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**MOD CIVIL DIVISION**

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TECHNICAL SPECIFICATIONS

**REV. 00**

**NIT NO. MOD/CIVIL/10051142**

**TECHNICAL SPECIFICATIONS**

**FOR**

**WORK OF CONSTRUCTION OF PRESS SHOP EXTENSION TOWARDS  
SOUTH SIDE INCLUDING MACHINE FOUNDATION**

**SECTION-III**

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**PROJECT DESCRIPTION:**

The tendered work envisages civil construction works pertaining to Electrical Machines capacity augmentation scheme to be carried out inside BHEL Bhopal factory premises.

The scope of work broadly consists of:

(1) Extension of press shop Block towards south side.

Extension shall comprise of constructions of two bays (i) 160.02m X 18.92m having height 18.3m with EOT crane of 30T capacity at 14.80m height (ii) 83.82m X 18.59m having height 11.72m with EOT crane of 10T capacity at 9.144m height including toilet units.

(2) Construction of various machine foundations either in the extended block or in Existing block of electrical machine.

I) CNC vertical Borer

II) Radial Arm Drilling M/C

III) CNC lathe 600 swing

IV) Hydraulic Umbrella press 180Ton

V) Putty pressing M/C – LEM

VI) Vacuum pressure impregnation Plant

VII) Electrically heated oven -500 KW

VIII) Balancing Machine - LEM

IX) Balancing Machine -IMM

X) 30 ton battery power system for inter section movement on rails.

XI) 12 Ton battery power system for inter section movement on rails.

XII) Test plant augmentation & Up-gradation – I MM

XIII) Test plant augmentation & Up-gradation - LEM

XIV) Programmable loop winding m/c

XV) Automatic hydraulic coil pulling machine

XVI) CNC vertical machining centre

The above scope may undergo some changes based on BHEL final requirement. Based on BHEL requirement, the work of similar nature may be executed at places other than specified above inside factory premises.

**BRIEF SCOPE OF WORK**

1. Substructure shall be of RCC grade of specified strength.
2. Superstructure shall be of structural steel members.
3. Side of the block shall be of Puff Insulated Galvalume sheet with brick Masonry Enclosure upto certain height from the floor level.
4. Roofing- Puff Insulated Galvalume Sheeting
5. Machine Foundation shall be of RCC of specified Grade.
6. Floor shall be industrial floor comprising of following layers
  - Boulder Soling
  - Lean concrete cement of Grade 1:3:6
  - RCC grade slab (M-20) of Specified Thickness.
  - Hardonite topping of 52mm.

**Note:-**

*1) Contractor may be required to protect the already executed work either done by them or other agency at their own expense for working in vicinity of such works, so as to avoid damaged to the already executed work. This may required temporary barricading covering or other measures as may be necessary for protecting the already executed works.*

*2) The contractor must satisfy himself by personal study and examination of the drawings / specifications furnished and understand thoroughly the scope of proposed work in detail and all conditions affecting the work before entering into the contract. There shall not be at any time dispute / complaint of any misunderstanding with regard to scope of work and interpretation of specifications or any misunderstanding with regard to nature or omission of the work to be done not shall any application for compensation in terms of time and money shall be accepted by company regarding the above.*

*3) The contractor shall arrange enabling works temporary in nature like construction of approach road to work site (if not available), cement godown, site office etc at their own expense.*



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**TECHNICAL SPECIFICATIONS****REV. 00****ABBREVIATIONS**

In the technical specifications, as well as in the bill of quantities, the following abbreviations have been used:

Cu. M.	Cubic Metre
Sq. M.	Square Metre
R. M.	Running Metre
Q. R.	Quote Rate
NO.	Numbers

**1.0 Specification for material****1.1 Cement****1.1.1 Standard**

Cement to be used in the Works shall conform to the following standards:

33 Grade Ordinary Portland Cement	IS: 269
43 Grade Ordinary Portland Cement	IS: 8112
53 Grade Ordinary Portland Cement	IS: 12269
Rapid Hardening Portland Cement	IS: 8041
Portland Slag Cement	IS: 455
Portland Pozzolana Cement(fly ash based)	IS: 1489 (Part 1)
Portland Pozzolana Cement (Calcinated clay based)	IS: 1489 (Part 2)
Low heat Portland cement	IS: 12600
Hydrophobic Cement	IS: 8043
Sulphate resistant Portland cement	IS 12330

Other relevant standards are as follows:

Method of Sampling Hydraulic Cement	IS: 3535
Methods of Physical Tests for Hydraulic Cement	IS: 4031(Part 1 to 15)
Methods of Chemical Analysis of Hydraulic Cement	IS: 4032

**1.1.2 SUPPLY**

The cement to be used for the Works shall be Ordinary Portland Cement (OPC).

Supply for cement for the Works shall be arranged by BHEL as per the provisions of the tender. Unless otherwise specified, OPC or PPC shall be supplied I bags containing 50kg each. The storage cement bags should be provided by the Contractor at the site of Works at his own cost, considering IS specifications for storage.

The CONTRACTOR, if asked by the Owner or his representative to provide double locking arrangement, shall do so at his cost. If such an arrangement is made, the key of one lock shall be with the CONTRACTOR and the key of the other lock shall be with the Engineer-in-charge or his representative.

**1.1.3 Tests**

Cement shall be kept, at all times, in covered storage in an approved manner. No cement shall be kept on the site longer than three months before use. Any cement, which is stored onsite in excess of 28 days, shall be tested in accordance with relevant Standard prior to use.



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Sufficient cement for one week's consumption shall at all times be available. Cement shall be consumed in the sequence in which it is received at the store.

The cement store for bagged cement shall be a weatherproof building or shed, ventilated, lit and free of dampness. The size will be sufficient to hold enough cement for continuous execution of the works. Bags for cement shall be lined in polythene or other damp-proof material.

Exposed Concrete: Concrete in parts of the Works which remain exposed to view, shall be made from the same batch of cement to ensure that surfaces have a consistent tint or shading.

**1.2 COARSE AGGREGATE****1.2.1 STANDARD**

Aggregates for use in concrete (other than light-weight concrete) shall comply with the requirements of IS 383. As far as possible preference shall be given to natural aggregates.

Coarse aggregate shall have a specific gravity as per mix design report. Aggregate below this specific gravity shall not be used without the special permission of the Engineer.

Coarse aggregate shall consist of natural or crushed stone, angular in shape with granular or crystalline surfaces or approved river shingle or gravel, rounded in shape. All aggregate shall be clean and free from elongated, friable, flaky or laminated pieces, adherent coatings, clay lumps, mica, organic matter and any other deleterious matter that may cause corrosion of reinforcement or impair the strength and / or durability of concrete. It shall be chemically inert, hard, strong, dense, and durable against weathering.

The maximum quantities of deleterious materials in the coarse aggregate shall not exceed the limits indicated in the IS 383 when tested as per IS 2386 Part-I & Part-II "Method of Tests for Aggregate for Concrete".

**1.2.2 SOURCE**

Once a specific source of supply of coarse aggregate is accepted, the source shall not be changed without prior approval of the Engineer. If quality of any other source is good then it can be accepted after approval of the Engineer-in-charge.

**1.2.3 STORAGE**

Coarse aggregate to available sizes shall be stored at site as separate stacks over clean and well maintained hard floor and areas not liable to flooding. Alternatively, they will be stored in bins.

Contamination with foreign matters and earth during storage and while heaping the materials shall be avoided. It shall be kept in layers not exceeding 1.2m in height to prevent coning or segregation.

Each type and grading of aggregate shall be stored separately in bins, in such a manner that mixing of the various size particles does not occur and shall be sloped sufficiently to ensure adequate drainage of surplus water.

Sufficient quantities of each type of aggregate shall be maintained on site at all times to ensure continuity of work.

**1.2.4 USAGE**

Coarse aggregate, which is not clean, shall be washed with clear fresh water before use in the job. Screening should be done, if considered necessary by the Engineer, without extra cost.



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**TECHNICAL SPECIFICATIONS****REV. 00****1.2.5 TRANSPORTATION**

During transportation to the site, all aggregates are to be protected from wind-borne contaminants. Should these contaminants be present at the time of delivery to site, then the aggregates shall be washed with water meeting the requirements of the above clauses/gradation. Transport vehicles shall be cleaned from possible contamination due to previous use.

Note: When aggregates have been approved, the entire supply of each type shall be secured from the approved source. Testing shall be carried out at the frequently specified below to ensure that the same quality and grading of the material is being maintained.

Tests shall be carried out at the following frequency:

Tests for clay silt and dust, moisture content and sieve analysis shall be carried out on every 20 tonnes of fine aggregates and 40 tones of coarse aggregates or as directed by Engineer-in-charge.

Chemical analysis shall be carried out on every 100 tonnes.

**1.3 FINE AGGREGATE****1.3.1 STANDARD**

Fine aggregate for different end uses (other than light-weight concrete) shall conform to the following standards:

- |    |                         |  |
|----|-------------------------|--|
| a. | For structural concrete | IS: 383 (between Grading Zones I & II) |
| b. | For mortar & grout      | IS 2116                                |
| c. | For plastering          | IS 1542 (Class A Grading)              |

Fine aggregate shall consist of natural sands or machine crushed rock/gravel. It shall be clean, sharp, hard, strong and durable and free from dust, vegetable substances, adherent coating, clay, loam, alkali, organic matter, mica, soluble sulphate, gypsum or any other deleterious substances which can be injurious to the setting qualities / strength / durability of concrete.

The use of sea sand is prohibited.

**1.3.2 SOURCE**

Once a specific source of supply of fine aggregate is accepted, the source shall not be changed without prior approval of the Engineer. If quality of any other source is good then it can be accepted after approval of the Engineer-in-charge.

**1.3.3 STORAGE**

Fine aggregates shall be stored at site in adequate quantity on clean and well-maintained hard floor and areas not liable to flooding. Contamination with foreign matter and earth, during storage and while heaping the materials, shall be avoided.

**1.3.4 USAGE**

Fine aggregate shall be thoroughly washed at site with clean fresh water such that the percentage of all deleterious matter is within the permissible limits as laid down in IS 2386 (Part-II).



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Screening of sand shall be done, if necessary and as directed by the Engineer-in-charge, to remove all objectionable foreign matter and affecting any grading.

**1.4 WATER****1.4.1 STANDARD**

Water supplied shall conform to the various provisions detailed under Clause 5.4 of IS 456:2000. Broadly stated, water used for mixing and curing as also for cooling / washing of aggregates shall be clean and fresh, free from oils, acids, alkalies, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Sea water or water from excavation shall not be used. And also, this water can be used for mixing grouts, rinsing aggregates.

