

سوست شماره ۱۵

مشخصات فنی

Concrete Works

۱. Materials

۱.۱. Cement

Used cement shall be an approved brand of Portland cement in accordance with ASTM C-۱۵۰ specification or approved equivalent. Type of cement shall be in accordance with geotechnical report, the environmental and soil aggressiveness conditions. In addition, underground concrete shall be coated with bituminous protection to the following specification:

Surfaces below ground level:

Surfaces below ground level shall be coated with a proprietary or bituminous coating to give a total minimum thickness of ۱mm. The bituminous coating shall be an emulsion with a solids content of at least ۵۵% bitumen and also containing ۱۰% of rubber latex compound.

With surfaces at grade to be painted as below this coating shall overlap the ground level coating by ۷۵mm. Care shall be taken to ensure a watertight seal between the applied coating and the polyethylene sheet below the foundations.

Exposed external surfaces at ground level:

Exposed external concrete surfaces for a depth of ۱۵۰mm below ground level and ۵۰۰mm above, or to underside of base plates, whichever is the lowest, shall be primed with a low viscosity primer and coated with two coats of a light grey colored epoxy paint with a minimum thickness of ۱۲۵ microns per coat, or a polymer modified cement system with a minimum thickness of ۵۰۰ microns. Where coating is to underside of base plates it shall cover the grout.

Painting:

Application trials shall be carried out on chosen coating. Concrete surface preparation and application shall be strictly in accordance with the manufacturer's recommendations.

The cement used in the work shall correspond to the cement used when selecting concrete proportions.

Cement shall be delivered in sound dry bags and stored in dry shaded and weatherproof conditions. Sufficient quantities of cement shall be delivered to ensure no suspension of concreting operations. Each consignment shall be separated from previous deliveries.

Any material which becomes damp or otherwise defective shall be immediately removed from the site. Cement in bulk shall only be used after the Engineer has approved: first, the method of delivery, second, type of container and third, the method of storage.

Cement test certificates shall be submitted to the Engineer. One brand of cement shall be used throughout the work to maintain uniform color and to establish undivided responsibility.

Test Certificates shall be submitted to the Engineer whenever requested.

۱.۲. Grouting

Grouting materials shall be designed and formulated for the severe conditions of work. Grouting materials, wherever applicable, shall be able to resist the efforts of heating/cooling and wetting/drying.

Major mechanical equipment and structural steel columns shall be grouted using a prepackaged cement based non-shrink grouting material. Small or minor mechanical equipment and steel members may be grouted using a sand/cement mix with an expansive additive.

۱.۳. Aggregates-Sand

Coarse aggregates and sand for concrete and mortar and grout shall conform to ASTM C۳۳ or BS ۸۸۲ or AASHTO M۶ and M۸۰ Standards.

Fine and coarse aggregates shall comply with ASTM C۳۳, and shall be delivered in sufficient quantities to ensure no suspension or interruption of concreting operations.

Aggregates shall be stored in such a manner as to prevent mixture of the materials and obviate contamination.

The source of the aggregate supply shall be approved by the Engineer. The Construction Contractor shall supply physical evidence including samples and details of the materials he proposes for the work for the Engineer's approval.

The Construction Contractor shall draw samples from stockpiles as directed by the Engineer for testing in the Laboratory. Any material which, as a result of such tests, does not conform to the required standard shall be removed from the site by the Construction Contractor. Testing shall be in accordance with ASTM C۳۳.

The following considerations regarding the limits of chloride and sulphate content in aggregates and concrete and potential AAR in concrete are described in this Specification and shall be strictly adhered to.

Chlorides in concrete

Maximum total chloride content of hardened concrete at ages from ۲۸ to ۴۲ days expressed as percentage of water soluble chloride ion by weight of cement

Concrete containing embedded metal and made with sulphate resisting Cement: ۰,۲

Concrete containing embedded metal and made with type I & II Portland Cement: ۰,۳

Test procedures shall conform to ASTM C ۱۲۱۸

Sulphates in Concrete

The total water soluble sulphate content of the concrete mix shall not exceed ۴,۰٪ SO_۳ by weight of the cement in the mix. The sulphate content, expressed as SO_۳ shall be calculated from the sulphate derived from the cement, any other cementitious material, the aggregate, any admixtures and any other source.

