

INDEX

Sl No.	Description	Pages
1	Customer Tech. Specification Civil & Structural work	94
2	Customer Tech. Specification ETC works	13

**TECHNICAL SPECIFICATION
FOR
CIVIL AND STRUCTURAL WORKS OF
400 KV SWITCHYARD AND ALLIED WORKS**

PART-I SCOPE OF WORK AND DESIGN BASIS

1.0 SCOPE

1.1 Civil Works are related to the following :-

- a) Towers, lightning masts, beams, columns, equipment supporting structure etc.
- b) Switchyard Control room Building.
- c) Foundations for towers, lighting masts, equipment support etc.
- d) Required modification / construction within the existing switchyard.
- e) Cable trench with covers, fencing with gate, fire protection walls, earthing mat, etc.
- f) Oil soak pits, oil separation pits, oil drains to the oil separation pits
- g) Roads and drains in switchyard area
- h) The work also includes
 - i) Site surveying.
 - j) Area grading and leveling. This is to be completed in the total switchyard area as per grade levels finalized during the detailed engineering stage.
 - k) Geo-Technical Investigation and preparation of soil investigation report.
 - l) Preparation of Architectural drawings.
 - m) Design, preparation of detailed drawings and construction of all structures.
 - n) Preparation of as built drawings of all structures and facilities to reflect as built status of construction.
 - o) Submission of as built drawings in AutoCAD latest version in CDs.
 - p) Plumbing & sanitary works.
 - q) Painting and Anti-termite treatment in all areas / buildings as per IS: 6313.



- r) Temporary roads and approach roads necessary for construction purpose.
 - s) Other facilities/works necessary which are not specifically mentioned here but required for construction, operation and maintenance of the switchyard
- 1.2 All structural steel members including stub members, bolts, nuts, spring washers etc., shall be hot dip galvanized after fabrication. Weight for zinc coating shall be at least 900 gm/m².
- 1.3 Structural arrangement, foundation system, miscellaneous requirements, finishes, etc. shall be as specified elsewhere in this specification.
- 1.3.1 Lightning masts shall be provided with minimum two numbers of platforms, (with one at top level) and an internal ladder for climbing purpose upto platform at top level. Top of platform shall have grating, railing and toe guard plates.
- 1.4 The structural and civil works associated with erection and commissioning of station switchyard shall be executed on detailed below. The scope covers design, engineering, fabrication, galvanizing, supply and erection of :
- a. Switchyard control room building, Lighting mast, towers, beams, equipment lattice support, equipment pipe support inclusive of all fixtures such as nuts, bolts, angles, shackles, clamps, anti-climbing devices, bird guards, step bolts/ladders, number plates, danger and phase plates, inserts in concrete, foundation bolts, base plates, stiffeners, dampers, fixtures for supporting and operating mechanism boxes, control cubicles, etc.
 - b. Cable tray supports, cable trays, embedments in cable trenches, bolts and nuts and other accessories etc.
 - c. Drainage and lighting of the area [cable trench should not be used drainage purpose]. An approved system for draining the transformer and oil collection, and disposal system shall be provided.
 - d. Finished yard area of switchyard is RL **(+) 174.0 M**. Accordingly top level of pedestals & tower foundation has to be kept. For preventing of vegetation in the switchyard area the ground level is to be well graded and natural soil is well compacted in layers and consolidated by using ½ ton roller and suitable water sprinkling. Then the soil sterilization / anti-weed treatment shall be sprayed as per manufacturer recommendations. Over that one layer of 20 mm thk. HBG metal layer is provided followed with another layer of 40 mm thk. HBG metal layer. Again anti-weed treatment chemical is sprayed over the entire area.



- e. RCC roads and chain link fencing for switchyard.
- f. R.C.C. cable trench and pipe trenches with necessary precast R.C.C. covers with lifting facilities, sump pit, cable trays, supports etc. (The top of trench shall be kept 150 mm above the grade level). The bed of trenches shall be slope 1 in 200 to drain water into a collection sump suitably. All trenches shall be given a slope of 1 in 500 along run of the trench.

2.0 DESIGN BASIS

2.1 Design

The steel girders shall be designed for static tension dead load of conductors, insulators and accessories, erection load, short circuit forces, wind/seismic loads and secondary stresses. The girders shall be connected with lattice column by bolted joints.

Supporting structures for equipment shall either comprise of G.I pipe supports (ERW pipe of grade Yst 210 or of higher grade) or lattice structural steel supports as per requirement. The pipe supports shall be designed as per IS:806 "Code of practice for steel tubes for structural purposes" the lattice steel supports shall be designed as per IS:802 "Code of practice for use of structural steel in overhead Transmission Towers".

The switchyard control room building shall be designed as per IS:456 (latest) "Code of practice for plain and reinforced concrete", The primary loads and load combinations for the control room building shall be as per IS:875(Latest-all parts), IS:1893-2002 and other relevant Indian standards.

All foundations for the switchyard structures (except transformer & buildings) shall be designed as per relevant IS:4091 "Code of practice for design and construction of foundations for transmission line towers and poles" and IS:456 (latest) "Code of practice for plain and reinforced concrete". All the foundations shall be protected by anticorrosive coatings.

Supporting structures for equipment shall either comprise of G.I. pipe supports (ERW pipe of grade Yst 210 or of higher grade) for lattice structural steel supports as per requirement. The pipe supports shall be designed as per IS:806, "Code of practice for steel tubes in general building construction" and IS:1161 "Specification for steel tubes for structural purposes". The lattice steel supports shall be designed as per IS:802, "Code of Practice for use of Structural Steel in Overhead Transmission Line Towers".

Cable trenches crossing the road shall be designed for class "AA" loading as per IRC standard. However, the design shall also be checked for class 'A' loading as per IRC standard. All precast slabs for trenches shall be provided with MS edge protection angle on all sides (min. size of angle 50x50x6 mm). The RCC trench edges shall be provided with MS angle protection (min. size of angle 50x50x6 mm).



The design of foundation and all trenches should take care of sub-soil water pressure as per relevant IS Codes. If the ground water table is above the base level of the trench, PVC water stops (minimum 230 mm wide and 5 mm thick) should be provided at all construction and expansion joints to the approval of the Engineer.

List of Codes and Standards:

Loads:

IS:875 (All Parts)	:	Code of practice for design loads (other than earthquake) for buildings and structure
IS:1893	:	Criteria for earthquake resistant design of structure
IS: 802 (Part-I & Part-II)	:	"Code of practice for use of structural steel in overhead Transmission Towers".

Foundations

IS:1080	:	Code of practice for design and construction of willow foundations in soils (other than raft, ring and shell)
IS:1904	:	Code of practice for design and construction of foundations in soils : General requirement loads (other than earthquake) for buildings and structure
IS:2950	:	Code of practice for design and construction of raft foundations; Part-1 : Design
IS:4091	:	"Code of practice for design and construction of foundations for transmission line towers and poles
IS:2974 (Part 1)	:	Code of practice for design and construction of machine foundation for reciprocating type machine
IS:2974 (Part 2)	:	Code of practice for design and construction of machine foundations for reciprocating type machine
IS:2974 (Part 3)	:	Code of practice for design and construction of machine foundations for rotary type machine (medium & high frequency)
IS:2974 (Part 4)	:	Code of practice for design and construction of machine foundations for rotary type machine of low frequency
IS:2974 (Part 5)	:	Code of practice for design and construction of machine foundations for impact machines other than hammer
IS:8009 Part-1	:	Code of practice for calculation of settlement of foundations
IS:8009 Part-2	:	Deep foundations subjected to symmetrical static vertical loading
IS:11089	:	Code of practice for design and construction of ring foundations



Reinforced Cement Concrete

IS:456	:	Code of practice for plain and reinforced concrete
IS:3370 (All Parts)	:	Code of practice for concrete structures for the storage of liquids.
IS:3414	:	Code of practice for design and installation of joints in buildings
IS:4326	:	Code of practice for earthquake resistant design and construction of buildings
IS:5525	:	Recommendation for detailing of reinforcement in reinforced concrete works
IS:11682	:	Criteria for design of RCC staging for overhead water tanks
IS:13920	:	Code of practice for ductile detailing of RCC structures subjected to seismic forces
IS-4995 (Part 1 &2)	:	Criteria for design of reinforced concrete bins for storage of granular and powdery materials: General requirements and assessment of bin loads.

Structural Steel

IS:800	:	Code of practice for General construction in steel
IS: 802 (Part-I & Part-II)	:	"Code of practice for use of structural steel in overhead Transmission Towers".
IS:808	:	Dimensions for hot rolled steel beam, column channel and angle sections
IS;813	:	Scheme of symbols for welding
IS:816	:	Code of practice for use of metal arc welding for general construction in mild steel
IS:9595	:	Recommendation for metal arc welding of carbon and carbon manganese steel
IS:3502	:	Specification for steel chequered plates

LOADING:**Dead Loads:**

Dead loads shall include the weight of structure complete with finishes, fixtures & partitions and shall be taken as per IS:875 (Part-I)

Imposed Loads

Imposed loads in different areas shall include live loads, erection, operation and



maintenance loads. Equipment loads (which constitute all loads of equipment to be supported on the building frame) are not included in the imposed loads furnished below and shall be considered in addition to imposed loads.

For consideration of imposed loads on structures, IS: 875 (Part-2) "Code of practice for design loads (other than earthquake) for buildings & structure" shall be followed. The following minimum imposed loads as indicated for some of the important areas shall however be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

Sl.No.	Location	Imposed Loads (T/Sq.m)
A)	Switchyard control room Building	
	i) Ground floor (general)	2.50
	vi) Roof (Where no equipment are located and non-accessible)	0.15
	Roof (where equipment are located and accessible)	0.50
	iii) Cable gallery	0.50 (In addition to this actual cable load shall be considered)
	iv) MCC & Control Building floors	1.5
	v) AHU room /battery room, air washer room	1.0
B)	Switchyard structures	
	Switchyard structures shall be designed for the worst combination of dead loads, live loads, wind load conditions as per IS:802, Part-I & Part-II using gust factor method, loads due to deviation of conductor, loads due to unbalanced tension in conductor, torsional load due to unbalanced vertical & horizontal forces, erection loads, short circuit forces including snap in case of bundled conductors, etc. The terminal / line take off gantries shall be checked for ± 30 degrees deviation of conductor in both horizontal and vertical planes. The distance between terminal and dead end gantry shall be taken as 200 metres. Design of foundations shall be carried out as per IS:4091.	
	The pipe supports shall be designed as per IS:806 and IS:1161. The lattice steel supports shall be designed as per IS:802.	

Sl.No.	Location	Imposed Loads (T/Sq.m)
C)	Underground Structures such as Sumps, Tanks, Trenches, etc. In addition to earth pressure and ground water pressure, the surcharge load of 2T/sqm. shall also be considered for design of all underground structures.	
D)	Road Culverts / Bridges and its allied structures including RCC Pipe Crossings & Road Crossing of Trenches. Design for class 'AA' loading (wheeled & tracked both) and checked for class 'A' loading as per IRC Standard.	
E)	Covers for Channels / trenches	0.40 (General) As per IRC Standard (at road crossings for vehicular traffic)
F)	Railway Supporting Structures, Rail Culverts	As per railway 'Bridge Rules'
G)	General (Unless Specified Otherwise)	
	i) Stairs, Landings and Balconies	0.50
	ii) Toilets	0.20

Note: Additional load for cable, piping / ducting, shall be considered as applicable.

Equipment, Piping and Associated Loads

Equipment loads shall be considered over and above the imposed loads. Equipment loads shall be considered as given by equipment suppliers.

Crane Loads

For crane loads, an impact factor of 25% and lateral crane surge of 10% (of lifted weight + trolley weight) shall be considered in the analysis of frame according to the provisions of IS:875. The longitudinal crane surge shall be 5% of the static wheel load. Longitudinal surge and lateral surge shall not be considered to act simultaneously.



Seismic Load

The project site is in Zone – II as per IS: 1893 – 2002.

Zone factor Z	=	0.1
Importance factor	=	1.75
Response reduction factor	=	5.0 (SMRF)
	=	3.0 (OMRF)

Wind Load

Basic wind speed at project site is 39m/sec. as per IS: 875 -1987 Part-3

Risk factor	=	1.06
Topography factor k_2	=	As per Table-2 of IS: 875 (Part 3) considering terrain category – I Class-B
Probability factor K_3	=	1.0

Damping in Structures

The damping factor to be adopted shall not be more than as indicated below:

Type of Structure	Wind Load	Seismic Load
a) Welded steel structure	1%	2%
b) Bolted steel structure	2%	2%
c) RCC structure	1.6%	5%

Temperature Load:

For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation.

Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns. The maximum distance of the expansion joint shall be as per the provisions of IS:800 and IS:456 for steel and concrete structures respectively.



Civil Design Concepts

8.9.1 Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion, etc. Criticality of erection/maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loadings.

The different load combinations shall be taken as per IS:875 (Part-5) for buildings and IS:802 for switchyard towers, equipments and other relevant IS Codes.

- a. Wind and seismic forces shall not be considered to act simultaneously.
- b. 'Lifted load' of crane shall not be considered during seismic condition.
- c. crane without lifted load but standing idle adjacent to first crane.
- d. Permissible stresses for different load combinations shall be taken as per relevant IS codes. **However shear enhancement for concrete design shall not be permitted in any load combinations.**
- e. Increase in net allowable bearing capacity of soil under wind load or seismic load along with other normal loads (dead + live) only shall not be permitted.

The design of steel structures shall be done by working stress method. Design shall be as per provision of IS: 800 & IS:802 and other relevant IS standards.

2.2

Fabrication Drawings

The Contractor shall prepare all fabrication and erection drawings for the entire work. The drawings shall be of one standard size and the details shown therein shall be clear and legible.

The Contractor shall not commence shop fabrication work unless such drawings or parts of such drawings are officially released for preparation of shop drawings. The Vendor/ Contractor shall be responsible for the correctness of all shop drawings. Two prints each of the Vendor/Contractor's drawings shall be submitted to the Purchaser and five prints to their nominated representatives for scrutiny and approval. Fabrication drawings shall be revised by the Vendor/Contractor to reflect all revisions in design drawings as and when such revisions are made by the Engineer. Revised fabrication drawings shall be submitted to the Engineer/Purchaser for approval.

No detail shop drawings will be accepted for examination by the Engineer unless entirely complete, first completely checked and approved by the Vendor/ Contractor's qualified structural engineer and accompanied by an erection plan shown the location of all pieces detailed. The Vendor/Contractor should check erection clearance and



ensure that detailing of connections is carefully planned to obtain clearance in erection of structures, including field welded connections and/or bolting. Particular care is required when joints with the use of High Strength Friction Grip bolts as this requires some minimum clearance for use of sockets with torque wrenches.

Fabrication shall be started until the Vendor/Contractor has received copies of such drawings upon which the Engineer has endorsed his approval. Approval by the Engineer of any of the drawings shall not relieve the Vendor/Contractor from the responsibility for correctness of engineering, design of connections, workmanship, fit of parts, details, material, errors or omissions of any and all work shown thereon. The Engineer's approval shall constitute approval of the size of members, dimensions and general arrangement but shall not constitute approval of the connections between member and other details.

The Vendor/Contractor shall submit design calculations for substitutions and for the connection details proposed by him.

Each lot of drawings sent by the Vendor/Contractor for approval shall contain a limited number of drawings and shall be in order and manner, which follows erection sequence, or as required by the Purchaser/Engineer based on priorities allocated.

The Engineer will return one copy of the Vendor/Contractor's drawings marked with his approval/comments. The Vendor/Contractor shall furnish the Purchaser with total six prints and the Engineer with four prints of all approved final drawings for field use and record purpose. The Vendor/Contractor shall also furnish, within one month of erection, the Purchaser as well as the Engineer with four direct reading reproducible of each drawing of quality not lesser than an "Auto positive on extra thin paper capable of reproducing legible prints. The reproducible shall incorporate all modifications, field changes; substitutions etc. effected and reflect the status "As built". It should be noted that so called "Sepia" or similar process reproducible shall be submitted rolled (not folded) on the outside of regular mailing tubes. All these drawings will remain the property of the Purchaser. The Purchaser reserves the right to use them in any manner whatsoever.

The drawings prepared by the Vendor/Contractor and all subsequent revisions etc. shall be at the cost of the Vendor/Contractor for which no separate payment will be made. Revisions shall incorporate all modifications, field changes, substitutions etc. effected. The rates/prices quoted for fabrication work shall be deemed to include the cost of such drawing work.

2.3

Procurement of all the material and construction equipments etc, required for construction is in contractor scope only.



**PART-II
WORK SPECIFICATION
FOR
EXCAVATION, SHORING,
DEWATERING, BACKFILLING, PILING, ETC.**

1.00 EARTHWORK IN EXCAVATION AND BACKFILLING

This part of specification covers the general requirements of earthwork in excavation in different types of soil/subsoil strata. Backfilling around foundations, conveyance and disposal of surplus to spoil to any lead and lift, stacking it properly as directed by Engineer, including all operations covered within the intent and purpose of this specification.

2.00 APPLICABLE CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to as applicable on the date of opening of the Bids. In case of discrepancy between this specification and IS codes referred to herein this specification shall govern.

- a. IS: 1200 : Method of Measurement of Building and Engineering works.
- b. IS: 3764 : Safety code for excavation work.
- c. IS: 3385 : Code of Practice for measurement of Civil Engineering works.
- d. IS: 2720 : Part-II , Part-VII, Part-VIII, Part-XXVIII, Part-XXIX - Determination of Moisture Content.

3.00 GENERAL

Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary, whether or not such items are specifically stated herein for completion of the job in accordance with specification's and requirements.

Contractor shall carry out the survey of the Site before excavation and set properly all lines and establish levels for various works such as earthwork in excavation for forming the embankment, basement, foundations, plinth filling, cable trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference/ grid lines at 5M intervals or nearer,



as determined by Engineer based on ground profile. These shall be checked by Engineer and thereafter properly recorded.

The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night for ensuring safety.

The rates quoted by the Bidder shall also include for dumping of excavated materials in regular heaps or bunds with regular slopes as directed by Engineer, within the basic initial lead of two (2) KM and leveling the same so as to provide natural drainage. Rock/soil excavated shall be stacked properly as directed by Engineer. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the side and the top. Rock shall be stacked separately. The excavated material so stacked and if found suitable for use in the work, shall be used by the Contractor, with the approval of the Purchaser/Engineer.

If during excavation the Contractor comes across some facility / structures / system he shall immediately intimate the Engineer and carry out the excavation with care under the Engineer's guidance and provide suitable supports/protection required. The Contractor shall include the cost of these in his rates. However, in case the Engineer requires the dismantling of such items and/or diversion facility for the same, it shall be paid for separately at initially agreed rates.

The earthwork in excavation shall include the removal of all materials to properly execute the work. Sides and bottom of excavation shall be cut sharp and trimmed to the required levels.

