

SPECIFICATIONS

TECHNICAL SPECIFICATIONS - CIVIL WORKS

1. Order of Precedence of Specifications

The order of precedence in referring to various specification are as follows in ascending order

- a. Technical specification of the Contract
- b. Indian Standard specifications
- c. PWD of Tamil Nadu state /TNBP
- d. CPWD
- e. Manufacturers recommendations

The Contractor shall also not be paid for any extra working space beyond concrete dimensions during excavation of foundations of various proposed structures in the Project. Any damage done to the work due to the contractor's operation beyond the excavation lines shall be repaired at the expense of the contractor. Any and all excess excavation or over breaking performed by the contractor for any purpose or reason except as may be ordered in writing by the PROJECT OFFICER/PMC and whether or not due to the fault of the contractor shall be at the expense of the contractor. Cost of refilling for all such excavation with materials as specified by the PROJECT OFFICER/PMC has to be done by the contractor at his expense.

2. General

The scope of work shall comprise of (but not limited to) supply, construction, installation, testing, commissioning and approvals from PROJECT OFFICER/PMC statutory authorities for all works described in the tender. Complete scope of works should be read in conjunction with all documents and drawings which are the part of tender. The drawings and documents attached in the tender document are for reference only.

The non-serviceable material and surplus soil shall be disposed off to the designated approved dumping yard or as directed by the PROJECT OFFICER/PMC. The contractor shall be responsible for all the statutory approvals from the statutory authority and all the concerned departments, as the case may be.

All materials shall conform to the latest edition of the Indian Standard Specifications. Standards issued elsewhere may be used only if approved by the PROJECT OFFICER/PMC and for those materials only for which appropriate Indian Standards do not exist.

If specification for any material/work is not available in these Technical Specifications, the material/work shall conform to the latest Specifications, with up to date correction slips, amendments and additions / IS CODES / Manufacturers specifications / as per drawings / as per instructions of PROJECT OFFICER/PMC.

The work shall be carried out according to the design, drawings and specifications issued by PROJECT OFFICER/PMC as "Good for Construction" drawings from time to time during execution stage and approved by PROJECT OFFICER/PMC.

All equipment and components shall be accommodated within the locations, space and dimensions indicated in the Architectural drawings. Any changes required shall be suggested by the Contractor and submitted for approval of PROJECT OFFICER/PMC. No changes shall be done without the approval of PROJECT OFFICER/PMC.

All sections of Tender documents and Tender drawings shall complement each other. Any discrepancy between various documents shall be studied and implemented as best for the project and as per decision of PROJECT OFFICER/PMC, without any cost implication.

The Tenderer has to ensure that all the designs, drawings, specifications and other things are in line with codal provisions applicable for the project and as per the requirements given by PROJECT OFFICER/PMC.

If there is any variation in Design and Specifications between tender documents/drawings and any of the statutory/standard's requirement, then higher standard of specifications from either of them shall be implemented in approval with PROJECT OFFICER/PMC. Nothing extra shall be payable on any account.

It shall be responsibility of the Contractor to ensure that all works are carried out in full compliance with the PROJECT OFFICER/PMC's requirements, System Requirements.

Reference must be made to the General Specification for general requirements and to the appropriate Technical Specification for the corresponding technical requirements of all work.

The Specifications listed below have been added for guidance of the PROJECT OFFICER/PMC responsible for carrying out the Works who shall however ensure that all aspects of the construction of the Works shall comply with Local Standards, Laws and Regulations and accepted good practice in India.

3. Contractor's Responsibility

Apart from carrying out necessary surveying and setting out of the buildings and equipment foundations wherever required collecting all materials, equipment, plant, labour, consumables, tools and services necessary for proper execution, fabrication, ensuring quality control by conducting required tests at the appropriate time and intervals during the execution, disposal of excavated material as instructed, carrying out all associated works like removal, disposal of the debris, getting out, remove temporary facilities on completion of the works, clearance from local bodies / authorities for commissioning of all installation / equipment of the project work shall be obtained and furnished before taking over of the completed work, all within the quoted rates only. Machinery operators, drivers should have valid license. Child labors are strictly prohibited. Top most attention shall be paid to the Health, safety of workers and Environment and the same shall be monitored on daily basis by qualified and experienced personnel in HSE.

TECHNICAL SPECIFICATIONS
CIVIL & PIPELINE WORKS

CONTENTS

1.	EARTHWORK IN GRADING, EXCAVATION AND BACK FILLING	5
2	DEWATERING	17
3	EMBANKMENT CONSTRUCTION.....	18
4	REINFORCED CONCRETE AND ALLIED WORKS	28
5	PIPE WORKS.....	56

1. EARTHWORK IN GRADING, EXCAVATION AND BACK FILLING

1.1. SCOPE

This specification covers the general requirements of earthwork in excavation in different materials, site grading, filling in areas as shown in drawing, filling back around foundations and in plinths, conveyance and disposal of surplus soils or stacking them properly as shown on the drawings and as directed by the PROJECT OFFICER/PMC and all operations covered within the intent and purpose of this specification.

1.2. APPLICABLE CODE

The following minimum codes and standards, unless otherwise specified herein, shall be applicable. In all cases, the latest revisions of the codes on the date of signing of contract agreement shall be referred to. The revisions in the relevant codes and standards after the date of award of contract shall be informed by the Contractor to the PROJECT OFFICER/PMC within 30 days of the issue of such revision of the code/ standard. PROJECT OFFICER/PMC may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

1	IS: 456	Code of practice for plain and reinforced concrete
2	IS: 783	Code of practice for laying of concrete pipes
3	IS: 1200	Method of measurement of Building and Civil Engineering works
	Part 1	Part 1 Earthwork
	Part 27	Part 27 Earthwork done by mechanical appliances
4	IS: 1498	Classification and Identification of Soils for General Engineering purposes
5	IS: 3764	Excavation work - code of safety
6	IS: 1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.
6	IS: 2720	Methods of test for soils
	Part 1	Preparation of dry soil samples for various tests
	Part 2	Determination of water content
	Part 4	Grain size analysis
	Part 5	Determination of liquid and plastic limit
	Part 7	Determination of water content - dry density relation using light compaction
	Part 9	Determination of dry density - moisture content relation by constant weight of soil method
	Part 14	Determination of density index (relative density) of cohesionless soils
	Part 28	Determination of dry density of soils in place, by the sand replacement method.
	Part 33	Determination of the density in place by the ring and water replacement method

	Part 34	Determination of density of soil in place by rubber balloon method
	Part 38	Compaction control test (HILF Method)
7	IS: 4081	Safety Code for Blasting and related Drilling Operations

1.3. DRAWINGS

The CONTRACTOR shall furnish good for construction drawings to the PROJECT OFFICER/PMC for review and approval as applicable. Such drawings shall indicate areas to be excavated/ filled, grade levels, areas demarcated for stacking of excavated material etc. The contractor shall follow strictly such drawings and instruction given by the PROJECT OFFICER/PMC.

Trench Excavation means excavation of trenches into which pipes are to be laid and the term pipes shall mean pipes of all kinds and for whatever purpose. The line and level of trenches shall be as shown on the Drawings or as may be required by the PROJECT OFFICER/PMC. Before commencing trench excavation, the route of the trench shall be pegged out accurately and the ground levels shall be agreed with the PROJECT OFFICER/PMC.

1.4. GENERAL

1.4.1 The CONTRACTOR shall visit site to understand the site condition and make his own assessment about sub-soil strata and water level likely to be encountered during the execution.

1.4.2 The CONTRACTOR shall obtain written approval from the PROJECT OFFICER/PMC on the execution method statement. Execution method statement prepared by contractor shall indicate the detailed sequential execution plan covering manpower & machinery, safety aspects, time duration etc. based on the project requirement. Contractor’s execution methodology will include detailed calculation related to:

- Slope stability and or shoring by using parameters related to proposed site, if it is in contractor’s scope otherwise the excavation drawing shall be followed.
- Dewatering.

However, the approval of construction methodology shall not in any way relieve the contractor of his responsibility for any consequent loss or damage. In case the project is expected to involve blasting, contractor will carry-out conditional survey of nearby properties to record it as a baseline prior to commencement of the excavation activities.

1.4.3 The Contractor shall at his own expense and without extra charges, take all precautions such as shoring for all depths or any other arrangement as approved by PROJECT OFFICER/PMC for ensuring that there shall be no sliding / collapsing of the excavated earth. The measurement for excavation shall be regulated as per the provisions of the CPWD / MORTH specification and nothing extra shall be payable because of shoring /other arrangements.

1.4.4 The Contractor shall also not be paid for any extra working space beyond concrete dimensions during excavation of foundations of various proposed structures in the Project. Any damage done to the work due to the contractor’s operation beyond the excavation lines shall be repaired at the expense of the contractor. Any and all excess excavation or over breaking performed by the contractor for any purpose or reason except as may be ordered in writing by PROJECT OFFICER/PMC and whether or not due to the fault of the contractor shall be at the expense of the contractor. Cost of refilling for all such excavation with materials as specified by the PROJECT OFFICER/PMC must be done by the contractor at his expense.

1.4.5 The contractor in accordance with the specification and project requirements shall mobilize all necessary tools, plants, qualified supervisory personnel, labour, instruments, materials (consumables and non-consumable) required for any temporary/permanent works etc., or any such items not specifically stated herein for completion of the job.

1.4.6 The CONTRACTOR shall carry out the detailed site survey prior to commencement of the site work and shall mark all footprints within + 10mm tolerance and record existing ground levels with respect to established reference/ grid lines at 10 m intervals or nearer or as determined by the PROJECT OFFICER/PMC based on ground profile. Initially ground levels, finish ground level, depth of excavation etc., at every intermediate and final stages shall be confirmed with PROJECT OFFICER/PMC and thereafter properly recorded.

1.4.7 The excavation shall be done to correct lines and levels within + 10mm tolerance. This shall also include, where required, proper shoring to protect the edges of excavation from soil collapse.

1.4.8 Temporary fences, guardrails, barricades, lights, and other protective measures around the excavation area required for the safety of personnel shall be provided and maintained in good condition.

1.4.9 The price quoted by CONTRACTOR shall also include for dumping of excavated materials in segregated manner within the areas demarcated, in regular heaps, bunds, riprap with regular slopes as directed by the PROJECT OFFICER/PMC and levelling the same to provide natural drainage. Rock/soil excavated shall be stacked properly as directed by the PROJECT OFFICER/PMC. As a rule, all softer material shall be laid along the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Expansive, organic soil or any unsuitable soil, if encountered shall be stacked separately and shall not be used in any case for site grading activities. The surplus excavated earth shall be disposed by the CONTRACTOR at a designated location by the local authorities or as directed by PROJECT OFFICER/PMC.

1.4.10 Known contaminated soils and water if any, shall be managed in accordance with approved soil management plan.

1.4.11 Soil erosion /sediment control shall be implemented in accordance with local authority regulations or approved erosion/sediment control measures.

1.4.12 Drainage of cuts, excavations, fills, stockpiles, spoil areas, surcharge embankments, and borrow areas shall always be maintained to prevent ponding of surface water because of ground water or rainfall by providing temporary ditches, swales, or pumping systems as required in each respective site area. Contractor shall submit management plan for the above-mentioned work along with work method statement.

1.4.13 The CONTRACTOR may, for facility of work or similar other reasons excavate, and backfill later, if so approved by the PROJECT OFFICER/PMC, at his own cost outside the lines shown on the drawings or directed by the PROJECT OFFICER/PMC. Should any excavation be taken below the specified elevations, the CONTRACTOR shall fill it up, with concrete of the same class as in the foundation resting thereon, up to the required elevation. No extra shall be claimed by the CONTRACTOR on this account.

1.4.14 The non-serviceable material and surplus soil shall be disposed off to the designated approved dumping yard or as directed by the PROJECT OFFICER/PMC. The contractor shall be responsible for all the statutory approvals from the statutory authority and all the concerned departments, as the case may be.

1.5 QUALITY CONTROL AND SUBMITTALS

1.5.1 A written Quality Control Program document that provides details of how compliance with the requirements of this specification and contract documents shall be achieved and submitted by contractor to purchaser for approval a minimum of 14 days before start of construction.

1.5.2 Certified laboratory test data for the materials and products to be used in the work shall be submitted to purchaser for approval a minimum of 14 days before shipping of materials and products.

1.5.3 Results of the quality control tests required during the performance of the work shall be submitted to PROJECT OFFICER/PMC within 2 days of completion.

1.5.4 An independent testing/inspection firm shall provide the following submittals to purchaser and contractor:

- A statement attesting that contractor's work is in accordance with the requirements of this specification and the contract documents.
- Informal daily "pass" or "fail" reports.
- Formal weekly reports including all test logs and comments. These formal reports shall include density and moisture content test logs, indicating location of tests by coordinates and elevation and all appropriate comments.
- Upon earthwork completion, all density and moisture content test logs and comments compiled and submitted for permanent project records.
- Sources and test results of all borrow materials used for fill.

1.6 QUALITY ASSURANCE

1.6.1 Unless otherwise specified in the contract documents, a qualified independent inspection and testing agency will be retained by purchaser to perform field and laboratory testing and/or evaluations in accordance with the criteria of ASTM D3740 to verify compliance of the work with the requirements of this specification and to ensure the achievement of the intents and purposes of the work.

1.6.2 The performance or lack of performance of the tests and inspections by purchaser's inspector shall not be construed as granting relief from the requirements of this specification or the other contract documents.

1.6.3 During construction, purchaser shall have access to all contractor's facilities and records for conducting performance inspection/audits.

1.6.4 During an audit by purchaser, all inspection and test reports, and/or engineering analyses and calculations associated with the scope of work shall be provided to purchaser upon request.

1.7 CLEARING

The areas to be excavated/ filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of trees are met during excavation, they shall also be removed. The material so removed shall be burnt or disposed as directed by local authorities or PROJECT OFFICER/PMC. Where earth fill is intended, the area shall be stripped of all loose/ soft patches, topsoil containing objectionable matter/ materials before fill commences.

1.8 PRECIOUS OBJECTS, RELICS, OBJECTS OF ANTIQUITY, ETC.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the EMPLOYER and the CONTRACTOR shall duly preserve the same to the satisfaction of the EMPLOYER and from time to time deliver the same to such person or persons as the EMPLOYER may from time to time authorise or appoint to receive the same.

1.9 CLASSIFICATION

All materials to be excavated shall be classified by the PROJECT OFFICER/PMC, into one of the following classes. The decision of the PROJECT OFFICER/PMC regarding the classification of the material shall be final and binding on the CONTRACTOR and not be a subject matter of any appeal or arbitration.

Earthwork will be classified under any of the following categories:

- **Ordinary and Hard Soils:**

These shall include all kinds of soils containing sand, silt, shingle, gravel, clay, loam, peat, ash, shale, etc., which can be easily excavated either manually or mechanically.

- **Soft and Decomposed Rock:**

This shall include completely to highly weathered/fractured rock, boulders, slag, chalk, slate, hard mica schist, laterite and all other materials, which in the opinion of PROJECT OFFICER/PMC is soft rock, difficult to excavate manually with a pick axe or required very light mechanical excavating machines but does not need blasting. The mere fact that the CONTRACTOR resorts to blasting without prior approval from local authorities or PROJECT OFFICER/PMC, shall not qualify for classification under 'Hard Rock'.

This shall also include excavation in macadam & tar roads and pavements, rock boulders not longer than 1 metre in any direction and not more than 500 mm in any one of the other two directions.

- **Hard Rock:**

This shall include all rock occurring in large continuous masses, which can only be excavated by blasting or by Pneumatic hydraulic breakers. Harder varieties of rock with or without veins and secondary minerals, which in the opinion of the PROJECT OFFICER/PMC require blasting, shall be considered as hard rock.

Where hard rock is met with and blasting operations are not permitted, the CONTRACTOR shall use other methods such as use of chemicals or Pneumatic hydraulic breakers or any other method approved by the PROJECT OFFICER/PMC for loosening the rock mass, developing cracks, etc. The loosened material shall be thereafter removed mechanically. Boulders of rock occurring in such sizes and not classified under (a) and (b) above shall also be classified as hard rock. Buried concrete work both reinforced and unreinforced to be dismantled will be measured under this item, unless a separate provision is made in the tender.

1.10 EXCAVATION

1.10.1 Contractor shall obtain written permission from intra departmental heads prior to commencement of work to ensure that there is no presence of underground utilities in the proposed excavation area.

1.10.2 The Contractor shall carry out further excavation as may be necessary to accommodate structures such as anchor blocks and valve chambers. Such excavation shall include for disposal of surplus material and where appropriate, for backfilling round the structures.

1.10.3 All the required work permits shall be obtained by CONTRACTOR from the EMPLOYER / PROJECT OFFICER/PMC / LOCAL AUTHORITIES / GOVERNMENT AGENCY, as applicable.

1.10.4 In case of existence of underground utilities, the same shall be diverted away from the excavation area in consultation with the PROJECT OFFICER/PMC. Payment of Diversion of utilities shall be made as per the item specified in the tender and if there is no provision in the tender then the same shall be executed based on the mutually agreed terms with the PROJECT OFFICER/PMC.

1.10.5 Excavation for permanent work shall be carried out as per the approved drawings. In area involving mass excavation, initially area shall be excavated up to a depth 150 mm above the final level. The balance depth shall be excavated with special care just prior (not more than 12 hours before) the laying of P.C.C. Soft pockets, if any, shall be removed even by excavating below the final level and extra excavation shall be filled up using Lean concrete or plum concrete or plain cement concrete as directed by the PROJECT OFFICER/PMC. It should be ensured that the foundation shall rest on single type of strata. The strata once excavated should not be exposed to environment to avoid degradation.

1.10.6 All excavation shall be done to the minimum dimensions as required for safety and working facility. The excavation must be carried out in the most expeditious and efficient manner. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the CONTRACTOR shall erect the necessary shoring, strutting and planking or cut slopes with or without steps, to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the PROJECT OFFICER/PMC. The scheme proposed by the CONTRACTOR shall take into consideration the presence of existing buildings/ structures/traffic movement in the vicinity, if any. All necessary precautions shall be taken to avoid slipping of loose soil / rock.

1.10.7 In case of deep excavation in rocky strata the fractured excavated rock sides shall be stabilised by using rock anchors.

1.10.8 The CONTRACTOR shall make all necessary pumping arrangements for dewatering the low-lying area or area where excavation is required to carry out below ground water table. CONTRACTOR shall keep area under execution to be workable. The low-lying areas may receive water from any source such as rains, accumulated rainwater, floods, leakages from sewer and water mains, water ingress from near-by canals / channels, subsoil water table being high or due to any other cause whatsoever.

1.10.9 In case of deep excavation in the area of high-water table special precautions shall be taken to main water table level at least 500 mm below the layer of binding concrete (Plain Cement Concrete (PCC) level to avoid uplift/damage of building basement raft/foundation due to water pressure. The water table shall not be allowed to rise above base of raft/foundation level until the structure attains adequate height required to counterbalance the uplift pressure.

1.10.10 The CONTRACTOR shall take all necessary precautions for the safety of traffic during construction and provide, erect and maintain such barricades including signs, markings, flags, lights and flagman, as necessary at either end of the excavation/ embankment and at such intermediate points as directed by the PROJECT OFFICER/PMC for the proper identification of construction area. He shall be responsible for all damages and accidents caused due to negligence on his part.

1.11 STRIPPING LOOSE ROCK

1.11.1 All loose boulders, semi-detached rocks (along with earthy stuff, which might move therewith) which is not directly in the excavation but so close to the area to be excavated, and in the opinion of the PROJECT OFFICER/PMC liable to fall or otherwise endanger the workmen, equipment, or the work, etc., shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion, which is originally sound and safe.

1.11.2 Any material not requiring removal as contemplated in the work, but which, in the opinion of the PROJECT OFFICER/PMC, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the PROJECT OFFICER/PMC.

1.12 EXCAVATION IN HARD ROCK

1.12.1 After removal of overburden, if any, excavation is likely to continue in rock to adequate depths and area of excavation footprint shown in the drawings and if the site condition permits to excavate rock by using blasting, then as far as possible, all blasting operations shall be completed prior to commencement of other construction activities.

1.12.2 All precautions shall be taken by the contractor during the blasting operations so that no damage is caused to adjoining buildings or structures because of blasting operations. In case of any damage to permanent or temporary structures, CONTRACTOR shall repair the same to the satisfaction of PROJECT OFFICER/PMC at his cost.

1.12.3 Specific permission of PROJECT OFFICER/PMC shall be taken by CONTRACTOR for blasting rock and he shall also obtain a valid Blasting License from the authorities concerned. If permission for blasting is refused by either by PROJECT OFFICER/PMC or by local authority, the rock shall be removed by wedging, pick, barring, heating and quenching, pneumatic hydraulic breakers etc., or other approved methods including chemicals required if any. All loose or loosened rock in the sides shall be removed by barring, wedging, etc. and if any unstable wedges of rock mass from sides of excavated surface shall be stabilised by providing temporary rock bolts. The price quoted by contractor for excavation in hard rock shall include the cost of all these operations. Safety net shall be used to arrest the movement of fractured rocks as a safety precaution for the workers working inside the pit.

1.12.4 In no case shall blasting be allowed closer than 30 metres from any structure or at locations where concrete has just been placed. In the latter case, the concrete must be at least 7 days old.

1.13 BEDDING

The depth and type of bedding shall be as shown on the drawings or as directed by the PROJECT OFFICER/PMC. Where rock or boulders are encountered, the trench shall be trimmed to a depth of at least 250 mm below the level at which the bottom of the barrel of the pipe is to be laid and filled to a like depth with sand as shown on the drawings or as directed by PROJECT OFFICER/PMC.

The class of bed and surround to be used are indicated below:

Class of bed and surround	Brief description of bedding material
Class A	Mass Concrete
Class S	Well Graded Sand
Class N	Granular material

Class S bed and surround shall be used on all pipes unless otherwise specified or shown on the drawings. The graded granular bed material for use in Class S bedding and surround shall consist of durable gravel, crushed stone or disintegrated rock. Selected material excavated from the pipe trench may be used, provided it contains no topsoil, clay or vegetable matter and is to the approval of the PROJECT OFFICER/PMC. Any imported bed and surround materials shall be to the approval of the PROJECT OFFICER/PMC and shall be supplied with certification which gives details of its content, source and grading. In all cases the soluble sulphate and chloride content of the granular material shall not exceed 0.5 % and 0.06 % by weight respectively.

a. Graded Material: The Contractor's method of grading the excavated material shall be to the approval of the PROJECT OFFICER/PMC. All Class S graded material shall pass through test sieves to IS 460 (Part 1) in the following proportions by mass:

Aperture Size	Percentage Passing
50 mm	100 %
37.5mm	90-100%
20.0mm	35-70%
14.0 mm	25-55%
10.0 mm	10-40%

b. Construction of Class S bed and Surrounds:

Class S pipe bed and surround shall be constructed as indicated on the Drawings.

The granular material shall be evenly spread over the full width of the formation and lightly compacted to a level slightly higher than level corresponding to the underside of the pipe barrel to allow for settlement of the pipe to the correct level. Following placement and jointing of the pipe further granular material shall be placed in the trench, special care being taken to fill under the sides of the pipes to ensure full contact with the barrel of the pipe. The backfill compacted material shall then be placed and compacted evenly on both sides of the pipe to a depth of 300 mm above crown of the pipe. Field joints which have not been tested shall be left exposed for a minimum length of 150 mm each side of the joint. Trench supports shall be withdrawn gradually in accordance with the progress of the fill with the provision that such withdrawal shall not prejudice the safety of the Works. The Contractor shall ensure that the material to the sides of the pipe is adequately compacted in layers having a maximum thickness of 150 mm and that the method of compaction used shall achieve not less than 95 % of the maximum dry density as determined from IS 2720: Part 7. After each section of the pipeline has passed the hydraulic test, the exposed joints shall be backfilled and compacted to the above Specification.

