SECTION 5A - Subsection 7: Concrete and Steel Works

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7 Concrete and Steel Works

7.1 Concrete Works

7.1.1 Scope

The bid prices entered in the Concrete Works as specified hereunder shall include the supply of materials, mixing of concrete, formwork, reinforcement, placing, compaction and curing of concrete and site clearance after completion of works.

The prices in the Schedule of Prices shall fully include the value of works described under the several items and shall cover the cost of all labour, subsistence, travelling, materials, admixtures, temporary works, yards and stockpiles, sampling and testing and any other expenses whatsoever together with all risks, liabilities and obligations set forth or implied in the Contract Documents.

7.1.2 Standards and rules

The Contractor shall carry out the works described in accordance with the appropriate Turkish Standards and EN standards. The main standards that shall be used are the following, but not limited to:

TS 498	Design loads for buildings
TS 500	Requirements for design and construction of reinforced concrete structures
TS 708	Steel bars for concrete
TS 1247	Mixing, placing and curing of concrete (normal weather conditions)
TS 1248	Mixing, placing and curing of concrete (abnormal weather conditions)
TS 2810	Jointing materials for construction and expansion joints in concrete work - rubber waterstops
TS 3078	Building construction - Jointing products and sealants - PVC plastic waterstops
TS 3440	Rules for making concrete exposed to aggressive effects of liquids, soils and gases
TS 3721	Steel wires for prestressed concrete
TS 3821	Aggregates for concrete-acceptability testing
TS EN 196-1	Methods of testing cement - Part 1: Determination of strength
TS EN 196-2	Methods of testing cement - Part 2: Chemical analysis of cement
TS EN 206-1	Concrete- Part 1: Specification, performance, production and conformity
TS EN 1008	Mixing water for concrete - Specifications for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete

Code for buildings to be built in 2018 Turkey Earthquake Building Regulations ,

Code for infrastructure to be built in 2018 Turkey Earthquake Building Regulations The Contractor shall provide printed or digital copies of these standards at the site office, for the use of the Engineer's and Contractor's personnel.

7.1.3 Record of concreting

The Contractor shall keep accurate and up to date records of concreting, showing for each day when sections of the works were concreted. These records shall include:

- Date, time, weather conditions and temperature
- Results of all concrete tests, including identification of which part of works the sampled material is representative
- Number of batches produced, weight and kind of cement used, volume of concrete placed, number of batches wasted or rejected
- Class of concrete, volume of concrete placed and number of batches used for each location.

The laboratory where the concrete tests have to be carried out shall be approved by the Engineer and the Employer and be accessible for the said parties at any time. The laboratory should preferably be placed at the site.

7.1.4 Classes of concrete

The grades of Concrete to be used in the works are shown in the following table:

Concrete class	Minimum cement content	Characteristic cylinder strength at 28 days	Characteristic cube strength at 28 days	Works to be used
C30/37	300 kg/m^3	30 N/mm^2	37 N/mm^2	- Water retaining structures - Water channels - Manholes for water & wastewater - Valve chambers, hand-holes - Concrete for Creek Lining - Precast concrete elements - Buildings - Waste reception
C20/25	250 kg/m^3	20 N/mm^2	25 N/mm^2	- Roads & kerbs - Surface drainage units
C16/20	200 kg/m^3	16 N/mm^2	20 N/mm^2	- Fill concrete and mass concrete inside/under water retaining structures - Thrust blocks - Pipe casings - Cable channels and cable manholes (if cast in situ)
C 8/10	150 kg/m^3	8 N/mm^2	10 N/mm^2	- Blinding layer below structures - Fills in trenches

The maximum cement content shall not exceed 400 kg/m^3. Grades of concrete shall be in accordance with EN 206-1. The maximum nominal aggregate size shall be 32 mm.

The concrete shall be capable of being transported and readily compacted by internal vibrators into a dense impermeable mass without segregation, bleeding or plastic cracking. Subsequently, the concrete shall be durable and free from crazing, thermal cracks and drying shrinkage cracks.

The slump shall be kept to the minimum compatible with approved placing and compacting requirements, but in no case shall the concrete be placed at a slump of more than 160 mm or less than 40 mm, determined in accordance with EN 12390, without the prior approval in writing of the Engineer.

Concrete mixes shall have the cement content necessary to meet the specified water-cement ratio, the workability and the compressive strength requirements.

Concrete mixes shall have the lowest possible sand content to meet the workability and water tightness requirements.

7.1.5 Organisation of concrete production at the site

At the commencement of the Contract, the Contractor shall submit, for the approval of the Engineer, a Method Statement detailing his proposals for the organisation of concreting activities at the site. The concrete production plant shall preferably place at the site.

The Method Statement shall include the following items:

- Plant proposed and layout of concrete production facility
- Proposed method of organisation of the concrete production facility
- Quality control procedures for concrete and concrete materials
- Transport and placing of concrete
- Details of formwork including striking times and procedure for temporary support of beams and slabs
- Protection and curing.

7.1.6 Ready-mixed concrete

Concrete obtained from a single supplier of ready-mixed concrete may be used in the Works, subject to the written approval of the Engineer. Such approval will not be given until the Engineer is satisfied that the organisation and control of the manufacture and delivery of all ready-mixed concrete is in accordance with the Employer’s Requirements.

7.1.7 Materials and testing

Type of Cement

The concrete used in water retaining structures shall be made with Sulphate Resistant Portland cement to be supplied from an approved source conforming to the requirements of Sulphate Resistant Portland cement in accordance to TS EN 196-1. Alternatively ground granulated blast furnace slag (GGBFS) may be used together with Portland cement, complying with EN197, in lieu of the Sulphate Resistant Portland Cement. In this case, the Contractor shall provide the Engineer with the method on how to use the GGBFS cement and obtain Engineer’s approval.

Tests of Cement

The Contractor shall submit to the Engineer, free of charge, test certificates relating to each consignment of cement. Each certificate shall show that a sample of the consignment has been tested by the manufacturer or by an approved laboratory and that it complies in all respects with the Employer's Requirements.

When required by the Engineer, the Contractor shall supply samples of cement taken on delivery to site, or during storage on the site, for testing at a nominated laboratory free of charge.

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

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

If cement has been stored on the site for more than 40 days or in the opinion of the Engineer is of doubtful quality, new tests may be required, at the Contractor's expense, to check whether or not the cement still conforms to the requirements.

