VOLUME – II B
CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

SPECIFICATION NO. PE-TS-999-600-C003

SECTION - D

GENERAL TECHNICAL SPECIFICATION

FORMWORK

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

TABLE - IV

SCHEDULE OF REMOVAL OF FORM

Part of Structure	Ordinary Portland Cement Concrete Temperature Deg.C				Rapid Hardening Portland Cement Concrete Temperature Deg.C			
	Above 40 Deg.C	40 Deg.- 20 Deg.	20 Deg.-Below 5 Deg.	5 Deg.	Above 40 Deg.	40 Deg.- 20 Deg.	20 Deg.- Below 5 Deg.	5 Deg.
	Days	Days	Days	Days	Days	Days	Days	Days
a) Columns & Walls	2	1	1	Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength	1	1	1	Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength
b) Beam sides	3	2	3		2	1	1	
c) Slabs, 125 mm	10	7	8		7	4	5	
d) Slabs over 125 mm thick and soffit of minor beams	18	14	16		12	8	9	
e) Soffit of main beams	24	21	22		14	10	12	

Wherever exposed surfaces of concrete can be effectively sealed to prevent loss of water, the periods specified for temperature above 40 Deg.C can be reduced to those of the temperature range of 20 Deg.C to 40 Deg.C subject to approval of the Engineer.

Construction joints in beams, if required to be provided, will be located within the middle third of span according to clause 3.13.1(b) of this specification. In such cases, however, entire span of beam shall have to be kept supported by formwork till its removal for the portion of beam, cast at a later date, is due and so approved by the Engineer.

If any type of cement other than ordinary portland cement and Rapid hardening portland cement is used the time of removal or forms shall be revised as approved by the Engineer such that the strength of this cement at the time of removal of forms match with strength of portland cement at

the time of removal of form as mentioned above . This has to be supported by regular tests.

3.20.6 **Tolerance**

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as shown on the drawings subject to the following tolerances unless otherwise specified in this Specification or drawings or directed by the Engineer :

For

a) Sectional dimension - ± 5 mm

b) Plumb - 1 in 1000 of height

c) Levels - ± 3 mm before any deflection has taken place

The tolerance given above are specified for local aberrations in the finished concrete surface and should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Any error, within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

3.20.7 **Re-use of Forms**

Before re-use, all forms shall be thoroughly scraped, cleaned, joints and planes examined and when necessary repaired, and inside surface treated as specified hereinbefore. Formwork shall not be used/re-used if declared unfit or unserviceable by the Engineer.

3.20.8 **Classification**

Generally, the 'ordinary' class formwork shall be used unless otherwise directed by the Engineer :

a) Ordinary : These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) Plywood : These shall be used in exposed surfaces, where a specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. Re-use may only be permitted after special inspection and approval

by the Engineer. He may also permit utilisation of used plywood for the 'ordinary' class, if it is still in good condition.

c) Ornamental: These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

3.21 **Opening, Chases, Grooves, Rebates, Blockouts etc.**

The Contractor shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings or as specified by the Engineer.

3.22 Anchor Bolts, Anchors, Sleeves, Inserts, Hangers/Conduits/Pipe and Other misc. Embedded Fixtures. The Contractor shall build into concrete work all the items noted below and shall embed them partly or fully as directed and secure the same as may be required. The materials, if required to be supplied by the Contractor, shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Engineer. Exposed surfaces of embedded materials are to be painted with one coat of approved anti-corrosive paint and/or bituminous paint. If welding is to be done subsequently on the exposed surface of embedded material the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be required or directed by the Engineer. Items to be embedded.

a) Inserts, hangers, anchors, frames around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.

b) Anchor bolts and plates for machinery, equipment and for structural steel work.

c) Steel structurals to be left embedded for future extension, special connection etc.

d) Lugs or plugs for door and window frames occurring in concrete work.

e) Flashing and jointing in concrete work.

f) Any misc. embedments and fixture as may be required.

Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.