1.14 FILL MATERIAL FOR BACK FILLING AND SITE GRADING

1.14.1 GENERAL

All fill material will be subject to the PROJECT OFFICER/PMC’s approval. If any material is rejected by the PROJECT OFFICER/PMC, the CONTRACTOR shall remove the same forth with from the site at no extra cost to the EMPLOYER. Surplus fill material shall be deposited/ disposed as directed by the PROJECT OFFICER/PMC after the fill work is completed. No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by the PROJECT OFFICER/PMC.

1.14.2 EXCAVATED SOIL

To the extent available, selected surplus soils from excavated materials shall be used as backfill subject to the approval based on the below test results. Contractor shall categorise the surplus excavated material and stack separately. Fill material shall be free from clods, salts, sulphates, organic or other foreign material and non-expansive in nature. The CONTRACTOR shall arrange **at his cost** to carry out the minimum following tests on selected soil samples from excavated material in an accredited geotechnical laboratory

- a) Grain size analysis
- b) Moisture content
- c) In-situ density
- d) Specific gravity
- e) Liquid limit and plastic limit
- f) Standard/Modified proctor density (based on project requirement) or relative density (in case of sandy strata)
- g) Free swell Index and Swelling pressure.
- h) Tri- axial test / direct shear test under undrained and unconsolidated condition.

1.14.3 BORROWED MATERIAL:

If any selected fill material is required to be borrowed, it shall be CONTRACTOR'S responsibility to locate suitable borrow areas for borrowing fill material, the CONTRACTOR shall decide for bringing such material from outside borrow pits. The material and source shall be subject to prior approval of the PROJECT OFFICER/PMC. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish, etc. Top loose soil containing salts/ sulphates and other foreign material shall be removed and disposed to an approved designated location as instructed by the PROJECT OFFICER/PMC. The CONTRACTOR shall arrange to have trial pits of specified dimensions and numbers dug at locations specified, for the PROJECT OFFICER/PMC to examine the nature and type of material to be obtained from the borrow area. Any material rejected by the PROJECT OFFICER/PMC shall be removed from the site immediately. The CONTRACTOR shall make necessary access road to the borrow areas and maintain the same, if such access road does not exist, CONTRACTOR shall obtain all necessary permits from local authorities.

The properties of borrow material shall meet following requirements:

SL	Properties	Range of Values
1	Field Characteristics	
1.1	Bulk Density (γ_{bulk})	1.8 to 2.1 gm/cc
1.2	Dry density (γ_{dry})	1.3 to 1.6 gm/cc
1.3	Moisture content	34 to 36 %
1.4	Modified Proctor Density	More than 1.8 gm/cc
2	Physical Properties	
2.1	Specific gravity	2.65 to 2.85
3	Index properties	
3.1	Liquid limit (%)	40 to 65%
3.2	Plastic Limit (%)	20 to 25 %
3.3	Shrinkage limit (%)	15 to 35 %
3.4	Free swelling index	Less than 50%
4	Mechanical analysis	
4.1	Gravel (above 2.0 mm)	0 to 10%
4.2	Sand (2.0 to 0.06 mm)	30 to 40%
4.3	Silt (0.06 to 0.002 mm)	0 to 45 %
4.4	Clay (Below 0.002 mm)	15 to 25 %
5.0	Chemical properties	
5.1	Loss on ignition	3.5-4.5
5.2	Chloride (Cl)	Less than 500 mg/litre
5.3	Sulphate (SO ₃)	Less than 400 mg/litre
6	Engineering properties	
6.1	C (kg/cm ²)	0.2-0.3
6.2	ϕ	10 to 25 degree
6.3	Permeability K (cm/sec)	10 ⁻⁴ to 10 ⁻⁵

SL	Properties	Range of Values
6.4	CBR (%)	3 -6

Filling with excavated earth shall be done in regular horizontal layers each not exceeding 150 mm in depth, well rammed, watered and consolidated. All lumps and clods exceeding 125 mm in any direction shall be broken. The CONTRACTOR shall make good all subsidence and shrinkage in earth fillings, embankments, traverses, etc. during execution and till the completion of work unless otherwise specified.

1.15 FILLING IN PITS AND TRENCHES AROUND FOUNDATIONS OF STRUCTURES, WALLS, ETC

As soon as the work in foundations has been accepted (after attaining 28 days strength) and measured, the spaces around the foundations, structures, pits, trenches, etc. shall be cleared of all debris, and filled with earth in layers as specified above., each layer being watered, rammed and properly compacted, before the succeeding one is laid. Each layer shall be compacted to the satisfaction of the PROJECT OFFICER/PMC. The final backfill surface shall be trimmed and levelled to proper profile as directed by the PROJECT OFFICER/PMC or indicated on the drawings. Backfilling for the retaining wall shall be done after the construction of upper level slabs and curing and de-shuttering is done.

1.16 FILLING IN TRENCHES

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. Backfilling should be placed in layers not exceeding 15 cm thickness per layer, and should be compacted to a minimum of 95% maximum dry density. The refilling should be done on both sides of pipe together & height difference in earth fill on each side should not be more to cause lateral movement of pipe.

Each layer shall be consolidated by watering, ramming, care being taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

The Contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the PROJECT OFFICER/PMC.

Most coarse-grained soils are acceptable. This may comprise of gravel or sand proposed to be used in conjunction with gravel or clean sand.

It is very important that the pipe zone backfill material does not wash away or migrate in to the native soil. Likewise, potential migration of the native soil in to the pipe zone backfill must also be prevented.

Heavy earth moving equipment used for backfilling should not be brought until the minimum cover over the pipe is 90 cm in the case of wide tracked bulldozers or 120 cm in the case of wheeled roaders or roller compactors.

1.17 GENERAL SITE GRADING

Site grading shall be carried out as indicated in the drawings and as directed by the PROJECT OFFICER/PMC. Excavation shall be carried out as specified under relevant clauses.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the CONTRACTOR.

Field compaction test shall be carried out as per relevant standard at different stages of filling and also after the fill to the entire height has been completed.

The CONTRACTOR shall protect the earth-fill from being eroded or washed away by rain or damaged in any other way. Should any slip occur, the CONTRACTOR shall remove the affected material and make good the slip at his cost.

The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill shall be considered as incomplete if the desired compaction has not been achieved.

Access roads, whether of temporary or other nature, required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material, etc. to or over borrow areas and/ or to or over areas on which fill must be deposited shall be constructed by the CONTRACTOR. Such access roads shall be maintained in good condition during all seasons to ensure completion of work according to time schedule.

1.18 FILL DENSITY

The compaction, where so called for, shall comply with minimum 95% Modified Proctor density at moisture content differing not more than 4% from the optimum moisture content. The Contractor shall demonstrate adequately by field and laboratory tests that the specified density has been obtained.

1.19 LEAD

Lead for deposition/disposal of excavated material, shall be as specified in the respective item of work. No extra compensation is admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or 'katcha' land/route.

1.20 MEASUREMENT AND PAYMENT FOR ITEM RATE CONTRACT

1.20.1 All excavation shall be measured net. Dimensions for purpose of payment shall be reckoned on the horizontal area of the excavation at the base for foundations of the walls, columns, footings, tanks, rafts or other foundations/ structures to be built, multiplied by the mean depth from the surface of the ground in accordance with the foundation drawings. Excavation inside slopes will not be paid for. The CONTRACTOR may make such allowance in his rates to provide for excavation inside slopes keeping in mind the nature of the soil and safety of excavation. However, if the concreting is proposed against the excavated sides, no such over excavation will be permitted. In such cases, over excavation shall be made good by the CONTRACTOR with concrete of the same class as in the foundations at his cost.

1.20.2 Unless otherwise specified, the unit rates quoted for excavation in different types of material shall also account for a basic lead as mentioned in BOQ for disposal as specified or directed. Only leads beyond the basic lead will be considered as extra lead and paid for at the rates quoted in the schedules.

1.20.3 Backfilling, as per specification, the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches, etc. with excavated material will not be paid for separately. It shall be clearly understood that the rate quoted for excavation including backfilling shall include stacking of excavated material as directed, excavation/ packing of selected stacked material, conveying it to the place of final backfill, compaction, etc. as specified. As a rule, material to be backfilled shall be stacked temporarily within the basic lead unless otherwise directed by the PROJECT OFFICER/PMC. If the PROJECT OFFICER/PMC directs/ permits a lead for such material, the conveyance of the material for the extra distance over the basic lead for backfilling will be paid for.

1.20.4 Payment for fill inside trenches, plinth or similar filling with selected excavated material will be made for only compacted soil volume as specified/ directed. Cost of all other operations shall be deemed to have been covered in the rate quoted for filling. Payment for this work will be made based on measurement of plinth/ trench dimensions filled. The plinth ground levels shall be surveyed before for this purpose. If no compaction is specified/ desired, such filling will not be separately paid for. In such an event the fill shall be levelled/ finished to the profile as directed at no extra cost.

1.20.5 Backfilling, plinth filling, etc. with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as clearing, excavation, lead and transport, fill, compaction, etc. as specified. Actual quantity of consolidated filling shall be measured and paid for in cubic metres. The lead, lift, etc. shall be as indicated in the Schedule of Quantities.

1.20.6 Actual quantity of consolidated sand filling shall be measured and paid in cubic metres

1.20.7 Volume of rock excavated shall be calculated based on length, breadth and depth of excavation dimension as per the foundation drawings.

1.20.8 No payment will be made for excavations/ over-break beyond payment line specified. Where such measurement is not possible as in the case of strata intermixed with soil, excavated rock shall be properly stacked as directed by PROJECT OFFICER/PMC and the volume of rock calculated based on stack measurements after making appropriate allowance for voids. The allowance to be made for voids shall be decided by PROJECT OFFICER/PMC and this will not be a subject matter of dispute or appeal.

1.20.9 Measurement for Site Filling will be made based on this specification

2 DEWATERING

2.1 SCOPE

This specification covers the general requirements of dewatering excavations in general.

2.2 GENERAL

2.2.1 All excavations shall be kept free of water. Grading and surface water drainage scheme in the vicinity of excavation shall be properly closed to prevent surface water from draining into excavated areas. CONTRACTOR shall remove by pumping or other means approved by PROJECT OFFICER/PMC any water inclusive of rain water and subsoil water accumulated in excavation and keep all excavations dewatered until the foundation work is completed and backfilled. Sumps made for dewatering must be kept clear of the excavation/ trench areas required for further work of foundation construction. Method of pumping shall be approved by PROJECT OFFICER/PMC; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in or excavation wall collapse due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

2.2.2 The CONTRACTOR shall take adequate measures for bailing and/ or pumping out water from excavations and construct diversion channels, bunds, sumps, coffer dams, etc. as may be required. Pumping shall be done directly from the foundation trenches or from a sump outside the excavation in such a manner as to preclude the possibility of movement of water through any fresh concrete or masonry and washing away parts of concrete or mortar. During laying of concrete or masonry and for a period of at least 24 hours thereafter, pumping shall be done to ensure that the surface below the concrete remains dry.

2.2.3 Capacity and number of pumps, location at which the pumps are to be installed, pumping hours, etc. shall be reviewed by the CONTRACTOR from time to time. The PROJECT OFFICER/PMC may direct the CONTRACTOR to make changes in his scheme if the adopted scheme fails to achieve the desired results.

2.2.4 Pumping shall be done in such a way as not to cause damage to the work or adjoining property by subsidence, etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structures nearby or shall not be a cause for environmental pollution of natural water bodies.

2.2.5 When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of PROJECT OFFICER/PMC as large, well point system - Single stage or multi stage, shall be adopted. CONTRACTOR shall submit to PROJECT OFFICER/PMC his scheme of well point system including the stages, the spacing, number and diameter of well points, headers, etc. and the numbers, capacity and location of pumps of approvals. Normal dewatering using bailing arrangement, submersible pumps shall be included in the item rate for excavation. Special dewatering system using well point system shall be considered as separate item.

2.2.6 In case well point dewatering is required, the Indian Standard IS 9759: 1981 (Reaffirmed 2016) - Guidelines for De-Watering During Construction shall be used for design of the dewatering system.

3 EMBANKMENT CONSTRUCTION

3.1 SCOPE

These Specifications shall apply to the construction of embankments including sub grades, earthen shoulders and miscellaneous backfills with approved materials obtained from roadway and drain excavation, borrow pits or other sources. All embankments, subgrade, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections shown on the Drawings or as directed by the PROJECT OFFICER/PMC.

3.2 PHYSICAL REQUIREMENTS OF MATERIALS

The materials used in embankments, sub grades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, a mixture of those or any other material approved by the PROJECT OFFICER/PMC. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment/subgrade.

Following types of materials shall be considered unsuitable for embankment:

Materials from swamps, marshes and bogs;

Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS: 1498.

Materials susceptible to spontaneous combustion;

Materials in a frozen conditions;

Clay having liquid limit exceeding 70 and plasticity index exceeding 45; and

Materials with salts resulting in leaching in the embankment.

Expansive clay exhibiting marked swell and shrinkage properties (“free swelling index” exceeding 50 percent when tested as per IS: 2720 Part 40) shall not be used as a fill material. Where expansive clay with acceptable “free swelling index” value is used as a fill material, subgrade and top 500 mm portion of the embankment just below subgrade shall be non-expansive in nature.

The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when being placed in the embankment and 50 mm when placed in the subgrade. The maximum particle size shall not be more than two-thirds of the compacted layer thickness. Ordinarily, only the materials satisfying the density requirements given in Table 3-1 shall be employed for the construction of the embankment and the subgrade.

Table 3-1 : Density Requirements of Embankment and Subgrade Materials

SI No:	Type of Work	Maximum laboratory dry unit weight when tested as per IS: 2270 (Part 8)
1.	Embankments up to 3 metres height, not subjected to extensive flooding.	Not less than 15.2 kN/cum.
2.	Embankments exceeding 3 metres height or embankments of any height subject to long periods of inundation	Not less than 16.0 kN/cum.
3.	Sub grades and earthen shoulders/verges / backfill	Not less than 17.5 kN/cum.

Notes:

This Table is not applicable for lightweight fill material e.g. cinder, fly ash etc.

The PROJECT OFFICER/PMC may relax these requirements at his discretion taking into account the availability of materials for construction and other relevant factors.

The material to be used in subgrade should also satisfy design CBR at the dry unit weight applicable as per Table 3-2.

3.2.1 General requirements of materials

The materials for embankment shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation or any other excavation under the same Contract. The work shall be so planned and executed that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

3.2.2 Borrow Materials

Where the materials are to be obtained from designated borrow areas, the location, size and shape of these areas shall be as indicated by the PROJECT OFFICER/PMC and the same shall not be opened without his written permission. Borrow pits along the road shall be discouraged. If permitted by the PROJECT OFFICER/PMC, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5 m. Also, no pit shall be dug within the offset width from the toe of the embankment required as per the consideration of stability with a minimum width of 10 m.

Haulage of material to embankments or other areas of fill shall proceed only when sufficient spreading and compaction plants is operating at the place of deposition.

No excavated acceptable material other than surplus to requirements of the Contract shall be removed from the site. Should the Contractor be permitted to remove acceptable material from the site to suit his operational procedure, then he shall make good any consequent deficit of material arising there from.

Where the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall, unless otherwise agreed by the PROJECT OFFICER/PMC, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the PROJECT OFFICER/PMC. It shall be ensured that the subgrade material when compacted to the density requirements as in Table 3-2 shall yield the design CBR value of the subgrade.

Table 3-2 : Compaction Requirements for Embankment and Subgrade

Sr	Type of work/ material	Relative compaction as percentage of max. laboratory dry density as per IS: 2720 (Part 8)
1	Subgrade and earthen shoulders	Not less than 97
2	Embankment	Not less than 95
3	Expansive Clays a. Subgrade and 500 mm portion just below the subgrade b. Remaining portion of embankment	Not allowed Not less than 90

The Contractor shall at least 7 working days before commencement of compaction submit the following to the PROJECT OFFICER/PMC for approval:

The values of maximum dry density and optimum moisture content obtained in accordance with IS: 2720 (Part 7) or (Part 8), as the case may be, appropriate for each of the fill materials he intends to use.

A graph of density plotted against moisture content from which each of the values in (1) above of maximum dry density and optimum moisture content were determined.

The Dry density-moisture content-CBR relationships for light, intermediate and heavy compactive efforts (light corresponding to IS: 2720 (Part 7), heavy corresponding to IS: 2720 (Part 8) and intermediate in-between the two) for each of the fill materials he intends to use in the subgrade.

Once the above information has been approved by the PROJECT OFFICER/PMC, it shall from the basis for compaction.

3.2.3 Construction Operations for Embankments

3.2.3.1 Setting out

After the site has been cleared, the work shall be set out. The limits of embankment/subgrade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment / subgrade shall be built sufficiently wider than the design dimension so that surplus materials may be trimmed, ensuring that the remaining material is compacted to the desired density and in position specified and conforms to the specified side slopes.

3.2.3.2 Dewatering

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the PROJECT OFFICER/PMC it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the PROJECT OFFICER/PMC and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair / restore it to original condition or compensate the damage at his own cost. If the embankment is to be constructed under Water, Clause 6.19.5 shall apply.

3.2.3.3 Stripping and Storing topsoil

In localities where most of the available embankment materials are not conducive to plant growth, or when so directed by the PROJECT OFFICER/PMC, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be unnecessarily trafficked either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

3.2.3.4 Compacting ground supporting Embankment / Subgrade

When necessary, the original ground shall be leveled to facilitate placement of first layer of embankment, scarified, mixed with water and then compacted by rolling so as to achieve minimum dry density as given in Table 3-2.

In case where the difference between the subgrade level (top of the subgrade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density as given in Table 3-2, the ground shall be loosened up to a level 0.5 m below

the subgrade level, watered and compacted in layers to not less than 97 percent of dry density as given in Table-3-2.

Where so directed by the PROJECT OFFICER/PMC, any unsuitable material occurring in the embankment foundation shall be removed and replaced by approved materials laid in layers to the required degree of compaction.

Embankment or subgrade work shall not proceed until the foundations of embankments/subgrade have been inspected by the PROJECT OFFICER/PMC for satisfactory condition and approved.

Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the PROJECT OFFICER/PMC. Where the ground on which an embankment is to be built has any of the material types specified in Clause 6.20.2, at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

3.2.3.5 Spreading material in layers and bringing to appropriate moisture content

The embankment and subgrade material shall be spread in layers of uniform thickness not exceeding 200 mm compacted thickness over the entire width of embankment by mechanical means, finished by a motor grader and compacted. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in Table-II and got approved by the PROJECT OFFICER/PMC. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such construction, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surfaces but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, discing or harrowing until a uniform moisture content is obtained throughout the depth of the layer.

If the material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

Moisture content of each layer of soil shall be checked in accordance with IS: 2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1% above to 2% below the optimum moisture content determined in accordance with IS: 2720 (Part 7) or IS: 2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

After adding the required amount of water, the soil shall be processed by means of graders, harrows, rotary mixers or as otherwise approved by the PROJECT OFFICER/PMC until the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have a maximum size of 75 mm when being placed in the embankment and a maximum size of 50 mm when being placed in the subgrade.

Embankment and other areas of fill shall, unless otherwise required in the Contract or permitted by the PROJECT OFFICER/PMC, be constructed evenly over their full width and their fullest possible extent and the Contractor shall control and direct construction plant and other vehicular traffic uniformly over

them. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength as the material had before it was damaged.

Embankments and other areas of unsupported fills shall not be constructed with steeper side slopes, or to greater widths than those shown in the Contract, except to permit adequate compaction at the edges before trimming back, or to obtain the final profile following any settlement of the fill and the underlying material.

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical on 4 horizontal, such faces shall be benched as per Clause 6.20.5 immediately before placing the subsequent fill.

All permanent faces of side slopes of embankments and other areas of fill formed shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the PROJECT OFFICER/PMC by tracking a tracked vehicle, considered suitable by the PROJECT OFFICER/PMC, on the slope or any other method approved by the PROJECT OFFICER/PMC.

3.2.3.6 Compaction

Only the compaction equipment approved by the PROJECT OFFICER/PMC shall be employed to compact the different material types encountered during construction. Smooth wheeled, vibratory, pneumatic tyred, sheepfoot or pad foot rollers, etc., of suitable size and capacity as approved by the PROJECT OFFICER/PMC shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of vibratory roller of 80 to 100 kN static weight with plain or pad foot drum or heavy pneumatic tyred roller of adequate capacity capable of achieving required compaction.

The Contractor shall demonstrate the efficiency of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the PROJECT OFFICER/PMC for approval.

Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

Each layer of the material shall be thoroughly compacted to the densities specified in Table 5-4. Subsequent layers shall be placed only after the finished layer has been tested according to Clause 903.2.2 of Most Specifications for Roads and Bridge Works (IV Revision) and accepted by the PROJECT OFFICER/PMC. The PROJECT OFFICER/PMC may permit measurement of field dry density by a nuclear moisture / density gauge used in accordance with agreed procedure and the gauge is calibrated to provide results identified to that obtained from tests in accordance with IS: 2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurement reveal any soft areas in the embankment / subgrade / earthen shoulders, further compaction shall be carried out as directed by the PROJECT OFFICER/PMC. If inspite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted to the density requirements and satisfaction of the PROJECT OFFICER/PMC.

3.2.3.7 Drainage

The surface of the embankment / subgrade at all times during construction shall be maintained at such a cross fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

3.2.3.8 Repairing of damages caused by rain / spillage of water

The soil in the affected portion shall be removed in such areas as directed by the PROJECT OFFICER/PMC before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with Clause 6.20.5. If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the PROJECT OFFICER/PMC to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery / equipment for the purpose.

3.2.3.9 Finishing operations

Finishing operations shall include the work of shaping and dressing the shoulders / verge / roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the Drawings or as directed by the PROJECT OFFICER/PMC subject to the surface tolerance described in Clause 902 of Most Specifications for Roads and Bridge Works (IV Revision). Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

The topsoil, removed and conserved earlier shall be spread over the fill slopes as per directions of the PROJECT OFFICER/PMC to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

Where directed, the slopes shall be turfed with sods in accordance with Clause 6.22.

3.2.4 Earthwork for embankment and subgrade to be placed against sloping ground

Where an embankment / subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed / scarified as required, before placing the embankment / subgrade material. Extra earthwork involved in benching or due to ploughing / scarifying etc. shall be considered incidental to the work.

For wet conditions, benches with slightly inward fall subsoil drains at the lowest point shall be provided as per the Drawings, before the fill is placed against sloping ground.

3.2.5 Embankment and subgrade around structures

To avoid interference with the construction of abutments, wing walls or return walls of culvert / bridge structures, the Contractor shall, at points to be determined by the PROJECT OFFICER/PMC suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of damage to the structure.

Unless directed otherwise, the filling around culverts, bridges and other structures up to a distance of twice the height of the road from the back of the abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the PROJECT OFFICER/PMC but in any case, not until the concrete or masonry has been in position for 14 days. The embankment and subgrade shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the PROJECT OFFICER/PMC.

The material used for backfilling shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to IS: 2720 (Part 5). Filling behind abutments and wing walls for all structures shall conform to the general guidelines given in Appendix 6 of IRC:78 (Standard Specifications and Code of Practice for Road Bridges-Section VII) in respect of the type of material, the extent of backfill, its laying and compaction etc. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of Table 3-2.