If the bottom of any excavation appears to be soft, unsound or unstable the Contractor shall report the matter to the Engineer and if the Engineer so directs, shall excavate it to the directed depth. Such extra excavation shall be filled up with lean cement concrete of grade M 10.

The Contractor shall perform excavation in such a way as to prevent immediate or future sliding or caving in of the ground. He shall be held responsible for damage to persons, works or things and entirely liable for all and any changes entailed in removal of material collapsed or for other work or supplies eventually required for re-conditioning.

4.00

PRECIOUS OBJECTS, RELICS, OBJECTS OF ANTIQUITY ETC.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the Site shall be the property of Purchaser and Contractor shall duly preserve the same to the satisfaction



of Purchaser and from time to time deliver the same to such person or persons as Purchaser may from time to time authorize or appoint to receive the same.

5.00

EXCAVATION

All excavation work shall be carried out by mechanical equipment as far as possible.

Rough excavation shall be carried out to a depth 150 mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed even below final level and extra excavation filled up as directed by Engineer. The final excavation if so instructed by Engineer, should be carried out just prior to laying the mud-mat. The Contractor at his own cost shall fill any excavation taken out to a depth greater than required for any reason whatsoever, with lean concrete of grade M-10.

Contractor may, for facility of work or similar other reasons excavate, and also backfill later, if so approved by Engineer, at his own cost

All excavation shall be done to the dimensions as required for safety and working facility. Working space provided shall not be less than as provided in IS:1200 (Part-I). Contractor shall obtain prior approval of Engineer in each individual case, for the method he proposes to adopt for the excavation, including dimensions, side slopes, dewatering, disposal etc. This approval, however, shall not in any way relieve the Contractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand safely for the actual soil conditions encountered. Every precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid.

Excavation shall be carried out with such tools, tackles and equipment as described herein before. Blasting or other methods may be resorted to if required in the case of hard rock, however, not without the specific permission of Engineer. Only controlled blasting shall be adopted.

Permissible Tolerances for Slope in Excavation

- | | | | |
|----|--|---|----------------------------|
| a) | Hard and soft shale | : | 1 horizontal to 4 vertical |
| b) | Hard and soft moorum
with or without boulder | : | 1 horizontal to 4 vertical |
| c) | Normally hard soil not
objected to change
of structure due to
variation of moisture | : | 1 horizontal to 2 vertical |



5.01 **EXCAVATION IN ROCK REQUIRING BLASTING**

As the excavation is to be done very close to the existing structures, the blasting is to be done with utmost care and in the manner as directed by an expert in blasting to be engaged by the contractor at no extra cost to the owner. All necessary precautions, as directed by Engineer-in-charge, to protect the existing structures, working personnel and machinery/ equipment in the nearby areas etc., shall be taken by the contractor.

The monitored peak particle velocities at the nearby structures during blasting shall not exceed the peak particle velocity specified in I.S: 6922–1973 and determined after conducting the initial tests. However, the peak particle velocity at the nearby structures shall not exceed 25mm/sec.

The ground vibrations shall be minimum and shall not cause damage to the adjacent structures.

The depth of blast hole, the charge to be provided, the spacing of the holes etc., shall be decided by the expert engaged by the contractor on the basis of trial blasts and as approved by the Engineer-in-charge .

The contractor shall adopt the smooth blasting or Pre-splitting techniques to minimize the danger to the adjacent structures.

Fly rock from blasting shall not damage the nearby structures. Incase due to unforeseen conditions if any structure gets damaged due to fly rock or excessive vibrations, the contractor has to restore the same to the original position at **his own cost and risk**.

- 5.01.01 The Contractor has to procure the explosives required as per relevant clauses of the Explosives Rules 1940 or as amended subsequently. The APGENCO will issue necessary certificates required for procurement of explosives.
- 5.01.02 The Contractor shall obtain license from the District Authorities for undertaking blasting work as well as for obtaining and storing the explosives as per Explosives Rules 1940, corrected upto date. The Contractor shall purchase the explosives, fuses, detonators etc. only from a licensed dealer and shall be responsible for the safe custody and proper accounting of the explosive materials. The Engineer or his authorized representative shall have the access to check the Contractor's store of explosives and his accounts.
- 5.01.03 It is the full responsibility of the contractor to transport the explosives as and when required for work in a safe manner to the work spot.
- 5.01.04 The Contractor shall acquaint himself with all the applicable laws and regulations concerning storing, handling and the use of explosives. All such laws, regulations and



rules etc. as were current from time to time shall be binding upon the Contractor (vide also specification no. 203 of APSS).

5.01.05 The provisions detailed in this are supplementary to the above laws, rules and regulations etc. and are applicable except where they conflict with the aforementioned laws etc. from time to time. Further, the Executive Engineer may issue modifications, alterations and new instructions from time to time. The Contractor shall comply with the same without these being made a cause for any claim.

5.01.06 **Materials**

All materials such as explosives, detonators, fuses tamping materials etc. that are proposed to be used in the blasting operations shall have the prior approval of the Executive Engineer.

5.01.07 Only explosives of approved make and strength are to be used. The fuses known as instantaneous fuse must not be used.

5.01.08 The issue of fuse with only one protective coat is prohibited. The fuse shall be sufficiently water resistant as to be unaffected when immersed in water for thirty minutes. The rate of burning of the fuse shall be uniform and not less than 4 seconds per inch of length with 10% tolerance on either side.

5.01.09 Before use, the fuse shall be inspected and moist, damaged or broken ones discarded. The rate of burning of fuses or when they have been in stock for long shall be tested before use.

5.01.10 The detonators used shall be capable of giving an effective blasting of the explosives, moist and damaged detonators shall be discarded.

5.01.11 **Personnel**

Excavation by blasting will be permitted only under personnel supervision of competent and licensed persons and trained workmen.

5.01.12 All supervisors and workmen in charge of make up, handling, storage and blasting work shall be adequately insured by the Contractor.

5.01.13 The storage shall be in charge of a very reliable person, approved by the Executive Engineer, who may if necessary cause police enquiries being made as to his reliability antecedents etc. The Contractor shall have to produce a security for the person in charge of the explosives, if and as required by the Executive Engineer or the Civil authorities of the districts.

5.01.14 The Contractor shall make sure that his supervisors and workmen are fully conversant with all the rules to be observed in storing, handling and use of the explosives. It shall



be assured that the supervisor in-charge is thoroughly acquainted with all the details of the handling and the blasting operations.

- 5.01.15 The explosives, detonators and fuses shall each be separately stored.
- 5.01.16 A careful and day to day account of the use of the explosives shall be kept by the Contractor in an approved register and in an approved manner. The register shall be produced by the Contractor for the inspection of the Executive Engineer when so required by the later. The Executive Engineer when so surprise visits to the storage magazine. In case of any unaccountable shortage of the explosives or if the account is not found to have been maintained in a manner prescribed by the Executive Engineer, the Contractor shall be liable to be penalized in which case he shall not be entitled to any compensation for the losses etc. The action taken under this clause shall be in addition to that which might be taken by the competent civil authorities in a court of law.
- 5.01.17 The magazine at all times shall be kept scrupulously clean.
- 5.01.18 No unauthorized person shall at any time be admitted inside the magazine.
- 5.01.19 The magazine shall, when not in use by authorized persons be kept well and securely locked.
- 5.01.20 The magazine shall, on no account be opened during or in the approach of a thunder-storm, and no person shall remain in the vicinity of the magazine during such periods.
- 5.01.21 Magazine shoes without nails shall at all times be kept in the magazines, and a wooden tub or cement tub about one foot high and eighteen inches in diameter, filled with water shall be fixed near the door of the magazine.
- 5.01.22 Persons entering the magazine must put on the magazine shows which shall be provided at the magazine for this purpose and should be careful.
- i. Not to put their feet on the clean floor unless they have the magazine shoes on.
 - ii. Not to allow the magazine shoes to touch the ground outside the clean floor.
 - iii. Not to allow any dirty or grit to fall on the clean floor.
- 5.01.23 Persons with bare feet, shall before entering the magazine dip their feet in water and then step direct from the tub over the barrier (if there be one) on to the clean floor.
- 5.01.24 A brush broom shall be kept in the lobby of the magazine for cleaning out the magazine, on each occasion if it is opened for the receipt, delivery or inspection of explosives.
- 5.01.25 No matches or inflammable materials shall be allowed inside the magazine. Illumination shall be obtained from an electric storage battery lantern.



- 5.01.26 No person having article of steel or iron on him shall be allowed to enter the magazine.
- 5.01.27 Oily cotton, rag waste and articles liable to spontaneous ignition shall not be allowed inside the magazine.
- 5.01.28 Workmen shall be examined before they enter the magazine to see that they have none of the prohibited articles on their person.
- 5.01.29 No tools or implements other than those of copper, brass, gunmetal or wood shall be allowed inside the magazine. All tools shall be handled and used with extreme care and gentleness.
- 5.01.30 Boxes of explosives shall not be thrown down or dragged along the floor, and shall be stacked on wooden trestles. Where there is pressure of white ants, the legs of the trestle shall rest in shallow copper, lead or brass bowls containing water. Open boxes of dynamite shall never be exposed to the direct rays of the sun.
- 5.01.31 Empty boxes of lose packing material shall not be kept inside the magazine.
- 5.01.32 The magazine shall have lightning conductor, which should be got tested at least once a year, by an officer authroised by the Executive Engineer. The testing fee shall be charge on the Contractor. The Contractor shall within 45 days comply with all the recommendations made by the officer testing the lightning conductor failing which the Executive Engineer shall be entitled to comply with the same at the Contractor's expense. This shall not be open to any question or the Executive Engineer may consider any action that be may consider fit.
- 5.01.33 A notice shall be kept hung near the store, prohibiting entrance of unauthorized people inside the magazine.
- 5.01.34 The following shall be kept hung in the lobby of the magazine:
- A copy of rules both in English and in the languages which the workers concerned are familiar with.
 - A statement showing the stock in the magazine at that particular time.
 - A notice that smoking is strictly prohibited.
- 5.01.35 The magazine shall be inspected at least twice a year by an officer authorized by the Executive Engineer-in-charge who will see that all the rules are strictly complied with. He will notify all omissions etc. to the Contractor, who shall rectify the defects within the period of 15 days from the date of receipt of the notice, failing which the Executive Engineer may take whatever action he considers suitable.

5.01.36 Use of Explosives

For the transport of the explosives and detonators between the store and the site, closed and strong containers made of sort materials such as timber, zinc, copper, leather and the like shall only be used.

5.01.37 Explosives and detonators shall be carried in separate boxes. For the conveyance of primers, special containers shall be used.

5.01.38 The boxes with half contents used shall be kept closed.

5.01.39 Explosives shall be stored and used chronologically to assure the ones, received earlier, are being used first.

5.01.40 A make up house shall be provided at each working place in which cartridges will be made up by experienced men as required for the work. The make up house shall be separated from other buildings. Only electric storage battery lamps shall be used in this house.

5.01.41 No smoking shall be allowed in the makeup house or generally while dealing with explosives.

5.01.42 Disposal of Deteriorated Explosives

All deteriorated explosives shall be disposed off in an approved manner. The quantity of the deteriorated explosives to be disposed off shall be intimated to the Executive Engineer prior to its disposal.

5.01.43 Preparations of Primers

The primers shall not be prepared near open flames or fires. The work of preparation of primers shall always be entrusted to the same personnel. Primers shall be used as soon as possible after they are ready.

5.01.44 Charging of Holes

The work of charging shall not commence before all the drilling work at the site is completed, and the supervisor has satisfied himself to that effect by actual inspection.

5.01.45 While charging open lamps shall be kept away. For charging with powered explosives, a naked flame shall not be allowed.

5.01.46 Only wooden tamping rods, without any kind of metal on them shall be allowed to be used. The tamping rods shall have cylindrical ends.

5.01.47 Bore holes must be of such a size that the cartridges can easily pass down them, they shall not however be too big.



- 5.01.48 Only one cartridge shall be inserted at a time and gently pressed home with the tamping rod. The same, clay or other tamping material used for filling the hole completely shall not be tamped too hard.
- 5.01.49 **Blasting**
- Blasting shall be carried out during fixed hours of the day, which shall have the approval of the Executive Engineer. The hours once fixed shall not be altered without prior written approval of the Executive Engineer.
- 5.01.50 The site of blasting operations shall be prominently demarcated by red danger flags. The order to fire shall be given only by the supervisor and this order shall be given only after giving the warning signal three times, so as to enable all labour, watchmen etc. to reach safe shelters.
- 5.01.51 A bugle with a distinctive note shall be used to give the warning signals. This bugle shall be made acquainted with the sound of the bungle and shall be strictly warned to leave their work immediately at the first warning signal and to make for safe shelter, and not to leave the shelters until all clear signal has been given.
- 5.01.52 All the roads and foot paths leading to the blasting area shall be watched.
- 5.01.53 The Executive Engineer may however permit blasting without restriction of fixed time provided that he is satisfied those proper precautions are taken to give sufficient warning to all concerned and that the work of other agencies is not unduly hampered.
- 5.01.54 For lighting the fuses, a lamp with a strong flame such as carbide lamp shall be used.
- 5.01.55 The supervisor shall watch the time required for the firing of the fuses and shall see that all the workmen are under safe shelters in good time.
- 5.01.56 **Electrical Firing**
- 5.01.56.01 Only the Supervisor in charge shall possess key of the firing apparatus and he shall keep it always with himself.
- 5.01.56.02 Special apparatus shall be used as a source of current for the blasting operations. Power lines shall not be tapped for the purpose.
- 5.01.56.03 The detonators shall be checked before use.
- 5.01.56.04 For blasts in series only detonators of the same manufacture and of the same group of electrical resistance shall be used.

- 5.01.56.05 Such of the electrical lines and could constitute danger for work of charging, shall be removed from the site. The firing cable shall be proper insulating cover so as to avoid short circulating due to contact with water, metallic parts or rock.
- 5.01.56.06 The firing cable shall be connected to the source of current only when nobody is in the area of blasting.
- 5.01.56.07 The use of the earth as a return line shall not be permitted.
- 5.01.56.08 Before firing, the circuit shall be checked by a suitable apparatus.
- 5.01.56.09 After firing, whether with or without an actual blast, the contact between the firing cable and the source of current shall be cut off before any people are allowed to leave the shelters.
- 5.01.56.10 During storms, charging with electrical detonators shall be suspended. The charts already placed in the holes shall be blasted as quickly as possible, but taking all the safety precautions and giving necessary warning signals. If this is not possible, the site shall be abandoned till the storm has passed.
- 5.01.57 **Precautions after Blasting**
- 5.01.57.01 After the blasting the supervisors must carefully inspect the work and satisfy himself that all the charges have exploded.
- 5.01.57.02 After the blast takes place in underground works, the workmen shall not allowed to go to the face till all the toxic gases are evacuated from the face.
- 5.01.58 **Misfires**
- 5.01.58.01 If it is suspected that part of the blast has failed to fire or is delayed, sufficient time shall be allowed to elapse before entering the danger zone. When fuse and blasting caps are used a safe time should be allowed and then the supervisor along shall leave the shelter to see the misfire.
- 5.01.58.02 None of the drillers are to work near misfired hole until one of the two following operations have been carried out by the supervisor.

Either (i) the supervisor should very carefully (when the tamping is of the damp clay) extract the tamping with a wooden scrapper to jet of water or compressed air (using a pipe of soft material and withdraw the fuse with the primer and detonator attached after which a fresh primer and detonator with fuse should be placed in this hole and fired out or (ii) the hole may be cleared of one foot of tamping and the direction then be ascertained the placing as a stick in the hole. Another hole may then be drilled at least 9" away and parallel to it, this hole should then be charged and fired. The balance of the cartridges and detonators found in the much shall be removed.



- 5.01.58.03 Before leaving his work, the supervisor shall inform the supervisor of the relieving shift of any case of misfires and shall point out the position with a red cross denoting the same, also stating what action, if any, he has taken in the matter. A register of misfires and their location and how they are dealt with shall be maintained.
- 5.01.58.04 The supervisor shall also at once report at the Contractor's office all cases of misfires, the cause of the same and what steps were taken in connection therewith.
- 5.01.58.05 The names of the day and night shift supervisors shall be noted daily in the Contractor's office.
- 5.01.58.06 If a misfire has been found to be due to a defective detonator, or dynamite, the whole quantity or box from which the defective article was taken, must be returned to the contractor's office for inspection.
- 5.01.58.07 Drilling in holes not completely explode by blasting shall not be permitted.

5.02 Trenches and Other Excavations

Width of the trench at the bottom shall be such as to provide 200mm clearance on either side of the pipe for facility of laying and jointing.

Excavated material shall be stacked sufficiently away from the edge of the trench and the side of the spoil bank shall not be allowed to endanger the stability of the excavation. Spoil may be carted away and used for filling the trench.

Turf, top soil or other surface material shall be set aside, turf being carefully rolled and stacked for use in reinstatement.

All excavation shall be properly timbered, where necessary,

Efficient arrangements for dewatering during excavation and keeping it dry till backfilling shall be made to the satisfaction of the Engineer. Sumps for dewatering shall be located away from the pipe layout. Where the excavation proceeds through roads necessary permissions shall be secured by the Contractors from the appropriate authorities.

Where the excavation proceeds through roads necessary permissions shall be secured by the Contractors from the appropriate authorities.

Special care shall be taken not to damage underground services, cables etc. These when exposed shall be kept adequately supported till the trench is backfilled.

The backfilling shall be done only after the pipeline has been tested and approved by the Engineer. Special care shall be taken under and sides of the pipe during hand packing with selected material. At least 300mm over the pipe shall also be filled with soft earth or sand consolidation shall be done 150mm layers. The surface water shall



be prevented from getting into the filled up trench. Traffic shall not be inconvenienced by heaping up unduly the backfilling material to compensate future settlement. All future settlements shall be made good regularly to minimise inconvenience of traffic where applicable.

6.00 **BENCH MARKS**

Throughout the construction the Contractor shall at his own cost establish, construct, protect and maintain all benchmarks and reference points to the satisfaction of the Engineer and provide necessary assistance in taking and recording of all measurements by the Engineer.

7.00 **PROTECTION**

The Contractor shall provide and maintain required decking, guard fencing, roping, planking, sign boards, red lights, etc. required to maintain safe pedestrian and vehicular traffic and for safety of persons and property.

8.00 **FILL, BACK FILLING**

General

All fill material will be subject to Engineer's approval. If Engineer rejects any material, Contractor shall remove the same forthwith from the Site at no extra cost to the Purchaser. Surplus fill material shall be deposited / disposed off as directed by Engineer after the fill work is completed.

No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by Engineer.

Material

To the extent available, selected surplus soils from excavated materials shall be used as backfill. Fill material shall be free from clods, salts, sulphates, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of moorum or earth to fillup the voids and the mixture used for filling. No expansive soil shall be used for backfilling or plinth filling. No expansive soil shall be used for backfilling or plinth filling.

