying layer is properly compacted.

Layers of fill shall extend over the full width of trench and to sufficient extra width to allow proper compaction to the full final width. When the trench have been completed apart from any surface soiling required, they shall be trimmed back to the correct line and level and the contractor shall remove and dispose off surplus material.

During the construction, contractor shall control and direct construction and other traffic uniformly. Unless permitted by the Supervisor's Representative or his Representative, fill materials shall not be stockpiled on the right-of-way of the road.

If any subgrade or fill material is damaged by any cause after it has been compacted, such material shall be removed, disposed off and replaced by properly compacted similar material, or shall be reworked to conform to the specification.

### 3.2.15 Compaction of Fill Materials

Each type of fill material shall be compacted by plant that in the opinion of the Supervisor's Representative is suitable for the purposes.

Work in compaction of fill material shall be carried out only when the moisture content is within the range shown by the field trials or by laboratory tests on that material to be suitable for the attainment of the densities specified hereafter.

If any suitable fill material is, on excavation, too wet or too dry for satisfactory compaction, the contractor shall carry out such operations as may be necessary to adjust the moisture content to an acceptable value.

### 3.2.16 Fill to Formation Level

Material for filling shall be obtained from approved sources or selected from excavations containing no vegetable or perishable matter, graded to ensure a dense stable and homogeneous fill when compacted and to the approval of the Supervisor's Representative.
Prior to commencement of filling, the Contractor shall submit in writing to the Supervisor's Representative for approval his proposals for carrying out the work such that the optimum use may be made of excavated material and the proposals shall include the compaction plant and methods for adjusting the moisture content of the material, which he intends to use. No filling shall be carried out until the Supervisor's Representative approves the proposals and the material intended to be used.

Fill shall be placed in layers not exceeding 250 mm thickness each layer being thoroughly compacted to obtain a dry density not less than 95% of the proctor maximum dry density as determined by Test No. 12 of BS 1377. The in-situ dry density of the compacted fill will be determined by the sand replacement method described in Test No. 15 BS 1377 at locations ordered by the Supervisor's Representative.

The fill material prior to compaction shall be brought to moisture content within the range 2% of the optimum as determined by Test No. 12 of BS 1377. If watering is required it shall be carried out in such a manner as to ensure the even distribution of water throughout the layer to be compacted and the compaction operations will follow whilst the moisture content remains within the specified range.

No layer of fill material shall be placed until the Supervisor's Representative's is satisfied that the underlying layer is properly compacted.

**3.2.17 Embankments, Tips and Fills**
Only suitable portions of the excavated material shall be used in refilling. Where ordered by the Supervisor's Representative, selected material from an approved source shall be imported for refilling for which extra payment will be allowed.

The Supervisor's Representative may direct the Contractor to place selected excavated material anywhere. Such material will not become the property of the Contractor and nothing in this specification shall be construed to give the Contractor the right of ownership.

The Contractor will not be permitted to incorporate in the works any puddle clay, or other material arising out of the excavations except with the permission in writing of the Supervisor's Representative.
Except where otherwise specified or ordered the refilling of pipe trenches, around the pipes and to a consolidated depth of 300mm (minimum) above the crown of the pipe or the surround shall be done with selected material free from large stones or rock. The fill shall be deposited by hand in layers of not more than 225 mm watered, if the Supervisor's Representative considers this necessary, and consolidated by hand rammers in the first layer above the pipe other subsequent layers shall be consolidated by compactors in separate layers.

Before placing material of any description on natural ground surfaces, the topsoil of such surfaces shall be excavated and removed as directed by the Supervisor's Representative.

The Contractor shall make due allowance for consolidation and settlement of fill in trenches and shall make good at his own expense any subsidence that may occur**.**

### 3.2.18 Timbering

The term ‘timbering’ shall cover all normal methods of temporary support including the use of timber, concrete, steel sheet piling or such other materials as may be approved by the Supervisor's Representative.
Where necessary in the opinion of the Contractor or of the Supervisor's Representative the Contractor shall supply and fix without extra cost to the supervisor strong and sufficient timbering to support the sides and/or bottom of the excavations to the satisfaction of the Supervisor's Representative.

Where any excavation is carried out near or under any existing structure or work liable to be affected by subsidence, the contractor shall at his own expense prevent damage by subsidence, due to his temporary works, in a manner approved by the Supervisor's Representative.

### 3.2.19 Control of Water

The Contractor shall provide, operate and maintain a system satisfactory to the Supervisor's Representative of temporary drains, intercepting ditches, cut-off drains, sub-drains, sumps, well points, de-watering equipment and all other things necessary to keep surface water, sub-soil water or water from any other source out of the excavations and maintain the water table below the formation level.

The Contractor shall keep all excavations clear of water. Where water forms or accumulates in the trench the contractor shall at his own expense maintain the trench free of water during pipe laying

### 3.2.20 Anti-Termite Treatment

All termite nests on the site shall be opened up, the Queen extracted and destroyed. The nests shall be broken open at the top and treated with chemical approved by the Supervisor's Representative. The nest and surrounds 3 days after treatment shall be totally excavated 300mm in each direction clear of the fungus gardens and filled with approved material.

During building operations, the Contractor is to make careful inspection daily and runways traced and treated as above until termite life is exterminated.

### 3.2.21 Restoration Works

The contractor shall restore or replace all removed or damaged curbing, sidewalk paving, gutters, shrub border, fences, sod, and other disturbed surfaces or structures in a condition equal to what it was before the work began. Costs shall be included in the rates for excavation.

### 3.2.22 Reinstatement of Roads

The contractor shall provide an approval from the responsible authority and shall give 10 days\ notice in writing of his intention to excavate and shall satisfy the Engineer and the police as to the precautions he proposes to take and the local reflector sign posts to be provided. On any road or tract, a local reflector signposts shall be suitably placed on each side of the trench, and diversions shall be clearly marked.

The contractor shall further provide a 24 hours' notice to the Engineer and the responsible authority before actually excavating through the thoroughfare. The cost of providing all diversions, signs, signal operators, flagmen and the like shall be at the contractor's expense and shall be deemed to be included in the contract, whether there are expressly billed or not.

**3.3 Ensuring Public Safety**

The Contractor shall so conduct his operations as to offer the least possible obstruction and inconvenience to the public. In this connection, the contractor shall conduct his haulage operations in such a way that no spillage shall result along or across any public place or travelled way.The contractor at his own expense shall remove any spillage resulting from his hauling operations along or across any public place or travelled way immediately.

Whenever the contractor's operation creates a condition hazardous to traffic or to the public, he shall furnish, erect, and maintain at his own expense such fences, barricades, signs, lights and other devices as are necessary to prevent accidents or damage or injury to the public. The contractor shall also furnish such flagmen and guards as are necessary to give adequate warning to traffic or to the public of any dangerous conditions to be encountered and payment therefore should be made according to the appropriate rate. Flagmen and guards, while on duty and assigned to give warning to the public that the highway is under construction and of any dangerous condition to be encountered as a result thereof, shall perform their duties and be provided with the necessary equipment in accordance with the current 'Instructions to Flagmen of the Ghana Highway Authority.

## 4.CONCRETE WORKS

### 4.1 General

This section includes the supply by the contractor of all the materials, mixing, placing, steel in the structures, labour and the equipment for the construction of all works in concrete: un-reinforced, reinforced and precast. The reinforced concrete is to comply with the requirements of the British Standard Code (B.S. 8110) or its equivalent.

Concrete shall consist of cement, graded aggregate, and water thoroughly mixed, placed and compacted as specified in the following clauses:

### 4.1.1 Cement

The cement used shall be Portland cement or Portland-Blast-Furnace Cement or approved manufactured Portland cement shall comply with the Requirements of the B.S. 12 or equivalent standard for 'Ordinary Portland and Rapid-Hardening Portland Cement'. Portland-Blast-Furnace Cement shall comply with the requirement of B.S. 146 for Portland-Blast-Furnace Cement not exceeding 65% blast furnace slag. The manufacturer's certificate of test will in general be accepted as proof of soundness, but the Supervisor's Representative may require additional test to be carried out on any cement which appears to him to have deteriorated through age, damage to containers, improper storage or for any other reason. The Supervisor's Representative without any test being made, order that any bag of cement, a portion of the contents of which has hardened, or which appears to be defective in any other way, be removed from the site forthwith. The contractor may elect to use Ordinary Portland Cement, Portland-Blast-Furnace Cement or Rapid-hardening, but no extra amount will be paid on account of using a cement priced higher than the price entered for normal Portland cement in the schedule of rates under the contract, work using such cement is ordered in writing by the Supervisor's Representative.

The cement shall be transported in covered vehicles adequately protected against water. It shall be stored in a weatherproof cement store to the approval of the Supervisor's Representative and shall be taken out for use in the works in the order of its delivery into the store. Cement required for use in 24 hours may be stored in the open on a floor raised 30 cm above the ground if covered by tarpaulins.

### 4.1.2 Cement Testing

All Cement must be certified by the manufacturers as complying with the requirements of the appropriate Specification. Before orders are placed, the contractor shall submit details of the proposed supplier(s) together with such information on the proposed methods of transport, storage and certification so that the Supervisor's Representative may satisfy himself that the quantity and quality required can be supplied and maintained throughout the construction period. Where necessary the Supervisor's Representative may require further representative samples of the proposed cement to be taken and forwarded to a nominated laboratory for analysis and testing before the source is approved.

Having obtained the Supervisor's Representative's approval of the source(s) of supply, transport, storage and certification of the cement, the contractor shall not modify or change the agreed arrangements without first having obtained the Supervisor's Representative's permission.

In addition to routine test certificates which are to be supplied by the manufacturer to show the average results of sample tests made on batches of cement produced at the works, the Supervisor's Representative may also make any further tests which he shall consider necessary

or advisable to satisfy himself that the cement on site complies with the specification and has not suffered deterioration in any manner during transit or storage.

The contractor shall ensure that the arrangements for the storage of the cement on the site as hereinafter specified are sufficient for the segregation and identification of each consignment until the results of the sampling and testing referred to in clause above are available.

No Cement shall be used in the Works until it has been passed as satisfactory by the Supervisor's Representative.

### 4.1.3 Storage of Cement

The cement shall be delivered to the site of the works in bulk or in sound and properly sealed bags and while being loaded or unloaded and during transit to the concrete mixer whether being conveyed in vehicles or by mechanical mans, must be protected from the weather by effective coverings.

If the Cement is delivered in bulk the contractor shall provide at his own expense approved silos of adequate size and numbers to store sufficient Cement to ensure continuity of work and the Cement shall be placed in these silos immediately it has been delivered on the site. Where directed by the Supervisor's Representative, the contractor shall supply and erect efficient screens at his own expense to prevent wastage of cement during strong winds. Approved precautions must be taken during unloading to ensure that the resulting dust does not constitute a nuisance.

If the Cement is delivered in bags, the contractor shall provide at his own expense perfectly weatherproof and well-ventilated sheds having a floor of wood or concrete raised at least 300 mm above the ground. The sheds shall be large enough to ensure continuity of work and each consignment must be sacked separately therein to permit easy access for inspection, testing and approval. On delivery at the site the Cement is at once to be placed in these sheds and shall be used in the order in which it has been delivered.

Cement which has been damaged in transit to the site or has become stale or otherwise unsuitable, and hardened lumps or cakes of cement which cannot be crumbled into fine powder in the hand shall not be used in the permanent Works except with the specific approval of the Supervisor's Representative.

## 4.2 Aggregates General

The fine and coarse aggregate shall be naturally occurring sand, gravel or stone, crushed or uncrushed, and shall comply with the requirements of BS 882 'Crushed Aggregate from Natural Source'.

They shall be obtained from a source approved by the Supervisor's Representative, and shall be hard, strong, durable, clean and free from adherent coatings, or harmful organic impurities and shall not contain any harmful materials in such a form or sufficient quantity as to affect adversely the strength, durability or permeability of the concrete or to attach the steel reinforcement. They shall not contain water-soluble sulphur ($SO_3$) in excess of 0.1 percent.

### 4.2.1 Fine Aggregate

The fine aggregate shall not contain silt or other fine material exceeding 6 per cent by volume when tested according to the Standard method given in BS 812 Clause 15, neither shall it contain

organic in sufficient quantity to show a darker colour than the standard depth of colour No. 3 when tested according to the Standard method given in the BS 812 Clause 28 'Organic Impurities'.

Fine aggregate shall be clean sand complying with BS 882 "Aggregates from Natural Sources for Concrete". The sand shall be from approved sources and the sand which in the opinion of the Supervisor's Representative is not clean shall be washed before use.

Crushed stone up to a maximum of 50% shall be added to natural sand in order to achieve the required grading. Crushed sand alone may be used with the approval of the Supervisor's Representative. Sand for use in mortar shall conform in all respects with the BS 1198-1200. "Building sands from Natural sources".

Fine aggregate subjected to five cycles of the soundness test, specified in ASTM C88 shall not show a loss exceeding 10% when magnesium sulphate solution is used except where otherwise approved.

### 4.2.2 Grading of Fine Aggregates

The grading of fine aggregates shall be within the limits given in the following table:

| S Sieve size | Per cent by weight Passing BS Sieve | |
|---|---|---|
| | Natural Sand or crushed gravel sand | Crushed Stone sand |
| 5 mm | 95 - 100 | 90 - 100 |
| No. 7 | 70 - 95 | 60 - 90 |
| No. 14 | 45 - 85 | 40 - 80 |
| No. 25 | 25 - 60 | 20 - 50 |
| No. 52 | 5 - 30 | 5 - 30 |
| No. 1000 | 0 - 10 | 0 – 15 |

### 4.2.3 Coarse Aggregate

The Coarse Aggregate shall be granite or other hard stone from a source approved by the Supervisor's Representative. The aggregate shall not contain clay lumps exceeding 1% by weight. A representative dry sample shall not show an increase in weight exceeding 8% after immersion in water when tested as laid down in the BS 812 Clause 19 - 21. It shall well shaped and flaky. The nominal size of the aggregate shall be as stipulated below

| **BS Sieve size** | **Per cent by weight Passing BS Sieve** |
|---|---|
| | **Nominal Size of Graded Aggregate** |

| | **38mm to 5mm** | **1.9mm to 5mm** |
|---|---|---|
| 75 mm | 100 > | - |
| 38 mm | 95 - 100 | - |
| 19 mm | 30 - 70 | - |
| 10 mm | 10 - 35 | 95 - 100 |
| 5 mm | 0 - 5 | 25 - 35 |

Coarse aggregate shall comply with BS 882 "Aggregate from natural sources for Concrete". Subject to sub-clause (4), It may be either natural gravel crushed or part crushed or crushed and be obtained from quarries, pits or other sources approved by the Supervisor's Representative.

Gravel or ballast shall be free from clay, earth, loam or other organic or similar material and shall be approved by the Supervisor's Representative. Gravel or ballast which in the opinion of the Supervisor's Representative is not clean shall be thoroughly washed before use.

The grading of coarse aggregate by analysis shall be within the limits laid down in the BS882, Table4, Coarse Aggregate. The material shall when mixed with sand produce a well graded mixture from the largest to the smallest size specified to ensure that concrete of high density shall be produce.

The 'flakiness Index' for coarse aggregate as determined by the sieve method in the BS 812 "Methods for sampling and testing of mineral aggregate, sands and fillers', shall not exceed 40 for 40 mm aggregate nor for 20 mm aggregate.

The "Elongation index" for coarse aggregate determined in accordance with BS 612 shall not exceed 35. The coarse aggregate shall have a "ten per cent fines" value of not less than 100 kN. The value shall be determined as described in BS 812.

Coarse aggregate subject to five cycles of the soundness test, specified in ASTM C88 shall not show a loss exceeding 10% when magnesium sulphate is used except where approved otherwise. Coarse aggregate shall be tested for drying shrinkage characteristics in accordance with BRE Digest No. 35.

### 4.2.4 Grading of Coarse Aggregate

The grading of coarse aggregate shall be within the limits given in the following tale:

### 4.2.5 Alkali Aggregate Reactivity

Aggregates must not contain any matter, which in the opinion of the Supervisor's Representative is likely to undergo disruptive expansive reactions with alkali in the concrete mix or which is likely to otherwise affect the long-term durability of the concrete.

### 4.2.6 Acceptability

Notwithstanding that the fine and coarse aggregate may each separately comply with the requirements stated above, they will not be accepted unless when mixed together in suitable

proportions, the combined aggregates produce uniformly graded and compacted dense concrete of the strength required with adequate workability for the position.

### 4.2.7 Samples of Aggregates

Samples of fine and coarse aggregates approved by the Supervisor's Representative shall be kept on site and shall give a fair indication of the general quality of the aggregates delivered during the course of the work.

Tests shall be carried out on samples of the latter taken at intervals as required by the Supervisor's Representative. The method of sampling and the amount of aggregates to be provided for the tests shall be in accordance with BS 812 Section One "Sampling and Aggregates".

The tests shall be those laid down in BS 812 Sections II to VI inclusive. The Supervisor's Representative or his representative will carry out the tests. Should a sample fail to comply with any of the tests, the Supervisor's Representative may, at his discretion, either reject the batch from which the sample was taken, order it to be washed and/or screened or permit it to be used with variations in proportions of the concrete mixes specified. Any batch of aggregates rejected by the Supervisor's Representative shall be removed from the works site forthwith.

### 4.2.8 Storage of Aggregates

The fine and coarse aggregates shall be stored in properly constructed open bins with hard clean drained floors or in such a manner that they shall not become contaminated with any deleterious extraneous matter.

All sand and aggregates shall be stored on close fitting timber, steel or concrete stage of approved design with drainage slopes or in bins of substantial construction in such a manner as to prevent segregation of sizes and to avoid the inclusion of dirt and other foreign materials in the concrete. All such bins shall be expiated and cleaned at intervals as instructed by the Supervisor's Representative. Each size of aggregate shall be stored separately unless otherwise approved by the Supervisor's Representative.

### 4.2.9 Water

The water shall be clean and free from harmful matter and shall be from a source approved by the Supervisor's Representative. The contractor shall make adequate arrangements to deliver and store sufficient at the works site for use in mixing and curing the concrete. Water shall comply with the latest edition of BS 3148 or equivalent standard.

### 4.2.10 Concrete Trial Mixes

The concrete for structural works shall be designated mix which will comply with the minimum requirements specified. The Contractor shall design the mixes with the specifications and shall submit to the Supervisor's Representative or his representative his proposed designs for provisional agreement. Following a tentative approval of the mix design of each class of concrete by the Supervisor's Representative, the contractor shall prepare a trial mix of each class of concrete in the presence of the Supervisor's Representative's Representative. The preliminary or trial mixes should generally give strength 25% higher than the specified "Works" strength. Each trial mix shall comprise not less than half a cubic metre of concrete and shall be mixed in a mechanical mixer of a type approved by the Supervisor's Representative or his representative.

The quantities of all the ingredients of each trial mix including water shall be carefully determined by weight according to the approved mix design and sieve analysis and shall be made by the method described in BS 612.

Six 150 mm test cubes shall be made by the contractor in the presence of the Supervisor's Representative's representative from each trial mix. The cubes shall be made, cured stored and tested for their compressive strength three at seven days and the other three at 28 days after manufacture, all according to the method described in the BS 1661.