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in Clause 2502 of MoST Specifications for Roads and Bridge Works (IV Revision) unless otherwise specified in the Contract.

Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory roller, plate compactor or power rammer. Care shall be taken to see that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

3.2.6 Embankment construction under water

Where filling or backfilling is to be placed under water, only acceptable granular material or rock shall be used unless otherwise approved by the PROJECT OFFICER/PMC. Acceptable granular material shall consist of graded, hard durable particles with maximum particle size not exceeding 75 mm. The material should be non-plastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

3.2.7 Earthwork for high embankment

In the case of high embankments, the Contractor shall normally use the material from the specified borrow area. In case he desires to use different material for his own convenience, he shall have to carry out necessary soil investigations and redesign the high embankment at his own cost. The Contractor shall then furnish the soil test data and design of high embankment for approval of the PROJECT OFFICER/PMC, who reserve the right to accept or reject it.

If necessary, stage construction of fills and any controlled rates of filling shall be carried out in accordance with the Contract including installation of instruments and its monitoring.

Where required, the Contractor shall surcharge embankments or other areas of till with approved material for the periods specified in the Contract. If settlement of surcharged fill results in any surcharging material, which is unacceptable for use in the fill being surcharged, lying below formation level, the Contractor shall remove the unacceptable material and dispose it as per direction of the PROJECT OFFICER/PMC. He shall then bring the resultant level up to formation level with acceptable material.

3.2.8 Settlement period

Where settlement period is specified in the Contract, the embankment shall remain in place for the required settlement period before excavating for abutment, wingwall, retaining wall, footings, etc., or driving foundation piles. The duration of the required settlement period at each location shall be as provided for in the Contract or as directed by the PROJECT OFFICER/PMC.

3.2.9 Plying of Traffic

Construction and other vehicular traffic shall not use the prepared surface of the embankment and / or subgrade without the prior permission of the PROJECT OFFICER/PMC. Any damage arising out of

such use shall, however, be made good by the Contractor at his own expense as directed by the PROJECT OFFICER/PMC.

3.2.10 Surface Finish and Quality Control of Work

The surface finish of construction of subgrade shall conform to the requirements of Clause 902 of most Specifications for Roads and Bridge Works (IV Revision). Control on the quality of materials and works shall be exercised in accordance with Clause 903 of most Specifications for Roads and Bridge Works (IV Revision).

3.2.11 Subgrade Strength

It shall be ensured prior to actual execution that the borrow area material to be used in the subgrade satisfies the requirements of design CBR.

Subgrade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed subgrade shall be determined on undisturbed samples cut out from the compacted subgrade in CBR mould fitted with cutting shoe or on remoulded samples, compacted to the field density at the field moisture content.

3.2.12 Measurements for Payment

Earth embankment/subgrade construction shall be measured separately by taking cross sections at intervals in the original position before the work starts and after its completion and computing the volumes of earthwork in cubic metres by the method of average end areas.

The measurement of fill material from borrow areas shall be the difference between the net quantities of compacted fill and the net quantities of suitable material brought from roadway and drainage excavation. For this purpose, it shall be assumed that one cum. of suitable material brought to site from road and drainage excavation forms one cum. of compared fill and all bulking or shrinkage shall be ignored.

Construction of high embankment with specified material and in specified manner shall be measured in cum.

Stripping including storing and reapplication of topsoil shall be measured in cum.

Work involving loosening and recompacting of ground supporting embankment / subgrade shall be measured in cum.

Removal of unsuitable material at embankment / subgrade foundation and replacement with suitable material shall be measured in cum.

Filter medium and backfill material behind abutments, wing walls and other retaining structures shall be measured as finished work in position in cum.

3.3 Pitching / Flood protection work on slopes

3.3.1 Scope

This work shall consist of covering the slopes of guide bunds, training works and embankments with stone, boulders or stones in wire crates over a layer or granular material called filter. While river side slopes are given this protection against river action, the rear slopes, not subjected to direct attack of the river, may be protected against ordinary wave splashing by 0.3-0.6 metre thick cover of clayey or silty earth and turfed.

3.3.2 Material for Pitching

The pitching shall be provided as indicated in the Drawings. The thickness and the shape of stone pitching shall be shown on the Drawing. The stone shall be sound, hard, durable and fairly regular in shape. Quarry stone should be used. Round boulders shall not be allowed. The stones subject to marked deterioration by water or weather shall not be accepted. The size and weight of stone shall conform to Clause 6.3.5.1 of IRC: 89. No stone, weighing less than 40 kg shall, however, be used. The sizes of spalls shall be a minimum of 25 mm and shall be suitable to fill the voids in the pitching.

Where the required size stones are not economically available cement concrete blocks in M15 grade conforming to Section 8 or stones in wire crates may be used in place of isolated stones of equivalent weight. Cement concrete blocks will be preferred wherever practicable.

3.3.3 Material for Filter Media

The material for the filter shall consist of sand, gravel, stone or coarse sand. To prevent escape of the embankment material through the voids the stone pitching / cement concrete blocks as well as to allow free movement of water without creating any uplift head on the pitching, one or more layers of graded materials, commonly known as a filter medium, shall be provided underneath the pitching.

Provision of a suitably designed filter is necessary under the slope pitching to prevent the escape of underlying embankment material through the voids of stone pitching/cement concrete blocks when subjected to the attack of flowing water and wave action, etc.

In order to achieve this requirement, the filter may be provided in one or more layers satisfying the following criteria:

- Ratio of D 15 (Filter) to D 85 (Base) shall be less than 5;
- Ratio of D 15 (Filter) to D 15 (Base) shall be within the limits of 4 and 20; and
- Ratio of D 50 (Filter) to D 50 (Base) shall be less than 25;

Notes:

- Filter design may not be required if embankment consists of CH or Ch soils with liquid limit greater than 30, resistant to surface erosion. In this case, if a layer of material is used as bedding for pitching, it shall be well graded, and its D 85 size shall be at least twice the maximum void size in pitching.
- In the foregoing, D 15 means the size of that sieve which allows 15 per cent by weight of the filter material to pass through it and similar is the meaning of D 50 and D 85.
- If more than one filter layer is required, the same requirement as above shall be followed for each layer. The finer filter shall be considered as a base material for selection of coarser filter.
- The filter shall be compacted to a firm condition. The thickness of filter is generally of the order of 200 mm to 300 mm. Where filter is provided in two layers, thickness of each layer shall be 150 mm.

3.3.4 Construction Operations

Before laying the pitching, the sides of banks shall be trimmed to the required slope and profiles put up by means of line and pegs at intervals of 3 metres to ensure regular straight work and a uniform slope throughout. Depressions shall be filled and thoroughly compacted.

The filter granular material shall be laid over the prepared base and suitably compacted to the thickness specified on the Drawings.

The lowest course of pitching shall be started from the toe wall and built up in courses upwards. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Clause 6.22.5 in case of dry rubble pitching and shall be in nominal mix cement concrete (M 15) conforming to Section 8 in case of cement concrete block pitching.

The stone pitching shall commence in a trench below the tow of the slope. Stone shall be placed by derrick or by hand to the required length, thickness and depth conforming to the Drawings. Stones shall be set normal to the slope and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching. The largest stones shall be placed in the bottom courses and for use as headers for subsequent courses.

In hand placed pitching, the stone of flat stratified nature should be placed with the principal bedding plane normal to the slope. The pattern of laying shall be such that the joints are broken, and voids are minimum by packing with spalls, wherever necessary, and the top surface is as smooth as possible.

When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices between adjacent stones shall be filled in with spalls of the proper size and wedged in with hammers to ensure tight packing.

When two or more layers of stones must be laid to obtain the design thickness of pitching, dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template cross walls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at suitable intervals and all along the length and width of the pitching. Within these walls the stones shall be hand packed as specified.

3.3.5 Toe Protection

In conformity with Clause 5.3.7 of IRC: 89, a toe wall shall be provided at the junction of slope pitching and launching apron of a guide bund so as to protect the slope pitching from falling even when the apron is not laid at low water level. The toe wall shall be in dry rubble masonry (uncoursed) conforming to Clause 11.5.3 in case of dry rubble pitching or pitching/revetment with stones in wire crates and in nominal mix cement concrete (M 15) conforming to Section 8 in case cement concrete blocks have been used in pitching. For protection of toes of bank slopes terminating either in short aprons at bed levels or anchored in flooring / rocky bed, the provisions of Clause 8.2.2 of IRC: 89 may be complied with. The relevant Specifications of the protective works for individual components will be followed.

3.3.6 Measurement

The filter and stone pitching shall be measured separately in cubic metres unless otherwise specified.

4 REINFORCED CONCRETE AND ALLIED WORKS

4.1 SCOPE

This Specification covers the general requirements for ready mixed concrete and for concrete using on-site production facilities including requirements with regard to the quality, handling, storage of ingredients, proportioning, batching, mixing, transporting, placing, curing, protecting, repairing, finishing and testing of concrete; formwork; requirements with regard to the quality, storage, bending and fixing of reinforcement; grouting as well as mode of measurement and payment for completed works.

It shall be very clearly understood that the specifications given herein are brief and do not cover minute details. However, all works shall have to be carried out in accordance with the relevant standards and codes of practices or in their absence in accordance with the best accepted current Engineering practices or as directed by PROJECT OFFICER/PMC from time to time. The decision of PROJECT OFFICER/PMC about the specification to be adopted and their interpretation and the mode of execution of work shall be final and binding on CONTRACTOR and no claim whatsoever will be entertained on this account.

4.2 APPLICABLE CODES AND SPECIFICATIONS

The following specifications, standards and codes, including all official amendments/ revisions and other specifications and codes referred to therein, should be considered a part of this specification. In all cases the latest issue/ edition/ revision shall apply. In case of discrepancy between this specification and those referred to herein below or other specifications forming a part of this bid document, this specification shall govern.

4.2.1 MATERIALS:

IS 455	Specification for Portland Slag Cement.
IS 1489: PART 1	Portland pozzolana cement - specification part 1 fly ash based
IS 1489: PART 2	Portland pozzolana cement - specification part 2 calcined clay based (fourth revision)
IS 12330	Specification for Sulphate Resisting Portland Cement
IS 383	Coarse and fine aggregate for concrete - specification (third revision)
IS 432	Specification for Mild Steel and Medium Tensile Steel Bars and Hand Drawn Steel Wire for Concrete Reinforcement – Part 1 and 2
IS 1786	High strength deformed steel bars and wires for concrete reinforcement - specification
IS 1566	Specification for hard-drawn steel wire fabric for concrete reinforcement
IS 9103	Concrete admixtures - specification
IS 2645	Integral waterproofing compounds for cement mortar and concrete - specification
IS 4990	Plywood for concrete shuttering work - specification
IS 4926	Ready-mixed concrete - code of practice
IS 8041	Specification for rapid hardening cement.
IS 12600	Specification for Low Heat Portland Cement
IS 6909	Specification for super-sulphated cement

IS 12089	Specification for granulated slag for manufacture of portland slag cement
----------	---

4.2.2 MATERIAL TESTING

IS 4031 (Part 1 to 15	Methods of physical tests for hydraulic cement
IS 4032	Method of chemical analysis of hydraulic cement.
IS 650	Specification for standard sand for testing of cement.
IS 2430	Methods for sampling of aggregates for concrete.
DIN EN 12620	Aggregates for concrete (Refer Note).
IS 2386	Methods of test for aggregates for concrete (Parts 1 to 8)
IS 3025 (Part 1 to 51	Methods of sampling and test (physical and chemical) for water and wastewater
ISS 6925	Methods of test for determination of water-soluble chlorides in concrete admixtures

NOTE: These tests are optional and shall be carried out by the contractor at his cost, if directed by PROJECT OFFICER/PMC.

4.2.3 MATERIAL STORAGE

IS 4082	Recommendations on stacking and storage of construction materials and components at site.
---------	---

4.2.4 CONCRETE MIX DESIGN

IS 10262	Concrete mix proportioning-guidelines
----------	---------------------------------------

4.2.5 CONCRETE TESTING

IS 1199	Method of sampling and analysis of concrete.
IS 516	Method of test for strength of concrete.
IS 9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS 8142	Method of test for determining setting time of concrete by penetration resistance.
IS 9284	Method of test for abrasion resistance of concrete.
IS 2770 (Part 1)	Methods of testing bond in reinforced concrete: Part 1 Pull-out test

4.2.6 EQUIPMENT

IS 4925	Specification for concrete batching and mixing plant.
IS 7251	Specification for concrete finishers.
IS 2750	Specifications for steel scaffoldings.

4.2.7 CODES OF PRACTICE

IS: 456	Plain and reinforced concrete - code of practice.
IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS 3370 (Part 1)	Concrete structures for storage of liquids - code of practice - part 1 : general requirements
IS 3370 (Part 2)	Concrete structures for storage of liquids - code of practice - part 2 : reinforced concrete structures
IS 3370 (Part 3)	Code of practice for concrete structures for the storage of liquids: part 3 prestressed concrete structures
IS 3370 (Part 4)	Code of practice for concrete structures for the storage of liquids: part 4 design tables
IS 3935	Code of practice for composite construction.
IS 2204	Code of practice for construction of reinforced concrete shell roof.
IS 2210	Criteria for the design of reinforced concrete shell structures and folded plates.
IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS 5525	Recommendation for detailing of reinforcement in reinforced concrete works.
IS 2751	Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
IS 9417	Welding of high strength steel bars for reinforced concrete construction- recommendations
IS 3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS 3414	Code of practice for design and installation of joints in buildings.
IS 4326	Earthquake resistant design and construction of buildings - code of practice
IS 4014 (Part 1)	Code of practice for steel tubular scaffolding Part 1 Definitions and materials
IS 4014 (Part 2)	Code of practice for steel tubular scaffolding: Part 2 Safety regulations for scaffolding (first revision)
IS 2571	Code of practice for laying in situ cement concrete flooring
IS 7861 (Part 1)	Code of practice for extreme weather concreting: Part 1 Recommended practice for hot weather concreting
IS 7861 (Part 2)	Code of practice for extreme weather concreting: Part 2 Recommended practice for cold weather concreting
IS 3812 (Part 1)	Pulverized fuel ash – Part 1 – For use as pozzolana in cement, cement mortar and concrete

IS 15388: 2003	Specification for Silica Fume
----------------	-------------------------------

4.2.8 CONSTRUCTION SAFETY

IS 3696 (Part 1)	Safety code of scaffolds and ladders: Part 1 Scaffolds (first revision)
IS 3696 (Part 2)	Safety code of scaffolds and ladders: Part 2 Ladders (first revision)
IS 7969	Safety code for handling and storage of building materials.
IS 8989	Safety code for erection of concrete framed structures.

4.2.9 MEASUREMENT

IS 1200 (Part 2)	Method of measurement of building and Engineering works (Part 2 and 5) Methods of measurement of building and civil engineering works: Part 2 Concrete works (third revision)
IS 1200 (Part 5)	Methods of measurement of building and civil engineering works: part 5 Form work (fourth revision)

4.3 **GENERAL**

PROJECT OFFICER/PMC shall always have the right to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged, and PROJECT OFFICER/PMC's approval obtained, prior to starting of concrete work. This shall, however, not relieve CONTRACTOR of any of his responsibilities. All materials, which do not conform to this specification, shall be rejected.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/ standards shall only be used. Other materials may be used after approval of the PROJECT OFFICER/PMC and after establishing their performance suitability based on previous data, experience or tests.

4.4 **MATERIALS**

4.4.1 CEMENT

4.4.1.1 The Portland Pozzolana Cement shall conform to IS: 1489 & Portland Slag Cement conforming to IS: 455 shall be used as directed by PROJECT OFFICER/PMC.

4.4.1.2 Sulphate Resisting Portland Cement conforming to IS: 12330 may be used for mass concrete construction and generally complying with IS: 12330, but with Tricalcium Aluminate (C3A) content not more than 5% by mass (as manufactured by an approved manufacturer) may be used for reinforced concrete construction.

4.4.1.3 Fly Ash Blended Cements conforming to IS: 1489 (Part I) or GGBS blended cements conforming to IS 16715 may be used in RCC structures as per the guidelines given below:

- IS: 456 - Code of Practice for Plain and Reinforced Concrete shall be followed about Concrete Mix Proportion and its production.
- The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause 9 of IS: 456.

- Concrete shall be manufactured in accordance with Clause 10 of IS 456 covering Quality Assurance measures.
 - Minimum M25 grade of concrete shall be used in all structural elements made with RCC both in load bearing and framed structure.
 - The mechanical properties such as modulus of elasticity, tensile strength, creep and shrinkage of fly ash mixed concrete or concrete using fly ash blended cements (PPCs) are not likely to be significantly different and their values are to be taken same as those used for concrete made with OPC.
 - If necessitated due to low water/ binder ratio, required workability shall be achieved by use of chloride free chemical admixtures conforming to IS: 9103. The compatibility of chemical admixtures and super plasticisers with each set OPC, fly ash and/ or PPC received from different sources shall be ensured by trials.
- In cases, where structural concrete is exposed to excessive magnesium sulphate, fly ash substitution/ content shall be limited to 18% by weight. Special type of cement with low C3A content may also be alternatively used. Durability criteria like minimum binder content and maximum water/ binder ratio also need to be given due consideration in such environment.
- Wet curing period shall be enhanced to a minimum of 10 days or its equivalent. In hot and arid regions, the minimum curing period shall be 14 days or its equivalent.

4.4.1.4 Use of Fly Ash Admixed Cement Concrete (FACC) in RCC Structures

There shall be no bar on use of FACC in RCC structures subject to following additional conditions.

- Fly ash shall have its chemical characteristics and physical requirements, etc. conforming to IS: 3812 (Parts I) and shall be duly certified.
- To ensure uniform blending of fly ash with cement in conformity with IS: 456, a specific facility needs to be created at site with complete computerised automated process control to achieve design quality or with similar facility from Ready Mix Concrete (RMC) plants.
- As per IS: 1489 (Part-I) maximum 35% of mass of total cementitious material is permitted to be substituted with fly ash conforming to IS: 3812 (Part-I).
- Separate storage for dry fly ash shall be provided. Storage bins or silos shall be weather proof and permit a free flow and efficient discharge of fly ash. The filter or dust control system provided in the bins or silos shall be of sufficient size to allow delivery of fly ash maintained at specified pressure to prevent undue emission of fly ash dust, which may interfere with weighing accuracy.

4.4.1.5 Use of Silica Fume Admixed Cement Concrete in RCC Structures

Silica fume conforming to IS 15388 may be used to the extent of 5 – 10% of the cement content as stipulated in IS 456 as a part replacement of cement.

4.4.1.6 Use of Fly Ash Blended Cements in Cement Concrete (PPCC) in RCC Structures

- Subject to General Guidelines detailed out as above, PPC manufactured conforming to IS: 1489 (Part-I) shall be treated at par with OPC for manufacture of Design Mix concrete for structural use in RCC.
- Till the time, Bureau of Indian Standards (BIS) makes it mandatory to print the percentage of fly ash on each bag of cement, the certificate from the PPC manufacture indicating the same shall be insisted upon before allowing use of such cements in works.
- While using PPC for structural concrete work, no further admixing of fly ash shall be permitted.

Only one type of cement shall be used in any one mix unless specifically approved by PROJECT OFFICER/PMC. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without prior approval from PROJECT OFFICER/PMC.

Cement, which is not used within 90 days from its date of manufacture, shall be tested at a laboratory approved by PROJECT OFFICER/PMC and until the results of such tests are found satisfactory, it shall not be used in any work.

4.4.2 AGGREGATES

Aggregates shall consist of naturally occurring stones and gravel (crushed or uncrushed) and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from dust/ silt/ organic impurities/ deleterious materials and conform to IS: 383. Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used.

Aggregates shall be washed and screened before use where necessary or if directed by the PROJECT OFFICER/PMC.

Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2. If use of sand having fineness modulus more than 3.2 is unavoidable then it shall be suitable blended with crusher stone dust.

Plums 160 mm and above of a reasonable size may be used where directed. Plums shall not constitute more than 20% by volume of concrete unless specified by PROJECT OFFICER/PMC.

4.4.3 WATER

Water used for both mixing and curing shall conform to IS: 456. Potable water is generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used. The pH value of water shall not be less than 6. Seawater shall not be used for concrete mixing and curing.

4.4.4 REINFORCEMENT

Reinforcement bars shall conform to IS: 432 and/ or IS: 1786 and welded wire fabric to IS: 1566 as shown on the drawing.

All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales, rust, dirt, dust or any other substance that will destroy or reduce bond.

Special precaution like coating of reinforcement may be provided with the prior approval of PROJECT OFFICER/PMC.

Reinforcement bars produced by re-rolling may be used subject to the approval of the PROJECT OFFICER/PMC. CONTRACTOR shall furnish the manufacturer's certificate stating the process of manufacture to the satisfaction of the PROJECT OFFICER/PMC and the test sheet signed by the manufacturer giving the result of each mechanical test applicable for each lot of the material supplied including result of chemical composition. At-least one Sample from each lot received at site shall be tested in the laboratory approved by the PROJECT OFFICER/PMC and the cost of testing shall be borne by the CONTRACTOR. It shall be ensured that all the test results conform to IS: 432 or IS: 1786 as applicable.

4.4.5 ADMIXTURES AND ADDITIVES

4.4.5.1 Approval of Admixtures

Admixture from approved manufacturer shall be used in concrete mix along with aggregates, cement and water without the written instruction or approval of the PROJECT OFFICER/PMC in each case. If more than one admixture is proposed for use in the same concrete mix, their interaction shall be checked by trial mixes to ensure their compatibility.

The CONTRACTOR shall note that the description of any proposed admixture by trade or brand name will not be enough for the approval of the PROJECT OFFICER/PMC.

The CONTRACTOR shall submit manufacturer's test certificates and technical literature of the admixture proposed to be used. If directed by the PROJECT OFFICER/PMC, the admixture shall be got tested at an approved laboratory at no extra cost.

The PROJECT OFFICER/PMC will, wherever appropriate, call for trial batches of concrete to be prepared to demonstrate the effect of the proposed admixtures both on the fresh concrete and on the hardened concrete before giving his approval. He may also lay down additional requirements for the control of the use of such admixtures.

Notwithstanding any previously given approval, the PROJECT OFFICER/PMC may withdraw such approval at any time with respect to any mix containing admixtures if, in his opinion, the performance of the admixture under actual Site conditions is not completely satisfactory.

4.4.5.2 Supply and Storage of Admixtures

Accelerating, retarding, water-reducing, super plasticizing and air entraining admixtures shall conform to IS: 9103, integral cement water proofing admixture to IS: 2645, any other admixture to BS: 5075, if it is applicable, unless otherwise specified or agreed. Admixtures shall be stored strictly in accordance with manufacturers' recommendations and precautions shall be taken during delivery and storage to prevent damage to or adulteration of admixtures.

4.4.5.3 Use of Admixtures

Any admixture used in any concrete mix shall only be used at the rate of dosage or in the proportions previously approved by the PROJECT OFFICER/PMC, method of mixing, etc. all in accordance with the manufacturer's instructions and within the manufacturer's recommended ambient temperature range.

Any batch of concrete, which has received an incorrect dose of an admixture or which shall show deterioration after placing because of incorrect use of admixtures, shall be broken out or otherwise replaced at no additional cost to the EMPLOYER.

The relative density of liquid admixtures shall be checked for each drum containing the admixture and compared with the stated/ specified value before acceptance. Liquid admixtures or powder admixtures that are to be used as solutions shall be dispensed by an appliance fixed to the mixer, which measures weight, volume or dosing time and is provided with a recorder. This appliance shall be accurately calibrated, and the calibration and dosage shall be checked at regular intervals or as directed by the PROJECT OFFICER/PMC. All such admixtures shall be dispensed with the mixing water.