Potable water is generally considered satisfactory for mixing concrete. As a guide, the following concentration represents the maximum permissible values:

To neutralise 100ml sample of water, using phenolphthalein as an indicator, it should not require more than 5ml of 0.02N NaOH. The test shall be conducted as detailed in Cl. 8.1 of IS 3025 (Part 22).

To neutralise 100ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02N H<sub>2</sub>SO<sub>4</sub>. The test shall be conducted as detailed in Cl. 8.1 of IS 3025 (Part 22). The test shall be conducted as given in Cl. 8 of IS 3025 (Part 23).

Permissible limits for solids shall be as given in the table below:

No.	Type	Tested as per	Permissible max. limit
1.	Organic	IS 3025 (Part 18)	200 mg/L
2.	Inorganic	IS 3025 (Part 18)	3000 mg/L
3.	Sulphates (as SO <sub>3</sub> )	IS 3025 (Part 24)	400 mg/L
4	Chlorides(as Cl)	IS 3025 (Part 32)	2000 mg/L for concrete not consisting of embedded steel and 500 mg/L for reinforced concrete work
5.	Suspended matters	IS 3025 (Part 17)	2000 mg/L

**1.4.2 STORAGE**

Water shall be so stored that it remains free from all deleterious matter as mentioned above.

**1.4.3 TESTS**

No water shall be used until tested for its chemical and other impurities in accordance with IS 3025 to ascertain its suitability. Tests shall be conducted whenever the source is changed or during seasonal variation.

**1.5 STEEL REINFORCEMENT**
**1.5.1 STANDARD**

Steel reinforcing bars shall conform to the following standards:

Mild steel and medium tensile steel bars	IS 432 (Part I)
High strength deformed steel bars	IS 1786
Hard drawn steel wire fabric	IS 1566
Structural steel, Grade A	IS 2062

Binding wire shall conform to IS 280 and shall be soft drawn mild steel wire of size not less than 1.5 mm. in dia. (16 g.) soft annealed/galvanized steel wire.

All reinforcement shall be free from loose mill scales, loose rust and coats of paints, oil, mud or any other substances, which may destroy or reduce bond.

**1.5.2 SUPPLY**

Supply of reinforcement for the Works shall be arranged by BHEL as per the provisions of the tender.

**1.5.3 STORGE**

Storage of materials shall be as described in IS 4082.

**2.0 SPECIFICATION FOR WORKMANSHIP**
**2.1. GENERAL**

In case of omissions or discrepancies, the specifications mentioned in IS 456-2000 shall be final. Surplus of cast concrete and completed plaster shall be marked with the completion dates.

**2.1.1. STANDARD**

In all cases the work shall be carried out in accordance with the latest Indian Standard Specifications and the best engineering practice. In the absence of such specifications, work shall be executed in accordance with any other relevant standards issued elsewhere as approved by the Engineer or as per the instructions and directions of the Engineer.

**2.1.2. CONSTRUCTIONAL PLANT**

The CONTRACTOR shall be responsible for the supply, use and maintenance of all Constructional Plant and Equipment so as to ensure smooth and efficient working of the job. The Engineer shall have access to the Plant at all times. In case of total/partial break down of plant, stand-by/alternative arrangements be made available.

**2.1.3. WORKMEN AND STAFF**

The CONTRACTOR shall ensure that he employs only capable and experienced labour force, foremen, other tradesmen and supervisory staff on the job capable of handling the types of





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work they are required to handle in a workman-like and efficient manner to the satisfaction of the Engineer. He shall also ensure that his Sub-Contractors or nominated Sub-Contractors also employ all workmen and supervisory staff capable of delivering work of high standard.

For all concrete work, a fully qualified and experienced quality control engineer shall be employed by the CONTRACTOR and he shall be available on Site at all times when concreting operations are in progress. Operators for mixers, mechanical vibrators and personnel in-charge of placing of concrete shall be fully trained and experienced for their class of work.

### 2.1.4. DEFINITIONS

Engineer-in-charge: PMO/Owner-designated engineer who is in charge of the site and its authorized representative(s).

Approved/Approval: Approval by the Engineer-in-charge.

### 2.2. CONCRETE – PLAN AND REINFORCED

#### 2.2.1. GRADES OF CONCRETE

Various grades of concrete shall be as per IS 456-2000 with specified characteristic compressive strength against these grades in accordance with Table 2 in the said IS. In the grade designation, letter M refers to the mix and the number to the specified characteristic compressive strength of 15-cm. cube at 28 days expressed in N/mm<sup>2</sup>. The characteristic strength is defined as the strength of material below which not more than 5 percent of the test results are expected to fail.

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in Table 2 of IS 456:2000. The target mean strength of concrete mix should be equal to the characteristic strength plus 1.65 times the standard deviation.

#### 2.2.2. DESIGN MIX OF CONCRETE

**2.2.2.01** All reinforced concrete (RC) work shall be in "Design Mix Concrete" only. The CONTRACTOR shall make all the necessary tests to determine for each grade of concrete, the preparation of various ingredients by weight to arrive at the desired design mix to the satisfaction of the Structural Consultant. Such mix will be known as the "declared mix". No deviation from the "declared mix" will be permitted without the expressed sanction of the Structural Consultant / Engineer in writing. No agreement by the Engineer to such "declared mix" shall relieve the CONTRACTOR of his responsibility to use in the Works at all times only concrete as specified in the relevant drawings.

**2.2.2.02** The CONTRACTOR shall be entirely responsible for design of concrete mixes of the specified performance to suit the degree of workability and characteristic strengths required for the various parts of the Works.

**2.2.2.03** Concrete shall meet with the strength requirements and minimum cement contents, maximum w/c ratio as indicated in Table 5 of IS 456-2000 hereinafter unless specifically stated otherwise.

**2.2.2.04** Alternative mixes may be designed by the CONTRACTOR for use in both thin and narrow sections and thick sections. Special mixes using finer aggregates may be



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designed by him for in filling pockets and narrow spaces and for regions of congested reinforcement.

**2.2.2.05** Notwithstanding the above, the following additional specifications shall be applicable.

**2.2.2.06** Design Assumptions:

**TABLE 1**

Main Reference Codes:	IS 456, 516, 10262, 383, 2386, 269, 8112, 12269, 1199 and other related codes. The latest revisions or amendments shall be enforced.
Type of exposure	Moderate
Degree of quality control	Good
Initial Slump	75-80mm.
Slump Retention after 60 minutes	25-30mm
Portland Cement	Grade 43/53 (from source approved by Owner)
Maximum size of aggregate	20mm (may be in two fractions)
Flakiness Index	Up to M35: Maximum 25% above M35 Above M35: Maximum 15%
Elongation Index	Up to M35: Maximum 25% Above M35: Maximum 15%
Crushing Value	As per IS 383
Sand	Natural sand of Zone II or Zone III only (as per IS 383). Blending of sand may be permitted.
Specific Gravity & Water Absorption	Actual
Trials	Trial shall be conducted with materials which the contractor plan to use at site

The minimum cement content and the maximum water-cement ratio shall be as per IS 456-2000.

**2.2.2.07** Submission of Design Mix for approval: The contractor shall submit the mix design of concrete mixes to the structural consultant/Owner well in advance for approval. The minimum period required for the approval shall be 30 days (for individual mixes).

**2.2.2.08** The Contractor is required to submit the following data along with the mix design:

Aggregate Test Results:

Sieve analysis for coarse and fine aggregate.

Specific gravity & water absorption for coarse & fine aggregate.

Flakiness index, elongation index and crushing value of coarse aggregate.

Water Test Results as per IS 456.

Cement Test Results:

Consistency.

Setting Time (Initial and Final).

Compressive Strength (3, 7 and 28 days)

Blains Fineness.



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Type of Exposure

Degree of Quality Control

Initial Slump and Compaction Factor recorded during the trials.

Retention (Slump and Compaction Factor) after 30 and 60 minutes.

**2.2.2.09** The Contractor shall submit materials for trials in sufficient quantity at his own cost as per the given detail (for the approval of each grade of mix):

Cement (1 bag, sealed)

Sand (2 bags, dry)

Coarse Aggregate (20mm) (3 bags, dry)

Coarse Aggregate (10mm) (2 bags, dry)

Superplasticizer (if proposed) (1 Lts, with product literature)

Compressive Strength achieved for 3, 7 and 28 days

Superplasticizer Details:

Specific Gravity

Chloride Content

Dose used ((mentioning maximum limit with all data, with respect to the slump/c.c. recorded with varying doses of superplasticizer)

Note:

1. The use of plasticizer/superplasticizer may not be allowed by the Owner/Consultant.
2. The base material of plasticizer/superplasticizer may be specified by the Owner/Consultant.
3. If superplasticizer is used, then the workability detail for controlled mix shall also be submitted and the water retention for plasticizer shall be minimum say 10 to 15% and for superplasticizer it shall be minimum 25 to 30%.
4. For the approval of superplasticizer, the Contractor shall conduct the performance trial in the presence of the Owner and the compressive strength to be verified for 3, 7, 28 and 180 days.
5. The basis for the approval shall be referred under title "Acceptance Criteria of Mix Design and Approval of Plasticizer/Superplasticizer".

**2.2.2.010** Acceptance criteria of mix design and approval of plasticizer / superplasticizer:

Place for the trials	At the Owner's laboratory
Restrictions to the number of trials	Contractor may submit three options for each grade of mix in the event of rejection of trial mixes contractor has to pay as per the approved rate of central material testing laboratory on per trial basis.
Witness of trials	One representative of the Contractor with the authorisation letter.
No. Of trials for one grade of mix	Minimum three trials
Total number of cubes:	3, 7, and 28 days (3 cubes for each age). The acceptance criteria for the mix design will be the 28 days average compressive strength. Out of three trials minimum two trials shall meet the compressive strength and workability requirements.
The average	The average shall be the average of three cubes.