3.23 Expansion and Isolation Joints

3.23.1 General

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Engineer. All materials are to be procured from reliable manufacturers and must have the approval of the Engineer. Where it is the responsibility of the Contractor to supply the material, the Engineer may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Engineer before starting the work.

3.23.2 Bitumen Board/Expanded Polystyrene Board

a) **Bitumen Board**

Bitumen impregnated fibre board of approved manufacturer as per IS:1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

b) **Expanded Polystyrene Boards**

If required, commercial quality\of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Engineer. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of Bitumen paint may have to be applied on the board against which concrete will be placed.

3.23.3 Joint Sealing Strips

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure.

The sealing strips will be non-metallic like rubber or P.V.C.

Sealing strips will not have any longitudinal joint and will be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Engineer. The Contractor is to supply all labour and material for installation including the material and tools required for jointing, testing, protection, etc. If desired by the Engineer, joints in rubber seals may have to be vulcanised.

Non - metallic sealing strips will be normally in Rubber or P.V.C. Rubber or P.V.C. joint seals can be of shape having any combination of the following features :

i) Plain

ii) Central bulb

iii) Dumb-bell or flattened ends

iv) Ribbed and Corrugated Wings

v) V shaped

As these types of seals can be easily handled in very large lengths, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer.

The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or as approved by the Engineer taking particular care to match the central bulbs and the edges accurately.

a) **Rubber Sealing Strips**

The minimum thickness of Rubber sealing strips shall be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings of items and/or as directed by the Engineer. The material will be natural rubber and be resistant to corrosion, abrasion and tear and also to attacks from the acids, alkalis and chemicals normally encountered in service. The physical properties will be generally as follows. The actual requirements may be slightly different as decided by the Engineer :

Specific Gravity : 1.1 to 1.15

Shore Hardness	:	65A to 75A
Tensile Strength	:	25 - 30 N/Sq.mm
Maximum Safe Continuous Temperature	:	75 Deg.C
Ultimate Elongation	:	Not less than 350%

b) **P.V.C. Sealing Strips**

The minimum thickness of P.V.C. sealing strips will be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings/schedule of items and/or as directed by the Engineer. The material should be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows. The actual requirements, which will be directed by the Engineer, may vary slightly :

Specific Gravity	:	1.3 to 1.35
Shore Hardness	:	60A to 80A
Tensile Strength	:	10 - 15 N/Sq.mm
Maximum Safe Continuous Temperature	:	70 Deg.C
Ultimate Elongation	:	Not less than 275%

3.23.4 **Joint Sealing Compound**

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS:1834.

Alternatively, when directed , the expansion Joints may be filled with joint sealing compound like "Sikalastic" or approved equivalent and shall be applied as per manufacturer's specification.

3.23.5 **Isolation Joints**

Strong and tough alkathene or PVC sheet about 1 mm in thickness and as approved by the Engineer shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

3.23.6 **Rubber Pad**

Hard foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings or as directed by the Engineer. The rubber shall have a unit weight of 1500 Kg/Cu.m, a shore hardness - 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

3.24 **Grouting under Machinery or Structural Steel Bases**

If required, grouting under base plates of machines or structural steel etc. shall be carried out by the Contractor. In general, the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Engineer, 6 mm down stonechips may have to be used in the mix. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. If desired by the Engineer, admixtures like Aluminium powder, 'Ironite' etc. may have to be added with the grout in proportions to be decided by the Engineer. Admixture, if directed to be added, will be measured and paid separately.

Alternatively non-shink , free flow, cementious grout like "Sikagrout 214/ Ankor NSG" or approved equivalent specifically selected for the type of equipment to be located (vibrating, static etc.) may also be used for grouting as per manufacturer's specification with necessary approval of the Engineer.

3.25 **Precast Concrete**

The Specification for precast concrete will be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose.