If any selected fill material is required to be borrowed, Contractor shall make arrangements for bringing such material from outside borrow pits or from Purchaser's acquired land within the specified lead. The material and source shall be subject to prior approval of Engineer. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish etc. top soil containing salts / sulphate and other foreign material shall be removed. The materials so removed



shall be burnt or disposed off as directed by Engineer. Contractor shall make necessary access roads to borrow areas and maintain the same, if such access road does not exist, at his cost.

Filling in Pits Around Foundations Etc.

As soon as the work in foundations has been completed and accepted and measured, the spaces around the foundations, structures, pits, trenches etc. shall be cleared of all debris and filled with earth in layers not exceeding 150mm, each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of Engineer. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless Engineer is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and leveled to proper profile as directed by Engineer or indicated on the drawings.

Sand Filling:

At places backfilling shall be carried out with local sand if directed by Engineer. The sand used shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for twenty four (24) hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to Contractor's account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until Engineer has inspected and approved the fill.

Filling in Trenches

The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to the concrete foundation.

Back fill shall not be dropped directly upon or against any structure/facility where there is a danger of displacement or damage. Trucks or heavy equipment for depositing or compacting back fill shall not be used within 1.5m of building walls, piers, or other facilities which may be damaged by their weights, operation or method of compaction, subject to approval of Engineer.

9.00

FILL DENSITY

The compaction shall comply with the specified proctor/ modified proctor density at moisture content differing not more than four (4) percent from the optimum moisture content. Test shall be carried out in accordance with relevant part(s) of IS:2720 and all tests shall be made by/or under the supervision of Purchaser at Contractor's own expense.



10.00

TIMBER SHORING

This specification covers the general requirements of timber shoring for excavation of trenches, pits, open excavations etc.

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 25 cm x 4 cm sections or as directed by Engineer. The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2m spacing, strutted with bullies or as directed by Engineer. The length of the bullies struts shall depend on the width of the trench or pit. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical walling, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by Engineer. It shall be the responsibility of Contractor to take all necessary steps to prevent the sides of excavations, trenches, pits etc. from collapsing.

Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons such shoring shall be carried out, except in an emergency, only under instructions from Engineer.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded with systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

In the case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width.

The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of Engineer. In all other respects, specification for close timbering shall apply to open timbering.

In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across sides of excavations/pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. Load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut.



No extra payment shall be made for timber shoring. This is deemed to be included in the tendered cost.

11.00

DEWATERING

Contractor shall ensure that during excavation ground water level shall be lowered by at least 0.5m below the foundation level, adopting appropriate method of dewatering. In case water gets accumulated in the excavated pit from any source, the same shall be kept continuously dewatered until the last pour of foundation concrete.

When there is a continuous inflow of water and quantum of water to be handled is considerable in the opinion of Engineer, a large, well point system - Single stage or multistage, shall be adopted. Contractor shall submit to Engineer his scheme of well point system including the stages, the spacing, number and diameter of well points, headers, etc. and the number, capacity and location of pumps for approval. The cost of dewatering shall be deemed to be included in the tendered cost of works

12.00

RAIN WATER DRAINAGE

This section covers the drainage of rainwater in excavated areas. Grading in the vicinity of excavation shall be such as to exclude rain / surface water raining into excavated areas. Excavation shall be kept clean of rain and such water as the Contractor may be using for his work by suitably pumping out the same at no extra cost to the Purchaser. The scheme for pumping and discharge of such water shall be approved by the Engineer.



**PART-III
WORK SPECIFICATION
FOR
CONCRETE AND ALLIED WORKS**

1.0 SCOPE

This part of specification covers the general requirements for concrete to be used on jobs using on-site production facilities including requirements in regard to the quality, handling, storage of ingredients, proportioning, batching, mixing and testing of concrete and also requirements in regard to the quality, storage, bending and fixing of reinforcement. This also covers the transportation of concrete from the mixer to the place of final deposit and the placing, curing, protecting, repairing and finishing of concrete.

2.0 APPLICABLE CODES AND SPECIFICATIONS

The following specifications, standards and codes of practice are made a part of this specification. All standards, codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as applicable on the date of opening of the Bids.

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

2.1 Indian Standard Codes for Material and its Test

- | | | | |
|----|----------|---|---|
| 1. | IS: 8112 | : | Specification for 43 grade ordinary Portland cement. |
| 2. | IS: 455 | : | Specification for Portland blast furnace slag cement. |
| 3. | IS: 1489 | : | Specification for Portland pozzolana cement. (Part 1 & Part 2) |
| 4. | IS: 4031 | : | Methods of physical tests for hydraulic cement. (Part 1 to Part 15) |
| 5. | IS: 650 | : | Specification for standard sand for testing of cement. |
| 6. | IS: 383 | : | Specification for coarse and fine aggregates from natural sources for concrete. |



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|-----|-----------|---|--|
| 7. | IS: 2386 | : | Methods of test for aggregates for concrete.
(Part I to VIII) |
| 8. | IS: 516 | : | Method of test for strength of concrete. |
| 9. | IS: 1199 | : | Method of sampling and analysis of concrete. |
| 10. | IS: 6909 | : | Specification for Super sulphate Cement |
| 11. | IS: 12330 | : | Specification for Sulphate resisting Portland Cement |
| 12. | IS: 3025 | : | Methods of sampling and test (physical and chemical) water used in industry. |
| 13. | IS: 432 | : | Specification for mild steel and medium (Part I & II) tensile steel bars and hard drawn steel wire for concrete reinforcement. |
| 14. | IS: 1566 | : | Specification for hard drawn steel wire (Part I) fabric for concrete reinforcement. |
| 15. | IS: 1786 | : | Specification for high strength deformed steel bars and wires for concrete reinforcement. |
| 16. | IS: 4990 | : | Specification for plywood for concrete shuttering work. |
| 17. | IS: 2645 | : | Specification for integral cement water proofing compounds. |
| 18. | IS: 6452 | : | Specification for high alumina cement for structural use. |

2.2

Equipment

- | | | | |
|----|----------|---|--|
| 1. | IS: 1791 | : | Specification for batch type concrete mixers. |
| 2. | IS: 2438 | : | Specification for roller pan mixer. |
| 3. | IS: 2505 | : | Specification for concrete vibrators immersion type. |
| 4. | IS: 2506 | : | Specification for screed board concrete vibrators |
| 5. | IS: 2514 | : | Specification for concrete vibrating tables. |
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6. IS: 3366 : Specification for pan vibrators.
7. IS: 4656 : Specification for form vibrators for concrete.
8. IS: 2722 : Specification for portable swing weigh batchers for concrete (single and double bucket type)
9. IS: 2750 : Specification for steel scaffoldings.

2.3

Codes of Practice

1. IS: 456 : Code of practice for plain and reinforced concrete.
2. IS: 2502 : Code of practice for bending and fixing of bars for concrete reinforcement.
3. IS: 2751 : Recommended practice for welding of mild steel bars used for reinforced concrete construction.
4. IS: 3558 : Code of practice for use of immersion vibrators for consolidating concrete.
5. IS: 3414 : Code of practice for design and installation of joints in buildings.
6. IS: 4014 : Code of practice for steel tubular (Part I & II) scaffolding
7. IS: 2571 : Code of practice for laying in situ cement concrete flooring.
8. IS: 3558 : Code of practice for use of immersion vibrators for consolidating concrete.

2.4

Construction Safety

1. IS:3696 - Safety code for scaffolds and ladders. (Part-I & II)

3.0

GENERAL

The Contractor shall furnish all labour, materials and equipment required for the construction of all concrete and associated work such as: transformer foundations,



foundations for transmission line towers and poles, RCC Roads within switchyard, fire protection works, RCC paving in the transformer yard, RCC cable trenches with necessary precast covers with lifting facilities, sump pits etc. as per drawings and as directed by the Engineer. All cement concrete, reinforced or plain shall conform to Indian Standard Code of Practice IS:456-2000, with latest amendment, unless otherwise specified herein. The concrete mixes used in various civil works shall be as per Drawing / Design of the structure. The proportions of fine and coarse aggregate, cement and water shall be as per mix design arranged by the Contractor. The contractor shall get the mix design from reputed institutes for approval of owner/customer consultant.

The Engineer shall have the right to inspect the source of materials used, its storage and order for any tests found necessary. The work shall be carried out to the Engineer's satisfaction.

4.0 MATERIALS FOR STANDARD CONCRETE

The ingredients to be used in the manufacture of standard concrete shall consist solely of a standard type Portland cement, clean sand, natural coarse aggregate, clean water, and admixtures.

4.1 CEMENT

Cement Grade 43 shall conform to IS:8112. Cement shall be ordinary Portland cement in 50kg. bags. The use of bulk cement will be permitted only with the approval of Engineer. Changing of brands or type of cement within the same structure or portions thereof shall be permitted only with the approval of Engineer.

Different type of cement shall not be mixed together. In case more than one type of cement is used in any work, a record shall be kept showing the location and the types of cement used.

Contractor will have to make his own arrangements for the storage of adequate quantity of cement. Cement bags shall be stored in a dry enclosed shed (storage under tarpaulins will not be permitted) well away from the outer walls (atleast 450mm away) and insulated from the floor to avoid contact with moisture from ground and stacking shall be done about 150 mm to 200mm clear above the floor using wooden planks and in a row of two bags leaving atleast 600mm space to provide ready access. Damaged or reclaimed or partly set cement will not be permitted to be used and shall be removed from the Site. The storage bins and storage arrangements shall be such that there is no dead storage. Not more than ten (10) bags shall be stacked in any tier to avoid lumping of cement under pressure. The storage arrangement shall be approved by Engineer. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery.



Special Test Requirement

Cement will be sampled at the work Site and tests will be performed by the Contractor under the supervision of Purchaser at contractor's expense. The Contractors will have to carry out the tests as regards conformity/suitability of cement with reference to IS: 8112.

4.2

REINFORCEMENT**Supply**

Reinforcement shall be either TMT or Tor steel (conforming to IS: 1786).

Storage

The reinforcement shall not be kept in direct contact with the ground but stacked on top of a platform made of timber sleepers or the like.

If the reinforcing rods have to be stored for a long duration, they shall be coated with cement before staking and / or be kept under cover or stored as directed by Engineer.

Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deterioration.

Quality

All reinforcement shall be clean, free from grease, oil, paint, dirt, loose mill scale, loose rust, dust, bituminous material or any other substances that will destroy or reduce the bond. All rods shall be thoroughly cleaned before being fabricated. Pitted and defective rods shall not be used. All bars shall be rigidly held in position before concreting. No welding of rods to obtain continuity shall be allowed unless approved by Engineer. If welding is approved, the work shall be carried out as per IS: 2751 according to best modern practices and as directed by Engineer. Special precautions, as specified by Engineer, shall be taken in the welding of cold worked reinforcing bars and bars other than mild steel.

Laps

Laps and splices for reinforcement shall be as per IS: 456-2000. Splices in adjacent bars shall be staggered and the locations of all splices, shall be approved by Engineer. The bars shall not be lapped unless the length required exceeds the maximum available lengths of bars at site.



Bending

Reinforcing bars supplied bent or in coils, shall be straightened before they are cut to size. Straightening of bars shall be done in cold and without damaging the bars. This is considered as a part of reinforcement bending fabrication work.

All bars shall be accurately bent. They shall be bent gradually by machine or other approved means. Reinforcing bars shall not be straightened and rebent in a manner that will injure the material; bars containing cracks or splits shall be rejected. They shall be bent cold, except bars of over 25 mm in diameter which may be bent hot if specifically approved by Engineer. No reinforcement shall be bent when in position in the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those required by design shall not be used.

Fixing

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position by the use of blocks, spacers and chairs as per IS: 2502 to prevent displacement during placing and compaction of concrete. Bars intended to be in contact at crossing points shall be securely bound together at all such points with 16 gauge annealed soft iron wire. The vertical distances required between successive layers of bars in beams or similar members shall be maintained by the provision of mild steel spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bars.

Cover

Unless indicated otherwise on the drawings, clear concrete cover for reinforcement (exclusive of plaster or other decorative finish) shall be as per IS:456 - 2000 and as per instruction of the Engineer.

Inspection

Erected and secured reinforcement shall be inspected and approved by Engineer prior to placement of concrete.

4.3

FINE AGGREGATES

Fine aggregate (sand) shall be clean, sharp, coarse sand with a fineness modulus as per IS code (Fineness modulus is the sum of cumulative percentages retained on the IS sieves given below for gradation divided by 100). The Contractor shall check and ensure that local sand will satisfy this requirement and if necessary shall include for and supply materials from other sources which comply with the specification

The objectionable foreign matter in sand shall be removed by screening or washing or both as required.



Screening and Washing

Sand shall be prepared for use by such screening or washing, or both, as necessary, to remove all objectionable foreign matter while separating the sand grains to the required size fractions.

Gradation

Unless otherwise directed or approved, the grading of sand shall be within the limits as per IS :383.

Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron IS Sieve, by total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron IS 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 be used unless mix designs and preliminary tests have shown its suitability for producing concrete of specified strength and workability.

The grading of sand for cement mortar for masonry work shall conform to IS: 2116-1980 & fineness modulus between 2.0 & 3.0.

Grading of sand for use in plaster shall conform to IS: 1542-1992.

The grading of sand shall be altered by Engineer depending upon the requirements, suitability and availability. The Contractor shall procure, process and supply the sand at no extra cost to the Purchaser.

Soundness

The average loss of weight for sand after five (5) cycles and subjected to sodium sulphate accelerated soundness test as specified in IS: 2386 (Part V) shall not be more than 10%.

4.4

COARSE AGGREGATE

Aggregate of sizes ranging between 4.75 mm & 150 mm will be termed as Coarse Aggregate. Only Coarse Aggregate of HBG metal (Hard Broken Granite) from approved quarries & conforming to IS:383 will be allowed to be used on the works.

Screening and Washing

Natural gravel and crushed rock shall be screened and/or washed for the removal of dirt or dust coating, if so demanded by Engineer.



Grading

Coarse aggregate shall be whether in single size or grade, in both cases, the grading shall be within the following limits as per IS :383.

The exact grading of coarse aggregate for different items of cement concrete works shall be approved by Engineer from time to time based on the laboratory test. Such changes in the grading shall be carried out by Contractor at no extra cost.

The pieces shall be angular in shape and shall have granular or crystalline surfaces. Friable, flaky and laminated pieces, mica and shale, if present, shall be only in such quantities that will not, in the opinion of Engineer, affect adversely the strength and/or durability of concrete. The maximum size of coarse aggregate shall be the maximum size specified above, but in no case greater than one fourth (1/4) of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. Plums above 160 mm and upto any reasonable size can be used in plain mass concrete work of large dimensions upto a maximum limit of 20% by volume of concrete when specifically approved by Engineer. Plums shall be distributed evenly and shall be not closer than 150mm from the surface. For heavily reinforced concrete members, the nominal maximum size of the aggregate shall be 5mm less than the minimum clear distance between the reinforcing main bars or 5mm less than the minimum cover to the reinforcement whichever is smaller. The amount of fine particles occurring in the free state or as loose adherent shall not exceed 1% when determined by laboratory sedimentation tests as per IS: 2386.

Should at any time the Engineer have reason to consider any aggregate defective or of poor quality, then irrespective of any previous approval or test, representative samples of such materials shall be immediately tested and until the results of such tests prove the material to be satisfactory, it shall not be used for any work. The Contractor shall not be entitled to any claim of any nature on this account. The cost of these tests (including collection of samples and transportation) shall be borne by the Contractor.

Crushing Value

The aggregate crushing value, when determined in accordance with IS:2386 (Part-IV) shall not exceed forty five (45) percent for aggregate used for concrete other than for wearing surfaces and thirty (30) percent for concrete for wearing surfaces.

Impact Value

As an alternative to clause 6.3 the aggregate impact value may be determined in accordance with the method specified in IS: 2386 (Part IV). The impact value shall not exceed forty five (45) percent by weight for aggregates used for concrete other than



for wearing surfaces and thirty (30) percent by weight for concrete for wearing surfaces.

Abrasion Value

Unless otherwise agreed to between the Purchaser and the Supplier the abrasion value of aggregates, when tested in accordance with the method specified in IS: 2386 (Part IV), using Los Angeles Machine, shall not exceed the following values:-

- | | | |
|----|---|---------------------|
| A. | For aggregates to be used in concrete for wearing surfaces. | Thirty (30) percent |
| B. | For aggregates to be used in other concrete (structural) | Fifty (50) percent. |

Storage of Aggregates

All coarse and fine aggregates shall be stacked separately in stock piles in the material yard near the work Site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign materials and earth during storage and while heaping the materials shall be avoided. The aggregate must be of specified quality not only at the time of receiving at Site but more so at the time of loading into mixer. Rakers shall be used for lifting the coarse aggregates from bins or stock piles. Coarse aggregate shall be piled in layers not exceeding 1.2m in height to prevent coning or segregation. Each layer shall cover the entire area of the stock pile before succeeding layers are started. Aggregates that have become segregated shall be rejected. Rejected material after remixing may be accepted, if subsequent tests demonstrate conformance with required gradation. After the completion of the piling of the aggregate upto the required height the piled aggregate shall be marked with time.

4.5

WATER

Water used for both mixing and curing shall be free from injurious amounts of deleterious materials. Potable waters are generally satisfactory for mixing and curing concrete.

In case of doubt, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time test specified in IS: 456-2000. The sample of water taken for testing shall be typical of the water proposed to be used for concreting, due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water. The PH value of water to be used shall not be less than 6.



Average 28 day compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water.

The initial setting time of test block made with the appropriate test cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by more than ± 30 minutes from the initial setting time of control test block prepared with the appropriate test cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of IS: 4031.

Where water can be shown to contain an excess of acid, alkali, sugar or salt, Engineer may refuse to permit its use. The following concentrations represent the maximum permissible values:

	<u>Permissible limit</u>
1) Organic	200mg/lit.
2) Inorganic	3000mg/lit.
3) Sulphates	400mg/lit.
4) Chlorides	2000mg/lit. for concrete not containing embedded steel and 500 mg/l for reinforced concrete work
5) Suspended matter	2000mg/lit.

5.0

MIX DESIGN

All mix design work and testing of samples/cubes etc. shall be got done by the Contractor at his own cost. The Contractor shall make all arrangements for transportation of samples from quarry/workshop to laboratory, he shall be required to associate himself with Purchaser in evolving the required design mixes by assigning the job to a qualified Engineer under his employment.

Minimum cement content for various grades of concrete shall be as per IS:456-2000.

MIXING OF CONCRETE

Cement, sand and crushed stone shall be measured by weight as directed by the Engineer; the components of the concrete shall be batched in such a way that each batch contains a whole number of cement bags. Concrete shall be mixed in concrete mixers of a size and type previously certified acceptable to the Engineer. Concrete shall be mixed in the machine for at least one (1) minute dry and for at least one and a half minutes after adding water. Mixed concrete shall be of even colour and uniform consistency.