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Strength Requirement	<p>The acceptable strength requirement shall not be less than the target strength (Characteristic strength + 1.65*Standard Deviation) and shall not be more than +10% of the target strength.</p> <p>In case the strength from the trial is more than +10% of target strength, the mix shall be considered uneconomical and shall be rejected and the Contractor shall submit a new mix design. The Owner shall not be responsible for this lapse of time and it will be considered on part of the Contractor to bear it.</p> <p>No allowance shall be paid for difference of cement content from the actual consumption of the base cement content used for the analysis. The variation in cement content with the assumed cement content (taken for analysis) will be applicable after the approval of mix design.</p>
Workability	<p>Initial Slump: 75-80mm After 60 minutes: 25-30mm.</p> <p>If the retention is not obtained, the Contractor may propose the use of superplasticizer.</p>
Plasticizers/Superplasticizers	<p>The trials for the performance check of plasticizers/superplasticizers will be conducted. The other requirements will be the same as mentioned above, but the numbers of trials are restricted to three different doses.</p> <p>For any approval of any mix, the two additional confirmatory trials will be required (of same mix and dose)</p>

Responsibility	<p>The responsibility to prepare mix design and submission for approval, shall be of the Contractor and no reminders will be given by the Owner. Irrespective of the approval, the Contractor is responsible for achieving characteristic strength in the field.</p> <p>Concrete cube strength shall be considered as indicative strength. Hence, in case of any doubt, the Engineer-in-charge is free to conduct non-destructive tests on the structure and the Contractor shall arrange for the same at his own cost.</p>
Review of Mix Design	<p>If there is a considerable drop in compressive strength, (i.e., characteristic strength) is observed more than 10%, then the review of mix design will be required at the Contractor's cost.</p> <p>If the drop in compressive strength is less than 10% of characteristic strength, the concrete making process, raw materials shall be thoroughly observed.</p>

### 2.2.3. NOMINAL MIX CONCRETE

Nominal mix concrete may be allowed by the Engineer at his discretion. The proportions of materials shall be in accordance with Table 9 of IS 456-2000. The relevant details at a glance are indicated in Table 2.

**TABLE - 2**

Grade of Concrete	Total quantity of dry aggregates by Mass per 50kg of Cement, to be taken as the sum of the individual Masses of Fine & Coarse Aggregate, Kg, <i>Max.</i>	Quantity of water per 50 Kg. of cement, <i>Max.</i>
M 5	800 Kg.	60 Litres
M 7.5	625 Kg.	45 Litres
M 10	480 Kg.	34 Litres
M 15	330 Kg.	32 Litres
M 20	250 kg.	30 Litres



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The proportion of fine aggregate to coarse aggregate by mass shall generally be 1:2 subject to an upper limit of 1:1 ½ and lower limit of 1:2 ½.

**TABLE – 3**

I.S. Sieve designation	Percentage passing for single sized aggregate of nominal size					Percentage passing for graded aggregate of nominal size			
	40 mm.	20 mm.	16 mm.	12.5 mm.	10 mm.	40 mm.	20 mm.	16 mm.	12.5 mm.
63 mm.	100	-	-	-	-	-	-	-	-
40 mm.	85-100	100	-	-	-	95-100	100	-	-
20 mm.	0-20	85-100	100	-	-	30-70	95-100	100	100
16 mm.	-	-	85-100	100	-	-	-	90-100	-
12.5 mm.	-	-	-	85-100	100	-	-	-	90-100
10 mm.	0-5	0-20	0-30	0-45	85-100	10-35	25-55	30-70	40-85
4.75 mm.	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36 mm.	-	-	-	-	0-5	-	-	-	-

In order that properties of the completed structure be consistent with the requirements and the assumptions made during planning and design, adequate quality assurance measures shall be taken. Quality Assurance procedures be developed and submitted to the approval of Engineer-in-charge . The said Quality Assurance plan shall fulfil the requirements detailed under Clause no. 10.1 of IS 456-2000.

### 2.2.5. PROPORTIONING AND BATCHING

Preliminary tests shall be carried out to determine the proportions by weight of cement, coarse and fine aggregate to produce the desired grade of concrete. These proportions shall be maintained during subsequent concrete batching by means of weight batchers conforming to IS 2722 (portable swing batcher for cement) capable of controlling weights with one percent of the desired value).

The accuracy of the measuring equipment shall be within +/- 2 percent of the quantity of cement being measured and within +/- 3 percent of the quantity of aggregate, admixtures and water being measured.

If the weigh batcher loses its calibration, an alternative arrangement of platform balance of required capacity shall be arranged by the Contractor.

The batcher shall be tested for accuracy of calibration before commencement of the work and at least once a week thereafter or more frequently, if so required by the Engineer. In case of failure, stand-by arrangement shall be available.



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In batching concrete, the quantity of both cement and aggregate shall be determined by mass; admixture, if solid, by mass; liquid admixture may however be measured in volume or mass; water shall be weighed or measured by volume in calibrated tanks.

All measuring equipment shall be maintained in a clean serviceable condition and their accuracy periodically checked.

Batching Plant where used should conform to IS 4925.

Grading of Aggregate and Foreign Material Limitations:

Coarse Aggregate:

Coarse aggregates shall be either in single size or graded; in both cases, the grading shall be within limits indicated in TABLE 3.

The percentages of deleterious substances in the coarse aggregate delivered to the mixer shall not exceed the volumes given in TABLE 4.

**TABLE - 4**

Deleterious Substance	PERCENT BY WEIGHT	
	Uncrushed	Crushed
i) Coal & Lignite	1.00	1.00
ii) Clay lumps	1.00	1.00
iii) Material finer than 75 micron	3.00	3.00
iv) Soft fragments	3.00	-
v) Shale	-	-
vi) Total of percentages of all the deleterious materials (except mica) including SI no. (i) to (v)	5	5

Fine Aggregate:

I. Unless otherwise directed or approved, the grading of sand shall be within the limits indicated in TABLE 5.

**TABLE - 5**

I.S. Sieve Designation	Grading Zone-I	Grading Zone-II	Grading Zone-III	Grading Zone-IV
10 mm.	100	100	100	100
4.75 mm.	90-100	90-100	90-100	95-100
2.36 mm.	60-95	75-100	85-100	95-100
1.18 mm.	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron I.S. sieve, by total amount not exceeding 5 percent, it shall be regarded as



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falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron I.S. sieve or to percentage passing any other sieve size on the coarser limit of Grading Zone I or the finer limit of Grading Zone IV. Fine Aggregates conforming to Grading Zone IV shall not be used unless mix designs and preliminary tests have shown its suitability for producing concrete of specified strength and workability.

Sand shall have a fineness modulus of not less than 2.2 or more than 3.2. The fineness modulus is determined by adding the cumulative percentages retained on I.S. sieve sizes 4.75 mm., 2.36 mm., 1.18 mm., 600 micron 300 and 150 micron and dividing the sum by 100.

The recommended sand for concrete is from Zone 2 and Zone 3.

Fineness modulus of sand shall be between 2.5 and 3.25.

Sand for Plaster shall comply with IS 1542

II. The percentage of deleterious substances in sand delivered to the mixer shall not exceed the values given in TABLE 6.

**TABLE - 6**

Deleterious Substance	PERCENT BY WEIGHT	
	Uncrushed	Crushed
i) Coal & Lignite	1.00	1.00
ii) Clay lumps	1.00	1.00
iii) Material finer than 75 micron	3.00	15
iv) Soft fragments	-	-
v) Shale	1.00	-
vi) Total of percentages of all the deleterious materials (except mica) including SI no. (i) to (v) for uncrushed and SI. No. (i) and (ii) for crushed fine aggregate.	5.00	2

**Water-Cement Ratio:**

The water-cement (W/C) ratio is defined as the weight of water in the mix (including the surface moisture of the aggregates) divided by the weight of cement in the mix. Free water-Cement should not exceed 0.40 for the substructure and 0.45 for superstructure.

Only such quantity of water shall be added to the cement and aggregates in the concrete mix as to ensure dense concrete, specified surface finish, satisfactory workability, consistent with the strength stipulated for each class of concrete. Water added to the mix shall be such as not to cause segregation of materials or the collection of excessive free water on the surface of the concrete.

The actual water-cement ratio to be adopted shall be determined in each instance by the CONTRACTOR and approved by the Engineer. W/C ratio determined and approved for use by the Engineer shall be maintained throughout the corresponding part of the Works. Approved tests shall be undertaken periodically by the CONTRACTOR for maintaining the consistency. Such ones comprise frequent determination of the water content of the aggregate during the Work progress as specified in IS 2386 (Part-III). To allow for the variation in weight of aggregates due to variation in their moisture content, suitable adjustments in the weights of aggregates shall also be made.

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The CONTRACTOR shall exercise special precautions on the water content for fair faced concrete work since the colour of such concrete is sensitive to small variations of water in the mix.

Volumetric mixing may be allowed by the Engineer at his discretion by converting the "declared mix" to corresponding mix by volume. Allowance for bulkage shall be made accordance with IS 2386(Part 3). Periodic checks shall be made on mass / column relationship of the materials. Similarly where cement is measured by bags directly reasonable number of cement bags should be weighed periodically to check the net mass as directed by the Engineer.

**Workability:**

Workability of concrete should be checked at frequent intervals. It shall be checked at frequent intervals by approved tests such as slump tests, compacting factor tests, etc., in accordance with IS 1199. If required, the same shall be controlled by adjusting the dosage of the admixtures, if permitted by the Engineer-in-charge.

The range of slumps for various types of work shall generally be as follows subject to approval by the Engineer unless stated otherwise. Slump required for workability shall be achieved, if necessary, by using approved superplasticizer without any extra cost.

Placing condition	SLUMP (in mm.)	
	Maximum	Minimum
Blinding concrete; shallow sections; Pavement using Pavers	75	25
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns; Floors; hand placed pavements; Strip footings	75	25
Heavily reinforced sections in slabs, beams, walls, columns;	100	50
Slipform work; Pumped concrete	100	75
Trench fill; In-situ piling	150	100

**Note:**

For most of the placing conditions, internal vibrators (needle vibrator) are suitable. The diameter of the needle shall be determined based on the density and the spacing of reinforcement bars and thickness of the sections. For trieme concrete, vibrators are not required to be used and clause 7.1.2 of IS 456:2000 shall be followed in such case.

**Mixing of Concrete:**

All concrete whether design mix or nominal mix shall be mixed in an approved mechanical mixer. The mixer shall comply with IS 1791 and IS 12119. The mixer shall be soffitted with water measuring (metering) devices.

Material for concrete shall be deposited into the mixer drum while it is in rotation in the following order: Coarse Aggregate, Cement, Fine Aggregate and Water.

The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete should be remixed.

For guidance, the mixing time shall be at least 2 minutes. For other types of more efficient mixers, manufacturer's recommendations shall be followed; for hydrophobic cement it may be decided by the Engineer-in-charge.

The volume of mixed material shall not exceed the manufacturer's rated mixer capacity.

Temperature of aggregate, water and cement when added to the mixer shall be such that the temperature of the concrete at the time of placement is less than 35 Deg. C.