This yard shall be dry, properly levelled and having a hard and even as well as well drained surface to prevent excessive uneven settlement due to softening of soil during casting & curing. If the ground is to be used as a

soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer, casting will have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 10 (Ten) days of curing and can be removed for erection after 28 (twenty eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal and must be rigid enough to prevent distortion during placing and compaction of the concrete.

Other than normal curing by applying water through spray nozzles or perforated hose curing by high pressure steam, steam vapour or other accepted processes may also be employed to accelerate the hardening of the concrete and to reduce the curing time.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

All members shall be imdelibly marked with a unique identification mark on a surface which will not be permanently exposed to show on which production line they were manufactured , their type , the class of concrete, the data of casting and if they are of a symmetrical section the face which will be uppermost when the member is in its correct position after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials and men to the Engineer for checking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Engineer. If centerings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar where called for in the drawings.

3.26 Waterproofing of Concrete Structure

3.26.1 General

Waterproofing of concrete structures shall be done by either suitable extraneous treatments like applying waterproofing paints like "Sikatop Seal"

fixing bitumen felts etc. or internally by suitable design of the concrete mix, addition of suitable admixtures conforming to IS:2645 and equivalent American or British codes in the concrete or mortar at the time of mixing and/or installing water bars at the joints.

The design, material and workmanship shall conform to the relevant I.S. Codes where applicable. The Engineer's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Engineer, test certificates for the materials and samples shall be submitted by the Contractor. The materials shall be of best quality available indigenously, fresh clean and suitable for the duties called upon.

3.26.2 **Water Bar/Seal/Special Treatment of Construction Joint**

Water bearing structures and underground structures may have water bar/seals installed at the joints. They may be rubber or P.V.C. The materials and installation will be as described under Clause 3.23.3. Construction joint should be provided as per clause 3.13.1 with or without water bar / Seal as shown on the drawing. In case of water bars being used at the construction Joint, fixing of the same has to be done carefully so that the water bar is not disturbed during concreting. The construction joint shall also be treated by any one of the following methods :

Method 1 : A surface retarder in the form of a thixotropic gel shall be applied on the joint surface of the previous pour in case of joint on the wall and in case of floor the same shall be applied on the formwork against which previous pour of concreting shall be done. The retarder may be liquid or paste form depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting in case of walls. The above bonding agent will be mixed with water which will be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer's specification. In case of floor joint, however, after washing of retarder a solvent free two component epoxy resin bonding agent will be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days :

Compressive strength	-	55 to 60 N /Sq. mm
Flexural Strength	-	25 to 30 N /Sq. mm.
Tensile strength	-	15 N Sq. mm (approx)
Bonding strength to concrete	-	3 N / Sq. mm (approx)
Bonding strength to steel	-	20 N / Sq. mm (approx)

The whole operation shall be done as per manufacturer's specification. The contractor shall provide manufacturer's supervision.

Method 2 : One row of threaded nozzles at regular intervals not exceeding 1.5 m centre to centre shall be placed in concrete along the construction joint during casting. Injection of cement water together with a suitable waterproof expanding grouting admixture of approved quality shall be done through the nozzles after the construction joint in walls and slabs. The injection shall be done under pressure of approximately 2 to 4 Kg/Sq cm . The nozzles shall be sealed off with suitable admixture after the injection is over. The whole operation shall be carried out as per manufacturer's specification and supervision.

3.26.3 **Waterproofing Admixtures**

The waterproofing admixture for concrete and cement mortar / plaster shall conform to relevant IS code. The admixture shall not cause decrease of strength of concrete / plaster at any stage and it is free from chlorides and sulphates. The admixture shall not affect the setting time by more than 5 %

The maximum permissible dosage of admixture will be 3% (three percent) by weight of cement but a lower dosage will always be preferred.

The product shall be stored in strong moisture proof packings.