Concrete shall be mixed only in such quantities as are required for immediate use. No more concrete shall be mixed in any one lot than that can be laid in position before the 'initial setting' occurs. Partly set or re-tampered concrete shall not be used. After the finish of each day's works the mixing plats shall be thoroughly washed and cleaned. .

The mixer and weigh batchers shall be maintained in a clean, serviceable condition. The accuracy of weigh batchers shall be periodically checked. They shall be set up level on a firm base and the hopper shall be loaded evenly. The needle shall be adjusted to zero when the hopper is empty. Fine and coarse aggregates shall be weighed separately. Volume batching will not be permitted. All concrete shall be mixed in mechanically operated batch mixers complying with IS: 1791 and of approved make with suitable provision for directly controlling the water delivered to the drum.

The water cement ratio to be adopted shall be determined in each case by the Contractor as frequently as desired by the Engineers.

Consistency and workability of Concrete

Consistency and workability of concrete shall be checked by measuring the slump of a truncated cone of concrete straight from the mixer under normal working conditions. The conical mould shall be of metal, 300mm high and 100mm and 200mm in diameter at top and base respectively.

Moulds shall be prepared by the Contractor. The slump range of concrete shall be as mentioned below.

Slump tests shall be performed as per IS: 1199 at intervals established by the Engineer at the Contractor's cost in such a way as to check that the degree of consistency established by the Engineer for work in progress is maintained. The table below gives the general slump range to be followed for various types of construction unless otherwise shown on drawings of instructed by the Engineer.

SLUMP FOR VARIOUS TYPES OF CONSTRUCTION

LIMITS OF CONSISTENCY

Degree of Workability	Slump in mm with Standard Cone <u>as Per IS: 1999</u>		Use for which concrete is suitable
	Min.	Max.	
Very low	0	25	Large Mass concrete structures with heavy Compaction equipments, roads and like.



Degree of Workability	Slump in mm with Standard Cone as Per IS: 1999		Use for which concrete is suitable
	Min.	Max.	
Low	25	50	Un congested wide and shallow R.C.C. Structures
Medium	50	100	Deep but wide R.C.C. structures with Congestion of reinforcement and inserts.
High	100	150	Very narrow and deep R.C.C. structures with Congestion due to reinforcement and inserts.

(Note: Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer)

Batching and Mixing of Concrete

The material and proportions of concrete materials as established by the preliminary tests for the mix design shall be rigidly followed for all concrete on the Project and shall not be changed except when specifically permitted by Engineer.

Concrete shall be produced only by weigh batching the ingredients. The mixer and weigh batchers shall be maintained in clean, serviceable condition. The accuracy of weigh batchers shall be periodically checked.

SAMPLING AND TESTING CONCRETE IN THE FIELD

Facility required for sampling materials & concrete in the field shall be provided by Contractor without any extra cost and the tests shall be got done by the Contractors at his own expense. The following equipment with operator shall be made available at Engineer's request (all must be in serviceable condition) :

- | | | |
|----|---|-------------|
| 1. | Concrete cube testing machine suitable for 15cm cubes of 100ton capacity with proving calibration ring. | 1 No. |
| 2. | Cast iron cube moulds 15cm size | 6Nos. (min) |
| 3. | Slump cone complete with tamping rod | 1 set |
| 4. | Laboratory balance to weigh upto 5kg. with sensitivity of 10gm. | 1 No. |



5.	IS sieves for coarse and fine aggregates	1 set
6.	A set of measures from 5 to 0.1	1 set
7.	Electric oven with thermostat upto 120 Deg.C	1 No.
8.	Flakiness gauge	1 No.
9.	Elongation index gauge	1 No.
10.	Sedimentation pipette	1 No.
11.	Pycnometer	1 No.
12.	Calibrated glass jar I liter capacity	2 Nos.
13.	Glass flasks & metal containers	As required
14.	Chemical reagents like sodium hydroxide, tannic acid, litmus papers etc.	As required
15.	Laboratory balance of 2 Kg. capacity	1 No. and of sensitivity of 1 gm.

6.0

ADMIXTURES**General**

Admixtures shall be supplied by Contractor and nothing extra shall be payable on this account. Admixtures may be used in concrete only with the approval of Engineer based upon evidence that, with the passage of time, neither the compressive strength nor its durability reduces. Calcium chloride shall not be used for accelerating setting of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted to be used, such as in mass concrete works, it shall be dissolved in water and added to the mixing water in an amount not to exceed 1.5% of the weight of the cement in each batch of concrete. When the admixtures are used the designed concrete mix shall be corrected accordingly. ISI mark Admixtures shall be used as per manufacturer's instructions and in the manner and with the control specified by Engineer.

To minimize the deterioration of concrete from harmful chemical salts, the levels of such salts in concrete coming from the concrete materials i.e. cement, aggregates, water and admixtures as well as by diffusion from the environments should be limited. Generally the total amount of chlorides and the total amount of soluble sulphates in the concrete at the time of placing should be limited to 0.15% of mass of cement and 4% by mass of cement respectively.



Air Entraining Agents

Neutralized Vinsol Resin or any other approved air entraining agent may be used to produce the specified amount of air in the concrete mix and these agents shall conform to the requirements of ASTM standard 6-260; Air Entraining Admixtures for concrete. The recommended total air content of the concrete is 4% ($\pm 1\%$). The method of measuring air content shall be as per IS: 1199.

Water Reducing Admixtures

Water reducing lignosulfonate mixture shall be added in quantities specified by Engineer. The admixtures shall be added in the form of a solution.

Retarding Admixtures

Where specified and approved by Engineer, retarding agents shall be added to the concrete mix in quantities specified by Engineer.

Water Proofing Agent

Where specified and approved by Engineer, ISI marked water proofing agent conforming to IS: 2645, shall be added in quantities specified by Engineer.

Other Admixtures

Engineer may at his discretion instruct Contractor to use any other admixture in the concrete.

Corrosion Protection

All foundations and underground structures shall be provided with concrete penetrating corrosion inhibitor (EPCO-KP 100) followed by application of EPCO-2020Tx Epoxy.

The coating system for (EPCO-2020-Tx) shall conform to the following:

Base	:	Tar extended Epoxy Amine adduct quick curing two component
Colour	:	Black
Volume of solids	:	80%
Drying Time (Touch Dry)	:	2 hours
DFT in two coats	:	300 microns –350 microns
Chemical resistant	:	Excellent against chlorides, salts, sulphates, alkalies
Salt spray test	:	Should pass as per ASTM-B-117 1000 hours minimum



Adhesion	:	3.8 KiloNewton minimum as per ASTM-D-4541
Resistance(Independence)	:	10^8
Surface preparation	:	As per manufactures specification or as per relevant IS codes

The coating system for (EPCO-100) shall conform to the following:

Application	:	Surface application minimum 4 Sq.Mt /Lt
Base	:	Water based organic corrosion
Appearance	:	Colourless slightly hazy liquid
Toxicity	:	Non-Toxic
Specific Gravity	:	1.02 to 1.07
PH	:	Minimum 10

The preparation of the surface and the application of the coating shall be as per the specification and instructions of the manufacturer.

7.0

LOAD TEST ON MEMBERS OR ANY OTHER TESTS

In the event of any work being suspected of faulty material or workmanship or both, Engineer requiring its removal and reconstruction may order, or Contractor may request for load test in accordance with the provisions of IS: 456 – 2000.

Unsatisfactory Test

Should the results of any test prove unsatisfactory, or the structure shows signs of weakness, undue deflection or faulty construction Contractor shall remove and rebuild the member or members involved or carry out such other remedial measures as may be required by Engineer/Purchaser. Contractor shall bear the cost of doing so, unless the failure of the member or members to fulfill the test conditions is proved to be solely due to faulty design.

8.0

CONCRETE PLACEMENT AND QUALITY CONTROL

Before the concrete is actually placed in position, the insides of the formwork shall be inspected to see that they have been cleaned and oiled. Temporary opening shall be provided to facilitate inspection, especially at bottom of columns and wall forms, to permit removal of saw dust, wood shavings, binding wire, rubbish, dirt etc. Openings shall be placed or holes drilled so that these materials and water can be removed easily. Such openings / holes shall be later suitably plugged.

The various trades shall be permitted ample time to install drainage and plumbing lines, floor and trench drains, conduits, hangers, anchors, inserts, sleeves, bolts, frames and other miscellaneous embedment to be cast in the concrete as is necessary for the proper execution of the work. Contractor shall



cooperate fully with all such agencies, and shall permit the use of scaffolding, form work etc., by other trades at no extra cost.

All embedded parts, inserts etc. supplied by Purchaser or Contractor shall be correctly positioned and securely held in the forms to prevent displacement during depositing and vibrating of concrete. Inserts etc. will have to be welded to reinforcement, if required, to keep them in position, as directed by Engineer.

All anchor bolts shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by Engineer. The use of all such templates, fixtures etc. shall be deemed to be included in the rates.

Slots, openings, holes, pockets etc. shall be provided in the concrete work in the positions as directed by Engineer.

Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.

Prior to concrete placement all work shall be inspected and approved by Engineer and if found unsatisfactory, concrete shall not be poured until after all defects have been corrected at Contractor's cost.

Approval by Engineer of any and all materials and work as required herein shall not relieve Contractor from his obligation to produce finished concrete.

Rain or Wash Water

No concrete shall be placed on a water covered surface. Any concrete that has been washed by heavy rains shall be entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage which may be caused by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work unattended. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no other concrete shall be placed thereon until such water is removed. To avoid flow of water over/around freshly placed concrete, suitable drains and sumps shall be provided.

Bonding Mortar

Immediately before concrete placement begins, prepared surfaces except formwork that will come in contact with the concrete to be placed, shall be covered with a bonding mortar as specified in this section.

Transportation

All buckets, containers or conveyors used for transporting concrete shall be mortar-tight. Irrespective of the method of transportation adopted, concrete shall



be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of Engineer and concrete shall not be rehandled before placing.

Retempered or Contaminated Concrete

Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete, which has become stiff or has been contaminated with foreign materials shall be rejected and disposed off as directed by Engineer.

Engineer's Approval for Equipment and Methods

Before any concrete is placed, the entire placing program, consisting of equipment layout, proposed procedures and methods shall be submitted to Engineer for approval if so demanded by Engineer and no concrete shall be placed until Engineer's approval has been received. Equipment for conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete during depositing without segregation of materials, considering the size of the job and placement location.

Time Interval Between Mixing and Placing

Concrete shall be placed in its final position before the cement reaches its initial set and concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer, and once compacted it shall not be disturbed.

Avoiding Segregation

Concrete shall, in all cases, be deposited as nearly as practicable directly in its final position, and shall not be rehandled or caused to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded inserts or impair its strength. For locations where direct placement is not possible, and in narrow forms, Contractor shall provide suitable drop and "Elephant Trunks" to confine the movement of concrete. Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in columns and thin walls.

Placing by Mechanical Equipment

The following specification shall apply when placing of concrete by use of mechanical equipment is specifically called for while inviting bids or is warranted considering the nature of work involved.

The control of placing shall begin at the mixer discharge. Concrete shall be discharged by a vertical drop into the middle of the bucket or hopper and this



principle of a vertical discharge of concrete shall be adhered to throughout all stages of delivery until the concrete comes to rest in its final position.

Vibration

Concrete shall be compacted during placing, with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, is free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms or against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that segregation results. Concrete to be vibrated shall be placed in level layers of suitable thickness not greater than the effective length of the vibrator needle. The concrete at the surface shall be distributed as horizontally, as possible, the vibration shall not be done in the neighborhood of slopes. The internal vibrator shall not be used to spread the concrete for filling. It is advisable to deposit concrete well in advance of the point of vibration. When the concrete is being continuously deposited to a uniform depth along a member, vibrator shall not be operated too near to the free end of the advancing concrete, usually not within 1.2m of it. Every effort shall be made to keep the surface of the previously placed layer of concrete alive so that the succeeding layer can be amalgamated with it by vibration process. The concrete shall be placed in shallow layers consistent with the method being used to place and vibrate the concrete. Usually concrete shall be placed in thickness not more than 300mm and on initial placing in thickness not more than 150mm.

Type of Vibrators

Vibrators shall conform to IS Specifications. Type of vibrator to be used shall depend on the structure where concrete is to be placed. Shutter vibrators to be effective, shall be firmly secured to the form work which must be sufficiently rigid to transmit the vibration and strong enough not to be damaged by it. Immersion vibrators shall have "no load" frequency, amplitude and acceleration as per IS: 2505 depending on the size of the vibrator. Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

Use of Vibrators

The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly usually at the rate of 75mm per second. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention shall be paid to vibration at the top of a lift e.g. in a column or wall.



Melding Successive Batches

When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, blending and melding of the concrete between the succeeding layers.

Penetration of Vibrator

The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic upto a depth of 10mm to 20mm to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

Stone Pockets and Mortar Pondages

The formation of stone pockets or mortar pondages in corners and against faces of forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding, as directed by Engineer.

Placement Interval

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for atleast 24 hours after the final set of concrete and before the start of a subsequent placement.

Special Provision in Placing

When placing concrete in walls with openings, in floors of integral slab and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slab, as the case may be. Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined by Engineer.

Placing Concrete Through Reinforcing Steel

When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congestion of steel makes placing difficult, it may be necessary to temporarily move the top steel aside to get proper placement and restore reinforcing steel to design position.

Bleeding

Bleeding or free water on top of concrete being deposited into the forms, shall be a cause to stop the concrete pour and the conditions causing this defect corrected before any further concreting is resumed.



Construction Joints and Keys

Concrete shall be placed without interruption until completion of the part of the work between predetermined construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made where the work is stopped. The concrete shall be rebated and/or keyed at the Joint to such shape and size as may be required by the Engineer. Joints shall be either vertical or horizontal. In case of an inclined or curved member, the joint shall be at right angles to the axis of the member. Vertical joints shall be formed against a stop board; which are rigidly fixed and slotted to allow for the passage of the reinforcing steel, 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 form work so as to ensure a horizontal line and if directed, shall also be used to form a grooved joint. 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.

Dowels

Dowels for concrete work, not likely to be taken up in the near future, shall be wrapped in tarpaper and burlap.

Mass Foundations

Mass foundations shall be poured in lifts not exceeding 1.5m in height unless otherwise indicated on the drawings or approved by Engineer.

Treatment of Construction Joints on Resuming Concreting

A drier mix shall be used for the top lift of horizontal pours to avoid laitance. All laitance and loose stones shall be thoroughly and carefully removed by wire brushing/hacking and surface washed.

Just before concreting is resumed, the roughened joint surface shall be thoroughly cleaned and loose matter removed and then treated with a thin layer of cement grout of proportion specified by Engineer and worked well into the surface. The new concrete shall be well worked against the prepared face before the grout mortar sets. Special care shall be taken to obtain thorough compaction and to avoid segregation of the concrete along the joint plane.

Expansion and Contraction Joints

Provision shall be made for expansion and contraction in concrete by use of special type joints located suitably. The bitumen impregnated fibre board shall be used as joint filler which shall fill space between the concrete surface at the joints. The minimum thickness shall be 12mm and the material shall conform to IS: 1838.



Concreting in Too Hot Weather

All concrete work performed in hot weather shall be in accordance with IS:456. Concrete shall not normally be placed when the atmospheric temperature exceeds 40° C in the open. If, inspite of programming concrete work in the cooler hours of early morning, evening or night placement is necessary in too hot a weather, then the Contractor shall take the following other precautions:

- Admixtures may be used only when approved by Engineer.
- Stock-pile aggregates in shade.
- Do not use fresh factory hot cement.
- Use cold water / crushed ice.
- Cool formwork by sprinkling water without collecting water inside.
- Reduce to minimum the time interval between mixing and placing.
- Place, vibrate and finish as quickly as possible.
- Initiate curing as soon as concrete hardens.

Concrete in Cold Weather

Special precautions specified in IS: 456 shall be taken, should concreting be necessary when atmospheric temperature in the open is below five (5) degrees centigrade.

Protecting Fresh Concrete

Fresh concrete shall be protected from the elements, from defacements and damage due to construction operations by leaving forms in place for an ample period as specified later in this specification. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by Engineer shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion or contact with other materials etc. that may impair the strength and/or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that workmen enter the area of freshly placed concrete, Engineer may require that bridges be placed over the area.



9.0

CURING, PROTECTING, REPAIRING AND FINISHING**Curing**

All concrete shall be cured by keeping it continuously damp for the period of required time for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, of pond water, continuously saturated coverings of sacking, canvas, hessian or other absorbent materials, or approved effective curing compound applied with spraying equipment capable of producing a smooth, even-textured coat. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as that used for mixing concrete.

Certain types of finish or preparation for overlaying concrete must be done at certain stages of the curing process and special treatment may be required for specific concrete surface finish.

Curing of concrete made of high alumina cement and supersulphated cement shall be carried out as directed by Engineer.

Curing with Water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin immediately after the concrete has hardened. Water shall be applied to unformed concrete surfaces within one (1) hour after concrete has set. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

Continuous Spraying

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by Engineer.

Alternate Curing Methods

Whenever, in the judgment of Engineer, it may be necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags which will prevent loss of moisture from the concrete may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during the curing period.



Curing Equipment

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

10.0

REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

Immediately after 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 Purchaser. Holes left by form bolts etc. shall be filled up and made good with mortar composed of one part of cement to one and half parts of sand passing 4.75mm IS sieve after removing any 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 honeycombed 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 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.

If reinforcement is exposed or the honey combing occurs at vulnerable positions e.g. ends of beams or columns it may be necessary to cut out the member completely or in part and reconstruct. The decision of Engineer shall be final in this regard. If only patching is necessary, the defective concrete shall be cut out till solid concrete is reached (or to a minimum depth of 25mm) the edges being cut perpendicular to the affected surface or with a small under cut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place. An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

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 form 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 5mm 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 10mm thick layers. After an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float 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 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 non-staining, 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 shrinkage cracks after the fillings have been cured and dried.

Finishing

This specification is intended to cover the treatment of concrete surfaces of all structures.

Finish for Formed Surfaces

The type of finish for formed concrete surfaces shall be as follows, unless otherwise specified by the Engineer.



For surfaces 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.

Standard Finish for Exposed Concrete

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 smoothened off and all blemishes, projections, etc. removed leaving the surfaces reasonably smooth and unmarred.

Integral Cement Concrete Finish

An integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithic or bonded, 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 troweling 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.

Rubbed Finish

A rubbed finish shall be provided only on exposed concrete surfaces. Upon removal of forms, all fins and other projections on the surfaces shall be carefully removed, offsets leveled and voids and/or damaged sections immediately saturated with water and repaired by filling with a concrete or mortar of the same composition as was used in the surface. The surfaces shall then be thoroughly wetted and rubbed with carborundum or other abrasive. Cement mortar may be used in the rubbing, but the finished surfaces shall not be brush coated with either cement or grout after rubbing. The finished surfaces shall present a uniform and smooth appearance.



Protection

All concrete shall be protected against damage until final acceptance by Engineer/Purchaser.