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The mixer shall be thoroughly cleaned of all hardened sticking concrete and foreign materials before beginning the concreting operations and also at frequent intervals between batches and at the end of concreting work by spraying the drum with cool water. Concrete shall be discharged from the mixer on to a level, clean and watertight surface. The area surrounding the mixer and the aggregate stacks shall be kept clean. Subject to the approval of the Engineer, the CONTRACTOR may use waterproofing admixtures and / or other chemical admixtures and additives in concrete. The proportions and the mode of use shall be as per the manufacturers' instructions. The CONTRACTOR shall furnish complete literature in regard to such admixtures / additives to the Engineer. Dosage of retarders, plasticisers and superplasticisers shall be restricted to 0.5, 1.0, and 2.0 percent respectively by weight of cementitious materials, unless a higher value is permitted by the Engineer-in-charge. Actual doses shall be worked out after trials. Mixing of cement mortar or concrete, which has partially set, shall not be permitted under any circumstances.

**2.2.6. TRANSPORTING AND PLACING OF CONCRETE**

Concrete shall be handled from the place of mixing to the place of final placing as rapidly as practicable by methods which will prevent the segregation or loss of any of the ingredients and maintaining the required workability. Entire operation shall not take time more than the initial setting time of concrete under the prevailing site conditions.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

The concrete shall be deposited as nearly as practicable in its final position to avoid re-handling. No concrete shall be permitted to be used in the Works after initial set has taken place. Concreting of beams, slabs and similar members shall be carried out in one continuous operation to the full depth of the member and the sequence of placing shall be so arranged as to avoid disturbance of partially-set concrete.

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Method of placing of concrete should be such that no segregation occurs during placing. Generally concrete shall not be dropped freely from a height of more than 1.5 meters in the Works of watertight structures and 2 m. in all other works. When required to be deposited from a greater height, it shall be done through a metal-lined chute with slope no flatter than 1:2 (vert. : Horiz.) and not steeper than 1:3. The discharge end of the chute will be provided with a baffle plate to prevent segregation. The discharge end of the chute shall be maintained above the surface of the concrete in forms and concrete shall not be permitted to fall from the end of chute by more than 1 m. During cleaning the chute, the waste water shall be kept clear of the forms.

When placing concrete by mechanical equipment, the following shall apply:

Central-bottom-dump buckets, which provide for positive regulation of the amount and rate of deposition of concrete in all dumping position shall be employed. Concrete shall be discharged by a vertical drop into the middle of bucket or hopper. In placing concrete in large open areas, the bucket shall be spotted directly over the position designated and then lowered for dumping. The open bucket shall clear the concrete already in place and shall be opened slowly to avoid high vertical bounce. The height of drop of concrete shall not exceed 1 m. Dumping in a manner which would result in segregation of concrete ingredients shall not be permitted.

If pumps and pneumatic placers are used for conveying and placing concrete:

Concrete mix shall be appropriately designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping is started.



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Before commencing to pump concrete, the pipeline shall be "lubricated" with two batches of 1:2 cement and sand mortar.

Manufacturers' instructions regarding pipeline layout, concrete quantity, etc., shall be taken to avoid problems as blockages and excessive wear, etc.

In case of break-down/failure, stand-by/alternative arrangements be made available & be used as directed and approved by Engineer-in-charge.

Concrete shall be placed in successive horizontal layers of uniform thickness ranging from 15 cm. to 30 cm. such that the formation of cold joints of planes of weaknesses between each succeeding layer within the pour are avoided. The bucket loads or other units of deposit shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with a minimum of shovelling.

Freshly laid concrete shall not be wheeled over or walked over or otherwise disturbed.

When depositing concrete adjacent to a construction joint, special care shall be taken not to disturb the dowels or other reinforcing bars projecting from the existing concrete. While resuming the concrete work, procedure as per clause no.3.2.12.03 to be followed.

In vertical members like walls, columns, piers, etc., where the full height is not being poured in one continuous operation, the surface of each lift shall be finished horizontal and any laitance removed between the period of initial and final set.

**2.2.7. COMPACTION OF CONCRETE**

Except for thin layer of plain concrete (for which tamping may be allowed) each layer of all grades / mixes of concrete shall be thoroughly compacted with approved mechanical vibrators of adequate power (Ref. IS 2505, IS 2506, IS 2514) supplemented by hand spreading, rodding and tamping as directed so that concrete works around the reinforcement, around embedded fixtures and into corners of the formwork, embedded air is expelled, dense concrete is obtained and the exposed surfaces are free from air pockets, honey-combing and other defects.

Type of vibrators (immersion vibrators, shutter vibrators, surface vibrators, etc.) to be used shall depend on the type of structure for which concreting is done and shall have the approval of the Engineer. The size and number to be provided shall be such as to ensure proper consolidation.

General precautions to be taken in vibration work shall be as follows:

Concrete once vibrated shall not be vibrated again.

Partially hardened concrete or mortar shall not be re-tamped.

Over-vibration, under-vibration or vibration of very wet mixes should be avoided.

Tapping or external vibration of forms by hand tools or immersion vibrators shall not be permitted.

Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. These vibrators shall not be allowed to come in contact with the reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

Whenever external vibrators are used, the design of formwork and the disposition of vibrators should be given special consideration to ensure sufficient compaction and surface blemishes.

**2.2.8. CONCRETING IN INCLEMENT WEATHER**

During heavy rains, concreting shall be stopped keeping appropriate temporary stop ends (V-grooves, etc.) and newly-cast concrete shall be instantly covered by suitable protective means. Any concrete damaged due to rainstorms, etc., shall be replaced appropriately as directed by the Engineer at the expense of the CONTRACTOR.



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When it is necessary to deposit concrete under water, the CONTRACTOR shall submit to the Engineer for his approval, the mode of carrying out the work together with the materials and proportions thereof he proposes to use. In no case such concrete be considered as "Design Mix Concrete".

**2.2.10. CURING**

All concrete shall be protected during hardening from the harmful effects of sunshine and drying winds. All exposed surfaces of newly placed concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar other absorbent materials and kept continuously wet for at least 7 days from the date of placing of concrete in case of ordinary Portland cement, 10 days incase of mineral admixtures or blended cements are used. Likewise all formwork directly in contact with concrete shall be kept wet. Curing compounds to provide surface coating with specking equipment may also be used if permitted by the Engineer. The necessary literature shall be furnished by the CONTRACTOR for the purpose.

For in-situ slabs (whether for flat roofs or other level surfaces, floors, pavements, side walks, etc.), curing shall be by ponding only.

In case of concrete exposed to dry and hot weather conditions or for watertight structures, curing period shall be 10 days. In the case of concrete where mineral admixtures or blended cements are used the curing period shall be extended to 14 days.

The CONTRACTOR shall take good care in the arrangement (whether by continuous fine mist spraying or sprinkling or by covering with clean sand or wet gunny bags or by any curing compounds) and execution of curing so that curing will be carried out without interruption during the nights, Sundays and holidays.

Water for curing shall be of the same quality as used for concrete.

**2.2.11. EXPANSION JOINTS**

Expansion joints in the watertight structures shall always be provided with water-stop for the entire length of joints or as specified. The work shall be carried out in strict accordance with the manufacturer's instructions.

**2.2.12. CONSTRUCTION KEYS AND JOINTS**

Concrete shall be placed without interruption until completion of the part of the work between predetermined construction as specified hereinafter. Time lapse between the pouring of adjoining units shall be as specified on the drawings or as directed by Engineer.

If stopping of concreting becomes unavoidable anywhere, a properly formed construction joints shall be made where the work is stopped. Joints shall be either vertical or horizontal, unless shown otherwise on drawings. In case of an inclined or curved member, the joint shall be at right angles to the axis of the member. Vertical joints in walls shall be kept to a minimum. Vertical joints shall be formed against a stop board, horizontal joints shall be level and wherever possible, arranged so that the joint lines coincide with the architectural features of the finished work. Battens shall be nailed to the formwork to ensure a horizontal line and if directed shall also be used to form a grooved joint. For tank walls and similar work joints shall be formed as per IS 3370. Concrete that is in the process of setting shall not be disturbed or shaken by traffic either on the concrete itself or upon the shuttering. Horizontal and vertical construction joints and shear keys shall be located and shall conform in detail to the requirements of the plans unless otherwise directed by Engineer. Where not described, the joint shall be in accordance with the following:

Column Joint: In a column, the joints shall be formed 75mm below lowest of soffit of the beams including haunches if any. In flat slab construction, the joint shall be 75 mm. below



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the soffit of column capital. At least 2 hours shall elapse after depositing concrete in columns, piers or walls, before depositing in beams, girders or slabs supported thereon.

**Beam and Slab Joints:** Concrete in a beam shall be placed throughout without a joint but if the provision of a joint is unavoidable the joint shall be vertical and at the centre or within the middle third of the span unless otherwise shown on drawings. Where a beam intersects a girder, the joints in the girder shall be offset a distance equal to twice the width of the beam and additional reinforcement provided for shear. The joints shall be vertical throughout the full thickness of the concrete member. A joint in a slab shall be vertical and parallel to the principal reinforcement. Where it is unavoidably at right angles to the principal reinforcement, the joint shall be vertical and at the middle of the span.

**Joints in Liquid Retaining Structures:** Vertical construction joints in watertight construction will not be permitted unless indicated on the drawings. Where a horizontal construction joint is required to resist water pressure, special care shall be taken in all phases of its construction to ensure maximum water tightness.

Where the work has to be resumed on a surface which as hardened, any skin or laitance shall be removed and the surface roughened by hammering with an approved power-operated "bush" hammer followed by wire brushing to remove all loose practices. When using this procedure, great care shall be taken to avoid breaking of the arises of the joint face and stunning the stones. The surface is then thoroughly wetted. Fresh concrete should thoroughly be vibrated near the construction joint so that mortar from the new concrete flows between large aggregates and develop proper bond with old concrete. Where high shear resistance is required at the construction joints, shear key may be provided. Sprayed curing membranes and release agents should be thoroughly removed from joint surfaces.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire on bristle brushes, care being taken to avoid dislodgment of particles of aggregate. The prepared surface should be in a clean saturated surface dry condition when fresh concrete is placed, against it. Fresh concrete should be thoroughly vibrated near construction joint so that mortar from new concrete floors between large aggregates and develop proper bond with old concrete.

**2.2.13. SAMPLING AND TESTING OF CONCRETE**

For preliminary tests, test specimen shall be prepared with at least two different water-cement ratios for each class of concrete consistent with the workability required for the nature of the work. The materials and proportions used in making preliminary tests shall be similar in all respects to those to be actually employed in the works. All the cubes shall be made, cured and tested in accordance with IS 516.