۱,۴. Water

Water used in mixing concrete shall be potable water free from oil, acid, alkali, organic, and other deleterious matter. Nonpotable water may be used if mortar test cubes made with this water have a ۷-day and a ۲۸-day strength equal to at least ۹۰٪ of the strength of companion specimens made with potable water. Mortar cubes shall be made and tested in accordance with ASTM C۱۰۹.

۱,۵. Reinforcement

Reinforcing bar material shall conform to the requirements building and structure design criteria. All steel reinforcement shall be free from loose rust, mill scale or other deleterious materials which might

obviate proper bonding of concrete. All steel shall be wire brushed where directed prior to the deposit of surrounding concrete. The contractor shall furnish the Engineer with copies of test certificate by the manufacture of an approved laboratory for the actual reinforcement supplied.

All reinforcement shall be stored in racks or on supports which will keep it off the ground.

۱,۶. Admixtures

Micro silica and super plasticizer admixtures shall be added to concrete to increase durability and strength of concrete. Any admixture used in concrete shall conform to the requirements of ASTM C ۴۹۴ and shall be shown to be capable of maintaining essentially the same composition and performance throughout the work.

All admixtures used to modify one or more characteristic of the concrete shall be accompanied by a certificate from an approved institute, stating:

- Exact range and method of application
- Physical and chemical composition
- Positive and negative side effects
- A recommendation on the maximum allowable quantities (as a percentage of the mass of the cement) to achieve the particular requirement
- Proportioning and mixing
- Compatibility with cement type intended to be used.

The admixtures shall contain no chlorides. If a retarder and plasticizer are required only a dual-purpose additive shall be used.

Admixtures shall be applied strictly in accordance with the manufacturer's instructions. However, the Construction Contractor shall be responsible for any defective concrete that may result from the use of such admixtures.

The Construction Contractor shall perform a trial batch and casting to substantiate the manufacturer's claims for workability, retardation and air entrainment.

۱,۷. Formwork

The moulds shall be made of steel. The formwork shall be of such design as to be in every respect suited to the structure and to the required surface finish of the concrete and shall meet with the Engineer's approval.

The moulds shall be fixed in perfect alignment and squarely braced so as to be able to withstand, without displacement, deflection, or movement of any kind, the weight of the construction and the movement of men, materials and other possible temporary construction loads. All joints shall be close enough to prevent leakage of liquid from concrete.

Wedges and clamps shall be used whenever practicable instead of nails. The use of plugs, bolts, wire, ties, holdfasts and any other appliances for supporting the formwork shall be kept to the minimum. Formwork for walls and columns shall be so built as to ensure the construction of them to the required elevation in one operation.

۲. Concrete Construction Works

The concrete work procedure will be as below:

- Foundation Excavation: Excavation, Disposal of Surplus Soil.
- Foundation Backfilling: Surplus Soil Selection (if any), Imported Soil (if any), Moistening and Compaction.
- Compacted Crushed Stone (or slag).
- Lean & Mass Concrete.
- Reinforced Concrete: Steel Buildings Footings & Walls, Equipment Foundations,
- Pavements and Floors, Cabins and Framed Buildings, Pits and Tanks.
- Reinforcing: Re-bars, Welded Mesh.
- Formwork: Scaffolding Forms.
- Steel Inserts: Plates, Profiles, Conduits, Corrugated Steel Pipes.
- No-shrink Grouting.
- Auxiliary Steelworks (not technological): Gratings and Covers, Stairs, Ladders,
- Walkway, Handrails.
- Steel Structures for Decking: Columns and Bracings, Beams and Bracings,

- Galvanized Steel Deck Profile.
- Refractory Linings.
- Bituminous Painting.
- Industrial Floor Hardener.
- Technological Finishes: Primary Grounding Grid, Membranes, Waterstops, Joints,
- Embedded PVC Conduits, Manholes, Protective Linings, Metallic Net for Internal Fencing.
- Necessary shop / erection drawings relevant to the above-mentioned items, including re-bar cutting & bending drawings.

۳. Concrete Requirements and Preparation

۳.۱. Durability

Requirements of ACI ۳۰۸ chapter “Durability” shall apply together with any project and contractual documents. The Contractor shall particularly note the amount of sulphates and chlorides present in the soil.

۳.۲. Consistency and Workability

Workability and consistency shall be such as to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding.