The contractor shall redesign the mix and make a further trial mix and test cubes:

- If the value of the ultimate compressive strengths of any of the mix cubes is less than the appropriate design strength, or
- If the difference between the greatest and the least compressive strengths of any of the six cubes of a set is greater than 15% of the average compressive strength of the six cubes.

The contractor shall allow ample time in his programme for designing and making trial mixes and the preparation and testing of compressive strength test cubes obtained.

The batches are to be gauged appropriately to obtain the strengths specified in the table below:

Table of Trial Concrete Mixes

| Concrete Class | Maximum Permissible size of Aggregate (mm) | Cube Strength (N/sq. mm) | | | | Maximum permissible slump (mm) |
|---|---|---|---|---|---|---|
| | | 7 Days after mixing | | 28 Days after mixing | | |
| | | Minimum expected works strength | Preliminary cube Strength | Specified Works Cube Strength | Preliminary Cube Strength | |
| 40/10 | 10 | 32 | 40 | 40 | 50 | 25 |
| 40/20 | 20 | 32 | 40 | 40 | 50 | 25 |
| 35/10 | 10 | 28 | 35 | 35 | 44 | 25 |
| 35/20 | 20 | 28 | 35 | 35 | 44 | 25 |
| 30/10 | 10 | 24 | 30 | 30 | 38 | 25 |
| 30/20 | 20 | 24 | 30 | 30 | 38 | 25 |
| 25/20 | 20 | 20 | 25 | 25 | 32 | 25 |
| 25/38 | 38 | 20 | 25 | 25 | 32 | 40 |
| 22.5/38 | 38 | 18 | 22.5 | 22.5 | 28 | 40 |
| 10/38 | 38 | 8 | 10 | 10 | 12.5 | 75 |

The Supervisor's Representative may require allowance to be made in the gauge of the aggregate to counteract the increase in volume (often termed "bulking") due to moisture content. The classes of concrete to be used in the works shall be as shown on the drawing, Bills of Quantities or as directed by the Supervisor's Representative. For each Class of concrete the characteristic 28-day crushing strengths when tested in accordance with the following clauses. The term characteristic strengths means above the value of the concrete below which not more than 5 % of the test results fall.

The characteristic strengths specified above are for concrete cured at a mean temperature between 25º C and 30º C and at a relative humidity of 70% to 90%. Should the curing

temperature and humidity be less or higher than the above ranges, the acceptable cube strength shall be modified by an amount acceptable to the Supervisor's Representative.

Concrete for paving or precast concrete units shall be tested in accordance with BS 1881 Part 4 and shall have a minimum flexural beam strength of 3.5 $N/mm^2$ at 28 days. Where concrete has a specified characteristic strength of 40 $N/mm^2$ or greater, then the minimum flexural strength shall be 4 $N/mm^2$.
The actual cement contents and the aggregate/cement ratios depend on the closeness of control which the contractor is prepared to exercise in the production and upon the quality of materials used. Where necessary the Supervisor's Representative may impose an upper or lower limit aggregate/cement ratio, which shall not be exceeded for any class of concrete.

Before any concrete is placed into the works the contractor shall submit to the Supervisor's Representative for his approval full details of the mixes he proposed to use for each class of concrete together with their expected average strengths. These mixes shall be based on the results of trial mixes as specified hereafter.

**4.2.11 Additional Cube Tests**
In addition to the works tests cubes described above, the Supervisor's Representative may order additional cubes to be made for the following purposes:- to determine the strength of concrete at the time of stripping moulds; to determine the duration of curing or to check resting errors.

**4.2.12 Test Failure**
If three or more in forty are below the characteristic strength, or where one result in forty is less than 85% of the characteristic strength an immediate examination shall be made to find the cause of the failure and a report sent to the Supervisor's Representative's Representative who will take suitable action which may be of the following:

The adjustment of the mix and/or improvement to the standard of quality control. The concrete corresponding to the cubes cut out and replaced. The affected structural member be load tested in accordance with the instructions of the Supervisor's Representative. If cracking or any other sign of failure appears, the concrete shall be cut out to the extent ordered by the Supervisor's Representative and replaced by sound material. Otherwise the member may be accepted as satisfactory.

When the failure in the opinion of the Supervisor's Representative's representative, is slight and occurs in a concreting operation for a large mass of concrete, the next works test results may be awaited and if the failure then persists, the Supervisor's Representative's representative may order that concreting shall cease forthwith and not be resumed until further preliminary tests indicate that the mix has been corrected. Otherwise the concreting may be allowed to continue with the same mix.

When the failure is serious and relates to a concrete mass, which lends itself to it, the Supervisor's Representative's, representative may order one or more test cylinders to be drilled out and tested in accordance with BS 1881 as modified by the general recommendations of the Concrete Society Report TR 11. According to the result of these tests the Supervisor's Representative may order the suspect concrete to be cut out and replaced.

If the range of individual cube strengths made from the same sample exceeds 15% of the mean then the method of making, curing and testing cubes shall be thoroughly examined. In the event

of a result having a range exceeding 20% the result shall be unacceptable and the Supervisor's Representative may order the actions outlined in the Sub-clauses (a) and (b) above.

**4.2.13 Cost of Testing**

Prices for concrete are to include for supplying all test cubes, slumps, cones and for carrying out all tests specified as and when required to the satisfaction of the Supervisor's Representative. And for making curing and sending test cubes carriage paid to the Nominated Testing Authority and for the cost of the testing of unsatisfactory cubes and specimens, etc.
The cost of laboratory testing satisfactory cubes and specimens shall be allowed for elsewhere in the Bills of Quantities.

**4.2.14 Testing of Works Concrete**

The consistency of the works concrete shall be determined at all times by means of the standard slump test. For normal concrete, the slump shall not exceed 75 mm; for mechanically vibrated concrete the slump shall not exceed 25 mm.

The strength of the works concrete by the testing of 150 mm specimen test cubes taken from the concrete at random during the progress of the work. Six such cubes shall be taken from each day's concreting or for 15 m3 of concrete placed, whichever is less. Three cubes shall be tested 7 days age and three at 28 days age.

The method of making, Marking, recording, curing and testing the cubes is to be agreed with the Supervisor's Representative before commencement of concrete work.

The test cubes referred to above, made, cured and tested in accordance with the foregoing provisions, shall show to the satisfaction of the Supervisor's Representative that the concrete complies with the following minimum requirements.
The slump and cube tests shall be carried out in accordance with BS 1881.

Table Of Works Concrete Mixes

| Concrete Class | Maximum Permissible size of Aggregate (mm) | Cube Strength (N/sq. mm) | | | | Maximum permissible slump (mm) |
|---|---|---|---|---|---|---|
| | | 7 Days after mixing | | 28 Days after mixing | | |
| | | Minimum Expected works Strength | Preliminary Cube Strength | Specified Works Cube Strength | Preliminary Cube Strength | |
| 40/10 | 10 | 32 | 40 | 40 | 50 | 25 |
| 40/20 | 20 | 32 | 40 | 40 | 50 | 25 |
| 35/10 | 10 | 28 | 35 | 35 | 44 | 25 |
| 35/20 | 20 | 28 | 35 | 35 | 44 | 25 |
| 30/10 | 10 | 24 | 30 | 30 | 38 | 25 |
| 30/20 | 20 | 24 | 30 | 30 | 38 | 25 |
| 25/20 | 20 | 20 | 25 | 25 | 32 | 25 |
| 25/38 | 38 | 20 | 25 | 25 | 32 | 40 |
| 22.5/38 | 38 | 18 | 22.5 | 22.5 | 28 | 40 |
| 10/38 | 38 | 8 | 10 | 10 | 12.5 | 75 |

**4.2.15 Water/Cement Ratio**

The maximum Water/Cement Ratio for all the concrete mixes, unless otherwise specified shall be 0.45 except for concrete Classes 22.5/38 and 10/38 which shall be 0.50 and 0.60 respectively.

They shall be determined by the trial mixes and shall not exceed the values given above. Efficient means shall be provided for the moisture content and absorption values of the sand and coarse aggregate at all times.

The contractor shall be required to have an accurate knowledge of the moisture content of all sand and coarse aggregate as they reach the mixer and he shall make such adjustments to the mix as are necessitated in the moisture content of all aggregates.

**4.2.16 Defective Concrete**

Should cubes fail before the specified strength is obtained the Contractor shall, if so ordered by the Supervisor's Representative, cut out and replace at his own expense all the work represented by these cubes.

Wherever practicable, concrete for test cubes shall be taken immediately after it had been deposited in the works. Where this is not practicable, sample of the concrete shall be taken as the concrete is being delivered at the point of deposit.

**4.2.17 Mixing of Concrete**

The aggregates are to be gauged by weight, the weight s of aggregates per batch must be accurately determined and agreed with the Supervisor's Representative.

The quantity of cement in a concrete mix is always to be measured by weight and the mixer is to be of sufficient size to ensure that a batch of specified mix may be made using whole bags of cement to achieve this. The 50 kg bag is to be considered to be of volume of 0.4 m3 in calculating volumetric proportions. The amount of water used is to be the minimum consistent with practical workability and is to be varied as required to suit the moisture content of the aggregates.

When the amount of water per batch has been determined by trial, the water is to be measured at this fixed amount throughout the concreting by means of the water gauge on the batch mixer or by a marked measuring can. In no circumstances is water to be added to the mix after it has the batch mixer.

All concrete is to be mechanically mixed in batch mixer of approved type. The dry concrete materials are to be mixed for at least three turns in the mixer, after which the gauge amount of water is to be generally added, while the mixer is turning. When the water has been added, the concrete is to be mixed for two minutes in the mixer and for such further time as may be necessary to achieve a uniform mix. On the cessation of work, the mixer and all handling plant are to be washed.

**4.2.18 Consistency**

The contractor shall carry out slump, compaction factor or other workability tests as required during concreting of permanent works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mixes.

**4.2.19 Concrete Returns and Records**

The contractor shall send weekly to the Supervisor's Representative a return showing the quantities of cement and number of mixes of each Class of concrete used in each section of the works.

Records shall be kept by the contractor of the positions in the works of all batches of concrete, of their Class and of all test cubes or other specimens taken from them. Copies of these records shall be supplied to the Supervisor's Representative.

**4.2.20 Transport of Concrete**

The concrete shall be discharged from the mixers and transported to the works by means which shall be approved by the Supervisor's Representative and which shall prevent contamination, (by dust, rain or other causes) segregation or loss of ingredients. The means of transportation shall ensure that the concrete is of the required workability at the point of placing.

**4.2.21 Placing of Concrete**

At the end of each day the Contractor shall give the Supervisor's Representative a realistic concreting programme for the next day. Also notice shall be given to the Supervisor's Representative's when formwork and reinforcement are complete and ready to receive concrete at least six working hours before concrete is to be placed.

**4.2.22 Depositing Concrete under Water**

The arrangements for placing concrete under water are to be such that there shall at all times be a minimum of disturbance of the water. Running water crossing or entering areas where concrete is to be deposited must be brought under control before concreting commences. Protection against possible wave wash must be provided. The concrete to be deposited under water shall be grade 40/20 as specified in the Table of concrete Mixes. The concrete mix design shall be such that the concrete shall be sufficiently fluid to flow freely. Concrete shall be deposited under water by means of trémie pipes or bottom dump skips, or other method approved by the Supervisor's Representative. The method and rate of deposition shall ensure that no segregation shall occur. Concreting shall be carried out in sections previously ordered or approved by the Supervisor's Representative and shall proceed continuously in each section until completed.

If concreting under water is by means of trémie pipe, the bottom of the trémie pipe must always be buried in the concrete and care must be taken not to allow the pipe to be emptied as it is moved over the area. If concreting under water is done by bottom dump skip, canvass or other approved covering shall be used to cover the surface of the concrete in the skip before it is lowered in to the water. The doors of the skip shall be opened only when the skip is resting on the bottom with no tension in the support cable. After opening the skip shall be lifted gradually so that the concrete flows out steadily.

**4.2.23 No Partially set Material to be used**

All concrete and mortar must be placed and compacted within 30 minutes of water being added to the mix or otherwise included through damp aggregate, unless admixtures are in use. If a plasticiser/admixture is used, tests shall be carried out to determine the initial set time. No partially set material shall be used in the works.

**4.2.24 Concreting in Adverse Weather**

No concreting will be allowed to take place in the open during storms or heavy rains. Where strong winds are likely to be experienced additional precautions to ensure protection from driving rain and dust shall also be taken. The Supervisor's Representative may withhold approval

of commencement of concreting until he is satisfied that full and adequate arrangements have been made.

**4.2.25 Concreting at Night or in the Dark**

Where approval has been given for concreting operations at night or in places where day-light is excluded, the Contractor is to provide adequate lighting at all points where mixing, transportation and placing of concrete are in progress.

**4.2.26 Construction Joints**

Construction joints shall be located in the positions directed by the Supervisor's Representative, and as shown in the drawings. Such joints shall be in a plane at right angle to the axis of the member concerned or, when forming the upper surface of lifts in certain walls or beams, shall be horizontal. At joints other than those occurring in horizontal plane, the concrete shall be prevented from flowing laterally by the use of rigid stopping-off forms to produce rebates in the face of the joints; these rebates shall be formed centrally in the case of piers and slabs and shall run the full length of the joint.

Horizontal joints shall have all excess water and laitance removed from the surface after the concrete has been compacted and before it has set.

Construction joints in floors shall be located near the middle of the spans of slabs, beams or girders, unless a beam intersects a girder at the middle location, in which case joints in girders shall be offset a distance equal to twice the width of the beam. Provision shall be made for transfer of shear and other forces through construction joints.

Beams, girders or slabs supported by columns or walls shall not be cast or erected until concrete in the vertical support members is no longer plastic.

Beams, girders, column capitals and haunches shall be considered as part of a slab system and shall be placed monolithically therewith.

Before concreting is resumed, the face of the joint already formed shall have all laitance removed, shall be well roughened, scrubbed clean and thoroughly saturated with water. The face shall then be rendered with a 12 mm thick mortar composed of equal parts of Portland cement and sand against which the freshly mixed concrete shall be immediately deposited and thoroughly tamped into the cement mortar.

**4.2.27 Expansion Joints**

Expansion Joints shall be formed where indicated on the drawings. The Contractor shall ensure that any space designed to be filled with a compressible material, or which is shown on the drawings as a void, is kept clean of any rubbish or other material likely to impair the efficiency of the joint, and shall provide such means as is approved by the Supervisor's Representative of sealing the joint until such time as a permanent seal can be made.

**Curing and Protection of Concrete**

Exposed surfaces immediately after final test shall be protected from the sun in a manner approved by the Supervisor's Representative. All concrete shall be well watered after it has set and shall be kept continuously damp until thoroughly cured. Provision shall be made for adequate water distribution to all parts of the works, so that, if required this treatment can be

continued efficiently throughout the whole period of construction. In order to keep the concrete continuously damp, all exposed surfaces shall be covered with continuously damped gunny sacks or shall have water impounded on them, for the full curing, which shall not be less than 10 days.

All work shall be protected from damage by shock, overloading, etc.

**4.2.29 Surface Treatment**

As soon as the formwork has been removed and after inspection by the Supervisor's Representative, honeycombing or small holes in the concrete surfaces shall be cut out to a depth and shape required by the Supervisor's Representative and made up with fine concrete of equal quality. Where the honeycombing, in the opinion of the Supervisor's Representative, is of such an extent or character as to affect the strength of the structure materially or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the portions of the structure affected. No further treatment shall be given to concealed surfaces. Permanently visible surfaces shall be taken treated as treated as follows:

All projecting imperfections shall be rubbed down with carborundum stones or other means approved by the Supervisor's Representative, the grit or dirt there from, thoroughly washed off with clean water.

As a separate operation, after completion as described above, surfaces shall be brushed over with a coating of Portland cement wash which shall be rubbed into the pores and smoothed off with carborundum blocks. The finished surfaces shall be protected against drying too rapidly by use of damp sacking or other approved means.

Top surfaces of slabs and other surfaces for which formwork is not provided shall be floated to a smooth finish with a wooden float after compaction of the concrete. The concrete surface finish on upward facing horizontal or sloping faces shall be, except for blinding concrete or otherwise stated on the drawing, a "fair" surface shall be obtained by screeding and trowelling with a wood floating.

Screeding shall be carried out following a compaction of the concrete, by the slicing and tamping action of a screed board running on the top edges of the formwork or screeding guides to give a dense concrete skin true to line and level.

Wood float trowelling shall be carried out after the concrete has stiffened and the film moisture has disappeared. Working should be kept to a minimum compatible with a good finish and the surface shall be trueto the required profile to fine tolerance. Whenever necessary the Contractor shall provide and erect overhead covers to prevent the finished surface from being marred by raindrops or dripping water.

The surface of blinding concrete shall be that obtained by screeding as described above. Where a "fair" surface is indicated upon the drawings this shall be obtained in a similar manner to "fair" surface save that, a steel float shall be used in lieu of the wood float.

**4.2.30 Additives**

The use of additives in the concrete, for the purposes of promoting rapid hardening, for waterproofing, for increasing workability or for other reasons, may be permitted in special

circumstances. Such additives shall be of a brand and a type approved in writing by the Supervisor's Representative and shall be used strictly in accordance with the manufacturer's instructions, and to be used only subject to such preliminary tests as the Supervisor's Representative may require before permission is given to use the additives, in any part of the structure.

**4.2.31 Precast Concrete**

Concrete members specified to be fabricated as Precast Concrete units shall be fabricated with concrete of the specified Class placed into a grout-tight mould. If so required the mould shall be laid on a vibrating table and vibration applied while the concrete is placed.

Permanently exposed surfaces shall have a finish obtained by casting the unit in properly designed moulds of closely jointed wrought boards or steel or other suitable material. The surface shall be improved by carefully removing all fine and other projections, thoroughly washing down and filling the most noticeable surface blemishes with a cement and fine aggregate paste matching the colour of the concrete.

Surfaces will subsequently receive grout or concrete to complete a structural connection or other composite structural component of the precast unit forms a part, shall be prepared as early as possible after casting. This preparation shall be carried out preferably when the concrete has set but not hardened by jetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortar skin and to expose the larger aggregates without it being disturbed. Where this treatment is impracticable, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking is to be avoided.

With the approval of the Supervisor's Representative, the contractor may be permitted to precast members which were specified to be constructed in-situ; in such cases the contractor shall carry out the work as described above but payment shall be made in a manner as appropriate to the method of construction originally specified. Generally members which are dependent on a rigid fixing with the adjoining structures will not be constructed by precasting.

Precast units shall be jointed with cement mortar as specified in Clause…hereof or other cement /mortar proportions as shown on the drawings, or may be directed by the Supervisor's Representative, but mixed as dry as possible so that it is only "earth moist". The mortar shall be parked in layers between the units with steel tools until the whole of the joint is solidly filled and the exposed surfaces of the joint shall be raked out to a depth of 5 mm and flush-pointed with similar mortar but of pointing consistency.

**4.2.32 Supply of Precast Concrete Units**

The contractor will be permitted to obtain precast concrete units from outside suppliers provided that they comply with the Specification and that the Contractor obtains the Supervisor's Representative's approval to each supplier.