Delivery and Storage of Cement

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

Rejection of Cement

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

Quality of Water

Water for use in concrete, mortar mixing and curing shall be obtained from an approved source and shall be of a quality that will not affect the setting time, strength, durability of the concrete or mortar, or the appearance of hardened concrete or mortar by discolouration or efflorescence, or the reinforcement at any age of the concrete or mortar.

Water shall be clean, potable, blended or unblended, with a pH between 5.0 and 9.0 and shall be tested in accordance with TS EN 1008. The following limits shall not be exceeded:

- Total dissolved solids (TDS) not greater than 2000 ppm
- Suspended solids not greater than 2000 ppm
- Chlorides (Cl) not greater than 500 ppm
- Sulphates (SO_4) not greater than 1000 ppm
- Alkali (HCO_3/CO_3) not greater than 1000 ppm.

Water shall be stored in approved, clean containers which are protected from sun, wind, dust, organic contamination or from contamination by any other source.

Fine and Coarse Aggregates

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

Aggregates for all types of concrete shall be from natural sources. They shall be hard, strong and durable and shall not contain harmful material of sufficient quantity to affect adversely the strength or durability of the concrete or, in the case of reinforced concrete, to attack the reinforcement. The aggregates shall be obtained from an approved source and shall conform to the requirements of TS 3821.

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

- Fine and coarse aggregates shall not contain more than 0.10% and 0.05% by weight of chlorides (as NaCl)
- Fine and coarse aggregates shall not contain more than 0.40% by weight of acid soluble sulphates (as SO_3)
- Coarse aggregates shall be a minimum of 85% by weight calcium carbonate
- Fine and coarse aggregates shall not be potentially reactive with alkalis
- Fine and coarse aggregates in concrete elements exposed to wastewater shall be equivalent to the high sulphate resistance of the cement. Appropriate aggregates are siliceous sand and gravel.

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

- the cement material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested in accordance with the method prescribed, or
- the total mass of reactive alkali in the concrete mix shall not exceed 3 kg per m^3 of concrete when defined, tested and calculated in accordance with the method prescribed.

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

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

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

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

Tests on Aggregates

The Contractor shall submit to the Engineer samples of the fine and coarse aggregates proposed for use in the Works. Samples shall be of a size sufficient to carry out all preliminary tests specified which the Engineer may order in addition to the concrete tests. The Contractor shall provide 50 kg samples for comparison purposes as described below. The samples shall then be tested in the presence of the Engineer by the Contractor in accordance with the Employer's Requirements or as the Engineer may direct.

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

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

During the course of the Contract, fine and coarse aggregates shall be tested at site as often as required by the Engineer and at the Contractors expense.

Delivery of Samples

Samples of cement, water and fine and coarse aggregates called for in the foregoing sections shall be delivered to the Engineer for testing by the Contractor before concreting. Cube tests shall be completed before work is due to start.

7.1.8 Mixing and testing

All common site tests, especially slump tests, shall be carried out on samples taken from every transmixer.

If the cubes fail to attain the required compressive strength as specified, the concrete which they represent shall be cut out, removed and replaced with concrete complying with the Employer's Requirements to the satisfaction of the Engineer.

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

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

7.1.9 Formwork

Formwork for concrete shall be rigidly constructed of approved materials and shall be true to the shape and dimensions. Formwork shall be constructed of material or lined with materials as may be necessary to achieve the finishes specified in this section. The formwork design shall be submitted to the Engineer for approval before construction commences.

All material brought onto the site as forms, struts or braces shall be new materials.

Faces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects. Joints shall be sufficiently tight to prevent the leakage of cement grout and to avoid the formation of fins or other blemishes. Faulty joints shall be caulked. 20 mm by 20 mm chamfers shall be formed on the external corners of concrete members, unless otherwise specified. Internal corners shall similarly be provided with 20 mm fillets.

Formworks for exposed surfaces shall be laid out in a regular and uniform pattern with the long dimension of panels vertical and all joints aligned.

If openings of the formwork for the escape of water used for washing out are made, they shall be formed so that they can be conveniently closed before placing the concrete.

Connections shall be constructed to permit easy removal of the formwork and shall be strong enough to retain the correct shape during consolidation of the concrete.

Metal ties or anchors within the form shall be so constructed as to permit their removal to a depth of at least 50 mm from the face without injury to the concrete. All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left shall be of the smallest possible size. Spreader cones or ties shall not exceed 25 mm diameter. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and uniform in colour.

Formwork shall be true to line and braced and strutted to prevent deformation under the weight and pressure of the unset concrete, constructional loads, wind, and other forces. Beams spanning more than 3 m shall have an upward camber of 1.5 mm per m of span.

Concrete shall normally not be placed in lifts deeper than 3 m. For lifts higher than 3 m, openings for placing the concrete shall be provided in order to avoid segregation of the concrete.

The approved mould oil or other material shall be applied to faces of formwork to prevent adherence of the concrete. Such coatings shall be insoluble in water, non-staining and non-injurious to the concrete. Liquids that retard the setting of concrete shall be used only when approved. Mould oil, retarding liquid and similar coatings shall be kept from contact with the reinforcement or previously cast concrete.

Before any concrete is placed, forms shall be properly cleaned by washing out with water and/or air under pressure to remove sawdust, shavings, metal and other foreign matter. All water shall then be drained and mopped out from the formwork. In no case shall concrete be placed in the forms until such forms have been approved by the Engineer. Such approval shall not relieve the Contractor of his responsibility for the formwork.

Details of any fixtures to be cast into the concrete shall be to the approval of the Engineer. No fixtures shall be attached to the concrete by shot-firing without prior permission of the Engineer. Notwithstanding any such authorization, the Contractor shall take full responsibility for any damage caused to the structure and make good to the satisfaction of the Engineer.

7.1.10 Placing and compaction of concrete

Mixing, placing and curing of concrete shall be made in accordance with TS 1247 and TS 1248.

Preparatory Work

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

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

The Engineer may completely forbid the placing of concrete in any shuttering which he believes has become too hot and/or dry and the condition of which could harm the quality and strength of the concrete. No extra payment for cooling or soaking of shuttering shall be made.

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

Depositing in Work

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

Concrete shall be placed directly in the Works as soon as possible without the need for rehandling and not more than 45 minutes after mixing and, in any case, before the initial setting has taken place. If any delay has occurred after mixing and the concrete has begun to set, it shall not be used in the Works and shall be removed from the site. Unless otherwise agreed by the Engineer on the basis of satisfactory site trials, concrete shall not be dropped into place from a height exceeding 2 m.