The slump determined in accordance with ASTM C ۱۴۳ shall range between the following limits. The stated ranges are consistent with concrete made with ordinary Portland cement. Changes due to use of super-plasticizer and cement type II are expected. A highly qualified laboratory shall be consulted, for obtaining allowable ranges of slump for the proposed concrete grades.

۴. Concrete Placing and Compaction

۴.۱. Placing

Concrete shall be conveyed from the mixer to its location as rapidly as possible, by methods that do not cause segregation, adulteration, loss of ingredients or contamination. The Construction Contractor shall ensure that all concrete is ready at the time of placing.

All foundations and tie beams shall be placed on minimum ۱۰۰ mm lean concrete over compacted natural soil. Thickness of lean concrete layer shall be increased on earth fills as required to place the bottom of the layer on natural soil with top soil removed.

The placing sequence of foundations shall be such that where adjacent footings at different depths occur; the deeper footing shall be placed first.

The Construction Contractor shall be responsible for the coordination of reinforced concrete drawings with all architectural, structural and other relevant drawings and shall refer to those drawings to verify that all necessary embedded items such as ducts, anchor bolts, piping, pipe sleeves and electrical boxes are in place before placing concrete. Embedded items shall be cleaned of all loose rust, scale, paint, grease and other deleterious material before being placed and shall be securely fastened in place prior to placing concrete. Embedded conduits, pipes, pipe sleeves, etc., shall be placed between the top and bottom layer of horizontal reinforcement and between the front and back layers of vertical reinforcement and shall be located such that the strength of the structures is not harmfully reduced. Conduits and/or pipes in a row shall be placed not closed to each other than ۳ diameters of the larger. In general, the contractors shall obtain the approval of the Engineer or the Owner Representative for the location of all embedded items not shown on the reinforced concrete drawings.

Concrete shall be placed in horizontal layers not exceeding ۴۵۰ mm thick and continuous between construction joints, the position and arrangement of which shall be predetermined.

Where chutes are used to convey concrete, height and slopes shall not be such as to cause segregation at discharge. Preferably the slopes shall be ۱:۲ to ۱:۳ and the maximum drop shall not exceed ۱,۲۰ m. The maximum time period between pouring successive horizontal batches of concrete shall be ۲۰ minutes. No partially hardened concrete or retempered concrete shall be used in the work unless such usage has been specifically allowed under this specification. Concrete for foundation shall be placed on a minimum ۱۰۰ mm thick blinding layer of Grade D concrete. The blinding is to be wetted down prior to pouring the foundation concrete. Alternatively, the concrete blinding can be replaced by other materials as directed by the Engineer.

۴,۲. Compaction

All concrete shall be fully compacted throughout the full depth to a dense homogenous mass thoroughly worked against formwork and around reinforcement and other embedded items without

displacing them. Successive layers of the same lift shall be thoroughly worked together. Unless otherwise directed, approved power – driven vibrator(s) shall be at such spacing and applied in such a manner as to ensure uniform compaction without segregation of materials. Immersion vibrator(s) shall be withdrawn slowly to prevent void formation. Immersion vibrators shall penetrate the full depth of the concrete layer and, where the lower layer is freshly placed, the vibrator shall revibrate the upper section of that layer to ensure a full mix between the concrete layers.

If concrete placing in a deep beam, wall, or column is intended to be continuous and monolithic with a slab above, a delay to provide for settlement of the deep concrete shall be scheduled before placing the upper concrete in soffits and slabs. Length of the delay will depend on temperature and setting characteristics of the concrete but should be as long as will still permit the vibrator to again make the deep concrete plastic as it revibrates it and further settles just before and during vibration of the soffit and slab concrete. No formwork leakage will be permitted.

Vibration of forms shall be avoided and any form of internal vibrator shall not be permitted to come into contact with reinforcement. For other requirements for compaction with vibrators refer to Clause ۳,۳. Where approved by the engineer, the compaction may be achieved by means of metal tamping rods.

۴,۳. Mix Proportioning

General

Proposed concrete proportions shall be subject to acceptance by the employer based on demonstrated ability to produce concrete meeting all requirements of this specification, of job specifications and any other contractual documents.

The selection of proportions for the concrete shall be preferably performed on the basis of ACI complying with strength and other job specification requirements.