**4.2.33 Handling and Stacking of Precast Units**

The Contractor is to give the Supervisor's Representative full details of his proposed method of handling and stacking precast concrete beams and units. The Supervisor's Representative will examine these details and will either approve the methods or order modifications designed to

ensure that no excessive stresses are set up in the beams or units. The finally approved methods are to be adhered to at all times and the Contractor shall be deemed to have included in his rates for all measures required to handle and stack beams and units safely and without undue stressing.

**4.2.34 Tolerances**

The accepted tolerances of concrete surfaces shall be in accordance with the following:

| | |
|---|---|
| Precast concrete members- | BS 8110 Part 1 Clause 6.11.3 |
| Foundation and other cast<br>In-situ buried concrete | British Standard Institute Document PD 6440, Clause 4.5.3.1, Grade II |
| Exposed Concrete (including internal surfaces of sewer culverts) | British Standard 5606 Code of Practice for accuracy in Building |

**4.2.35 Cement Grout**

Cement grout for general purposes shall consist of Portland cement and water mixed in the proportion of one part by volume of cement and one and a half parts by volume of water. The grout shall be used within one hour of mixing.

**4.2.36 Cement Mortars**

Cement mortar shall, unless specified otherwise, consists of three parts of sand and to one part of ordinary Portland cement mixed and thoroughly incorporated together. Cement lime mortar shall, unless otherwise specified, consist of three parts of sand to one part of a mixture comprising one part of cement to one part of hydrated lime. In each mortar just enough water will be added to give a workability appropriate to its use. The above proportions are by volume. Mortar shall be used while freshly mixed and no softening and re-tempering will be allowed.

**4.2.37 Dry Mix Concrete**

Should the Contractor wish to use dry mix concrete for any sections of the work, he shall submit his proposals to the Supervisor's Representative for his approval. The Contractor must satisfy the Supervisor's Representative that the method he proposes to use will produce a finished concrete of specified strength and density.

**4.2.38 Granolithic Concrete**

Granolithic concrete shall consist of one part of Portland cement to two and half parts of combined aggregate by volume and it is to be mixed with the minimum amount of clean water necessary to permit satisfactory spreading and compacting.

The fine and coarse aggregate shall comply with the relevant British Standard Clauses, and shall be combined to produce a workable grading falling between the following limits:

| BS Sieve | Percentage Passing |
|---|---|
| 14 mm | 100 |
| 10 mm | 90 - 100 |
| 5 mm | 30 - 45 |
| 2.36 mm | 20 - 35 |

| | |
|---|---|
| 1.18 mm | 15 - 25 |
| 0.6 mm | 10 - 20 |
| 0.3 mm | 5 - 10 |
| 0.15 mm | 0 - 5 |

Granolithic concrete is to be laid while the base concrete is still unset. Before it is laid the base concrete shall be thoroughly compacted and roughly screeded. After placing, the granolithic concrete shall be compacted and worked to the correct levels. The surface shall be floated with a steel float after the concrete has hardened sufficiently for all water sheen to disappear from the surface. No dry cement or mixture of cement and sand is to be sprinkled direct on to the surface.

Where so directed by the Supervisor's Representative, the Contractor shall add approved compounds to the concrete materials before mixing to give a concrete with improved dust-proof and oil-proof qualities. Such compounds shall be added in accordance to the instructions of the manufacture.

Granolithic concrete paving shall be placed in panels not exceeding 3 m square. Construction joints are to be provided around the perimeter of each panel and are to be of an approved manufacture.

### 4.2.39 Breaking of an Existing Concrete

Where existing concrete is to be broken prior to carrying out repair works, the precise extent of such breaking out shall be agreed by the Supervisor's Representative.

The edge of broken out sections shall be formed square to provide a neat finish.
Concrete shall be broken back carefully to expose a sound surface.

Where existing steel reinforcement is to be retained, breaking out of concrete shall be carried out carefully to cause no damage to reinforcement.

## 5 REINFORCEMENT, FORMWORK AND TOLERANCES

## 5.1 REINFORCEMENT

### 5.1.1 Steel for Reinforced Concrete

Steel reinforcement, other than steel for pre-stressing, used in reinforced concrete shall comply with the following British Standards or otherwise as stated in the reinforcement drawings:

B. S. 4449 "Specification for Hot rolled steel bars for the reinforcement of concrete".
B. S. 4461 "Specification for Cold worked steel bars for the reinforcement of concrete".
B. S. 4482 "Hard drawn mild steel wire for the reinforcement of concrete".
B. S. 4483 "Steel fabric for the reinforcement of concrete"
B. S. 8110 "The Structural use of Concrete" Part I

Steel fabric reinforcement shall be lapped a minimum of 150mm at all joints and well tied with wire to the approval of the Supervisor's Representative.

### 5.1.2 Testing Reinforcement

The contractor shall furnish the Engineer with copies of the manufacture's certificating of tests for the steel reinforcement to be supplied. The Engineer may however order independent tests to be made on the steel delivered to the site, notwithstanding the existence of a manufacturer's test

certificate showing compliance with the specifications. For such ordered Test Specimens from the steel reinforcement delivered to the site shall be taken by the contractor from any consignment as required by the Engineer and sent carriage paid to the nominated testing Authority for testing. No steel shall be used before the Engineer has approved such testing/or the steel in writing.

The contractor shall remove from the site any consignment not complying in all respects with the appropriate foregoing specifications at his own expense within 24 hours upon notification to do so by the Engineer. Not less than one such specimen shall be taken from every diameter of each cast. Where one cast exceeds 25 tonnes, a second specimen shall be taken from each diameter cast. The contractor is to make arrangements with steel suppliers so that the cast number shall be clearly given on a label attached to each consignment and if one consignment shall include steel from more than one cast, the steel from each cast shall be bundled separately from any other cast. The cost of such tests shall be borne by the contractor.

**5.1.3 Bending Reinforcement**

Reinforcement shall be cut and bent to the shapes and dimensions shown on the finally agreed bending schedules. All reinforcement shall be carefully bent to the correct dimensions in a manner, which will not damage the material. In particular no reinforcement shall be heated before bending.

Bends cranks and other labours on reinforcement bars shall be carefully formed in accordance with the Drawings, BS 4466 "Bending dimensions and scheduling of bars for the reinforcement of concrete" and BS 8110, Part I "The Structural use of concrete"

For each supplier and for each size of round mild steel bar exceeding 10mm diameter, a test certificate in accordance with BS. 785 shall show the country of origin of the steel, the true diameter of each bar, the yield tensile force and the ultimate tensile force.

Reinforcement shall be stored by type, size and length in covered racks either above ground level or on cleaned surface areas.

Reinforcement shall not be joined by welding, unless indicated on the drawing. The method of welding shall be approved by the Supervisor's Representative.

Immediately before placing the concrete, the Contractor shall ensure that all reinforcement is free from loose mild scale, loose rust, oil and grease, or other deleterious matter.

The contractor shall check the Bending schedules against the Detail Drawings before ordering reinforcement and shall notify the Supervisor's Representative immediately of their discrepancies. All bars shall be accurately shaped to the dimensions indicated for the bar Bending Schedules.

Reinforcement shall not be bent or straightened in a manner, which will damage the material.

Reinforcement shall be fixed in the position indicated on the drawings. The maximum deviation of the actual position of reinforcement from the indicated position shall be in accordance with Table 3 hereunder. All intersections of bars shall be securely tied with malleable iron wire of suitable gauge. Specified contractor shall allow in his rates for the supply of all devices required

for maintaining reinforcement in position. No metal part of such device, including typing wire, shall remain permanently within the specified concrete cover to the reinforcement.

Where reinforcement concrete slabs or walls are constructed against tanking, care shall be taken in positioning reinforcement to avoid damage to tanking.

The Supervisor's Representative shall approve the fixing of all reinforcement before concreting commences. The requirements are below: -

| DIMENSION | MAXIMUM DEVIATION |
|---|---|
| **Lateral Dimension between Bars** | **+ 12m** |
| **Longitudinal Position of Bars** | **+ 25m** |
| **Concrete Cover Position of Bars** | **+ 3m** |

## 5.2 FORMWORK

### 5.2.1 General

The Contractor shall be responsible for the design of formwork and its supporting members, which shall be sufficiently strong to support all construction loads. The Contractor shall submit for approval to the Supervisor's Representative, details of his proposals for the formwork. All joint in the formwork and joints between the formwork and previous formwork in the correct position shall remain permanently within the specified concrete cover to the reinforcement.

### 5.2.2 In-situ Concrete

The formwork for all suspended slabs and beams shall be constructed with an upward camber as follows: -

Roof slabs and beams having two or more supports; 6mm at mid-span for each 3 metres of clear span. Other slabs and beams having two or more support; 6mm at mid-span for each 3 metres of clear span. Other slabs and beams having two or more support; 3mm at mid-span for each 3 metres of clear span.

Cantilever slabs and beams; 12mm at unsupported and for each 3 metres of projection.

Where board marked formwork is specified it shall be made from 225mm wide rough sawn timber boards. The edge joints of the boards shall be covered with 12mm x 32mm twice-sprayed wrought hardwood filled to form a groove in the concrete.

The resulting concrete shall clearly show grain and individual board marks, shall be free from honey-combing and excessive air holes, and shall be or uniform colour.

Where wrought formwork or plywood lined formwork in specified for the concrete the formwork shall be made from plywood or such other approved material as will ensure that the finished surface of the concrete shall be preferably true, smooth and even. After inspection by the Supervisor's Representative of the as-struck surface of the concrete, small imperfections may be made good by rubbing with a carborundum stone dipped in cement paste.

Where a concrete surface is covered in the finished works, the formwork shall be made from rough sawn timber boards not necessarily of uniform width. Where concrete surfaces are required to be rendered in the finished work, the concrete surface shall be scored or backed to provide a key for the render.

The contractor shall incorporate on concrete members all electrical conduit, pipes, fixing blocks, chases, holes, etc. required by any Sub-Contractor. The Contractor shall obtain from the Sub-Contractor full details of his requirements and shall submit details to the Supervisor's Representative for approval before work is put in hand.

All fixing chases, holes, etc. shall be accurately set out and cast into the concrete. Neither holes nor chases shall be cut in the hardened concrete without the prior approval of the Supervisor's Representative.

Before reinforcement is placed, the internal faces of the formwork shall be coated with an approved preparation to prevent adhesion of the concrete to the forms. This preparation shall not be allowed to come in contact with the reinforcement.

Immediately before placing concrete all extraneous materials shall be removed from the exterior of the formwork. Each section of the formwork shall be inspected immediately before concreting commences.

Formwork shall remain in position throughout the periods indicated in following table:

| Location of Formwork | Minimum Period |
|---|---|
| Beam sides, columns and walls | 12 days |
| Beam soffits (props left under) | " |
| Beam props (props left under) | 14 " |
| Slab soffits (props left under) | 4 " |
| Slab props (props left under) | 10 " |

The Contractor shall be responsible for the safe removal of all parts of the formwork of preparing.

**5.2.3 Precast Concrete**

Generally, the material and workmanship for precast concrete shall conform to Specification for Reinforced cast in-situ concrete construction. Before commencing construction of the formwork, the contractor shall submit working drawings of the proposals to the Supervisor's Representative for approval. The drawings shall indicate all necessary inserts and lifting devices.

The Contractor shall provide a sample precast unit which; if approved, shall define the acceptable standard for all such finished work. The sample may be incorporated in the works with the approval of the Supervisor's Representative.

Formwork shall remain in position for a minimum period of 2 days. The contractor shall be responsible for the safe removal of formwork and shall ensure that the concrete has adequate strength to enable formwork to be struck without damage to the concrete surface of arrives.

**5.3 TOLERANCES**

All dimensions exceeding 100mm + 6mm
All dimensions less than 100mm + 3mm
Deviation of any point on a surface from the specified place + 6mm

The Contractor shall submit to the Supervisor's Representative for approval his proposals for handling, lifting and storing the units. The Contractor shall at all times provide adequate strength to enable formwork to be struck without damage to the Concrete surface or arrives.
The units shall be positioned, levelled and fixed as specified on the drawings. The units shall be positioned to the following tolerances:

| | |
|---|---|
| Horizontal location of unit | - / + 6mm |
| Vertical location of unit | - / + 6mm |
| Alignment between corresponding planes on | |
| Adjacent unit at joints | - / + 3mm |

**5.3.1 FINISHED WORK**

The dimensions of the finished concrete shall be within the tolerance set out in the following table:-

| DIMENSIONS | MAXIMUM DEVIATION |
|---|---|
| Vertical and horizontal setting out exceeding 6 metres | ± 6mm |
| Vertical and horizontal setting out less than 6 metre | ± 3mm |
| Cross section of member | ± 6mm |
| Column eccentricity in full height | ± 6mm |
| Column eccentricity in full height | ± 19mm |

All angles and corners of concrete shall be finished straight and true and shall be carefully protected as work proceeds.

# 6. STORAGE TANK

## 6.1 REINFORCED CONCRETE RESERVOIR

### 6.1.1 General Description

The levels of the finished tanks must be precisely in accordance with the levels shown on the drawings. Support towers shall be set on reinforced concrete foundation slabs which also support all fittings and valves at ground level. Support towers shall be of reinforced concrete or other materials shown on the drawings. The tanks can be of Glass Reinforced Plastic (GRP), Hot Pressed Steel (HPS) or reinforced concrete. In the coastal areas, only the GRP or reinforced concrete receptacle on reinforced concrete towers shall be constructed. Three coats of Vandex or approved equal waterproof material shall be applied to the internal surface of concrete tanks. For the HPS tanks, see below.

Reinforced concrete reservoirs are constructed with construction joints between the base and walls and between the walls and roof slab. Each of these elements shall be poured in one continuous operation. All reservoir pipework is of uPVC tube that shall be cast into the base slab. Grade 35 concrete is used for the reservoir structure.

### 6.1.2 Foundations

The site is excavated to a depth indicated on the drawing any large boulders visible at this depth shall be removed from the excavation. The base of the excavation is levelled and a 300mm thick layer of aggregate placed in the excavation. This aggregate may be of local stone and should have a size range of 20-50mm. A blinding layer of 50mm of weak concrete is placed over the aggregate and carefully finishes so as to provide a smooth and level surface for the construction of the foundation. Kickers of 100mm height shall be cast at the same time as an integral with the foundation slab for construction of the columns.

### 6.1.3 Columns

The reinforcement and formwork for the columns shall be set up as specified in the drawing. The uPVC pipes for the reservoir inlet, outlet, vent pipe, overflows and washouts are cast into the columns. The concrete for the columns shall be poured in one continuous operation.

### 6.1.4 Suspended Base Slab

The reinforcement and formwork for the suspended base slab are set up. Kickers of 100mm height shall be cast at the same time as an integral with the base slab. The starter bars for the walls shall extend at least 600mm above the surface of the kickers. The uPVC pipes for the reservoir inlet, outlet, vent pipe, overflows and washouts are cast into the base slab. The concrete for the base slab shall be poured in one continuous operation. The surface of the kickers should be prepared for the formation of construction joint. The surface of the base slab shall be left rough and kept moist for 14 days to receive screed.

### 6.1.5 Walls

The vertical reinforcement bars in the walls shall extend above the level of the top of the wall to provide sufficient overlap with the roof bars. The walls shall be poured in one continuous operation.

The contractor is referred to section 3.1.5 of this specification dealing with formwork. If the formwork is not correctly constructed or if the engineer judges that the support of the formwork is inadequate the Contractor shall be required to correct or reconstruct the formwork before pouring concrete. The Contractor shall observe the precautions concerning the construction joints between the base slab and walls and between the walls and roof slab. The external formwork shall be left in place for 145 days to enable proper curing of the concrete. The internal formwork may be removed after 24 hours to allow construction of the soffit formwork.

### 6.1.6 Roof Slab

The roof slab shall be poured in one continuous operation. No construction joints are permitted. Particular care shall be taken to ensure that the soffit formwork is tight to prevent any loss of grout or mortar from the fresh concrete. When placing the concrete for the roof slab particular care should be taken to ensure that concrete placed at the edge of the slab and around openings has a sufficient fines content and is fully compacted and dense. The Contractor is advised to use less coarse aggregate in the concrete placed in these areas. The surface of the roof slab shall be sloped 2½% from the centre to the edges to drain rainwater.

This slope shall be formed while casting the concrete of the roof slab and not by adding a layer of topping. The steel access cover and frame are cast into the roof slab so that the frame is level and the flange of the frame is 30mm above the finished level of the concrete on the side nearest the centre of the slab. Concrete is then placed around the frame and neatly finished to a slope of $45^{o}$.

The surface of the slab shall be finished by floating on a topping layer while the concrete is still fresh. Addition of a topping to dry concrete is not acceptable. After placement of the concrete the slab shall be immediately covered with heavy-duty polythene sheet, which shall be kept in contact with the surface of the slab for 14 days. Alternatively, the slab may be covered with 25mm of sand, which shall be kept moist for 14 days.

### 6.1.7 Access Cover and Ladder

The ladder is made of galvanized pipe welded together. Welds are well coated with galvanizing paint and the ladder is fixed to the frame of the access cover with bolts and nuts and the foot of the ladder is cast into a small concrete block on the base slab.

The access cover and frame is painted with 2 coats of red oxide or similar primer and 2 coats of enamel paint. A heavy-duty padlock shall be provided for the access cover.

## 6.2 FORMWORK

For casting the concrete columns of the support tower, the formwork for successive vertical lifts shall be used which must make such perfect contact with concrete in the preceding lift that there shall be no excrescences, bulges tears and other outward signs of faulty junction. For this purpose, forms lined with steel sheets, form boards, blackboard or hardboard of approved manufacture, or timber boarding planed on both sides to equal thickness, are recommended.

Ferrules and wire ties shall be used for connection of the opposite sides of formwork for members of water retaining or conveying structures.

## 6.3 WATER STOPS FOR CONCRETE TANK STRUCTURE

The contractor shall supply and fix water stops in all contraction and expansion joints as shown on the reinforcement drawing. Such joints shall be watertight. The water stops will be made of rubber and shall be of the hollow centre bulb type or approved equal. The number of water stops made on site shall be kept to a minimum and these shall be joined by approved means. The water stops shall be carefully maintained in the position shown on the drawings and properly protected from damage and the harmful effects of light and heat during all stages of construction. The stop boards on each side of the water stop shall be accurately wrot to match the profile of the water stop. The concrete shall be carefully compacted under and around the water stop so as to leave no cavities.

For pipework passing through watertight concrete structure, puddle flanges with flanges on each end have to be used. The puddle flanges have to be positioned as shown on the drawings when assembling the reinforcement.

## 6.4 TESTING OF CONCRETE RESERVOIRS

Tank water tightness test shall be conducted according to the following procedure:
Tanks are filled gradually with portable water at a rate of 0.5 m depth per day.

Potential leakage measurement shall be carried out for one week starting from the eighth day after completion of filling of the tank to its full capacity.

The drop-in water level in the tank shall not fall below that of a tight container (a small plastic bucket), placed inside the tank, due to evaporation occurring and used as a reference.

No leakage whatsoever shall be detected and walls shall not exhibit any sigh of stress or oozing.

A report of each test shall be established jointly by the contractor and the Supervisor's Representative. A provisional acceptance certificate shall be issued to the contractor only on account of the tank passing this test.