All admixture dispensers shall be thoroughly cleaned before commencing each day's work and at every interruption to the work.

Where admixtures are to be used in bulk form, these shall be weigh-batched as is provided in this Specification for the batching of cement.

Powder admixtures to be used in dose form shall only be allowed if premixed and used as solutions and then only if the premixing procedure has been previously approved by the PROJECT OFFICER/PMC.

4.4.5.4 Corrosion Inhibitor

The use of proprietary corrosion inhibitors, whether specified or not, shall be subject to the written agreement of the PROJECT OFFICER/PMC. Their prime function shall be to form a protective film on the reinforcing steel.

Proprietary corrosion inhibitors shall be added to the concrete in accordance with the recommendations of the manufacturer. The dosage and rate of application shall be established by the CONTRACTOR following consultation with the admixture manufacturer and shall be confirmed to the PROJECT OFFICER/PMC in writing.

4.4.5.5 Chlorides

Under no circumstances shall calcium chloride or chloride-based admixtures be used in any concrete mix, grout or mortar. The chloride content of admixtures shall be independently tested in an approved laboratory for each batch of admixture before acceptance. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5% of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

4.5 WASTAGE

Wastage allowance for cement and steel and higher rolling margin for steel shall be considered in the item rate and no extra payment shall become payable to the Contractor on any account.

4.6 SAMPLES AND TESTS

All materials used for the works shall be tested before use. The frequency of such confirmatory tests shall be decided by PROJECT OFFICER/PMC.

Manufacturer's test certificate shall be furnished for each batch of cement/ reinforcing steel and when directed by PROJECT OFFICER/PMC samples shall also be got tested by the CONTRACTOR in a laboratory approved by PROJECT OFFICER/PMC at no extra cost to EMPLOYER. However, where material is supplied by EMPLOYER, all testing charges shall be borne by EMPLOYER, but transportation and preparation of material samples for the laboratory shall be done by CONTRACTOR at no extra cost.

Sampling and testing of aggregates shall be as per IS: 2386 under the supervision of PROJECT OFFICER/PMC. The cost of all tests, sampling, etc. shall be borne by CONTRACTOR.

Water to be used shall be tested to comply with Clause 5.4 of IS: 456.

CONTRACTOR shall furnish manufacturer's test certificates and technical literature for the admixture proposed to be used. If directed, the admixture shall be got tested at an approved laboratory at no extra cost.

4.7 STORING OF MATERIALS

All material shall be stored in a manner to prevent its deterioration and contamination, which would preclude its use in the works. Requirements of IS: 4082 shall be complied with.

CONTRACTOR shall make his own arrangements for the storage of adequate quantity of cement even if cement is supplied by PROJECT OFFICER/PMC . If such cement is not stored properly and has deteriorated, the material shall be rejected. Cost of such rejected cement, where cement is supplied by PROJECT OFFICER/PMC , shall be recovered at issue rate or open market rate whichever is higher. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by PROJECT OFFICER/PMC. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt. CONTRACTOR shall maintain record of receipt and consumption of cement.

Each size of coarse and fine aggregates shall be stacked separately and shall be protected from dropping leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

CONTRACTOR shall make his own arrangements for storing water at site in tanks of approved capacity. The tanks shall be cleaned at least once a week to prevent contamination.

The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/ water. Each type and size shall be stacked separately.

4.8 CONCRETE

4.8.1 GENERAL

Concrete grade shall be as designated on drawings. Concrete in the works shall be "DESIGN MIX CONCRETE" or "NOMINAL MIX CONCRETE". All concrete works of up to grade M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.

4.8.2 DESIGN MIX CONCRETE

For this specification, Design Mix Concrete is classified as "Normal Concrete". It shall be identified by a prefix and two numbers. Prefix "M" would denote Normal Concrete. The two numbers e.g. 25 - 40 would denote the crushing strength of cube at 28 days in N/mm² and maximum size of the coarse aggregates in millimeters respectively. Normal concrete shall have a net dry unit weight of not less than 25 kN/m³, for the finished structure after curing.

4.8.3 MIX DESIGN AND TESTING

For Design Mix Concrete, the mix shall be designed as per IS 10262 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS: 456. The design mix shall in addition be such that it is cohesive and does not segregate during placement and should result in a dense and durable concrete capable of giving the specified finish. For liquid retaining structures, the mix shall also result in watertight concrete. The CONTRACTOR shall exercise great care while designing the concrete mix and executing the works to achieve the desired result.

The minimum grade of concrete shall be as per Table 5 of IS: 456 for various exposure conditions of concrete. For various environmental conditions, refer to Table 3 of IS: 456.

The minimum cement content for Design Mix Concrete shall be as mentioned in the Schedule of Quantities.

The quantity of maximum mixing water per unit volume of concrete may be determined from Table 2 of IS 10262. The water content in Table 2 is for angular coarse aggregate and for 25 to 50 mm slump range. The water estimate in Table 2 can be reduced by approximately 10 kg for sub- angular aggregates, 20 kg for gravel with some crushed particles and 25 kg for rounded gravel to produce same workability. For the desired workability (other than 25 to 50 mm slump range), the required water content may be established by trial or an increase by about 3 percent for every additional 25 mm slump or alternatively by use of chemical admixtures conforming to IS 9103. Water reducing admixtures or super plasticizing admixtures usually decrease water content by 5 to 10 percent and 20 percent and above respectively at appropriate dosages.

It shall be CONTRACTOR's sole responsibility to carry out the mix designs at his own cost. He shall furnish to PROJECT OFFICER/PMC for approval at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS: 516 shall comply with the requirements of Table – 2 of IS: 456.

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested i.e., the sampling should be spread over the entire period of concreting and cover all mixing units. The minimum frequency of sampling of concrete of each grade shall be in accordance with the cl. 15.2 of IS 456.:

3 test specimens (cubes) shall be made for each sample for testing at 28 days. The test results of the sample shall be the average of the strength of 3 specimens.

In the 'very low' category of workability where strict control is necessary, for example pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (refer to IS: 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (refer to IS: 9103).

Where single size graded coarse aggregate are not available, aggregates of different sizes shall be properly combined. The CONTRACTOR's mix design shall show that combined grading of coarse aggregate meets the requirements of Table 2 of IS: 383 for graded aggregates.

4.9 BATCHING AND MIXING OF CONCRETE

Proportions of aggregates and cement, as per approved concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within $\pm 2\%$ for cement and $\pm 3\%$ for aggregate. The batching equipment shall be calibrated at the frequency decided by PROJECT OFFICER/PMC.

Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. Each time the work stops, the mixer shall be cleaned out, and while recommencing, the first batch shall have 10% additional sand and cement to allow for sticking in the drum.

Arrangement should be made by CONTRACTOR to have the cubes tested at his own expense in an approved laboratory or in field with prior consent of PROJECT OFFICER/PMC. Sampling and testing of strength and workability of concrete shall be as per IS: 1199, IS: 516 and IS: 456. It is preferable to cast additional cubes (minimum 3 specimens) for testing at 7 days and 14 days.

4.10 READY MIXED CONCRETE

All specification as per IS: 4926 – "Specification for Ready Mixed Concrete" shall be applicable.

The design mix prepared by the RMC supplier shall be the responsibility of the CONTRACTOR. The testing of concrete as per Codal provisions and the specifications shall be done by the CONTRACTOR same as the normal concreting works.

4.11 PRECAST CONCRETE

4.11.1 GENERAL

Precast concrete shall comply with the preceding Sections relating to Concrete as far as they are applicable.

CONTRACTOR shall submit a method statement to PROJECT OFFICER/PMC for approval, before any work is commenced on the manufacture, furnishing details of each stage of operation. The method statement shall inter alia include full details of the plant and equipment to be used and method and location of precast concrete manufacture, striking of shutters, curing, lifting, handling, storage, transportation and installation in the Works.

4.11.2 FORMWORK

The formwork shall be either steel or lined with steel, waterproof/ laminated board or such other material as directed and approved by the PROJECT OFFICER/PMC. Forms shall be strongly constructed, closely jointed and smooth and shall be such as to ensure true sharp arises and a perfect surface. Forms shall be so designed that they can be taken apart and reassembled readily.

4.11.3 SURFACE FINISH

Surface Finish of precast units shall comply with requirements of this specification. The class of Finish shall generally be of F2 type unless detailed differently on the drawings or as directed by the PROJECT OFFICER/PMC. No construction joints will be permitted within any precast work.

4.11.4 CASTING TOLERANCE

The casting tolerance, unless otherwise ordered or directed, shall be within +3 mm of true dimensions.

4.11.5 STRIKING FORMS

The method and time of striking the side shutters after casting the units will normally be left to the discretion of the CONTRACTOR, but the PROJECT OFFICER/PMC may specify minimum time in which case the CONTRACTOR must comply with the PROJECT OFFICER/PMC's directions. In the event of any damage resulting from premature removal of shutters, or from any other cause, the unit will be liable to rejection and replacement by the CONTRACTOR at his own cost, whether the PROJECT OFFICER/PMC has specified a minimum striking time or not.

4.11.6 LIFTING, STACKING AND REMOVAL

Precast units shall not be lifted, transported or used in the Works until they are sufficiently mature. The crushing tests on the test cubes, which are to be kept along with the relevant precast units, will be used to assess the maturity of the units.

Lifting, stacking and removal of precast units shall be undertaken without causing shock, vibration or undue stress to or in the units. The CONTRACTOR shall satisfy the PROJECT OFFICER/PMC that the methods he proposes for lifting, transporting and setting precast units will not overstress or damage the units in any way. In the event of overstress or damage due to whatever cause, the unit or units concerned will be liable to rejection. Rejected units shall be immediately broken up and removed from the site. The CONTRACTOR shall replace such rejected units at his own cost.

4.11.7 CURING

The top and sides of all precast units shall be kept covered constantly and in a damp condition with clean, potable fresh water for at least seven days after casting or for such further period as the PROJECT OFFICER/PMC may direct. It is preferable to have a curing pond for this purpose.

4.11.8 PRECASTING RECORDS

The CONTRACTOR shall maintain records for each unit, which shall include the following:

- Type and reference number.
- Date of manufacture/ casting.
- Bed/ mould number.
- Curing method and duration.
- Date of removal from bed/ mould.
- Test Cube reference number and results.
- Date of placing in the Works.
- Location in the Works.

These records shall be in a format agreed by the PROJECT OFFICER/PMC and shall always be available for inspection. Copies of these records shall be supplied to the PROJECT OFFICER/PMC on completion.

4.12 **FORMWORK**

Formwork shall be all inclusive and shall consist of but not limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs, etc. including ties, anchors, hangers, inserts, falsework, wedges, etc.

The Design and Engineering of the formwork as well as its construction shall be the responsibility of CONTRACTOR. However, if so, directed by PROJECT OFFICER/PMC, the drawings and calculations for the design of the formwork shall be submitted to PROJECT OFFICER/PMC for approval.

Formwork shall be designed to fulfil the following requirements:

Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits as given in clause 11.1 of IS 456.

The formwork may be of lined timber, waterproof/ plastic coated plywood, steel, plastic depending upon the type of finish specified. Sliding forms and slip form may be used with the approval of PROJECT OFFICER/PMC. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints between formwork and formwork and between formwork and structure shall be sufficiently tight to prevent loss of slurry from concrete using foam and rubber seals.

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust, etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

Forms intended for reuse shall be approved by the PROJECT OFFICER/PMC. CONTRACTOR shall equip himself with enough quantity of shuttering to allow for wastage to complete the job in time.

Permanent formwork shall be checked for its durability and compatibility with adjoining concrete before it is used in the structure. It shall be properly anchored to the concrete.

For liquid retaining structures sleeves shall not be provided for through bolts nor shall through bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

Forms for substructure may be omitted when, in the opinion of PROJECT OFFICER/PMC, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavation shall be slightly larger, as directed by PROJECT OFFICER/PMC, than that required as per drawing to compensate for irregularities in excavation.

Formwork showing excessive distortion, during any stage of construction, shall be removed. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at CONTRACTOR's cost.

The striking time for formwork shall be determined based on the following requirements:

- Development of adequate concrete strength;
- Permissible deflection at time of striking formwork;
- Curing procedure employed - its efficiency and effectiveness;
- Subsequent surface treatment to be done;
- Prevention of thermal cracking at re-entrant angles;
- Ambient temperatures and aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).

Before removing formwork of soffit of slabs/ beams compressive strength at 7/ 14/ 21 days shall be checked.

Under normal circumstances (generally where temperatures are above 200 Celsius) forms may be struck after expiry of the period given in IS: 456 unless directed otherwise by PROJECT OFFICER/PMC. It is the CONTRACTOR's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resists surface damage and any stresses arising during the construction period.

4.13 REINFORCEMENT FABRICATION AND PLACEMENT

4.13.1 Reinforcing bars shall be bent and fixed in accordance with the procedure specified in IS 2502.

4.13.2 All bars shall be bent by Bar bending machines.

4.13.3 Re-bending or straightening incorrectly bent bars shall not be done without approval of PROJECT OFFICER/PMC.

4.13.4 Reinforcement shall be accurately fixed and maintained firmly in the correct position using blocks, spacers, chairs, binding wire, etc. to prevent displacement during placing and compaction of concrete in accordance with clause 12.3 to 12.6 of IS 456. The tied in-place reinforcement shall be approved by PROJECT OFFICER/PMC prior to concrete placement. PVC or concrete spacers of appropriate size shall be used with the approval of PROJECT OFFICER/PMC.

- 4.13.5 Binding wire shall be 18-gauge soft annealed wire. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.
- 4.13.6 Substitution of reinforcement, laps/ splices not shown on drawing shall be proposed by CONTRACTOR at his own cost and approved by PROJECT OFFICER/PMC.
- 4.13.7 If permitted by PROJECT OFFICER/PMC, welding of reinforcement shall be done in accordance with IS: 2751, IS: 9417 and SP: 34 as applicable.
- 4.13.8 Tolerance on placement of reinforcement shall be as per Cl. 12.3 of IS: 456.

4.14 TOLERANCES

Tolerance for formed and concrete dimensions shall be as per IS: 456 unless specified otherwise. Tolerance is a specified permissible variation from lines, grade or dimensions given in drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Unless otherwise specified, the following tolerances will be permitted.

4.14.1 TOLERANCES FOR RC BUILDINGS

4.14.1.1 Variation from the Plumb

	In the lines and surfaces of columns, piers, walls and in arises 5 mm per 2.5 m or 25 mm, whichever is less.		
	For exposed corner columns and other conspicuous lines.		
	In any bay or 5 m maximum	-	5 mm
	In 10 m or more	-	10 mm

4.14.1.2 Variation from the level or from the grades indicated on the drawings

	In slab soffits, ceilings, beam soffits and in arises		
	In 2.5 m	-	5 mm
	In any bay or 5 m maximum	-	10 mm
	In 10 m or more	-	15 mm
	For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines		
	In any bay or 5 m maximum	-	5 mm
	In 10 m or more	-	15 mm

4.14.1.3 Variation of the linear building lines from established position in plan and related position of columns, wall and partitions

	In any bay or 5 m maximum	-	10 mm
	In 10 m or more	-	20 mm

4.14.1.4 Variation in the sizes and locations of sleeves, openings in walls and floors - 5 mm except in the case of and for anchor bolts.

4.14.1.5 Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	-	5 mm
Plus	-	10 mm

4.14.1.6 Footings

i.	Variation in dimension in plan		
	Minus	-	5 mm
	Plus	-	50 mm
ii.	Misplacement or eccentricity		
	2% of footing width in the direction of misplacement but not more than 50 mm		
iii.	Reduction in thickness		
	Minus	-	5% of specified thickness subject to a maximum of 50 mm

4.14.1.7 Variation in steps

i.	In a flight of stairs		
	Rise	-	3 mm
	Tread	-	5 mm
ii.	In consecutive steps		
	Rise	-	1.5 mm
	Tread	-	3 mm

4.14.2 TOLERANCES IN OTHER STRUCTURES

4.14.2.1 All structures

i.	Variation of the construction linear outline from established position in plan.		
	In 5 m	-	10 mm
	In 10 m or more	-	15 mm
ii.	Variation of dimensions to individual structure features from established positions.		
	In 20 m or more	-	25 mm
	In buried construction	-	50 mm
iii.	Variations from plumb, from specified batter or from curved surfaces of all structures.		
	In 2.5 m	-	10 mm

	In 5 m	-	15 mm
	In 10 m or more	-	25 mm
	In buried construction	-	Twice the above values
iv.	Variations from level or grade indicated on drawings in slabs, beams, soffits, horizontal grooves and visible arises.		
	In 2.5 m	-	5 mm
	In 7.5 m or more	-	10 mm
	In buried construction	-	Twice the above values
v.	Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members.		
	Minus	-	5 mm
	Plus	-	10 mm
vi.	Variation in the thickness of slabs, walls, arch sections and similar members.		
	Minus	-	5 mm
	Plus	-	50 mm

4.14.2.2 Footing for Columns, Piers, Walls, Buttresses and Similar Members

i.	Variation of dimension in Plan		
	Minus	-	10 mm
	Plus	-	50 mm
ii.	Misplacement or eccentricity		
	2% footing width in the direction of misplacement but not more than 50 mm		
iii.	Reduction in thickness		
	5% of specified thickness subject to a maximum of 50 mm		

4.14.3 TOLERANCE IN FIXING ANCHOR BOLTS

i.	Anchor bolts without sleeves	:	1.5 mm in plan
ii.	Anchor bolts with sleeves	:	5.0 mm in elevation
	for bolts up to and including 28 mm dia.	:	5 mm in all directions
	for bolts up to 32 mm dia.	:	3 mm in all directions
iii.	Embedded parts	:	5 mm in all directions

4.14.4 TOLERANCES IN FORMWORK

The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings within the tolerances given below:

1.	Deviation from specified dimensions of cross section of columns and beams	-6 mm
----	---	-------

2.	Deviations from dimensions of footings (tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowels)	+12 mm
a)	Dimension in Plan	-12 mm +50 mm
b)	Eccentricity	0.02 times the width of the footing in the direction of deviation, but not more than 50 mm
c)	Thickness	± 0.05 times the specified thickness

4.14.5 Tolerance for top of concrete of equipment and structural steel foundations shall be as under unless more stringent requirements are specified by equipment manufacturer:

- Where grout thickness is less than or equal to 25 mm: ±5 mm.
- Where grout thickness is more than 25 mm: ±5 mm.

4.15 EXECUTION AND REMOVAL OF FORMS

Before placing concrete, the surface of all forms shall be coated with suitable non-staining form releasing agents such as raw linseed oil to prevent adhesion of concrete and to facilitate removal of forms.

The form releasing agent shall cover the forms fully and evenly without excess over drip. Care shall be taken to prevent form releasing agents from getting on the surface of the construction joints and on reinforcement bars. Special care shall be taken to thoroughly cover form strips for narrow grooves, to prevent swelling of the forms and the consequent damage to concrete prior to or during removal of forms.

Immediately before concrete is placed care shall be taken to see that all forms are in proper alignment and the supports and fixtures are properly secured and tightened.

Where forms for continuous surfaces are placed in successive units, the forms shall lap and fit tightly over the completed surface to prevent leakage of cement slurry from the fresh concrete and to maintain accurate alignment of the surface.

Forms shall be left in place until their removal is authorised and shall then be removed with care to avoid injury to concrete.

Removal of forms shall be started when the concrete has achieved strength of at least twice the stress to which the concrete may be subjected at the time of removal of formwork.

In normal circumstances and where ordinary Portland cement is used forms can be allowed to be struck as per the guideline given in clause 11.3 of IS 456.

Note: Time shall be measured from last batch concreted in respect to the structural member under consideration. For other cement stripping time as recommended above may be suitably decided by PROJECT OFFICER/PMC.

Re-propping shall be done to the below floor to carry the construction load transferred through props/equipment, etc. during construction of upper floor and props left under till the period of removal of props

supported to or any other load due to construction load on the upper floor. Re-propping shall be part of shuttering/ formwork for concrete without any claim for extra cost.

4.16 SETTLEMENT OF FORMWORK AND CAMBER

Due to various reasons such as closure of form joints, shrinkage of timber, dead load deflections, elastic shortening of form members or formwork, deflections, settlement may occur. The CONTRACTOR shall take precautions, including using adequately rigid formwork, to prevent excessive settlement/ deflection; the usual acceptable limit being 1/500 of the spans of the formwork.

In the absence of any specified camber on the drawings, soffit of all beams more than 5 m in span and other than pre-stressed concrete beams shall be laid to a camber, the amount of which at mid span shall not be less than 1/500 of the span of the structure. The profile of soffit shall be parabolic.

4.17 PREPARATION PRIOR TO CONCRETE PLACEMENT

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust, etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

All arrangements - formwork, equipment and proposed procedure, shall be approved by PROJECT OFFICER/PMC. CONTRACTOR shall maintain separate Pour Card for each pour.

4.18 TRANSPORTING, PLACING AND COMPACTING CONCRETE

Concrete shall be transported from the mixing plant to the formwork with minimum time lapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

In all cases concrete shall be deposited as nearly as practicable directly in its final position. For locations where, direct placement is not possible and in narrow forms, CONTRACTOR shall provide suitable drops and "Elephant Trunks". Concrete shall not be dropped from a height of more than 1.5 m.

Concrete shall not be placed in flowing water. Under water concrete shall be placed in position by tremie or by pipeline from the mixer and shall never be allowed to fall freely through the water.

While placing concrete the CONTRACTOR shall proceed as specified below and ensure the following:

- Continuously between construction joints and predetermined abutments.
- Without disturbance to forms or reinforcement.
- Without disturbance to embedment.
- Without dropping in a manner that could cause segregation or shock.
- In deep pours only when the concrete and formwork is designed for this purpose and by using suitable chutes or pipes.
- Do not place if the workability is such that full compaction cannot be achieved.
- Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting, if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.

- If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.
- Ensure that there is no damage or displacement to sheet membranes.
- Record the time and location of placing structural concrete.
- When concrete is brought from batching plant to site in millers, the time of mixing and the time of pour shall be checked to ensure that setting has not started.

Concrete shall normally be poured & compacted in its final position within initial setting time. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids, thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set. Over-vibration leads to segregation and shall be avoided.

Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by PROJECT OFFICER/PMC. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to be pumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

CONTRACTOR shall submit a method statement to PROJECT OFFICER/PMC for approval, furnishing details of pour sequence, thickness of each layer, mixing and conveying equipment proposed, etc. preferably with a sketch.

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete before the start of subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom surface of slab, in slab and beam construction, and it shall be resumed before concrete takes initial set but not until it has had time to settle as determined by PROJECT OFFICER/PMC. Concrete shall be protected against damage until final acceptance.

4.19 PLACING OF CONCRETE BY PUMPING METHODS

4.19.1 GENERAL

Placing of concrete by pumping will be as specified or authorised by PROJECT OFFICER/PMC to achieve the required speediness of construction and maintain targeted schedules.

Pumping of concrete shall be done only after conducting pumpability trials to ascertain the performance of fresh concrete on pumping in presence of the PROJECT OFFICER/PMC as per approved procedure. During pumping, concrete shall be conveyed either through rigid pipe or through flexible hose and discharged directly into the desired area. A steady supply of pumpable concrete is necessary for satisfactory pumping. Pumpable concrete requires properly graded aggregates, material uniformity, consistent batching and thorough mixing. They shall be used for concreting densely reinforced structures, internal structural elements of buildings and for large pours of concrete. Concrete pumps used shall be able to deliver concrete over a horizontal and vertical distance as per the directives of the PROJECT OFFICER/PMC.