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

Where a delay of more than one hour has occurred between concreting operations in one section or unit of work, concreting shall only be resumed when, in the opinion of the Engineer, the previously placed concrete has had ample time to harden and the resulting joint shall be treated as a construction joint. At all times when concrete is being placed, a competent steel fixer shall be in continuous attendance to adjust and correct the position of any reinforcement which may become displaced.

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

Depositing in Layers

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

Concrete Placed in Water

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

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

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

Concreting in Hot Weather

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

The Contractor shall pay particular attention to the requirements specified herein for curing.

Formwork shall be shaded from direct exposure to the sun both prior to placing of the concrete and during its setting. The Contractor shall take appropriate measures to ensure that reinforcement in the section to be concreted is maintained at the lowest temperature practicable.

Concrete at placing shall have a temperature of not more than 32°C. If necessary, the Contractor shall cool the aggregates and mixing water by methods approved by the Engineer.

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

The temperatures of ambient air, concrete at various levels and intervals not exceeding 5 m and cooling water where applicable shall be measured by means of thermocouples and recorded

Concreting in Cold Weather

Cold weather is defined as the situation existing at the Works, where either or both of the following conditions existing:

- The air temperature at the time considered is below 2°C
- The mean daily air temperature over three or more successive days has dropped below 5°C.

Under no circumstances may concrete be placed in contact with frozen ground or formwork, or in contact with ice, snow or frost on the ground or on formwork or reinforcement. Concrete shall not be made with frozen materials.

Concreting may proceed in cold weather provided that special precautions are taken to ensure that the surface temperature of the concrete at the time of placing is not less than 5°C for a succeeding period of at least:

- 4 days when the cement used in the concrete is ordinary Portland cement
- 2 days when the cement used in the concrete is rapid hardening Portland cement.

Such precautions may include the following:

- Warming the aggregates and heating the water, provided that the temperature of either does not exceed 60°C. Water and aggregates shall be mixed for a period sufficiently long for them to acquire a uniform temperature before cement is added.
- Completely surrounding the freshly placed concrete with a cover and heating the enclosed air, which shall be kept moist. Draughts of hot or dry air shall not be directed at surfaces.
- Insulating the formwork and finished concrete surfaces.
- Providing screens to protect the concrete from air currents.

The Contractor shall provide the Engineer with details of the precautions he proposes to take to protect the concrete from the effects of low temperatures and with details of the methods he proposes to use assess the correct timing at which such protection may be removed. No concreting shall be done in cold weather prior to the approval the Engineer for the proposed measures.

Concreting in Unfavourable Weather

Concreting shall not be permitted during heavy rain or snowfall, or when the air temperature falls below 2°C, or when the concrete temperature rises above 32°C. When the air temperature exceeds 25°C, concreting shall only be permitted after special precautions, approved by the Engineer, have been taken to prevent early setting of the concrete, such as lowering the temperature of the water to be used in the mix or by means of a cooling-system, keeping the aggregates and shutters continuously sprayed with water and erection of temporary sun shades over the working area. During concreting operations the temperature of the placed concrete shall be recorded.

Compaction of Concrete

The Contractor shall regard the compacting of the concrete to be of fundamental importance. A watertight concrete of maximum density and strength shall be obtained.

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

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

Vibrators shall be inserted into the uncompacted concrete vertically and at regular intervals. Where the uncompacted concrete is in a layer above freshly compacted concrete, the vibrator shall be allowed to penetrate vertically for about 100 mm into the previous layer. Vibrators shall be withdrawn slowly from the mass of concrete so as to leave no voids. Internal type vibrators shall not be placed in the concrete in a random or haphazard manner nor shall concrete be moved from one part of the work to another by means of the vibrators.

Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete flows in the formwork over distances so great as to cause segregation.

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

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

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

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

Placing Concrete on Previously Executed Work

Where concrete is to be placed against or on top of previously executed work, the surface of the old concrete shall be thoroughly wire brushed, hacked and cleaned with water and air under pressure to expose the surface of the aggregate and to remove all laitance.

Special care shall be taken to ensure that the new concrete is thoroughly compacted and rammed against the old.

Protection and Curing of Concrete

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

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

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

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

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

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

7.1.11 Joints

In order to incorporate the effects from thermal action, shrinkage and creep, the Contractor shall make construction joints or contraction joints in accordance with this Specification. The Contractor shall make his design calculations in accordance with the intended location of joints.

Construction Joints

In construction joints, the reinforcement passes through the joint. The purpose of this type of joint is to separate the structure into sections equal to a size which easily can be cast. In critical sections with a high stress, the joints shall be made with an approved water stop.

The surface of the concrete shall be thoroughly cleaned. The surface layer shall be completely removed with a steel brush to expose the aggregates.

The hardened concrete shall be watered continuously for 1 hour prior to casting the adjacent concrete. When casting, the hardened concrete surface shall be saturated but free from water on the surface.

Cement grout and adhesives shall not be used at joints.

Contraction Joints

Complete contraction joints have no restraint to movement, but are intended to accommodate only contraction of the concrete. Partial contraction joints provide some restraint, but are intended to accommodate some contraction of the concrete. Both types of contraction joints are allowed in the works.

Expansion Joints

Expansion joints have no restraint to movement and are intended to accommodate either expansion or contraction of the concrete. Expansion joints are allowed in the works.

The following general requirements shall apply to both expansion and contraction joints:

(a) Filler Boards

Filler boards in expansion joints shall be of approved material securely fixed at right angles to the surface of the concrete within a tolerance of 1º. The boards shall extend without any gaps from the underside of the sealing groove to the base and between side forms or existing slabs. Dowel bars where specified shall be a close fit where they pass through boards. Joints in boards shall be taped to prevent discontinuities.

(b) Dowel Bars

Dowel bars shall be round mild steel complying with TS 708 and shall be sawn or flame cut to length. Flame cut bars shall be dressed by grinding to remove any snags or lips. Dowel bars shall be straight without any irregularities likely to interfere with longitudinal movement in the concrete.

Dowel bars in expansion joints shall be fitted at one end with sleeves which are a sliding fit on the bar and which contain compressible filling in the end remote from the bar, all to the dimensions and details shown in the Drawings.