Facilities required for sampling materials and concrete in the field, if Engineer so desires, shall be provided by CONTRACTOR at no extra cost. The following equipment with operator shall be made available at Engineer's request (all must be in serviceable conditions):

Concrete cube-testing machine suitable for 15 cm. cubes of 100 Tonnes capacity with providing calibration ring	1 No.
Cast Iron cube moulds 15 cm. Size	18 Nos. (min.)
Slump cone complete with temping rod	1 Set
Laboratory balance to weight upto 5 Kg. with sensitivity of 10 gm.	1 No.
1.5 sieves for coarse & fine aggregates	1 Set
A set of measures from 5 l to 0.1 l	1 Set
Laboratory balance of 2 Kg. capacity and of sensitivity of 1 gm.	1 No.



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Note: Arrangement can be made by CONTRACTOR to have the cubes tested in an approved laboratory in lieu of a testing machine at site at his expense, with the prior consent of the Engineer.

Three test specimens shall be made from each sample for testing at 28 days. Additional samples shall be taken for determining the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS 9103. The specimen shall be tested as described in IS 516.

For works test, samples from fresh concrete shall be taken as per IS 1199 and cubes shall be made, cured and tested in accordance with IS 516 unless specified or instructed otherwise by the Engineer. Minimum frequency for sampling of concrete of each grade shall be in accordance with the following:

Quality of concrete in the Work, m <sup>3</sup>	Number of samples
1 – 5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional sample for each additional 50 m <sup>3</sup> as part thereof.

Note: At least one sample shall be taken from each shift when concrete is produced at continuous production unit, such as ready-mixed concrete plant, frequency of sampling subjected the approval of Engineer-in-charge.

The acceptance criteria of concrete tests shall be as per Clause 16.1, 16.2, 16.3, 16.4, 16.5 & 16.6 of IS 456-2000.

### 2.2.14. CONCRETE BELOW SPECIFIED STRENGTH

Should the concrete tests fail to meet the minimum specified strength requirements for the respective grades of concrete, the Engineer may take one of the following decisions:

Instruct the CONTRACTOR to carry out such additional tests (e.g. core test, load-test etc.) and/or remedial measures to ensure the soundness of the structure at the CONTRACTOR's expense.

The Consultant may accept the work provided it meets the relevant acceptance criteria as stipulated in IS 456-2000. Any decision to accept the work shall be entirely at the discretion of the Engineer who may make a reduction in the rate of the appropriate item.

The work will be rejected and any consequential action as needed shall be taken at the CONTRACTOR's expenses including cutting out and replacing a part or whole of the work.

### 2.2.15. REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

Immediately the shuttering is removed, the surface of concrete shall be very carefully gone over and all defective areas called to the attention of Engineer who may permit patching of the defective areas or also reject the concrete unit either partially or in its entirety.

**Rejected concrete shall be removed and replaced by CONTRACTOR at NO additional expense to Owner.** Holes left from belts, etc., shall be filled up and made good with mortar composed of one part of cement to one and half parts of sand passing 2.36 mm. IS sieve after removing may loose stones adhering to the concrete. Mortar filling shall be struck off flush at the face of the concrete. Concrete surfaces shall be finished as described under the particular items of work.

Superficial honey compound surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of Engineer and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float Excess water shall be avoided. Unless instructed otherwise by Engineer, the surface of the exposed concrete placed against shuttering shall be rubbed down



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immediately on removal of shuttering to remove fine or other Irregularities, care being taken to avoid damaging the surface. Surface irregularities shall be removed by grinding.

Use of Epoxy: The use of epoxy for bonding fresh concrete used for repairs will be permitted upon written approval of Engineer. Epoxies shall be applied in strict accordance with the instructions of the manufacturer.

Method of Repair: Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of from bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows. The holes to be patched shall be roughened and thoroughly soaked with clean water until absorption stops.

A 5 mm. thick layer of grout of equal parts of cement and sand shall be well brushed into the surface to be patched, followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly proud of the surrounding surface. The concrete patch shall be built up in 10 mm. thick layers. After an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden flat and a smooth finish obtained by wiping with hessian, a steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportions as that used in the concrete being repaired, although some reduction in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible

Mortar filling by air pressure (guniting) shall be used for repair of areas too large and / or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so directed by Engineer, to match the shade of the patch with the original concrete.

Curing of Patched Work: The patched area shall be covered immediately with an approved water retaining, water saturated material such as gunny bags which shall be kept continuously wet and protected against sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray or sprinkling for not less than 10 days.

Approval by Engineer: All materials, procedures and operations used in the repair of concrete and also the finished repair work shall be subject to the approval of Engineer. All fillings shall be tightly bonded to the concrete and shall be sound, free from cracks after the fillings have been cured and dried.

**2.2.16. Finishing**

This specification is intended to cover the treatment of concrete surfaces of all structures. Areas requiring special finish not covered by this specification shall be clearly indicated on the drawings and special specifications shall be furnished.

Finish for Formed Surfaces: The type of finish for formed concrete surfaces shall be as follows, unless otherwise specified by the Engineer:

For surface against which backfill or concrete is to be placed, no treatment is required except repair of defective areas.

For surfaces below grade, which will receive, waterproofing treatment the concrete shall be free of surface irregularities, which would interfere with proper application of the waterproofing material, which is specified for use.

Unless specified, surfaces which will be exposed when the structure is in service shall receive no special finish, except repair of damaged or defective concrete, removal of fins and abrupt irregularities, filling of holes left by form ties and rods and clean up of loose or adhering debris.

Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless the drawing specifies a horizontal surface or shows the slope required, the tops of narrow surface such as stair treads, walls, curbs and parapets shall be sloped across the width approximately 1 in 30. Broader surface such as walkways, roads, parking areas and platforms shall be sloped about 1 in 50. Surfaces that will be covered by backfill or concrete, sub-floors to be covered with concrete topping, terrazzo or quarry tile





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and similar surfaces shall be smoothing screeded and levelled to produce even surfaces. Surface irregularities shall not exceed 6 mm. Surfaces which will not be covered by backfill, concrete or tiles toppings such as outside decks, floors of galleries and sumps, parapets, gutters, side walks, floors and slabs, shall be consolidated, screeded and floated. Excess water and laitance shall be removed before final finishing. Floating may be done with hand or power tools and started as soon as the screeded surface has attained and stiffness to permit finishing operations and these shall be the minimum required to produce a surface uniform in texture and free from screed marks or other imperfections. Joints and edges shall be tooled as called for on the drawings or as directed by the Engineer.

Standard Finish for exposed concrete: Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the job. Unless otherwise specified on the drawings, the standard finish for exposed concrete shall be a smooth finish. A smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces and edges. Panels and form linings shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms the joint marks shall be smoothed off and all blemishes, projections etc. removed leaving the surfaces reasonably smooth and unmarred.

Integral Cement Concrete Finish: When specified on the drawings an integral cement concrete finish or specified thickness for floors and slabs shall be applied either monolithic or bonded, as specified on the drawings, as per IS 2571. The surface shall be compacted and then floated with a wood float or power floating machine. The surface shall be tested with a straight edge and any high and low spots eliminated. Floating or trowelling of the finish shall be permitted only after all surface water has evaporated. Dry cement or a mixture of dry cement and sand shall not be sprinkled directly on the surface of the cement finish to absorb moisture or to stiffen the mix.

Protection: All concrete shall be protected against damage until final acceptance by Engineer/Owner.

**2.3. FORMWORK****2.3.1. GENERAL**

Formwork (or shuttering) comprises of all forms and moulds made up of planks and sheeting, etc., shores, bracings and struts, ties, anchors and hangers, steel rods, bolts and allied inserts, uprights, walling, wedges and all other temporary supports for concrete work during the process of concreting and setting.

**2.3.2. MATERIAL**

Formwork may be of timber, plywood, steel or other metal, plastic or concrete or any suitable material. For special finishes, the formwork may be lined with plywood, steel sheets, oil tempered hard board, etc. Dented steel plates will not be allowed and shall not be used at all.

Timber shall be easily workable without splitting and shall not warp when exposed to sun or rain or wetted during concreting. Plywood shall be 12 mm. thick complying with IS 4990 and steel shall be 3 mm. black sheets suitably stiffened with angles or appropriate equivalent.

Sliding forms and slip forms may be used for special purpose construction with the approval of the Engineer.

**2.3.3. DESIGN**

Formwork shall be adequately designed to cater to all the vertical (dead load of wet concrete, superimposed live loads during working, materials, equipment, etc.) and lateral loads, without causing displacement, deflection or movement of any kind. The





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CONTRACTOR shall be entirely responsible for the design and stability of formwork regardless of whether he is instructed to furnish the design calculation, drawings and other particulars of his proposal or not, and regardless of whether his proposal has been approved by the Consultant or not. All the expenses arising out of defective shuttering resulting in dismantling/redoin the work, etc., shall be made to the Contractor's account. For details regarding design, detailing, etc., reference may be made to IS 14687.

**2.3.4. ERECTION OF FORMWORK**

Forms shall be true to shape, lines, levels and dimensions of the concrete work as shown on the drawings and shall be rigidly constructed using adequate number of props, struts, ties, braces, etc. Where props rest on natural or filled-up ground, the soil shall be thoroughly compacted to avoid any settlement. False-work shall be so constructed that vertical adjustments can be made to compensate the settlements. Wedges may be used at the top or bottom of timber shores, but not at both ends to facilitate vertical adjustments or dismantling of the formwork. No bamboo and wooden bullies shall be permitted to be used for props or cross beams.

Proper precautions shall be taken to see that all joints in the formwork are watertight to prevent escape of slurry, by using masking tapes.

Connections in formwork shall be constructed to permit easy removal of the shuttering and shall be adequately secured by screws, bolts, clamps, wire, etc. so as to be strong enough to retain the correct shape during consolidation.

Faces in contact with concrete shall be free from adhering ground, projecting nails, splits or any defects so that when stripped, any formation of blemishes is avoided. All formwork shall be carefully cleaned and thoroughly wetted or treated with an approved composition, care being taken to keep all reinforcement away from contact from such composition.

Unless specifically allowed in writing, wire ties passing through the walls and through bolts are not permitted. For fixing of formwork, alternative arrangements such as coil nuts shall be adopted at the CONTRACTOR's cost.

Plywood shall be used for all concrete surfaces; where called for. Sawn and wrought timber may not be used unless allowed or approved by EIC. Inside faces of forms for concrete surfaces which are to be rubbed finished shall be planed to remove irregularities or unevenness in the face. Formwork with linings will be permitted.

All new and used from timber shall be maintained in good condition with respect to shape, strength, rigidity, water tightness.

Excessive construction camber to compensate for shrinkage, settlement, etc., that may impair the structural strength of members will not be permitted.

Forms for substructure concrete may be omitted when, in the opinion of Engineer, the open excavation is firm enough to act as the form. Such excavations shall be slightly larger than required by the drawings to compensate for irregularities in the excavation and to ensure the design requirements.