However, in case of important structures where M25 or higher grade concrete is specified, the use of melamine based, high range water resistant concrete admixture shall be used to provide a waterproof concrete around 410 Kg/ Cm.m a melamine based super plasiticizer will be preferable.

a) In concrete : The approved admixture shall be based on modified lignosulphonate like "Plastocrete - N/Super" or approved equivalent. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer. The Contractor shall have the services of the manufacturer's supervisor to supervise the work, if desired by the Engineer.

b) In Plaster : The concrete surface, to be plastered, shall be hacked to Engineer's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture like "Noleak CP/Sika Latex" or approved equivalent and laid in appropriate thickness and in layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the

Engineer. If desired by the Engineer, the Contractor shall have the work supervised by the manufacturer's supervisor. On completion, the plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

3.26.4 **Bituminous or Tar Coating on External Surface**

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacturer and quality as per IS:216 (not heated above 375 Deg.F) using not less than 2 Kg. per Sq.M. or with hot asphalt i.e., bitumen according to IS:73 (not heated above 400 Deg.F) using not less than 1.5 kg. per Sq.M. When the first coat has completely dried up and approved by the Engineer, the second coat shall be applied in the same manner using not less than 1.25 Kg. per Sq.M. in case of coal tar and 1 Kg. per Sq.M. in case of asphalt. Immediately after application of the second coat and before it is dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before backfilling is done in order to allow the final coat to dry up completely. In place of hot application by coal tar / asphalt the coating of the outside surfaces of walls may be carried out using a ready to use liquid, bituminous emulsion/rubber protective coating of approved manufacturer.

3.26.5 **Protective Coating on Inside Surface**

Two coats or cement based to components polymer modified flexible protective and waterproofing slurry having 1 mm thick for each coat shall be applied on the walls/ floor after proper surface preparation as mentioned above. The slurry shall be applied by brush.

3.26.6 **Bitumen Felt : Application for Tanking**

This specification shall cover laying the waterproof course on the outside and inside of the walls and bases of structures.

The materials shall conform to IS:1322, and the workmanship to IS:1609. The bitumen felt shall be hessian base and/or fibre base as specified in Drawing/Schedule of Items. If required by the Engineer, tests as specified in relevant IS Codes shall be arranged by the Contractor.

The Contractor shall execute this work in direct collaboration with one of the well known specialised approved by the Engineer.

Cleaning the surface, keeping it dry, providing necessary corner fillets and cement rendering and cutting chases, etc. shall be included in the rate for this item. If any protective brickwork on/against concrete sub-bases or walls are required, these will be paid extra under suitable items in the contract. A 20

(twenty) years' guarantee for satisfactory performances shall be given by the Contractor as well as his specialist sub-contractor jointly and severally, for this item of work. Free rectification of any defects noted in the work within this guarantee period will be carried out by the Contractor even if it is beyond the specified maintenance period of the contract as a whole.

3.26.7 Polyethelene Films : Application in Walls or base of Structures

Waterproof treatment shall be applied as outlined and as per sequence given hereunder :

i) the concrete surface shall be made smooth with 12 mm cement plaster 1:6

ii) apply hot bitumen 80/100 grade (IS:73-1961) at the rate of 1.0 Kg/Sq.m minimum

iii) lay black polyethelene film 250 micron (IS:2508-1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed, taking care not to puncture the film.

Alternatively, the overlaps shall be heat sealed by an electric iron having three parallel sealing bars. A long piece of plywood is to be placed below the polyethelene film to be heat sealed. On the plywood a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a celophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another celophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat sealing, the celophane tape is to be removed and the joints are to be tested for leaks.

iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen.

v) Lay hot bitument 80/100 grade (IS:73-1961) at 1.0 Kg/Sq.m minimum.

vi) Lay 250 micron polyethelene film as second layer similar to (iii) above.

vii) Lay second layer of 100 gm. brown craft paper laminated similar to (iv) above.

viii) Apply hot bitumen (straight run grade) to IS:73-1961 at 1.0 Kg/Sq.m dusted with fine sand.

ix) Protecting with a layer of 75 mm plain cement concrete M-100, or a layer of brick laid in cement mortar 1:6. In case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

3.27 **Protective coating on Concrete Surface**

3.27.1 **On Foundation**

The outside faces of foundation of important structures will be protected from adverse effect of soil/ underground water, if shown on drawing or instructed by the Engineer , by using bitumen emulsion protective coating of approved manufacturer.