11.0**CONCRETE FOR EQUIPMENT OR STEEL STRUCTURES FOUNDATIONS**

Concrete for equipment foundation, whether principal or auxiliary, shall be poured continuously so that the structure becomes monolithic, particular care being exercised to see that the base slabs, if any, are of compact impervious construction. Tunnels, passages apertures and so forth shall be provided in accordance with the drawings for the installation of mechanical and electrical equipment, pipes or cables. The top elevation of the equipment foundations or parts shall be accurately cast to 20mm / 50mm (or more as may be specified on the drawings) above the level required for grouting and it shall be pneumatically chiseled off and well roughened just prior to the erection of the equipment concerned. All embedded anchor bolts or bolt sleeves shall be accurately and firmly set with the aid of approved templates, steel supports and/or other accessories. For holding the embedded bolts or sleeves in the correct position during concreting, template shall have to be of steel of suitable section approved by the Engineer. Two (2) sets of templates shall have to be provided, one to hold the bottom and the other the top of the bolts or sleeves. The bottom template shall be securely and rigidly fixed by providing anchorage arrangement and by welding to the lowest part of the steel reinforcement and other structural supports. The top templates shall be securely fixed by tying with guy wires and turn buckle arrangement to firm and rigid adjoining structures and staging.

Bolt pockets, where required, shall be cast with wooden taper wedges. These shall be withdrawn at an appropriate time when the concrete has set, the pockets cleaned roughened and then covered or blocked thoroughly to prevent debris getting into these. The exposed portions of bolts and embedded parts shall be kept well greased and adequately protected from damage throughout construction. Any damages found shall have to be corrected at the Contractor's cost. The Purchaser shall have the right to use the foundations, pads, piers, slabs, floors and all concrete work as needed for other works or equipment erected prior to its 'Taking Over'.

12.0**FORMWORK**

All formwork shall be made mortar proof and sufficiently strong and well anchored to withstand the loads they have to bear without any distortion. Before constructing forms, the Contractor, if required, shall submit detailed drawings and design, wherever necessary in critical areas of proposed formwork for examination by the Engineer. Safety against buckling of any member shall be investigated in all cases. If such drawings are not satisfactory to the Engineer, the Contractor shall make such changes as may be required prior to start of the work. The Engineer's approval of the drawings as submitted, or as corrected shall in no way relieve the Contractor of his responsibility for adequately designing, constructing and maintaining forms and the



safety of formwork so that they will function properly under applicable conditions of work.

The formwork shall consist of shores, bracings, sides of beams and columns of slabs etc. including ties, anchors, hangers, inserts etc. complete which shall be properly designed and planned for the work. False work shall be so constructed that vertical adjustments can be made to compensate for take up and settlements. Wedges may be used at the top or bottom of timber shores, but not at both ends, to facilitate vertical adjustment or dismantling of the formwork.

Design of Formwork

The design and Engineering of the formwork as well as its construction shall be the responsibility of Contractor. If so instructed, the drawings and/or calculations for the design of the formwork shall be submitted to Engineer for approval before proceeding with work, at no extra cost to Purchaser. Engineer's approval shall not however relieve Contractor of the full responsibility for the design and construction of the form work. The design shall take into account all the loads vertical as well as lateral, that the forms will be carrying including live and vibration loadings.

The vertical loads assumed shall consist of the dead load plus allowance for live load. The weight of formwork together with weight of freshly placed concrete is considered dead load. The live load consists of the weight of workmen, equipment, runways, and impact and will be taken as not less than 400 kg/m² of horizontal projection.

Forms, ties, and bracing must be designed for a lateral pressure of fresh concrete of maximum of 10 to 15 tonnes/m² unless higher loads are likely to occur in any special cases as may be specified on the drawings. Braces and shores must be designed to resist all forceable lateral loads such as wind, cable tensions inclined supports, dumping of concrete, and starting and stopping of equipment. In no case should the assumed value of lateral load due to wind, dumping of concrete and equipment acting in any direction at each floor line be less than 150kg/m of floor edge or two (2) percent of total dead load of the floor, whichever be greater. Wall forms should be designed for maximum wind load atleast 50kg/m² and bracing for wall forms shall be designed for a lateral load of atleast 150 kg/m of wall applied at the top.

The formwork must be designed for any special conditions of construction likely to occur, such as unsymmetrical placement of concrete, impact of machine delivered concrete, uplift, and concentrated load. Imposition of construction load on the partially completed structure shall not be allowed.

A design analysis will not be required for formwork for structures less than 5m in height if all loads are transmitted directly to the ground by vertical supports. However, safety against buckling of any member shall be investigated in all cases. For heavy construction and for all other cases, design analysis shall be made and got approved by the Engineer. The formwork system shall be designed to transfer all lateral loads to the ground in such a manner as to ensure safety at all times. Diagonal bracing shall



be provided in vertical and horizontal planes where required to provide stiffness and to prevent buckling of individual members.

Before constructing forms, the Contractor, if required, shall submit detailed drawings of proposed formwork for examination by the Engineer. If such drawings are not satisfactory to the Engineer, the Contractor shall make such changes as may be required prior to start of work. Although the Contractor shall be responsible for the design, construction and safety of formwork, the formwork design shall be subject to the approval of the Engineer. The Engineer's approval of the drawings as submitted, or as corrected in no way shall relieve the Contractor of his responsibility for adequately construction and maintaining the forms so that they will function properly under applicable conditions of work including emergent conditions.

The internal dimensions of the forms shall conform precisely to the structure to be built; they shall have smooth surfaces and their corners shall be rounded with 20mm side triangular wooden stats, unless otherwise specified on drawings. Forms shall be sufficiently rigid to hold without distortion the fresh concrete, the vibrations ensuing from transit and distribution of the concrete, with a minimum factor of safety of 2.0.

Beam forms shall be provided with ties to avoid horizontal distortion; formwork for columns shall be reinforced with square braces and those of considerable cross-section or height shall be bound with spirals of twisted wire.

All forms shall be generously nailed; boards for slab work shall have atleast two (2) nails on such supporting tie-rod. Boards shall be of uniform thickness; edges shall be at right angles and smooth for easy jointing.

The number of supports shall be such as to safely support the loads specified; the Engineer may demand that their number be increased whenever it is considered necessary. A load-spreading plate shall be placed on the top of the supports; their base shall rest on a dual wooden wedge arrangement.

Prior to the concreting and after concreting, the exposed surfaces of the shuttering or moulds shall be cleaned of all adhering concrete before depositing of fresh concrete. Details of construction joints shall be arranged so that a 'Starter' is provided to which the forms for the next pour can be tightly clamped and suitable baulking shall be used to prevent leakage of grout from the concrete.

Wherever concreting of narrow members is required to be carried out within forms of considerable depth temporary openings in the sides of the forms shall, if so directed by the Engineer, be provided to facilitate the pouring and consolidation of concrete.

Small temporary openings shall be provided if necessary at the bottom of forms for columns and beams to permit the expulsion of rubbish etc. Shuttering must be used for all slopes exceeding 15 degrees to the horizontal, to enable the concrete to be properly rammed.



No load shall be put or any weight suspended from slabs, for one month after casting and temporary props shall be left in for the support of the under-side of slabs, beams etc. for as long as is reasonably practicable after stripping of shuttering.

No shuttering or temporary props shall be removed without permission being obtained from the Engineer and being recorded in the Contractor's Log Book under the Engineer's signatures.

Form stripping shall be performed slowly and gradually. No shuttering or temporary props shall be removed without permission being obtained from the Engineer and being recorded in the Contractor's Log Book under the Engineer's signatures.

The form work in contact with concrete shall be clean and well coated with mould oil. Mould oil used shall be insoluble in water, non-staining and not injurious to concrete. It shall not become flaky or be removed by water.

Tolerances

Tolerance is specified permissible variation from lines, grade or dimensions. No tolerances specified for horizontal or vertical building lines or footing shall be construed to permit encroachment beyond the legal boundaries. Unless otherwise specified, the following tolerance will be permitted.

Tolerance for Reinforced Concrete Works:

- | | | |
|------|--|--|
| a) | Deviation from specified dimension of cross section of column & beam | - 5 mm
+ 10 mm |
| b) | Deviation from dimension of footing | |
| i) | Dimension in plan | - 5 mm
+ 50 mm |
| ii) | Eccentricity | 0.02 times the width of the footing in the direction of deviation but not more than 50 mm. |
| iii) | Reduction in Thickness | -5% of specified thickness subject to a maximum of 50 mm |

Tolerances in other types of structures shall generally conform to those given in Clause 2.4 of Recommended practice for Concrete Formwork (ACI 347).

Tolerances in fixing anchor bolts shall be as follows:



- i) Anchor bolts without sleeves $\pm 1.5\text{mm}$ in plan
- ii) Anchor bolts with sleeves $\pm 5.0\text{mm}$ in elevation
 - a) For bolts upto & including 25mm dia $\pm 5\text{mm}$ in all directions
 - b) For bolts 32mm dia and above $\pm 3\text{mm}$ in all directions
- iii) Embedded Parts - $\pm 5\text{mm}$ in all directions

Type of Formwork

Formwork may be of steel plate/plywood. For special finishes the formwork may be lined with plywood, special, oil tempered hard board, etc. Sliding forms and slip forms may be used with the approval of Engineer.

Formwork Requirements

Forms shall conform to the shapes, lines, grades and dimensions including camber of the concrete as called for on the drawings. Ample studs, walers, braces, ties, straps, shores, etc. shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of forms. Forms shall be strong enough to permit the use of immersion vibrators. In special cases form vibrators may also be used. The shuttering shall be close boarded. Timber shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps or other surface defects in contact with concrete. Faces coming in contact with the concrete shall be free from adhering grout, plaster, paint projecting nails, splits or other defects. Joints shall be sufficiently tight to prevent loss of water and fine material from concrete.

Steel plate shuttering shall be used below 0.0m level for all the concrete structures. Any structure above 0.0m level and where plastering is not envisaged and for all water proof structures even below 0.0m level plywood shuttering shall be used.

All new and used form lumber shall be maintained in a good condition with respect to shape, strength, rigidity, water tightness, smoothness and cleanliness of surfaces. Form lumber unsatisfactory in any respect shall not be used and; if rejected by Engineer, shall be removed from the Site.

Shores supporting successive storeys shall be placed directly over those below or be so designed and placed that the load will be transmitted directly to them. Trussed supports shall be provided for shores that cannot be secured on adequate foundations.

Formwork, during any stage of construction showing signs of distortion or distorted to such a degree that the intended concrete work will not conform to the exact contours indicated on the drawings, shall be repositioned and strengthened.



Poured concrete affected by the faulty formwork, shall be removed in its entirety and the formwork corrected prior to placing new concrete.

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 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 surfaces require a minimum finish.

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. Bamboos 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 bottoms. Repropping 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. If the shuttering for a column is erected for the full height of the column, one side shall be left open and built up in sections as placing of concrete proceeds, or windows may be left for pouring concrete from the sides to limit the drop of concrete to 1.0m or as directed by Engineer.

Mould Oil

Care shall be taken to see that the faces of form work 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.

Chamfers and Fillets

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 20mm x 20mm. 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 Joint Chamfers

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.

Wire Ties

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

Reuse of Forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, nails removed, holes that may leak suitably plugged and joints examined and when necessary, repaired and the inside retreated to prevent adhesion, to the satisfaction of Engineer. Warped lumber shall be resized. Contractor shall equip himself with enough shuttering to complete the job in the stipulated time.

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 there from.

In no circumstances shall form 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 form work.

In normal circumstances (generally where temperatures are above 20° C forms may be struck after expiry of the following periods:



		Minimum Period before striking Formwork
a)	Walls, columns and vertical sides of beams	16-24 hours
b)	Slabs (Props left under)	3 days
c)	Beam soffits (Props left under)	7 days
d)	Removal of props to slabs:	
	i) Spanning upto 4.5m	7 days
	ii) Spanning over 4.5m	14 days
e)	Removal of props to Beams:	
	i) Spanning upto 6.0m	14 days
	ii) Spanning over 6.0m	21 days

Striking shall be done slowly with utmost care to avoid damage to arises and projections and without shock or vibration, by gently easing the wedges. If after removing the form work, it is found that timber has been embedded in the concrete, it shall be removed and made good as specified earlier.

Reinforced temporary openings shall be provided, as directed by Engineer, to facilitate removal of formwork which otherwise may be inaccessible.

Tie rods, clamps, form bolts, etc. which must be entirely removed from walls or similar structures shall be loosened not sooner than 24 hours nor later than 40 hours after the concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled toward the inside face. Cutting ties back from the faces of walls and grade beams will not be permitted.



13.0

GROUTING**Standard Grout**

The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. The grout proportions shall be limited as follows:

	Use	Grout Thickness	Mix Proportions	W/C Ratio
a)	Fluid Mix	Under 25 mm	One part Portland Cement to one part of sand	0.44
b)	General	25 mm and over but less than 50 mm	One part Portland cement to 2 parts of sand	0.53
c)	Stiff Mix	50 mm and over	One part of Portland cement to 1 parts of sand and 2 parts of coarse aggregate with 12mm or down chips	0.53

a) Sand shall be such as to produce a flowable grout without any tendency to segregate.

b) Sand, for general grouting purposes, shall be graded within the following limits:

Passing IS 2.36 mm sieve 95 to 100%

Passing IS 1.18 mm sieve 65 to 95%

Passing IS 300 micron sieve 10 to 30%

Passing IS 150 micron sieve 3 to 10%

c) Sand for fluid grouts, shall have the fine material passing the 300 and 150 micron sieves at the upper limits specified above.

d) Sand, for stiff grouts, shall meet the usual grading specifications for concrete.



- a) Surfaces to be grouted shall be thoroughly roughened and cleaned of all foreign matter and laitance.
- b) Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot, strong caustic solution for this purpose will be permitted.
- a) Prior to grouting, the hardened concrete surfaces to be grouted shall be saturated with water.
- b) Water in anchor bolt holes shall be removed before grouting is started.

Forms around base plates shall be reasonably tight to prevent leakage of the grout.

Adequate clearance shall be provided between forms and base plate to permit grout to be worked properly into place.

Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and break-down of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more complete contact between base plate and foundation and to help release entrapped air link chains can be used to work the grout into place.

Grouting through holes in base plates shall be by pressure grouting.

Special Non-Shrinking Grout

Proprietary material of approved manufacture used as an admixture to obtain non-shrinking grout shall be mixed in the proportion of 1:1:1 (1 cement:1 admixture: 1sand), or as per manufacturer's instructions.

Pre-mixed non-shrinking grout of approved manufacture shall be used, all as per manufacturer's instructions and without any additional materials/admixtures such as cement, sand and aggregates etc.

14.0

PRE-MOULDED BITUMINOUS JOINT FILLER AND SEALING COMPOUND

Pre-moulded joint fillers shall be of non-deteriorating and resilient type conforming to IS:1834. Sealing compound shall be of Grade 'A' as per IS:1834. Bitumen primer shall conform to IS:3384.

The concrete surface shall be made clean, smooth and free from dirt or loose particles. When the surface is completely dry a coat of hot blown bitumen conforming to IS: 702 of grade 85/25 shall be given with brush or spray.

When the bitumen is still hot the pre-moulded joint filler fiber board shall be pressed against the surface held in position till the time it automatically remains fixed in



position. Where the joint filler has been specified in two layers, the second board will be fixed on the board fixed as above with a few tacking patches to bitumen between the two. After placing the filler in position, the surface of the filler against which further concreting is to be done is given a coat of bitumen.

Before application of the sealing compound the joints are sprayed or brushed with bitumen primer. The primer is then allowed to dry thoroughly for atleast 24 hours and then mixed with a mixture of 30% fine sand and 70% sealing compound by weight.

Deleted

15.0

INSERTS AND CUTOUTS IN CONCRETE WORKS

Numerous inserts are required to be fixed/embedded as indicated in construction drawings/as directed by Engineer in various civil works and other miscellaneous equipment foundations and works. These inserts comprise plates, angles, pipe sleeves, anchor bolt assemblies etc. While most of the inserts will be supplied by owner/purchaser, free of cost at his stores, for incorporation in the works, certain inserts are required to be fabricated by the tenderer/contractor. These would be indicated clearly on the construction drawings.

The rate quoted by the tenderer for placing in position of inserts shall hold good for accurately fixing the inserts at the correct levels/alignment and shall include for the cost of any temporary or permanent supports/anchors such as bars including cutting, bending, welding etc. as required.

Steel templates shall be used by Contractor to locate and very accurately position bolts, group of bolts, inserts, embedded parts etc. at his cost. Such templates shall be got approved by the Engineer. Templates shall invariably be supported such that the same is not disturbed due to vibration, movement of labourers, materials, shuttering work, reinforcement etc. while concreting. The contractor will have to suitably bend, cut or otherwise adjust the reinforcement in concrete at the locations of inserts as directed by the Engineer. If the Engineer so directs, the inserts will have to be welded to reinforcement to keep them in place. Contractor shall be responsible for the accuracy of dimensions, levels, alignments and centerlines of the inserts in accordance with the drawings and for maintenance of the same until the erection of equipment/structure or final acceptance by Owner.

Contractor shall ensure proper protection of all bolts, inserts, etc. from weather by greasing or other approved means such as applying white lead putty and wrapping them with gunny bags or canvas or by other means as directed by Engineer to avoid damage due to movement of his labourers, material, equipment, etc. No extra claim from the contractor on this account shall be entertained. Contractor shall be solely responsible for all the damages caused to



bolts, inserts, etc. due to his negligence and in case damages do occur, they shall be rectified to the satisfaction of Engineer at the Contractor's cost.

Cutouts, chamfers, pockets, etc shall be left as indicated in the drawings and no extra cost shall be payable for providing these at correct locations. Contractor shall take all necessary precautions to protect the cutouts from accidentally getting filled up or the edges getting broken.

CLEAN-UP

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

All debris i.e. empty containers, scrap wood, etc. shall be removed to "dump" daily or as directed by Engineer.

The finished concrete surfaces shall be left in a clean condition satisfactory to Engineer.