Forms shall be so designed and constructed that their removal will not damage the concrete. Face formwork shall provide true vertical and horizontal joints, conform to the architectural features of the structure as to location of joints and be as directed by Engineer.

Where exposed smooth or rubbed concrete finishes are required, the forms shall be constructed with special care so that the resulting concrete surface requires a minimum finish.

**2.3.5. BRACINGS, STRUTS AND PROPS**

Shuttering shall be braced, strutted, propped and so supported that it shall not deform under weight and pressure of the concrete and also due to the movement of men and other materials. Bamboo shall not be used as props or cross bearers.

The shuttering for beams and slabs shall be so erected that the shuttering on the sides of the beams and under the soffit of slabs can be removed without disturbing the beam



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bottoms. Re-propping of beams shall not be done except when props have to be reinstated to take care of construction loads anticipated to be in excess of the design load. Vertical props shall be supported on wedges, or other measures shall be taken whereby the props can be gently lowered vertically while striking the shuttering.

**2.3.6. MOULD OIL**

Care shall be taken to see that the faces of formwork coming in contact with concrete are perfectly cleaned and two coats of mould oil or any other approved material applied before fixing reinforcement and placing concrete. Such coating shall be insoluble in water, non-staining and not injurious to the concrete. It shall not become flaky or be removed by rain or wash water. Reinforcement and/or other items to be cast in the concrete shall not be placed until coating of the forms is complete. Adjoining concrete surfaces shall also be protected against contamination from the coating material. Use of form oil will not be permitted on the surfaces which require painting.

**2.3.7. CHAMFERS AND FILLETS**

All concrete and angles exposed in the finished structure shall be formed with moldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise specified, shall be 20 mm. x 20 mm. Care shall be exercised to ensure accurate moldings. The diagonal face of the molding shall be planed or surfaced to the same texture as the forms to which it is attached.

**2.3.8. VERTICAL CONSTRUCTION JOINT CHAMFERED**

Vertical construction joints on faces which will be exposed at the completion of the work shall be chamfered as above except where not permitted by Engineer for structural or hydraulic reasons.

**2.3.9. WALL TIES**

Wire ties passing through the walls shall not be allowed. In their place, bolts passing through sleeves shall be used.

**2.3.10. REUSE OF FORMS**

Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes that may leak suitably plugged and joints examined and when necessary, repaired and the inside retracted to prevent adhesion, to the satisfaction of Engineer. Warped timber shall be resized. Number of repetitions will be decided on the quality of plywood used after successive repetitions.

**2.3.11. REMOVAL OF FORMS**

CONTRACTOR shall record on the drawing or a special register, the date upon which the concrete is placed in each part of the work and the date on which the shuttering is removed therefrom.

In no circumstance shall forms be struck until the concrete reaches a strength of at least twice the stress due to self weight and any construction/erection loading to which the concrete may be subjected at the time of striking formwork.

In normal circumstances, generally where ambient temperatures are above 15 Degree C and ordinary Portland cement is used, forms may be struck after expiry of the following periods:

Type of formwork	Ordinary Portland Cement Concrete

Vertical formwork to columns, walls, beams		16-24 hrs
Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)		3 days
Soffit formwork to beams (Props to be refixed immediately after removal of formwork)		7 days
	Props to slabs	
	1) Spanning up to 4.5 m	7 days
	2) Spanning over 4.5 m	14 days
Props to beams and arches:		
1) Spanning up to 6 m		14 days
2) Spanning over 6 m		21 days

For other cements and lower temperature, the stripping time as above may be suitably modified with prior approval of the Engineer-in-charge.

### 2.3.12. TOLERANCES

Variation from the plumb:

In the lines and surface s of columns, piers, walls and in arises: 5mm per 2.5m, but not more than 25mm.

For exposed corner columns and other conspicuous lines:

In any bay of 5m maximum: 5mm.  
In 10m or more: 10mm.

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

In slab soffits, ceilings, beam soffits, and in arises:

In 2.3 m. .5mm.  
In any bay or 5 m. maximum 8mm  
In 10 m. or more 15mm.

For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines:

In any bay of 5m maximum: 5mm.  
In 10m or more: 10mm.

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

In any bay of 5m maximum: 10mm.  
In 10m or more: 20mm.

Variation in the sizes and location of sleeves, openings in walls and floors: 5 mm. (except in the case of and for anchor bolts).

Variation in cross sectional dimensions of columns and beams and in the thickness of slabs and walls: (-5mm. +10mm).

Variation in Footings:

Variation in dimension in plan: -5mm. +50mm.



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Misplacement or eccentricity:

2% of footing width in the direction of misplacement, but not more than 50 mm.

Reduction in thickness:

5% of specified thickness subject to a maximum of 50 mm.

Variation in Steps:

	RISE	TREAD
In a flight of stairs	3mm.	5mm.
In consecutive steps	1.5mm	3mm.

Tolerances in other concrete structures:

Variation of the constructed linear out line from established position in plan:

In 5m	10mm.
In 10m or more:	15mm.

Variation of dimensions to individual structure features from established positions:

In 20mm or more	25mm.
In buried construction	50mm.

Variation from plumb, from specified better or from curved surfaces of all structures:

In 2.5m.:	10mm.
In 5m.:	15mm.
In 10m. or more:	25mm.
In buried construction:	Twice the above amounts

Variation from level or grade indicated on drawings in slabs, beams, soffits, horizontal grooves and visible arises:

In 2.5m.:	5mm.
In 7.5m.:	10mm.
In buried construction:	Twice the above amounts

e. Variation in cross sectional dimensions of columns, beams buttresses, piers and similar member **(- 5 mm. + 10 mm.)**

f. Variation in the thickness of slabs, walls, arch sections and similar members.

**(-5 mm. + 10 mm.)**

g. Footings for columns, piers, walls, buttresses and similar members

i) Variation of dimensions in plan **(-10 mm. + 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

5% of specified thickness subject to a mix. of 50 mm.

Tolerances in other types of structures shall generally conform to those given in Clause 2.4 of Recommended Practice for Concrete Form-work (ACI-347).

### 2.3.13. REMOVAL

Nor formwork shall be removed or otherwise allowed to move until concrete attains sufficient strength against own weight and external load as per the stipulations of Clause 11.3 of IS 456-2000.

2.14.2. The stripping of formwork shall be done without shock or vibration so that no damage is caused to cast concrete. Any damage resulting from premature removal of shutters or from any other cause whatsoever shall be made good by the CONTRACTOR at his own expense as directed by the Engineer.

### 2.3.14. SPECIAL PROVISION

Where exposed smooth or rubbed concrete finishes are required, the forms shall be constructed with special care so that the resulting concrete surfaces will required a minimum finish.

All corners and angles exposed in the finished structure shall be formed with mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise specified, shall be 20 mm. x 20 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached. Vertical construction joints on faces which will be exposed at the completion of the work shall be chamfered as above except where not permitted by Engineer for structural or hydraulic reasons.

Wherever the concreting of narrow members is required to be carried out within shutters of considerable depth, temporary openings in the sides of the shutters shall, if so directed by the Engineer, be provided to facilitate the pouring and consolidation of the concrete. Small temporary openings shall be provided as necessary at the bottom of shutters of columns, walls and deep beams to permit the expulsion of rubbish, etc.

## 2.4. REINFORCEMENT

### 2.4.1. FABRICATION

Bar bending schedule shall be prepared by the CONTRACTOR and approved by consultants/ Engineer-in-charge before commencement of work. Bending of reinforcement shall be in accordance with IS 2502-1963 and as required by the Drawings and sketches and any written instructions in this connection, bars shall not be bent or straightened in a manner injurious to the materials. All bars shall be bent cold except for bars over 25 mm. dia. which may be bent hot if specifically approved by the Engineer. Bars which depend on their strength on cold working shall not be bent hot. Bars bent hot shall not be heated beyond cherry red colour (not exceeding 645 Degree C) and after bending shall be allowed to cool slowly without quenching.

No reinforcement bar shall be bent when in position without the Engineer's approval, whether or not it is partly embedded in hard concrete.

Spiral reinforcement shall have 1 ½ finishing turns at both top and bottom unless shown otherwise.

Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care shall be taken to ensure that at no time is the radius of the

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bend less than 4 bar diameters for plain M.S. bars and 6 bar diameters for deformed bars. Care shall also be taken when bending back bars, to ensure that concrete around the bar is not damaged.

Cut ends of galvanized rods shall be given a protective coat of an approved zinc paint immediately after cutting.

**2.4.2. BINDING**

All bars shall be bound tightly together where they cross, with black annealed steel binding wire. The free ends of the binding wire shall be bent inwards. The binding wire shall satisfy IS 280.

**2.4.3. PLACING AND FIXING**

The reinforcement as per the Drawings and instructions shall be placed, fixed and maintained in the forms within a tolerance of  $\pm 10$  mm. for effective depth 200 mm. or less and  $\pm 15$  mm. for effective depth over 200 mm. during the placing and compaction of concrete.

Precast concrete blocks, MS chairs and spacers as required shall be provided to maintain the steel in position. In fair faces of concrete temporary spacers only shall be used and withdrawn as compaction of concrete proceeds.

Tack welding of crossing bars shall be done without any extra cost any only if permitted by the Engineer.

**2.4.4. COVER**

Spacing of reinforcement shall be governed by Clause 25.3 and cover to reinforcement by Clause 25.4 of IS 456. Increased covers, if shown on the drawings or instructed by the Engineer, shall be provided at the respective locations. Cover to reinforcement shall be as per IS 456. Fully cured cement mortar blocks of 1:2 max shall be used as cover blocks where no grade of concrete is specified and where grade of concrete as specified it shall be as per proportion of cement and sand in the approved mix of concrete. Any other cover blocks shall be used only on approval by the Engineer. However, use of pebbles or stones shall not be permitted. Where the bars cross, the outer one shall have the minimum cover. Minimum curing of cover blocks shall be 14 days.

**2.4.5. SPLICING AND LAPPING**

Where splicing and / or overlapping in reinforcement are required, the bars shall be provided with such splices or overlaps as are shown on the drawings or directed by the Engineer. Laps shall be staggered only as approved by the Engineer.

