TECHNICAL SPECIFICATIONS
FOR
SEWERAGE SYSTEMS

Scope of Work

1. Project Identification: The “EXTENSION OF LEBAA SEWAGE NETWORK” project comprises the construction, completion and maintenance during the defects liability period of a sewage network located in LEBAA, Saida, South Lebanon.

2. Scope of Works consist of the construction, completion and maintenance during the defects liability period of the sewage network.

   The Work includes structural and mechanical disciplines as defined in the drawings.

3. Project will be constructed under the conditions of contract stated in the tender documents.

   Name of Contract: “EXTENSION OF LEBAA SEWAGE NETWORK”.

SECTION 2 - EARTHWORKS

2.1 SCOPE OF WORK
2.2 SITE PREPARATION
   i) Existing Subsurface Structures and Utilities
   ii) Clearing, Grubbing and Grading.
2.3 SETTING-OUT
2.4 EXCAVATION
   i) Road along the line
   ii) Excavation to reduce levels
   iii) Storing of Suitable Excavated Material
   iv) Disposal of Unsuitable and Surplus Excavated Material
   v) Unauthorized Excavation
2.5 REMOVAL, RESTORATION AND MAINTENANCE OF SURFACE
   i) Removal of Pavement
   ii) Restoration of Damaged Surfaces and Property
2.6 TRENCH EXCAVATION
   i) General
   ii) Types of Trench Excavation
   iii) Mechanical Excavation
   iv) Alignment and Minimum Cover
   v) Excavation in Confined Areas
   vi) Padding of Trench Bottom
## Technical Specifications for Sewerage Systems

### SECTION 4: PIPELAYING

2.7 **EXCAVATION FOR CONCRETE VALVE CHAMBERS**.................................

2.8 **EXCAVATION FOR CONCRETE BLOCKS**..............................................

2.9 **BACKFILLING OF TRENCHES**............................................................
   - i) **General**.............................................................................................
   - ii) **Backfilling of Trenches in or Adjacent to Streets**.............................
   - iii) **Backfilling of Trenches with Excessive Slopes**...............................
   - iv) **Restoring Trench Surface**..............................................................

2.10 **BACKFILLING AROUND STRUCTURE**.................................................
   - i) **General**.............................................................................................
   - ii) **Backfilling - Common Fill**..............................................................
   - iii) **Backfilling - Structural Fill**............................................................

2.11 **MATERIAL USED IN BACKFILL**........................................................
   - i) **General**.............................................................................................
   - ii) **Common Backfill Material**..............................................................
   - iii) **Selected Backfill Material**..............................................................
   - iv) **Structural Fill**................................................................................
   - v) **Crushed Stones**..............................................................................

2.12 **QUALITY ASSURANCE**....................................................................
   - **Laboratory Testing**.............................................................................

2.13 **REPLACEMENT OF PAVEMENTS AND STRUCTURES BY THE CONTRACTOR**

2.14 **MEASUREMENT AND PAYMENT**.......................................................15

## SECTION 3: CONCRETE AND REINFORCED CONCRETE

3.1 **GENERAL**............................................................................................

3.2 **MATERIAL**..........................................................................................
   - i) **Cement**.............................................................................................
   - ii) **Aggregate** ......................................................................................
   - iii) **Water**............................................................................................
   - iv) **Reinforcing Steel**...........................................................................
   - v) **Additives**.......................................................................................15

3.3 **TYPES AND STRENGTH OF CONCRETE**.............................................

3.4 **FORMS AND SHUTTERING**.................................................................

3.5 **MIXING AND PLACING OF CONCRETE**.............................................

3.6 **JOINTS**...............................................................................................

3.7 **CURING**..............................................................................................
   - i) **Materials**..........................................................................................
   - ii) **Method of Curing**..........................................................................15
   - iii) **Curing Time**................................................................................

3.8 **CONCRETE REPAIRS AND FINISH**....................................................

3.9 **CONSTRUCTION OF MANHOLES**....................................................
   - i) **General**..........................................................................................
   - ii) **Manholes**......................................................................................
   - iii) **Cleaning**......................................................................................
   - iv) **Reinstatement of Staircases**............................................................

3.10 **METAL COMPONENTS EMBEDDED IN CONCRETE**............................

3.11 **CONCRETE TESTS**.............................................................................

3.12 **PRECAST ELEMENTS**........................................................................
   - i) **Materials**......................................................................................
   - ii) **Fabrication**...................................................................................
   - iii) **Workmanship**..............................................................................

3.13 **MEASUREMENT AND PAYMENT**.......................................................26

## SECTION 4: PIPELAYING

4.1 **HANDLING AND TRANSPORTING OF PIPES**......................................
   - i) **General**..........................................................................................

Technical Specifications for Sewerage Systems

ii) Concrete Pipes ..................................................................................................

iii) Polyvinyl Chlorine (PVC) and Polyethylene (PE) Pipes..................................................

4.2 STACKING AND STORAGE OF PIPES...........................................................

i) General..............................................................................................................

ii) Concrete Pipes..................................................................................................

iii) PVC and PE Pipes...........................................................................................

4.3 MATERIALS SUPPLIED BY THE EMPLOYER...................................................

4.4 PIPELAYING IN TRENCHES...............................................................................

i) General..............................................................................................................

ii) Concrete Pipes..................................................................................................

iii) PVC and PE Pipes...........................................................................................

4.5 JOINTS INSTALLATION......................................................................................

i) General..............................................................................................................

ii) Flanged Joints...................................................................................................

iii) Mechanical Joints ............................................................................................

4.6 FABRICATION OF STEEL FITTINGS .................................................................

4.7 CONNECTIONS TO EXISTING MAINS...............................................................

4.8 HOUSE CONNECTIONS......................................................................................

4.9 PROTECTION OF JOINTS..................................................................................

4.10 HYDROSTATIC TEST .......................................................................................  

i) General..............................................................................................................

ii) Procedure ........................................................................................................

iii) Duration of Test...............................................................................................  

iv) Permissible Leakage.........................................................................................

v) Sewer Line With One Pipe Dimension............................................................

iv) Extent of Testing...............................................................................................  

4.11 FIELD AIR TEST ............................................................................................  

i) General..............................................................................................................

ii) Procedure ........................................................................................................

iii) Safety Requirements.......................................................................................  

4.12 HYDROSTATIC PRESSURE TEST.....................................................................

i) General..............................................................................................................

ii) Preparations for Pressure Test........................................................................

iii) Filling the Line with Water............................................................................

iv) Pressure Test...................................................................................................

4.13 MEASUREMENT AND PAYMENT.....................................................................

i) Pipes and Fittings..............................................................................................

ii) Manholes .........................................................................................................

iii) Hydrostatic Tests and Air Field Test..............................................................
SECTION 2 - EARTHWORKS

2.1 Scope of Work

A. This section covers trenching and backfilling work and shall include the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property; backfilling; pipe embedment; surfacing and grading; and other related work.

2.2 Site Preparation

a) Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey, record existing ground elevations and stake the location of trenches to be excavated.

b) The Contractor shall prepare the site for construction by clearing, removing and disposing of all items not indicated on the Drawings to remain or so defined by the Engineer.

c) The Contractor shall obtain relevant excavation and road cutting permits as required to commencing work.

   i) Existing Subsurface Structures and Utilities

A. For all works required to deal with existing subsurfaces and utilities refer to General Section of these Specifications.

   ii) Clearing, Grubbing and Grading

a) The Contractor shall perform the clearing and grubbing (if any), of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300 mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and off loaded, spread and leveled to approved dumps as directed by the Engineer.

b) The Contractor shall include for grading the route to provide access for his equipment and personnel, executing all cuttings to remove the high point of rises in terrain and in all respects prepare the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.

2.3 Setting-Out

A. The Contractor shall stake-out the work as shown on the Drawings and secure the Engineer’s approval of his stake-out before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out, the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-out for further approval in accordance with the relevant Clause of the Conditions of Contract.
2.4 **Excavation**

a) The Contractor shall perform all excavation true to lines, widths and depths shown on the Drawings or to such further lines, depths or dimensions as may be directed by the Engineer.

b) Excavation work will be classified according to the quality of the material to be excavated. In three classes as follows

   a) Excavation in Rock
   b) Excavation in sand
   c) Excavation in mixed soil

c) The soil classes in every section of the pipeline will, if necessary, be determined by the engineer on the basis of the following definitions:

d) **Excavation in Rock** shall include the removal of hard and solid rock in continuous layers or boulders that cannot be broken up by ordinary excavating equipment including rooter, and which necessitate the use of pneumatic tools or wedges for loosening and removal.

e) **Excavation in Sand** shall include excavation in loose or dense sand, such as drifting sand (dunes).

f) **Excavation in mixed soil** shall include the removal of all material that cannot be classified as rock or sand as defined above (Heterogenous Soil).

g) Everything said in the specification with regard to the execution of excavations, disposal of excavated materials, etc. shall equally apply to rock, sand and common excavation, unless otherwise stated.

   i) **Road along the line.**

      a) Wherever necessary the Contractor shall prepare a road along the line at such distance from the line that the traffic on the road will in no way interfere with pipelaying work. The Contractor shall also prepare access roads from the highway or other public roads to the said access road.

      b) The road along the line and the access roads shall permit the normal movement of trucks and other vehicles and all equipment and plant required for the execution of the works.

      c) The employer’s employees shall at times have the use of the roads prepared by the Contractor, free of charge.

      d) The Contractor shall maintain the road along the line and the access roads in a good and serviceable condition and shall make all repairs that may be necessary during the whole period of construction.

   ii) **Excavation to reduce levels.**

      a) Wherever shown on the drawings, the Contractor shall reduce the ground level on the trench site, prior to commencement of trench excavation. Before starting excavation for reducing of levels the Contractor shall move the marking of the alignment to such a distance that the marks will not be destroyed and will not interfere with the execution of the work.

      b) Excavation for reducing levels shall be done to the lines and levels shown on the drawings. Where the depth of excavation is not so shown it shall be done to a line parallel to the trench bottom in the section concerned.
iii) Storing of Suitable Excavated Material
A During excavation, materials suitable for backfill and fill will be stockpiled on the site at sufficient distance from the sides of the excavation to avoid over-loading and prevent cave-ins or mixing with the concrete during the construction of the foundation.

iv) Disposal of Unsuitable and Surplus Excavated Material
A Upon the order of the Engineer, all unsuitable and surplus materials shall be immediately removed, loaded and transported off the Site area by the Contractor to approved dumps and he shall abide by the relevant local regulations.

v) Unauthorized Excavation
A If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled by well graded material at the Contractor’s expense with thoroughly compacted to an acceptable proctor as directed by the Engineer, if the excavations are for a structure or a manhole, then the void should be filled by class B150 concrete.