**PART-IV
WORK SPECIFICATION
FOR
STRUCTURAL STEEL**

1.0 Applicable Codes and Specifications for Material

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

- | | | | |
|-----|------------|---|---|
| 1. | IS:808 | - | Dimensions of Rolled Steel Beam, Channel and Angle Sections |
| 2. | IS:8500 | - | Structural Steel – Micro alloyed (medium and high strength qualities). |
| 3. | IS:2062 | - | Steel for general structural purposes |
| 4. | IS:1977 | - | Structural Steel (Ordinary Quality) |
| 5. | ASTM A6 | - | General Requirements for Delivery of Rolled Steel Plates, Shapes Sheet Piling and Bars For Structural Use |
| 6. | ASTM A 325 | - | High strength friction grip bolts and nuts |
| 7. | IS:1363 | - | Black hexagonal head bolts, screws and Nuts and Lock Nuts (diameter 6 or 39 mm) and Black hexagonal Screw (diameter 6 to 24 mm) |
| 8. | IS:1364 | - | Hexagonal head bolts, screws and nuts of product grades A & B (size range M1.6 to M64) |
| 9. | IS:1367 | - | Technical supply conditions for threaded steel fasteners |
| 10. | IS:3757 | - | Specification for high strength structural bolts. |
| 11. | BS.1083 | - | Precision Hexagonal Bolts, Screws and Nuts (BSW & BSF Threads) |
| 12. | IS:3138 | - | Hexagonal bolts and nuts (M42 to M150) |



13.	IS:2016	-	Plain Washers
14.	IS:814	-	Specification for Covered Electrodes for Metal Arc Welding for Mild Steel
15.	IS:3613	-	Acceptance Tests for Wire Flux Combinations for Submerged – Arc Welding.
16.	IS:1852	-	Specification for Rolling and Cutting Tolerance for Hot Rolled Steel Products
17.	IS:5369	-	General requirements for plain washers and lock washers
18.	IS:1395	-	Low and Medium alloy steel covered electrodes for manual metal arc weldings.
19.	IS:5206	-	Covered electrodes for manual metal arc welding of stainless steel and other similar alloy steels
20.	IS:4759	-	Hot dip Zinc coatings on structural steel and other allied products
21.	IS:2721	-	Galvanised steel chain link fence fabric
22.	IS:1161	-	Steel tubes for structural purpose
23.	IS:9595	-	Recommendations for metal arc welding of carbon and carbon manganese steels
24.	IS:800	-	Code of Practice for Use of Structural Steel in General Building Construction
25.	IS:802	-	Code of practice for use of structural steel in overhead Transmission Towers”.
26.	IS:875	-	Code of Practice for design load other than earthquakes for building and structures
27.	IS:1893	-	Criteria for Earthquake Resistant Design of Structures



28.	IS:919	-	ISO systems for Limits and Fits for Engineering
29.	IS:4000	-	Code of Practice for high strength bolts in steel structures
30.	IS:816	-	Code of Practice for Use of Metal Arc welding for General Construction
31.	IS:4353	-	Recommendation for Submerged Arc welding of Mild steel and Low alloy steels
32.	IS:813	-	Scheme of symbols for welding
33.	IS:817(Part I & II)	-	Code of Practice for Training of Metal Arc Welders & Oxygen welding.
34.	IS-818:1968	-	Code of practice for Safety & Health requirements in electric & gas welding and cutting operation
35.	IS 1161:1998	-	Steel Tubes for structural purposes
36.	IS:1181	-	Qualifying Tests for Metal Arc Welders (engaged in welding structures other than pipes)
37.	IS:1182	-	Recommended Practice for Radiographic examination of Fusion Welded Butt Joints in Steel Plates
38.	IS:1239	-	Mild Steel Tubes
39.	IS:1608	-	Mechanical Testing of metals
40.	IS:2595	-	Code of Practice Radiographic Testing
41.	IS:3658	-	Code of Practice for Liquid Penetrant flaw detection
42.	IS:5334	-	Code of Practice for magnetic particle flaw detection of welds
43.	ASTM E94	-	Recommended Practice for Radiographic Testing
44.	ASTM E109	-	Dry Powder Magnetic Particle Inspection



Rayalaseema Thermal Power Station
Stage #IV, Units # 6 (1 x 600 MW)
Spec # 3215

65



45.	ASTM E138	-	Wet Magnetic Particle Inspection
46.	ASTM E165	-	Liquid Penetrant Inspection
47.	IS:1477 (Part I & II)	-	Code of Practice for Painting of Ferrous Metals in Building (Pretreatment & Painting)
48.	IS:3757	-	Specification for High Strength Structural Bolts
49.	IS:2074	-	Ready Mixed Paint, air drying, Red Oxide – Zinc Chrome Priming specification
50.	IS:2932	-	Specification for enamel synthetic exterior type (a) under coating, (b) Finishing
51.	IS:2933	-	Specification for enamel exterior (a) undercoating, (b) finishing
52.	IS:822	-	Code of practice for inspection of welds
53.	IS:7205	-	Safety code for Erection of Structural steel work
54.	IS:7215	-	Tolerance for fabrication of steel structures
55.	IS:9595	-	Recommendations for Metal arc welding of carbon carbon and carbon manganese steels recommendations
56.	IS:7280	-	Bare wire electrodes for submerged arc welding of structural steel
57.	IS:1442	-	Covered electrodes for metal welding of high tensile structural steel
58.	IS:6610	-	Specification for heavy washers for steel structures
59.	IS:6649	-	Hardened and tempered washers for high strength structural bolts and nuts
60.	IS:4912	-	Safety requirement for floor and wall opening, railings and toe boards
61.	IS:3502	-	Steel chequered plates



- | | | | |
|-----|---------|---|--|
| 62. | IS:5624 | - | Foundation bolt specification |
| 63. | IS:4091 | - | Code of practice for design and construction of foundations for transmission line towers and poles |

2.0 **Materials**

Steel shall conform to IS:2062. Where plate cut pieces are used to form a part of either flange plates or web plates of fabricated columns with butt joints, length of such pieces shall not be less than 3 (three) meters. When cut pieces out of rolled sections are to be joined by butt welding, the length of such pieces shall not be less than 3 (three) meters and the total number of pieces of any member shall not exceed three. The steel structures for the switchyard shall be double dip galvanized with zinc coating not less than 0.900 kg/m².

2.1 **Fabrication**

2.1.1 **General**

All workmanship and finish shall be of the best quality. The fabrication and erection of the work shall be carried out generally as per IS:802 Part-II, IS:800. All material shall be completely shop fabricated. Towers, beams etc. shall be trial assembled at shop, keeping in view the actual site condition for convenient pre-assembly during erection. Necessary match marks shall be made on these components before dismantling the shop. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly finished. Material at the shop shall be kept clean and protected from weather.

2.1.2 **Connections**

Shop connections shall be effected either by welding, or bolting as specified on the Engineer's design drawings.

However; standard M.S. bolts to IS:1363 may be used for field connections, for light members such as purlins, girts, staircase stringers, hand railings, and landing beams.

High tensile bolts shall comply with the requirements of IS:4000. Or its equivalent.

Where ever necessary, tapered washers or flat washers or spring washers shall be used with bolts. In case of high strength friction grip bolts, hardened washers shall be used under the nuts or the heads depending upon whether the nuts or the heads are turned to tighten the bolts. The length of the bolt shall be such that at least one thread of the bolt projects beyond the nut, except in case



of high strength friction grip bolts where this projection shall be at least three times the thread pitch.

In all cases where bearing is critical, the unthreaded bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, if a longer grip bolt has to be used for this purpose.

All connections and splices shall be designed for full strength of members or loads indicated unless otherwise approved. Column splices shall be designed for the full strength of the minimum cross section at the splice. Unless otherwise specified, beams and connections shall be designed for shear capacity of the beam section plus additional axial forces, if any, shown on the Engineer's design drawings.

All bolts, nuts, washers, rivets, electrodes, screws etc. shall be supplied/brought to site in adequate quantity as per the requirement in each category and size. Rates of fabrication and erection shall cover the cost of this extra quantity.

Not more than one shop splice shall be provided to make up the full length of a member.

2.2 Preparation

2.2.1 Straightening

Rolled material, before being worked, shall be straightened, unless otherwise required/specified. If straightening or flattening is necessary, it shall be done by methods that will not injure the material, long plates shall be straightened by passing through a mangle or leveling rollers and structural shapes by the use of mechanical or hydraulic bar/section straightening machines. Heating or forging shall not be resorted to. Minor kinds of bends may be corrected by limited heating under careful supervision and with the prior approval of the Engineer in writing.

Cutting

Cutting may be by shearing, cropping, sawing or by gas cutting by mechanically controlled torch. Gas cutting by hand may only be used when specially authorized in writing by the Engineer in Charge. The edges of all plates shall be perfectly straight and uniform all through. Shearing, cropping and gas cutting shall be clean, square and free from distortion and burrs, and if found necessary the edges shall be ground afterwards by the contractor with the unit rates quoted by him.

Grinding



All the edges cut by flame shall be ground before they are welded. Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom. The maximum permissible gap between the bearing stiffeners and the flanges shall be not more than 0.1 mm locally.

Rolling and Forming

Plates channels, R.S.J, etc. for circular bins, rectangular bunkers, hoppers gantry girders etc. shall be accurately laid off and rolled or formed to required profile/shapes as called for on the drawings. Adjacent sections shall be match marked to facilitate accurate assembly, welding and erection in the field.

2.2.2 Punching and Drilling

Holes in secondary members such as purlins, girts, lacing bars etc. may be punched full size through material not over 12 mm thick. Holes shall be without burr or ragged edges. Holes for all other connections shall be drilled accurately and the burrs removed effectively. Where several parts are to be connected to very close tolerances such parts shall be first assembled, tightly clamped together and drilled through.

Sub-punching may be permitted before assembly provided the holes are punched 3 mm smaller in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not, even in such case, exceed 16 mm.

When batch-drilling is carried out in one operating through two or more separable parts, these parts shall be separated after drilling and the burrs removed.

Holes for turned and fitted bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to H8 tolerance specified in IS:919.

Where reamed members are taken apart for shipping or handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. Poor matching, over drilling, and ovality in holes shall be a cause for rejection. Burning holes for bolts with gas is strictly prohibited.

Wherever a horizontal member is likely to collect water suitable holes shall be provided for drainage.



2.2.3 Bolting

Every bolt shall be provided with a steel washer (as per IS:5369 & IS:2016) under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

Flat washers shall be circular with an out site diameter 3 times that of the bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

All bolts and nuts shall be of well formed hexagonal heads unless specified otherwise, forged from the solid and shall be dipped in hot boiled linseed oil as soon as they are made. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up. At least 6 mm threaded portion of bolt shall project beyond the nut when it has been finally tightened up.

Notwithstanding anything contrary contained in IS:1364 and IS:1367 the unthreaded length of the bolt shank shall be equal to total thickness of metal being bolted together plus 2 mm. The threaded length shall be equal to at least the diameter of the bolt plus 6 mm.

High Strength Friction Grip Bolting

High strength friction grip bolts and nuts shall conform to IS:3757 and/or ASTM A325.

Installation of high strength friction grip bolts in joints shall comply with IS:4000 and/or Specification for Structural Joints Using ASTM A325 or A490 Bolts by Research Council for Rivetted and Bolted Structural Joints. The diameter of the bolt holes must not be more than 1.5 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the bolt heads, nuts and washers, shall be free of scale, burrs, dirt and other foreign matter tending to inhibit uniform sealing of the joint components. However, tight mill scale and the light residual oil coating on bolts, nuts and washers need not be removed.

All fasteners in a joint shall be tightened to a tension equal to the load values specified in the latest revision of the relevant IS code.

Tightening may be achieved by use of pneumatic powered impact wrenches, long-handled manual torque wrenches with or without torque multipliers or electric wrenches. A hardened washer shall be placed under the element being



turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges.

When using the calibrated wrench method, adjustable power impact wrenches and manual torque wrenches shall be calibrated to induce bolt tensions of 5 percent in excess of the proof load values for each size of bolt to be used in the installation. Every wrench shall be calibrated by having it tighten a minimum of three bolts of the same diameter, in a hydraulic tension-measuring device. Calibration shall be repeated whenever a wrench is required to tighten different size bolts, of at least once each working day if there is no change in the bolt size. Impact wrenches shall be set so as to stall or cut at the torque effort corresponding to the prescribed fastener tension. When manual torque wrenches are used the torque indication corresponding to the calibrating tension shall be determined and taken as the job standard. Torque measurements shall be read while the turned element is in tightening motion. As subsequent tightening of bolts in any particular assembly is liable to loosen bolts already tightened, all bolt must be "Touched up".

When using the turn of nut method a sufficient number of bolts must initially be "snugged up" to bring the connection components into full contact, by either a standard power impact wrench or an ordinary spud wrench. Snug tight condition shall indicate the point at which the turned element ceases to rotate freely and impact wrench begins to impact or if common spud wrench is employed, snug tightness shall mean the position resulting from the full effort of a man. Subsequently, the remaining bolts in the joint shall also be brought to snug tightness. All nuts and projecting bolt points shall be match marked in this starting position and all bolts in the joint given the additional differential rotation prescribed in the relevant specifications for the bolt length and type of connection proceeding in a orderly fashion from the most rigid portion of the joint, towards the free edges.

If the finger-tight condition is used as a starting point an extra full turn shall be taken to correspond to one half turn from the snug tight position.

Load indicating bolts or load indicating washers may be used if so approved by the Engineer in writing.

Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the methods of tightening and the type of bolt used.



2.2.4 Welding

Electrodes for shielded arc manual welds shall comply with the requirements of IS:814 and/or BS.634 and/or AWS A-5.1 and shall be of approved make Advani Oerilikon, DHShering, Philips etc.

The electrodes for manual arc welding shall be suitable for use in the position and type of work, as laid down in the above specifications and as recommended by the manufacturers. Electrodes classification group 1 or 2 as given in IS:814 shall be used for welding steel conforming to IS:2062 and electrodes shall conform to IS:1442 for steel conforming to IS:8500. Joints in materials above 20 mm thick and all important connections shall be made with low hydrogen electrodes.

The filter wire and flux combination for submerged arc welding shall conform to the requirements for the desired application as laid down in IS:3613. The weld metal deposited by the submerged arc process shall have mechanical properties not less than that specified for American Welding Society's classification 5.17 F60 for Steel conforming to IS:2062 and AWS classification 5.17 F70 for steel to IS:8500.

Electrodes flux covering shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. Covered electrodes for manual arc welding shall be properly stored in a oven prior to use in a manner recommended by the Manufacturer and only an hors's quota shall be issued to each welder from the oven.

Electrodes larger than 5 mm diameter shall not be used for root-runs in butt welds.

Welding plant and accessories shall have capacity adequate for the welding procedure laid down and shall satisfy appropriate Standards and be of approved make and quality the Vendor/Contractor shall maintain all welding plant in good working order. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided.

All welds shall be made only by welders and welding operators who have been properly trained and previously qualified by tests to perform the type of work required as prescribed in the relevant applicable standards.

All welds shall be free from defects like blow holes, slag inclusions, lack of penetration, undercutting, cracks etc. All welds shall be cleaned of slag or flux and show smoothness of weld metal, feathered edges without overlap and freedom from porosity.



Fusion faces and surfaces adjacent to the joint for a distance of at least 50 mm on either side shall be absolutely free from grease, paint, loose scales, moisture or any other substance which might interfere with welding or adversely affect the quality of the weld. Joint surfaces shall be smooth, uniform and free from fins, tears, laminations etc. Preparation of fusion faces shall be done in accordance with the approved fabrication drawings by shearing, chipping, machining or matching flame cutting except that shearing shall not be used for thickness over 8 mm.

In the fabrication of cover-plated beams and built up members all shop splices in each component part shall be made before such component part is welded to other parts of the member. Wherever weld reinforcement interferes with proper fit up between components to be assembled for welding, these welds shall be ground flush prior to assembly.

Members to be joined by fillet welding shall be brought and held as close together as possible and in no event shall be separated by more than 3 mm. If the separation is 1.5 mm or greater the fillet weld size shall be increased by the amount of separation. This shall only apply in the case of continuous welds. The fit up of joints at contact surfaces, which are not completely sealed by welds shall be close enough to exclude water after painting.

The separation between laying surfaces of lap joints and butt joints with backing piece shall not exceed 1.5 mm. Abutting parts to be butt-welded shall be carefully aligned and the correct root gap maintained throughout the welding operation. Misalignments greater than 25 percent of the smaller shall be corrected and in making the correction the parts shall not be drawing into a slope sharper than 2 degrees (1 in 27.5).

Pre-qualified welding procedures recommended by appropriate welding standards and known to provide satisfactory welds shall be followed. For non standard procedures, qualification tests as prescribed in IS:823 shall be made to verify the adequacy of the procedures. A welding procedure shall be prepared by the Vendor/Contractor and submitted to the Engineer for approval before start of welding. This shall include all detail of weld procedure with reference to provisions of IS:9595 and IS:4353.

Approval of the welding procedure by the Engineer shall not relieve the Contractor of his responsibility for correct weld without undue distortion in the finished structure.

Submerged arc, automatic or semi-automatic welding shall generally be employed. Only where it is not practicable to use submerged arc welding manual arc welding may be resorted to.



Voltage and current (and polarity if direct current is used) shall be set according to the recommendations of the Manufacture of the electrode being used and suitability to thickness of material, joint from etc.

The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided.

No welding shall be done when the surface of the members is wet nor during periods of high wind unless the welding operator and the work are properly protected.

In joints connected by fillet welds, the minimum sizes of single run fillet welds or first runs and minimum full sizes of fillet welds shall conform to the requirements of IS:9595.

Fillet welds larger than 8mm shall be made with two or more passes.

All complete penetration butt welds made by manual arc welding, except when produced with the aid of backing material or welded in flat position, from both sides in square edge material not over 8mm thick with root opening not less than one half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross section.

Butt welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where abutting parts are 20mm or more in thickness run on and run off plates with similar edge preparation and having a width not less than the thickness of the thicker part joined shall be used. These extension pieces shall be removed upon completion of the weld end, the ends of the weld made smooth and flush with the abutting parts. Where the abutting parts are thinner than 20mm the extension pieces may be omitted but the ends of the butt welds shall then be chipped or gouged out to sound metal and side welded to fill up the ends to the required reinforcement.

Each layer of multiple layer weld except root and surface runs may be moderately peened with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

No welding shall be done on base metal at a temperature below 5° C. Base metal shall be preheated to the temperature given in the table below prior to tack welding or welding. When base metal not otherwise required to pre-heat, is at a temperature below 0° C it shall be preheated to at least 20°C prior to tack welding or welding. Preheating shall bring the surface of the base metal within



75 mm of the point of welding to the specified preheat temperature, and this temperature shall be maintained as minimum interpass temperature while welding is in progress.

Thickness of Thickest part at <u>Point of welding</u>	Minimum Preheat & Interpass Temperature			
	<u>Other than low Hydrogen welding Electrodes</u>		<u>Low Hydrogen- welding electrodes</u>	
	IS:2062 Steel	IS:8500 Steel	IS:2062 Steel	IS:8500 Steel
Upto 20 mm incl.	None	Welding with these electrodes	None	10°C
Over 20mm to 40mm Incl.	65°C	Not allowed	10°C	65°C
Over 40mm to 63mm Incl.	110°C	Not allowed	95°C	110°C
Over 63mm	150°C		110°C	150°C

The minimum Preheat & Interpass Temperature values should satisfy the latest revision of the relevant IS Code.

Electrodes other than low-hydrogen electrodes shall not be permitted for thickness of 75mm and above.

Before commencing fabrication of a member or structure in which welding is likely to result in distortion and/or locked up stresses a complete programme of fabrication, assembly and welding shall be made and submitted to the Engineer for approval. Such a programme shall include, besides other appropriate details, full particulars in regard to the following:

- i. Proposed prebending in components such as flanges and presetting of joints to offset expected distortion.