**2.4.6. WELDED LAPS**

Butt welding of reinforcing steel bars shall be used only when specified or shown on the drawings or expressly permitted in writing by the Engineer. When butt-welding is carried out, the ends of the bars shall be prepared with single 45 Degree C and a backing plate shall be used. The minimum root face will be one quarter of the bar diameter. Welding shall be done in accordance with the recommendations of IS 2751 and 816. Electrodes shall comply with IS 814. The maximum size of electrodes shall be based on following table:

Diameters of Bars in mm.	Diameters of Bars in inches	Maximum size of Electrodes	Amperage corresponding to maximum size of Electrodes



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Diameters of Bars in mm.	Diameters of Bars in inches	Maximum size of Electrodes	Amperage corresponding to maximum size of Electrodes
12 to 25	½" to 1"	10 3.25 mm. (0.128)	} <b>As specified by the } manufacture of } Electrodes</b>
25 to 32	1" to 1 ¼"	8 4.06 mm. (0.160)	
	Double bevel	10 3.25 mm. (0.128)	
32 to 50	1 ¼" to 2"	10 3.25 mm. (0.160)	
	Double bevel	8 4.06 mm. (0.160)	
25 to 50	1" to 2"	6 4.06 mm. (0.160)	}
		6 4.88 mm. (0.192)	

Before doing the welding of bars at site, the CONTRACTOR shall make minimum 3 No. joints and get them tested in an approved laboratory (including X-ray testing of welds if necessary). Only on these tests proving satisfactory, the CONTRACTOR would be permitted to weld at site.

The following precautions shall be taken while providing welded laps:

If the cold twisted deformed bar has an untwisted end at the lapping point, the said portion shall be cut off for a minimum length of 10 cm. from such end prior to welding.

Bars shall be aligned on a proper axis to avoid crookedness after welding.

The joints to be welded shall be rust free.

Weld slag shall be chipped off and removed by brush.

Welding Contract:

The welding work shall not be given to a CONTRACTOR who does not produce satisfactory evidence of his ability to handle the work in a competent manner. The CONTRACTOR shall also prove the ability of the operators employed by him to produce welding connection of the required strength.

The CONTRACTOR shall employ a competent welding supervisor or charge-hand to ensure that the standard of workmanship is satisfactory.

The Engineer shall have free access to the work being carried out by the CONTRACTOR at all reasonable times and facility shall be provided so that during the course of welding he may be able to inspect any layer of weld metal. He shall be at liberty to reject any work not conforming to the relevant specifications; defective welds shall be cut out and re-welded.

Safety Requirements and Health Provisions: The CONTRACTOR shall make all safety and health provisions for his welders as are laid in IS 818-1968 i.e. Code of Practice of safety and health requirements in electric and gas welding and cutting operation.

All steel reinforcement before the concrete is deposited shall be clean, free dust, loose scales, oils, rust, grease or any other deleterious materials. Particular care shall be taken to avoid contamination of reinforcement with mould oil.

No concrete shall be deposited until all formwork and reinforcement have been inspected and approved by the Engineer. There shall be in attendance on each concreting gang a competent steel fixer who shall ensure that the reinforcement and other embedded soffittings are kept in position during placing and compaction of concrete.



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The CONTRACTOR shall provide temporary gangways, platforms and other means of access to prevent men from walking on the reinforcement bats. These shall be independent of the reinforcement.

**2.5 GENRAL NOTES ON STRUCTURAL STEEL WORKS****A.1 STRUCTURAL STEEL**

1. All structural steel work shall involve rolled steel section, plate, flats, rounds, chequered plate etc. of tested quality mild steel conforming to IS:2062 and black pipe (medium) as per IS:1161 Pipe chain etc.
2. All structural steel work pipe used for welded structures shall conform to IS:2062 grade – A ( FE 4204) except for M.S plates over 20mm thickness which shall conform to IS:2062 grade- B (Fe 410W) unless otherwise noted.
3. All raw steel plate of thickness more than 20mm shall be checked against lamination prior to starting of fabrication work.
4. Fabrication and erection of structural steel shall be as per IS:800
5. Separator diaphragms, filler plates, washers-tapered or plain shall be used wherever necessary or as required by the engineer.
6. Unless otherwise erection clearance at each end of members connecting steel to steel shall not be greater than 2mm for cleaned ends of beams and 3mm for beams without web cleats.

**A.2. CONNECTION**

1. All shop connection shall be welded unless otherwise specified.
2. Bolted field connection if so required shall be bolted with high tensile and/ or M.S Bolts.
3. In specific cases site welding may be required. The same should be subjected to the approval of the engineer.

**A.2.a. WELDING**

1. All welds are continuous fillet of 8mm (MIN) unless otherwise noted.
2. Welding should be done as per IS: 9595
3. All welding electrodes shall conform to IS: 814 (Test Certificates are required to be submitted for all welding electrodes brought)
4. All fillet welds shall be minimum 6mm thickness (U.N.O)
5. Thickness of fillet welds shall not exceed the thickness of thinner member of plate connected
6. Length of the filler welds shall not be less than 4 times nominal size of the weld of 40mm whichever is more.
7. Fillet welds terminating at ends must have returns around corners not less than twice the nominal size of the weld.
8. Welding symbols shall conform to IS: 813
9. All butt weld shall be full penetration radio graphically tested. Radio graphically testing of butt welds is required and mandatory. Butt welds. Joints shall be done using run on plates of same profile as the parent plates. Such plates should be cut off after welding and the edges to be ground flush.
10. Size & shape of the gusset and lengths of the inclined member are to be verified from actual shop layout to ensure minimum weld indicated in the drawing.





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2. Web plate splice top flange plate splice & bottom flange Plate splice should not at one place

**A.2.b BOLTING**

1. All bolts and shall conform to relevant standards laid down in IS:1367
2. All mild steel bolts have minimum ultimate tensile strength of 44kg/sq.mm
3. All high tensile steel bolts shall have minimum ultimate tensile strength of 58kg/sq. nuts for high strength bolts be of compatible material as per relevant table in IS:1367
4. U.N.O all bolts are grade C mild steel black bolts of class 4.6 conforming to IS:1977 of St-44 or IS:2062
5. Bolt holes shall be formed by drilling.
6. Diameter of bolt holes for steel connection shall be more than bolt dia. But dia less than 25mm,  
A 1.5mm for bolt dia. less than less than 25mm  
B. 2.0 mm for bolt dia. Equal of Erector than 25mm
7. Diameter of bolt holes in base plates shall be 3mm more than the diameter of holding down bolt (U.N.O)
8. for all permanent bolt the threads shall be damaged or nuts shall be welded with shank after proper tightening of all bolts in the joint.
9. Bolts in direct tension shall be provide with lock nuts conforming to IS: 1363 in direct tension shall be provide with lock nut conforming to IS: 1363 of double coil spring washers conforming to IS: 6755.

**A.3 PAINTING**

1. Surface preparation for all structural members shall be done by scraping with wire brush and as instructed by engineer in charge.
2. Unless stated otherwise all structural members shall receive one coat of red-oxide 25 microns DFT per coat after fabrication (Thickness check are required to carried out by contractor).
3. After erection all damaged/ deteriorated paint surface shall be cleaned and repainted buy same primer. Then all surfaces shall receive two coats of synthetic enamel paint 30microns DFT per coat (U.N.O) (Thickness check are required to carried out by contractor).
4. Steel members which are inaccessible after assembly shall receive another coat of primer over the first coat before assembly. These two coats of primer shall be of different shades.

**2.4.7. APPLICATION OF SPECIFICATION**

Notwithstanding what is stated in he specifications herein, general structural drawings and notes appended thereon, shall be deemed to form part of the specifications and to supersede the same in case of discrepancy.

All drawings submitted by the architects or Structural Engineer shall be checked for dimensions, figures, sizes and strength of structural members and connections and any discrepancy or inaccuracy shall be reported forthwith.



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Full facilities shall be provided to enable the architect or the consultant or his representative to visit the workshop at any reasonable time for the purpose of inspecting equipment and structural steel work under fabrication. Similar facilities shall be provided at site.

A set of shop drawings bearing the approval stamp shall be supplied to the workshop inspector.

A program or progress chart shall be drawn up within two weeks of intimation of the award in consultation with the architects. The program will be chalked out so as to start erection as fabrication progress.

**2.4.9. MATERIAL**

All raw materials are to be supplied as per schedule B of Price Schedule by BHEL. The process of manufacture and the quality of all steel used or structural members and connections shall be governed by the following requirements:

Mild steel shall conform to the requirements of latest editions of I.S. 226.

Other steel not complying with the above specification can be used only by approval in writing of the Architects or Consultant. If approval is obtained, due regard will be given to the yield point stress, ductility, ultimate resistance to tensions and other essential properties.

All sections must be free from seams, flaws, cracks, laminations or injurious defects of any kind.

**2.4.10. TESTING AND INSPECTION**

All materials used be inspected by the Engineer's representative and the contractor shall produce the manufacturers' test certificate.

**2.4.11. SETTING OUT ON SITE**

The contractor shall accept responsibility for accuracy in positioning and levelling of all steel work, plumbing in columns, and the placing of every part of structure in accordance with the approved drawings and to the satisfaction of the architect and the structural consultants. Any checking or approval of the setting out by the architect and the structural consultants shall not relieve the contractor of his responsibilities in this respect.

Foundations will be provided by the general contractor. Anchor bolts should be supplied by the contractor earlier enable the general contractor to put these in foundation. The contractor will have to check for the correctness of the centres of bolts and in no case he shall get relieved of his responsibility in this respect.

Stanchion bases shall be mounted on steel wedges preferably square bar cutting of requisite size as packing clear of the top of footings, stanchions accurately set in position plumbed and leveled and the beam above fixed. The gap shall then be rammed solid with a stiff 1:2 cement mortar using minimum of water so as to entirely fill up the spaces.

**2.4.12. FABRICATION**

General: All workmanship and finish of the fabricated steel work shall be of the highest class in every respect conforming to the best accepted standard of practice. Methods of fabrication,, transportation and erection shall be such that the finished structure is free from defects or injuries, which would render it unfit for use. Greatest accuracy shall be observed to ensure that all parts will properly fit together on erection. In repetition, work the standard of accuracy such that similar parts are infact, interchangeable.

Fabrication should conform to IS800.

Straightening, planning, machining, etc.: Cold straightening & flatterring of sections must be by pressure and not by hammering. All materials before being used shall be straight and



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free from furs, etc. All ends of beams used as stanchions are to be machined or cut true, any burring of the edges being removed. Flange plates, if made from sheared plates, must have had at 1/8" removed on each sheared edge by planning.

Cutting: Cutting shall be effective by shearing, cropping or sawing. Sheared members shall be free from distortion at the sheared face.

Holes for Bolts and Rivets: Ordinary round holes are to be of a diameter 1/16" larger than the specified diameter of bolt or rivet. Where not otherwise stated, holes must be drilled or else punched 3 mm small and afterwards drilled or reamed (but not drifted) to the required size. All burrs due to punching or drilling must be removed. All holes for site connections must be accurately centered so as to render reaming or drifting during erection unnecessary. Multiple members such as flange plates to be drilled as far as practicable in one operation.