Workability and consistency shall be such as to permit concrete to be worked readily into forms and around reinforcement under conditions of placement to be employed, without segregation or excessive bleeding.

Determination of required average strength on the basis of field experience or trial mixtures

The value of required average strength shall be established, in accordance with the procedures set out in ACI ۳۰۱ on the basis of previous field experience or laboratory trial batches when less than ۱۰ tests are available.

The required average compressive strength to be complied with shall be calculated on the basis of specified strength plus the amount determined in accordance with the procedures established in above said standard.

Should trial mixtures be performed the test cylinders shall be tested for strength in accordance with ASTM C ۳۹ at ۷ and ۲۸ days.

Proportioning based on empirical data is not permitted unless the concrete is to be used for non-structural casting.

۴.۴. Concrete Curing Protection and Patching

The concrete shall be adequately protected and cured in accordance with the requirements of ACI ۳۰۱.

Freshly deposited concrete shall be protected from premature drying and excessively hot or cold temperatures, and shall be maintained without drying at a relatively constant temperature for the period of time necessary for the hydration of the cement and proper hardening of the concrete. All curing procedures shall be in accordance with ACI ۳۰۸ Standard Practice for Curing Concrete.

Water shall be applied to formed surfaces while forms are still in place. Steeply sloping and vertical formed surfaces shall be kept continuously moist prior to and during form removal by applying water to top surfaces so that it will pass down between the forms and the concrete.

Unformed surfaces shall be kept moist by wetting for at least ۲۴ hours, and curing shall be started as soon as the concrete has hardened sufficiently to withstand surface damage. Spray nozzles shall be provided to keep covering materials soaked.

The Contractor shall ensure that the curing water is not much cooler than the concrete at all times during curing and the maximum temperature difference between concrete and curing water shall not be more than 10° Centigrade. Water mixed with ice shall not be used at any time during curing of concrete.

No person, vehicle, equipment or loading shall be allowed on any structure, or part thereof, before the concrete is sufficiently hardened.

Protection for curing of the concrete after the initial set shall be by a method such that adequate water is available for full hydration of the cement. This may be attained by keeping the surfaces of the concrete damp by covering with a layer of sacking, or a similar absorbent material, such as sand, which must be kept soaked with water applied as fine spray. Alternatively, after thoroughly wetting the surfaces they shall be covered with an approved waterproof paper or plastic membrane kept in contact with the concrete, or immediately after placing of the concrete or removal of the forms applying to the concrete surfaces an approved liquid curing membrane, containing a dye, strictly in accordance with the manufacturer's instruction. Liquid curing membranes shall not be applied to surfaces which will later receive grout.

Curing shall be continued for a period of at least ۷ days in the case of all concrete except high-early-strength concrete, for which the period shall be ۳ days.

Steel forms heated by the sun and all wood forms in contact with the concrete during the curing period shall be kept wet. If forms are to be removed during the curing period, one of the curing methods stated above shall be employed immediately, and for the remainder of the curing period.

Immediately after the forms have been removed, all exposed concrete surfaces shall be inspected for defects, and all fins, bulges, projections, honeycombing, and other defects repaired before the concrete is fully matured. Defective areas, such as honeycombed concrete, shall be cut back to solid concrete for repair. If before or during this operation any reinforcing bar is exposed the cutting out shall continue right round the bar to form a key. When reinforcing bars are so exposed, care should be taken to ensure that the bars or any other inserts are not damaged by the tools used for cutting out the concrete.

Patching of defective concrete shall be carried out with a suitable proprietary epoxy resin mortar. All surface preparation, mixing, placing and curing shall be carried out strictly in accordance with the manufacturer's instructions.

۵. Reinforcement

۵.۱. General

Reinforcing steel shall be cut and bent cold and conform to the shapes and dimensions specified in the construction drawings. No hooks shall be provided for deformed steel bars unless specified in the construction drawings.

Bars and fabric displaying defects, improper fabrication or non-compliance with the specifications shall be rejected. Reinforcement which has been bent to facilitate transportation in short trucks will be rejected by the Engineer.

Reinforcing bars shall be bent to conform to the shape and dimensions specified on the construction drawings. All bending shall be done cold. Re-bending or straightening shall not be permitted, except where shown on the construction drawings, or with the prior written approval of the Engineer. Unless permitted, reinforcement shall not be bent after being partially embedded in hardened concrete.