3.28 **Waterproofing by Pressure /Chemical Grouting**

Where required, waterproofing for underground concrete structure shall be done by injecting high polymer based non- shrink waterproof grouting compound through nozzle under pressure as per manufacturer's recommendation. The pressure during injection shall not be less than 2.5 kg/Sq.cum and the thickness of epoxy resinous emulsion waterproof paint (to be applied on the external surface of walls/slabs) shall not be less than 700 microns.

4.0 **SAMPLING AND TESTING**

4.1 **General**

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in this specification. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

4.2 **Cement**

Representative samples will be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths. Soundness Tests may also be required to be carried out if required by the Engineer. The tests shall be carried out free of charge by the Owner if cement is supplied by him. In case the Contractor is directed to arrange for the supply of cement as per the terms and conditions of the Contract the tests shall be carried out by him. In case due to any circumstances, the agency of supply is changed in the middle of the Contract, the party who bore the original contractual obligation will carry on with the test, free of charge to the other, till the end of the job. No cement from a particular consignment/batch will be used on the works unless satisfactory 3 (three) days and 7 (seven) days test results for compressive strength are known. The Owner, Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the Owner or the Contractor. These tests are of great importance as their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

4.3 **Aggregates**

The Contractor shall carry out any or all the tests aggregates as may be required by the Engineer in accordance with IS:2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

4.4 **Water**

Sampling and Testing of water being used for concrete works as per IS:3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The final acceptance criteria in case of doubt will be as per IS:3025 & IS:456.

4.5 **Admixture**

4.5.1 **Air Entraining Agents** (A.E.A)

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cube crushing strength vis-a-vis quantity of A.E.A. used for all types of concrete will be established by the Contractor by carrying out sufficiently large number of tests. After then, at regular intervals and whenever directed by the Engineer, the Contractor will check up the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

4.5.2 **Other Admixtures**

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Contractor.

4.6 **Concrete**

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS:516 and IS:1199 the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Engineer may require other tests to be performed in accordance with IS:516.

Sampling procedure, frequency of sampling and test specimen shall conform to Clause 14 of IS:456.

To control the consistency of concrete from every mixing plant, slump tests and/or compacting factor tests in accordance with IS:1199 and as mentioned in Clause 3.6 of this Specification shall be carried out by the Contractor every two hours or as directed by the Engineer. Slumps corresponding to the test specimens shall be recorded for reference.

The acceptance criteria of concrete shall be in accordance with Clause 15 of IS:456.

Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant formwork and reinforcement, embedded fixtures, etc. wasted in the dismantled portion shall be made. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good to the satisfaction of the Engineer.

5.0 ACCEPTANCE CRITERIA

5.1 Standard Deviation

Standard deviation shall be based on test results and determination of Standard deviation shall conform to clause 16 of IS:456.

5.2 Acceptance Criteria

The strength requirements and acceptance criteria shall conform to Clause 16 of IS:456.

5.3 Inspection and Core Tests

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to Clause 17 of IS:456.

5.4 Load Test

Load tests of structural members may be required by the Engineer, when the strength of test specimen results fall below the required strength, as per 'Load Test on Parts of Structures', Clause 17.6 of IS:456. If load testing is decided by the Engineer, the member under consideration shall be subjected to a test load equal to 1.25 (one and a quarter) times the specified live load used for design and this load shall be maintained for a period of 24 (twenty four) hours before removal. The detailed procedure of the test is to be decided by the Engineer. Load tests shall not be made until the structure is at least 56 days old.

If the member shows evident failure, such changes as are necessary to make the structure adequately strong shall be made by the Contractor. Alternatively, if permitted under Statutory Regulations and at the discretion of the Engineer, the structure under test or a portion thereof may be retained as such without any modification by derating its load bearing capacity, provided the design criteria allows such derating.