Placement of normal concrete by pumping will be permitted as specified or authorised by the PROJECT OFFICER/PMC. The decision, whether to pump any mix shall rest entirely with the PROJECT OFFICER/PMC and no extra claims for payment on this account will be entertained. The pumping equipment, pipe lines and accessories as well as proportioning of pumpable concrete shall generally

conform to the recommendations of ACI-304.2R (latest revision) – Placing of concrete by pumping method - Proportioning of pumpable mixes gives certain guide lines on concrete mix. However, final selection of mix shall be as instructed by the PROJECT OFFICER/PMC.

4.19.2 PUMPING EQUIPMENT

Requisite number of modern dependable concrete pumps capable of pumping concrete of specified quality at a rate required to meet the construction schedules, together with a balanced complement of pipelines, accessories, spare parts, power-controlled placing booms, and experienced pump operators and maintenance staff shall be provided at locations and in a manner approved by the PROJECT OFFICER/PMC.

The pumping plant shall be completely installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of a concrete pour, to enable the PROJECT OFFICER/PMC to conduct pumpability tests and necessary adjustments for the concrete mix, prior to use of the pumping for placement of concrete.

4.19.3 PROPORTIONING PUMPABLE CONCRETE

Basic Consideration

- a. Although the ingredients of concrete to be placed both by pumping and by other means are the same, more emphasis shall be laid on the quality control and proportioning of a dependable pumpable mix. Dependability is ensured by the equipment and the operator, with the control of all the ingredients in the mixture, the batching and mixing operations, and the knowledge and experience of all the personnel from beginning to end.
- b. Concrete mixes for pumping shall be “plastic” at all times. Stiff mixes shall not be used for pumping as they do not pump well. Attention shall be given to the mortar (cement, sand and water) and the amounts and sizes of coarse aggregates.

4.19.4 TESTING FOR PUMPABILITY

No mix shall be accepted for use on a pumping job until an actual test under field condition has been completed. Testing a mix for pumpability involves duplication of the anticipated job condition from beginning to end. The batching and conveying by truck mixers shall be the same as will be used, the same pump and operator shall be present. The pipe and hose layouts shall simulate the actual condition as far as practicable. Prior use of a mix on another job may furnish evidence of pumpability, but only if conditions are duplicated. Before commencing a new concreting job, the CONTRACTOR shall carry out pumpability tests in consultation with the PROJECT OFFICER/PMC. Concrete used in such tests shall not be used in the actual construction, unless specifically permitted by the PROJECT OFFICER/PMC.

Following parameters shall be established by pumpability trials:

- In-situ compressive and split tensile strength of concrete.
- Curing the sample at Site by sprinkling water.
- Curing the sample at Laboratory in curing tanks.
- Wet sieve analysis of concrete to ensure that proportions of ingredients before and after pumping are same.

4.19.5 FIELD PRACTICES

Proper planning of concrete supply, pump location, line layout, placing sequence and the entire pumping operation shall be done by the CONTRACTOR and got approved by the PROJECT OFFICER/PMC on every occasion before commencement of concreting job. The pump shall be as near the placing area as practicable, and the entire surrounding area must have adequate bearing strength to support the concrete delivery trucks, thus assuring a continuous supply of concrete. For important concrete placements and large jobs, adequate standby power and pumping equipment shall be provided as replacement, should break down occur.

Direct communication shall be maintained between the pump operator, concrete placing crew and batching plant. The placing rate shall be estimated so that concrete can be operated at an appropriate delivery rate. As a final check, the pump shall be started and operated without concrete to ascertain that, all moving parts are operating properly. As stated previously, the grout mortar shall be pumped into the line to provide initial lubrication for the concrete. As soon as concrete is received, the pump shall be run slowly until the lines are completely full and the concrete is slowly moving. Once the pumping is started, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking. Continuous pumping should be ensured. If a delay occurs because of concrete delivery, form repairs, or other factors, the pump shall be slowed down to maintain some movement of the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be made to last as long as possible by moving the concrete in the lines occasionally with one stroke of the pump. In confined areas, attempt shall be made by the CONTRACTOR to run a return line back to the pump, so that concrete can be re-circulated during delays.

The CONTRACTOR shall ensure that obstructions are not found in the pipe due to interruption in the feed of the concrete by more than 30 to 45 minutes.

Minor blockages shall be cleared by operating a few strokes of the pump in reverse momentarily and then by returning to normal forward pumping. If this fails, a succession of reverse and forward strokes shall be carried out to remove the blockage. Should this fail also, the blockage may be due to air-lock and the entrapped air must be removed.

Attempt to push through the obstructions by repeatedly starting the pump will result in compaction of the concrete and complicate the removal of the concrete in the pipe. Blockages in the pipe are usually discovered by the sound when the pipe is struck. To remove the obstruction, the concrete pipe shall be taken apart at the assured position and cleaned. Then the pumping process shall be started all over again.

This method of checking the blockage and setting it right shall be done with great speed as excessive delay will cause setting of concrete in the pipeline downstream of the choke and will lead to further blockage. When the blockage is being found out and remedied, the pump shall periodically be given one or two strokes forward to keep the concrete in motion. If blockage occurs in the placer boom, a pipe joint near the base of the placer boom shall be opened and the boom made vertical to drain the pipeline by gravity.

Cleaning blockages are time consuming and as such major blockages shall best be avoided by ensuring a pumpable mix. Concrete that is either under or over sanded, short of fines, gap graded, has an excess of a size, or excessively wet or dry will be rejected by the pump either by blockage or by hard pumping involving excessive pressures.

The termination of pumping operations shall be carefully planned to utilise the concrete dormant in the pipeline and the hopper when the pump is stopped and to avoid wastage.

When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped, and a go-devil be inserted and forced through the line to clear it out. Water under pressure shall be used to push the go-devil. The go-devil shall be stopped about one metre from the end of the line, so that the water in the line will not spill over into the placement area. After flushing, water in the pipe shall be removed by drain cock which shall be located for this purpose in the lowest part of the line. After all concrete has been removed from the lines, all lines and equipment shall be immediately cleaned thoroughly.

4.19.6 QUALITY CONTROL

CONTRACTOR shall ensure that workmanship and plant shall be maintained at peak efficiency. Degree of control on all the concrete operation from selection of the ingredients to the final testing of specimen shall be in line with the assumptions made in mix design with respect to the standard deviation and coefficient of variation.

The CONTRACTOR shall ensure that any compromise in quality is not done for the pumped concrete. To be pumpable, a high level of quality control for the assurance of uniformity must be maintained. Sampling at both the truck discharges and point of final placement shall be done by the CONTRACTOR and the PROJECT OFFICER/PMC jointly, as frequently as the PROJECT OFFICER/PMC desires to determine, if any change in the slump air content, and other significant mix characteristics occur take necessary corrective actions.

The CONTRACTOR shall engage experienced supervision at all levels. The placing crew shall be experienced and qualified and each operation shall be well planned and properly scheduled.

All the crew engaged in each of the concrete activities shall demonstrate in the presence of the PROJECT OFFICER/PMC, their skills and capabilities to produce the final product as specified.

4.20 MASS CONCRETE WORKS

Sequence of pouring for mass concrete works shall be as approved by PROJECT OFFICER/PMC. CONTRACTOR shall exercise great care to prevent shrinkage cracks and shall monitor the temperature of the placed concrete if directed.

4.21 PLACING TEMPERATURE OF CONCRETE

Placing temperature of concrete should be maintained as specified in Schedule of Quantities or as directed by PROJECT OFFICER/PMC, to avoid shrinkage cracking.

Mixing water shall be kept cool by storing it under cover. Chilled water or crushed ice as part of the mixing water to achieve the specified placing temperature shall be used. For chilled water, it is recommended that the CONTRACTOR install and maintain refrigeration facility of required capacity. The CONTRACTOR shall also build and maintain well insulated adequate capacity storage tank for cold water with insulated connected piping. To supplement this refrigeration facility, the CONTRACTOR will have to have ice plant or use commercial ice subject to approval of the PROJECT OFFICER/PMC. The full quantity of crushed ice shall be stored in cold storage 24 hours in advance of the start of concreting. The temperature in cold storage shall not be more than -20 C. The CONTRACTOR should study the placing temperature condition and work out plant capacity commensurate with the construction schedule requirements and submit his scheme along with the tender.

Ice when used as replacement for a portion or all the mixing water shall be produced from water, which meets the requirements of clause 4.4.3. Ice when used shall be in flakes of size 3 mm or below or crushed condition and the crushed ice shall be such as to pass completely, 10 mm sieve.

4.22 CURING

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

- Premature drying out, particularly by solar radiation and wind;
- Leaching out by rain and flowing water;
- Rapid cooling during the first few days after placing;
- High internal thermal gradients;
- Low temperature or frost;
- Vibration and impact, which may disrupt the concrete and interfere with its bond to the reinforcement.

All concrete, unless directed otherwise by PROJECT OFFICER/PMC, shall be cured as specified in clause 13.5 of IS 456. The quality of curing water shall be the same as that used for mixing.

Where a curing membrane is directed to be used by the PROJECT OFFICER/PMC, the same shall be of a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be got approved from the PROJECT OFFICER/PMC before use and shall be applied with spraying equipment capable of a smooth, even textured coat.

Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

Extra precautions shall be exercised in curing concrete during cold and hot weather as per clause no. 8.3 of IS: 7861 (Part II) and clause no. 8.2 of IS: 7861 (Part I) respectively.

Curing arrangement shall be subjected to PROJECT OFFICER/PMC's approval.

4.23 CONSTRUCTION JOINTS AND KEYS

Construction joints (location and type) shall be as shown on the drawing or as approved by PROJECT OFFICER/PMC. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of PROJECT OFFICER/PMC.

Dowels for concrete work, not likely to be taken up soon, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as directed by PROJECT OFFICER/PMC.

Before resuming concreting on a surface, which has hardened all laitance and loose aggregates shall be thoroughly removed by wire brushing and/ or hacking, the surface washed with high pressure water jet and treated with thin layer of cement slurry for vertical joints and a 15 mm thick layer of cement sand mortar for horizontal joints, the ratio of cement and sand being the same as in the concrete mix.

4.23.1 CONSTRUCTION JOINT TREATMENT

Methodology stated herein under must be followed by CONTRACTOR wherever instructed by the PROJECT OFFICER/PMC at no additional cost to the EMPLOYER.

The entire construction joint shall be treated by green cutting using air/ water jet at suitable pressure to remove the laitance from the green concrete surface to receive subsequent pour over it. Suitable, approved brand of surface retarder shall be used to retard the setting time of green concrete to a depth of 5 to 8 mm. Green cutting shall be done only after the final setting of concrete, so that the additional water available from the air water jet used for green cutting on the surface does not harm the quality of the concrete.

4.23.2 APPLICATION OF SURFACE RETARDER AND GREEN CUTTING AT CONSTRUCTION JOINT OF CONCRETE

4.23.2.1 Scope

Work under this procedure covers application of surface retarder over the green concrete and green cutting the exposed surface of concrete after final setting time to expose the aggregate, for proper bonding with fresh concrete of successive pours.

4.23.2.2 Material Qualification

The surface retarder shall be qualified for use based on number of site trials/ mock-ups for achieving the desired surface after green cutting during different ambient conditions

4.23.2.3 Application

Surface retarder shall be applied uniformly with the help of agricultural spray machine at the rate of 5 to 6 sqm/litre. Form panel at construction joint: Wherever the side of a pour is to receive concrete later, a bulk head of such sides will be coated with surface retarder at least one hour before the receipt of concrete.

For horizontal construction joints: Wherever the concrete is to be placed above a pour, surface retarder shall be applied on the finished top surface of the said pour within half an hour of finishing.

4.23.2.4 Green Cutting

Green cutting shall be started after final setting time of concrete to expose the aggregate, for proper bonding with fresh concrete of successive pours. The surface of concrete shall be green cut using air-water jet. Bunds shall be made using cement mortar at convenient locations and cut out shall be made in the side shutter to drain off excess water. All the laitance and green cut material shall be removed from the green cut surface simultaneously.

The time of green cutting shall be displayed on Tags, which will be placed at appropriate locations so that said activity can be controlled in the proper way.

When concreting is to be resumed on a surface, which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed, and a coat of cement slurry applied. On this a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

Approved epoxy Bonding agent, for bond between old (say 28 days or more) and new concrete may also be used as per manufacturer's specifications.

4.24 FOUNDATION BEDDING

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy area shall be cleaned out and back filled with either soil-cement mixture, lean concrete or clean sand compacted as directed by PROJECT OFFICER/PMC. The surfaces of absorptive soils shall be moistened.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

4.25 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

Immediately after the shuttering is removed, all the defective areas such as honeycombed surfaces, rough patches, etc. shall be brought to the notice of PROJECT OFFICER/PMC who may permit patching of the defective areas or reject the concrete work. PROJECT OFFICER/PMC's decision on rejection of concrete work shall be final.

All through holes for shuttering shall be filled with cement mortar for full depth and neatly plugged flush with surface.

Rejected concrete shall be removed and replaced by CONTRACTOR at no additional cost to PROJECT OFFICER/PMC's

For patching of defective areas all loose materials shall be removed, and the surface shall be prepared by cleaning by compressed air or water jetting.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the PROJECT OFFICER/PMC as to be the method of repairs to be adopted shall be final and binding on the CONTRACTOR and no extra claim shall be entertained on this account. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as directed by PROJECT OFFICER/PMC.

CONTRACTOR shall submit a method statement for such repairs to PROJECT OFFICER/PMC for approval.

4.26 HOT WEATHER REQUIREMENT

Concreting during hot weather shall be carried out as per IS: 7861 (Part I).

Adequate provisions shall be made to lower concrete temperatures, which shall not exceed 400 C at the time of placement of fresh concrete.

Where directed by PROJECT OFFICER/PMC, CONTRACTOR shall spray non-wax based curing compound on unformed concrete surface at no extra costs.

4.27 COLD WEATHER REQUIRMENTS

Concreting during cold weather shall be carried out as per IS: 7861 (Part 2).

The ambient temperature during placement and up to final set shall not fall below 50 C. Approved anti-freeze/ accelerating additive shall be used where directed.

For major and large-scale concreting works the temperature of concrete at times of mixing and placing, the thermal conductivity of the formwork and its insulation and stripping period shall be closely monitored.

4.28 LIQUID RETAINING STRUCTURES

The CONTRACTOR shall take special care for concrete of liquid retaining structures, underground structures and those other specifically called for to guarantee the finish and water tightness.

The minimum level of surface finish for liquid retaining structures shall be of smooth type. All such structures shall be hydro-tested.

The CONTRACTOR shall include in his price hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines, etc.

Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been considered while quoting the rates.

Any leakage/ sweating that may occur during the hydro-test or subsequently during the defect liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/ epoxy pressure grouting, guniting or such other method as may be approved by the PROJECT OFFICER/PMC. All such rectification shall be done by the CONTRACTOR to the entire satisfaction of the PROJECT OFFICER/PMC at no extra cost to the EMPLOYER.

4.29 HYDRO TESTING CONCRETE STRUCTURES

Hydrostatic test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by PROJECT OFFICER/PMC, as described below:

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven-day period for absorption after filling with water. In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hours over period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The PROJECT OFFICER/PMC shall decide on the actual permissible nature of this drop in the surface level, considering whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/ segment of the structure shall be tested individually and then all together.

For structures such as pipes, tunnels, etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

4.30 OPTIONAL TESTS

If PROJECT OFFICER/PMC feels that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the PROJECT OFFICER, as per relevant IS Codes. EMPLOYER shall pay only for the testing of material supplied by the EMPLOYER, otherwise CONTRACTOR shall have to pay for the tests. Transporting of all material to the laboratory shall however be done by the CONTRACTOR at no extra cost to EMPLOYER.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strength, PROJECT OFFICER/PMC reserves the right to order the CONTRACTOR to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, as per relevant IS specifications. All these tests shall be carried out by CONTRACTOR at no extra cost to the EMPLOYER. Alternately PROJECT OFFICER/PMC also reserves the right to ask the CONTRACTOR to dismantle and re-do such unacceptable work at the cost of CONTRACTOR.

If the structure is certified by PROJECT OFFICER/ PMC as having failed, the cost of the test and subsequent dismantling/ reconstruction shall be borne by CONTRACTOR.

The quoted unit rates/ prices of concrete shall deem to provide for all tests mentioned above.

In case of doubt regarding the grade of concrete used, either due to poor workmanship or based on cube strength results, Non-Destructive Tests (NDT) shall be carried out to ascertain the strength of the concrete as per the technical specification attached in the tender document.

4.31 QUALITY CONTROL

CONTRACTOR shall adopt the Quality Control format provided by the PROJECT OFFICER/PMC. A copy of formats shall be furnished to CONTRACTOR by PROJECT OFFICER/PMC/ EMPLOYER after the contract is awarded.

Alternatively, if CONTRACTOR has his own QC formats he may adopt them subjected to such modifications considered necessary by PROJECT OFFICER/PMC.

In either case CONTRACTOR shall submit his detailed Quality Assurance Plan along with the bid. This would be reviewed, appropriately modified and approved by CONSULTANT/ PROJECT OFFICER/PMC after the award of contract.

4.32 INSPECTION

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of PROJECT OFFICER/PMC. Materials rejected by PROJECT OFFICER/PMC shall be expressly removed from site within 3 working days and shall be replaced by CONTRACTOR immediately at no extra cost to EMPLOYER.

4.33 CLEAN-UP

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood, etc. resulting from the work shall be removed and the premises left clean.

4.34 ACCEPTANCE CRITERIA DURING CONSTRUCTION STAGE AND HARDENED STATE

Any concrete work shall satisfy the requirements given below individually and collectively for it to be acceptable.

- Properties of constituent materials;
- Characteristic compressive strength;
- Specified mix proportions;
- Minimum cement content;
- Maximum free-water/cement ratio;
- Workability;
- Temperature of fresh concrete, if specified.;
- Density of fully compacted concrete, if specified;
- Cover to embedded steel;
- Curing;
- Tolerances in dimensions;
- Tolerances in levels;
- Surface finishes;

PROJECT OFFICER/PMC's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the CONTRACTOR.

For work not accepted, PROJECT OFFICER/PMC may review and decide whether remedial measures are feasible to render the work acceptable. PROJECT OFFICER/PMC shall in that case direct the CONTRACTOR to undertake the remedial measures. These shall be expeditiously and effectively implemented by CONTRACTOR. Nothing extra shall become payable to CONTRACTOR by EMPLOYER for executing remedial measures.

4.35 MODE OF MEASUREMENT AND PAYMENT

The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment because of such items and leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the Schedule of Quantities. No extra claim shall also be entertained due to change in the number, position and/ or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift, lead of scaffolding, etc. All these factors shall be taken into consideration

while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

Payments for concrete will be made based on unit rates quoted for the respective items in the Schedule of Quantities.

Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned up to the underside of slabs.

The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement, etc. complete. Reinforcement and inserts shall be measured and paid for separately under respective item rates.

Only the actual quantity of steel embedded in concrete including laps as shown on drawings or as approved by PROJECT OFFICER/PMC shall be measured and paid for, irrespective of the level or height at which the work is done. The unit rate for reinforcement shall include all wastage, binding wires, chairs, spacer bars, etc. for which no separate payment shall be made.

Where the formwork is paid for separately, it shall be very clearly understood that payment for formwork is inclusive of formwork, shuttering, shoring, propping, scaffolding, de-shuttering, etc. complete. Only the net area of concrete formed (shuttered) shall be measured for payment.

Where reinforcement is supplied by EMPLOYER, the quantity of chairs and spacer bars shall be measured for accounting wastage only.

Cost of Admixtures shall be deemed to be included in the rates and no separate payment shall be made.

5 PIPE WORKS

5.1 SCOPE

This specification covers the general requirements for manufacture/fabrication, supplying, laying, jointing, testing and commissioning of welded steel pipeline (either plate welded or spiral welded) above/below ground, including associated civil works required for the same.

5.2 STANDARDS

The following details, standards, and codes are part of this specification. All standards, specifications and codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions.

In case of discrepancy between this specification and those referred to herein, this specification shall govern.

IS: 269	Specification for 33 grade Ordinary Portland cement
IS: 383	Specification for coarse and fine aggregate from natural sources for concrete.
IS: 432 (Part-1)	Specification for Mild Steel & Medium Tensile bars and hard drawn steel wire for concrete reinforcement: Part 1 Mild steel and medium tensile steel bars.
IS: 432 (Part-2)	Specification for Mild steel & Medium Tensile steel bars and hard drawn steel wire for concrete reinforcement: Part 2 Hard drawn steel wire.
IS:456	Code for practice for plain and reinforced concrete.
IS:800	Code of practice for general construction in Steel.
IS: 814	Covered Electrodes for manual metal arc welding for carbon and carbon manganese steel-Specification
IS:816	Code of practice for use of Metal Arc Welding for General Construction in mild steel.
IS:817	Code of practice for Training and Testing of Metal Arc Welders
IS:1182	Recommended practice for Radiographic examination of Fusion Welded Butt Joints in steel plates
IS: 1367	Technical supply conditions for threaded steel fasteners
IS:1566	Hard drawn steel wire fabric for concrete reinforcement

IS: 1786	High yield strength deformed Steel bars and wires for concrete reinforcement.
IS:1916	Steel cylinder pipe with concrete lining and coating-Specification
IS: 2016	Specifications for Plain Washers
IS: 2062	Steel for general structural purposes-Specification.
IS: 2595	Code of practice for Radiographic Testing
IS:2720	Methods of test for soils.
IS: 3589	Steel pipes for Water and Sewerage (168.3 to 2540 mm outside dia)- Specification
IS: 3600	Methods of testing of Fusion Welded Joints and Weld metal in steel
IS: 3613	Acceptance tests for wire flux combination for submerged arc welding
IS: 3658	Code of Practice for Liquid Penetrant Flaw Detection
IS: 4353	Submerged Arc Welding of Mild Steel and Low Alloy Steels-Recommendations
IS: 4853	Recommended Practice for Radiographic inspection of fusion welded butt joints in Steel Pipes
IS: 5334	Code of practice for Magnetic Particle Flaw Detection of welds
IS: 5504	Specifications for Spiral welded pipes
IS: 5822	Code of Practice for laying of electrically welded steel pipes for water supply
IS: 6419	Welding rods & bare electrodes for glass shielded arc welding of structural steel.
IS: 6631	Steel pipes for Hydraulic Purposes-Specification
IS: 7307	Approval tests for welding procedures

IS: 7310	Approval tests for welders working to approved welding procedures
IS: 7322	Specials for steel cylinder reinforced concrete pipes- Specification
IS: 8041	Specification for Rapid hardening Portland cement
IS: 8112	Specification for 43 grade Ordinary Portland cement
IS: 10748	Hot-rolled steel strips for welded tubes and pipes
IS: 10221	Code of practice for coating and wrapping of underground mild steel pipeline
IS: 11906	Recommendation for cement mortar lining for cast iron, mild steel and ductile iron pipes and fittings for transportation of water.
IS: 12269	Specification for 53 grade Ordinary Portland cement
IS: 12330	Specifications for Sulphate Resisting Portland cement
IS: 14846	Sluice valves for water work purposes. (50 to 1200 mm size)- Specification
BS 5155	Specification for Butterfly valves
AWS: S -5.1	Specifications for Mild Steel Covered Arc Welding Electrodes
AWS: A-5.17	Specification for Bare Mild Steel Electrodes and Fluxes for submerged arc welding
ASTM E 94	Recommended Practices for Radiographic Testing
ASTM E 109	Dry Powder Magnetic Particle Inspection
ASTM E 138	Wet Magnetic Particle Inspection
ASTM E 165	Liquid Penetrant Inspection

5.3 **MATERIALS**

Spiral welded pipes manufactured from HR Coils conforming to IS:10748 Grade 3 steel.