(c) Sealing Grooves and Sealant

Caulking grooves shall be provided where necessary and as specified. At all joints where a caulking groove is formed, the groove shall be wire brushed and loose material removed and blown out by compressed air immediately prior to caulking. After the groove has dried, it shall be primed and caulked with approved jointing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and a 50 mm width of concrete on either side shall be painted with two coats of primer having the same base as the caulking compound.

Joints in the concrete shall be sealed with an approved sealant from an approved manufacturer, which is suitable for the particular location and environment. Joints shall be sealed immediately after the expiry of the concrete curing period or as soon thereafter as weather conditions permit.

Before sealing is carried out, the sealing grooves shall comply with the following requirements:

1 Grooves shall extend across the bays from edge to edge in the case of transverse joints and shall be continuous in the case of longitudinal joints.

2 In expansion joints, the filler material shall be exposed for the full length of the joint.

3 All grooves shall be dry and free of loose aggregate, paint, corrosion, oil, bitumen spillage, waterproofing agents, concrete curing agents, or release agents.

Bond breaking tape or other suitable material acceptable to the Engineer shall be placed in the bottom of the groove to leave the specified depth for the seal.

Primer shall be applied evenly to the sides of the grooves ensuring complete coverage. The interval between priming and sealing shall be within the limits specified by the sealant manufacturer. In dusty conditions, the primed joints shall be protected from contamination.

The sealant shall be prepared and applied in accordance with the manufacturer's instructions. Care shall be taken to avoid trapping air or forming bubbles and the finished surface of the sealant shall be smooth and free from blemishes to the specified level.

Expansion and contraction joints shall be placed in the positions and in accordance with the details shown on the Drawings.

7.1.12 Waterstops

Waterstops shall comply with TS 2810 and TS 3078.

When waterstops are placed for water tightness, the waterstops shall be made by an appropriate material resistant to chlorides, sulphates, chemicals and the like which is approved by the Engineer.

The width of the waterstops shall be according to the manufacturer's specifications.

All waterstops shall be made continuous and shall be welded at all connections. Overlapping shall not be allowed. All joints in waterstops shall be made by the manufacturer of the waterstop.

If a joint ends at another part of the structure, such as the connection between a wall and a bottom slab, the waterstop shall also be placed at least 300 mm inside the adjacent part of the structure.

Waterstops shall be placed in accordance with the manufacturer's specifications. Waterstops shall be carefully placed and maintained in position during concreting and compaction operations. Concrete shall be carefully compacted around the waterstops so as to leave no cavities.

Waterstops shall fulfil the following requirements:

Property at 25°C	Rubber	PVC
Minimum tensile strength (N/mm^2)	20	15

Minimum elongation at break (%)	450	285
Hardness (IRHD/ Shore A)	60 - 75	70 - 75
Softness (BS 2571)	42ºC - 52ºC	
Specific gravity	1.1 (+5%)	1.3 +(5%)

The Contractor shall submit details of the waterstops, including a description of the installation of the waterstops, to the Engineer for his approval at least one month before commencement of the formwork at site.

7.1.13 Testing of tanks

All tanks shall be tested for water tightness in accordance with EN 1992-3. The testing procedure shall be according to the following procedure.

Excavation for tanks shall not be filled and tank wall faces shall not be coated or plastered outside and inside before the watertightness tests have been passed successfully.

- Filling of tanks with water shall take place with a constant flow rate. The chosen flow rate shall raise the level in the tank not more than 2 m height in 24 hours.
- A period of 1 week shall be allowed for saturation and stabilisation (admission of water into the concrete).
- Water levels shall be measured by approved means at 24 hours intervals for a test period of 5 days.
- During the test period the total permissible water level drop, after allowing for evaporation and rainfall, shall not exceed 1/500 of the average water depth of the full tank or 10 mm, whichever is greater.

The testing procedure shall be used also for small chambers (flow confluence or distribution chambers) and for manholes of gravity pipelines.

Notwithstanding the satisfactory completion of the above test, any leakage or soaking visible on the outside face of the tank walls shall be stopped, after allowing for self-sealing. Any sealing or making good of cracks in the concerned wall section shall, where practicable, be carried out from the inside face. Adjacent internal chambers within a structure shall be tested sequentially in case the treatment process allows for emptying of the respective chamber independently of the whole structure. In this case, the chambers adjacent to the chamber under test shall be empty during the test period.

7.1.14 Tolerances of dimension and surfaces of in-situ concrete

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

The tolerances within which concrete work shall be constructed are as summarized below:

Item of construction	Permissible deviation
Position in plan	± 20 mm
Wall and slab thickness	± 6 mm
Columns and beams	± 6 mm.
Dimensions of foundations	+ 50 mm / - 0 mm.
Variation from plumb:	(vertically - up to 5 m) ± 12 mm.
Levels to slabs and beams:	± 10 mm.
Holes Placement:	± 10 mm
Hole Size	± 3 mm.
Cast-in items (reinforcement bars or wire strands) Placement:	± 10 mm
Distance between interconnected items:	± 2 mm.

The Contractor shall be responsible for keeping the deviations of the finished concrete structures within the limits given, and any rectification of work not constructed within the tolerances set out shall be entirely at the expense of the Contractor.

7.1.15 Remedial treatment of concrete surfaces

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

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

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

a) Holes left for formwork supports shall be thoroughly cleaned out to remove all loose material and the sides shall be roughened, if necessary, to ensure a satisfactory bond. They shall then be filled with dry-pack mortar.
b) Fins, pinhole bubbles, surface discoloration and minor defects may be rubbed down with sacking and cement immediately the formwork is removed.
c) Abrupt and gradual irregularities may be rubbed down with carborundum and water after the concrete has been fully cured.
d) Small defects and minor honeycombing shall be chipped out perpendicular to the face of the concrete to a depth of at least 25 mm and filled with dry-pack mortar.
e) Fissures shall be repaired by using epoxy based materials or by using materials approved by the Engineer.

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

7.1.16 Dry-pack mortar

Dry-pack mortar for filling holes and repairing surface blemishes shall be from one part by weight of cement and three parts fine aggregate passing a 1 mm sieve and epoxy based materials. Additives to improve workability may be added to the approval of the Engineer. The colour of the mortar shall match that of the surrounding concrete. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands.

The dry-pack material shall be placed and packed in layers having a thickness not greater than 15 mm. The compaction shall be carried out by use of hardwood stick and hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction the surface of each layer shall be scratched before further loose material is added. Holes shall not be over filled and the surface shall be finished by laying a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

In the case of using epoxy based materials, the Contractor shall provide material catalogues and method of application to the Engineer for his approval. No additional payments shall be done for these requirements and any necessary tests shall be carried out after repair.