### 6.4.1 Tests

Soil tests to ascertain the type of foundation to provide for a particular tank shall be conducted in an authorised laboratory and results sent to the Supervisor's representative.
Concrete cube tests shall be made on concrete when being cast.
Sample of sand from stockpile on site must be taken for tests before use.

### 6.4.2 Pipes

All tanks shall be equipped and fitted with galvanised pipes for supply, distribution main, washout or drain and overflow as shown on the drawings.

The overflow pipe shall be fitted just below the level of the supply pipe. The distribution main shall be fitted close to the base of the tank situated higher than the drain opening and on opposite side to the supply pipe. The tank drain shall be connected to the overflow pipe via an appropriate gate valve with a hand wheel. All tanks shall be fitted with a drain to allow them to be emptied completely. Duck foot bends of appropriate diameter shall be installed on all pipe change of direction from vertical to horizontal below the tanks. The inlet strainer should be fixed at 200 mm from the invert of the tank. The tank shall have mosquito-proofed ventilation.

### 6.4.3 Flow Control Valves

Flow into the tank shall be controlled by an adequate float-valve. A washout valve with a hand wheel shall be located not more than 1500 mm below the soffit of the tank and above the y-tee connection of the overflow pipe to allow the flow of the overflow unimpeded. A general isolating valve shall be fixed just before the general meter to allow for maintenance. The level indicator calibrated in metric units, which can be read from the ground, shall be fitted. A lightning strike protection shall be installed on top of the roof and connected using an approved conductor to a pit filled with appropriate earthing material. A bulk metre

**6.4.4 Metal Works**

All tanks shall be equipped with an external steel ladder with safety hoops at 500 mm centres starting 1500 mm from the ground level forming a cage (the bottom end of the hoop shall have a lockable hatch; and the top shall bend on to the top of the tank) in order to allow for a safe access to the roof of the tank. The ladder shall be staggered at the valve platform to break the climb into two lifts.

It shall also have an internal removable aluminium ladder to be anchored vertically inside the tank hooking up to the manhole; all components of the ladder and its fixations shall be in aluminium; for heights of more than 3 m, the ladder shall include an aluminium safety cage as described above and placed inside the tank.

A valve platform, base 6 mm thick non-slip steel chequered plate, shall be provided with a safety guardrail. The top of the tank shall be fitted with a 37.5 mm Ø galvanised pipe balustrade 1200 mm height to direct the operators straight to the entrance hatch of the tank, the contractor shall submit a drawing of the balustrade to the Supervisor's Representative for approval before manufacture and installation.

All storage tanks shall have an entrance hatch situated at the first third section, next to the inlet of the transmission pipe with a lockable cover that would exclude foreign matter and rainwater, and to hygienically protect the contents. The cover to the manhole shall be dimensioned to allow a man in at a time for maintenance purposes. The cover shall be suitable for all loading types including those of men on maintenance duties.

All storage tanks shall be fenced as specified to a height of 1800 mm and have a minimum clear distance of 1500mm all round.

**6.5 GROUND LEVEL TANKS**

The receptacle material specified for the elevated tanks also apply to the ground level tanks. For RC tanks half the height of the tank shall be buried into the ground. The remaining surrounding area of the tank on completion shall be backfilled to a slope of 1:2 to a height leaving 1/4 of the height unfilled. Backfilling shall follow the procedure specified above. The backfill shall be covered with 10 0mm of black soil to receive grassing. A manhole shall be constructed to access the valves on the ground. The under basement of the tank shall be filled with carefully compacted homogenous sand on which will be cast a 100mm blinding. All fixtures specified for the elevated tanks apply to the ground level tanks.

**6.6 STEEL SUPPORT TOWERS**

Steel support towers shall be designed for a wind velocity of 45 m/s. They shall be made of commonly available U or L steel profiles conforming with BS 5950 or other approved standard.

The profiles shall be connected by bolts. For corrosion protection, the steel structure shall be galvanised or painted in accordance with BS 5493 SL5 or equivalent, with:

(a) Two coats of two-pack epoxy zinc phosphate primer (KP 1A) to total D.F.T. of 140 microns.

(b) Two coats of two-pack epoxy under coat (KU 1B) to total D.F.T. of 200 microns.

(c) One coat of chlorinated rubber finishing coat (HF1D) t0 total D.F.T. to 100 microns D.F.T.

Alternately the finishing coat could be two-pack polyurethane (KF 2D) to 100 microns D.F.T. in accordance with BS 5493. SK 4 painting system or equivalent.

Steel support towers shall always be designed and supplied by the manufacturer supplying the tank.

## 6.7 SECTIONAL STEEL WATER TANKS

All sectional steel tanks shall be of rectangular construction using mass produced tank plates, 1220 mm square or 1000 mm square and bolted together. All tanks shall conform to BS 4360 grade 43A, or equivalent and shall be between 4 mm and 6 mm in thickness, determined by the depth of the tank.

Plates shall be formed with 45º or 90º flanges according to their position on the tank. All plates shall be clearly marked to identify them for erection purposes.

Pipe connections shall be flanged.

Tank plates and cover plates shall be hot dipped galvanised to BS 729 or equivalent after suitable pre-treatment.

### 6.7.1 Cleats and Stays

All internal fittings shall be designed to ensure the rigidity and strength of each tank. They shall be manufactured from steel BS 4360 43A or equivalent.

### 6.7.2 Bolts, Nuts, Washers and Jointing Materials

All Bolts, Nuts, Washers shall comply with BS 4190 or equivalent. Steel tanks shall be supplied with a complete set of spanners and a percentage of spare nuts, bolts and washers. Jointing strips shall be used between the flanges of adjacent tank plates, under the tank cleats and for seating cover plates. Materials for jointing strips shall be acceptable for use with potable water.

## 6.8 GLASS REINFORCED PLASTIC (GRP)-PANEL-TYPE WATER TANKS

GRP tanks shall be of rectangular construction using hot-pressed moulding system with sheet mould compound suitable for potable water. The unsaturated polyester resin shall conform to BS 3632 or equivalent and the glass fibre shall be non-alkali to BS 3396 and BS 3749 or their equivalent. The glass content shall not be less than 30%.

The GRP panels shall be externally flanged and manufactured with the single flange at right angle to all the sides of each panel. The thickness of flange shall not be less than 6 mm for proof panels, or less than 10 mm for other panels, and the landed width of all flanges shall not be less than 55 mm. Holes for bolts shall have a clearance of 1.5 to 2.0 mm in diameter.

Bolts, nuts and washers for immersed internal fixings shall be stainless steel grade A2-70 to BS 6105 or equivalent. All other tank fixing bolts shall be grade to BS 3692 or equivalent, galvanised finish to BS 729 or equivalent. Diameter of tank bolts shall not be less than 12 mm.

Jointing and sealing materials in contact with the water shall be of approved non-toxic ribbed synthetic rubber and/or plastic.

**6.9 TESTING OF WATER RESERVOIRS**

All water retaining structures shall be subjected to water tightness test after completion and all concrete has attained its specified strength and cleaning of the structure according to the following procedure:

- The structure shall be filled at a uniform rate of increase of water level of not more than 2 m in 24 hours to the intended top water level and left to stand for seven days.
- Installation of approved rain gauge and evaporation pan
- The water level shall be measured and recorded on the seventh day
- Measurements shall be taken every 24 hours for following seven days

The structure shall be deemed to be watertight when the total drop in water level does not exceed 10 mm in seven days, taking into account losses due to evaporation and re-charge due to precipitation. The level measurements shall be carried out using a hook gauge.

If the total loss is greater than 10 mm the contractor shall empty the tank slowly in stages and institute an investigation into the cause and to remedy the failure immediately to the satisfaction of the Engineer. The contractor shall repeat the tank filling and testing as described above. All investigation, maintenance, re-cleaning and re-testing shall be at the contractor's own expense.

If the structure does not satisfy the conditions, and the daily drop in water level is decreasing, the period may be extended to a further seven days and if the specified limit is not exceeded, the structure may be considered as satisfactory and passed.

Where internal division walls are present in the structure, each compartment shall be tested for water tightness separately.

The Engineer will not accept the structure until it has been ascertained to be in a perfect 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 time requested by the contractor.

**6.9.1 Disinfections**

On completion of the water tightness test, the contractor shall thoroughly clean the interior of the 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.

The contractor shall then, when instructed by the Engineer, and under his direction, disinfect the 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 at a steady rate into the tank.

The contractor shall introduce at least 30 ppm of free chlorine while filling the tank to a minimum depth of 100 mm. 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 diesel or petrol as its prime mover, shall be used inside the tank, but an electrical pump may be used.

On completion of the spraying process the heavily chlorinated water shall be drained off from the tank and its compartments and each compartment shall be filled with potable water to a depth of 200 mm from approved source. This water shall be drained out and the tank filled with potable water to overflow level.

Samples shall be taken as directed by the Engineer after the tank has been full for a period of at least two hours and shall be sent to a qualified bacteriological laboratory for analysis. If the test result shows that the water contains any presumptive or typical coliform organisms in 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 shall be at the contractor's expense.

On completion of the disinfection, the contractor shall close off all 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 tank. 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 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 or disinfection.

**6.9.2 Testing of Roofs**

The roofs of reservoirs or tanks shall be watertight. The roof shall be first inspected and any signs found noted. The roof shall then be thoroughly wetted by continuous hosing for a period of 6 hours and the roof inspected again for any leaks or damp patches on the soffit. The roof is declared water tight if no noticeable change is found from the first and the second inspection.

An item is included in the bill to cover for all costs, including the supply and disposal of the test water, associated with carrying out this test, to the satisfaction of the Engineer. Payment will be made for successful test only.

**6.9.3 Systems with Iron/Manganese Removal Units**

For systems with iron/removal units, the following additional fixtures shall be included for their tanks:

- The flow is lowered into the sedimentation tank via a dipping pipe, which ends in a stilling basin at a height of 400 mm from the invert of the tank.

- Automatic stopping devices (in place of a float valve) shall be installed in the tank for each pump to control flow into the storage tank.
- The strainer to the distribution pipe shall be fixed at 500 mm for tanks, which do not have sedimentation tanks attached.
- For an iron/manganese removal system with a sedimentation tank an additional aluminium ladder shall be provided inside the sedimentation tank.
-

**6.10 IRON REMOVING SYSTEM**

The iron removal system includes:

- An aeration system shall be installed above the highest level of the tank to enable the water to go into the storage tank by gravity.
- A sand filter for filtration of the water before distribution to the mains, located not less than 3 m below the tank
  (Approval by Consultant)

**6.10.1 Water Aeration**

The aeration system shall be installed on the roof of the tanks and protected against lightning strikes. A typical aeration system shall be in accordance with the drawings and the following technical specifications.
The width of the system should be adapted to at least 90% of the design flow of the water system.

The raw water shall pass through a compartment and then spill over on to a cascade aerator arranged in steps of perforated plates or other. The aerated water shall pass into a collection bin through a galvanised pipe, which ends at 400 mm above the floor of the tank/or the sedimentation tank if that is attached.

**6.10.2 Water Sedimentation**

Sedimentation shall be done in an adjacent tank to the storage tank. This water shall well up slowly on to a weir and pass over into the storage tank.

**6.10.3 Water Filtration**

- The water filter shall be adapted to the flow rate of the system
- Two layers of crushed silica with the following characteristics

| **Layer** | **Thickness** | **Grain Size (mm)** | **Uniformity Coefficient (UC)** | **Mean Effective Media Size** |
|---|---|---|---|---|
| Inferior | 25% | 1.2 - 2.4 | 1.5 | 1.2 |
| Superior | 75% | 0.4 - 0.8 | 1.5 | 0.5 |

- Mean effective media size is the size of mesh opening which will pass 10% of sand sample.
- The uniformity coefficient is the ratio of size of mesh opening, which will pass 60% of filter sand/size of mesh opening, which will pass 10% of filter sand.

The total thickness of the sand layer shall allow sufficient filtration within a 0.3 bar headloss increase in differential pressure over the clean condition.

The filters shall be fitted with a semi-automatic cleansing system. Each filter shall be equipped with, on the upstream side and the downstream side, one each of a manometer, isolating valve,

air valve and a sampling tap connected to the pipe. The type of the manometers shall be adequate to the pressures to be measured (between 0 to 2 bar only).

The contractor shall supply the filters with a stock of spare sand, which will allow a complete renewal of each filter sand for the first year of operation and sieving equipment to enable staff to manufacture their filter media from ordinary sand. The spare sand shall be stocked in 200 litre drums and to be stored next to the storage tank.

### 6.10.4 Number of Sand Filters

In order to reduce head losses, and improve on the efficiency of filtration, an adequate number of typical filters shall be fixed in parallel in order to sustain the peak flows of about four times the peak flows. The contractor shall present his calculations, characteristics and the number of the filters to be within 30 days of commencement of works.

## 7 TREATMENT UNITS

### 7.1 Intake Structure

Intake structures shall be constructed upstream of abstraction point. An intake structure shall consist of an intake well with an abstraction trough. An infiltration gallery consisting of 200mm uPVC pipes and 50mm slotted pipes will abstract raw water from the intake well. The intake well shall be covered with rough filter material to strain unwanted material from the raw water. The intake shall be connected to the treatment plant using uPVC or galvanised pipes.

### 7.2 FILTER UNITS

Filter units shall be provided for treatment of surface water sources.
Influent and effluent pipes and all pipe work shall be embedded in the filter walls. Pipe work shall consist of uPVC pipes (mainly 75mm diameter) class C.

### 7.2.1 Slow Sand Filters (SSF)

The filter under drain system of a slow sand filter shall comprise perforated lateral uPVC Class C pipes. These pipes shall discharge into a centrally located effluent pipe. The lateral pipes shall be equally spaced (1m centres and 0.5m from the walls). Each lateral pipe shall be perforated. The effluent pipe shall be placed a minimum of 0.1m above the sand level.

### 7.2.2 Upflow Roughing Filters (URF)

A URF shall have a false filter bottom used as a drainage facility. The false bottom shall consist of perforated concrete slabs of a minimum 50mm thickness installed on concrete blocks of a minimum height of 150mm with 6mm open joints between th blocks.

### 7.2.3 Horizontal Roughing Filters (HRF)

HRF shall have 75mm diameter perforated uPVC Class C pipes as drainage pipes.

### 7.2.4 Ball Valves

The filters and iron removal plants shall be controlled by quarter-turn ball valves regulating the flow. An inlet chamber shall be constructed on top of the filter box on the SSF and URF. A V-notch is installed in the inlet chamber and the regulating valve and the float shall be placed in the inlet box. The float valve shall be of an adjustable type and is used to set the water level in the inlet box and thereby the flow over the v-notch and into the filter.

Float valves shall be used as controls in the URF.

## 7.3 REINFORCED CONCRETE FILTER BOX

### 7.3.1 General

All filter components shall be constructed of reinforced concrete to the concrete specifications provided above. As far as practicable each element of the filter boxes shall be cast in one operation. Rubber water bars shall be provided at all joints.

### 7.3.2 Foundations

Sites for filter boxes shall be excavated to a minimum of 500mm, unless a uniform rock base is reached. However, any large boulders found shall be removed and backfilled to the satisfaction of the Supervisors Representative. The base of the excavation shall be levelled and aggregate (20-30mm) be placed in to a level of 300mm minimum.

### 7.3.3 Base Slab

A concrete blinding layer of 50mm shall be cast over the aggregate and carefully finished to provide a smooth and level surface for the construction of the base slab. The base slab shall be constructed in one continuous operation together with kickers of 100mm height. Starter bars for walls shall extend at least 600mm above the surface of the kickers. The kickers shall be prepared for the formation of a construction joint.

### 7.3.4 Filter Walls

As far as practical vertical walls of filter boxes shall be poured in one continuous operation. Alternatively, a rubber water bar shall be placed if the need for a construction joint. There shall be sufficient overlap between vertical reinforcement bars and starter bars. External formwork shall be left in place for 14days to enable proper curing of concrete. The internal formwork may be removed after 24 hours to allow for the construction of the soffit of other components of the filter.

### 7.3.5 Quality of Materials

The media used for the treatment plant shall be hard, clean and inert gravel and shall be free from all organic matter. The sizes of media require are as specified as below:

For up-flow roughing filters the filter media shall be graded as follows:

| Turbidity | < 20 NTU | 20 – 50 NTU | 50 – 150 NTU |
|---|---|---|---|
| | Gravel 18 – 24 mm | Gravel 12 – 18 mm | Gravel 8 – 12 mm |
| | Gravel 12 – 18 mm | Gravel 8 – 12 mm | Gravel 4 – 8 mm |
| | Gravel 8 – 12 mm | Gravel 4 – 8 mm | Gravel 2 – 4 mm |
| | | | |

For horizontal roughing filters the filter media shall be graded as follows:

| Turbidity | 150 – 250 NTU | 250 – 1000 NTU |
|---|---|---|
| | Gravel 12 – 18 mm | Gravel 8 – 12 mm |
| | Gravel 8 – 12 mm | Gravel 4 – 8 mm |
| | Gravel 4 – 8 mm | Gravel 2 – 4 mm |
| | | |

For slow sand filters the filter media shall be graded as follows:

Gravel 0.4 – 0.6 mm to underdrain
Gravel 1.5 – 2 mm to underdrain
Gravel 5 – 8 mm to underdrain
Filter sand of size 0.15 – 0.35 mm with uniformity co-efficient of 1.5 – 3.

Material for use in filters shall be broken stones or rocks from a quarry. All materials shall be approved by the Supervisors Representative before being used on site.

**7.3.6 Testing of Filter**

The filter box shall be tested for water tightness before commissioning. This shall be done after the cleaned. It is then filled with water and the water tightness test carried out as for tank receptacle.

**7.3.7 Disinfection of Filter Boxes**

After testing for leakages, the filter box is filled with potable water containing free chlorine (at least 50mg/l concentration) and left to stand for at least 24 hours, after which samples are taken to measure the residual chlorine. The measured concentration of the residual chlorine should not be less than 10mg/l.

**7.3.8 Water Quality Test**

Water Quality shall meet the relevant Ghana Standards Board (GSB) criteria for drinking water. After four weeks of operation, a water sample shall be taken for bacteriological, physical and chemical analysis. All parameters shall meet the GSB standards.

## 8. CONTROL HOUSE

### 8.1 FOUNDATIONS OF CONTROL HOUSE

The foundations shall be the continuous footing type, placed on blinding. The depth of the foundation shall be to solid ground or 750 mm from the ground level, whichever is deeper. In flood-prone areas, the floor level shall be at least 300 mm above the highest known flood level and in areas not flood prone, the floor level shall be 300 mm from the existing ground level. The space between the foundation and the walls shall be filled with selected material placed in layers not exceeding 100 mm thickness after compaction, wetted and compacted with wooden tampers or mechanical vibrators. On top of this backfill the floor slab of the building shall be cast.

### 8.2 FLOOR SLAB OF THE CONTROL HOUSE

The floor slab will be reinforced with No. 65 BRC mesh to BS 4483 specified above or in its with 6mm mild steel rods fixed at 100 mm centres both ways, which should be placed at the bottom of the slab together with ground clips. UPVC cable ducts must be positioned in the formwork in such a manner that concrete cover is a minimum of 50 mm.

In the control room, the groove on the drawing has to be provided and spared. The slab and the plinths shall be screeded with 50 mm granolithic concrete as described in "Granolithic Concrete" above.