Plate welded pipes manufactured from Mild Steel plate milled plate conforming to IS:2062 Grade B steel.

Pipe fittings, specials and stiffeners shall be of mild steel conforming to IS:2062 Grade B steel.

Cement - Ordinary Portland cement conforming to IS:8112

Aggregate - The aggregate shall conform to IS: 383.

Water - The water used in preparation of concrete mix shall conform to the requirements of mixing water specified in IS: 456.

Steel for reinforcement shall conform to IS: 1786 or IS: 432 (Parts 1 and 2)

Welding consumables - such as electrodes, filler rods and wires shall conform to IS: 814, IS: 3613, IS: 6419 and IS: 7280.

When requested by the PROJECT OFFICER/PMC, the Contractor shall provide test samples of the materials to be used in the works for different tests. The cost of such tests shall be borne by the Contractor and shall be included in his item rates.

5.3.1 Plate Welded Pipes

All pipes shall be manufactured out of mild steel plate milled plates conforming to IS:2062 Grade B steel. The procedure of cutting plates to size, rolling of plates, post bending, tack welding, internal and external welding, facing should be such that it results in pipes of required diameter and thickness conforming to IS:3589, or equivalent or better international standards.

5.3.2 Spiral Welded Pipes

All spiral welded pipes shall be manufactured as per IS: 5504. The requirements for weldable hot-rolled carbon steel strip in coils should conform to IS: 10748 Grade 3. The process of manufacture should be such that it results in pipes conforming to IS: 3589/IS: 5504 or equivalent international standards. All specials shall be manufactured out of mild steel milled plates conforming to IS:2062 Grade B steel.

5.3.3 Thickness and Diameter

The wall thickness and diameter of pipe shall be as mentioned below except as otherwise specified

Internal Diameter (mm)	Outside Diameter before Coating (mm)	Nominal Wall Thickness (mm)
1800 ID spirally welded /plate welded pipe	1848	12

5.3.4 Length of the pipe

Steel pipes of lengths ranging from 6 to 12 meters shall be fabricated to suit to Contractor’s methodology of works. The permissible variation in pipe lengths shall be in accordance with IS: 3589.

5.3.5 Pipe Ends

Pipes shall have bevelled ends suitable for welding in accordance with IS: 3589 or as shown in Drawings.

5.3.6 Demonstration

The Contractor shall make necessary arrangements to demonstrate at the pipe manufacturing mill individual items of work before commencement of works and during the works at intervals specified and as directed by the PROJECT OFFICER/PMC. No payment shall be made in this regard.

The works under demonstration shall include but not limited to the following:

- (i) Manufacture of pipe and specials
- (ii) Chemical and mechanical testing of pipes and specials
- (iii) Machine and manual welding to qualify 'Welding Procedures'
- (iv) External coating/Guniting
- (v) Cement mortar lining
- (vi) Hydraulic testing after cement mortar lining at 6 bar pressure

5.3.7 Specials

Specials shall be fabricated from IS: 2062 Grade B Steel. The Specials, such as tees, Y-pieces, bends, tapers, etc. shall be in accordance with IS: 7322/BS 534/AWWA C208 and ASME standards and tested and laid in the same manner as the pipes.

Standard fittings shall be used wherever possible in preference to fabricated fittings. Standard fittings shall be manufactured in accordance with standards specified above. Where fabricated fittings are supplied, with approval of PROJECT OFFICER/PMC they shall be fully workshop fabricated and tested in accordance with above standards.

Tee and Branches on steel pipelines must be reinforced by welding reinforcement collars around the base of the branch and in the case of large diameter branches, increasing the main pipe wall thickness or making use of crotch plates.

The fittings shall be designed and if considered necessary by the PROJECT OFFICER/PMC, fabricated by a specialist Contractor and the design calculations and Drawings shall be submitted to the PROJECT OFFICER/PMC for approval. For oval shaped collars the width given in the above table shall be at the narrowest point. All other fittings, tees, branches, crosses and bends are to be designed by the fabricator.

5.3.8 Tolerances

Tolerances for pipes shall be in accordance with IS: 3589 except for the following:

1. Negative tolerance on pipe wall thickness is not permissible.
2. The permissible tolerances for specials for diameter, arm length and angular deviation shall be in accordance with IS: 7322/BS 534.

5.3.9 Electrodes

The Contractors shall use appropriate type and size of electrodes with suitable flux covering depending on the wall thickness of pipe and the type of joint. They shall also use standard current and voltage required for the machine in use as per manufacturer's directions. Welding electrodes shall conform to IS: 814 and IS: 4353. Electrodes from reputed manufacturers shall be used with the approval of PROJECT OFFICER/PMC. Wherever possible, Indian made or equivalent foreign made electrodes of the approved quality shall be used. The Contractor shall provide suitable equipment and ovens to keep the electrodes dry at the desired baking temperature.

5.3.10 Welding

Upon receipt of the order and prior to the start of works, the Contractor shall submit to the PROJECT OFFICER/PMC for his approval the 'Welding Procedure Method Statement' he intends to use for the field welding.

All components of pipe shell; either straight or bent etc. shall be welded by use of automatic arc welding machine by submerged arc process with alternating current. The strength of the joint shall be at least

equal to that of the parent material. Manual welding shall be adopted only when machine welding is not possible.

The Contractor shall use electrodes of approved make and size, the size depending on the thickness of plate and the type of joint. Standard current and arc voltage required for the machine shall be used with necessary modifications as may be found necessary after experimental welding. For this purpose, samples of welded joints shall be prepared and tested in the presence of the PROJECT OFFICER/PMC for qualifying the Welding Procedure Method Statement. Only approved welding procedures shall be used throughout the work and if any modifications are to be made, the written permission of the PROJECT OFFICER/PMC shall be obtained.

All the shop and field welding shall conform to IS: 4353, IS: 9595 and IS: 816.

All longitudinal / spiral and circumferential joints shall be Single-V or Double-V butt joints with or without backing plates. After completing the welding joints of pipes or plates from one side, and before the welding on the other side, the joints shall be back chipped/gouged and ground to remove irregular penetration till the even surface is exposed. Gouging shall be resorted to when the plate thickness is above 6 mm.

All circumferential welds involving plates of unequal thickness shall be so kept that the inside surface of plates match to provide stream lined joints without alteration in the internal diameter.

The welding shall be of the best workmanship free from weld defects. In order to maintain a good standard in welding, welders shall be tested by the Contractor before they are entrusted with the job. Qualification standard for welding procedures, welders and welding operators shall conform to IS: 7307 and IS: 7310. Only those who pass the test shall be allowed to work on the job. Periodical tests as regards their competence shall also be taken at suitable intervals and those found incompetent shall be removed from the job. If an incompetent welder has already welded some pipes, all welding done by him previously shall be fully checked by X-ray in addition to the regular X-ray inspections. The defects if any shall be rectified to the satisfaction of the PROJECT OFFICER/PMC. All such check tests and rectification of defects shall be entirely at the cost of the Contractor. No pipes or steel sections shall be erected unless the work of the welder concerned has been proved to be satisfactory and qualified. Site welds shall be done by welders qualified for the various welding positions as per applicable IS codes and standards.

A record shall be maintained showing the names of welders and operators who have worked in each individual joint. Manual arc welding shall preferably be carried out by a pair of welders so that, by observing proper sequence, distortion can be avoided. A joint entrusted to a particular individual or a pair shall be as far as possible, completed by them in all respects, including sealing run. No helper or other unauthorised person shall be permitted to do any welding whatsoever.

The weldment should not become brittle or sensitive to blows and there should be no loss of toughness due to welding or heat treatment. The material after welding and heat treatment shall match with the base metal properties including original ductility. The weld should in no point be less than the nominal thickness of plate. A slight reinforcement as per IS codes shall be maintained on all weld joints. Final welding of closure gaps should be carried out within a temperature range of average air temperature $\pm 8^{\circ}$ C.

5.3.11 Radiograph of welded joints

Soon after welding, each longitudinal / spiral and circumferential welded length, the minimum length of the weld at random for each pipe shall be radiographed to detect welding defects, as per the requirements of IS: 4853 and as directed by PROJECT OFFICER/PMC. This sampling will be at random to ensure 100% coverage of junctions of longitudinal / spiral and circumferential joints. If the results of such radiography fail to conform to the requirements, the Contractor shall carry out at his expense 100 % radiography test for the pertinent pipe as directed and fully satisfying the PROJECT OFFICER/PMC.

The percentage breakdown of radiography is as follows:

Pipes and Specials manufactured at Mill / Factory: 10%

Field joints welded at site: 5%

The weld ripples or weld surface irregularities and slag etc., on both inside and outside shall be removed by any suitable mechanical process to a degree such that resulting radiographic contact due to any remaining irregularities cannot mark or be confused with that of objectionable defect. The radiograph shall be made in strict accordance with the latest requirements and as per the latest and most efficient technique either with X-ray or gamma ray equipment. The safety requirements during radiography shall be in accordance with IS: 2598.

The radiographs are to be marked in such a way that the corresponding portion of the welded seam and the welder can be readily identified. All radiographs will be reviewed by the PROJECT OFFICER/PMC to identify the defects and determine those which requires rectification. Defects that are not acceptable shall be removed by chipping, grinding or flame gouging to sound metal and the resulting cavities shall be welded. After rectification, the joint is to be radiographed again to prove the quality of the repair. The radiographs will be judged as acceptable or unacceptable by the PROJECT OFFICER/PMC based on the latest standards prescribed by relevant Indian Standard specification.

All X-rays shall be taken with equipment and by personnel of the Contractor. Films shall be developed within 24 hours of exposure and be readily accessible at all times for inspection by the PROJECT OFFICER/PMC. The Contractor shall provide for the use of the PROJECT OFFICER/PMC suitable X-ray viewing equipment. X-ray films shall be properly maintained by the Contractor. A complete set of radiographs and records as described in IS: 2595, for each job shall be retained by the Contractor. All films shall be identified by the number and chart prepared indicating location of any work associated with the pipe erection and such inspection shall be performed by the Radiographer at the discretion of the PROJECT OFFICER/PMC.

5.3.12 Radiographic Inspection of welded joints:

All welded joints to be radiographed shall be examined in accordance with

IS: 2595 - Code of Practice for Radiographic Testing

IS: 4853 - Recommended Practice for Radiographic Examination of Fusion Welded Butt – Joints in Steel Pipes

Radiographers performing radiograph shall be qualified in accordance with SNT-TC-1A. Supplements and Appendices “Recommended Practice for Non-destructive Testing Personnel Qualification and Certification” published by the American Society for Non-destructive Testing as applicable for the technique and methods will be used.

Final acceptance of radiographs shall be based on the ability to see the prescribed penetrometer image and the specified hole.

Sections of welds that are shown by radiography to have any of the following types of imperfections shall be judged unacceptable and shall be repaired.

- (i) any type of crack, or zone of incomplete fusion or penetration,
- (ii) any elongated slag inclusion which has length greater than 6 mm
- (iii) any group of slag inclusion in line that have an aggregate length greater than thickness in a length of 12 times thickness, except when the distance between the successive imperfections exceeds 6 L where L is the length of the longest imperfection in the group,
- (iv) Rounded indications in excess of that specified by the acceptance standards given earlier.

5.3.13 Hydraulic Pressure Test at Pipe Manufacturing Mill

A hydraulic test shall be carried out at the mill for each pipe length fabricated. All pipes and specials shall be subjected to hydraulic test after fabrication, but before application of protective coatings and linings.

Prior to testing, the pipe shall be inspected thoroughly and all the apparent defects in welding such as slag, porosity etc. shall be repaired by gouging and re-welding.

Each pipe shall be filled with water slowly and the pressure increased uniformly until the required test pressure is reached. The test pressure shall be as follows:

MS pipes and fittings 6 bar.

The pipe to be tested shall be given a serial number which shall be painted with details such as pipe number, shell thickness, diameter, length etc. It shall be entered in the register to be maintained by the Contractor. The register shall be maintained in suitable format giving the following information for each shell tested:

- a) Serial No.
- b) Pipe No.
- c) Date of test
- d) Specification, diameter and wall thickness
- e) Weight of pipe shell tested
- f) Maximum test pressure
- g) Details of test performance
- h) Name of PROJECT OFFICER/PMC's representative witnessing tests

A copy of these details shall be furnished to the PROJECT OFFICER/PMC.

For indicating the pressure inside the pipe an accurate pressure gauge of approved make duly tested and calibrated for the accuracy of readings shall be mounted on one of the closures which close the pipe ends.

The pressures shall be applied gradually by approved means and shall be maintained for at least 10 minutes or till the inspection of all welded joints is done during which time the pipe shall be hammered throughout its length with sharp blows, by means of a 1 kg. hand hammer.

The pipe shall withstand the test without showing any sign of weakness, leakage, oozing or sweating. If any leak or sweating is observed in the welded joints, the same shall be repaired by gouging and re-welding done after dewatering the pipe. The repaired pipe shall be re-tested to conform to the specified pressure.

If any leak or sweating is observed in pipe shell the pipe under test shall be rejected. The PROJECT OFFICER/PMC shall be supplied with two copies of the results of all the tests carried out.

No pipe shall be transported from the mill to the site and laid unless they have been hydraulically tested.

5.3.14 Tests and Inspection

The Contractor should submit results of inspection and testing covering the following in a suitable proforma, at the time of delivery of pipes in accordance with IS: 3589/IS: 5504. In case of discrepancy between the requirements of the above standards the more stringent conditions shall apply. Each pipe shall be subjected to mechanical and hydraulic tests as per IS: 3589 and the corresponding test certificates shall be furnished along with. The test specimen shall exhibit mechanical and chemical properties not lower than those specified for IS: 2062 Grade B/IS: 10748 Grade 3 steel. The tests should also include determination of yield strength, tensile strength, elongation and bend tests. Tensile tests shall be carried out in accordance with IS: 1894 on a test specimen provided from each lot of 100 lengths of pipe. Guided bend tests shall be carried out in accordance with IS: 3589/IS: 3600. One bend test shall be carried out from each lot of 50 lengths. The tests shall comply with the requirements specified in IS: 3589/IS: 3600.

The Contractor shall submit the following:

- pipe manufacturing process
- grade of pipe
- chemical composition – product analysis
- jointers
- tensile test report
- flattening test report
- weld test reports
- hydrostatic test report
- bend test report
- radiography report
- weld test report

The Contractor should notify the PROJECT OFFICER/PMC, in advance of the procurement of materials and fabrication in order that the Employer may arrange for mill and shop inspection (including third party inspection). The cost of tests including third party inspection shall be at Contractor's expense. The PROJECT OFFICER/PMC in his opinion may reject any or all materials or work that does not meet with any of the requirements of this specification. The Contractor shall rectify or replace such rejected material/performed work at his own cost to the satisfaction of the PROJECT OFFICER/PMC. The PROJECT OFFICER/PMC has the right to have the material tested independently to confirm the quality of the works.

The Contractor shall supply free of cost required specimen of materials for testing by the PROJECT OFFICER/PMC at any time during the progress of work and shall bear the cost of such tests or retests to the satisfaction of PROJECT OFFICER/PMC.

5.3.15 Mechanical Tests

The test plates shall be subjected to all mechanical tests as per the approved Method Statement, or as otherwise reasonably directed by the PROJECT OFFICER/PMC. Tests shall be carried out in accordance with relevant standards. The tests shall include determination of yield strength, tensile strength, elongation and bend tests. Tensile tests shall be carried out in accordance with IS: 1894. One test plate shall be provided for from each lot of 100 lengths

If a test specimen shows defective machining or develops flaws not associated with welding, it may be discarded, and another specimen submitted. The welded joint shall exhibit mechanical and chemical properties not lower than those specified for IS: 2062 Grade B.

Guided Bend test shall be in accordance with IS: 3589 /IS: 3600. One bend test shall be carried out from each lot of 50 lengths. The test shall comply with the requirements specified in IS: 3589 /IS: 3600.

The field welded joints shall be tested in accordance with the procedure laid down in IS: 3600. One test plate shall be taken for every 10 joints and shall be subjected to mechanical and chemical tests as specified above.

5.3.16 Marking

All pipes and specials shall be carefully marked for identification in the field. The marking shall be on the side which will be the inside of the pipe after bending. The marking operation shall be conducted with full size rulers and templates with suitable paints.

The following information shall be clearly mentioned on each pipe and special.

Manufacturer's name with his registered trademark

Pipe / special with its serial number

Process of manufacturer and type of steel
 Outside diameter (mm)
 Pipe wall thickness (mm)
 Length of pipe / angle of bend (in degrees)
 Date of manufacture of pipe and special
 Test pressure

After the hydraulic tests on the specials the direction of flow shall be stamped in a prominent manner.

5.4 JOINTS

5.4.1 General

Unless detailed otherwise, all pipes and fittings shall have welded joints and whereas shown on the Drawings, flanged joints or collar sleeve joints shall be provided.

5.4.2 Welded Joints

The use of butt-welded joints for joining pipes shall be in accordance with Clause 7.3.10 and end preparation shall be in accordance with IS: 3589.

5.4.3 Sleeve collar joints

The use of sleeve collars shall generally be limited to the jointing of pipes at tie-ins. The thickness of the external steel sleeve collar shall be not less than that of the pipe itself and the length a minimum of 300 mm. The sleeve shall be joined to the pipe with an internal full depth structural weld and external sealing welds to allow the joint to be gas tested. A gas testing hole shall be made at each end of the sleeve and for the purpose of gas testing the joints.

5.4.4 Flanged Joints

Flanges shall comply with IS: 7322/BS 4504. The nominal pressure rating shall be at least equal to the highest-pressure rating of the pipes or fittings to which they are attached, but with a minimum PN 16. The Contractor shall fabricate flanges meeting the requirements of pipe sizes under this contract or otherwise to suit the abutting valves or other connections, if they are not readily available. Flanges shall be provided with all necessary nuts, bolts, washers and gaskets, as specified herein. The Contractor shall also supply in suitable containers sufficient graphite grease for application to the bolt threads when joints are made.

5.4.5 Slip on Type Couplings

Slip-on type couplings shall include the following couplings:

- (a) straight flexible couplings
- (b) stepped flexible couplings

Slip-on type couplings shall be procured from approved suppliers whose fittings meet the same Specification.

The preparation of pipe ends for slip-on type couplings shall be in accordance with the requirements of and the tolerances specified by the joint manufacturer. Couplings shall be installed fully in accordance with the manufacturer's recommendations.

Slip-on type couplings shall be protected if buried with Densomastic and Densotape wrapping or similar approved material applied in accordance with the manufacturer's recommendations. Flexible joints shall be harnessed or tied where shown on the Drawings. Flexible couplings shall be supplied with transit protection.

5.5 TRANSPORTATION, HANDLING, STACKING AND INSPECTION

5.5.1 General

All pipes and specials manufactured at the mill shall be transported to the site of laying after cleaning them internally, etc. Vehicles on which pipes are transported shall have a body of such length that the pipes do not overhang. Pipes should be secure during transit. To ensure that laying of pipes is not held up at any time, the Contractor shall maintain an adequate stock of standard specials, flange rings, plug plates, manhole covers and short length of smaller diameter pipelines at site in his field stores in consultation with the PROJECT OFFICER/PMC. Whenever possible, the Contractor shall arrange one full month's requirement of pipes, specials, etc. stacked suitably along the alignment. All gaskets, nuts and bolts flange adaptors and other similar items shall be stored in dry conditions, raised off the ground in sheds or covered areas. Until required for incorporation each rubber ring or gasket shall be stored away from windows, electrical equipment and other materials like oil and chemicals and also from heat and cold. Where items require special storage requirements, the method of storage shall be to the approval of PROJECT OFFICER/PMC and in accordance with manufacturer's requirements. Storage areas shall be set out to facilitate unloading, loading and checking of materials. End covers, and other protection shall not be removed until incorporation of the pipes or fittings into the Works.

5.5.2 Transportation and Handling

The pipes and specials shall be handled in such a manner as not to distort their circularity or cause damage to their surface. Contractor shall provide temporary props in order to prevent any sagging of the pipes while they are stacked in their yard and while transporting to the site of laying. The props shall be retained until the pipes are laid. Details of proposed propping (strutting) system shall be submitted to PROJECT OFFICER/PMC for approval and if required by the PROJECT OFFICER/PMC, the method of propping (strutting) shall be demonstrated and tested at site. Valves shall not be lifted by the spindle.

Pipe handling equipment shall be maintained in good condition and any equipment which in the opinion of the PROJECT OFFICER/PMC may cause damage to the pipes shall be discarded. Under no circumstances shall pipes be dropped, be allowed to strike one another, be rolled freely or dragged along the ground. No defective/damaged pipe shall be used in the works without rectification to the satisfaction of the PROJECT OFFICER/PMC. Any damage to the coating shall be repaired by the Contractor at his own cost to the satisfaction of the PROJECT OFFICER/PMC.

5.5.3 Stacking and Inspection

The Contractor shall keep a responsible representative to take delivery of pipes, specials and appurtenances, etc., transported from the pipe manufacturing factory or a stock yard. Pipes and appurtenances should be handled, stored and stacked in a suitable manner as directed by PROJECT OFFICER/PMC. Padding shall be provided between coated pipes and timber skids to avoid damage to the coating. Gaps must be left between stacked pipes to permit access from one side to the other. The pipes, specials and appurtenances received at site shall be inspected and defects such as protrusions, grooves, dents, notches, damage to the protected coating, etc., shall be pointed out to the PROJECT OFFICER/PMC at site and in acknowledgement challans. Such defects shall be rectified or repaired by the Contractor at his expense, to the satisfaction of the PROJECT OFFICER/PMC. It will be the responsibility of the Contractor to protect the pipes, specials and other items stacked along the alignment against any possible damages or theft.

5.6 **PIPELINE CONSTRUCTION**

5.6.1 General

Laying/Erection of pipes shall be carried out by the Contractor who shall equip himself, at his cost, with all necessary tools, machinery, labour etc., required for the purpose. The pipeline shall be constructed in lengths with a separate full-time gang working on each length.

Except for routine welding of joints, no other work shall be done in the absence of the PROJECT OFFICER/PMC.

The components of the exposed sections of the pipeline such as plates, and pedestals have been so designed that the centres of the plates and pedestals shall coincide at the mean temperature of the locality. For this reason, all works such as fixing flanges, plates etc. in true alignment and in correct position and tack welding pipes shall be done at the mean temperature. For ascertaining the temperature, the Contractor shall provide mercury cups and fix them to the pipe shell from outside and shall also provide thermometers of the required type and range. No extra payment shall be made for this.

5.6.2 Laying Programme

The Contractor shall submit a detailed bar chart for procuring and laying of the pipeline, which shall be subject to the PROJECT OFFICER/PMC's approval. In preparing this bar chart, the Contractor shall plan his activities such that the laying of pipes shall closely follow the procurement schedule and no pipes shall remain stacked at site for a period more than one month or as decided by PROJECT OFFICER/PMC. The Contractor shall submit a procurement schedule of pipes and fittings for PROJECT OFFICER/PMC's approval.

Together with the chart he shall submit a methodology describing how he will carry out this Work within the contractual period and the required resources in terms of construction equipment and other facilities that he shall utilise to complete the Works.

5.6.3 Contractor to Resurvey the Pipeline Route

While setting up the site the Contractor shall undertake a survey of the pipeline route and compare this with the survey supplied at the time of tender and maintain a joint record. Levels are to be taken at 30m intervals and at any sharp changes in level. Where practical, the chainage points shall coincide with those original surveys. Not less than 28 days before commencement of pipe laying the Contractor shall supply the PROJECT OFFICER/PMC, any discrepancies if observed with two hard copies and one computer disk copy of the survey.