2.5 Removal, Restoration and Maintenance of Surface

i) Removal of Pavement
A The Contractor shall remove pavement and road surfaces as a part of the trench excavation, and the volume removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures. The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the top width of the trench specified by more than 200 mm on each side of the trench. The widths and lengths of the area of pavement removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 300 mm on each side. Wherever, in the opinion of the Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the Engineer but shall receive no extra compensation therefore. The Contractor shall use such methods, either drilling or chipping, as will assure the breaking of the pavement along straight lines. The cut must be sharp and approximately vertical. The Engineer’s representative may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

ii) Restoration of Damaged Surfaces and Property
A If any pavement, trees, shrubbery, fences, poles, or other property and surface structures have been damaged, removed, or disturbed by the Contractor, whether deliberately or through failure to carry out the requirements of the contract documents, state laws, municipal ordinances, or the specific direction of the Engineer or through failure to employ usual and reasonable safeguards, such property and surface structures shall be replaced or repaired at the expense of the Contractor. If the Employer specifies that the replacements or repairs shall be made by the Contractor, he shall replace or repair and restore the structures to a condition equal to that before the work began and to the approval of the Engineer and shall furnish all incidental labour and materials.

2.6 Trench Excavation
Technical Specifications for Sewerage Systems

i) General

3 The minimum trench width at the bottom shall be equal to the external pipe diameter plus 500 mm provided that the minimum clearance between the installed pipe and the trench side shall not be less than 250 mm. The rest of the trench, unless otherwise shown on the drawings or instructed by the Engineer, shall be excavated with approximately vertical sides as much as possible.

4 The trench width at the ground surface shall be excavated as narrow as practicable but may vary with, and depend upon its depth and the nature of the ground encountered.

5 Trenches shall be of such extra width, when required, as will permit the convenient placing of timber support, sheeting and bracing and handling of specials.

6 The graded material bedding under the pipe shall be not less than 150 mm thick in any point and as shown on the drawings and as directed by the Engineer.

7 The trench depth shall give the required minimum cover over the pipe as specified.

8 The trench bottom shall be straight and even so as to provide a good support for the pipe on its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating. The excavated material shall be placed alongside the trench in such a manner as not to interfere with the work and to prevent its falling down into the trench.

9 Where welds or joints of pipes and accessories are required to be done in the trench, it shall be widened or deepened to the usual enlarged dimensions or as directed by the Engineer so as to easily permit the proper execution of all welding and fixing works at all their stages, coating repairs, and thorough inspection of all these operations.

10 Separate excavations are to be made for manholes, pipe junctions, etc.

11 No more trench shall be opened in advance of pipe laying than is necessary to expedite the Work. 100m shall be the maximum length of open trench within urban areas and 500m in rural areas.

12 Hand excavation must be applied where existing cables, water mains, sewers, etc., cross or are in the main roads where traffic is likely to be unreasonably dislocated by use of machine or where instructed by the Engineer. In other places hand or machine excavating may be employed at the discretion of Contractor.

ii) Types of Trench Excavation

   A When excavating in ordinary soil or sand the Contractor shall take all precautions to prevent slides caused by material placed alongside the trench or for any other reason. Wherever the danger of slides exists, the Contractor shall slope the trench walls, install supports, bracing, etc., and shall make all other arrangements which may be necessary to prevent slides.

2. Trench Excavation in Rock.
   A Trench walls excavated in rock shall be as nearly vertical as possible, and the Contractor shall consolidate the walls wherever they have been loosened by blasting or for other reasons, or shall remove the loosened material.

3. Trench Excavation in water.
   A Where rivers carrying water during construction are to be crossed, the Contractor will have to excavate the pipe trench under water. The depth and width of the trench at such places shall be as specified above. The exact trench profile at river crossing will be shown on drawings or determined by the Engineer on the site. The
Contractor shall take all necessary measures to maintain the trench in its proper shape and to prevent it from being filled with eroded earth or mud until the pipe has been laid.

**iii) Mechanical Excavation**

(a) The use of mechanical equipment must be jointed with the approval of the Engineer. The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, buildings, culverts or other existing property, utilities or structures above or below ground. In all such locations hand excavation shall be used. The Contractor will be held responsible for making good at his own cost all additional damage to road surfaces and private lands caused by the use of mechanical excavators.

(b) Mechanical equipment if used for trench excavation shall be of type approved by the Engineer. Equipment shall be so operated that the rough trench excavation bottom can be controlled, that uniform trench widths and vertical sides are obtained at least from an elevation 200mm above the top of the installed pipe when accurately laid to specified alignment will be centered in the trench with adequate clearance between the pipe and sides of the trench.

**iv) Alignment and Minimum Cover**

(a) The alignment of each pipeline shall be fixed and determined from offset stakes. Horizontal alignment of pipes and the maximum joint deflection used in connection therewith, shall be in conformity with requirements of the section covering installation of pipe.

(b) Pipe grades or elevations are not definitely fixed by the Contract Drawings, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe 500mm and above; at certain locations, the locations and depths will be determined by the Engineer, and will be followed by the Contractor. Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finish ground or pavement surface elevation except where future surface elevations are indicated on the Drawings. Where there is no adequate minimum cover, concrete encasement will be used as hereinafter and as shown on the Drawings and as directed by the Engineer.

**v) Excavation in Confined Areas**

A in confined areas, where the passage of excavating equipment is impossible, or where the Engineer deems to use of such equipment impracticable or undesirable for any reason whatsoever, trench excavation shall be done by hand. All requirements specified above for common or sand excavation shall also apply to trench excavation by hand.

**vi) Padding of Trench Bottom**

(1) Wherever the trench bottom is in rock or where the Engineer will decide that the trench bottom is unsuited for laying of pipe on it, the trench will be excavated to an additional depth, and the Contractor shall pad the trench bottom with a layer 100 mm thick of selected excavated material not containing stones larger than 30 mm measured in any direction provided that the quantity of stones smaller than 30 mm is not more than 20% by volume.

(2) The surface of the padding shall be finished to grade as specified above so as to provide an even and solid support for the pipes to be laid.
2.7 Excavation for Concrete Valve Chambers

1. Excavation for the concrete valve chambers shall be carried out to the dimensions, lines and grades shown on the Drawings or required by the Engineer.

2. Wherever the depth of the excavation or the nature of the soil makes it necessary to avoid caving in, the Contractor shall excavate the walls to a slope or brace and support the excavation.

3. Should nevertheless earth slides occur, the Contractor shall remove the material resulting therefrom, clean the excavation of all stones, clods and other loose material and shall provide a clean excavation surface in which concrete can be cast according to the required dimensions and grades.

4. Should it appear that the bottom of the excavation does not provide a solid base for the casting of the concrete floor, the Contractor will be required to consolidate the bottom using hand tampers and increasing the moisture content, if required, until the required density is obtained, a/o placing concrete class (B150) as blinding, all as directed by the Engineer.

5. Any over-excavation at the bottom of the structure shall be restored to the proper grade by filling the overexcavation class (B150) concrete or shall be filled with the concrete of which the structure is cast. In the case of over-excavation in the walls, whether caused by careless work or by the necessity to prevent slides by excavating to a slope or for any other reason, the Contractor shall remove all loose material from the excavation, cast the walls of the structure to the dimensions shown on the Drawings and fill the spaces between the structures and the sides of the excavation with compacted backfill in layers of 100mm thickness. The material of the backfill shall be moistened if necessary and compacted to the level of the adjacent natural soil.

2.8 Excavation for Concrete Blocks

1. Excavation for concrete anchoring blocks shall be performed according to the shapes and dimensions shown on the drawings. The bottom and sides of the excavation shall be smooth, even, and solid so that concrete can be cast against them. Wherever necessary, such surfaces shall be moistened and consolidated to make them suitable for the casting of concrete against them. Any over excavation on the bottom or sides shall be cleaned, smoothened out, and filled with concrete cast integrally with block.

2. After the block has been cast, and subject to the Engineer’s approval, it shall be covered where necessary with excavated material up to the natural ground surface. The rest of the excavated material shall be removed and dump as specified above for the material excavated for valve chambers.

2.9 Backfilling of Trenches

i) General

1. Every section of the pipeline shall be covered as soon as possible after being lowered into trench, but no section of the line shall be covered without express approval of the Engineer. Each section shall be backfilled after the pipe has been placed in its final position on the trench bottom and after all weld joints and bends have been coated and all defects in the pipe coating repaired.

2. Backfilling shall be done carefully to prevent displacement of the pipe or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench surfaces, without leaving any voids.
Technical Specifications for Sewerage Systems

3. Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil. Stones removed during trench excavation may be used in the second stage of backfilling as specified below.

4. On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench.

5. Where the pipeline crosses natural drainage channels, an opening in the backfill shall be made to avoid interference with normal drainage of the surrounding land.

6. Backfilling shall be done so as not to spoil the road or disrupt its continuity.

ii) Backfilling of Trenches in or Adjacent to Streets

Where the pipes are laid in or adjacent to streets, the backfilling of trenches shall be done as follows:

1. **Soft Backfill** shall be done as specified above in paragraph 2.9(ii-A)

2. **Final Backfill** for the remainder of the trench shall be by using well graded approved backfill material. (as specified herein after in paragraphs 2.11(i, ii))

3. The selected backfill shall be up evenly on all sides, in layers not exceeding 250 mm measured before compaction, thoroughly wetted and compacted by rolling, tamping, or vibrating with mechanical compacting suitable equipment or hand tamping, to 95 percent of maximum dry density. Where these methods are not practicable, compaction shall be done by using of pneumatic ramming with tools weighing at least 10 Kg. The materials in this case being spread and compacted in layers not more than 150 mm in thickness. If necessary, sprinkling shall be employed in conjunction with ramming.

4. The top 250mm sub-base for pavement replacement, shall consist of one layer of approved basecourse material, wetted and compacted to 95 percent of maximum dry density.

5. Should the contractor wish to use the material excavated from the trench as sub-base for pavement replacement, the contractor shall at his own expense have samples of the material tested by an independent and certified laboratory at intervals not to exceed 150 m, in order to establish its compliance with the specifications. Only material which has been tested by the contractor and approved by the engineer shall be allowed to be incorporated into the work.

iii) Backfilling of Trenches with Excessive Slopes

1. On trenches with slopes exceeding 15 percent, a 300 mm wide, stone partitions shall be built across the trench every 10 meters length.

2. These partitions shall be done constructed over the first stage of the backfill up to the natural ground level, and shall exceed the trench width with 200 mm from each side inside the ground.

iv) Restoring Trench Surface

1. Where the trench occurs adjacent to paved streets, in shoulders, sidewalks, or in cross-country areas, the contractor shall thoroughly consolidate the backfill and shall maintain the surface as the work progress. If settlement takes place, he shall immediately deposit additional fill to restore the level of the ground. In some areas it may be necessary to remove excess materials during the clean-up process, so that the ground may be restored to its original level and condition.
2. The surface of any driveway or any other area which is disturbed by the trench excavation and which is not a part of the paved road shall be restored by the contractor to a condition at least equal to that existing before work began.