7.2 Steel Reinforcement

7.2.1 Types, quality and storage

Reinforcement shall comply with EN 10080, TS 708 (Steel bars for concrete) and TS 4559 (Steel mesh for concrete).

Prestressing steel wire or bars shall be of low relaxation strand type in accordance to TS 3721, BS 5896-80 or DIN 4227.

Reinforcement bars shall have strength equal to high yield steel bars and shall be ribbed bars.

The characteristic yield stress of reinforcement steel shall be at least 420 N/mm^2 (BÇ III Class).

The Contractor shall furnish the Engineer with copies of the manufacturer's certificates of tests for the steel reinforcement to be supplied.

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

All reinforcement shall be clean and free from pit corrosion, loose rust, mill scale, paint, oil, grease, adhering earth, or any other material that may impair the bond between the concrete and

the reinforcement or that which may cause corrosion of the reinforcement or may be detrimental to the quality of the concrete.

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

7.2.2 Bending and cutting schedules

The Contractor shall prepare for his own use bar bending schedules and bar lists, cutting schedules and sheet lists for wire fabrics for each individual structure from the information given in the approved working Drawings and in the Employer's Requirements, and shall be responsible for ensuring that correct information is given when ordering reinforcement. Copies of these schedules, lists and orders shall be submitted to the Engineer for his approval. Steel bar supports shall be included in the bending schedules.

The approval of the bar bending and cutting schedules, lists and orders shall not relieve the Contractor of his responsibility to execute the reinforcement fixing in accordance with the Drawings and/or according to the requirements specified in TS 500 and the code for buildings to be built in 2018 Turkey Earthquake Building Regulations .

7.2.3 Protection and cleaning

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

7.2.4 Bending of bars

Steel reinforcement shall be cut from straight bars free from kinks and bends or other damage and shall be bent cold by experienced competent workmen. Bars of diameter greater than 12 mm shall be bent in a bending machine designed for the purpose and approved by the Engineer. Any reinforcing bar that has already been bent shall not be re-bent at the place of the previous bend.

7.2.5 Cutting of wire fabrics

Wire fabric reinforcement shall be cut straight from the sheets. The use of off-cuts in the Works will not be permitted.

7.2.6 Lapping of bars and wire fabrics

Lapping bars and wire fabrics shall be permitted when necessary and approved by the Engineer. No welding of reinforcement shall be carried out.

Unless otherwise specified, lap length of bars shall be at least fifty (50) times the diameter of the larger bar, and laps shall be positioned in a staggered pattern.

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

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

7.2.7 Fixing of reinforcement

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

Spacer blocks for holding the reinforcement from contact with the forms, or adjacent reinforcement, shall be of dense precast concrete blocks of approved shapes and dimensions. The blocks shall be fitted with a semi-circular hollowing and double bent poured-in binding wires. The water tightness of these blocks must be at least similar to the concrete into which they are concreted. The use of pebbles, pieces of broken stone or brick or other materials shall not be permitted. Steel shall be bound and tied in its correct position using steel wire. Apart from any other requirement, the reinforcing steel shall be fixed in such a manner that it shall support its own weight and any loads which may be imposed upon it during construction without displacement, deflection or movement of any kind.

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

The concrete cover to the nearest reinforcement exclusive of plaster or other decorative finish and concrete blinding shall be accordance with TS 500 unless otherwise stated in the Employer's Requirements for the relevant structure.

The distance between any two parallel bars except at laps shall not be less than 5 mm greater than the nominal aggregate size.

All reinforcement exposed to the weather for long periods before concreting is commenced shall be covered with polythene binding tape, cement grout or other materials to the surrounding concrete. Should rust staining occur on any permanently visible surfaces, it shall be removed at once to the satisfaction of the Engineer.

7.2.8 Thickness of cover

The thickness of cover for the reinforced concrete shall be as described below:

- For manhole elements (walls, covers, bottom slabs) 50 mm
- For external works, water retaining structures and casting of concrete in/under water: 50 mm.

Structures other than water retaining structures:

- For beams and columns 30 mm

- For slab reinforcement — 20 mm or the same as the diameter of the largest steel bar, if the diameter is greater.

7.2.9 Tolerances

Tolerances in placing reinforcement shall be:

- For members 60 cm or less in depth: +/- 0.5 cm
- For members more than 60 cm in depth: +/- 1.5 cm

7.2.10 Approval before concreting

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

7.3 Precast Concrete Units

7.3.1 General

Buildings, pipeline manholes and cable manholes may be designed as precast concrete structures. Precast concrete units shall not be used for building water retaining structures.

Precast concrete units, both reinforced and unreinforced, shall comply with the Employer's Requirements. The Contractor shall submit drawings to the Engineer in accordance with Technical Specifications. If ordered by the Engineer, the Contractor shall also submit detailed calculations for precast concrete units.

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

All precast concrete units shall have the date of casting and identification number engraved on them before the concrete is fully hardened. Any undated units shall be liable to be rejected by the Engineer. The Contractor shall take all measures concerning the curing and protection of the units after fabrication.

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

- 28 days after fabrication, or
- after the required compressive strength has been reached.

Where the installation of precast concrete units in any particular structure is such that the faces of the units are to be left exposed either internally or externally, the exposed surfaces of the units as finished shall be uniform in colour and in texture. All cement, aggregates and other materials used in the manufacture of the units shall be obtained from the same approved sources throughout the period of manufacture.

Concrete for precast units shall be placed and compacted by methods approved by the Engineer.

7.3.2 Concrete quality and tests on concrete

The concrete used in the manufacture of precast concrete units shall comply in every respect with these Specifications and the class of concrete required shall be in accordance with the requirements of TS 500.

The design, mixing, testing, curing and quality control of the concrete used in precast units shall be in accordance with these Specifications.

7.3.3 Cast-in parts

Cast-in parts, such as lifting lugs, fasteners, jointing materials supporting structures, etc shall be fixed in the positions as shown on the drawings. Cast-in parts shall be free from rust, dirt or grease and shall be properly stored before using.

7.3.4 Transport, storage and erection

At all stages and until completion of the Works, precast units shall be adequately protected to preserve all permanently exposed surfaces and arises. The protection shall not mark or otherwise disfigure the concrete.