### 8.3 BLOCK WORK

The cement shall be as before described in “Concrete Work”. The sand for mortar shall comply with BS. 1200

The cement mortar shall be to the proportions of one part of cement to four parts of sand by volume. The mortar shall be used within one hour of mixing. Such mortar shall not be used for mixed with any other mortar after it has begun to set nor shall any kind of the previous days' mixing be used. A proper timber or concrete stage shall be provided to receive the mortar when made.

The whole of the block required shall be made on the site in approved machine, to be provided by the contractor and shall have a minimum crushing strength of 4 MPa of gross area at 28 days. The blocks shall be composed of one part of cement to five parts of sand by volume, unless otherwise specified or directed on site, turned three times dry until of an even colour and consistency throughout. Water shall them be added gently from a watering can through a hose, the quantity of water added being just sufficient to secure adhesion. After wetting, the mixing should be turned over three times and well rammed into moulds and smoothed off with a steel-faced tool. After removal from the machine on pallets, the blocks shall be matured in the shade in separated rows one block high a space between each block, for at least 24 hours. They shall then be removed from the pallets but shall not be stocked up or removed from shade for at least a further 7 days them stacked not more than 5 blocks high in shade for a minimum of 14 days and kept well-watered at all times.

Alternatively, blocks meeting the specifications above may be obtained from an approved manufacturer. No blocks shall be built into the building until they have been matured for at least 28 days. The faces of blocks, except where otherwise described shall be left rough for plastering or rendering. The blocks shall be 450mm long 225mm deep and generally be of the 'holes' type with 31mm minimum wall thickness. Blocks of special size, and shape shall be solid. All shall be cast true to shape, even in size, square and free from flows or bore- holes with clean and sharp arises and equal to a sample approved by the Supervisor's Representative. All blocks shall be careful handled. Blocks with broken arises shall not be use.

The block work shall be carried up in a uniform and even manner. No one portion shall be raised more than three feet above another at any time. The work shall be carried up course by course and the height of any four courses when laid shall be one metre.

All perpends and quoins shall be kept strictly true and square and all work properly bounded together and levelled through every second course. All corners cross wall junctions and reveals shall be properly bounded. Special care shall be taken that all vertical joints are filled with mortar.

All internal and external faces shall have raked out joints for plaster or render unless otherwise specified. All blocks shall be thoroughly wetted before being laid or built on. Any defective blocks found in the work shall be out and replaced by sound ones at the contractor's expense.

**8.3.1 Plastering**

All exterior and interior concrete block and concrete surfaces to buildings shall be rendered. Rendering shall be applied in two coats: an undercoat of 12 mm thick and scored to form a key for the second coat, which shall not be less than 6 mm thick. The mortar for both coats shall be in 1:4 cement-sand.

**8.3.2 Reinforced Concrete Lintel**

The lintel for walls with doors and windows shall be made of Reinforced concrete 1:2:4 mix, with maximum size of aggregate 40 mm. The reinforcement shall be as shown on the drawing of the control house.

**8.3.3 Doors and Windows**

All doors and windows and frames shall be made to the exact sizes shown on the drawings and shall fit snugly into the openings left for them. Door or window frames shall be either screwed to the block work or secured with 100 mm nails at 450 mm centres driven into the back of a 50 mm frame and built into every other course.

The external doors shall be completely weatherproofed and shall be of approved seasoned hardwood, securely put together with white lead. Windows shall be completely weather tight and weatherproof. Shutters shall be in timber.

**8.4 CARPENTRY AND JOINERY**

Timber shall be from an approved sawmill, be sound, well-conditioned and properly seasoned to suit the particular use, straight grained, and free from defects or combination of defects rendering it unsuitable for the purpose intended and containing not more than 15% moisture for joinery work or 18% moisture for carpentry work.

Structural timber is to be approved hardwood as specified of strength grade 2 supplied in long lengths, with a tolerance of 5mm on scantling, but of uniform width and thickness. Boards and scantlings, which are specified as 25mm or less in thickness, are to hold up to the full size. Structural timber shall be deemed to be sawn on all faces unless otherwise stated as wrought.

Joinery timber shall be select grade hardwood as specified by the Supervisor's Representative and shall be held to be wrot by machine dressing unless otherwise stated.

All timber for the Works is to be purchased immediately the Contract is signed and is to be open stacked for as long as possible use kiln or dried.

All timber and assembled woodwork shall be protected from weather and stored in such a way as to prevent attack by termites, insects, decay or fungi. Any timber brought to the site and rejected by the Supervisor's Representative shall be removed from the site at the Contractor’s expenses.

**8.4.1 Carpentry**

The whole of the carpentry work shall be accurately set out and framed in a workmanship-like manner and fitted with bolts and screws. All joints, battens, purlins, rafters and sprockets are to be sawn square, purlins shall be as long as possible. The roof shall be framed as shown on the drawing.

**8.4.2 Roofing**

Roofs shall be covered with corrugated aluminium sheets. Roofing ceiling sheets must be overlapped 150 mm and fixed to hardwood purlins at 1200 mm centres with drive screws and washers in accordance with manufacturer’s instructions.

**8.4.3 Ceiling**

Ceiling in the control room shall be as shown on the drawing and to be in 6mm plywood.

**8.4.4 Painting**

All woodwork shall be properly rubbed down and painted 2 coats of oil paint after priming with one coat of lead primer. Plaster shall be painted with 3 coats of emulsion paint. Before painting all plaster will have dried thoroughly and any efflorescence on the surface shall have been removed by dry brushing. The colours used for control houses should generally be white and blue.

**8.4.5 Internal Water supply**

Each control house shall be equipped with a a tap with hose connection. Water shall be taken from the transmission line directly with a pressure-reducing valve installed if the control house is remote from the distribution lines.

**8.4.6 Ironmongery**

Where items of ironmongery are not specified by manufacturer's catalogue reference, the Contractor shall submit for the Supervisor's Representative's approval within one month of the date of possession of site, specifications including manufacturers catalogue reference numbers of the item he proposes to purchase.

Prior to fixing any item of ironmongery, the Contractor shall obtain the Supervisor's Representative's approval of a sample.

All keys must differ unless instruction to the contrary is given in writing by the Supervisor's Representative.

All locks and fittings are to be tested to make certain that they are well oiled and work properly and easy and all left in good order at completion.

Mild steel shall be free from all defects and shall comply with the requirements of BS> 15.

All welding shall be in accordance with BS. 938 neatly ground, filed and cleaned off. The units shall be fabricated in the shop wherever possible and only the minimum of site welding employed.

All mastic sealers for bedding shall be approved by the Supervisor's Representative. They shall be of such composition that they will not stain surrounding materials, will receive paint without bleeding, will not sag or run and will not set hard or dry to under any conditions of climate or temperature recorded in the locality of the site.

**8.4.7 Plumbing**

All materials shall conform with the relevant British Standard and the whole of the installation is to comply with the requirements of the Local Authority and to the approval of the Supervisor's Representative. All runs of pipes are to be agreed with the Supervisor's Representative before work is commenced.

Cast iron pipes fittings and accessories shall comply with BS. 416, asbestos cement pipes and fittings shall comply with BS. 569. The prices for asbestos cement and cast iron pipes are to include for all cutting and waste and fixing with approved holderbrats at 1.50 metre centres where applicable. The prices of fittings shall include for the extra joints.

Galvanized steel tubing shall comply with BS. 1387 with plain galvanized malleable cast iron fittings complying with BS. 1256. The prices for galvanized pipes are to include for fixing with approved clips or brackets, all short length, nipples and couplings, cutting and waste, threading and for made bends in pipes not exceeding 19mm diameter. The prices of fittings shall include for the extra joints. The prices of fittings shall include for the extra joints.

Plastic pipes, fittings and accessories shall be of an approved colour heavy grade PVC obtained from an approved manufacturer.

PVC tubing shall be jointed strictly in accordance with the manufacturer's instructions and fixed with approved brackets or clips. The prices for tubing are to include for all short length, couplings, cutting and waste and for made-bends in pipes not exceeding 19mm diameter. The prices of fittings shall include for the extra joints.

The pump house is to be equipped with a lockable writing desk with two drawers, a chair and a shelve for holding some spares which cannot be placed on the floor of the pump house.

## 9. STANDPIPES

### 9.1 CONSTRUCTION OF STANDPIPES

The site shall be excavated to remove all topsoil and to a minimum depth of 300mm and built up with hard-core or aggregate if necessary. A layer of 50mm of blinding concrete shall be placed over this base and the surface finished providing an even sloping surface for the construction of the base slab. A layer of reinforcement shall be provided to control cracking of the base slab and this reinforcement shall extend into the pillar.

The formwork shall be arranged so that the base slab slopes towards the drainage channel, which shall be formed in the concrete with a piece of shaped wood. After placing the concrete, it should be covered with heavy-duty polythene sheet or moist sand for a minimum of 7 days. The surface of the slab shall be finished by floating while the concrete is still fresh. Addition of a topping to the dry concrete is not acceptable.

The valve and meter box shall be of prefab steel construction and fitted with a steel door all according to the detailed drawing and cast into the centre concrete pillar.

The soak-away shall be made outside the standpipe concrete slab, situated approximately3 meters away from the standpipe platform. The soak away is made of reinforced concrete and equipped with precast concrete cover slabs. Lifting handles in the cover slabs shall be fitted in tubes cast through the slab so that when not in use they lie on top of the slab.

## 10. PIPEWORK

### 10.1 GENERAL

Pipework laid in trenches shall not have diameter less than 50 mm and shall be of UPVC or Galvanised Iron pipes.

Pipework above ground level, across water bodies, culverts or bridges in/or on buildings shall be in cast iron, ductile iron, galvanised iron or steel pipes with the inside and outside corrosion protected.

For pipes smaller than 50 mm GI pipes shall be used. The pipes shall be supported by means of pipe hangers and/or brackets to be approved by the Engineer at 3.0 m centres. These pipe hangers shall allow removal of any part without having to unseal the laid pipe. Pipes that run across deep gorges shall be supported on reinforced concrete pillars at intervals of 3 m and shall be held in position by collars and brackets allowing for easy dismantling.

While laying pipe from below ground level to above ground level, the change from steel or ductile iron to PVC shall take place below the ground level. The contractor shall wrap the buried DI pipe with corrosion protection tape to be approved by the Engineer. All necessary supports, saddles, slings fixings, bolts and foundation bolts shall be supplied to support the pipework and its associated equipment in an approved manner. Changes in pipe-bore sizes shall only be allowed by the use of proprietary fittings to avoid sudden changes. All pipes laid above ground shall be painted with 3 coats of oil paint.

**10.2 PIPES BUILT INTO STRUCTURES**

The external surface of all pipes and fittings to be built into structures shall be thoroughly cleaned and free from any oily substance immediately before installation. Where ordered, the protective coating at a section of metal pipe to be built-in shall be removed and caulked prior to building-in after which a coating of bituminous material shall be applied to all exposed surfaces of the barrel of the pipe as before. For clay ware and concrete pipes, the external surfaces shall be hacked to provide for good anchorage before building-in.

Pipes passing through water retaining structures shall have an integral puddle flange built in-situ into the structure. Shuttering shall fit closely to pipe barrels and concrete placed and compacted thoroughly around the pipe and the puddle flange. Where fixing is not possible during the course of the work, the locations shall be temporarily boxed-out to accommodate the subsequent insertion of the prepared pipe and fittings. The opening shall be made to taper towards the dry face of the structure and shall include a water stop.

**10.3 UPVC AND HDPE PIPES**

uPVC pipes shall comply with BS 3505 and BS 3506. The fittings shall comply with BS 4346 and BS 8062. Pipes up to 75 mm diameter shall be glue-jointed, but joints on larger diameters shall be mechanical, of the "Spigot & Socket" type with rubber ring sealing.

Jointing of pipes shall be carried out in strict compliance with manufacturer's instructions. Glue joints shall be made only with the glue recommended by the pipe manufacturer. Glue that has passed its expiry date shall not be used under any circumstances.

The HDPE pipes should conform to metric pipe pressures ISO 4422 standard. Pipes shall be joined by coupling or butt welling.To simplify maintenance works in the future, pipe sizes are restricted to those below specified:

| Internal diameter (mm) | Pressure (PN 10) | Pressure (PN 16) |
|---|---|---|
| | Wall thickness (mm) | |
| HDPE 32 | 1.80 | 2.40 |

| | | |
|---|---|---|
| HDPE 40 | 2.40 | 3.7 |
| HDPE 50 | 3.0 | 4.6 |
| HDPE 63 | 3.8 | 5.8 |
| HDPE 75 | 4.5 | 6.8 |
| HDPE 90 | 6.6 | 10.0 |
| HDPE 110 | 6.6 | 10.0 |
| 40 | 1.90 | 3.00 |
| 50 | 2.40 | 3.70 |
| 75 | 3.60 | 5.60 |
| 100 | 7.00 | 9.30 |
| 150 | 8.00 | 12.00 |
| 200 | 9.60 | 14.90 |
| 250 | 10.0 | 16.0 |

- The unit prices of pipe laying shall include:

- Cutting and clearing of vegetation from pipe routes
- Supply of pipe
- Thrust blocks for tees and elbows
- Supply and Installation of fittings
- Excavation
- Sand bedding and sand topping of pipe
- Backfilling and provision of erosion checks where necessary
- Provision and installation of pipe markers

**10.4 CAST IRON OR DUCTILE PIPES**

DI pipework shall generally be in accordance with BS 4772 or equivalent. All pipes and fittings shall be protected against corrosion with internal cement mortar lining and external zinc and bitumen coatings in accordance with BS 3416 or equivalent for use with potable water supplies.

Spigot and Socket iron pipes shall be jointed with mechanical flexible joints. All flexible joints shall be made in strict compliance with manufacture's jointing instructions. Flange joints shall be made with rubber joint rings or other approved material.

In making the mechanical joint, the gland shall be placed on the spigot end of the pipe closely followed by the rubber gasket after both have received a coating of the manufacture's recommended lubricant to properly lubricate them. The spigot shall then be inserted on to the socket. The gasket shall be pressed into place within the socket and then the gland moved up into position for bolting. The bolts and nuts shall then be assembled by hand and tightened evenly with a suitable spanner. Care shall be taken with the bolts at the bottom of the gland.

These pipes shall be able to withstand a nominal pressure of 25 bars.

| **Pipe Diameter (in)** | **Pipe External Diameter (mm)** | **Pipe Internal Diameter (mm)** |
|---|---|---|
| 2 1/2 | 77 | 63 |
| 3 | 98 | 86 |
| 4 | 118 | 105.8 |
| 6 | 170 | 157.4 |

The unit prices of pipe laying shall include:

- Cutting and clearing of vegetation from pipe routes
- Supply of pipe
- Supply and Installation of fittings
- Excavation
- Sand bedding and sand topping of pipe
- Backfilling and provision of erosion checks where necessary
- Provision and installation of pipe markers
-

**10.5 STEEL PIPES**

Steel pipes and fittings over 80 mm diameter, shall be carbon steel in accordance with BS 8601 or equivalent. Joints shall be flanged or welded. Joints to fitting of other material than steel are only allowed with flanges properly separated with rubber gaskets.

Flanges on steel pipes shall be welded in accordance with BS 2633 or BS 2971 or equivalent and shall have raised or flat faces.

Steel pipes that have to be welded shall be made free of external coating for a distance of 75 mm from each weld line.

After fabrication all welding scale and beads as well as hardened fluxes shall be removed and joints shall be free of pores and as smooth as possible.

For fixing of pressure gauges, air-release valves and for connecting of small diameter GI pipes or injection valves, female threaded sockets shall be welded on to the steel pipes. Following this procedure the steel pipe shall be drilled and burrs from drilling shall be removed.

Completed welds shall have a substantially uniform cross-section around the entire circumference of the pipe. At no point shall the crown surface be below the outside surface of the pipe. All joints on which welding has started shall be completed before the end of each day's work.

For corrosion protection, steel pipes shall be coated with a paint corresponding to BS 5493 SL 5. This painting shall be:

(a) Two coats of two-pack epoxy zinc phosphate primer
(b) Two coats of two-pack epoxy under coat
(c) One coat of chlorinated rubber finishing coat

Alternatively, the finishing coat shall be two-pack polyurethane.

**10.6 GI PIPES**

Pipework for sanitary installations in control house where specified, shall be of galvanised mild steel. Joints shall be screwed. Pipes and fittings shall comply with BS 1887. The tapered internal and external threads shall comply with BS 16.

**10.7 JOINTS FOR PIPES OF DIFFERENT MATERIALS**

For joints between different materials and valves generally, flanges or joints as specified in the relevant contract drawings.

**10.8 FITTINGS**

**10.8.1 Air Valves**

Air valves shall be fixed at the highest points of mains and also on flat gradients of under 1 in 500 where distances are more than 800 m, they shall be provided at 800 m centres or part thereof. They shall be the double-orifice type with a large and a small orifice for automatic release of air under normal working pressure. The valve shall be suitable for the maximum working pressures in the systems, and tested for mechanical strength at 1.5 time's maximum working pressures. The testing pressure is 10 bars. Air valves shall be provided with an isolating valve and flanged end connections and shall be housed in a chamber.

**10.8.2 Gate/Sluice Valves**

Gate/Sluice valves are used when the flow through a pipe is to be controlled. They shall be inserted on branches of pipes within 1.5m of the junction for isolation of the branches for maintenance purposes. Gate/Sluice valves shall have cast iron bodies and bronze mountings. They shall be double-flanged to enable them to be removed, repaired and re-inserted without disturbing the rest of the pipe lines or jointed in accordance with BS 5163, housed in a manhole with a lockable cover as shown on drawings. The valves shall be the non-rising spindle type that has the screw totally enclosed within the cast iron casing shall be operated by a hand wheel that open by turning anti clockwise. Valves, which are embedded in the ground, shall be provided with extension spindles, protection tubes, spindle caps and spindle supports. The valves shall be able to sustain a minimum of the working pressure of the system.

**10.8.3 Hydrants**

A fire hydrant, where instructed by the Engineer to be placed, shall be of an 80 mm diameter branch from the main with a duck foot on which rests the screw-down hydrant and standpipe.

**10.8.4 Non-Return Valves**

Shall be of cast iron body and be the single door swing or rolling ball type and shall comply with BS 5153. The direction of normal flow and the size of pipe shall be indicated on them.

**10.8.5 Pressure-Reducing Valve**

The pressure-reducing valve provides a constant pressure downstream at less than that upstream. It is desirable to install pressure-reducing valves near standpipes to let out not more than 10 m head at the standpipe.

**10.8.6 Pressure Gauge and Pressure switches**

Pressure gauges shall have concentric scale and have wide aperture 150 mm and shall comply with BS 1780 or equivalent. The gauge shall be isolated from the pressure line by an isolating cock. The entire installation shall be screwed to a female threaded socket welded on the pressure

line. The pressure switch shall be mounted on the line in the same way as the gauge and shall be isolated by an isolating cock.

**10.8.7 Washout Valves**
Washouts shall be branches of 80 mm diameter with an ordinary sluice valve control, leading from the mains to a ditch or a river. Washouts shall be provided with special branch tees having the invert of the branch coincident with that of the main to enable any sediment to be washed out of the mains completely. The outfalls of the pipes shall be built as shown on the drawings.