3. Where the pipes are laid in cross-country areas, and where the danger of erosion exists, the uppermost 300 mm part of the trench may be backfilled with common backfill material containing fragments of ledge and boulders smaller than 150 mm providing that the quantity in the opinion of the engineer, is not excessive. Small stones and rocks shall be placed in thin layers alternating with earth to insure that all voids are completely filled.

4. All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

2.10 Backfilling arround Structure

i) General

1. Surfaces to receive backfill shall be cleared of debris and unsatisfactory materials prior to the placement of the backfill material

2. When the top 200mm of surface to receive backfill has a density less than the required maximum dry density, break up surface, pulverize, moisten and compact such that the required degree of compaction is achieved to form a “compacted subgrade”.

3. Backfill excavations as promptly as the work permits, but not until completion of inspection, testing, approval, and recording of location of underground utilities, as required.

ii) Backfilling - Common Fill

1. Common Fill may be used as fill against exterior walls of structure as indicated on the drawings. Materials conforming to the requirements of common backfill shall be placed in layers having a maximum thickness of 300 mm measured before compaction, each layer of fill or backfill shall be moistened or aerated and compacted to at least 90 percent of maximum dry density, or as specified in the Bill of Quantities.

2. Backfill or fill materials shall not be placed on surfaces that contain excessive moister, preventing specified degree of compaction.

3. Material placed in fill areas shall be deposited to the lines and grades shown on the drawings making due allowance for settlement of the material.

4. No compacting shall be done when the material is too wet either from rain or from excess application of water. At such cases, work shall be suspended until previously placed and new materials have dried sufficiently to permit proper compaction.

iii) Backfilling - Structural Fill

1. Structural fill shall be placed in layers having a maximum thickness of 200 mm in open areas and 150 mm in confined areas including points where conduit and piping join structures, measured before compaction. Each
Technical Specifications for Sewerage Systems

layer shall be moistened or aerated and compacted to at least 95 percent of maximum dry density, or as specified in the Bill of Quantities, by methods approved by the Engineer. The limits of structural fill adjacent to structures shall extend as shown on the drawings.

2. Compaction of Structural fill in open areas shall consist of fully loaded ten-wheel trucks, a tractor dozer weighing at least 13.5 ton and operated at full speed, a heavy vibratory roller, or any method approved by the Engineer.

3. Compaction of structural fill in confined areas shall be accomplished by hand operated vibratory equipment or mechanical tampers approved by the Engineer.

2.11 Material Used in Backfill

i) General
1. Backfill and fill material shall be suitable excavated material, natural or processed mineral soils obtained from off-site sources, or graded crushed stones or gravel.

2. Backfill and fill material shall be free from all organic material, trash, snow, ice, frozen soil, or other objectionable material which can’t be properly compacted. Soft, wet, plastic soils which may be expensive, clay soils having a natural in-place water content in excess of 30 percent, soil containing more than 5 percent(by weight) fibrous organic material, and soil having a plasticity index greater than 30 shall be considered unsuitable for use as backfill and fill material.

3. Backfill and fill material shall have a maximum of one percent expansion when testing is performed on a sample remolded to 95 percent of maximum dry density at a two percent below optimum moisture content under a 490 kg/m² surcharge.

ii) Common Backfill Material
1. Common Backfill or fill material shall not contain Granite blocks, broken concrete, masonry rubble, asphalt pavement, or any material larger than 150 mm in any dimension provided that this material is not more than 25 percent of the backfill or fill material.

2. Common Fill shall have physical properties, as approved by the engineer, such that it can be readily spread and compacted.

iii) Selected Backfill Material
A Selected Backfill and Fill material shall conform to the requirements of common Backfill except that the material shall not contain any materials larger than 50 mm in its largest dimension provided that this material is not more than 20 percent of the Backfill or fill material.

iv) Structural Fill
A Structural Fill shall be gravel, sandy gravel, or gravelly sand. Material shall have a plasticity index of less than 15 and shall conform to the gradation limits shown in table 2.1 below:
### Table 2.1

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<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Finer By Weight</th>
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<td>5 - 35</td>
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</tbody>
</table>

**v) Crushed Stones**

A Crushed stones shall be sound, durable stone, angular in shape, and free of foreign material, structural defects and chemical decay. Crushed stones shall be of a maximum dimension of 50 mm and in a minimum of 12 mm measured in any direction.

### 2.12 Quality Assurance

#### Laboratory Testing

At least seven days prior to the placement of any Backfill or Fill material, the contractor shall deliver a representative sample of the proposed material weighing at least 22 Kg to an approved soils testing laboratory to perform:

1. Grain size analyses of the samples to determine their suitability for use as Backfill or Fill material in accordance to the material requirements specified in section 2.11

2. The appropriate Proctor analysis to determine the maximum dry densities required for compaction testing as specified in the contract documents.

3. The test results and determinations of suitability shall be delivered to the engineer no later than three days prior to the placement of Backfill or Fill materials.

### 2.13 Replacement of Pavements and Structures by the Contractor

1. Unless otherwise shown on the Drawings or mentioned in the bill of quantities, the Contractor shall restore all pavements, sidewalks, sidewalks, curbs, gutters, shrubbery, fences, poles, sod, or other property and surface structures removed or disturbed as a part of the work to a condition equal to that before the work began, and shall furnish all incidental Labour and materials. No permanent pavement shall be restored unless and until, in the opinion of the Engineer, the condition of the backfill is such as to properly support the pavement and not before written approval from the Engineer to commence such works.

2. Where pipelines pass underneath asphalted roads and parallel to the axis of the road, the final 250 mm of the trench backfill shall be furnished as follows:

   1. 200 mm (after compaction) shall be done by using approved base course material, placed, wetted and compacted to not less than 95% of the modified Proctor density.

   2. Spraying 2 kg of prime coat(MCO) per each square meter over the compacted base course, and applying a layer of asphalt mix of size , in a thickness not less than 50 mm, after compaction which should satisfy the specification of Palestinian Ministry of Public Works.
2.14 Measurement and Payment

1. All Excavated material of whatever type shall be measured as “unclassified” which shall be deemed to include all materials encountered of any nature, including silts, clays, sand, gravel and granular materials and fractured, jointed and solid rock, and unsuitable material.

2. Trench Excavation shall be measured in lin.m of each range of depth, as classified in the Bill of Quantities, and trimmed to required line, grade and cross section, including depositing excavated material along the side of trench if directed or hauling away and wasting, stockpiling or depositing on or in the vicinity of the works completed and accepted.

3. Structural Excavation shall be measured by cubic meter of original ground elevations. Limits shall not be greater than vertical planes 500mm (working space) from the maximum dimension, on each side of the footing or other controlling portion of the structure. Where structures are to be constructed against natural ground or rock, excavation limits shall be the dimensions of the structure as shown on the Drawings. Bottom limits shall be the ordered foundation elevations. Only material excavated from its original position shall be measured for payment. No measurements shall be made of structural excavation in embankments previously constructed by the Contractor.

4. Structural Excavation shall be paid for material excavated for chambers, valves or any needed fittings, hauled away and disposed of as directed, or stockpiled on or in the vicinity of the works, and the excavated areas backfilled, completed and accepted.

5. Sub excavation of Unsuitable Material shall be measured by lin.m for trench and cu.m for structures of unsuitable material subexcavated as ordered, hauled away and disposed of as directed, and the excavated areas backfilled, completed and accepted.

6. Unauthorized overdepth and overwidth excavation and the concrete backfill required in such cases, shall not be measured for direct payment, but shall be considered as Subsidiary Works the cost of which will be deemed to be included in the Contract Prices for Pay items.

7. Temporary cofferdams, temporary shoring and cribbing, bailing, drainages pumping, sheeting, and all other Temporary Works shall not be measured for direct payment, but shall be considered as Subsidiary Works the costs of which will be deemed to be included in the Contract Prices for Pay Items.

8. Backfilling of trenches mentioned in item 2 above shall be measured in lin.m. Backfilling shall include preparation of subgrade, furnishing required suitable backfilling materials, placing and compaction of backfilling material as specified and shall be made in accordance with methods specified in two stages:

9. Soft Backfilling from the bottom of the trench to at least 200 mm above the crown of the pipe, with sand or fine aggregate fill as specified

10. Final Backfilling for the remainder of the trench above the zone around the pipe with selected fill material as specified.

11. Reinstatement of roads, side walks, and paved surface shall be measured in lin.m. The work will include removal, restoration and maintenance of surfaces and property, preparation of road foundation and replacement of hard core, asphalted layer and structures.
SECTION 3 : CONCRETE AND REINFORCED CONCRETE

3.1 General

1. This section consists of furnishing all plant, equipment, appliances and materials and in performing all operations necessary in the construction in accordance with the Specifications, Drawings and Engineer’s instructions and subject to the terms of the Conditions of Contract.

2. Unless approved by the Engineer to mix the concrete on Site for small quantities, all types of concrete will abide with the requirements of Palestinian Standards (PS 40) and will be furnished to the site as ready mixed concrete supplied from an approved ready mixed plant by the Palestinian Standards Institute. Contractor must obtain Engineer’s approval of the concrete plant prior to the delivery of concrete from same.

3. All concrete works except for foundations shall be executed as exposed fair faced concrete and will abide with all requirements for same.

4. All concrete casting will fully abide with “good” control conditions requirements and approved by the Engineer.

3.2 Material

i) Cement

A. The cement shall be sulphate-resisting cement of local manufacturer meeting requirements similar to those of ASTM Specifications C150, latest edition, for type V. Cement shall be fresh and suitable for use as approved by the Engineer.

ii) Aggregate

Fine Aggregate

1. Sand for concrete, mortar and grout shall be furnished by the Contractor from any approved source and shall be natural sand or a mixture of natural sand and fine crushed stone. The sand shall meet the requirements of Palestine Standards PS 48-1997, with the additional requirement that the specific gravity of the sand shall not be less than 2.50.

2. Unless otherwise specified the sand shall be graded as shown in table 3.1 below:

<table>
<thead>
<tr>
<th>Sieve Size mm</th>
<th>Percentage Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75</td>
<td>100</td>
</tr>
<tr>
<td>2.36</td>
<td>80-100</td>
</tr>
<tr>
<td>1.18</td>
<td>30-75</td>
</tr>
</tbody>
</table>
Coarse Aggregate

1. Coarse Aggregate for concrete shall be furnished by the Contractor from an approved source and shall consist of hard dense durable uncoated rock fragments and shall meet the requirements of Palestine Standards No. PS 48-1997, with the following limitations.