Reinforcing bars when bent to schedules shall be securely bundled and labelled with a metal tag, which shall be stamped with the bar mark and its identification prefix as noted on the bar bending schedule.

Reinforcing bars shall be stored on suitable racks to avoid contamination. Wire mesh reinforcement shall be stored on a level floor to prevent distortion.

۵.۲. Fabrication of reinforcing steel

Reinforcing steel shall be cut and bent cold and conform to the shapes and dimensions specified in the construction drawings.

No hooks shall be provided for deformed steel bars unless specified in the construction drawings.

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Reinforcing bars shall be stored on suitable racks to avoid contamination. Wire mesh reinforcement shall be stored on a level floor to prevent distortion.

۵.۳. Placing of reinforcing steel

Reinforcing bars shall be free of any extraneous and deleterious matter that could impair their adherence to concrete.

The number, size, form and position of all reinforcement shall be strictly in accordance with the drawings, unless otherwise authorized by the Engineer in writing.

Bars shall be tied using annealed iron wires at intersections, to form a rigid cage that shall maintain its position without distortion or twisting while the concrete is being placed.

Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved enough to exceed the above tolerances, the resulting arrangement of bars shall be subject to approval by the Engineer. Extra bars may have to be added to maintain the design requirements.

۶. Joints and Embedded Items

۶.۱. Construction joints

Construction joints not indicated in the valid construction drawings shall be carried out only after having received the employer's approval; position and construction shall be such as to minimize the impact on the strength of the structure.

Construction joints shall be arranged to minimize the effect of shrinkage of the concrete. Proposed location of the joints shall be approved by the Engineer.

Construction joints specified on the construction drawings shall not be omitted or relocated without the prior written permission of the Engineer. All construction joints other than horizontal joints shall be formed with proper stop-boards, which shall be fixed vertically unless otherwise directed.

Prior to pouring new concrete, all exposed reinforcement shall be wire brushed to ensure removal of all concrete residue from previous pouring operations. Immediately prior to pouring new concrete, all joint faces shall be hacked clean of all laitance and honeycombed concrete. Hacking shall terminate ۱۲mm from any exposed edge, and further be treated with cement water mix.

At vertical joints, the fresh concrete shall be placed directly against the hacked concrete face which shall be thoroughly wetted immediately prior to pouring.

Horizontal joints shall be prepared while the concrete is still "green". The surface skin shall be removed by means of an air-and -water jet or by wire brushing, to expose the larger aggregate. This operation shall be carried out one to three hours after compaction, depending upon weather conditions.

When it is impractical to carry out the above procedures the joints shall be prepared by sand blasting or needle gun to remove the surface skin and laitance. Hacking of hardened surfaces shall be avoided. Before commencing with the fixing of reinforcement or shuttering for the new concrete, the surface of the hardened concrete shall be inspected and approved by the Engineer.

۶.۲. Expansion and control joints

Expansion joint filter shall be of the type required and shall confirm to ASTM.

Expansion joints shall extend for the full depth of the concrete; control joints shall be made by superficial cutting of the concrete.

The sealing operation of a joint shall be as follows:

- applying of masking tape on both sides of joint
- cleaning of joint seat

- inserting of close cellular backing cord, leaving the necessary space for the mastic; underneath remaining space to be filled with expanded polystyrene
- applying of tack primer coat
- applying of joint filler to seal perfectly the concrete joint
- removing of masking tape.

The joint filler shall be self-levelling hydrocarbon-resistant if it is to be used in plant areas and/or in case of aggressive liquids, and shall have thixotropic characteristics if the laying surface is inclined.

۷. Finished Surfaces

۷.۱. General

The horizontal surfaces shall be level and wood-float finished; the surfaces in contact with the form work shall be smooth, compact, with uniform planes, free from color patches, voids or burrs, after the form work has been removed.

Tie holes shall be plugged with cement mortar to match the adjoining concrete in color and texture.

Finished surfaces shall not have any defects that require repairs. Protruding concrete formations that can be easily removed, any surface unevenness due to placing or removal operations provided they are limited in quantity, and tie holes shall be then repaired/plugged using mortar (made with the same type of cement used in the concrete mix), in such a way as to obtain uniformity of color and surface.

۷.۲. Finishing of formed surfaces

Rough form finish shall be provided for all concrete surfaces not exposed to view; smooth form finish shall be provided for concrete surfaces exposed to view. Rough and smooth finishes are defined in ACI ۳۰۱.