- ii. Make up of subassemblies proposed to be welded before incorporation in final assembly.
- iii. Proposed joints forms, classification of wire and flux or covered electrodes, welding process including fitting and welding sequence with directions in which freedom of movement is to be allowed.
- iv. Proposed number, spacing and type/details of jigs and fixtures for maintaining proper fit up and alignment during welding.
- v. Any other special features like assembling similar members back to back or stress relief.

If so desired by the Engineer mock up welding shall be carried out at the Vendor/Contractor's cost to establish the efficacy of the proposed programme, with any modification suggested by the Engineer in limiting distortion or/and residual stress to acceptable levels. Such modification will not relieve the Vendor/Contractor of any of his responsibilities.

Inspection of welds: All welds shall be inspected for flaws by any of the methods described under clause 9 "Inspection". The Purchaser/Engineer shall determine the choice of the method adopted.

The Vendor/Contractor shall quote separately for carrying out each tests as called for in the schedule of quantities. The Vendor/Contractor shall be paid only for tests which establish soundness of welds. In case the tests uncover defective work, such tests will be at the Vendor/Contractor's cost and the Vendor/Contractor shall correct such defects at his own cost, and prove the soundness of rectified work.

The correction of defective welds shall be carried out as directed by the Engineer without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means as prescribed by the Engineer shall be used to ensure that the whole of the crack and material up to 25mm beyond each end of the crack has been removed. Cost of all such tests and operations incidental to correction shall be to the Vendor/Contractor's account.

2.2.5

Tolerance

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS:1852 for indigenous steel and equivalent applicable codes for imported steel. The acceptable limits for straightness (sweep and camber) for rolled or fabricated members are:



Struts and columns - L/1000 or 10mm whichever is Smaller

For all other members not primarily in compression such as purlins, girts, bracing and the web members of trusses and lattice girders - L/500 or 15mm whichever is smaller

Where L is the length of finished member of such lesser length as the Engineer may specify.

A limit for twist prior to erection in Box girders and Heavy Columns - L/1500

Other members - L/1000

The twist of the member between any two sections shall be measured with the web vertical at one of the sections.

End of Members

Beam to beam and beam to column connections – where the abutting parts are to be jointed by butt welds, permissible deviation from the squareness of the end is:

Beams upto 600mm in depth - 1.5mm
Beams over 600mm in depth - 1.5mm every 600mm depth to a max. of 3mm

Where abutting parts are to be jointed by bolting through cleats or end plates, the connections require closer tolerance. Permissible deviation from the squareness of the end is:

Beams upto 600mm - 1mm per 600mm of depth to a Max. of 1.5mm

Butt Joints

For full bearing, two abutting ends of columns shall first be aligned to within 1 in 1000 of their combined length and then the following conditions shall be met:

- a. Over at least 80% of the bearing surface the clearance between the surfaces does not exceed 0.1 mm.



- b. Over the remainder of the surfaces the clearance between the surfaces does not exceed 0.3mm.

Where web stiffeners are designed for full bearing on either the top flange or bottom flange or both, at least half the stiffener shall be in positive contact with the flange. The remainder of the contact face could have a max. gap of 0.25mm.

Depth of Members

Acceptable deviation from the specified overall depth is:

For depth of 900 mm and under	-	+3mm
For depth over 900mm and under 1800mm	-	+5mm
For depths of 1800 and over	-	+5mm

Web Plates

An acceptable deviation from flatness in girder web in the length between the stiffeners or in a length equal to the girder depth shall be $1/150^{\text{th}}$ of the total web depth.

Flange Plates

A reasonable limit for combined warpage and tilt on the flanges of a built up member is $1/200$ of the total width of flange or 3mm whichever is smaller measured with respect to centerline of flange.

Lateral deviation between centerline of web plate and centerline of flange plate at contact surfaces, in the case of built up sections shall not exceed 3mm.

End Milling

Column end bearing on each other or resting on base plates and compression joints designed for bearing shall be milled true and square to ensure proper bearing and alignment. Base plates shall also have their surface milled true and square.

2.2.6

Inspection

The Vendor/Contractor shall give due notice to the Purchaser/Engineer in advance of the materials or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the Purchaser/Engineer's approval/inspection. The fact that certain material has been accepted at the Vendor/Contractor's shop shall not



invalidate final rejection at site by the Purchaser/Engineer if it fails to be in proper condition or has fabrication inaccuracies, which prevents proper assembly. No materials shall be painted or dispatched to site without inspection and approval by the Purchaser/Engineer unless the Engineer waives such inspection in writing.

Shop inspection by the Engineer or his authorized representative or submission of test certificates and acceptance thereof by the Engineer shall not relieve the Vendor/Contractor from the responsibility of furnishing material conforming to the requirements of these specifications, nor shall it invalidate any claim which the Purchaser may make because of defective or unsatisfactory material and/or workman ship.

The Vendor/Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified. The Vendor/Contractor's inspection work shall be under the control of a competent Chief Inspector whose primary responsibility is inspection, reporting to management and not to production departments.

For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the Engineer.

Inspection and tests on structural steel members shall be as set forth below:

Material Testing

If mill test reports are not available for any steel materials the same shall be got tested by the Vendor/Contractor to the Engineer's satisfaction to demonstrate conformity with the relevant specification.

Test on Welds

Visual Inspection

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawings. It may be slightly over sized but should not be under sized. The profile of weld is affected by the position of the joint but it should be uniform. In case of butt and corner welds, the profile shall be convex and in case of submerged arc fillet weld it shall be slightly concave. The welds should have regular height and width of beads. The height and spacing of ripples shall be uniform. The joints in the weld run where welding has been recommended shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from unfilled craters



on the surface, under cuts, slags on the surface and visible cracks. Such inspection shall be done after cleaning the weld surface and with steel wire brushes and chisel to remove the sputter metal, scales, slag etc. If external defects mentioned above are noticed there is every possibility of internal defects and further radiographic/ultrasonic examination shall be undertaken as per Indian Standards. Weld gauges shall be used to measure the size of the welds.

Dye Penetration/Liquid Penetrant Inspection

100% DPT shall be done on all fillet welds in main column & sections fabricated entirely from plates.

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with IS:3658. All defects shown shall be repaired and rechecked.

Radiographic Inspection

100% radiographic testing on tension zone welds of crane girder shall be carried out. Also 10% of the full strength butt weld joints not covered above shall be radiographed in accordance with the recommended practice of radiographic testing as per IS:2595/ASTM E-94 and Part U.N. 53 of ASME Code Section VIII.

Wherever Radiographic testing is not possible ultrasonic test shall be carried out. However the extent of UT shall be limited as stated above.

Mechanical Test

Mechanical test shall be done on sample pieces for checking the strength and ductility, continuity fusion and soundness, the penetration and internal weld configuration etc. At least five representative samples if other wise not mentioned in the drawing shall be taken for testing. The strength shall be checked as per the relevant IS codes.

Rectification of Defective Welding Works

Wherever defects like improper penetration, extensive presence of blowholes, undercuts, cracking, slag inclusion, etc., are noticed by visual inspection/other tests, the welds in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary, and re-welded. The gouging shall as far as possible be done using gouging electrodes.



Dimensions, Workmanship and Cleanliness

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown the Vendor/Contractor's approved shop drawings and the Engineer's drawings.

Inspection or Test Failure

In the event of any failure of members to meet an inspection or test requirement, the Vendor/Contractor shall notify the Engineer or his authorized representative. The Vendor/Contractor must obtain permission from the Engineer Before Repair is Undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subjected to approval by the Engineer.

The Engineer has the right to specify additional inspection or testing as it seems necessary, and the additional cost of such testing will be borne by the Purchaser.

Shop Matching

Some steel work, particularly columns along with the tie beams/bracings may have to be shop assembled to ensure satisfactory fabrication, obtaining of adequate bearing areas etc. If so desired by the Engineer, at not extra cost to the Purchaser.

Drilling Holes for Other Works

Holes in members required for installing equipment or steel furnished by other manufacturers or other contractors shall be drilled at no extra cost to the Purchaser, in the Vendor/Contractor's shop as part of this contract, the information for which will be supplied by the Purchaser/Engineer before fabrication.

2.2.7

Painting/Galvanizing

All fabricated steel material, except those galvanized, shall receive coating as specified below:

1. Two coat of Primer shop coat with Zinc chromate primer of DFT 25 microns per coat.
2. Touch up coat of primer after erection, wherever paint is damaged.



3. Two coats of matt finish synthetic enamel paint or equivalent with DFT of 25 microns each.
4. Total DFT shall be 100 microns including primer & finish.

Painting shall not be done in frosty or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted.

Galvanizing

All structural steel works and pipe supports other than that of fencing shall be hot double dip galvanized after fabrication as per relevant IS codes. Zinc required for galvanizing shall be arranged for by the Contractor. Purity of zinc to used for galvanizing shall be 99.5% as per IS:209. All burrs and irregular edges shall be ground smooth before galvanizing.

After completion of all shop work, all structural material shall be punched with the erection marks and be hot dip galvanized including the portion to be embedded in concrete and foundation bolts & nuts. Each grillage member including stubs shall also be fully galvanized. Before galvanizing, the steel section shall be thoroughly cleaned of any paint, grease, rust, scale, acid or alkali or such other foreign matters likely to interfere with the galvanizing process or with the quality and durability of the zinc coating. Pickling shall be carefully done and shall be proper.

The weight of the zinc coating shall be at least 0.9 kg/sq.m including stub members. The galvanized surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky deposits, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

There shall be no flaking or loosening when struck squarely with chisel faced hammer. The galvanized steel member shall withstand minimum four one minute dips in copper sulphate solution as per IS:2633. When the steel section is removed from the galvanizing kettle, excess spelter shall be removed by 'bumping'. The process known as 'wiping' or 'scrapping' shall not be used for this purpose.

All bolts, nuts, washers, etc. shall be hot dip galvanized. Excess spelter from bolts, nuts etc. shall be removed by centrifugal spinning of bolts and nuts. Threading after galvanizing, shall not be permitted. Nuts, however, may be



tapped, but not to cause appreciable racking of the nuts on the bolts. Spring washers shall be electro-galvanized.

Defects in certain members indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the specification or lack of quality control in any manner in the galvanizing plant shall render the entire production in the relevant shift liable to rejection. All the towers, pipe supports and accessories shall be treated with sodium dichromate or an approved equivalent solution after galvanizing, so as to prevent white storage stains.

If the galvanizing of any member is damaged, the galvanizing shall be redone in the similar manner as stated above to Engineer's approval. The Contractor shall also furnish sufficient quantity of appropriate paint, for repairing galvanized surfaces, damaged in transit.

The work shall be done as per approved drawing clearly indicating various details of joints to be welded, type of weld, length and size of weld, whether shop weld or site weld etc. Symbols for welding on erection and shop drawings shall be according to IS:813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.

Inaccessible Parts

Surfaces not in contact, but inaccessible after assembly shall receive two coats of primer positively before assembly. This does not apply to the interior of sealed hollow sections. The inaccessible parts shall also receive two coats of synthetic enamel paint before assembly.

Contact Surfaces

The contact surfaces shall be cleaned by hand wire brushing or by other methods of removing loose mill scale, rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by use of solvents.

Finished Surfaces

Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily

Painting after Erection

After erection touch up painting, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Contractor free of cost to the Purchaser. The materials and specifications shall



be in accordance with the requirements of good practice. All bolts, welds, and abrasions to the shop coat shall be painted with the same paint used for shop coat.

Grouting under Stanchion or Other Bases

The work covers all operation in connection with grouting of column bases, foundation bolts sleeves any recess and groove of any type at any elevations. Non shrink Grouting shall be ready mix of GP-2 brand or equivalent. For grouting only fresh grout materials shall be allowed to use and prior to grouting operation this shall be tested against its various characteristics as required or recommended. All the grout material shall be mixed thoroughly as per manufacturers specification and instruction of the Engineer. Nominal thickness of the grout shall be 50mm. Non shrink cum plasticizer admixture shall be added to the grout. Crushing strength of the grout shall generally be one grade higher than that of the base concrete. Minimum grade of grout shall be M25.

Dismantling – Alteration and Re-erection of Steel Work

Dismantling any structural member due to the changes in planning, or location of machines or due to hindrance of pipe at any elevation and lowering them to the ground if necessary and transporting them to the fabrication yard and re-erecting after necessary changes shall be done as per the direction of the Engineer-in-Charge.

2.2.8

Erection Scheme

Each bid shall be accompanied by a broad erection scheme with dates and estimated completion time for various parts of the work prepared by Bidder after a thorough study of the bid drawings and the site conditions. This erection scheme shall describe the methods proposed to be employed by Bidder for transporting his equipments, tools, tackles, gas cylinders, electrodes and all that is necessary to Site, unloading, transporting within the site, handling, assembling, hoisting and erecting of the structural and miscellaneous steel components and the type, capacity and quantity of equipment that Bidder scheme shall also indicate the strength and tradewise composition of the work force and supervisory personnel that will be deployed by Bidder for the various operations.

Erection Programme

Within three weeks of the acceptance of his bid, the successful Bidder shall submit, a detailed erection programme. This programme shall be accompanied by a layout plan identifying the areas proposed for unloading, main storage, subsidiary storage, assembly and the transportation of equipment and



fabricated material between the storage and work areas. The layout shall clearly indicate the points at which proposed erection begins the direction in which it is proposed to progress, the deployment of equipment, access route for cranes to reach work areas etc. The locations and extent of site offices and stores, labour quarters if any, layout of electrical cables and water pipes from the tap off points shall also be indicated in detail on the above layout. Full details of the method of handling, transport, hoisting and erection programme along with complete details of the quantity and capacity of the various items of erection equipment that will be used shall be given. A site organization chart showing the number of supervisory personnel, and the number and composition of the various gangs shall also accompany the erection programme.

Any modifications to the erection programme directed by Engineer for the reasons of inadequacy of the quantity and/or capacity of the erection equipment, erection personnel and supervisors, temporary bracing, guying etc., or safety of the erection methods, or suitability of the erected portions of structures, or unsuitability of the erection sequence due to interference with the work of other agencies shall be incorporated by Contractor with the revised programme. Approval by Engineer shall not relieve Contractor from the responsibility for the safe, sound, accurate and timely erection of structural steel work as required by Engineer/Purchaser. Contractor shall also make no extra claims for bringing additional equipment to site for erection, if so directed by Engineer. Contractor shall be deemed to have visualized all erection problems while bidding for the work and no additional compensation shall be claimed on this account.

Site Operations

An experienced and qualified Superintendent shall be full time in charge of the job.

Contractor shall complete all preliminary works at site well before the arrival of structural steel, such as establishment of a well equipped and adequately staffed site office, stores, unloading gantry, unloading and preassembly yard, labour quarters if any, electrical and water connections, electrical winches, derricks, cranes, compressors, all tools and tackles, rivet guns, welding sets, torque wrenches, spud wrenches, staging, etc. as well as experienced erection and supervisory personnel as part of this contract and any other work immediately after the arrival of the first batch of steel at site.

Contractor shall furnish at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after completion of the job. Contractor shall also provide necessary passageways, fences, safety belts, helmets, light and other fittings to the satisfaction of Purchaser/Engineer and to meet the rules of



Royalaseema Thermal Power Station
Stage #IV, Units # 6 (1 x 600 MW)
Spec # 3215

85



local authorities and for protection to his men and materials. A licensed electrician shall be kept on the job for the entire duration of the work to maintain Contractor's electrical equipment and connections.

Contractor shall protect all existing plant, structures, piping, conduits, equipment and facilities against damage during erection. Any damage caused by Contractor shall be rectified entirely at Contractor's cost, to the satisfaction of Purchaser/Engineer. If work has to be carried out adjacent to existing switchyards or electrical installations, which are live, Contractor must ensure suitable safety precautions in consultation with Engineer.

If a portion of the work of the project area cannot be made available to contractor for his activities due to operations being carried out by other agencies, he shall suitably modify his sequence of operations so as to continue work without interruption. Contractor shall work in coordination with other agencies working on the project site and plan his work suitably so as not to hinder the progress of construction at site.

Anchor Bolts and Foundations

Contractor shall carefully check the location and layout of anchor bolts prior to concreting and take all measures to see that the bolts remain in proper position, alignment & level. In short all measures shall be taken to ensure that the structures can be properly erected as shown on the drawings and as per IS:5624.

Levelling of column bases to the required elevation may be done either by providing shims or three nuts on the upper threaded portion of the anchor bolts. All shim stock required for keeping the specified thickness of grout and in connection with erection of structures on foundation, crane brackets or at any other locations shall be good M.S. plates and shall be supplied by Contractor at his cost.

A certain amount of cleaning of foundations and preparing the area is considered normal and shall be carried out by Contractor at no extra cost.

Assembly and Connections

Field connections may be effected either by bolting, welding or by use of high strength friction grip bolts as specified and as shown on the design and fabrication/erection drawings.

All field connection work shall be carried out in accordance with good engineering practice. All bolts nuts washers, electrodes required for field connections shall be supplied free of cost by the Contractor.



All assembling shall be carried on a level platform.

Drift pins shall be used only for drawing the work to proper position and must not be used to such an extent as to damage the holes. Size of drift pins larger than the nominal diameter of hole shall not be used any damaged holes or burrs must be rectified to the satisfaction of Engineer.

Any error in the shop, which prevents proper fit on a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to Engineer.

Erection

All structural steel shall be erected as shown on the drawings. Proper size steel cable slings, etc. shall be used for hoisting Guys shall not be anchored to existing structures, foundations, etc. unless so permitted by Engineer in writing. Care shall be taken to see that ropes in use are always in good condition.

Steel columns in the basement, if any are to be lowered and erected carefully with the help of a crane and/or derrick without damaging the basement walls or floor.

Structural steel frames shall be erected plumb and true. Frames shall be lifted at such points that they are not liable to buckle and deform. Trusses shall be lifted only at node points. In the case of trusses, roof girders all of the purlins and wind bracing shall be placed simultaneously and the columns shall be erected truly plumb on screed bars over the pedestals. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety and stability.

Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as directed by Engineer. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding. The erection of chequered plates shall include:

- a. Welding of stiffening angles/vertical stiffening ribs.
- b. Cutting to size and making holes to required shape wherever necessary to allow service piping and/or cables to pass through.



- c. Splicing as shown in relevant drawings.
- d. Smoothing of edges.
- e. Fixing of chequered plates by tack welding or by counter sunk bolts.
- f. Providing lifting hooks for ease of lifting.

As erection progresses, the work shall be securely bolted to take care of all dead load, wind, seismic and erection stresses.

No welding or final bolting shall be done until the structure has been properly aligned and approved by Engineer. No cutting, heating or enlarging or the holes shall be carried out without the prior written approval of Engineer.

Inspection

Engineer/Purchaser or their authorized representatives shall have free access to all parts of the job during erection and all erection shall be subjected to their approval. In case of faulty erection, all dismantling and re-erection required will be at Contractor's cost. No paint shall be applied to field welds or bolts until these have been approved by Engineer.