**10.8.8 Water Meters**
Production metres shall be of the in-line helical vane-type conforming to the requirements of BS 5728 or equivalent.

Meters shall be accurate to within +/- 2% over the range specified in BS 5728 and shall have flanged cast SG iron casing coated with epoxy enamel.

The rotor shall be manufactured from polypropylene with stainless steel shafts.

The counter shall be sealed and provided with a straight reading digital counter calibrated in cubic meters.

Counter covers shall be provided with a hinged poly-acetal or brass cover.

The meter shall be flanged and be supplied complete with a low strainer to prevent any large particles in the water from clogging the meters. The meters must be mounted in a distance of minimum 6 times diameter of pipe to the foregoing fitting, leaving a straight undisturbed flow section entering the meter.

Domestic water meters are specified below.

## 11. PIPELAYING

### 11.1 HANDLING AND STORING OF PIPES

When handling, transporting and laying pipes and accessories, care must be taken to prevent cracks and other damage to the pipes and the accessories. Special care shall be taken to keep the coating and lining of the pipes intact.

PVC pipes, rubber gaskets, glue, etc. shall always be stored under cover and in the shade.

In storage, pipes shall be arranged in such a manner that the pressure of pipes placed on each other will not cause cracking or deformation or damage to the pipe and/or the coating.

The interior and the machined ends of the pipes shall be kept free from dirt and foreign matter at all times.
Pipes shall not be moved by dragging or rolling them on the ground, but shall be lifted and placed carefully.

### 11.2 LAYING OF PIPES

Pipes shall be laid to a minimum cover of 900 mm under roads and footpaths and to a minimum invert of 900 mm below ground level elsewhere.

The pipes shall be laid to the lines and levels shown on the drawings and generally at a minimum gradient of 1 in 500. Each pipe shall be separately laid upon an even foundation of 100 mm sand bedding prepared as shown in the drawings and to be free from stones and any other projections. If the characteristics of the excavated material is found to be close to that of sand (grain size, uniformity, absence of hard bodies likely to damage pipe), the Engineer may approve the use of this material to be used wholly for the backfilling.

No pipe shall be laid in wet trench condition that precludes proper bedding.

Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes.

When pipe laying is not in progress, the open ends of installed pipes shall be closed by approved means. In case this is not adhered to, the Engineer is entitled to ask at the contractor's own cost for re-excavation and inspection of the incriminated pipe. The plugs shall be imperforated and shaped to close the pipe bore completely so water from the trench excavation shall not gain access into the pipeline. Whenever pipe is laid in water, water must be excluded from the pipe, and enough backfill shall be placed on the pipe to prevent it from floating. Any pipe that shall float shall be removed from the trench and re-laid. The procedure of working in water shall be approved by the Engineer.

Where curves of a long radius are required, these shall be obtained by deflection at the joints; such deflections, however, shall not exceed either vertically or horizontally the limits given in the relevant contract drawings.

Where a change of direction cannot be made by deflection at the joints or straight pipes, prefabricated bends shall be used.

**11.3 THRUST BLOCKS**

At all bends, reducers, tees, valves etc, concrete thrust blocks shall be cast which shall be carefully placed to ensure contact with undisturbed ground and to the dimensions to be given by the contractor in a drawing approved by the Engineer or his representative. The concrete mix ratio of these thrust plugs shall be able to withstand a pressure of 1.5 times MPS of the specific pipeline.

In order to ensure that the blocks fulfil their purpose, they must be in close contact with undisturbed ground and therefore, where timbering has been used during excavation, it must be withdrawn as the concrete is cast. The thrust block must be in place before testing of pipework.

**11.4 CUTTING OF PIPES**

No cutting shall be made on any kind of pipe with chisel and hammer. Where cutting is necessary it shall be done with an approved turning machine or approved cutting saw or knife. The cut and turned ends of pipes shall be neatly trimmed and burrs and sharp edges shall be removed.

**11.5 BACKFILING OF PIPE TRENCHES**

**11.5.1 Backfilling of Trench before and after Tests**

Sand topping of 100 mm from the crown of the pipe shall be provided and hand-punned into place and around the pipe with the exception of pipe joints and compacted by wooden rammers.

Additionally, in road crossings, 150 mm thick precast concrete slab of the same width as the trench shall be placed on the finished sand topping to distribute vehicular load.

Subsequent refilling with the right moisture content shall be placed and consolidated in 150 mm layers after compaction by mechanical means and carried to the original ground level.

The balance of backfill shall contain no stones more than 150 mm in their largest dimension, and the backfill mixture shall not contain more than 25% stones. The contractor shall not permit excavation to be used for disposal of refuse.

On completion of pressure and leakage tests, the exposed joints shall be backfilled according to the procedure of the backfilling before tests.

**11.6 RESPONSIBILITY OF THE CONTRACTOR**

Until final acceptance, the contractor remains responsible for any deformations or settling occurring in the vicinity of the backfilled trenches, which could result from a faulty execution of the work. The contractor shall obtain the necessary authorisations from the relevant authorities before proceeding to excavate in widely used public roads. In addition, he shall take all the precautions and minimum required guarantees to meet his civil liabilities, obligations in the work context.

**11.6.1 Testing of Pipelines**

Pressure test is to afford the contractor identify points of leakage and cracks in the laid pipe to be rectified. The contractor shall notify the Engineer 24 hours before a test is conducted.

The tests shall be carried out in sections of a length proposed by the contractor but not exceeding 500 m or 100 joints whichever is less. The test shall be carried out as soon as possible after laying of the section. Each section to be tested shall have been backfilled except the joints, which shall be left open for inspection. The contractor MAY also backfill the joints but has to bear in mind that he will have to re-excavate them at his own cost if the section does not pass the test. All thrust blocks on each line to be tested must have been cast at least 72 hours before testing.

All valves shall be operated and examined and a special check shall be made on the air valves for proper functioning. The contractor shall take care to properly close all valves on each section to be tested. Chambers, if completed shall be checked for proper finish and easy access.

Procedure to be followed for pipe testing:

- All valves within the testing section shall be opened fully
- Pipe section to be tested shall be cleaned using potable water
- Close off all temporary ends
- Fill pipe slowly with potable water and leave to stand for 24 hours before the start of the test
- Expel all air from the system
- Apply the pressure in increments of 1. 0 bar with a pause of one minute between each increment, until the requisite pressure or the nominal pressure of the pipe, whichever is higher
- The pressure drop measured shall not exceed 0.2 bars for 500 m of test section in 30 minutes or 2 hour for pipe section exceeding 500 m, but not more than 1500 m.

For the test the contractor shall supply the following equipment:
- A pressure gauge calibrated in meters of water column
- A low horsepower pump for filling of pipe
- A high horsepower pump for pressurising and performing the test

If a test fails, the contractor shall locate and repair the leakage(s) then repeat the test following the first procedure, all at his own expense. The test on each section shall be repeated until the specified degree of water tightness has been obtained.

An allowance shall be made for static head between the lowest point and the point of measurement if both are not on the same level.
The contractor shall establish a report of the test on an approved format.

The water for testing shall be free from silt, sand or grit and shall have no deleterious effect on the pipeline or fittings. The quality of the water to be used for the testing shall be approved by the Engineer or his representative.

The water in the test piece shall be discharged safely to a drain, stream or a river without harmful causing any effects or flooding to residents after the completion of the test on each section.

The test points shall be connected and well jointed and testing of the whole system shall be conducted for leakages of the tests points to the same pressure and by the same procedure as for the sectional testing.

The cost of preparing lines for testing and execution of tests including the supply of all necessary test equipment, supply of water for scouring, filling and testing the line, any work done in connection thereof shall be deemed to be included in the contractor's rates for pipe laying and jointing.

**11.7 STERILISATION OF PIPELINES**
All pipelines that have passed the pressure test as laid out, shall be flushed out until the wash water runs clear.

Sterilisation of pipelines shall be effected by introducing a chlorine solution (the chlorine solution shall be derived from a 1% solution of calcium hypochlorite in water or chlorinated lime, also called "bleaching powder" or liquid sodium hypochlorite known as "liquid laundry bleach"), in a concentration of 25 mg per litre into the pipeline so that a residual-chlorine of not less than 10 mg per litre remains in the water after 24 hours standing in the pipes during which time, all intermediate valves shall be operated at least once.

The point of measurement of the residual chlorine shall be the furthest from the point of injection of the solution. If the free chlorine is less than 10 mg per litre, the sterilisation process shall be repeated until this value is achieved or bacteriological tests are conducted in an approved laboratory showing that the pipeline is not contaminated.

In all cases, bacteriological tests shall be conducted and results submitted to the Engineer before the system is commissioned.

Upon the issue of a satisfactory bacteriological test reports, the chlorinated water shall be flushed out, the pipeline recharged with potable water and taken into service. The contractor shall

dispose off the waste chlorinated water in a manner avoiding pollution of natural waters, reservoirs and artificial watercourses.

The client will supply, free of charge sufficient potable water, for one sequence only of the scouring, disinfecting, re-charging and commissioning procedures as defined. The contractor shall allow in his rates, for any re-disinfections including the cost of potable water, deemed necessary by the supervisor's representative, all laboratory bacteriological tests, the provision and injection of chlorine solutions, all temporary works, labour, equipment and other items necessary for the specified procedures.

### 11.8 PIPELINE MARKERS

Pipe line indicators in class B concrete and according to the approved drawing of the contractor shall be supplied and installed by the contractor 1000 mm from the centre of the pipeline at 100 m intervals, and at all junctions, locations of valves, washouts, road crossings and all characteristics points on the mains. The pipe markers shall be placed as far as possible from roads along which pipes have been laid.

The pipe marker shall be engraved with the symbol of the item by which it is placed and shall also show the direction of pipeline.

The indicator posts shall be set up in holes dug into the ground and backfilled with tamped earth, and where in rocky ground, shall be concreted.

## 12. HOUSE CONNECTIONS

### 12.1 EQUIPMENT AND PROCEDURE

House connections should as far as possible be made during the time when the pumps are not operating and the pipe concerned is not under pressure. Therefore, the pipe section has to be isolated also from the elevated tank by the corresponding gate valve.

For connecting the G1 20mm (3/4") service line to AC mains, pipes saddles with flexible "wrap around" straps shall be used. Between the strap and the pipe, a rubber gasket must be laid for protection unless the gasket is not part of the saddle. Part of the saddle must be a female threaded cast iron body, with nuts or screw to span the straps. Between pipe and iron body a rubber gasket shall provide sealing between pipe and drilling opening.

For UPVC pipes full circle pipe collars have to be used so as not to deform the pipe cross-section. The collar as well as the body can be carried out before fixing the saddles.

If drilling under pressure is unavoidable, O-ring shuts off adapters must be used. For drilling under pressure special equipment provided by the manufacturer of the saddles are recommended.

On top of the saddles body a right-angle service valve (ferrule) as shown in the relevant drawings shall be screwed. The service valve must be equipped with a vertical spindle, and thread connections suitable for connecting a 20mm GI pipe or "push in type" connection suitable for connecting a 20mm GI UPVC pipes. An extension spindle in a protecting tube shall be set on top of the service valve. The extension spindle and the protecting tube have to be adjusted to the ground level by cutting. Alternatively telescope extension spindles can be used. A surface box and a base plate shall be set on top of the spindle. The backfill has to be properly compacted, and the surface box shall be half buried.

Alternatively, special connection points for private connections shall be provided on the pipe mains. House connections as far as practicable shall be made from these connection points. Each connection point shall take five connections and the points shall be on distribution mains.

The connection point shall be located in a manhole with the following minimum inside dimensions: 1 m x 1.4 m, Depth 1 m. This particular manhole shall be sized so as to contain 5 ND 63 pipes, which are connected to the 5 volumetric meters.
This item includes supply and installation of all pipes and fittings, including this specific manhole. It also includes the supply but not the installation of the five (5) volumetric meters, which shall be given to the WSDB.

The connection point for private connections is composed of the following:
- 5 domestic water meters, with 5 spherical ball valves ND 25,
- approximately 1,5 m of ND 25 (1") galvanised pipes, in 5 parts,
- 5 tees in ND 63 (2"1/2) galvanised pipe,
- approximately 1,5 m. of ND 63 (2"1/2) galvanised pipes,
- a spherical ball valve, ND 63 (2"1/2), downstream from pipe tapping collar,
- a pipe-tapping collar on the main pipe, including a union coupling between the HDPE and galvanised pipes,
- 2 steel clamp supports for the ND63 galvanised pipe.

**12.2 SERVICE LINE**
Pipe materials shall be of 20mm UPVC pipes. In any case, the pipe section above ground level shall be GI. The line must rise from the pipe connection towards the connected building as shown in the relevant contract drawing.

**12.3 DOMESTIC WATER METER**
The meters are intended for measurement of flow of potable water in household connections in outdoor conditions; at a nominal pressure of PN 10 and temperature ranging from 10 to 38 Degree Celsius. Meters may have to withstand ambient temperature of up to 50 Degree Celsius in humid tropical conditions.

The water meters shall be manufactured in accordance with International Standards, such as OIML R 49, ISO 4064/1, BS 5728, or equivalent provided that they meet the requirements of these specifications. These specifications must be considered as binding.

Measurements by the meters shall be electronic measurements based on the ultrasonic principle. All meters shall be supplied complete with connectors and washer
Water quality standard is shown below:

| Parameter | Units | Standard |
|---|---|---|
| pH | | 6.5 – 8.5 |
| Colour | H.U. | 15 |
| Turbidity | NTU | 5 |
| Chlorine Residual | mg/L | 0.5 |

| | | |
|---|---|---|
| Iron | mg/L | 0.3 |
| Manganese | mg/L | 0.1 |

A stop cock must be mounted before the meter and a non-return valve after the meter. If pressure exceeds 10 bar a pressure reducing valve is additionally required.

## ENVIRONMENTAL, SOCIAL, HEALTH AND SAFETY REQUIREMENTS

### Safety, Security and Environmental Management

### General

1. Before the order to commence any works, the contractor is required to implement the Environmental Management Plan (EMP) for the project as specified in the Environmental Impact Statement (EIS) prepared for this particular Project. The plan shall spell out how the contractor should achieve environmental targets and objectives specified in the EMP (Excerpts available for reference). The plan shall include, to the extent practicable and reasonable, all steps to be taken by the Contractor to protect the environment in accordance with the current provisions of national environmental regulations and or the EMP established for this project.

2. Notwithstanding the contractors' obligation under the above clause, the Contractor shall implement all measures necessary to restore the sites to acceptable standards and abide by environmental performance indicators specified under the EMP to measure progress towards achieving objectives during execution or upon completion of any works. These measures shall include but not limited to the following: -

(a) Minimize the effect of dust on the surrounding environment resulting from earth mixing sites, asphalt mixing sites, dispersing coal ashes, vibrating equipment, temporary access roads, etc. to ensure safety, health and the protection of workers and communities living downwind of dust producing activities.

(b) Ensure that noise levels emanating from machinery, vehicles and noisy construction activities are kept at a minimum for the safety, health and protection of workers within the vicinity of high noise levels and communities near rock - blasting areas.

(c) Ensure that existing water flow regimes in rivers, streams and other natural or irrigation channels is maintained and/or re-established where they are disrupted due to civil works being carried out.

(d) Prevent bitumen, oils, lubricants and waste water used / produced during the execution of works from entering into rivers, streams, irrigation channels and other natural water bodies/reservoirs and also ensure that stagnant water in uncovered borrow pits is treated in the best way to avoid creating possible breeding grounds for mosquitoes.

(e) Prevent and minimize the impacts of quarrying, earth borrowing, piling and building of temporary construction camps and access roads on the biophysical environment including protected areas and arable lands; local communities and their settlements. In as much as possible restore/rehabilitate all sites to acceptable standards.

(f) Upon discovery of ancient heritage, relics or anything that might or believed to be of archeological or historical importance during the execution of works report such findings to National Commission on Culture (NCC) in fulfillment of the measures aimed at protecting such historical or archaeological resources.

(g) Discourage construction workers from engaging in the exploitation of natural resources such as hunting, fishing, collection of forest products or any other activity that might have a negative impact on the social and economic welfare of the local communities.

(h) Implement soil erosion control measures in order to avoid surface run off and prevents siltation etc.

(i) Ensure that garbage, sanitation and drinking water facilities are provided in construction workers camps.

(j) Ensure that in as much as possible, local materials are utilized to avoid importation of foreign material and long distance transportation.

(k) Ensure public safety and meet traffic safety requirements for the operation of work to avoid accidents.

3. The contractor shall indicate the period within which he/she shall maintain status on site after completion of civil works to ensure significant perturbations arising from such works have been taken into account.

4. The contractor shall adhere to the proposed activity implementation schedule and the monitoring plan / strategy to ensure effective feedback of monitoring information to project management and the Director / EPA so that impact management can be implemented properly, and if necessary, adapt to changing and unforeseen conditions.

5. Besides the regular inspection of the sites by Site Supervisor for adherence to specification, the Consultant for Engineering Supervision shall appoint an Inspector to oversee the compliance with and to inspect significant sites where works have been carried out and proposed mitigation measures implemented and shall give certification regarding the adequacy or inadequacy of rehabilitation measures carried out on the bio-physical environment and compensation for socio-economic disruption resulting from implementation of any works.

6. If the Contractor fails to implement the approved Environmental Management Plan after written instruction by the Engineer to fulfil his obligation within the requested time, the Client reserves the right to arrange through the Engineer for execution of missing action by third party on account of the Contractor.

**SPECIFIC ENVIRONMENTAL ISSUES TO BE CONSIDERED**

**Worksite/camp site Waste Management**

- All vessels (drums, containers, bags, etc.) containing oil/fuel/surfacing materials and other hazardous chemicals must be bunded in order to contain spillage. All waste containers, litter and any other waste generated during the construction shall be collected and disposed off at designated disposal sites in line with the Waste Management Regulations of the Environmental Protection Agency of Ghana.

- All drainage and effluent from storage areas, workshops and camp sites shall be captured and treated before being discharged into the drainage system in line with the Water Pollution Control Regulations of the Environmental Protection Agency of Ghana.
- Used oil from maintenance shall be collected and disposed off appropriately at designated sites or be re-used or sold for re-use locally.

- Entry of runoff to the site shall be restricted by constructing diversion channels or holding structures such as banks, drains, dams, etc. to reduce the potential of soil erosion and water pollution.

- Construction waste shall not be left in stockpiles along the road. Waste and other excess material shall be used for rehabilitating borrow areas and landscaping around the road.

- If other spoil disposal sites are necessary, they shall be located in areas, approved by the Engineer, of low land use value and where they will not result in material being easily washed into drainage channels. Whenever possible, spoiled materials should be placed in low-lying areas and should be compacted and planted with species indigenous to the locality.

**Material Excavation**

- Contractors will have to indicate the source of material such as gravel for concrete production, sand bedding of pipes or any other purpose.

- Contractors shall obtain appropriate licenses/permits from relevant authorities to operate quarries or borrow areas.

- The location of quarries and borrow areas shall be subject to approval by relevant authorities including traditional authorities if the land on which the quarry or borrow areas fall in traditional land and by the Environmental Protection Agency of Ghana.

- New Extraction sites shall not be located in the vicinity of settlement areas, cultural sites, wetlands or any other valued ecosystem component and shall not be located at less than 10km from such areas.
- New Extraction sites shall not be located adjacent to stream channels wherever possible to avoid siltation of river channels. Where they are located near water sources, borrow pits and perimeter drains shall surround quarry sites.