Special architectural finishes shall be provided when required by the valid for construction drawings.

۸. Concreting in Hot Weather

The temperature of concrete as placed at ۳۲ deg C or higher shall be regarded as “Hot Weather” conditions.

It shall be observed that cement must not be subjected to temperatures greater than ۷۷°C and that coarse aggregates shall be heavily sprayed with water immediately before mixing.

۸,۱. Cement and aggregates

It shall be observed that cement must not be subjected to temperatures greater than ۷۷°C and that coarse aggregates shall be heavily sprayed with water immediately before mixing.

۸,۲. Water

In order to keep the concrete temperature as low as possible effort shall be made to use water from a cool source and to keep it cool by protecting pipes and tanks. Pipelines for conveying mixing water shall be buried, insulated, shaded, or painted white. Water storage tanks shall be treated in a similar manner.

Water may be cooled by adding ice provided it is completely melted by the time the water is entered into the mixer.

۸,۳. Placing

The Contractor shall have ample personnel available to handle and place concrete immediately on delivery. The temperature of concrete at placement shall not be greater than ۳۲°C.

۸,۴. General

A combination of hot, dry weather and high winds or high temperatures resulting in immediate vicinity of the formwork shall be sprinkled with cool water. All subgrade foundation etc., which are to receive concrete shall be wetted down or flooded with water immediately before concreting, preferably during the night for early morning concreting, as directed by the Engineer.

Section C: Excavation and Filling

۱. Excavation Works

۱.۱. General

Excavation shall be carried out mechanically by Contractor's selected methods which shall be submitted for review to owner. Special care may be required by Contractor to ensure no damage occurs to existing buried pipes or cables, if any. Adequate protection shall be provided. This specification defines the types, methods and procedures of excavation.

This specification applies to topsoil removal, general excavation, limited section excavation, made in soil, soft or hard rock, whether in the presence of water or not.

۱.۲. Definition of Excavation Types

Topsoil removal

Topsoil removal means the excavation made along the ground profile to an average depth of ۰,۲۰ m below ground level, in soils of any nature and consistency excluding rock, to remove the superficial soil layer.

Topsoil removal also includes clearing of bush, grass, shrubs, and other unsuitable material (for example debris); this material shall be removed using the same mechanical equipment as for topsoil removal (for example bulldozer, etc.).

General excavation

General excavation means excavation made at any depth, with a horizontal surface area greater than ۱۵۰ m² and a minimum width of ۳,۵۰ m.

As an example, general excavation includes, but is not limited to, excavation for grading and levelling of plant or construction areas, for cutting of embankments, for construction of yards, roads, channels, buildings, pipe ways, foundations of storage tanks and etc.

Limited section excavation

Bottom of trench shall be to a depth ۰,۲ m below the intended inverts level. The width of trenches shall be +۰,۲ m on each side if the exterior pipe diameter is ۴۰۰ mm or less. If the diameter exceeds ۴۰۰ mm, the trench width shall have a minimum of the pipe exterior diameter plus ۰,۸ m. But always the width of the trench shall be as necessary for sheeting bracing and the proper performance of the work:

a) Excavation for foundation works

This means limited section excavation made for footings, continuous foundations, foundations for machinery, equipment and steel structures, pits, walls, concrete trenches, etc.

b) Trench excavation

Trench excavation means limited section excavation for laying of sewers, aqueducts, pipes and ducts in general, electric and instrument cables, etc. Trench excavation also covers excavation for making openings in tank earth bunds for the passage of pipes, cables and/or equipment, as well as excavation for construction of ditches.

۱,۳. Definitions of Excavation According to the Soil Nature**Earth excavation**

Earth excavation means any excavation in soil of any nature and consistency, which can be carried out without the use of a ripper, even in the presence of stones provided the volume of individual stones does not exceed ۰,۵ m^۳.

Soft rock excavation

Soft rock excavation means any excavation in soft rock with uniaxial compressive strength less than ۲۵ MPa; these rocks can normally be broken by suitable mechanical equipment and/or by ripper single cut.

Hard rock excavation

Hard rock excavation means any excavation in compact rock with uniaxial compressive strength ≥ 20 MPa or greater; these rocks can normally be broken only by mechanic methods and/or pneumatic jack hammer. Removal of individual stones with volume not less than 0.50 m^3 during earth or soft rock excavation shall be regarded as excavation in hard rock.