2. The Los Angeles Abrasion test should not exceed 32% according to PS 48 for grade B and 28% for grade A. Water absorption should not be more than 2.5% more than the absorption of Bazelt aggregate retained an 9.5 mm sieve i.e. the total absorption should not exceed 3.5% and the specific gravity shall not be less than 2.50. The grading of coarse aggregate shall be as shown in table 3.2 below:

### Table 3.2

<table>
<thead>
<tr>
<th>Nominal Sizes 19.0 mm</th>
<th>Percentage Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size mm</td>
<td></td>
</tr>
<tr>
<td>25.0</td>
<td>100</td>
</tr>
<tr>
<td>19.0</td>
<td>85-100</td>
</tr>
<tr>
<td>14.0</td>
<td>0-20</td>
</tr>
<tr>
<td>9.5</td>
<td>0-5</td>
</tr>
</tbody>
</table>

### Nominal Size 25.0 mm

<table>
<thead>
<tr>
<th>Sieve Size mm</th>
<th>Percentage Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td>100</td>
</tr>
<tr>
<td>25.0</td>
<td>85-100</td>
</tr>
<tr>
<td>19.0</td>
<td>0-20</td>
</tr>
<tr>
<td>14.0</td>
<td>0-5</td>
</tr>
</tbody>
</table>

C. The size of coarse aggregate used in any part of work shall be such that it does not contain any particles larger than 1/3 of the thickness of the thinnest concrete member or of the smallest distance between reinforcement bars whichever is smaller

Combined Aggregate

A. The grading of combined aggregate shall be approximately as shown in table 3.3 below:

### Table 3.3

<table>
<thead>
<tr>
<th>Sieve Size mm</th>
<th>Percentage Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grading No. 1</td>
<td>Grading No. 2</td>
</tr>
<tr>
<td>63</td>
<td>95-100</td>
</tr>
<tr>
<td>50</td>
<td>80-100</td>
</tr>
<tr>
<td>37.5</td>
<td>65-85</td>
</tr>
<tr>
<td>25</td>
<td>50-75</td>
</tr>
</tbody>
</table>
### Technical Specifications for Sewerage Systems

<table>
<thead>
<tr>
<th>Sieve Size mm</th>
<th>Percentage Passing by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grading No. 1</td>
</tr>
<tr>
<td>0.3</td>
<td>4-9</td>
</tr>
<tr>
<td>0.15</td>
<td>1-7</td>
</tr>
<tr>
<td>0.075</td>
<td>0-5</td>
</tr>
</tbody>
</table>

### Water

A Water used in concrete either for mixing or curing shall be fresh potable water derived from an approved source of supply and shall be free from silt, oil, organic matter, acid, alkali-slate and other detriouse substances. The temperature of the water shall not be less than 10? C. the water shall meet the requirement of Palestinian Standards No. PS 41-1997.

### Reinforcing Steel

1. The steel bars to be used are of plain steel complying with PS 50 and deformed ribbed steel bars complying with PS 52. Before bending the steel is to be straightened to the Engineer’s satisfaction and cleaned of all rust loose mill scale, oil or any other dirt.

2. Spacers shall be made of precast concrete cubes which shall match the concrete into which they are cast in every way (strength proportion, color).

3. Jointing of reinforcement bars shall be done with overlap no less than 50 times the diameter of the respective bar.

### Additives

1. Where required or approved by the Engineer, the Contractor shall use additives such as plasticisers or retarders in the concrete. Proportioning and mixing of additives thereof to be used in the concrete shall be in accordance with manufacturer’s recommendations and subject to the Engineer’s approval. Additives shall be added to the batch in solution in a proportion of the mixing water according to the manufacturer instructions. This solution shall be batched in such a manner as will ensure uniform distribution of the additive throughout the batch during the specified mixing period.

2. Additives shall be suitable for use in contact with potable water after 30 days of concrete curing.

3. All additives shall satisfy the requirements of PS 125 accompanied with a certificate of compliance from approved laboratory.

4. The additives used shall be furnished by the Contractor, and the cost of the materials and all costs incidental to their use shall be included in the unit prices bid in the Bill of Quantities for concrete in which the materials are used.


3.3 **Types and Strength of Concrete**

A Types and Strength of Concrete to be used in the works are as shown in table 3.4 below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Cube Strength after 28 days [MPa]</th>
<th>Minimum Quantity of cement kg per m³ of concrete</th>
<th>Maximum Permissible Water/cement Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 150</td>
<td>18</td>
<td>220</td>
<td>0.60</td>
</tr>
<tr>
<td>B 200</td>
<td>23</td>
<td>260</td>
<td>0.55</td>
</tr>
</tbody>
</table>

1. Concrete type B200 shall be used as watertight for manholes chambers, thrust blocks, encasements, benching or where specifically directed by the Engineer. Concrete type B150 for fill below pipes in trenches, blinding, street crossing or as indicated on Drawings.

2. The Contractor shall be free to fix the proportions of the mix provided that it could be demonstrated that the mixes used have the lowest possible water content consistent with proper grading and good workability for the sake of minimum drying shrinkage, and on condition that the Contractor can prove by advance testing carried out in approved laboratory, that they are suitable, comply with all the requirements of the specifications, and that they can be transported, placed and compacted by the methods and equipment used on site.

3.4 **Forms and Shuttering**

1. All forms for casting of concrete shall be made of steel, plywood, mazonite or similar material providing a completely smooth surface of the face coming in contact with the concrete. Only new, strong and smooth timber shall be used for shuttering and scaffolding.

2. The Contractor shall bear the sole responsibility for the safety and stability of the forms, scaffolds etc., and in the case of collapse, excessive deflections, buckling and/or any other changes in shape, the damage shall be repaired by the Contractor at his expense.

3. Form ties shall be internal where possible. The typing of forms in the walls shall be made with special accessories fitted with cones or accessories of approved type by the Engineer so as to ascertain complete sealing after stripping of forms, and avoid any seepage of water at the ties. After the tie fittings have been removed, the holes shall be filled with epoxy on the inside and cement grout of the approved type by the Engineer on the external face.

4. Forms shall be stripped only with the Engineer’s approval. The minimum period from completion of casting to commencement of stripping will be as follows:

   - Walls - 48 hours
   - Roof - 14 to 21 days

3.5 **Mixing and Placing of Concrete**

1. Contractor will have to submit for Engineer’s approval a scheme of the proposed forms and shuttering as well as a detailed schedule for casting proceedings.

2. Contractor must inform the Engineer of any scheduled casting at least 48 hours prior to the casting and must obtain Engineer’s approval to the proposed schedule.

3. When mixing on site is approved by the Engineer, concrete shall be machine mixed with approved machines.
4. The location of the mixing plants shall be agreed on with the Engineer and the Contractor must submit to the Engineer for approval before erection of any mixing plant his proposed arrangements for the storing of aggregates, batching and mixing of the concrete.

5. The placing of concrete in any element is to be carried out continuously without pause, in a manner which will not produce construction joints or cold joints due to partial drying of compacted concrete.

6. The concrete transported by transit mixer or agitators, the time elapsing from the time water is added to the mix until the concrete is deposited in place shall not be greater than the time taken for 300 revolutions of the transit mixer or agitator or 20 minutes, whichever is the least.

7. Driver of delivery trucks shall be provided with trip tickets, which shall be signed by a responsible member of the central plant staff, for submission to the Engineer. The ticket shall contain name and address of the central plant, serial number of the ticket and date, truck number, class and/or strength of concrete, cement content of the mix, loading time, slump and any other type of relevant information. The Engineer may send his representative to the central plant to check the batching and mixing, verify loading time and take a copy of the trip ticket.

8. The placing of fresh concrete will be gently placed in position and will not be allowed if the free fall is more than 2.0m. Concrete shall not be placed in such a manner that it displaces reinforcing bars, ties, etc. The fresh concrete is to be placed in its final destination in accordance with the above mixing and batching procedures. Any concrete that has become so stiff that proper placing cannot be assured, shall be wasted.

9. Concrete shall be consolidated to a maximum practicable density, by means of vibration, so that it is free from pockets of coarse aggregate and entrapped air, and closes snugly against all surfaces of forms, reinforcing steel bars and embedded materials. The slump for concrete thus consolidated must be fairly high and the cement quantity increased accordingly to achieve specified strength.

3.6 **Joints**

1. Working joints in the concrete will be permitted only in places marked on the Drawings or as approved by the Engineer.

2. Working joints will not be measured for payment and Contractor will incorporate their cost in the unit prices for concrete works.

3. Joints with P.V.C water stops will be constructed as marked on the Drawings or requested by the Engineer.

4. The water stops will be of P.V.C strips 240 x 4 mm. supplied by an approved manufacturer and approved by the Engineer. Contractor must furnish samples of water stop to be used along with the manufacturer’s certificate specifying the characteristics and quality of the material.

5. Engineer’s approval of the sample does not release the Contractor from any responsibility to the quality of the material and the proper execution of the joint.

6. Water stops will be furnished to the site as complete units having the shape and dimensions as indicated on the Drawings.

7. The edges of the water stop will be joined by welding since no overlap will be permitted.

8. The water stop will be inserted accurately in the elements of the structure cast first and will be properly protected from any damage, dirt or distortion of its shape and position. Prior to casting the adjoining part of the concrete element, face of the joint will be properly cleaned and a 3 mm. hot asphalt coat will be applied on the whole of the joint area. Sealing of joints shall be completed by filling the groove with an elastoseal pack as marked on the Drawings.
3.7 Curing

i) Materials

1. Hessian or Burlap: They shall be clean and free from harmful materials. Their unit weight shall be not less than 230g/m³.

2. Impermeable membrane: The following impermeable membranes may, with the Engineer’s approval, be used.
   1. Clear polyethylene film with no holes, tears, scratches and contamination of any type.
   2. Hessian coated with white polyethylene of density not less than 300g/sq.m. The coating may be on one side only but shall be not less than 0.1mm thick and shall not peel during and after use.

Curing Compounds: These shall conform to AASHTO M148 (ASTM-C309).

D. Sand: It shall be natural sand free of silt and clay and contaminants which can be harmful to the concrete.

A. Water: It shall satisfy the requirements of Section 3.2 of the Specification.

ii) Method of Curing

1. General: The method of curing to be used shall be approved by the Engineer. It shall not cause any undesirable blemishes such as surface discolorations and surface roughness. Curing compounds shall not be used on construction joints and surfaces that are to receive waterproofing, paint or membranes.

2. Ponding: Curing by ponding may be used for horizontal surfaces such as bases, pile caps and slabs. Large areas of horizontal surfaces shall be separated into ponds not exceeding 5 sq.m. The ponds shall first be filled between 12 to 24 hours after pour, unless otherwise authorised by the Engineer, and shall be replenished from time to time so as to maintain the ponding for the specified curing period. The concrete temperature and the temperature of the curing water shall be not greater than 20°C.

3. Sprinkling: Unless otherwise approved by Engineer, curing by spraying shall commence between 12 to 24 hours after the concrete pour. The concrete shall be maintained damp at all times during the curing period by periodic light sprays.

4. Wet Hessian / Burlap: Members to be cured by wet hessian or wet burlap shall be completely wrapped with the material which shall be kept moist at all times during the curing period by regular spraying. Unless otherwise approved by the Engineer, the overlap under normal conditions shall be not less than one-quarter the width of the hessian or burlap and not less than one-half the width in windy and/or rainy conditions. Before members are wrapped for curing, they shall first be evenly moistened. Unless approved by the Engineer, burlaps shall be supplied only in rolls and burlap bags shall not be used. Secondhand hessian and burlap, if approved for use, shall be clean without holes and contamination of any kind that can affect the concrete.