Transportation, storage and erection of the precast concrete units shall be done carefully and in such way as to avoid any damage and to keep the surfaces of the units free from dirt or other unwanted marks. Loading and unloading, storage and erection of the precast concrete units at the site shall be carried out by skilled labour and under supervision of a competent supervisor.

Any precast concrete unit which is found cracked, damaged or otherwise inferior in quality either before or after erection shall be rejected and shall be replaced by the Contractor.

7.3.5 Installation of precast concrete

All precast concrete units shall be laid, bedded, jointed and fixed in accordance with the lines, levels and other details shown on the approved drawings provided by the Contractor.

Dry-pack mortar, where necessary, shall be used for jointing or packing in accordance with these Specifications. The mortar shall be placed and packed in stages where possible from both sides of the space being filled using a hardwood stick hammered until the mortar is thoroughly compacted.

7.3.6 Manufacturing in a factory

Precast concrete units may be manufactured in a factory approved by the Engineer. The Contractor shall give the Engineer full information, in advance, concerning the name and address of the factory and details of the probable date of commencement of manufacture. The Contractor shall make the necessary arrangements for the Engineer to inspect the factory during working hours.

The conditions stipulated in Section 6.1 of these Specifications shall also be valid for precast concrete.

7.3.7 Work programme and method statement

The Contractor shall submit to the Engineer, for his approval, the work programme and method statement giving full details of his proposed method of carrying out all operations connected with the manufacture and erection of precast concrete units, which shall include the following:

- period required to produce the drawings and detailed calculations
- dates of commencement of manufacturing of the concrete units
- dates of delivery to site
- sequence of erection and the period required for site erection works
- a description of the types of casting bed, mould and shuttering for the various types of members
- the procedure for reinforcing, concrete casting and method of curing the concrete
- the procedure for transporting, handling, hoisting and placing of each type of precast concrete unit
- the necessary strength of in situ cast concrete before starting site erection works
- the design, manufacturing and mounting details to adapt the in situ cast concrete to the assembly
- particulars of temporary supports as deemed necessary to ensure adequate stability during erection and to sustain the effects of construction loads, wind loads or other transient loads.

No works shall be started until the programme and the method statement have been approved by the Engineer.

7.4 Steelworks

7.4.1 General

The Contractor shall fabricate, supply, deliver and erect all steelworks, fixing materials and associated parts according to the Employer's Requirements and drawings and shall comply with the requirements of the relevant standards, unless otherwise specified or instructed by the Engineer.

The steelworks shall comprise of the following main items:

- open mesh flooring and gratings, including framework and supports
- manhole covers
- bar screens and accessories in overflow chambers and outfalls
- flanges and bolted connections
- anchorings
- step irons, ladders and pipes where shown on the approved drawings or instructed by the Engineer
- staircases, landings and platforms in buildings.

For all fabricated steel works, the Contractor shall submit fabrication details and drawings and calculations for the approval of the Engineer prior to the manufacture of any of the items.

The structural steelworks comprise mainly the fabrication and erection of the following constructions:

- columns and beams
- gratings, including frameworks
- hatches, including frameworks
- angles for protection of edges in several lengths, including anchors
- ladders and step irons
- staircases, landings and platforms
- other structural steelwork associated with the specified mechanical and electrical plant.

Prior to any steel fabrication work, the supplier shall submit full details of his proposed procedure, qualification and methods of fabrication to the Engineer for approval.

This information shall include (but not be limited to) the following details where they are relevant:

1 The method of plate forming

2 Joint design

3 Proposed welding procedure and proof of competence of welders

4 Method of straightening, sizing and hydrostatic testing

5 Quality control and inspection procedures.

7.4.2 Standards and rules

The Contractor shall carry out the works described in accordance with the appropriate Turkish Standards (TS) and European (EN) standards. The main standards are, but shall not be limited by the following:

TS 498	Design loads for buildings
TS 11590	Paints - Epoxy resin based - Used for steel structures
TS EN 10025-1	Hot rolled products of structural steels - Part 1: General technical delivery conditions
TS EN 10029	Hot rolled steel plates 3 mm thick or above; tolerances on dimensions, shape and mass
TS EN 10034	Structural steel I and H sections; tolerances on shape and dimensions
TS EN 10067	Hot rolled bulb flats - Dimensions and tolerances on shape, dimensions and mass
TS EN 444	Non-destructive testing - General principles for radiographic examination of metallic materials by X and gamma-Rays
TS EN 583-1	Non-destructive testing - Ultrasonic examination - Part 1: General principles

TS EN 1289	Non-destructive examination of welds - Penetrant testing of welds - Acceptance levels
TS EN 1712	Non-destructive examination of welds - Ultrasonic examination of welded joints - Acceptance levels
TS EN 1011-1	Welding - Recommendations for welding of metallic materials - Part 1: General guidance for arc welding
TS 6062 EN 25184	Straight resistance spot welding electrodes
TS 1478 EN 124	Gully tops and manhole tops for vehicular and pedestrian traffic - Design requirements, type testing, marking, quality control
	Steel Structures Design, Calculation and Construction Principles - 2016

Contractor shall provide printed or digital copies of these standards at the site office, for the use of the Engineer's and Contractor's personnel.

7.4.3 Quality and testing of materials

Should the Contractor propose to use materials complying with standards other than those specified above, he shall have submitted details of such standards with his Tender. At least two weeks before ordering materials, the Contractor shall send a written notice to the Engineer giving the following details:

- type, quality and quantities to be ordered from a steel mill
- type, quality and quantities to be ordered from available (local or non-local) stocks.

Test certificates from the steel manufacturers shall be required to be submitted to the Engineer for the materials ordered. Material obtained from stocks shall be checked by the Engineer for the exterior defects either in the workshop or at the site.

7.4.4 Manhole and access covers and frames

Manhole and access covers and frames shall have minimum openings of 625 mm diameter or 600 mm x 600 mm or 750 mm x 750 mm and shall be capable of taking a load of 40 tonne (400 kN) in accordance with TS 1478 EN 124 Traffic Class D400.

Manhole covers and frame material shall be spheroid graphite cast iron in accordance with TS 526 EN 1563.

Employer's name, logo and the collector type (rainwater or wastewater) shall be designated on the manhole covers.

A heavy grease seal is to be formed between the cover and frame to prevent the ingress of sand.

Keyways in manhole covers shall be closed.

7.4.5 Surface boxes

Cast iron surface boxes shall comply with the relevant requirements of TS 1478 EN 124. The lid shall be chained to the frame.