The format of the survey shall be identical to the longitudinal sections which formed part of the tender documents and shall be produced using AutoCAD software package. The PROJECT OFFICER/PMC shall supply the Contractor with a computer disk containing a copy of the longitudinal section template file and the Contractor is to use this to produce new drawing files. Details of all the benchmarks which were used in the original survey of that length of pipeline shall be supplied to the Contractor by the PROJECT OFFICER/PMC.

The PROJECT OFFICER/PMC shall resolve any problems arising from discrepancies between the two surveys and supply the Contractor with any revised Drawings that may be required.

No separate payment will be made for this work.

5.6.4 External Guniting

Unless otherwise specified or stated on the drawings the pipeline to be laid underground and the exposed pipeline supported on saddles shall be cement mortar coated.

Coating shall be in accordance with IS: 1916.

- (i) Cement shall be Portland Cement in accordance with IS: 8112
- (ii) The cement content shall be 600 kg/m³ and water: cement ratio by mass shall not exceed 0.3:1
- (iii) A length of 15 cm at each end of the pipe shall be left ungunited to facilitate site welding. The end faces shall be vertical.

5.6.4.1 Mix Proportion

Cement mortar shall consist of 3 parts sand to 1 part cement by volume. The water in the mixture shall be carefully controlled so as to attain the required strength and so that the mortar will not run, sag or segregate.

5.6.4.2 Thickness of coating

The minimum thickness of the coating shall be 30 mm with a positive tolerance of 3 mm and no negative tolerance. Checking of the coating thickness shall be by non-destructive means such as ultrasonic thickness gauge.

5.6.4.3 Surface Preparation

The surface of all pipes to be coated with cement mortar shall be thoroughly cleaned by hand or by sand steel grit blasting if necessary. After cleaning the external surface of pipe shall be given a coat of cement wash.

All oil and greases on the surface of the metal shall be removed thoroughly by flushing and wiping using suitable solvents and clean rags. The use of dirty or oily rags will not be permitted. All other foreign materials shall be removed by buffing or by scrapping and wire brushing. After cleaning, the pipe shall be protected and maintained free of all oil, grease and dirt that might fall upon from whatever source until the pipe has received its cement mortar coating.

If blasting is necessary, all metal surfaces shall be thoroughly blasted to bright metal. Blasted surface which acquire a coat of rust shall be cleaned/reblasted as directed by the PROJECT OFFICER/PMC

5.6.4.4 Reinforcement

Reinforcement for the coating shall comprise of 50 x 50 x 3 mm wire mesh conforming to IS: 1566- and 8-mm dia. bar to IS: 1786. The mesh sheets shall overlap each other by a minimum of 100 mm and be tied with mild steel wire at 200 mm intervals. The reinforcement shall be held off the pipe wall by a series of 10 numbers equally spaced 8 mm dia. reinforcement bars which shall run the full length of the coating. Clear cover to the reinforcement shall be in accordance with IS: 1916.

5.6.4.5 Application

The pressure in the lower chamber of 'Cement Gun' shall be sufficient to produce a nozzle velocity of 115 to 150 m/sec when a tip with 19 mm opening is used. The compressor used shall be of an adequate capacity to maintain a pressure of at least 2.8 kg/cm² at the gun end. The nozzle shall be held at such a distance (65 to 100 cm) and position so that the stratum of flowing materials shall impinge as nearly as possible at right angles to the surface being gunited. All deposits of loose sand shall be removed prior to placing any layer of gunite. Gunite shall be shot in one coat to the specified thickness. Every precaution shall be taken to prevent the formation of sand pockets and if any develop, they shall be cut out and replaced with satisfactory machine placed material. No hand patching will be allowed. The Contractor shall apply the coating in such a manner that no sloughing shall occur at any time during or following its application.

Gunite shall be placed in the top and sides of the pipe, then screeded to a uniform thickness and the ground lines or blocks removed. All rebound, and waste materials shall then be removed by air blowing and gunite placed in the bottom of the fittings and screeded. When completed, the coating shall be concentric with the barrel of an even thickness. The entire surface shall then receive a final flash coat of gunite and shall be steel towelled to a true surface equal in smoothness to the spun lining in such a manner not to impair the bond between mortar and steel plate. The guniting and surface finishing shall complete in set and shall be applied continuously without the use of construction joints. In case, for any reason whatsoever, the cement does not adhere to the walls of pipes and sloughs off, swabbing the pipe with cement slurry shall not be permitted.

If for any reason it is necessary to interrupt the placing of the gunite for a length of time that will result in the material taking a permanent set, a square shoulder shall be formed at the ends of the sections and/or elsewhere by shooting against a back or by working with a trowel or other suitable tools the irregular edges of the material last placed to a clean unbroken surface face perpendicular to the pipe

that will provide a suitable connection or construction joint between such material and the material to be placed subsequently. When performing this work, care shall be taken not to shatter or disturb the material remaining in place or disturb the embedded wire mesh. Before placing fresh material against the surface of such joints, they shall be carefully cleaned and wetted to ensure a good bond between the fresh material and that previously applied.

The ungunited portion at the ends of the pipe lengths left for the purpose of field welding shall be coated with M15 concrete by hand after the field welding and hydraulic testing are completed.

5.6.4.6 Curing

After the mortar has set, but not later than twelve (12) hours after application of the coating, curing shall be commenced. Coating shall be kept continuously moist and in the shade for at least 14 days.

5.6.4.7 Inspection

Pipe coatings shall be inspected prior to transports, to laying site and broken, defective or otherwise unsatisfactory areas may be rejected at any time during construction. All defective areas shall be made good to the satisfaction of the PROJECT OFFICER/PMC. Coating cracks over 0.25 mm wide or over 500 mm long shall be made good.

5.6.4.8 Tests

Compressive strength test of concrete shall be conducted on 150 mm cubes in accordance with IS: 516. The number of tests shall be at least 4 cubes for each age and each water cement ratio for each day's work. The concrete mix shall have a minimum characteristic compressive strength of 25 N/mm² at 28 days.

5.6.5 Epoxy painting

5.6.5.1 General

Unless otherwise specified, pipes and fittings on pipe bridges shall be painted externally. The shop applied painting is to be stopped 150 mm short at each end of pipe to facilitate field welding and then made up on site following testing of the joint.

Painting shall be generally in accordance with general painting specifications mentioned elsewhere in this document except for the following:

All pipes, fittings and ring girders on bridges shall be painted externally with zinc rich epoxy primer and epoxy paint. Both shop and site application are to be done by airless spray equipment. Paints of reputed make and approved by PROJECT OFFICER/PMC shall be used. Thinning or heating of paints will not be permitted except with specific approval from PROJECT OFFICER/PMC and in accordance with manufacturer's instructions.

Each lot of primer and paint used by Contractor shall be accompanied by certified copies of the test results on hardness, impact and heat resistance and resistance to corrosion carried out by manufacturers in accordance with relevant Indian or International standards.

Surface preparation shall be in accordance with manufacturer's instructions, but as a minimum the pipes shall be abrasive blast cleaned to BS 7079 Grade Sa 2.5 or equivalent to achieve surface roughness profile of 40 – 50 microns. The primer shall be applied within 2 hours of surface preparation, before flash rusting can occur. Two coats of Zinc rich epoxy primer shall be applied by spray equipment on the pipes and fittings.

The priming coat shall be uniform in thickness and free from floods, runs, sags, drips, and bare spots. Any bare spots or defects shall be recoated with an additional application of the primer. All defects shall be rectified as per the instructions of the PROJECT OFFICER/PMC.

Though the priming coats become touch dry in 10 to 15 minutes, the finishing coats with epoxy paints shall be applied after allowing the film to cure at least for 48 hours. The final dry film thickness shall be a minimum of 300 microns. This may be achieved by applying in 2 to 4 coats.

On completion of the work, the contractor shall remove any oil stains or paint spots, leaving the pipes and fittings in a clean and acceptable condition.

5.6.5.2 Inspection and Testing

The entire procedure of applying the paint as specified will be rigidly inspected right from the cleaning stage to the application of final coat by the PROJECT OFFICER/PMC. If, at any time, it is found that the procedure of applying the paint or defects noticed, all such painting work done shall be rectified or redone by the Contractor at his own cost, as directed by the PROJECT OFFICER/PMC.

Samples of the paint brought by the Contractor shall be sent to the testing laboratory for testing, as directed by the PROJECT OFFICER/PMC. If any sample is found to be not conforming to the specifications, the entire consignment to which the sample may pertain shall be rejected. Samples shall be taken at intervals at the option of the PROJECT OFFICER/PMC. The entire cost incidental to such testing shall be deemed to be included in the rates quoted by the Contractor.

5.6.6 Buried Pipelines

5.6.6.1 Trenching

Trenching includes all excavation which is carried out either by hand or by machine and shall be carried out in accordance with all general requirements of Specifications for Earthworks in Standard Basic Specifications. In addition to those general requirements, the following requirements shall apply to pipelines:

The width of the trench shall be kept to a minimum consistent with the working space required and having regard to the safety of the trench, the method of laying and jointing the pipe and the need to avoid damage to pipe coating and to provide the minimum horizontal clearance as stated in the table below. The bottom of the trench shall be properly trimmed to permit even bedding of the pipeline.

The portion of the trench which extends from the formation level to not less than 300 mm above the crown of the pipe when laid in its correct position, shall, unless otherwise specified or ordered by the PROJECT OFFICER/PMC, be formed with vertical sides. The clearance between the sides and bottom of the trench and the barrel of the pipe shall not exceed the following, inclusive of any allowances required for temporary trench supports.

Pipe Nominal Bore (mm)	Bottom Clearance (mm)	Side Clearance (mm)
600 to 1000	250	400
1050 to 2750	300	500

The clearance at joints may be increased to allow the joints to be made and inspected; any proposed increase shall be approved by the PROJECT OFFICER/PMC.

All trenches deeper than 1.2 m shall have the trench walls battered or supported to ensure the safety of all persons working in the trench if required. The Contractor is to provide details of these arrangements for approval by the PROJECT OFFICER/PMC prior to any work being undertaken in such a trench.

No excavations with battered sides shall be made in roads, footpaths, private gardens, or within 10 m of any buildings or other structures.

The Contractor shall erect temporary fencing around all open excavations and post warning signs in English and the local language. All fencing shall be at least 1 m tall, rigid in nature and strong enough to prevent people falling into the trench. The Contractor shall also take all other necessary measures to ensure the safety of the public and others.

The maximum length of excavation which may be left open in any length is 500 m. The opening of two lengths within 500 m of each other shall require the approval of the PROJECT OFFICER/PMC.

The excavation shall be kept free of water to allow: placing of bedding, laying of pipes, welding of pipes, inspection and testing of joints, coating of joints, placing of backfill and other activities within the pipe trench, to be carried out in a satisfactory manner.

5.6.6.2 Bedding

The depth and type of bedding shall be as shown on the Drawings or as directed by the PROJECT OFFICER/PMC. Where rock or boulders are encountered, the trench shall be trimmed to a depth of at least 300 mm below the level at which the bottom of the barrel of the pipe is to be laid and filled to a like depth with sand as shown on the Drawings or as directed by PROJECT OFFICER/PMC.

The class of bed and surround to be used are indicated below:

Class of bed and surround	Brief description of bedding material
Class A	Mass Concrete
Class N	Well Graded Sand
Class S	Granular material

Class S bed and surround shall be used on all pipes unless otherwise specified or shown on the Drawings.

The concrete to be used for Class A bedding and surround shall be M15 type. Class A bedding shall be used at all road crossings under the road and for a distance of 5 m back from the back edge of road or footpath.

Class N bed material shall only be used where the pipe trench is founded in hard rock or otherwise as directed by the PROJECT OFFICER/PMC. The sand shall be clean and well graded and free from topsoil, clay or vegetable matter and to the approval of the PROJECT OFFICER/PMC. If the sand supplied is unclean it shall be washed. In no case shall sand containing more than 3.5% by dry volume or 5% by wet volume of clay, loam or silt be accepted. Tests specified for determining silt in sand and organic impurities as described in IS: 383 shall apply.

The graded granular bed material for use in Class S bedding and surround shall consist of durable gravel, crushed stone or disintegrated rock. Selected material excavated from the pipe trench may be used, provided it contains no topsoil, clay or vegetable matter and is to the approval of the PROJECT OFFICER/PMC. Any imported bed and surround materials shall be to the approval of the PROJECT OFFICER/PMC and shall be supplied with certification which gives details of its content, source and grading. In all cases the soluble sulphate and chloride content of the granular material shall not exceed 0.5 % and 0.06 % by weight respectively.

5.6.6.3 Graded Material

The Contractor’s method of grading the excavated material shall be to the approval of the PROJECT OFFICER/PMC. All Class S graded material shall pass through test sieves to IS: 460 (Part 1) in the following proportions by mass:

Aperture Size	Percentage Passing
50 mm	100 %
37.5 mm	90 - 100 %
20.0 mm	35 - 70 %
14.0 mm	25 - 55 %
10.0 mm	10 - 40 %
5.0 mm	0 - 5 %

Construction of Class A bed surround shall be constructed as indicated on the Drawings.

Before placing concrete, the pipes shall be supported near each joint with a padding of compressive material on a precast concrete block. Concrete shall not be placed until the pipes have been jointed, inspected and tested. The concrete shall be placed to ensure full contact with the pipe barrel throughout its length.

The concrete shall be made discontinuous at flexible pipe joints by a diaphragm of fibre board or other compressible material of at least 20 mm thickness extending for the full area of the surround.

No concrete shall be placed around joints of a welded steel pipe until that length of pipe has passed a sectional hydraulic test.

Construction of Class S bed and Surrounds

Class S pipe bed and surround shall be constructed as indicated on the Drawings

The granular material shall be evenly spread over the full width of the formation and lightly compacted to a level slightly higher than level corresponding to the underside of the pipe barrel to allow for settlement of the pipe to the correct level.

Following placement and jointing of the pipe further granular material shall be placed in the trench, special care being taken to fill under the sides of the pipes to ensure full contact with the barrel of the pipe.

Field joints which have not been tested shall be left exposed for a minimum length of 150 mm each side of the joint. The granular material shall then be placed and compacted evenly on both sides of the pipe to a depth of 300 mm above crown of the pipe.

Trench supports shall be withdrawn gradually in accordance with the progress of the fill with the provision that such withdrawal shall not prejudice the safety of the Works.

The contractor shall ensure that the material to the sides of the pipe is adequately compacted in layers having a maximum thickness of 150 mm and that the method of compaction used shall achieve not less than 95 % of the maximum dry density as determined from IS:2720: Part 7

After each section of the pipeline has passed the hydraulic test, the exposed joints shall be backfilled and compacted to the above Specification.

The same general requirements shall apply to Class N bedding.

5.6.6.4 Pipe Laying

Pipes shall be laid in accordance with IS: 5822 unless otherwise specified herein.

The pipeline shall be constructed in lengths with a separate full-time gang working on each length. The work on lengths may proceed concurrently. The programme for pipe-laying shall be submitted to and be approved by the PROJECT OFFICER/PMC at the start of the Contract. Any subsequent changes to the programme shall be submitted to and approved by the PROJECT OFFICER/PMC before work to a different programme is started. Excavation for the pipeline in any one length shall not at any time proceed more than 2 km beyond the end of a hydraulically tested, completed and backfilled length of pipe, unless otherwise approved by the PROJECT OFFICER/PMC. The exposed joints between tested sections shall be disregarded in the above definition.

No metal tools or heavy objects shall be permitted to come into contact with the pipes or fittings. External coated pipe shall be handled at all times with wide non-abrasive canvas, rubber or leather straps or other equipment to prevent damage to the coating. The use of chains, wire slings, or any other handling equipment found to be injurious to the coating shall not be permitted. The timber or skids used to support the coated pipe prior to lowering into the trench shall be properly padded with sufficient bags stuffed with sand or straw for the purpose of protecting the coating. Alternatively, the pipe may be supported alongside the trench on mounds of sand. Any injury to the protective coating from any cause must be repaired before the pipes or fittings placed in the trench. During laying operations, no debris, tools cloth or other material shall be placed in the pipe. Pipes and fittings shall be lowered into the trench with equipment suitable for the weight of the pipes and fittings, and they shall be carefully cleaned before jointing.

Pipes shall be laid accurately to the lines and levels shown on the Drawings, within a tolerance of ± 10 mm.

Pipe alignments shall be straight between bends or curves. Length laid to curves shall only be allowed where shown on Drawings or in accordance with detailed proposals approved by the PROJECT OFFICER/PMC.

Properly painted sight rails shall be supplied and erected, with boning rods of predetermined measurement for the boning of individual pipes to the correct gradient. The sight rails shall be situated vertically above the line of the pipe or immediately adjacent thereto, and there shall at no time be less than three sight rails in position on each length of pipeline under construction to any one gradient.

The Contractor may submit to the PROJECT OFFICER/PMC for his approval an alternative method of the control of pipe laying to the correct levels and alignment.

The joining of pipes shall be made in accordance with the requirements of this Specification. The Contractor shall obtain from manufacturers all special information regarding the handling of the pipes, joints and other fittings and he will be deemed to have made himself thoroughly conversant with all phases of pipe laying before commencing the works,

A "badger" or "bung" about 10mm smaller than the internal diameter of the pipe shall be kept in the pipe at all times, pulled forward as the work progresses. When pipe laying is not in progress, including overnight, the open ends of the pipeline shall be blanked off with a temporary watertight fitting approved by the PROJECT OFFICER/PMC. The pipe shall be suitably held down so that the pipe does not become buoyant in the event of the trench becoming flooded.

To restrict the flow of rain runoff along the trench the Contractor shall plug the trench with backfill material at distances not exceeding 250 m until the pipeline can be filled in. The plugs shall be removed when trench filling is taking place. In granular bedding areas the plugs shall be of clay and shall be left in.

5.6.6.5 Level Control

The criterion for the level to which transmission main shall be laid such that the cover above the crown of the pipe to ground level shall be as specified in the drawings but in no case shall be less than 1200 mm unless otherwise directed by PROJECT OFFICER/PMC.

5.6.6.6 Laying to Curves

Where pipes are to be laid to curves, the deflection at each joint shall not exceed one degree. For sharper curves specifically made bends shall be provided.

5.6.6.7 Lowering and Jointing

The pipe shall be lowered into the trenches such that no part of any shoring is disturbed or damaged and, if necessary, additional temporary struts may be fixed during the lowering operations. Care shall be taken to ensure that the longitudinal joints of two consecutive pipes at each circumferential joint are staggered by 90°. While assembling the pipes, the ends shall have to be brought close enough to leave a uniform gap not exceeding 4 mm. There shall be no lateral displacement between the pipe faces to be joined. If necessary, spiders from inside and tightening rings from outside or other suitable equipment shall be used to bring the two ends in perfect contact and alignment. In no case shall hammering or longitudinal slitting be permitted. Jacking may be permitted for this purpose in particular circumstances and approval by the PROJECT OFFICER/PMC,

When the pipe is properly assembled firmly supported on wooden beams and wedges or by other approved means it shall be checked for correct line and level and tack welded. The tack welded circumferential joints shall then be welded fully.

On completion of the pipe jointing the external portion shall be coated with M15 concrete and the trench and the welding pits shall be cleaned. The welding pit shall be filled with approved bedding material and compacted in 150 mm layers.

5.6.6.8 Floatation

The Contractor shall take proper precautions against the risks of floatation and of flooding of the excavated works and shall make due allowance in his programme for any closure he considers necessary on account of monsoon.

Should any section of the pipeline be affected by floatation in the course of works, the entire work shall be removed and then reinstalled to the satisfaction of PROJECT OFFICER/PMC. The entire cost of laying it again to the correct line and level shall be to account of the Contractor.

5.6.6.9 Steel Props

In order to effectively provide cement mortar lining to the inside of the pipes and to avoid difficulties during the work, it is necessary that the roundness of the pipes is maintained circular till the lining work is taken up. The props shall be moved prior to applying lining. To achieve the same, steel adjustable screw type props of screw or similar approved type consisting of minimum six legs (three props) shall be fixed inside the pipe and the diameter correctly set.

The design and drawings of the props that the Contractor intends to use should be approved by the PROJECT OFFICER/PMC before starting the work. These props shall be fixed vertically at intervals as directed by the PROJECT OFFICER/PMC. The props should be kept in position at least for three days after the encasing of the pipe in that section is completed or until refilling is done to the full height of fill over the pipe in case the pipes are not encased. The props shall be removed only after obtaining permission from the PROJECT OFFICER/PMC

5.6.7 Internal Cement Mortar Lining

All pipes and fittings shall be internally lined with cement mortar in accordance with IS: 11906/AWWA C602. Cement mortar in lining shall be applied in-situ after pipe laying and after sectional hydraulic testing.

- (i) Cement shall be Portland cement in accordance with IS: 8112.
- (ii) Sand used for lining shall be tested with standard sieves as per IS: 460 and requirements specified in IS: 11906
- (iii) The mortar shall stop 100 mm back from the faces of any joints. The end faces shall be vertical

5.6.7.1 Surface Preparation

The interior surface of pipe to be lined shall be cleaned to remove all rust, chemical or other deposits, oil, grease and all accumulations of water, dirt, and debris. The cleaning of the surface shall be carried out by the use of suitable chemical or mechanical means to the approval of the PROJECT OFFICER/PMC. The extent of cleaning shall be to the satisfaction of the PROJECT OFFICER/PMC.

All loose mill scale, dirt, rust, and accumulation of construction debris shall be removed from the interior of the steel pipeline. The pipeline shall be cleaned by use of power-driven cleaner incorporating revolving brushes on rotating arms.

Immediately prior to the travel of the lining machine through the pipeline, all foreign material shall be removed. This includes sand and loose mortar that might have accumulated since the work of preparation of surfaces was completed.

5.6.7.2 Mix Proportion

Proportion of sand to cement shall not be more than 1.5 parts sand to 1-part cement by volume. Mortar composing of cement, sand and water shall be well mixed and of proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the pipe surface. The cement mortar mix shall comply with strength and density requirements specified in IS: 11906/AWWA C602. No admixtures shall be permitted unless approved by the PROJECT OFFICER/PMC.

5.6.7.3 Thickness of lining

Lining shall be uniform in thickness. The lining thickness shall be 14 mm with a negative tolerance of 1 mm and with a positive tolerance of 3 mm.

5.6.7.4 Lining Procedure

The lining shall be placed by centrifugal method in one course by a machine travelling through the pipe and discharging the mortar at a high velocity over all pipe sections and long radius bends. The discharge shall be from the rear of the machine so that the freshly applied mortar will not be marked. The rate of travel of the machine and the rate of mortar discharge shall be mechanically regulated so as to produce uniform thickness throughout. The mortar must be densely packed and shall adhere to the pipe wherever applied.

5.6.7.5 Surface Finish

Mortar lining shall be mechanically trowelled except for the places where hand trowelling is expressly permitted by the PROJECT OFFICER/PMC.

The lining machine shall be provided with attachments for mechanically trowelling the mortar. Both the application and trowelling of the mortar shall take place at the rear of the machine so that the freshly placed and trowelled mortar will not be damaged. The trowel attachment shall be such that the pressure applied to the pipe will be uniform and produce a lining of uniform thickness with a smooth and even finished surface free of spiral shoulders. The finished surface of machine-placed and trowelled linings in pipe shall be examined according to the following procedure.

Thickness of lining shall be ascertained frequently during placing of mortar and trowelling using an approved non-destructive method.

In the stretch of pipe that has been lined and trowelled in each day's run, ten places shall be selected in straight sections of the pipe by the PROJECT OFFICER/PMC. In each of the ten places the thickness of the lining shall be re measured by non-destructive means as directed by the PROJECT OFFICER/PMC.