- New Extraction sites shall not be located in forest reserves. However, where there are no other alternatives, permission shall be obtained from the Ministry of Lands Forestry and Mines and an environmental impact study shall be conducted.

- New Extraction sites shall not be located on high or steep ground or in areas of high scenic value.

- Only sites that can easily be rehabilitated shall be chosen. Areas with minimal vegetation cover such as flat and bare ground or areas covered with grass only or covered with shrubs with height of less than 1.5 m.

- New Extraction site boundaries shall clearly be demarcated and marked to minimize vegetation clearing.

- Vegetation clearing shall be restricted to the area required for safe operation of construction work. Vegetation clearing shall not be done more than three months in advance of operation

- New Extraction sites shall not be located in archaeological areas. Excavations in the vicinity of such areas shall proceed with great care and shall be done in the presence of NHCC staff.

- Stockpile areas shall be located in areas where trees can act as buffers to prevent dust pollution. Perimeter drains shall be built around stockpile areas. Sediment and other pollutant traps shall be located at drainage exist from workings

**Material Deposit**

- The Contractor shall deposit any excess material in accordance with the principles of the EMP at areas approved by local authorities and/or the Engineer.

- The Contractor has in advance of the commencement of work clarify with the local authorities' dumpsites or areas for hazardous deposits for contaminated liquid and solid materials, that cannot be used any longer as backfill.

**Rehabilitation and soil erosion prevention**

- To the extent practicable rehabilitate the site progressively so that the rate of rehabilitation is similar to the rate of construction.

- Always remove and retain topsoil for subsequent rehabilitation. Soils shall not be stripped when they are wet as this can lead to soil compaction and loss of structure.

- Topsoil shall not be stored in large heaps. Low mounds of no more than 1 to 2m high are recommended.

- Re-vegetate the stockpile to protect the soil from erosion, discourage weeds and maintain an active population of beneficial soil microbes.

- Locate stockpiles where they will not be disturbed by future construction activities.

- To the extent practicable reinstate natural drainage patterns where they have been altered or impaired.

- Remove toxic materials and dispose off them in designated sites. Backfill excavated areas with soils or overburden that is free of foreign material that could pollute ground water and soil.

- Identify potentially toxic overburden and screen with suitable material to prevent mobilization of toxins.

- Ensure the reshaped land is formed so as to be inherently stable, adequately drained and suitable for the desired long-term land use and that would allow natural regeneration of vegetation.

- Minimize the long-term visual impact by creating landforms, which are compatible with the adjacent landscape.

- Minimize erosion by wind and water both during and after the process of reinstatement.

- Compacted surfaces shall be deep ripped to relieve compaction unless subsurface conditions dictate otherwise.

- Re-vegetate the area with plant species that will control erosion, provide vegetative diversity, and that will through succession; contribute to a stable and compatible ecosystem. The choice of plant species for rehabilitation shall be done in consultations with local research institutions, forest department and the local people, as they will be long-term beneficiaries.

**Water resources management**

- The contractor shall at all costs avoid conflicting with water demands of local communities.

- Abstraction of both surface and underground water shall only be done with the consultation of the local community and after obtaining a permit from the relevant Water Authority.

- Abstraction of water from wetlands shall be avoided. Where necessary, authority has to be obtained from relevant authorities.

- Temporary damming of streams and rivers shall be done in such a way that disruption of water supplies to communities downstream is avoided and maintain the ecological balance of the river system.

- No construction water containing spoils or site effluent especially cement and oil shall be allowed to flow into natural water drainage courses.

- Wash water from washing out of equipment shall not be discharged into water courses or road drains.

- Site spoils and temporary stockpiles shall be located away from the drainage system and surface run off shall be directed away from stockpiles to prevent erosion

**Traffic management**

- Location of access roads/detours shall be done in consultation with the local community especially where access road shall traverse important ecosystem component. Access roads shall not traverse wetland areas.

- Upon the completion of civil works, all access roads shall be ripped and rehabilitated.

- Access roads shall be sprinkled with water at least five times a day in settled areas and three times in unsettled areas to suppress dust emissions.

**Blasting**

- Blasting activities shall not take place in the vicinity of settlement areas, cultural sites, or wetlands and shall not be located at less than 10km from such areas.

- Blasting activities shall be done during working hours and local communities shall be consulted on the proposed blasting times

- Noise levels reaching the communities from blasting activities shall not exceed 90 decibels.

**Disposal of Relocated Elements**

- In some areas, no longer usable materials and construction elements will have to be disposed of, such as electro-mechanical equipment, pipes, accessories and demolished structures.

- The Contractor has to agree with the local administration of the Client, which of these elements are to be surrendered to the Clients premises, or in which way they could be recycled best.

- As far as possible unused pipelines shall remain at their current position. Where for any reason no alternative alignment for the new pipeline is possible, the old pipes have to be stored at a safe place to be agreed upon with the Client and the local authorities concerned.

- AC-pipes as well as broken parts thereof have to be treated as hazardous material and deposed subsequently as indicated before.

- Unsuitable and demolished elements shall be dismantled to size fitting on ordinary trucks to be transported for the purpose of recycling to an official scrap-yard.

- For each area where exists the probability of disposal of AC debris, the Contractor has to make arrangements with the Local Authorities for adequate disposal areas.

**Health and Safety**

- The contractor in advance of the construction work shall mount an awareness and hygiene campaign. Workers and local residents shall be sensitized on health risks particularly of AIDS and STDs
- Provide sex protective devices to employees to prevent unprotected sex
- Adequate road signs to warn pedestrians and motorists of construction activities, diversions, etc. shall be provided at appropriate points.
- Construction vehicles shall not exceed maximum speed limit of 40km per hour.
- Work safety gears such as helmet, hand grooves, construction boots etc, shall be provided to all employees for site operations

**Repair of Private Property**

Wherever the Contractor, whether deliberately or incidentally damages private property it has to be repaired. For each repair the contractor has to obtain from the owner the certificate, that the damage has been made good satisfactorily in order to indemnify the Client from subsequent claims.

In case where compensation for inconveniences, damage of crops etc. are claimed by the owner, the Client has to be informed by the Contractor through the Engineer. This compensation is in general be settled under the responsibility of the Client along with the particular EMP or even before signing the Contract. In unforeseeable cases the respective administrative entities of the Client will take care of compensation

**Cost of compliance with the EMP**

It is anticipated, that the compliance with the EMP is already part of standard good workmanship and state of art as generally required under this Contract. However, the awareness has to be conveyed to the Contractors staff. In addition, some costs are arising from establishing an individual EMP for each subproject or site respectively, as well as the related monitoring and reporting. The item “Compliance with the EMP” of the BOQ covers these costs. No other payments will be made to Contractors for compliance with any request to avoid and/or mitigate an avoidable negative environmental

# HANDPUMPS

## Introduction

The majority of people in the developing world gain access to groundwater either by means of a bucket and rope, or by using a handpump. Using a bucket and rope can be made easier if the well is provided with a windlass to help to lift the bucket. However, although easy to operate and repair, the bucket and windlass arrangement has serious disadvantages: it does not allow the well to have a cover slab which can be sealed to prevent ingress of polluted water or other contaminants, and the bucket and rope themselves are continually being polluted by mud and dirty hands. Therefore if the water to be raised from a well or borehole is for people to drink, it is preferable to instal a handpump.

## Main principle of handpumps

There are many different types of handpump. However, most of them are positive displacement pumps and have reciprocating pistons or plungers. In a piston pump, the piston is fitted with a non-return valve (the piston valve) and slides vertically up and down within a cylinder which is also fitted with a non-return valve (the foot valve). Raising and lowering the handle of the pump causes vertical movement of pump rods which are connected to the piston.

When the piston moves upwards, the piston valve closes and a vacuum is created below it which causes water to be drawn into the cylinder through the foot valve, which opens. Simultaneously, water above the piston, held up by the closed piston valve, is displaced upwards; in a simple suction pump it emerges through the delivery outlet; in a pump with a submerged cylinder it is forced up the rising main.

When the piston moves downwards, the foot valve closes, preventing backflow, and the piston valve opens, allowing the piston to move down through the water in the cylinder.

## Range of lift

The ranges over which water can be lifted are grouped in the following categories:

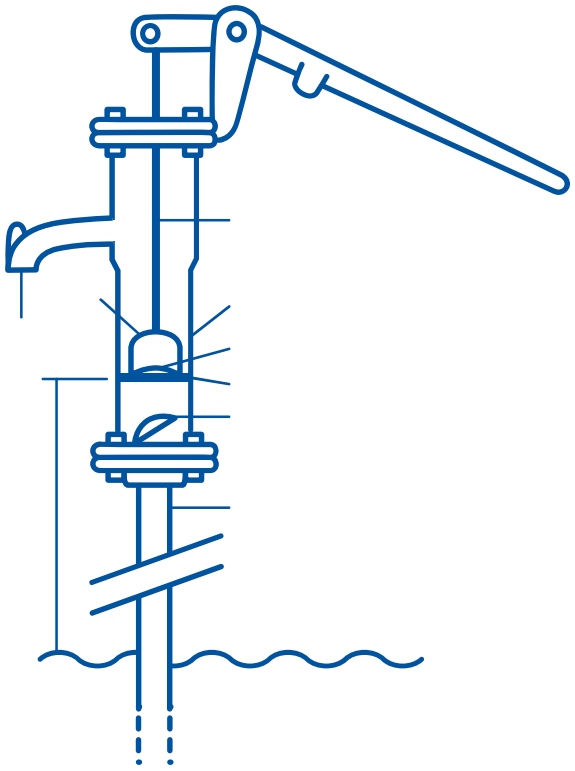
| | |
|---|---|
| Suction pumps | 0 – 7 metres |
| Low lift pumps | 0 – 15 metres |
| Direct action pumps | 0 – 15 metres |
| Intermediate lift pumps | 0 – 25 metres |
| High lift pumps | 0 – 45 metres, or more |

## Suction pumps

At shallow lifts the cylinder and piston operate by suction and can be housed in the pumpstand above ground. In practice, the maximum suction lift is about seven metres (i.e atmospheric pressure less about 30% system losses due to the ineffectiveness of seals, friction etc) and defines the working range of the suction pump.

Suction pumps have to be primed where seals have dried out or have been replaced; therefore they can be contaminated by dirty priming water. They have a limited range of application, but are the most numerous handpumps in the world, mainly because they are relatively cheap and are suitable for use as a household pump.

The following diagram shows a shallow well suction lift handpump:



# Low lift pumps

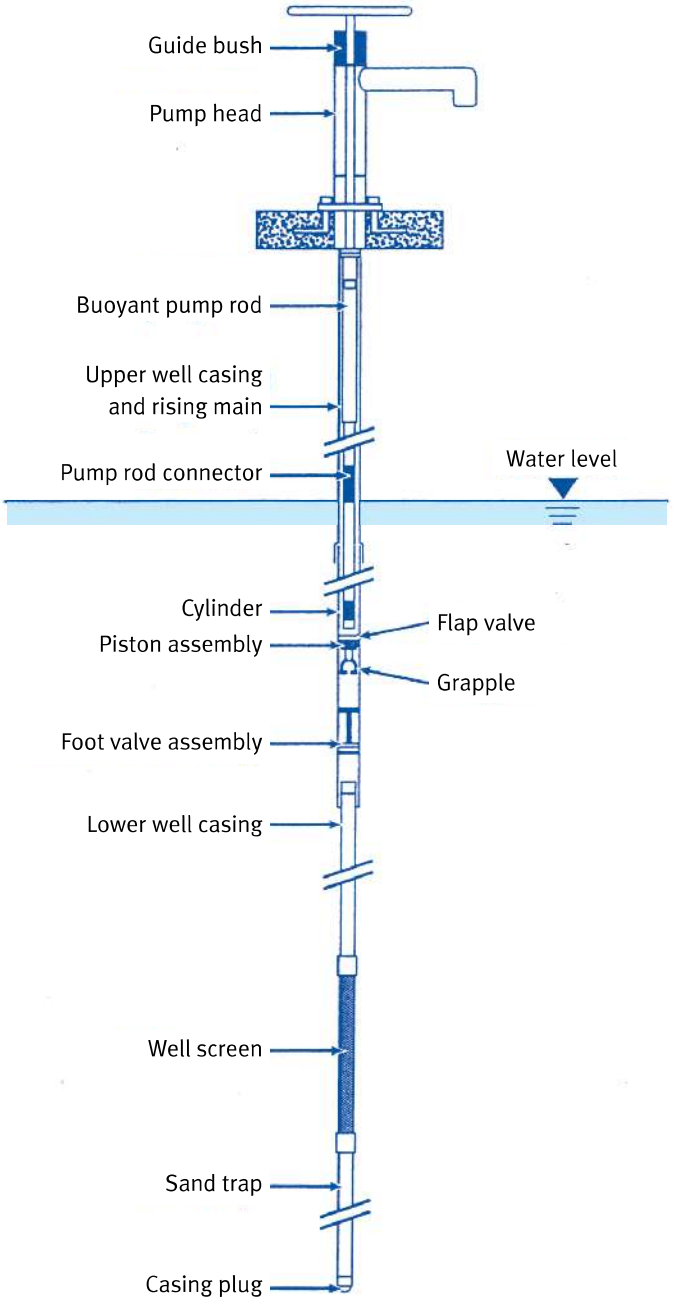
These operate in the range 0–15 metres. With lifts above seven metres, the cylinder and piston have to be located down the well, or borehole, and preferably below water level in order to provide a positive suction head. Theoretically, the lift could be achieved by operating with the cylinder seven metres above the water table but it is usually better to provide a positive suction head, as this assists pumping.

# Direct action pumps

In the low lift range some piston handpumps are designed to operate as simple direct action pumps, ie ones which operate without the help of leverage, linkages and bearings. Direct action pumps depend upon the strength of the operator to lift the column of water.

Some designs, such as the Tara (illustrated below) make this easier by using as the pump rod a plastic pipe filled with air, the buoyancy of which helps the upstroke operation. Other designs use very small diameter cylinders and rising mains to pump smaller quantities from greater depths.

In general, direct action pumps, being simple in action, are cheaper to buy and operate than high lift handpumps.



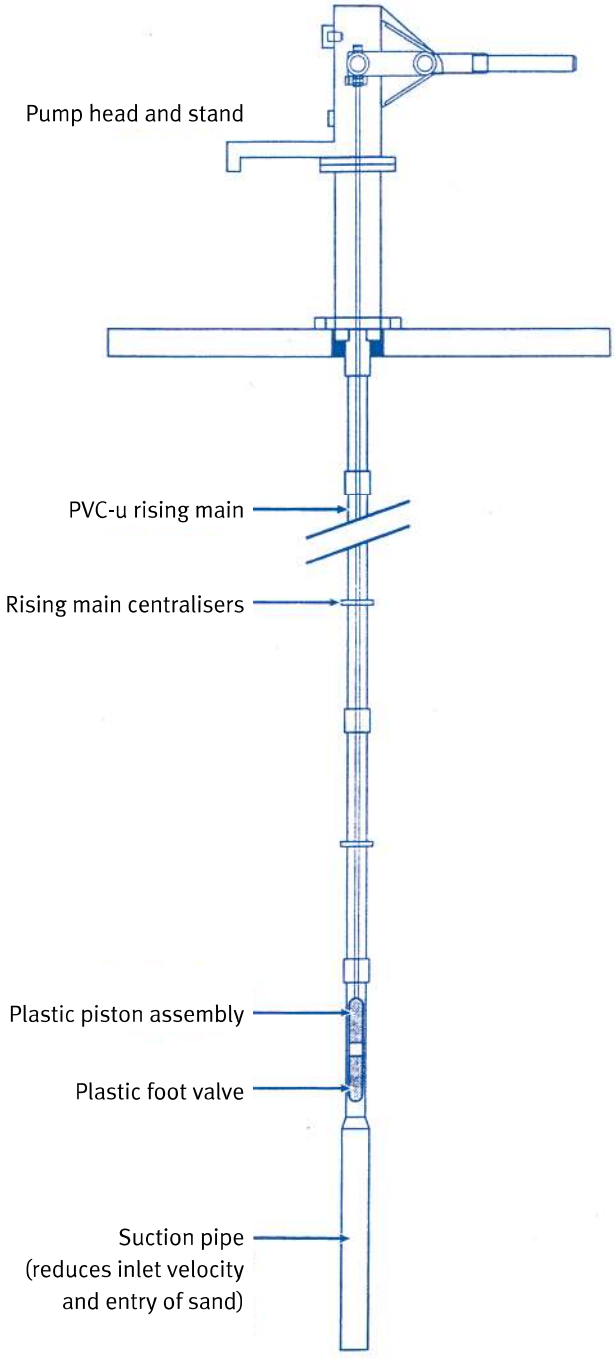
# Intermediate and high lift (deep well) handpumps

An intermediate lift pump operates in the range 0 – 25 metres and a high lift one in the range 0 – 45 metres. Some of the high lift handpumps can operate at lifts of 60 metres or more, albeit with reduced output.

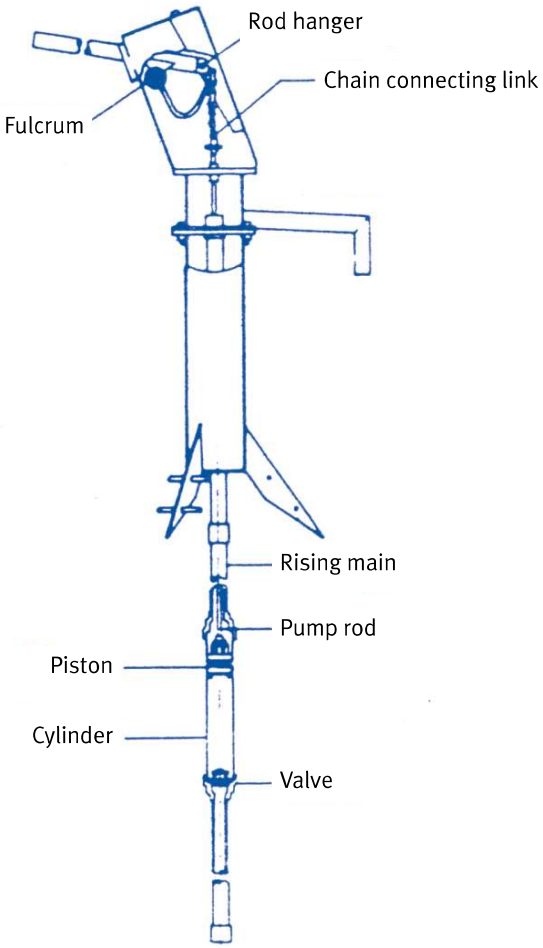
Intermediate and high lift piston handpumps are designed so as to reduce, by means of cranks or levers, the physical effort required when pumping. They have to be more robust and are provided with bearings and components capable of handling the larger stresses which are imparted by the pumping efforts required.

The Afridev handpump is shown in the following diagram and a more detailed one, showing the component parts, is given at the end of this section.