Excavation in water

Excavation in water means any part of excavation made below the level of the water table and in the constant presence of groundwater such as to require the installation and continuous use of drainage systems and/or equipment.

۱.۴. Methods of Excavation

The requirements in this specification shall apply whichever the geological soil nature may be and in the presence or not of water. All excavations shall comply with the sizes and elevations indicated in the Drawings and/or required by the Employer.

The bottoms of foundation excavations shall be made perfectly horizontal and/or levelled to the specified elevation.

To avoid collapse, the Contractor shall carry out any temporary works required for supporting the sides of limited section excavations using shoring props, supports and reinforcement of any kind and size, including steel sheet piles or equivalent.

Dumped materials resulting from excavations shall not be prejudicial to the works, to the free drainage of surface water, or to existing structures.

۲. Filling Works

۲.۱. Classification of Fill

Fill according to the source of materials

- Material from excavation: Material coming from stock piles located in the site area and/or coming directly from excavation operations.
- Material from borrow pits: Material supplied from borrow pits located inside and/or outside the plant and/or construction site area.

Fill according to destination

- Structural fill for general filling of areas and for embankments: This fill is to be used for general filling to design elevations in areas to be subsequently used as support of the following:
 - reinforced concrete foundations (footing, raft, etc.)
 - buildings
 - reinforced concrete basins and trenches
 - storage tanks
 - sub-base and base courses for roads, parking areas, operating areas for trucks, cranes, etc.
 - railway
 - local replacing of unsuitable material
 - paved areas
 - pipeway.
- Structural fill for general filling of areas with existing works: This structural fill and/or backfill is to fill to design elevations the areas to be subsequently used as support of the works listed above, and is carried out in the presence of existing foundations and/or above-mentioned works. Filling and backfilling are eventually carried out manually when the limited space does not allow the use of mechanical equipment.
- Structural fill for tank foundations:
 - Tank pad: This structural fill can be used on the whole bearing surface of the tank load, or inside a reinforced-concrete or crushed-stone ring; depending on requirements, the filling material may be:
 - a) soil-aggregate mixture
 - b) granular material
 - c) sand.

- Ring: This structural fill made of crushed stone is used to form the trapezoidal section ring, which shall bear the load transmitted by the tank shell.
- Non-structural filling for bund walls: This fill is to be used for non-structural embankments, for example retaining walls for storage tanks, basins, etc.
- Non-structural filling for areas: This is to fill to design elevations the areas not to be subsequently used as support of the works listed above, graveled areas, and open areas where filling is required only to reach design elevations.
- Non-structural backfilling of trench excavation: This backfilling is to be carried out after laying buried cables and/or pipes in areas not to be used as support of the works listed above.
- Replacing unsuitable material: This fill is to replace the existing soil (if unsuitable) with a better material.
- Foundations for concrete pavement: This fill, is to adequately support concrete pavement; it is to be properly shaped according to the pavement slope to maintain a uniform thickness of the pavement.

۲.۲. Setting Out

The contractor shall set out the works in accordance with the elevations and alignments specified on construction drawings, with reference to the bench marks fixed by the employer.

The contractor shall take account of deductions from finished levels due to the thicknesses of trimming and top soiling layers, road sub-bases, etc.

۲.۳. Preparation of Sub grade

The ground surface that shall support the first layer of fill shall be cleared of topsoil and vegetation through soil stripping and removal.

Any facilities and equipment used during excavation, including propping for wall support, etc., shall be removed from the excavation before and during backfilling.

In the event of interruption of fill construction, the work can be resumed only after removing the shrubs, bushes and vegetation that may have grown, and after making the required furrows for connection of the new materials with those previously employed.

If the sub grade is sloping more than ۱۵%, stepped platforms shall be constructed, with steps about ۰,۳۰ m in height and slope opposite to the ground slope.

After topsoil removal, the sub grade shall be compacted to at least ۹۰% of the maximum dry density determined as per ASTM. The water content of the material shall range between -۳% and +۵% the laboratory value. The frequency of the compaction tests shall be as specified for the layer supported.

For plastic soils (in case they are affected by groundwater) the degree of compaction of the sub grade may be reduced up to ۸۵% of the maximum dry density determined as per ASTM, if soil compaction is difficult as pointed out by the tests made.