A reinforced concrete beam, floor or roof shall be deemed to have passed the test if the maximum deflection at the end of 24 hours does not exceed the deflection given in Clause 17.6 of IS:456.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification.

If, in the course of dismantling, any damage is done to the embedded items and or other adjacent structures, the same will be made good by the Contractor to the satisfaction of the Engineer.

6.0 LIST OF I.S. CODES AND STANDARDS FOR REFERENCE

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not specifically covered by Indian Standard Specifications, any other standard practice, as may be specified by the Engineer, shall be followed :-

IS : 73 - Indian Standard Specification for Paving Bitumen

IS : 216 - Indian Standard Specification for Coal Tar Pitch

IS : 269 - Indian Standard Specification for 33 grade Ordinary Portland Cement

IS : 383 - Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete

IS : 432 - Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement - Part 1 & 2

IS : 455 - Indian Standard Specification for Portland Slag Cement

IS : 456 - Indian Standard Code of Practice for Plain and Reinforced Concrete

IS : 457 - Indian Standard Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive Structures

IS : 516 - Indian Standard Specification for Methods of Test for Strength of Concrete

IS : 737 - Indian standard specification for wrought Aluminium and Aluminium Alloy sheet and strip for general Engineering purpose. IS : 1199 - Indian Standard

		Specification for Methods of Sampling and Analysis of Concrete
IS : 1200	-	Indian Standard Specification for Method of (Part-II) Measurement Cement Concrete Works.
IS : 1200	-	Indian Standard Specification for Method of (Part-V) Measurement of Formwork
IS : 1322	-	Indian Standard Specification for Bitumen Felts for Waterproofing and Damp-proofing
IS : 1489	-	Indian Standard Specification for Portland - Pozzolona Cement - Part 1 & 2
IS : 1566	-	Indian Standard Specification for hard drawn steel wire fabric for concrete reinforcement.
IS : 1609	-	Code of Practice for Laying Damp-proof Treatment using Bitumen Felts
IS : 1786	-	Indian Standard Specification for high strength deformed Bars & wires for Concrete Reinforcement
IS : 1791	-	Indian Standard Specification for Batch Type Concrete Mixers
IS : 1834	-	Indian standard specification for hot applied sealing compound for joint in concrete.
IS : 2062	-	Steel for general structural purpose.
IS : 2185	-	Indian Standard Specification for Hollow and solid / solid light wt. Cement Concrete Blocks - Part - 1 & 2
IS : 2210	-	Indian Standard Specification for Design of Reinforced Concrete Shell Structures and Folded Plates
IS : 2386	-	Indian Standard Specification for Methods of Test for Aggregates for Concrete - Part-I to VIII
IS : 2430	-	Indian standard specification for method of sampling of Aggregate for concrete.
IS : 2502	-	Indian Standard Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement
IS : 2505	-	Indian Standard Specification for Concrete Vibrators Immersion Type
IS : 2506	-	Indian Standard Specification for Screed Board Concrete Vibrators

IS : 2514	-	Indian Standard Specification for Concrete Vibrating Tables
IS : 2645	-	Integral Cement water proofing compound
IS : 2722	-	Indian Standard Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket type)
IS : 2751	-	Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction
IS : 2770	-	Indian Standard Specification for Method of Testing Bond in Reinforced Concrete. Part - 1 : Pull out Test
IS : 3025	-	Indian Standard Specification for Methods of Sampling and Test (Physical and Chemical) for Water & waste water - art - 1 to 37
IS : 3201	-	Indian Standard Specification for Design and Construction of Precast Concrete Trusses and purlins.
IS : 3370	-	Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids Part 1 to 4
IS : 3384	-	Indian standard specification for / Bitumen primer for use in waterproofing and Danp proofing
IS : 3414	-	Code of practice for Design and Installation of joints in Buildings
IS : 3550	-	Indian Standard Specification for Method of Test for Routine Control for Water used in Industry
IS : 3558	-	Code of Practice for use of Immersion Vibrators for Consolidating Concrete
IS : 3696	-	Safety Code for Part-1 : Scaffolding and Part 2: Ladders
IS : 3812	-	Indian Standard Specification for Fly Ash for Use as Pozzolone & Admixture
IS : 4031	-	Indian Standard Specification for Method of Tests for Hydraulic Cement - Part - 1 to 14
IS : 4082	-	Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site
IS : 4090	-	Indian Standard Specification for Design of Reinforced Concrete Archs