5. Waterproof Sheets: Waterproof sheets used for curing shall, unless directed by the Engineer, be spread immediately after the pour. The sheet shall, unless approved by the Engineer, be clear of the concrete surface but be arranged in such a manner as to prevent the movement air over the concrete surface. Waterproof sheets shall not be used when the air temperature is 25°C or higher.

6. Curing Compounds: Curing compounds shall be applied in two applications at a coverage rate of not less than 1 ltr/ 7.4 sq.m. per application or as recommended by manufacturer.
7. The first coat shall be applied immediately after the removal of the forms and the acceptance of the concrete finish and after the disappearance of free water on unformed surfaces. If the concrete is dry or becomes dry, it shall be thoroughly wetted with water and curing compound applied just as the surface film of water disappears. The second application shall be applied after the first application has set. During curing operations, any unsprayed surfaces shall be kept wet with water. The curing membrane will not be allowed on areas against which further concrete is to be placed.

8. Hand operated spray equipment shall be capable of supplying a constant and uniform pressure to provide uniform and adequate distribution of the curing membrane at the rates required. The curing compound shall be thoroughly mixed at all times during usage.

9. The curing membrane shall be protected against damage for the entire specified curing period. Any coating damaged or otherwise disturbed shall be given an additional coating. Should the curing membrane be continuously subjected to injury, the Engineer may require wet burlap, polyethylene sheeting, or other approved material to be applied at once.

10. No traffic of any kind will be permitted on the curing membrane until the curing period is completed, unless the Engineer permits the placement of concrete in adjacent sections, in which case the damaged areas shall be immediately repaired as directed.

11. Steam Curing
   Low Pressure Steam Curing: This shall be in accordance with recommendations of ACI 517.
   High Pressure Steam Curing: This shall be in accordance with the recommendations of ACI 516.

   iii) Curing Time

1. The minimum curing time shall be the number of days given in the Table below unless the average surface temperature of the concrete during the required number of days falls below 10°C, in which case the period of curing shall be extended until the maturity of the concrete reaches the value given in the Table.

### NORMAL CURING PERIODS

<table>
<thead>
<tr>
<th>Conditions under which concrete is maturing</th>
<th>Number of days (where the average surface temperature of the concrete exceeds 10°C during the whole period)</th>
<th>Equivalent maturity (degree hours) calculated as the age of the concrete in hours multiplied by the number of degrees Celsius by which the average surface temperature of the concrete exceeds minus 10°C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other*</td>
<td>SRPC</td>
<td>OPC or RHPC</td>
</tr>
<tr>
<td>1. Hot weather or drying winds</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>2. Conditions not covered by (1)</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

**NOTE** Other* includes all permitted cements except OPC, PHPC and SRPC.

**KEY.**
- OPC = Ordinary Portland Cement
- RHPC = Rapid-hardening Portland Cement.
Technical Specifications for Sewerage Systems

SRPC = Sulfate Resisting Portland Cement.

2. The minimum curing time given in the Table above shall be compared with the time required for cubes, cured under identical conditions to those which the concrete is subjected to, attain 70% of the characteristic strength. The greater shall be taken as the minimum curing time.

3.8 Concrete Repairs and Finish

1. All repair works that might be required on sections of the cast concrete shall be performed by the Contractor not later than 24 hours after removing of forms.

2. If not otherwise instructed, Contractor will cut all projecting tie wires to a depth of 15 mm, into concrete face and fill the recess with fresh concrete. Concrete projection caused by roughness of forms will be chiseled away or otherwise removed by a polishing carborundum stone. Gravel pockets, holes or faulty spots shall be chiseled out until clean and healthy concrete is exposed. All recesses shall be filled up with fresh concrete of approved cement grout and properly repaired. The repaired section will merge with the concrete of the structure and smoothened level with its surface.

3. All repair works will be performed only after damaged part has been checked by the Engineer.

4. All finish works shall be performed by the Contractor at his expense and he would not be entitled to any compensation for the same.

3.9 Construction of Manholes

i) General

1. The Contractor shall construct manholes in reinforced cast-in-place concrete or in precast concrete rings to the levels, dimensions and shapes shown on the Drawings, or as directed by the Engineer.

2. All manholes shall be constructed with incoming and outgoing pipes neatly and truly concreted in, complete with benching, cast iron steps and manhole cover and frame as here specified and shown on the Typical Drawings.

ii) Manholes

1. The Contractor shall construct a well compacted blinding layer of plain concrete Type B 150 to the required levels after the Engineer has inspected and approved bottoms of excavations. The surface of the blinding layer shall be regular and smooth.

2. The Contractor shall set tops of manhole frames and covers to the elevations as indicated on Drawings, unless otherwise directed.

3. All items built into walls of manholes and structures such as pipe ends shall be adequately sealed to obtain watertight construction to the satisfaction of the Engineer. Steps shall be installed in a staggered pattern to the extent indicated at not more than 300 mm centers and shall be well grouted.

4. Changes in direction of gravity sewers shall be made through the use of a manhole.

5. House connections shall be made to manholes using a piece of pipe called socket.

6. Drilling shall be used when connecting pipes into manholes.

7. Covers and frames shall be well centered and anchored all around to the approval of the Engineer.
Technical Specifications for Sewerage Systems

8. After the installation of the cast iron frames, the Contractor shall provide plain concrete Type B 150 in surrounds as indicated on Drawings. Surrounds shall be well haunched all round and trowelled smooth.

9. Drop fittings: Drop manholes shall have drop pipes and fittings installed such that the crown of the incoming drop pipes shall be at the same elevation as that of the outgoing pipe. Drop pipes shall be of the same diameter as the incoming pipes. The drop pipes and fittings shall be encased in plain concrete Type B 200 as indicated on the Typical Drawings.

10. Benching to manholes shall be constructed in plain concrete, Type B 200, well formed and streamlined and smooth trowelled in channels, bends and junctions.

11. All manholes steps, covers and its frames shall be well cleaned and painted with black paint of bituminous base after complete installation and to the approval of the Engineer.

12. All manholes shall be properly ventilated as shown in the Typical Drawings.

iii) Cleaning

A. All manholes shall be cleaned of any accumulation of silt, mortar, debris or other foreign matter and shall be free of any such accumulation at the time of final inspection.

iv) Reinstatement of Staircases

A. Staircases shall be reinstated as shown on the Typical Drawings and the type of reinstatement shall be decided by the Engineer according to the equal to that before the work began.

3.10 Metal Components Embedded in Concrete

A. All metal components that have to be fixed in the concrete such as pipe sections, steel frames and covers, hooks, ladders etc., shall be tightly placed in their right position within the shuttering prior to casting of concrete. All faces of metal parts that will be embedded in the concrete shall be thoroughly cleaned removing all dirt like, oil, paint, scale etc., in order to secure thorough adhesion between concrete and metal. Where pipes have to be anchored in the concrete, anchoring rings shall be welded to the pipe. In case a free passage of the pipe is required through the concrete, pipe should be wrapped with a bitumen saturated felt or a similar elastic sealing material.

3.11 Concrete Tests

A. Concrete tests shall be carried out in accordance with PS 55. Preliminary tests shall be made by the Contractor to determine suitable mixes. Routine tests shall be taken for cube strength according to PS 55-part1-1997 as as shown in table 3.5 below:

<table>
<thead>
<tr>
<th>Quantity of Concrete [m³]</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 40</td>
<td>3</td>
</tr>
<tr>
<td>from 40 up to 60</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3.5
Minimum No. of concrete samples.
Technical Specifications for Sewerage Systems

<table>
<thead>
<tr>
<th>Quantity of Concrete [m$^3$]</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 up to 80</td>
<td>5</td>
</tr>
<tr>
<td>80 up to 100</td>
<td>6</td>
</tr>
<tr>
<td>100 up to 130</td>
<td>7</td>
</tr>
<tr>
<td>130 up to 160</td>
<td>8</td>
</tr>
<tr>
<td>160 up to 200</td>
<td>9</td>
</tr>
<tr>
<td>for each additional 50 m$^3$ above 200</td>
<td>additional sample</td>
</tr>
</tbody>
</table>

Note: every sample consists of two cubes one to be tested at 7 days and the other at 28 days.

1. If the mean value of strength does not comply with the requirement of PS 45 the particular structural element must be core tested according to PS 55 part 6-1997, if the cores don’t comply with the requirement, Engineer shall have the right to require strengthening or replacement of that element which fail to develop the required strength. All remedies associated costs shall be at the expense of the Contractor.

2. All costs in connection with the tests shall be at the Contractor’s own expense.

3.12 Precast Elements

A. Precast elements shall be either of concrete or mortar as shown on the Drawings and as specified hereinafter

   i) Materials

   1. Precast Concrete Elements
   Precast concrete elements shall be of plain or reinforced concrete dimensions, thickness and reinforcement rods and bars shown on the Drawings and stated in the Bill of Quantities.

   2. Precast Mortar Elements
   Moist tamped mortar precast elements shall be of a mixture of ordinary or tinted cement and sand (fine aggregate) approximately in the proportions of one part cement to two and one-half parts of sand. The sand shall be specially selected for colour and grading. The sand shall be screened through 3mm square meshes and all oversize particles shall be discarded. Only sufficient water shall be used in mixing to permit the immediate removal of the member from the mould. The pattern, dimensions and thickness shall be as shown on the Drawings and/or as directed in writing by the Engineer.

3. Mortar

   Mortar for joining the precast elements shall be composed of one part of portland cement and three parts of clean sand unless otherwise specified. The cement and sand shall conform to the requirements portland cement and aggregate for mortar specified herebefore.

   ii) Fabrication

   A. Precast concrete or mortar elements shall be cast in Mortar tight metal lined timber moulds and shall be mechanically vibrated when cast. The Precast elements shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days. Any elements that show checking or soft corners or surfaces shall be rejected. The method of storage and handling shall be such as to preserve true and even edges and corners, any precast element which becomes chipped, marred or cracked before or during the process of placing shall be rejected, sampling of precast elements shall be submitted to the Engineer for approval, prior to fabrication, at the Contractor’s own expense.
iii) Workmanship

A. All precast concrete or mortar elements shall be well cleaned and thoroughly wetted with clean water before placing in their positions shown on the Drawings. The precast elements shall be bedded and jointed in cement and sand mortar (1:3) mix and the joints raked out on both faces to receive plaster or pointing as indicated on the Drawings and/or stated in the Bill of Quantities to the satisfaction of the Engineer.

3.13 Measurement and Payment

1. All concrete structures shall be measured by volume in cubic meters of each type of concrete according to dimensions marked on the Drawings or as specified by the Engineer. Anchor or Thrust Blocks shall be measured for payment by number of units.

2. Ready-made manholes shall be measured for payment by number of units.

3. All recesses, openings or any other space not actually filled with concrete shall be deducted in calculating the volume for payment. Any extra concrete which was cast due to the Contractor’s negligence and is not marked specifically on the drawings shall not be measured for payment.