# High lift 'Afridev' handpump



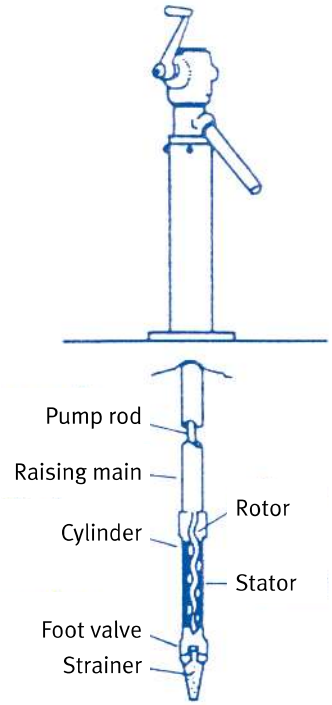

# Deepwell reciprocating pumps

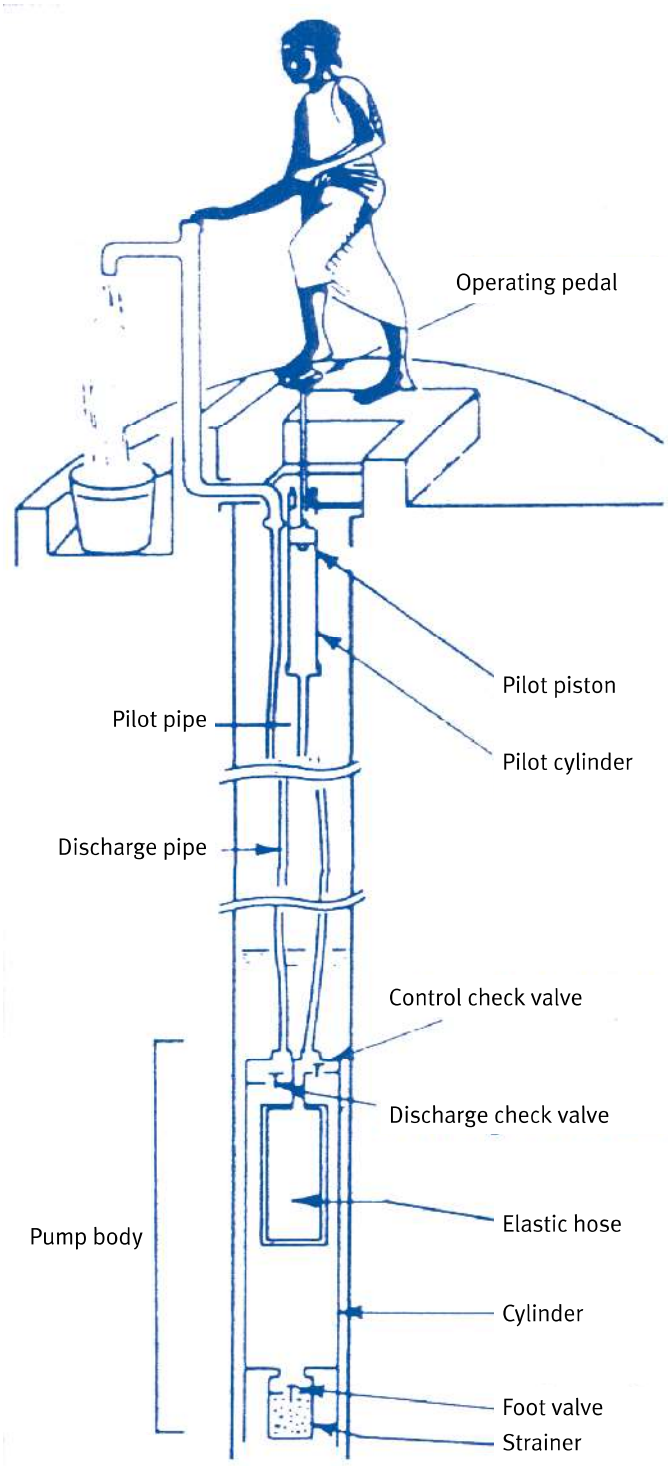


# Non-piston pumps

A high lift pump that is not a piston pump is the Mono progressing cavity hand pump; this has a rotating pump rod in the rubber stator within the pump cylinder, thereby producing a progressing cavity, which screws the water upwards. The meshing surfaces provide a moving seal.

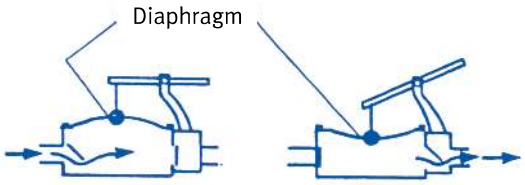
Although a very reliable handpump, any maintenance task that requires removal of the rods and rotor assembly requires special lifting equipment.




# Diaphragm pumps

Another type of deep well handpump is the diaphragm pump.




This operates by the expansion and contraction of a flexible diaphragm within a closed system actuated by a secondary piston pump, itself actuated by a foot pedal or hand lever. The primary rigid cylinder has a suction valve and a delivery check valve. On the contraction of the diaphragm the suction valve opens to draw water into the primary cylinder and the discharge valve closes. When the diaphragm is expanded by operating the secondary system, the suction valve closes and the discharge valve opens to pump water up a flexible rising main. Although the pump is easy to maintain, replacement diaphragms are required at relatively short intervals; these are expensive and the cost is often beyond the capacity of village communities to fund repeatedly.

# Choice of handpumps

The recommendations for handpumps which are proposed for use in community based water supply projects have been set out clearly in the World Bank/UNDP Handpumps Project (see Reference No.1 below). As well as the manufacture and performance specifications, the VLOM principles (see below) outline many attributes relating to ease of maintenance, local manufacture, robustness, standardisation, low capital cost and operating costs, availability of spares, community management and maintenance, etc.

When considering the most appropriate pump for a particular project, it is also important to take into account local preferences and government policy. The adoption of subsidised or 'free' handpumps by a major donor should be resisted if they are inappropriate and would not be sustainable in use.

# Handpump performances

Typical performances of some common types of handpumps.

| Name | Type | Lift range (metres) | | | Discharge rates (litres/min) | | | VLOM | Origin |
|---|---|---|---|---|---|---|---|---|---|
| Afridev | Deep well | 7 | 25 | 45 | | 22 | 15 | Yes | Kenya, etc. |
| Afridev | Direct action | 7 | 15 | | 26 | 22 | | Yes | Kenya, etc. |
| Bucket pump | Improved bucket and rope | 6 | 15 | | 5 | 10 | | Yes | Zimbabwe |
| Consallen | Deep well | 7 | 25 | 45 | 14 | 14 | 14 | | UK |
| India MK II | Deep well | 7 | 25 | 14 | 12 | 12 | 12 | No | India, etc. |
| India MK III | Deep well | 7 | 25 | 45 | 50% of MK I | | | | India, etc. |
| Monolift | Deep well progressing cavity | 25 | 45 | 60 | 16 | 16 | 9 | No | UK, South Africa |
| Nira AF 76 | Deep well | 7 | 25 | | 25 | 26 | | No | Finland |
| Nira AF 84 | Deep well | 7 | 25 | 45 | 23 | 22 | 21 | No | Finland |
| Nira AF 85 | Direct action | 7 | 15 | | 26 | 24 | | Yes | Finland |
| New No. 6 | Suction pump | 7 | | | 36 | | | | Bangladesh |
| Tara | Direct action | 7 | 15 | | 24 | 23 | | Yes | Bangladesh |
| | Windlass and Bucket | 0 | 45 | | 5 | 15 | | | Universal |

Notes

Deep well handpumps are lever-operated reciprocating action pumps unless otherwise stated.

# The VLOM concept

The term VLOM (Village Level Operation and Maintenance) was coined during the World Bank/UNDP Rural Water Supply Handpumps Project which, from 1981 – 91, considered the availability around the world at that time of handpump technologies and maintenance systems. A series of performance tests was undertaken: laboratory testing of 40 types of handpump and field performance monitoring of 2700 handpumps. It was concluded that centralised maintenance systems were the cause of many problems and that village level maintenance was desirable, but only feasible if the design of the pump made it possible.

Initially the VLOM concept was applied to the hardware, with the aim being to develop pumps which were designed to be:

- Easily maintained by a village caretaker, requiring minimal skills and few tools
- Manufactured in-country, primarily to ensure the availability of spare parts
- Robust and reliable under field conditions
- Cost effective

Subsequently, the VLOM concept was extended into software and organisational matters. Thus the "M" in "VLOM" has become "management of maintenance", for the success of a project was generally seen to be dependent on a strong emphasis on village management. Therefore the following elements were added:

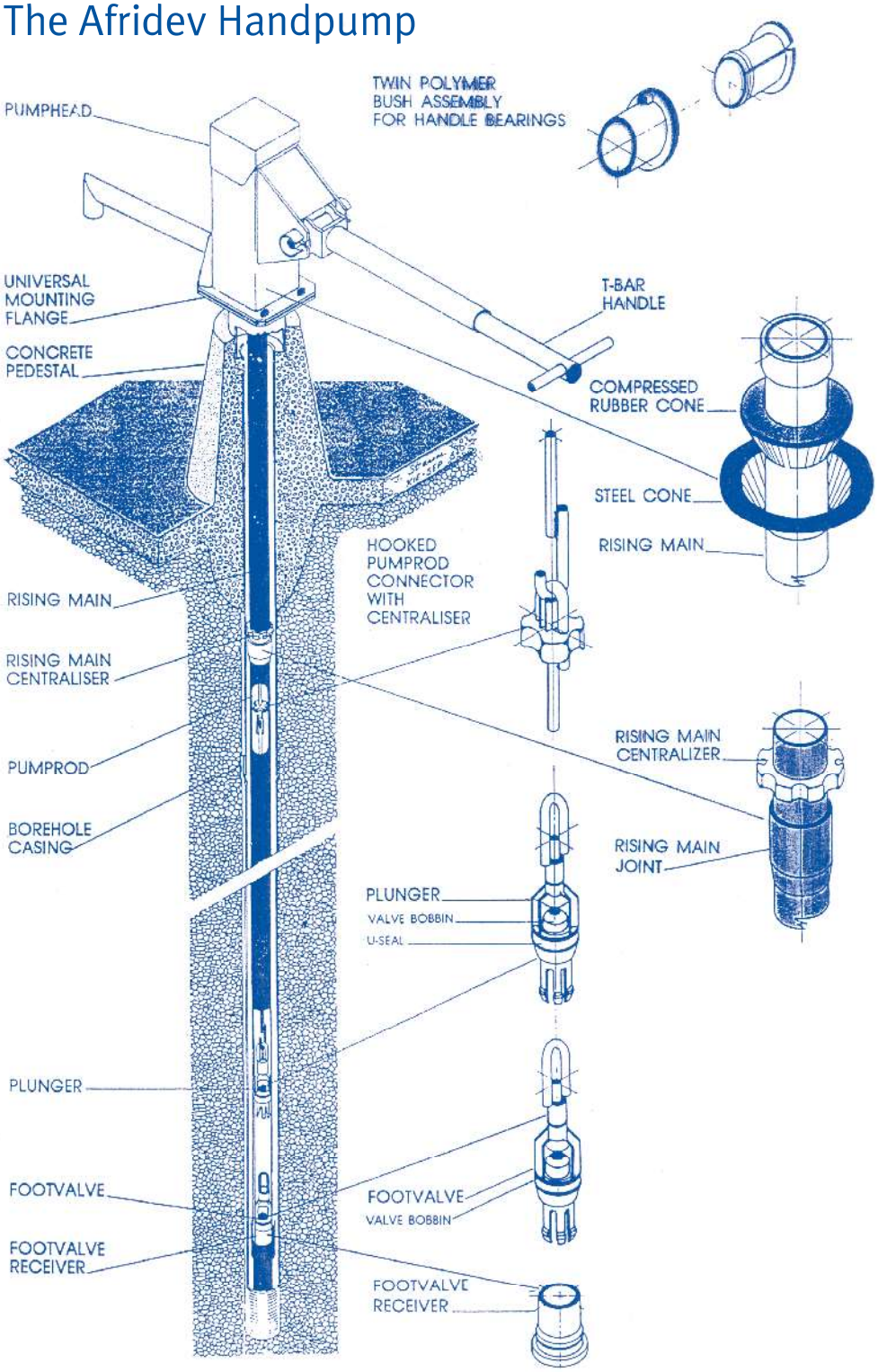
- Choice by the community of when to service pumps

- Choice by the community of who will service pumps
- Direct payment by the community to the caretakers

The application of VLOM principles, when considering pump selection, often involves compromising one principle to take advantage of another. A handpump with a low rate of breakdown might be thought preferable to another with a higher rate. However, a handpump that breaks down monthly, but can be repaired in a few hours by a local caretaker, is preferable to one that breaks down once a year but requires a month for repairs to be completed and needs replacement parts to be imported and skilled technicians to be available.

The Afridev handpump was developed during the course of the project to embody all of the VLOM design principles. Production began in Kenya in 1985 and modifications were made after field trials in Kwale in Southern Kenya. Improvements continue to be made. SKAT (Swiss Centre for Development Cooperation in Technology and Management) acts as a repository for the design drawings and specifications for the benefit of users and manufacturers of the handpumps. An exploded view of the pump is shown in the following diagram:

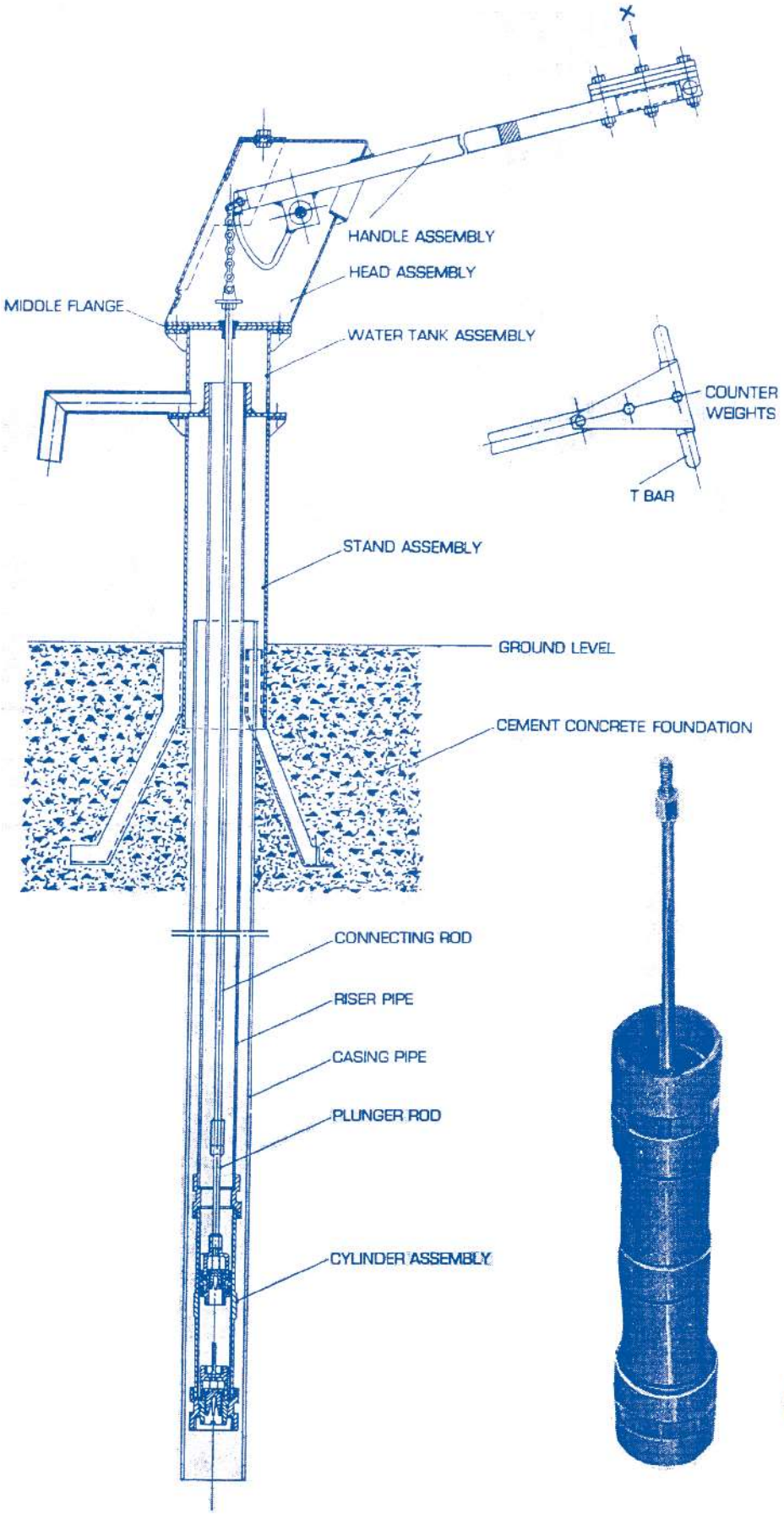
## The Afridev Handpump

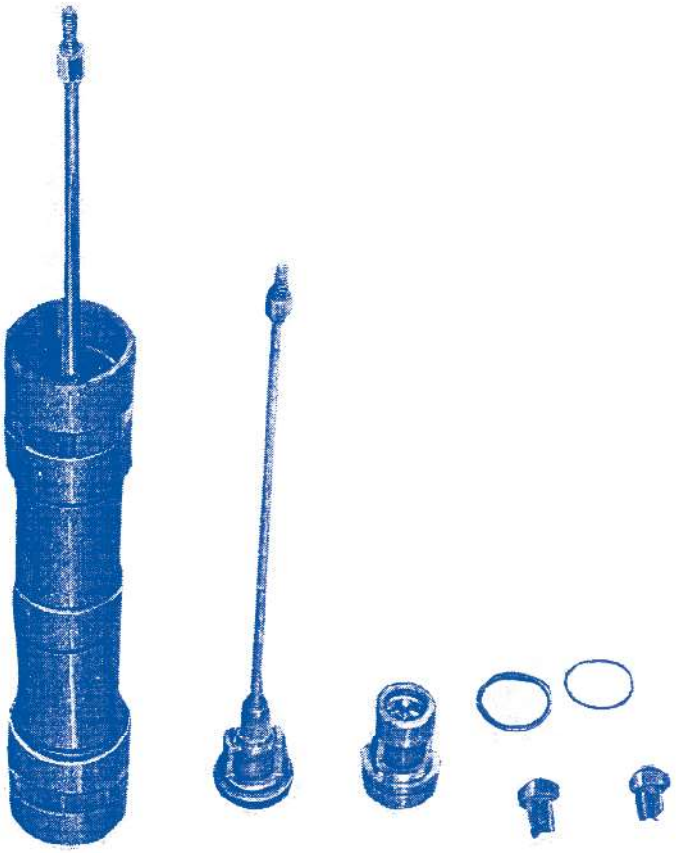



REFERENCES:


1. *Community water supply: The handpump option, rural water supply project,* UNDP/World Bank ISBN 08213-0850 1986
2. *Rural water supply handpumps project: Laboratory testing, field trials and technology development,* UNDP/World Bank Report No. 1 March 1982
3. **Reynolds J** *Handpumps: Towards sustainable technology – research and development during the water supply and sanitation decade,* UNDP/World Bank Report No. 5

# Meera Vlom India Mark IV extra deepwell handpump



CYLINDER WITH SINGLE PIECE PLUNGER AND CHECK VALVE