IS : 4634	-	Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixers
IS : 4656	-	Indian Standard Specification for Form Vibrators for Concrete
IS : 4925	-	Indian Standard Specification for Concrete Batching and Mixing Plant
IS : 4926	-	Indian Standard Specification for Ready Mixed Concrete
IS : 4990	-	Indian Standard Specification for Plywood for Concrete Shuttering work
IS : 4991	-	Indian Standard Specification for Blast Resistant Design of Structure for Explosion above ground
IS : 4995	-	Indian Standard Specification for Design (Part-I of Reinforced Concrete Bins for the Storage & II) of Granular and Powdery Materials
IS : 4998	-	Indian Standard Specification for Design of (Part - I) Reinforced Concrete Chimneys
IS : 5512	-	Indian Standard Specification for Flow Table for use in Tests of Hydraulic Cement and Pozzolanic Materials
IS : 5513	-	Indian Standard Specification for Vicat Apparatus
IS : 5515	-	Indian Standard Specification for Compaction Factor Apparatus
IS : 5751	-	Indian Standard Specification for Precast Concrete Coping Blocks
IS : 5816	-	Indian Standard Specification for Method of Test for Splitting Tensile Strength of Concrete Cylinders
IS : 5891	-	Indian Standard Specification for Hand Operated Concrete Mixers
IS : 6452	-	Indian Standard Specification for High Alumina Cement for Structural Use
IS : 6909	-	Indian Standard Specification for Supersulphated Cement
IS : 6923	-	Indian Standard Specification for Method of Test for performance of Screed Board Concrete Vibrators

IS : 6925	-	Indian Standard Specification for Method of Test for Determination of Water Soluble Chloride in Concrete Admixtures
IS : 7242	-	Indian Standard Specification for Concrete Spreaders
IS : 7246	-	Indian Standard Specification for Table Vibrators for Consolidating Concrete
IS : 7251	-	Indian Standard Specification for Concrete Finishers
IS : 7320	-	Indian Standard Specification for Concrete Slump Test Apparatus
IS : 7861	-	Indian Standard Specification for (Part-I Recommended Practice for hot and cold & II) Weather Concreting
IS : 7969	-	Safety Code for Storage and Handling of Building Materials
IS : 8041	-	Indian Standard Specification for Rapid Hardening Portland cement
IS : 8043	-	Indian standard specification for hydrophobic cement
IS : 8112	-	Indian Standard Specification for 43 grade Ordinary Portland Cement
IS : 8142	-	Indian Standard Specification for Determining Setting time of Concrete by Penetration Resistance
IS : 8989	-	Safety Code for Erection of Concrete Framed Structures
IS : 9013	-	Indian Standard Specification for Method of Making, Curing and Determining Compressive Strength of Accelerated - cured Concrete Test Specimens
IS : 9077	-	Code of Practice for Corrosion Protection of Steel Rails in RB and RCC Construction
IS : 9103	-	Indian Standard Specification for Admixtures for Concrete.
IS : 9417	-	Recommendation for welding cold worked bars for reinforced concrete construction
IS : 10262	-	Recommended Guideline for concrete Mix Design
IS : 12269	-	Indian standard specification for 53 gradeordinary portland cement

IS : 12330 - Indian standard specification for sulplate resting portland cement

IS : 12600 - Indian standard specification for low heat portland cement