To preserve the fill from moisture (which may seep upwards due to capillary forces from the sub grade) and from horizontal motion of water at the foot of the fill, if the fill consists of earth material, the employer may request the contractor to lay on the sub grade a dry material layer having a finished thickness of ۲۰۰mm (۳۰۰mm if gravel), consisting of crushed stone or gravel (size ۱۰-۷۰mm), to be completed with drains if requested by the employer.

۲,۴. Method of construction

Placing of fills

Where groundwater is present, it shall be lowered to a level that does not affect the placing and compaction of the layers, for at least ۴۰۰mm.

The material shall be placed in regular layers so as to avoid particle segregation, until obtaining - after compaction and settling - the finished work in accordance with design sections and elevations.

Each layer shall have a suitable slope to permit quick removal of rain water, but in any case the slope shall not be greater than ۳%.

The best material available, whether from excavation or borrow pits, shall be used for the top layers. In any case the employer reserves the right to establish the laying sequence for the various materials on a case-by-case basis.

The larger size rock fragments shall be spread in the lower part of the fill, and the smaller size fragments in the upper layers.

The contractor may start a new layer only after the underlying layer, finished and compacted, has been accepted by the employer on the basis of the tests made. Any deviation from the above shall be subject to the employer's prior approval.

Methods and equipment for construction

On the basis of the materials properties and the analyses made, the contractor shall propose to the employer specific methods and equipment for the required filling; details of machinery shall be attached, as well as any results obtained from previous experience on similar materials or specific trial tests.

The required compaction degree shall be obtained using suitable equipment, and shall also be reached in limited areas and/or adjacent to existing works or foundations.

Compaction operations shall be continuous, from the outer edges of the area to be compacted towards the center, until the laid material has reached the required compaction.

Thickness of the layers

If compaction is performed manually using suitable equipment, the maximum allowable thickness of the compacted layer is reduced to ۱۰۰ mm, unless otherwise agreed with the employer.

Compaction degrees for the various fills

The material placed shall be compacted to the degree expressed as a percentage of the maximum dry density per ASTM or ASHTO. All fills intended to carry loads shall be compacted to not less than ۹۵% modified AASHTO density.

Finishing of fills

Fills shall be finished with regular and flat slopes, well-shaped and aligned edges. During the work, and until work acceptance, the necessary cutting or refilling shall be performed, as well as trimming and grading of the slopes, and cleaning of any ditches.

Special requirements for general filling in plant areas

The employer may request that placing of fill in plant areas should be performed in two stages.

During the first stage, filling is to be performed up to the level of top of foundation base slab and/or the bottom level of the plant buried systems (this level normally ranges between -۱,۲۰ m and -۰,۸۰ m from the finished grade level).

During the second stage, after the construction of foundations and laying of buried systems, the filling of areas is to be carried out up to the pavement formation level.

This second stage is more complex because of the presence of foundations and piping, and because its timing is determined by the construction schedule, which the employer reserves the right to define as and when appropriate.

۲,۵. Surface Finishing

Top-soiling

Slopes, road shoulders, traffic islands, etc., if required by the design and/or by the employer, can be covered with topsoil having a thickness between ۱۵۰ mm and ۲۰۰ mm.

The final design elevation of embankments shall be suitably reduced to allow for subsequent placing of topsoil, which shall be properly levelled in accordance with the design sections.

The required topsoil may be obtained from topsoil removed from the site or elsewhere: in any case it shall ensure growing of the vegetation and shall be subject to the employer's prior approval.

Top-soiling shall be carried out in horizontal strips to be compacted by suitable equipment so as to avoid slips.

Proper measures (e.g. use of boards fixed by steel rods, etc.) shall be taken to prevent the topsoil from slipping down the slopes.

Placing of Gravel Layer

A gravel layer, which is a form of finishing for non-paved areas to be carried out where required by the design and/or by the employer, shall be obtained by means of a layer of fine crushed stone or gravel having a uniform, levelled thickness of at least ۵۰ mm.

The fine crushed stone and fine gravel shall have a particle size between ۱۰mm and ۲۵mm and shall be good quality, perfectly clean and free from foreign matter.

Samples of the material shall be submitted to the employer for approval before use.

ing backfilling or protection be started