4. Unit price quoted by Contractor shall include all works required to obtain designated concrete quality as well as supply of cement admixtures, and all aggregates, installing of forms and shutters and dismantling same, casting, vibrating, and compacting of concrete forming curved shapes as well as grooves or sleeves for pipes as may be required. Prices will include also taking samples, performing any laboratory tests that may be required by the Engineer and providing certificates of test results.

5. Reinforcing steel shall be measured for payment by weight as per Drawings or Engineer’s instructions. No overlaps, neither any odds or leftovers shall be counted as part of the total approved weight.

6. Unit price for reinforcing steel shall include: supply, cleaning, bending, cutting, shaping, placing and tying of steel bars as well as overlaps, chairs and spacers.

7. No payment will be due for working joints. Joints with water stops will be measured for payment in meter length of complete joint. Price shall include: supply of P.V.C water stop, placing, tying and jointing of water stop, applying of asphalt coat on joints face and protecting of exposed part of water stop.
SECTION 4: PIPELAYING

4.1 Handling and Transporting of Pipes

i) General

1. The Contractor’s arrangements for handling, lifting, transporting and stacking pipes, valves and specials, shall ensure that these articles are brought to their final place in the works undamaged and in good order.

2. All damage to the pipes or their coating while in the Contractor’s charge shall be repaired as required and directed by the Engineer, and all expenses in connection with such repairs shall be borne by the Contractor. In the event of any pipe being damaged to such an extent as to make the repair thereof, in the Engineer’s opinion, impossible or uneconomical the Employer will provide a new pipe in place of the damaged one, and the Contractor shall pay the cost thereof to the Employer.

3. When loading and unloading, handling, transporting, and moving and placing the pipes alongside and in the trench, care shall be taken to preserve the undamaged condition and roundness of the pipes, particularly at the ends. Special care shall be taken to keep the pipe coating intact.

4. Pipes shall not be stacked on the vehicles to such a height as may cause flattening of the lowermost pipes or damage to the coating. The height of the load for the various pipe diameters shall be as recommended by the Manufacturer and approved by the Engineer. Pipe specials shall be supported by sandbags or other padding and lashed down as described above so that they are not damaged during transport.

5. The trucks and cars used for the transporting of the pipes shall be adequately equipped to prevent displacement of pipes and/or damage to pipes or coating. Pipes shall be well secured to the vehicles to ensure stability of the load, and all parts of trucks and cars as well as cables coming into contact with coated pipes shall be well padded.

6. Unloading of pipes from trucks or cars shall be done by means of cranes or other suitable equipment ensuring slow and careful lowering of each pipe length. Pipes shall not be gripped by hooks or other equipment liable to injure or distort pipe ends.

7. The Contractor shall provide cranes for lifting and lowering pipes at the site of work and at the storage area and wherever pipes are being handled.

8. Pipes must not be dropped on the ground or on other pipes. When lifting or lowering pipes by means of a crane, each pipe shall be kept under full control when suspended to prevent its colliding with equipment, rocks, trees or any other objects that may injure the pipe or its coating.

9. Pipes shall not be moved by dragging them on the ground, but shall be lifted by crane or other means and placed carefully at their new locations. In rocky country, pipes shall be deposited with their bare ends on wooden skids at least 100 mm wide.

10. Each pipe placed on the ground shall be prevented from rolling. Walking on coated pipes in the field shall not be permitted. Pipes shall also be protected from contact with metal tools or heavy objects that may injure the coating.

11. No steel cables or ropes likely to injure the coating shall be used for handling the pipes, but only belts at least 250 mm wide or such special tackle as will not damage the coating.

iii) Concrete Pipes

1. Considering all above mentioned general instructions, concrete pipes and fittings shall not be dispatched from the factory before 28 days have elapsed after manufacturing.
2. All pipes, and fittings shall be Sulphide resistant, and be carefully inspected and examined for cracks and other defects while suspended above the trench immediately before installation in final position.

3. Material found to be defective or damaged shall be rejected and removed from the Work. Spigot ends shall be examined with particular care as this part is the most vulnerable to damage from handling. Any damage to exterior protective coatings shall be repaired before the pipe is laid in the trench. In case of damage to the interior protective coating or lining, the said pipe or fitting shall be laid aside for inspection by the Engineer, who will prescribe corrective repairs or rejection. Where a portion of a length of pipe is damaged, the damaged part shall be cut off in an approved manner and discarded and the remaining sound portion may be used. Any materials which fail or become damaged will be deemed to have been caused by the Contractor’s negligence in handling and must be replaced with new or repaired as the Engineer decides without cost to the Employer.

iv) Polyvinyl Chlorine (PVC) and Polyethylene (PE) Pipes

1. Considering all above mentioned general instructions, PVC and PE items deteriorate in sunlight and are slightly brittle, especially at lower temperatures, so care shall be taken in loading, transporting and unloading items to prevent injury to the items. All items shall be examined before installation and no piece shall be installed which is found to be defective. Handling and installation of pipe and fittings shall be in accordance with the manufacturer’s instructions, referenced standards and as specified herein.

2. Any pipe or fitting showing a crack or which has received a blow that may have caused an incident fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.

3. In handling the items, use special devices and methods as required to achieve the results specified herein. No uncushioned devices shall be used in handling the item.

4.2 Stacking and Storage of Pipes

i) General

1. Pipes stored in the field shall be arranged in piles in such a manner that the pressure of the pipes placed on each other will not cause deformation of the pipe or damage to the coating.

2. The Supply Contractor shall properly stack the pipes in the storage yard of the Employer and the stacks shall be laid out in a regular pattern and the limits of each stack marked to that the movement of cranes and vehicles is restricted to access tracks between stacks and the control of delivery and removal pipes is facilitated.

3. The number of tiers of steel and ductile iron pipe stacks shall be as per the Manufacturer’s instructions and approval of the Engineer and each pipe, including those in the bottom course, shall bear evenly upon not less than three timbers with an aggregate width not less than 300 mm. The pipes shall be stacked parallel to each other and arranged so that in each course all sockets are at one side and in the next course all spigots are on the other side.

4. The timbers supporting each course of pipes in a stack shall be of uniform thickness and stiff enough for the pipes to be rolled across the stack and shall be supplied by the Contractor at his own expense.

5. The outermost pipes in each course shall be secured against rolling by sandbags or by wedges.

6. Where the pipes are to be delivered and stacked by the Supply Contractor on designated sites lying on the pipeline route, unless it is otherwise specified elsewhere, the areas where the pipes are to be stacked shall, if required, be graded flat by the Supply Contractor at his own expense to provide a firm even surface, and kept free from loose stones, rubble or waste liable to damage the pipe coating.

ii) Concrete Pipes
Technical Specifications for Sewerage Systems

1. In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench.

2. The Contractor shall keep the pipe and appurtenances clean during the progress of the work. Dirt, debris or other foreign material shall be removed from the interior of the pipe before installation. All openings in the pipeline shall be plugged watertight with standard cast iron test plugs, expandable type sewer plugs or other means approved by the Engineer at the end of each day’s operations or whenever the workmen are to be absent from the work area. The use of burlap, wood or other similar temporary plugs will not be permitted. All surface or ground water shall be prevented from entering the pipe and shall be removed from the trench. Should water nevertheless enter the trench, laid pipes shall be secured against lifting.

3. Rubber rings for pipe joints shall be stored and protected in a proper manner to prevent deterioration.

   iii) PVC and PE Pipes

   A. While stored, pipe shall be adequately supported from below at not more than 900mm intervals to prevent deformation. The pipe shall be stored in stacks no higher than that given in Table 4.2:

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Max. No. of Rows Stacked</th>
</tr>
</thead>
<tbody>
<tr>
<td>200mm or less</td>
<td>5</td>
</tr>
<tr>
<td>300 to 530mm</td>
<td>4</td>
</tr>
<tr>
<td>600 to 760mm</td>
<td>3</td>
</tr>
<tr>
<td>840 to 1220mm</td>
<td>2</td>
</tr>
</tbody>
</table>

1. Pipe and fittings shall be stored in a manner which will keep them at ambient outdoor temperatures and out of the sunlight. Temporary shading as required to meet this requirement shall be provided. Simple covering of the pipe and fittings which allows temperature build-up or direct or indirect sunlight will not be permitted.

2. If any defective item is discovered after it has been installed, it shall be removed and replaced with an exact replacement item in a satisfactory manner by the Contractor, at the Contractor’s own expense. All pipe and fittings shall be thoroughly cleaned before installation and the interior shall be kept clean until testing.

4.3 Materials supplied by the Employer

1. In case the pipes and ancillary fittings, specials and valves are to be supplied by the Employer the latter shall supply to the contractor free of charge at his stores or at the place indicated in the Particular Conditions and Specifications, the required quantities of different pipes of various diameters together with the respective fittings, specials, adapters and valves as outlined in the Particular Conditions and Specifications and the Contractor shall load transport and unload the materials so supplied at the site of works and shall be responsible for proper unloading, stacking and storing.

2. The pipes shall be unloaded from the trucks in an approved manner and the Contractor shall take utmost care not to damage the pipes or any of the materials so supplied. Any damage caused to the materials in loading, transport and unloading at the site of works shall be repaired by the Contractor at his own expense in accordance with the Engineer’s instructions and to his satisfaction.

3. Material irreparably damaged shall be replaced by the Contractor at his own expense or charged to his account.

4. The Contractor shall stack the pipes in a secure, safe and approved manner and in a way to allow easy handling.

5. Pipes found damaged before handling them over to the Contractor shall be counted and stacked by the Contractor separately each diameter aside and the damage of each pipe, shall be fully described. Such pipes
shall not be used in the works unless and until the Contractor has used all the sound pipes delivered to him and is so ordered by the Engineer.

6. The Contractor will be required to sign the vouchers for the materials supplied to him, and shall keep proper stores book to show at any time the quantity of materials received and those which have taken from the stores for use in the works. The Engineer or his representative shall have the right to inspect at any time the store books, and to check the materials in the stores and on site of works to satisfy themselves that everything is in order and the Contractor will be required to account for any discrepancy found.

7. The Contractor shall at his own expense provide and constantly maintain day and night watching and shall be responsible for the theft or loss for any materials supplied to him by the Employer whether theft occurred from the stores or from the site of works. Any materials so found missing shall be immediately replaced by the Contractor at his expense.

8. On completion of works, the materials used in the works shall be counted and / or measured and the balance shall be handed over by the Contractor to the Employer at his indicated storage yard. The loading, transport, unloading and proper stacking of materials shall be carried out in accordance with the relative clauses of the Specifications and shall be at the Contractor’s expense.

9. Any materials not accounted for shall be replaced by the Contractor at his own expense or shall be charged to the Contractor’s account C.I.F. site plus 20% as the Engineer deems it suitable.

4.3 Pipelaying in Trenches

i) General

1. Pipes and fittings will be installed in strict accordance with the Manufacturer’s Specifications and instructions to the satisfaction and approval of the Engineer.