Rivets: Rivets to be of soft steel of the quality and to the test prescribed for rivets in I.S. 1148. Ordinary rivets to have cup head formed groom length of shank equal to not less than 40 mm diameters. Rivets on bearing surfaces to be flush counter - sunk whether indicated on the drawing or not. All rivets are to be machine-drawn as far as practicable and must completely fill the holes when closed. If loose or if the heads are badly formed, cracked or eccentric to the shank, or do not bear truly on the plate or bar, such rivets shall be cut out and replaced. All surface to be riveted to be in close contact throughout.

Bolts: Ordinary bolts & nuts to be of mild steel conforming to I.S. 1148. Bolt head and nuts to be hexagonal and to with worth standard, the heads being forged out of the solids, truly concentric and square with the shank which must be perfectly straight. Treads to be cut in oil and the fit of the nuts should be spanner tight. Bolts must be long enough, allowing for washers, to project (say 1/4") beyond the nut when tightened and the screwed portion must be long enough for subsequent tightening. When nut or bolt heads bear on the tapered flanges of joints, angles etc. bevel washers to be provided of corresponding taper. In all cases the threads should be clear of the parts bolted together. The nut shall be secured after tightening by barring when there is the risk of their becoming loose of accidental removal. Turned bolts to be driven soffit in the hole they occupy and to have the screwed portion 1/16" less in diameter than the shank and the bearing faces of the heads and nuts shall be machined squared. The shank of turned bolts shall have sufficient length to ensure contact through the entire thickness of the plates. Accordingly, washers, truly flat, must be provided under the nuts to ensure that they can be screwed home.

Connections: The assembly of fabricated parts shall be permitted only after all parts are properly straightened and are free burrs, mid oil etc. The Structural Engineer's drawings show only typical connection details. The main principal governing all connection between beams and columns shall be that all vertical loads are to be carried by riveted cleats, whereas sufficiently rigid and conditions take up binding moments, eccentric loading and/or wind pressure are to be accomplished by welding. All shop connections shall be riveted or welded. Head of rivets in surfaces carrying brick walls shall be flattened to 3/8".

Painting: The whole of the finished iron and steel work shall be cleaned of all scale, rust or dust and shall be thoroughly coated with one coat of freshly mixed re-lead paint before erection, well worked into joints and open spaces.

Steel work which will be entirely embedded in concrete is not to be painted but coated with two coats of Portland cement wash of the consistency of cream, the second coat being applied immediately prior to encasing. Where tow surfaces will be permanently in contact, after assembly, each of them shall receive, immediately before being assembled after being thoroughly scrapped, one coat of red oxide paint and the surface shall be brought together while the paint is still wet.



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For Fabrication of Sag Rod, the contractor shall arrange at their own expense threading of ends either at Site or through some workshop located outside the factory.

Erection: The contractor must furnish and erect at his own expense all derricks, gantries, sheer legs, staging and centering necessary for the proper completion of the work and perform all adjustment required to place the material in its correct position in the completed structure.

His tender must include for all transport of materials on site and unloading and erecting, and care of the steel work during construction.

At the completion of the erection, the contractor must remove at this own cost all temporary staging, centering and other obstructions when ordered by the architects or Engineer and leave work in a neat and workman like condition.

Erection, in general, shall conform to I.S. 800. All parts of the structure shall be suitably lettered or numbered to facilitate erection at site.

Instalment checking for correctness of setting up of structures as also the final adjustment should be carried out immediately after the completion of assembling of each block of building (frame work) in the sequence determined by the design. Crane girders and rails requiring higher accuracy while setting them up, should be adjusted after the consolidation of basic structures.

As each part of the contract works is erected, it shall be passed by the architect/consultants. This, particularly, applies to the accurate plumbing of all stanchions and columns, and to the levelling, setting and aligning of the various parts and to the fitting and adjusting of bearing plates and other parts. Previous ascertainment from the purchaser which parts they wish to inspect and pass from time to time but such passing in no way exonerate the contractor from any of his guarantee.

Supervision: The carrying out of all work included in this contract shall be supervised throughout by a sufficient number of qualified representatives of the contractor who have had through experience in the erection structure similar to that to be supplied.

Tests: The contractor shall carry out the test specified (at the manufacturer's works) and are necessary to determine that the contractor's work comply with the conditions of the specifications. The cost of such tests should be borne by the contractor.

Clearance: The erection clearance for cleated ends of members connecting steel to steel not be greater than 1/16" at each end. The erection clearance at ends of beams without wed cleats shall be not more than 1/8" at each end. Where, for practical reasons, greater clearance is necessary, suitably designed seating shall be provided.

**2.4.13. METAL ARC WELDING**

Electrodes: All electrical welding shall be carried out with coated electrodes of best make from approved manufacturers (such as ADVANI ORLIKON, ESAB or equivalent) to conform to relevant Indian Standards. The welding procedure shall be taken as meaning the following:

Size of electrodes in S. W. G.

Current in amperes

Number of runs

Length of run per electrode

Position of welding

Welding sequences

The welding procedure shall be arranged to suit the details of joints as indicated on the drawings and the position in which the welding is to be carried out and shall be such as to ensure that the weld metal can be fully and satisfactorily deposited throughout the length and thickness of all joints.



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The contractors shall record the welding procedure and shall provide each operator with all relevant details.

Butt welds: All steel parts shall before butt welding, be separated by a gap the dimension of which shall be shown on the drawings. The ends of the butt welds shall be extended so that the weld metal at the extreme ends of the weld is sound and the additional metal shall be afterwards ground smooth. In all other respects butt welds shall conform to the requirements of I.S. 815.

Fillet welds: Minimum leg length of the fillet welds to deposited shall be not less than the specified size. The throat of the fillet weld so deposited shall be not less than 7/10ths of the specified size.

Where a fillet is applied to the rounded toe of a rolled section the specified size of the weld shall generally not exceed 3/4 of the thickness of the sections of the toe.

Fillet welds terminating at the ends of the sides or parts of members shall, where ever practical, be returned continuously around the corners about a distance not less than twice the size of the welds.

In all other respects, fillet welds shall conform to the requirements of I.S. 816, clause 6.2.

Welding Standards: The surface to be welded and the adjoining metal for a distance of atleast 15mm. must be cleaned free of rust, scale paint, etc., by a wire brush.

Means must be adopted to minimize distortion of the finished parts, e.g. by jigs, tack welding or other effective means, and shall be securely held in their relative positions during welding.

For fusion faces, which require to be cut, a special form or shape may be cut by shearing, clipping or gas cutting.

In all cases the prepared fusion faces should be regular and should be dressed by chipping, filling or grinding.

Each bead of metal must have the slag removed by light hammering and wire brushing before the next bead is deposited.

The weld must show a good clean contour and on a cut specimen, good fusion with purest metal.

The current used must be within the range defined by the electrode manufacturers.

Under-cutting must be avoided and if it occurs, any reduction of area from this cause must be made good by an additional run. Before applying paint to welded joints, they should be carefully chipped or wire brushed.

Adequate steps shall be taken to ensure that the work is of the highest quality and thoroughly reliable so that all work is done under competent and skilled supervision.

Mode of measurements: Rate for fabrication, supply and erection shall be quoted on the basis of unit price per metric tone which rate will be applied to the estimated weight of finished steel work. The weight shall be figured on the basis of minimum rectangular dimensions of all plates and the minimum rectangular overall dimensions of all structural shapes with no deductions for copes, clips, sheared edges, etc. and the theoretical weights of the steel section in accordance with the I.S. Specifications, no deduction being made for bolt and rivet holes. Deductions shall not be made for skew cuts. No allowances shall be made for extra weight due to rivet heads and nuts or welded material and rolling margins.

The structural steel including chequered plates shall be supplied by the OWNER free of cost. The rate shall be inclusive of supply of all raw materials, fabrication, delivery at site and



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erection, oiling and painting, temporary erection etc. all bolts and nuts, electrodes and electrical energy for welding.

Electrical Energy: Electricity will be supplied by the owners at one suitable point free of charge and further distribution cost will have to be borne by the contractor. Contractor will put his own tested meter and bear energy consumption charges as per meter reading, and prevalent rates.

Metal Work: Steel used in the manufacture of rolled steel sections shall conform to IS 226 and IS 1977 latest edition or any alternative quality of steel subject to structural.

**2.4.14. ANTI-CORROSIVE TREATMENT**

Polysulphide epoxy zinc chrome anti-corrosive primer - a two component air drying polysulphide - epoxy composition with polyamino curing and anti-corrosive chrome pigments as per manufacturers specification.

Method of application of polysulphide epoxy steel structural coating:

Clean the steel surface by sand blasting/hand or power tool cleaner.

If the surface is rusted, remove by cleaning with 10% phosphoric acid solution followed by cleaning with water to remove acid traces. Allow to dry and wipe out with clean cloth soaked with solvent.

Apply polysulphide epoxy zinc chrome anti-corrosive primer tow coats at an interval of 20-24 hours. this will give a coverage of 80 sq.ft. per liter for single coat. for two coats it will be in between 40-45 sq.ft. per ltr. Before application of finish coat lightly sand the primer surface with emery paper no.320. clean the dust with dry cloth. apply two coats of polysulphide epoxy finish coat at an interval of 16 to 20 hrs. this will give a coverage of 100-125 sq.ft./ltr. for single coat. for two coats it will be 50-60 sq.ft. per ltr. If required use xylene as a thinner or Asian thinner t-121. Method of application of polysulphide epoxy concrete structural coating:

Remove dirt and dust by wire brushing.

Treat the surface with 10-15% dilute hydrochloric acid solution. Allow it to remain there for 15-20 minutes. Wash it with water 3-4 times. Allow the surface to dry.

Apply one coat of polysulphide epoxy primer this will give a coverage of 80 sq.ft./ltr. Allow to cure for 20-24 hrs. Before application of finish coat lightly sand the primer surface with fine emery paper no.320. Remove the dust by clean dry cloth. Apply two coats of polysulphide epoxy finish coat. This will give coverage of 80-90 sq.ft./ltr. for single coat. for 2 coats it will be 40-45 sq.ft./ltr. Apply two coats at an interval of 16-20 hrs.

**Note: If difference is observed between the specifications mentioned above & CPWD Specifications of the relevant Items; the stringent most shall be followed. In General for execution of all civil works envisaged under the scope & their measurements, latest CPWD specification and relevant Indian Standard Codes shall be followed unless otherwise stated against a particular item of work. If CPWD specification and/or Indian Standards do not provide details of specification of any item of work then the work shall be carried out as per the instructions of Engineer-in Charge with best Engineering Practices.**



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