7.4.6 Ladders and step irons

With the exception of internal access ladders to water tanks, reservoirs and wet sumps, ladders shall be in steel (fully hot-dip galvanised). Ladders for internal access shall be in stainless steel.

The stringers shall be sized to suit the height of the ladder and the interval of the stringer supports. Stringers shall be radiused over the top and drilled to receive the rungs, which shall be welded to the stringers on each side of each stringer. The bottom ends of the stringers shall not be designed for floor fixing, but shall terminate at wall fixing supports at least 150 mm above the floor. All edges of stringers shall be ground smooth to remove burrs and sharp edges.

Where the installation of hoops is not possible or appropriate, as agreed with the Engineer, anchorage points shall be provided for attaching safety harnesses.

7.4.7 Steel stairways in buildings

Stairways shall be designed for a loading of 5.0 kN/m² of plan area of the stairway. Steel stairways shall be provided with tubular hand railing, stringers of cross section suitable for the span and loading and treads of open mesh flooring or chequer plating. Except where specified otherwise, the rise between treads shall be uniform and between 150 mm and 175 mm. Stairways in the same area of the works and in similar locations shall have the same angle and height of rise between treads.

The width of the treads shall be between 250 mm and 300 mm. The width of the stairways shall not be less than 750 mm.

The stringer shall be mounted by means of angle brackets with slotted holes for adjustment of line and level.

The specifications for stairways in water tanks, wastewater manholes and water retaining structures are described in Section 8 of these Specifications.

7.4.8 Handrails in buildings

Handrails shall consist of galvanized steel and be designed to withstand a horizontal force at handrail level of 350 N/m. The deflection of rails shall not exceed 0.8% of their span between standards and the deflection of standards shall not exceed 0.8% of their height.

Standards and handrails shall be not less than 30mm in diameter.

Horizontal handrails shall be 1100 mm high with an intermediate rail 550 mm high The handrail height shall be measured vertically from finished floor level to the handrail centreline.

Sloping handrails shall be as specified for horizontal handrails but with the top rail 900 mm vertically above the line of pitch. Stanchions shall be vertical and spaced at not more than 1.5 m measured parallel to the line of pitch.

Horizontal mounting flanges shall be drilled for not less than three bolts with two bolts on a line parallel to and on the walkway side of the line of the handrail. Vertical mounting flanges shall be drilled for not less than two bolts with the line through the bolts being vertical. Fittings shall be screwed or secured with grub screws. The standards shall be set at not more than 1.5 m centres. When provided in sections, handrails shall be joined together with purpose-made fittings secured by screws or grub screws.

Ladder and other openings shall be closed with two galvanized mild steel hanging chains which shall be secured at one end and detachable at the other.

Bolts, nuts and washers shall be hot-dip galvanized.

Handrails, balustrades, bolts and nuts in the Buildings shall be made of stainless steel.

The Contractor shall ensure that, unless specified to the contrary, all handrails shall be of uniform appearance and manufacture.

Detailed drawings of handrails shall be submitted by the Contractor for the approval of the Engineer.

The specifications for handrails in wastewater tanks, wastewater manholes and water retaining structures are described in Section 8 of these Specifications.

7.4.9 Structural steelwork

The permissible design stresses for materials, bolts, rivets, etc are given in Steel Structures Design, Calculation and Construction Principles - 2016.
Rolled structural steel sections shall be mild steel complying with the requirements of TS EN 10025 and TS EN 10029. The dimensions, tolerances and properties of the structural sections shall conform to TS EN 10034 or TS EN 10067

Structures and components, such as required for ladders, hoppers etc shall be shop fabricated so as to form sub-assemblies of the largest practical size suitable for transportation, handling and erection.

The Contractor shall submit drawings and calculations of his proposals for structural steelwork prefabricated building frames in duplicate for the Engineer’s approval, 21 days before commencing fabrication.

The coating systems shall be as given in Employer's Requirements, Section 7.

7.4.10 Bolts and nuts

Steel bolts and nuts for structural steelwork shall be high strength friction grip galvanized bolts conforming to ISO 887 or black bolts conforming to DIN 7990. Nuts shall conform to DIN 934 . Washers shall conform to DIN 7989.

High strength friction grip bolts shall be used in conjunction with approved proprietary load indicating washers.

7.4.11 Welding

All welding carried out during fabrication or erection shall be in accordance with the requirements of TS EN 1011 and as shown on the approved detail drawings. Details of the proposed weld procedures shall be submitted to the Engineer for approval at the same time as the detail drawings. All connections shall be welded in such a manner as to make the finished connections neat and smooth in appearance and suitable for painting. All slag shall be removed and all sharp projections shall be round smooth.

Before welding is commenced either in the fabrication shop or on Site, weld procedure tests shall be carried out in accordance with TS EN 15614 where directed by the Engineer.

All welders employed either in the fabrication shop or on Site shall pass qualification tests relevant to the weld procedures in use in accordance with TS EN 287-1. Welders shall have satisfactory evidence of having been engaged in welding for at least 9 months in the preceding 12 month period. If the work of any welders employed on the Contract is unsatisfactory, the Contractor shall carry out such further welder qualification tests as are necessary to demonstrate that the welders are proficient.

Welds shall be subjected to non-destructive testing by processes which may include but shall not necessarily be limited to radiographic, ultrasonic, magnetic particle or dye penetrant methods, depending on the type of weld and its position in the structure. The standards of acceptance shall be as defined in TS EN 444, TS EN 583-3, TS EN 1289 and TS EN 1712, unless otherwise agreed with the Engineer. If any work shows defects or fails to comply with the requirements of the detailed drawings or Specification for any reason it shall be repaired or rejected, even though it may have been carried out by qualified welders using approved procedures.

All welding consumables (electrodes, wire, filler rods, flux, shielding gas and the like) shall comply with the requirements of TS EN 1011.

Weld electrodes for metal arc welding shall conform to TS 6062 EN 25184 and with the requirements of the appropriate weld procedure.

7.4.12 Fabrication tolerances

The general tolerance on all dimensions shall be ± 2 mm. Holes shall be aligned such that fasteners can be freely inserted through the members at right angles to the contact face. Where holes in members cannot be aligned without damaging or distorting the structure, the member or members shall be rejected unless the Engineer shall permit reaming the holes.

A structural member shall not deviate from straightness (or from the specified shape) by more than:

- 1/1000 of the lengths between lateral restraints in the case of compression members and beams, or
- 1/500 of the overall lengths (maximum 25 m) in the case of other members.