2. The pipe route shall be determined by the Engineer. The Engineer reserves the right to vary or abandon any part or parts of the routes of pipelines indicated on Drawings and the contractor shall lay the pipes in accordance with any such variations which the Engineer may issue.

3. The Contract Drawings show the approximate lines and levels to which the pipeline is to be built and are subject to amendments by the Engineer on site. Before setting out any sections of the pipeline, the Contractor or his representative shall make an inspection of the site in company with the Engineer and obtain from him his instructions in this respect.

4. All pipes, curves, bends and other specials shall be laid accurately in accordance with the alignment, levels and gradients so determined, so that the top of the pipe is not less than the minimum specified depth below the finished ground level along the pipeline. Changes in gradient and the numbers of air valves and wash-out valves will be the minimum necessary to secure efficient operation and economy in excavation.

5. The Contractor shall provide the surveying instruments, surveyors, skilled staff and everything necessary for setting out the works to line and level and for checking the accuracy of pipe-laying and jointing. He shall attend upon the Engineer and provide him with such assistance as may be necessary to enable him to check the setting out of the works.

6. The finished pipeline shall run straight between bends or curves and a uniform gradient shall be accurately maintained between changes of gradient shown on the drawings or authorized by the Engineer.

7. The bottom of the trenches shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of pipe and bell holes shall be provided. The Contractor shall inform the Engineer sufficiently in advance when the formation levels of the trenches are ready for inspection. No pipe laying will be allowed
Technical Specifications for Sewerage Systems

until the bottom of trenches have been inspected and approved by the Engineer and the depths of the trenches and the kind of excavation have been recorded and agreed upon by both the Contractor and the Engineer.

8. As a general rule, water pipes and sewers should not be laid in the same trench. They should be laid in separate trenches at least 3m apart in horizontal direction. If local conditions, such as in very narrow streets, do not permit the horizontal minimum separation of 3m, this distance could be decreased but the bottom of the water pipe must be kept at least 500 mm above the top of the sewer. But if the vertical separation of not less than 500 mm cannot be obtained, concrete encasement shall be provided to sewer pipe as shown on the Drawings.

9. The pipe shall be positioned and bedded in the trenches in an approved manner and properly aligned. Before being positioned, each pipe shall be thoroughly examined to ensure that it is free from defects and shall have all dirt removed from the inside thereof. The Contractor shall cut the pipes if and where needed to the required length and shall thread, chamfer or bevel the cut ends of pipes as the case may be and shall supply and install all fittings, specials and adapters as may be necessitated for the proper execution of the works and shall joint the pipes in accordance with the Specifications and to the Engineer’s Satisfaction.

10. All pipe shall be sound and clean before laying. Good alignment shall be preserved in laying. The deflections at joints shall not exceed that recommended by the manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided.

11. Any injury to the protective coating of the pipes from any causes during the construction of the pipeline shall be repaired by the Contractor at his own expense to the satisfaction of the Engineer.

12. At the end of each day’s work a strong watertight plug or other approved means shall be firmly fixed in each open end in order to exclude all foreign materials.

13. In order to prevent the pipes from “creeping” from the mechanical joints and to protect the welds against thermal stresses, which are specially dangerous when pipelaying is done in summer, the following instructions shall be strictly adhered to:

14. Lowering-in and jointing of sections shall be done, as far as possible; in the early hours of the morning.

15. As soon as the tack-welds have been completed, in the case of overhead weld joints, or as soon as the bolts have been tightened, where sections are connected by mechanical joints, the first stage backfill (between joints) shall be executed, so that no more than one section at a time will remain uncovered in the trench.

16. Lowering-in and/or placing of welded sections on temporary supports shall be done carefully so as to prevent any damage from being done to existing coating or paint.

17. The method employed for lowering-in shall be subject to the Engineer’s approval.

ii) Concrete Pipes

1. The pipes shall be laid accurately to line and level and jointed in an approved manner. The pipes shall be laid on the backfilled and finished bedding of the trench, and special hollows be made for the joints. The spigot part of the pipe shall be placed below the grade line to avoid any cracks between the pipe and the spigot.

2. The whole inside and outside area forming the joint of pipe and fittings shall be thoroughly cleaned before laying. Every precaution shall be taken to prevent foreign material from entering the pipes. During laying operations, no debris, tools, cloth or other materials shall be placed in the pipe.

3. After placing a length of pipe in the trench, the spigot end shall be centred in the socket (or corresponding) and pipe forced home and brought to correct line and grade. The pipe shall be secured in place with approved backfill material tamped under it except at the joint. Pipe and fittings which do not allow a sufficient and uniform space for joints shall be removed and uniform space provided. Precautions shall be taken to prevent
dirt from entering the joint space. Pipes shall be laid such that the whole body of the pipes is in contact with the bedding. All pipeline must be inspected and approved by the Engineer before they are covered.

iii) PVC and PE Pipes

1. No single piece of pipe shall be laid unless it is straight. The centerline of the pipe shall not deviate from a straight line drawn between the centers of the openings at the ends of the pipe by more than 1.5mm per 300mm of length. If a piece of pipe fails to meet this requirement check for straightness, it shall be rejected and removed from the site. Laying instructions of the manufacturer shall be explicitly followed.

2. If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Employer. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required. Pipe and fittings shall be installed in accordance with requirements of the manufacturer, and AWWA C605 or as otherwise provided herein.

3. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. cut ends of pipe to be used with a bell shall be beveled to conform to the manufactured spigot end.

4. The Engineer may examine each bell and spigot end to determine whether any performed joint has been damaged prior to installation. Any pipe having defective joint surfaces shall be rejected, marked as such and immediately removed from the job site.

5. Each length of the pipe shall have assembly mark aligned with the pipe previously laid and held securely until enough backfill has been placed to hold the pipe in place. Joints shall not be “pulled” or “cramped”. Deflection in horizontal or vertical alignment shall not performed without the approval of the Engineer’s Representative as to the extent of the deflection. In no case shall such deflection be done at the pipe joint. If any bending is required it should be done at the central portion of the pipe and not exceeding the limits specified by the manufacturer. Whenever the required deflection exceeds the permissible limits, the contractor shall install proper bends in the line and anchor same as required. Care should be exercised to lay the pipe in such manner as to minimize the high and low points in it.

6. Before any joint is made, the pipe shall be checked to assure that a close joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe shall not driven down to grade by striking it. Bell or coupling holes shall be formed so that, upon being placed only the pipe barrel is in contact with the trench bottom.

7. Jointing of PE pipes will be made using electro-fusion method. During jointing with electro-fusion, care should be taken that joints are not moved before the cooling process has been completed.

8. For PVC pipes, flexible joints with spigot and sockets sealed with rubber rings or gaskets will be used. Spigot ends shall be centralized within sockets, and shall be pushed into the socket, strictly following the manufacturer’s instructions, until reach the depth of the entry mark. The pipe should never be over inserted. I. Precautions shall be taken to prevent flotation of the pipe in the trench.

1. When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care shall be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe, or disturbance of the pipe bedding and the backfill. Trench boxes, moveable sheeting, shoring or plates shall not be allowed to extend below top of the pipe. As trench boxes, moveable sheeting, shoring or plates are moved, pipe bedding shall be placed to fill any voids created and the backfill shall be recompacted to provide uniform side support for the pipe.

2. Joints shall be made in strict accordance with the manufacturer’s instructions.
4.4 Joints Installation

i) General

1. Joints shall have natural or synthetic rubber rings maintained in place in such manner as to ensure watertight joints during the specified tests, and the subsequent life of the installed pipes. The ring shall be highly resistant to deterioration in contact with sewage.

2. The joint material shall further more comply with the requirements of the B.S, ASTM or DIN.

3. No cementitious or adhesive material shall be used to construct or make repairs at the joints.

ii) Flanged Joints

1. The flanges shall be scraped clean and correctly positioned and the component parts including any insertion ring cleaned and dried. Insertion rings shall be fitted smoothly to the flange without folds or wrinkles. The faces and bolt holes shall be brought fairly together and the joints shall be made by gradually and evenly tightening bolts in diametrically opposed positions. Only standard length spanners shall be used to tighten the bolts.

2. The protective coating, if any, of the flange shall be made good when the joint is completed.

iii) Mechanical Joints

1. Before installing mechanical joints, the pipe ends shall be cleaned of any paint, asphalt and dirt and their perfect roundness shall be ensured for a distance of not less than 200 mm from the edge.

2. Joint rings shall slide freely into the pipes. Forcing on of rings by hammer blows will not be permitted.

3. Rubber gaskets shall be protected against sunlight until immediately before installation. Where a “bored Dresser” is required, the ridge in the central ring shall be removed by turning on lathe in the shop or by chiseling if the work is done in the field. Removing the ridge by flame gouging is strictly prohibited.

4. Where shown on the drawings or required by the Engineer, Dresser couplings shall be fitted with anchors. The shape and method of installation of these anchors shall be as shown on the drawings.

5. Every Dresser coupling shall be bridged for cathodic protection as shown on the drawings (see clause 6.2).

4.5 Connections to Existing Mains

A Where connections are to be made to any part of the existing mains the Contractor must make all necessary arrangements with the Engineer and have all necessary material, plant and labour in readiness on the ground and shall complete the work as rapidly as possible with the minimum of inconvenience to consumers. The actual connection to an existing main will be the Contractor under the close supervision of the Engineer. B All connections to an existing main should be through manholes.

4.6 House Connections

1. House connection shall be extended inside the property of the customer at a distance of 1m inside the lot of the satisfaction of the Engineer. The pipe should be sleeved with a suitable sleeve material where it passes through the boundary wall and as indicated on the Drawings.

2. A stop valve shall be installed adjacent to the meter on the entry side as indicated on the Drawings, to work as an isolating valve for maintenance purposes.
3. The Engineer will issue instructions regarding size, location and fittings for each service connection.

4. All service connections shall be subjected to a hydrostatic pressure test in the presence of the Engineer’s Representative. Sterilization of the service connection will be carried out at the same time as the main to which it is connected.

4.7 Protection of Joints

1. All buried steel and ductile iron flange joints, flange adapters and couplings shall be protected by wrapping with “Denso Tap” or similar approved material.

2. The joints shall be thoroughly cleaned to remove all loose rust and extraneous matter and thoroughly and adequately wrapped with the protective tape to the satisfaction of the Engineer.

4.8 Hydrostatic Test

i) General

1. After completing the installation of a sewer line or a section of the line, and before backfilling is carried out, a hydrostatic test of the line shall be made.

2. The test pressure shall be 1.0 meter head of water at the highest point of the section under test. The length of each section to be tested shall not exceed 100 meters and the pressure at the lowest point shall not exceed 10 meters head of water for gravity lines.

ii) Procedure

1. Whenever possible, testing of sewers shall be carried out from manhole to manhole. Short branch sewers connected to a main sewer between manholes may be tested as one system with the main sewer. Long branch sewer shall be tested separately.