Defects in lining including but not restricted to sand pockets, voids, over sanded areas, blisters, cracked and dummy areas, and thin spots shall be removed, and the area shall be repaired to the full required thickness of the mortar lining. Defective areas encompassing the full diameter of the pipe shall be replaced by machine. Defective lining rejected at the time of lining shall be removed before initial set of the mortar. Defective lining rejected after initial set shall be replaced or repaired by the most practical method as determined by the PROJECT OFFICER/PMC.

Hair cracks or cracks up to 0.25 mm width and not over 300 mm in length in finished linings may be considered acceptable at the discretion of the PROJECT OFFICER/PMC but larger cracks shall be repaired or removed and redone all as directed by the PROJECT OFFICER/PMC.

5.6.7.6 Hand Application

Cement mortar lining of bends, specials, areas closely adjacent to valves and other such places where machine placing may not be practical shall be performed by hand. The PROJECT OFFICER/PMC may order the correction for any defect by hand application.

Cement mortar for hand work shall be of the same materials as the mortar for machine placed lining.

The areas to be lined shall be thoroughly cleaned as specified earlier and, if necessary, shall be moistened with water immediately prior to placing the hand-applied mortar.

Steel finishing trowels shall be used for the hand application of cement mortar, except at bends the outer edges of hand trowelled areas may be brushed in order to reduce the abutting offset.

All hand finishing work in a section of the pipeline shall be completed within 24 hours after completion of the machine application of mortar lining that section. If necessary, application of mortar lining by machine shall be delayed or stopped to assure compliance with this schedule.

Hand placed mortar shall have a uniform and smooth surface with smooth transitions to adjacent machine placed linings.

5.6.7.7 Curing

Curing shall commence immediately after completion of the mortar lining and hand finishing of a section of pipeline. This shall, however, not be later than 8-hours after mixing of mortar. The lining shall be kept continuously in moist condition for a period of 14 days. During the operation of lining, finishing and curing, exterior surface of the pipe exposed to sunlight shall be sprinkled with enough water to keep the pipe cool. Open ends of pipes shall be suitably closed so as to maintain a moist atmosphere and prevent draught. Curing of mortar lining and simultaneous cooling of the pipeline externally shall be continued even beyond the period of 14 days if so directed by the PROJECT OFFICER/PMC.

5.6.7.8 Tests

Test blocks of the same material as used for the lining shall be made in 150 mm cube moulds and subjected to cube crushing tests. Each block shall be removed from its mould as soon as practicable and cured under the conditions of temperature and humidity identical with those in which the lining of the pipe is cured. The number of tests shall be at least 4 cubes for each age and each water cement ratio for each days work. The works cube strength of the test cube shall not be less than 300 Kg/cm² after 28 days of curing or 170 Kg/cm² of 7 days of curing. The density of the test cube shall not be less than 2300 Kg/m³.

5.6.8 Backfilling

On completion of the pipe laying operations in any section, for a length of about 100 m and while further work is still in progress, refilling of trenches shall be started by the Contractor with a view of restricting the length of open trenches. Pipe laying shall closely follow the progress of trench excavation and the Contractor shall not permit unreasonably excessive lengths of trench excavation to remain open while awaiting testing of the pipeline. If the PROJECT OFFICER/PMC considers that the Contractor is not complying with any of the foregoing requirements, he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trenches. Filling to a level of 300 mm above the crown of the pipe shall be done in accordance with the requirements of the clause on bedding. Care shall be taken during backfilling, not to injure or disturb the pipes, joints or coating. Filling shall be carried out simultaneously on both sides of the pipes so that unequal pressure does not occur. Walking or working on the completed pipeline shall not be permitted unless the trench has been filled with the instructed bedding and surround material up to height of at least 300 mm over the top of the pipe except as may be necessary for tamping etc., during backfilling work.

The remaining portion of the trench shall be filled in with selected excavated material free from and topsoil, vegetation or boulders and clods of earth larger than 75 mm in size. Filling shall be done in layers not exceeding 150 mm in thickness accompanied by adequate watering, ramming etc., so as to be compacted to 95% of the maximum dry density as per Part 7 of IS: 2720. The water contents of the soil shall be kept as near the optimum moisture content as possible. The trench shall be refilled so as to build up to the original ground level, keeping due allowance for subsequent settlement likely to take place. The surface of the refilled excavations shall be left slightly higher than the adjacent ground and be maintained by the Contractor to a smooth even slope.

The PROJECT OFFICER/PMC shall, at all times, have powers to decide which portion of the excavated materials shall be used for filling and in which portion of the site and in what manner it shall be so used.

If suitable material for refilling is not available from already excavated material, the Contractor shall import material of approved quality as directed by the PROJECT OFFICER/PMC.

Regular measurement of the field dry density shall be taken by the Contractor at various levels in the backfilling as required by the PROJECT OFFICER/PMC.

No mechanical plant other than approved compacting equipment shall run over or operate within the trench until backfilling has reached its final level or the approval for the PROJECT OFFICER/PMC has been obtained.

Should any subsidence take place either in the filling of the trenches or near about it during the works the Contractor shall make good the same at his own cost.

Surplus excavated material shall be used to fill in any low spots above the pipeline which are identified on the Drawings or are instructed by the PROJECT OFFICER/PMC. Such material shall be evenly placed and compacted in layers not exceeding 200 mm thick after compaction. The method of compaction employed shall achieve not less than 90% maximum dry density as determined from IS: 2720 (Part 7). Unless approved of by the PROJECT OFFICER/PMC, the width of areas to be filled shall not exceed 20m.

5.7 ABOVE GROUND PIPELINES

5.7.1 General

The procedure for handling the pipes, lowering and assembling specified in previous clauses shall be followed for lifting and laying pipes on supports. The pipeline should be laid either on saddle or ring girder supports as specified in Drawings and directed by PROJECT OFFICER/PMC. No material shall be erected unless they have been previously approved by the PROJECT OFFICER/PMC.

Erection of fabricated pipes shall be carried out by the Contractor who shall equip himself, at his cost, with all necessary tools, machinery, labour etc., required for the purpose. The pipeline shall be constructed in lengths with a separate full-time gang working on each length.

Except for routine welding of joints, no other work shall be done in the absence of PROJECT OFFICER/PMC, either during the day time or at night.

5.7.2 Expansion Joints

Expansion joints are designed to allow for thermal induced movement of pipelines laid above ground.

Expansion joints shall be welded on to pipelines at locations indicated on Drawings. Expansion joints shall be fabricated true to shape and sizes as shown in the drawings. All contact surfaces shall be properly machined and finished smooth to ensure smooth working of the joints. The steel bolts and nuts used in the manufacture shall comply with BS 1083. The joints shall be assembled without undue hammering or forcing in, to avoid damage to any part thereof. The packing material to be used in the expansion joint shall be asbestos synthetic rubber/or any other suitable material and rubber ring as approved by the PROJECT OFFICER/PMC. It shall be capable of withstanding at the test pressure and shall have high compressibility and properties to withstand deterioration by abrasion or water action. For despatch to the site, the expansion joint shall be assembled with steel ring without other packings

using bolts and nuts only in a locked position. The machined surfaces shall be greased before assembly. The remaining bolts, nuts and washers and the packing material including rubber rings shall be supplied by the contractors at the site of laying along with expansion joining.

If any defects are noticed after its erection at site, the Contractor shall carryout necessary repairs either at site or at their works as directed by the PROJECT OFFICER/PMC. All expenses in this connection including its removal, transporting and re-fixing shall be borne by the contractor. The responsibility as regards the defects noticed shall be determined by the PROJECT OFFICER/PMC and his decision shall be final and binding on the Contractor.

Hydrostatic pressure test shall be conducted in accordance with BIS or equivalent international standards for the water tightness of expansion joints. The expansion joints shall prove to be sound and water tight at the time of testing. Any leakage shall be stopped by normal tightening of bolts on the gland.

The rates for expansion joints shall be inclusive of steel plates and other materials required for fabrication, installation, painting and testing.

5.7.3 Laying procedure

Pipes shall be laid in accordance with IS: 5822 unless otherwise specified herein.

The PROJECT OFFICER/PMC will give the Contractor the detailed working drawing showing the positions of the pedestals to be cast in the section, the formation of which is ready for laying the pipeline. Pipe laying shall generally start from the fixity points on either side, the expansion joints being provided last. Fixity points are at all anchor blocks and fixed supports.

Anchor blocks shall be constructed in stages, if specified. The anchorages shall be made from concrete and constructed to the dimensions shown on the drawings:

The concrete pedestals shall be cast at least 3 weeks before the pipeline is laid on them. In case of any errors in casting the pedestals, corrections shall be applied as directed by the PROJECT OFFICER/PMC. The method of joining the pipes and erecting them on the previously cast pedestals shall be determined by the Contractor in consultation with the PROJECT OFFICER/PMC.

The pipe shall be assembled in position on the pedestal by the equipment approved by the PROJECT OFFICER/PMC.

5.8 ANCHOR BLOCKS

Anchor blocks shall be provided at horizontal bends, vertical bends or/and at intervals on pipelines with gradients in excess of 1 in 6 as noted on the Drawings, and at other locations ordered by the PROJECT OFFICER/PMC. The anchorages shall be made from concrete and constructed to the dimensions shown on the Drawings. Where faces of anchor blocks are shown to bear against undisturbed ground, the Contractor shall take all necessary measures to ensure that such bearing is given over the full dimensions shown.

Curves formed by welded bends and pipe lengths will not require anchoring unless specifically shown in the Drawings.

Welded pipelines shown on the Drawings as having tied couplings and flanges shall require anchor blocks only at the positions specifically noted on the Drawings.

5.8.1 Pipework Surrounded by Concrete

When pipework is given a Class A bed and surround or surrounded in concrete at thrust and anchor blocks etc, only bare pipes without any external protection shall be used.

5.8.2 Vertical Thrust Blocks

Vertical thrust blocks shall be located wherever there is a transition between above ground and buried pipelines. The Contractor shall undertake the construction of the thrust blocks as early in the programme

of work as is practical and at least six months prior to the installation of the above ground pipeline, in order to reduce the risk of settlement of imposing additional loads on the pipeline supports.

Where possible the base of the thrust block shall be cast against solid rock in order to prevent any settlement. Any material overlying the rock shall be excavated and replaced with class M15 mass concrete. In the event of no rock being encountered the base of the thrust block shall be cast against undisturbed ground. Any ground which in the PROJECT OFFICER/PMC's opinion is unsuitable shall be excavated and replaced with class M15 mass concrete.

5.9 PIPELINES UNDER EXISTING ROADS

The Contractor shall programme the Works to reduce disruption to road traffic to a minimum, and before any work commences in existing roads shall:

- (i) Obtain the full permission and approval of all authorities concerned serving notices of intent to start work as may be necessary and observing all the local Laws and Regulations
- (ii) Submit details of his proposals, and obtain approval from the PROJECT OFFICER/PMC and local highway authority
- (iii) Constructing of temporary diversion roads

The pipelines crossing roads shall be encased in M15 concrete as shown on the Drawings.

Pipelines which are laid along a road shall be laid in trench. The bed and surround shall be as previously specified but above this the trench shall be backfilled with crushed rock up to the underside of the road sub-base. Not more than 20 % of the crushed rock shall pass through a test sieve with 4.75 mm apertures and all material shall pass through a test sieve having an aperture of 40 mm. The backfill shall be compacted in layers having a maximum thickness of 200 mm and the method of compaction used shall achieve not less than 95 % maximum dry density as determined from IS:2720: Part 7.

5.10 REINSTATEMENT OF ROADS

The replacement of road structures shall be carried out as soon as practicable after backfilling has been completed. Suitable excavated road pavement which complies with the requirements of the PROJECT OFFICER/PMC may be used at the sub-base levels. Compaction shall be carried out with approved mechanical compacting equipment. The depth and type of reinstatement shall consist of the following:

- (i) Laying and compacting 200 mm granular subbase with crushed stone
- (ii) Laying and compacting a 150 mm thick layer of Water Bound Macadam
- (iii) Laying and compacting a 150 mm thick of Built Up Spray Grout
- (iv) Where the carriage way surface adjoining the trench is of rolled asphalt the Contractor shall lay a wearing course of 40 mm thick rolled asphalt

The edges of the trench shall be cut to form a uniform line consistent with the varying width of the trench and the agreed trimming allowances. Any part of the structure of the road which has been damaged beyond the width of trench must be cut out and made good. Prior approval for such additional work must be obtained from PROJECT OFFICER/PMC before additional payment can be considered in cases where the damage was beyond the Contractor's control.

A vertical joint shall be formed between the new work and the existing road surface and shall be painted with hot bitumen or as approved by the PROJECT OFFICER/PMC. The joint between the base course and wearing course shall be stepped 75 mm.

The finished levels of the completed reinstatement shall conform to adjoining carriage way surface

Reinstatement of wearing courses shall match as nearly as practicable the colour or other characteristics of the existing surface.

5.11 INTERNAL CLEANING OF PIPELINE

Pipelines shall be cleaned of all dirt, debris, dust or other deposits by repeated hosing of copious quantities of water on the pipe surface and simultaneously rubbing the surface with gunny cloth to the satisfaction of PROJECT OFFICER/PMC. Cleaning with metal cleaning solution, acid, wire brushes, scrappers or sand paper shall not be permitted.

The section of the pipeline once cleaned shall not be entered into for any purpose later. Sufficient precaution shall be taken to prevent the ingress of any dirt, debris, or dust inside the section. Failing this the section shall be cleaned again at the discretion of the PROJECT OFFICER/PMC.

In the case of above ground pipeline, the length of the section to be taken up for cleaning shall be decided in consultation with the PROJECT OFFICER/PMC from the point of view of ventilation etc.

In case of buried pipeline a section shall be taken up for cleaning after the work of back filling around and over the pipeline is completed and the spiders have been removed from inside with approval of PROJECT OFFICER/PMC.

During the pipe laying operation in the adjoining section, the Contractor shall take all precautions to prevent ingress of water, debris, dirt, etc. in the cleaned section, failing which the section shall be cleaned again at the discretion of the PROJECT OFFICER/PMC. When deemed necessary by the PROJECT OFFICER/PMC suitable closures shall be provided at the open end or the ends of the cleaned sections.

No separate payment will be made for the work of cleaning and providing closures. The rates quoted for the laying of pipes shall include the cost of cleaning also.

5.12 HYDRAULIC TESTING OF PIPELINE

Pipelines and fittings shall be subjected to hydraulic pressure tests in the presence of the PROJECT OFFICER/PMC which shall comply with IS: 5822 unless otherwise specified.

Testing shall be carried out in two stages:

- (i) Test of sections as construction proceeds before internal cement mortar lining
- (ii) A test of the whole of the pipeline on completion

The Contractor shall equip with all plant, equipment, fittings and water necessary for the hydraulic tests. The Contractor shall submit to the PROJECT OFFICER/PMC, well in advance of the time of tests, details of his proposals, including the supply of water either by tankers or boreholes. No connections from the existing pipelines will be allowed, nor will any connections to the pipeline and pipework which would involve cutting, tapping or altering the Permanent Works be allowed.

Test gauges shall be of approved manufacture having dials at least 200 mm diameter, graduated such that the test pressure is at least 75 % of the full scale reading shall be used. If necessary, different gauges shall be supplied for different pipeline sections. Two gauges shall be provided for the sole use of the PROJECT OFFICER/PMC and shall remain in the PROJECT OFFICER/PMC possession for the duration of the Contract. All gauges shall be dead weight tested and calibrated at the commencement of work and at regular intervals as required by the PROJECT OFFICER/PMC.

The Contractor's arrangements for testing shall include a suitable means of quick installation and removal of the PROJECT OFFICER/PMC's gauges during testing.

5.12.1 Testing procedure

The Sectional Hydraulic Test shall be carried out after the pipeline section to be tested has been laid, jointed and backfilled to a depth sufficient to prevent floatation, but leaving the joints exposed which have not been tested. The sections to be tested shall be to the approval of the PROJECT OFFICER/PMC and shall be no longer than 2000 m or 500 m when either the pipeline is laid adjacent

to or underneath the carriageway or when section includes an air valve chamber. The joints between each tested section shall be left exposed until the pipeline has passed the Test on Completion.

In addition to the above requirements the Contractor shall perform a hydraulic test on the first 200 m length of pipeline to be laid under the contract. This test shall be undertaken within one month of the Contractor commencing the laying of pipes. Should the pipeline fail the test or the Contractor fail to undertake the test, all laying and welding work shall come to a halt until that section of pipeline passes a hydraulic test.

Each length of the pipeline to be tested shall be capped or blanked off at each end and securely strutted or restrained to withstand the forces which will be exerted when the test pressure is applied. Testing against closed valves will not be permitted. Washout valves shall be fitted with blank flanges and these together with in-line valves shall be left open. Air valves already fitted shall be permitted to function during the test.

Proposals for testing where thrusts on structures are involved, even where thrust flanges on the piping are installed, shall be submitted, with the calculations of the forces to be carried, to the PROJECT OFFICER/PMC for approval.

The method of filling the pipeline with water shall be approved by the PROJECT OFFICER/PMC. The length under test shall be filled making certain that all air is displaced through an air valve installed at the top of the blank flange situated at the high end of the line. The length shall then remain under constant moderate pressure, 10 to 20 m head of water, for a period of several hours until the pressure can be maintained without additional pumping.

The pressure shall then be slowly increased at a maximum rate of 1 bar per minute to the full test pressure and pumping discontinued for 3 hours or until the pressure has dropped by 10m, whichever occurs earlier. Thereafter pumping shall be resumed and continued until the test pressure has been restored. The quantity of water pumped to restore the pressure shall be the measure of leakage from discontinuation of pumping until its resumption.

The pipe length shall pass the test if the leakage is not more than 0.33 litres per mm diameter per kilometre per 24 hours for each 100m head of pressure applied.

Notwithstanding the satisfactory completion of the hydraulic test, if there is any discernible leakage of water from any pipe or joint the Contractor shall, at his own cost, replace the pipe, repair the pipe or re-make the joint and repeat the hydraulic test.

No pipeline shall be accepted until the leakage on any length is not more than the rate of leakage specified above and all sources of leakage have been rectified.

The Test on Completion shall be carried out after all the pipeline sections have been satisfactorily tested and the joints between each section completed to provide a continuous test length between contract interfaces.

Pipelines shall be tested as above except where the PROJECT OFFICER/PMC issues such instructions as are necessary for testing parts of the Works that have been designed for stresses limited by considerations other than those applying to the pipeline systems.

5.12.2 Test Pressures

Test pressures are to be measured in bars at the centre of the blank flange situated at the lowest end of the pipeline under test. Unless otherwise specified or shown on the drawings pipeline test pressure shall be in accordance with the following:

5.12.3 Steel pipe and fittings 12 mm wall thickness: 6 bar

Test pressures for sections of pipeline containing air valve chambers shall be such that the pressure at the chamber does not exceed valve design pressure as specified by manufacturer.

5.13 PIPELINE DISINFECTION

Upon completion of a newly laid main, the main shall be cleaned, disinfected and dewatered as directed by the PROJECT OFFICER/PMC.

The internal surfaces of pipeline, specials and appurtenances shall be disinfected using chlorine solution in accordance with procedure specified in IS: 5822. Alternative methods may be adopted with the approval of the PROJECT OFFICER/PMC. The chlorinated water shall stand in pipeline for a minimum period of 24 hours and all valves in the system shall be operated twice during this period.

The chlorinated water shall be neutralised and disposed off as directed by PROJECT OFFICER/PMC.

After final flushing and before the pipeline is placed into service, water samples shall be collected and tested for bacteriological quality and shall not indicate the presence of califorms. If the initial disinfection fails to produce satisfactory results, disinfection shall be repeated until satisfactory samples are obtained.

The Contractor is expected to carry out the cleaning, disinfecting and dewatering work as a part of laying the pipes and his rates for laying the pipes should include the cost of cleaning and other related works.

5.14 MARKINGS

Details like valve type, size, and cistern number shall be painted on all valve chambers as directed by PROJECT OFFICER/PMC.

In case of the pipeline laid above ground details such as chainage, invert levels of pipe, pedestal/saddle number, culvert number, anchor/thrust block number etc., shall be suitably painted either on the pipeline or the supporting structure in distinct colour.

5.15 RING GIRDER SUPPORTS

Unless specified otherwise ring girders are to be used to support pipe work on all pipe bridges. They shall be fabricated from IS: 2062 Grade A steel and supported by pipe bridge piers.

On the day the pipe is tack-welded, the proposed ring girder center shall be marked on the pedestal. If the pipeline is on a slope, correction for the slope shall have to be applied.

The bolt shall then inserted into the bolt holes, and the plate be placed in position.

The base plate must be true in relation to the line and the level.

The line of the base plate is seen by dropping plumb and at right angles to the horizontal diameter. It shall assume the slant of the ring girder and shall have a good fit with the ring girder, elastomeric bearings.

The welding of the stool shall be done symmetrically, so as to prevent creep and heat distortion. If distortion takes place the welding operation shall have to be redone after adjusting the stool again in its true position. Hence this welding must be done with extra care under strict supervision. Immediately after the stool is welded, it shall be checked again to see if there is any distortion.

If a gap is noticed between bearings and the stool plate, the base plate may be adjusted by use of steel shims and grouted.

The stool shall be checked to see that the plate in contact with bearings has no curvature, and shall be rejected if found defective, i.e., if the variation is more than 1.5 mm.

With all the checks mentioned above, the centre of the base plate shall not fall out from the centre of the ring girder at mean temperature by more than 12 mm on either side.

This shall be checked every day from the starting fixed point to the next. Where the error exceeds 12mm, it must be immediately rectified in consultation with the PROJECT OFFICER/PMC.

Where ring girders are to be fixed on the pipe in the field, spiders must be used on inside during the operation.

Either compensating pipes or longer cants shall be used to get the ring girders in correct centres where required.

5.16 SADDLE SUPPORTS

Where the Pipes are to be laid on continuous saddle supports (continuous over base of pipe) the pipe shall be erected at mean temperature of locality as specified in drawings. The saddle support shall have a reinforcement plate, for the part circumference of the pipe base that will make contact with the saddle.

Where pipes are to be laid on concrete saddles discontinuous over base of pipe, the pipe shall be supported on pads at four locations separated by drainage gulleys formed in concrete, spread over an arc subtending an angle of 120° at the centre of the pipe.

The pads shall be Grafted asbestos sheets or teflon pads, stuck to pipe surface as well as on to MS pads embedded in concrete to ensure smooth sliding of pipe in the longitudinal direction. The pads shall be stuck to the steel surface by using Araldite.

5.17 BENDS

Bends shall be fabricated taking into account the vertical and horizontal angles for each case.

The bends shall have welded joints and the upstream and downstream ends of each bend shall have a straight piece of variable lengths as required.

Large bends shall be designed with deflection angle of maximum 10° between segments.

When the point of intersection of a horizontal angle coincides with that of a vertical angle, or when these points can be made to coincide, a single combined or compound bend shall be used, designed to accommodate both the angles. The combined bend should have a pipe angle equal to the developed angle arrived at from appropriate formula.

Details of anchor bolts, holding down straps, collars, saddle plates should be furnished together with full specifications in Contractor's fabrication drawing.

5.18 MANHOLES

Manholes shall be placed at locations as shown in drawing and as directed by the PROJECT OFFICER/PMC. Manholes in the pipeline shall be placed in suitable position in the top quadrant.

The Contractor shall fabricate different parts of manhole in conformity with relevant IS Specification, well established practices and as directed by the PROJECT OFFICER/PMC.