A structural member shall not deviate from its intended length by more than:

- 1 mm in the case of compression members faced at both ends for bearing, or
- + 0 to - 4 mm in the case of other members.

Lengths of components shall be such that cumulative variations do not prejudice the accurate alignment of the completed structure.

Where two steel surfaces are required to be in contact to affect a bearing or frictional contact, the surfaces shall be prepared so that at least 90% of the area is touching before any clamping force is applied.

7.4.13 Dissimilar metals

Where dissimilar metals are used in close proximity to structural steel members or their connections, contact between such metals and the steel shall be avoided unless the Contractor can demonstrate to the satisfaction of the Engineer that contact between the dissimilar metals will not lead to galvanic corrosion.

Contact between aluminium or aluminium alloy and galvanized mild steel shall be permitted. For fixing aluminium to steel structures, bolts, nuts, washers and screws shall be galvanized.

Where galvanized parts may become sacrificial anodes to the main structure or where the electrolytic potential difference exceeds 250 mV, the parts shall be separated by an insulating medium of adequate strength.

7.4.14 Stainless steel

The requirements for stainless steel are given in Section 8 of these Specifications.

7.5 Structural Design Requirements

7.5.1 General

Structures should be capable of withstanding external lateral soil pressure when empty.

Structures should be capable of withstanding internal pressure when filled with water and assuming no lateral external load from soil and/or groundwater.

Combined structures should be capable of withstanding internal water pressure when one compartment is filled with water and the adjacent compartment is empty.

Structures should be capable of withstanding both external pressure support from soil and/or groundwater and internal pressure when filled with water.

The pressure from ground water and any external water should be taken into consideration.

All structures should be secured against uplift by their own weight together with the surrounding soil.

7.5.2 Minimum structural requirements

Walls

The thickness of reinforced concrete walls should be designed in conformity with the calculation criteria and shall under no circumstances be less than 250 mm.

All walls shall be reinforced in both sides and in both directions.

Walls shall be considered as fixed to the bottom slab. Hinged or sliding walls shall not be allowed.

Partition walls in liquid-retaining structures shall be designed for unilateral water pressure.

Bottom Slabs

The thickness of walls should be designed in accordance with the calculation criteria. The thickness of the bottom slab beside the walls can be reduced with 100 mm per every metre. The thickness of slabs shall under no circumstances be less than 250 mm.

Bottom slabs shall be reinforced in both directions in top and bottom.

Crack Width Criteria for Concrete

In calculating the stress using an elastic analysis, account shall be taken of whether or not the section is expected to crack under service loads and also of the effects of creep and shrinkage. The maximum allowable crack widths in concrete under service loads are given in the following table.

	Crack Width w_{max} (mm)	
Exposure class	**Pure tension**	**Tension in bending**
Freeze-thaw attack and chemical attack	0.15	0.20

Special account shall be taken for the reduction of crack width due to temperature, creep and shrinkage in the concrete. These provisions shall fulfil the requirements given in EN 1992-3 with a maximum allowable crack width of w_{max} = 0.20 mm.

Minimum Cover on Reinforcement

Type of structure	Concrete cover
Liquid-retaining structures, retaining walls etc	Minimum 50 mm
Other concrete structures:	Minimum 35 mm.

7.5.3 Loads, characteristic values

Dead load:

- Concrete: 25 kN/m^3
- Water: 10 kN/m^3
- Soil: According to Geotechnical Report laboratory tests performed by the Contractor.

Imposed load:

- Imposed load on buildings: According to related EN standards and TS498; Turkish Regulations for constructions to be built in seismic areas
- Traffic load on ground level along tanks: 10 kN/m^2 (characteristic)
- Temperature: T1 not less than 200C, EN 1992-3 T2 not less than 200C, EN 1992-3.

Seismic loads:

The project site is located in a zone of seismic activity and all structures shall be designed to withstand earthquake loads. Design includes also pipe connection to structures.

Other loads:

- Loads from equipment
- Loads from supports
- Loads distributed by the pipes in its longitudinal direction

7.5.4 Load Combinations

Serviceability Limit State

- Load Combination 1 (normal):
  In the serviceability limit state, the structures are filled with water to the normal working level and surrounded by backfilling if any. Any ground water level and the pressure from the surrounding soil should in this state be stipulated with low values.

  In this state, the effects from thermal action, shrinkage and creep should be taken into account in accordance with the temperature loads stated above.

  In the serviceability limit state the maximum allowed crack width as specified above.

Ultimate Limit State

- Load Combination 2.1 (empty): In this state the structures shall be assumed empty with pressure from the backfilling and ground water if any.

- Load Combination 2.2 (full): In this state the structures shall be assumed to be filled with water to the maximum possible level of filling in the structure even though this is above the normal working level. No pressure from external soil or groundwater should be considered in this state.

- Load Combination 2.3 (uplift): This combination should be checked if applicable only

The safety factor against uplift should meet the following requirements when calculated:

The safety factor to be at least 1.05 when the weight of the concrete together with the weight of soil on bottom slabs (calculated vertical upwards from the edges of the slabs - without any friction in the soil) only is taken into consideration.

The safety factor to be at least 1.2 when allowing friction in the soil to be taken into account.

- Load Combination 2.4 (earthquake): This combination shall be calculated according to Turkish Standards and norms.

- 2.4 a: In this state the structures shall be assumed empty

- 2.4 b: In this state the structures shall be assumed full

- 2.4 c: Different load cases and combinations.

Water Testing State

Load Combination 3.1 (water testing of liquid-retaining structures):

Even though the crack widths normally are calculated in the serviceability limit state only, the maximum allowed crack width in the state of testing structures for water tightness is 0.20 mm. In this state the structures should be assumed filled with water to a level of 70% of the height of the normal working level only. Pressure from surrounding soil or ground water must not be taken into account.

Load Combination 3.2 (water testing of digester):

In this state the digester should be assumed filled with water to the normal working level and internal gas pressure shall be taken into consideration.

Relaxation of stressing steel and frictional losses shall be taken into consideration in the design.

The load combinations should be also arranged for building types of structures in accordance with requirements of load combinations in TS 500.

7.5.5 Calculations

The Contractor has the full responsibility for the structural design calculations.

All acting forces should be calculated based upon the theory of elasticity wherever possible. An approximate assumption of the load distribution is allowed if realistic only. Loads which support the structures should be stipulated with low values.