2. Both ends of the Sewer to be tested, as well as inlets and outlets to manholes and other connections in between shall be sealed effectively. At the upper end of the sewer a gauge glass shall be connected to the sealing plug to enable the observation of the water level during the test. The gauge glass should have an inner diameter of about 50 mm and shall be provided with a mark located at 1.0 meter above the top of the sewer. An air vent and a cock should also be installed at the same end for release of air during the filling of water for the testing. The air vent shall be connected to the sewer so that all air can be released. The trench shall be kept free of all kinds of water during the test.

iii) Duration of Test

A. The pipe shall be filled with water for a period of minimum 2 hours and maximum 24 hours before the test is assumed to begin to allow for a soaking period and a complete release of air. If 25 hours have passed with water in the pipe, filled or partially filled, without being tested the pipe should be emptied completely and left for 24 hours and then filled again with water and tested within 2-24 hours soaking period. The water level shall be at the mark on the gauge glass during the whole soaking period. The test shall be carried out immediately after the soaking period.
iv) Permissible Leakage

1. Leakage is defined as the quantity of water which must be supplied to the laid pipe during 10 minutes to maintain the specified water level after the pipe has been filled with water and the air expelled. The additional quantity of water filled into the pipe shall be measured with an accuracy of 0.1 litres.

2. The sewer will be accepted in respect of water tightness if the quantity of water added during 10 minutes is less than quantity calculated in accordance with the following clauses (v) and (vi).

v) Sewer Line With One Pipe Dimension

1. The maximum permissible quantity of water which may be supplied to the line during the test is estimated as follows:

   \[ Q = (0.118) (L) (d) \]

   Where \( Q \) = quantity of water in litres during 10 minutes  
   \( L \) = length of line in meters  
   \( d \) = inner diameter of pipe in meters

2. The maximum permissible leakage in manholes is estimated as 0.35 liters per 10 minutes per meter diameter per meter depth of water inside the manholes.

vi) Extent of Testing

1. The Contractor shall provide at his own expense all equipment, labour, and materials necessary and carry out testing of 100% of the total lengths of the lines included in the works before covering the pipes. House connections and manholes are not included. 50% percent of the manholes should be tested separately or with the line.

2. Manholes shall be tested before benching is made in manholes and before backfilling and after installation of the steps. A maximum of 5% of the lines shall be tested including house connections after backfilling is complete.

3. The lines to be tested shall be chosen by the Engineer. should any line tested before backfilling exceeded the permissible Q by more than 5% the Contractor shall after repairing and making good any leaks carry out further tests all as above described and within the specified soaking period. If it continues of fail by more than 5% of permissible Q at the end of the soaking period, the line should be dismantled and reconstructed with new pipes and should be retested, all at the Contractor’s expense.

4. The same procedure is applied for lines and house connections that are tested after backfilling but with a tolerance of 15% of permissible Q. Repair and making good, referred to above, is to correct the alignment, level of the pipes or to fix properly any two pipes. Brushing, grouting, cementing or concreting is not allowed neither before nor after the test is run. All tests and retests and repairs shall be at the expense of the Contractor.

4.9 Field Air Test

i) General

1. An alternate leak test for sewerage pipe systems may be conducted with air pressure instead of water, if instructed by the Engineer due to shortage of water for testing.
Technical Specifications for Sewerage Systems

2. Field air test is a low pressure air test which determines the rate of which air under pressure leaves an isolated section of the pipeline. This rate indicates the presence or absence of leaks.

**ii) Procedure**

1. As with the hydrotest, the section of pipe together with its connected ends of all bends, laterals and wyes should be plugged and braced against internal pressure. One of the plugs provided must have an inlet tap or other provisions for connecting an air hose, the other end of the hose to be connected to the portable air control equipment.

2. Slowly pressurize the system to 24 kPa. The pressure must be regulated to prevent over pressurization (maximum 35 kPa). Allow the air pressure to stabilize for at least 2 minutes while maintaining the pressure at 24 kPa. During this stabilization period, with soap solution detect any possible leakage. If any plug is found to leak, bleed off the air, tighten the plug and start again.

3. After the stabilization period, adjust the air pressure to 24 kPa and shut-off or disconnect the air supply.

4. The pipeline passes this test if the pressure drop is 3.5 kPa or less during the time periods given in Table 4.3 below.

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Time (min.)</th>
<th>Diameter (mm)</th>
<th>Time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2 1/2</td>
<td>1000</td>
<td>25</td>
</tr>
<tr>
<td>150</td>
<td>3 3/4</td>
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<td>27 1/2</td>
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<tr>
<td>200</td>
<td>5</td>
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<td>30</td>
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<tr>
<td>250</td>
<td>6 1/4</td>
<td>1300</td>
<td>32 1/2</td>
</tr>
<tr>
<td>300</td>
<td>7 3/4</td>
<td>1400</td>
<td>35</td>
</tr>
<tr>
<td>350</td>
<td>8 3/4</td>
<td>1500</td>
<td>37 1/2</td>
</tr>
<tr>
<td>400</td>
<td>10</td>
<td>1600</td>
<td>40</td>
</tr>
<tr>
<td>500</td>
<td>12 1/2</td>
<td>1800</td>
<td>45</td>
</tr>
<tr>
<td>600</td>
<td>15</td>
<td>2000</td>
<td>50</td>
</tr>
<tr>
<td>700</td>
<td>17 1/2</td>
<td>2200</td>
<td>55</td>
</tr>
<tr>
<td>800</td>
<td>20</td>
<td>2400</td>
<td>60</td>
</tr>
<tr>
<td>900</td>
<td>22 1/2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**iii) Safety Requirements**

1. Considerable potential energy is stored in a pipeline under pressure. This is particularly true when air (even at low pressure) is the test medium. Take great care to ensure that the plugs are properly secured. It is also obvious that the pressure in the pipe is completely relieved before the plug is loosened.

2. Under no circumstances should a person be allowed to be inside a manhole while the air pressure is applied to the pipelines

**4.10 Hydrostatic Pressure Test**
Technical Specifications for Sewerage Systems

i) General

1. The pressurised sewers will be tested by a hydrostatic pressure test. After pipelaying, casting of concrete structures on the line and partial backfill have been completed, the line shall be subjected to a hydrostatic pressure test. The line shall be tested over its entire length or, in the case of long lines, in sections. The pressure test shall only be performed in the presence of the Engineer.

2. The test pressure shall be determined by the Engineer in each case. The required pressure shall be obtained by means of a special pressure pump or by connecting the line to a suitable source of pressure.

ii) Preparations for Pressure Test

1. Filling of the line with water shall not begin until 6-7 days after the last concrete structures have been cast. Prior to filling the line, all joints and structures shall be inspected and the good condition and proper functioning of all valves shall be ascertained. When testing a section not ending in a valve, the open end shall be bulkheaded and securely anchored. The testing installation and the working of the pump shall also be examined.

iii) Filling the Line with Water

1. The line shall not be filled until the Engineer’s written approval thereto has been given. The line shall be filled gradually and slowly in order to prevent water hammer or chattering in the pipe and to permit the escape of all air from the pipeline.

2. At the commencement of filling, all blowout valves shall be open, and each valve shall be closed after the water has flushed all dirt that may have accumulated in the pipes.

3. After the filling has been completed, but before the pressure is raised, all valves shall be inspected for watertightness and all leaks in gaskets and stuffing boxes shall be stopped. Should this inspection show any leaks at the joints or defects in the valves that can not be repaired while the line is full of water, the line shall be drained and the necessary repairs done. This inspection shall be repeated until all leaks are stopped.

iv) Pressure Test

A. The pipelines of the transmission and water distribution system and all the joints shall be tested by the Contractor at a test pressure as shown in table 4.3 below:

<table>
<thead>
<tr>
<th>Working Pressure Range [atm]</th>
<th>Factor *</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 12</td>
<td>1.5</td>
</tr>
<tr>
<td>13 - 20</td>
<td>1.25</td>
</tr>
<tr>
<td>more than 20</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Test pressure = Working pressure * Factor

The testing shall be carried out in sections as the pipes are laid.

1. The length of sections and the procedure of testing shall have the prior approval of the Engineer. The Contractor shall furnish and fix on the pipelines at locations indicated by the Engineer Tees provided with 1/2” stop-cocks
Technical Specifications for Sewerage Systems

for the purpose of releasing the air from the pipelines. After pressure testing of the lines the stopcook shall be removed and the opening properly plugged.

2. An efficient stop and strutting block shall be placed at the end of the section to be tested. After the pipes have been completely filled with water and all air has been exclude therefrom, the pressure shall be raised by pumping to the specified test pressure as instructed by the Engineer.

3. The pipeline shall be maintained under this pressure for a period of 24 hours, during which period the pressure shall not be allowed to fall below 75% of the test pressure but shall be restored to the full test pressure by such pumping as may be necessary.

4. The test pressure shall be calculated as one and a half times the maximum working head at the lowest point in the section to be tested.

5. The test shall be deemed to be satisfactory if the pipeline holds after the initial 24 hours the specified pressure for a final period of not less than two hours or such final period as is determined on site by the Engineer, with a loss not exceeding (5%) of the total test pressure during this two hours period. No pumping shall be permitted during this final test period.

6. If the test is not successful, the Contractor shall proceed to locate immediately and rectify the defects, after which he shall re-test until a satisfactory test result can be secured.

7. The Contractor shall provide the clean water, all pumps, meters, pressure gauges and other appliances required for the purpose of the test. The Contractor shall also arrange for meters and gauges to be tested for accuracy, if required to do so by the Engineer.

4.11 Measurement and Payment

i) Pipes and Fittings

A. The construction of sewers of the sewerage collection system and the installation of house connections shall be measured and paid for by the meter run respectively for every kind of pipe and diameter of completed and accepted works in accordance with the Drawings and Specifications to the satisfaction of the Engineer and the unit price for each shall include but not limited to the following:

1. The supply and laying and/or the collection and hauling from the Employer’s stores to Site of Work, laying and proper jointing the respective pipeline including all fittings and specials and all incidentals required for the proper laying and completion of the relative pipeline and service lines and connections in accordance with the Drawings and Specifications.

2. All ancillary works relating to the construction of sewerage collection system which are not explicitly mentioned in the Contract but could be inferred therefrom or which are customarily performed or evidently necessary to carry out the intent of the Drawings and Specifications and all other liabilities and obligations setforth in the tender Documents.

ii) Manholes

1. The supply and erection of manholes and their necessary incidentals. This will be executed in full details according to the Drawings and Specifications and to the interactions of the Engineer’s Representative. The measurement and payment will be made for the completed installed and accepted piece respectively for every type and diameter of the manhole.

iii) Hydrostatic Tests and Air Field Test
A. The supply of water, pumps and the necessary equipment for execution the hydrostatic testing of the lines, or the source of compressed air, the control equipment and the necessary equipment for execution the field air testing of the lines. The payment will be made on a lump sum basis for the testing of the whole project sewerage system.