Tolerances for Erection

Tolerance mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb. The tolerances specified below do not apply to steel structures where the deviations from true positions are intimately linked with and directly influence technological process. In such cases the tolerances on erected steel structures shall be as per recommendations of process technologists/suppliers, which will be indicated in the drawings. In general tolerance shall be as per relevant IS Codes or as mentioned below, which ever is more stringent:

Towers

Out of Plumbness (Verticality from the true vertical axis	$\pm$	$\frac{1}{1000}$	of the height of the tower in mm
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Painting

After steel has been erected, all bare and abraded spots, field welds, bolt heads and nuts shall be spot painted with primer specified elsewhere in this



specification. Before paint is applied, the surface shall be dry and free from dust, dirt, scale and grease. All surfaces inaccessible after erection shall receive two coats of the approved paint before erection.

Erection Bolts

Erection bolts installed may be left in position of completion of erection however no additional payment shall be made either for supply or use of such bolts. If erection bolts are removed after erection is complete, holes shall be plug welded and ground smooth. No extra payment shall be made for such plug welding.

Clean up of Work Site

During erection, the contractor shall without any additional payment, at all times keep the working and storage areas used by him, free from accumulation of waste materials or rubbish. Before completion of erection, he shall remove or dispose of in a satisfactory manner all temporary structures, waste and debris and leave the premises in a condition satisfactory to Purchaser/Engineer.

Fencing

The fence around switchyard area shall comprise of 12 gauge G.I. chain link fencing of mesh size 75 mm to a height of 2.4 m above the toe wall with a 600 mm high galvanized concertina at the top such that total fence height of 3.0 m above toe wall level is achieved. Toe wall shall be minimum 200 mm above the formation level.

The chainlink fencing shall comprise of size 2400 x 2000 mm size panel made from 75 x 75 mm & 8 gauge GI chainlinks (including PVC coatings) and 50x50x6 mm angle including fixing the chainlike in angle frame by means of 40 x 3 mm. MS flat welded to angle frame drilling to holes in angle frame & flat and fixing the same with angle post in the level and plumb by means of 10 mm dia. bolts frames and flat & nuts, 3 coats of epoxy base paint to achieve required 250 DT to angle iron etc. completed. This chainlink fencing panel shall be fixed with the fence posts of 65x65x6 MS angles spaced as per requirement.

Above the chain link fencing panel 3 horizontal rows of barbed wire of gauge 12/14 with 3 diagonal rows shall be fixed as per drawing.

All fence posts shall be 65 x 65 x 6 MS angles spaced at 2.5 m c/c distance. All straining posts i.e. end posts shall be 65 x 65 x 6 angles. Suitable concrete foundations for the angle iron posts and stays shall be provided based on the prevailing soil conditions. Toe walls either of bricks of minimum 50 kg/cm²



compressive shall be provided between the fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200 mm above the switchyard formation level with PCC coping (M-20) and minimum 300 mm below the switchyard formation level. All gates shall be of hot dipped galvanized structural steel as specified.

All structural steel work for the fencing shall be painted with chlorinated rubber paint over a suitable primer or epoxy based paint (of total DFT 250 microns) to withstand severe marine / corrosive exposure condition for protection.

Foundation Bolts

The contractor from steel rods shall fabricate foundation bolts for main Power House Columns. These bolts shall be in diameter and length as per design. Bolts shall be secured in foundation by grouting of sleeves and block-outs as specified. Nuts, locknuts, washers, templates, shims (including strips up to the thickness of grout required to be welded under the base plate for leveling purpose) etc. shall be supplied by the contractor.



**PART-V
WORK SPECIFICATION
FOR
ROAD WORKS**

1.0 APPROACH ROADS

- 1.1 The technical requirement for the roads shall include preparation of sub-grade, sub-base, base & bituminous surfacing and shoulder works in accordance with relevant codes of Indian Road Congress (IRC). The roads shall be designed in accordance with IRC 37 (latest). For crossing of drains, pipes, cable trenches etc., suitable culverts shall be provided designed for class A loading; and checked for class A loading in accordance with IRC. The shoulder on either side of the roads shall be of 150 mm thick PCC (M-20 Grade) over moorum of minimum 150 mm thickness. The total thickness of the road section shall be 370 to 390 mm as per IRC 37.
- 1.2 Sub-grade: In case of expansive nature of soil, appropriate treatment to sub-grade to counteract the swelling potential of sub-soil shall be provided. The Contractor shall submit the proposed treatment for approval before starting the work. The contractor shall carryout CBR test in soaked and un-soaked conditions of sub-grade as per IS:2720 (Part XVI). Minimum 500 mm depth of the sub-grade of the roads shall be compacted to 95% of max. dry density. The cut formation shall be prepared to receive the sub-base/base course as directed by the Engineer. Any unsuitable material encountered shall be removed & replaced by good material.
- 1.3 The construction of Water Bound Macadam (WBM) shall be carried out in accordance with IRC-19.
- i. Sub-base and base course:
- a. Crushed or broken stone shall be hard durable & free from excess of flat, elongated, soft & disintegrated particles, dirt & other objectionable matter. The materials shall meet the physical requirements of coarse aggregate as per IRC standards when tested as per IS:2386.
- b. Grading # 1 having aggregate size of 90 to 40 mm shall be used for preparation of sub base. Grading # 2 (size 63 to 40 mm) & grading # 3 (size 50 to 20mm) shall be used for



- preparation of base. All gradings shall be in accordance with IRC standards.
- c. Screening to fill voids in the coarse aggregate shall generally consist of the same materials such as moorum or gravel (other than rounded river borne material) shall be used for this purpose.
 - d. Binding material to be used for WBM construction shall comprise of suitable material approved by the Engineer having plasticity index value of less than 6 as determined in accordance with IS:2720 art-V (latest).
- ii. The coarse aggregate shall be uniformly spread upon the prepared base in such quantities that the thickness of the compacted layer is 100 mm for grading 1 and 75 mm for grading 2 & 3. The aggregates shall not be dumped in heaps directly on the surface prepared.
 - iii. Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power roller of 6 to 10 tonne capacity or tandem or vibratory rollers of approved type. First the edges shall be compacted and then moved inwards parallel to the centerline of road. During rolling slight sprinkling of water may be done.
 - iv. Application of screenings: After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. Dry rolling shall be done while the screenings are being spread. The screening shall not be dumped in piles but be spread uniformly in successive thin layers.
 - v. Sprinkling & Grouting: After the application of screenings, binding material shall be applied successively in two or more thin layers at a slow & uniform rate. After each application, the surface shall be copiously sprinkled with water & rolled. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.
 - vi. Setting & Drying: After the final compaction of WBM course, the road shall be allowed to dry overnight. Next morning, hungry sports shall be filled with screenings of binding materials as directed, lightly sprinkled with water if necessary & rolled. No traffic shall be allowed on the road until the macadam has set.



- vii. Edging: Brick on edge shall be provided between the toe of WBM and prepared base. Recommendations of IRC 14 shall generally be followed for providing bituminous surfacing.

1.4 Bituminous Surfacing: 50 mm thick premix carpet shall be provided over prepared base. Recommendations of IRC 14 shall generally be followed for providing bituminous surfacing.

- i. Materials:
- a. Binder: The binder shall conform to IS:73 or 217 or 454.
 - b. Coarse aggregate: This shall consist of angular fragments and be clear, hard touch, durable & of uniform quality throughout.
 - c. Fine aggregates: The fine aggregates or sand shall be clean, hard, durable uncoated, coarse particles & free from dust, organic matters etc.
- ii. Preparation of base: The underlying base on which the bituminous carpet is to be laid shall be prepared as directed by Engineer. The surface shall be well cleaned by removing caked earth & other foreign matter with wire brushes, sweeping with brooms & finally dusting with sacks.
- iii. Tack Coat: A tack coat shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to laying of the carpet.
- iv. Preparation of premix: The mixing of aggregate with the bituminous binder shall be done in mixers. The binder shall be heated in boiler to the temperature appropriate to the approved grade of bitumen. The aggregates shall be dry when placed in mixer. The bitumen binder used for 12.5 mm size aggregate shall be at the rate of 52 kg/m³.
- v. Spreading & Rolling: The premixed material shall be spread on the road surface with rakes to the required thickness and camber. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 6 to 10 tonne power rollers. Rolling shall begin at the edges and progress towards the center longitudinally.
- vi. Seal Coat: A seal coat shall consist of premixed sand. Seal coat mixed in mixer should be applied immediately after laying the carpet & rolled. The bitumen used for medium coarse sand or fine grit passing



IS sieve no. 1.70 mm & retained on IS sieve no. 180 microns shall be 0.06 m³ per 10 M². The longitudinal & transverse profile of the road shall be checked before opening of the road to traffic.

- vii. 4.0M width flexible peripheral roads are to be provided in switchyard area, yard pavement shall be done with fly ash bricks over 300 mm ash filling.



PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

TOWER LINE ERECTION AND STRINGING

1. LIST OF STANDARDS (LATEST EDITION OF STANDARDS SHALL BE FOLLOWED)

Unless specified otherwise analysis & design of various components and systems of transmission line shall be in accordance with latest editions, latest amendments, of the relevant Indian & other international standards.(except for those references where the year of publication is specifically mentioned)

	<u>Indian Standards</u>	<u>Title</u>	<u>International & Internationally recognized standards</u>
1.	IS:209	Specification for Zinc	ISO/R/752-1968 AST, B6
2.	IS:2062	Structural Steel (Standard Quality)	ISO/R/6F30-1967 CAN/CSA G40. 21 BS 4360
3.	IS:269	Ordinary rapid hardening & low heat Portland Cement.	ISO/R/597-1967
4.	IS:278	Specification for barbed wire	ASTM A 121
5.	IS:383	Coarse and fine aggregates from natural sources for concrete.	CSA A 23.1/A 23.2
6.	IS:398	Alum. Condr. galvanised steel reinforced	
7.	IS:406	Methods of Chemical Analysis of Slab Zinc	
8.	IS:432 (Part 1 & 2)	Mild steel and medium tensile bars and hard drawn steel wire for concrete reinforcement	CSA-G-30
9.	IS:456-1978	Code of practice for plan and reinforced concrete	
10.	IS:731-1971	Porcelain Insulators for Overhead lines with a Nominal Voltage greater than 1000 volts	BS:137-1973 (I & II) Power IEC:274-1968 IEC:383-1976
11.	IS:800-1984	Code of practice for use of structural in general Building construction	CSA STEAM 16.1 steel
12.	IS:802	Code of practice for use of structural steel in overhead transmission Line. (Load, Permissible stresses. Fabrication, Galvanising, Inspection, and Packing and Testing)	IEC 826 ASCE 52 BS 8100
13.	IS:1139-1966	Hot rolled mild steel medium tensile steel and high yield strength deformed Bars for concrete reinforcement	CAN / CSA G 30 18
14.	IS:1367-1967	Technical supply conditions for threaded fasteners	

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

15.	IS:1489-1991	Portland Pozzolena Cement	ISO/863-1968
16.	IS:1521-1972	Method of Tensile Testing of Steel wire	
17.	IS:1573-1976	Electroplated Coating of Zinc on Iron & Steel	
18.	IS:1778-1980	Reels and Drums of Barewire	
19.	IS:1786-1985	High strength deformed steel bars and wires for concrete reinforcement	
20.	IS:1893-1984	Criteria of Earthquake resistant design of structures.	IEEE 693
21.	IS:2016-1967	Plain Washers	ANSI B 18.22.1 ISO/R/887-1968
22.	IS:2070-1962	Method of impulse voltage testing	
23.	IS:2071	Method of high voltage testing	
24.	IS:2121-1981 Part-I Part-II	Specification for conductors and earthwire Accessories for Overhead Power Lines Armour Rods Mid-span joints & repair sleeves for conductors	
25.	IS:2131-1967	Method of Standard penetration test for soils.	ASTM D 1883
26.	IS:2551-1982	Danger Notice Plates	
27.	IS:2486	Specification for Insulator Fittings for overhead Power Lines with a nominal voltage greater than 1000 volts Part-I General Requirements and Tests Part-II Dimensional Requirements Part-III Locking Devices	BS:3288-1972 IEC:120-1960 IEC:372-1976
28.	IS:2629-1985	Recommended practice for hot dip galvanising of iron & steel.	ASTM A 123 CAN/CSA G 164
29.	IS:2633-1986	Method of testing uniformity of coating of zinc coated articles.	ASTM A 123 CAN/CSA G 164
30.	IS:3043-1987	Code of Practice for earthing (with amendment No. 1 & 2).	
31.	IS:3063-1994	Single Coil Rectangular Section spring washers for bolts, nuts, screws.	DIN -127-1970
32.	IS:3138-1966	Hexagonal bolts and nuts	ISO/R 947 and ISO/R 272
33.	IS:3188-1980	Characteristics of string insulator units	IEC:305-1906
34.	IS:4091-1979	Code of practice for design and construction of foundation for transmission line tower and poles.	ASCE / IEEE 691
35.	IS:4218-1976	Metric Screw Threads.	ISO:68-1969 R-26-1963, R-262-1969 R-965-1965

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

36.	IS:4826-1979	Galvanised coatings on round steel wire	BS:443-1969
37.	IS:5300-1980	Porcelain Guy strain insulators	
38.	IS:5358-1969	Hot dip galvanised coatings on fasteners	ASTM A 153 CAN/CSA G 164
39.	IS:5613 (Part-II) 1985	Code of practice for Design, installation & maintenance of overhead power lines	
40.	IS:6610-1972	Specification for heavy washers for steel structures.	
41.	IS:6639 -1972	Hexagonal bolts for structure	ASTM A 394 CSA B 33.4
42.	IS:6745-1972	Methods for determination of weight of Zinc coated iron and steel articles	ASTM A 90
43.	Pub. No. 19 (N)/ 700-1963	Regulation for Electrical Crossing of Railway Tracks.	
44.	IS:7814-1985	Phosphor bronze sheet, strip and foil	BS:2870-1968
45.	IS:8263-1976	Method of Radio Interference tests on high voltage insulators	NEEMA:107 – 1964 CISPR/IEC:437-1973
46.	IS:8269-1976	Method of switching impulse test on high voltage insulators	IEC:506-1975
47.	IS:8500-1991	Specification for weld-able structural steel (Medium and High strength qualities).	BS : 4360
48.	IS:9708-1993	Specifications for Stockbridge Vibration Dampers for overhead power lines	
49.		Thermal mechanical performance test and mechanical performance test on String insulator units	IEC: 575-1974

2. GENERAL REQUIREMENTS

- a) The details of the scope of erection work shall include the cost of labour, all tools and plants like tension stringing equipment and all other incidental expenses in connection with erection and stringing work.
- b) The Contractor shall be responsible for transportation of all the materials to be provided by the Contractor as per the scope of work to site, proper storage and preservation at their own cost till such time the erected line is taken over by the Owner.

3. TREATMENT OF MINOR GALVANISING DAMAGE

In case any minor damage to galvanising is noticed, the same shall be treated with zinc rich paint (having at least 90% zinc content) before erection.

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

4. ASSEMBLY

I) The method followed for the erection of towers, shall ensure the points mentioned below :

- a) Straining of the members shall not be permitted for bringing them into position. It may, however, be necessary to match hole positions at joints and to facilitate this, tommy bars not more than 450 mm long may be used.
- b) Before starting erection of an upper section, the lower section shall be completely braced and all bolts provided and tightened adequately in accordance with approved drawings to prevent any mishap during tower erection.
- c) All plan diagonals relevant to a section of tower shall be placed in position before assembly of upper section is taken up.
- d) The bolt position in assembled towers shall be as per IS: 5613 (Part-II/Section 2).
- e) Tower shall be fitted with number plate, danger plate, phase plate and anti-climbing device as described.
- f) All bank holes, if any left, after complete erection of the tower, are to be filled up by bolts and nuts of correct size.

II) Tightening and Punching of Bolts and Nuts

- a) All nuts shall be tightened properly using correct size spanner/torque wrench. Before tightening, it shall be ensured that filler washers and plates are placed in gaps between members wherever applicable, bolts of proper size and length are inserted, and one spring washer is inserted under each nut. In case of step bolts, spring washers shall be placed under the outer nut. The tightening shall progressively be carried out from the top downwards, care being taken that all bolts at every level are tightened simultaneously. The threads of bolts projecting outside the nuts shall be punched at their position on the diameter to ensure that the nuts are not loosened in course of time. If during tightening a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be replaced.
- b) The threads of all the bolts projected outside the nuts shall be welded at two diametrically opposite places. The welding shall be provided from ground level to waist level for single circuit towers and to bottom cross arm level for double circuit towers. After welding, cold galvanised paint having at least 90% Zinc content shall be applied to the welded portion. At least two coats of the paint shall be applied. The cost of welding and paint including application of paint shall be deemed to be included in the erection price.
- c) In addition to the tack welding of nuts with bolts, as described above, the Contractor can also propose some alternative arrangements, like use of epoxy resin adhesive which can serve the purpose of locking the nut permanently with the bolt and thus preventing pilferage of the tower members.

5. INSULATOR HOISTING

- a) I-Suspension insulator strings shall be used on suspension towers and tension insulator strings on angle and dead end towers. These shall be fixed on all the towers just prior to the stringing. Damaged insulators and fittings, if any, shall not be employed in the assemblies. Before hoisting, all

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for the purpose. Corona control rings/arching horn shall be fitted in an approved manner. The yoke arrangements be horizontal for tensions strings. Torque wrench shall be used for fixing different line materials and their components, like suspension clamp for conductor and earthwire, etc., whenever recommended by the manufacturer of the same of river crossing towers.

6. **HANDLING OF CONDUCTOR AND EARTHWIRE**

- a) The Contractor shall be entirely responsible for any damage to the towers or conductors during stringing. While running out the conductors, care shall be taken that the conductors do not touch or rub against the ground or objects which could cause scratches or damages to the strands. The conductors shall be run out of the drums from the top in order to avoid damage due to chafing. Immediately after running out, the conductor shall be raised at the supports to the levels of the clamps and placed into the running blocks. The groove of the running blocks shall be of such a design that the seat is semi-circular and larger than the diameter of the conductor earthwire and it does not slip over or rub against the sides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.
- b) The running blocks shall be suspended in a manner to suit the design of the cross arm. All running blocks, especially those at the tension end, will be fitted on the cross-arm with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work. In case suspension or section towers are used even for temporary terminations, if this be unavoidable, they shall be well guyed and steps shall be taken by the Contractor to avoid damage. The drums shall be provided with a suitable braking device to avoid damages, loose running out and kinking of the conductor. The conductor shall be continuously observed for loose or broken strands or any other damage. When approaching end of a drum length, at least three coils shall be left when the stringing operations are to be stopped. These coils are to be removed carefully, and if another length is required to be run out, a joint shall be made as per the recommendations of the manufacturers.
- c) Repairs to conductors, if necessary, shall be carried out during the running out operations, with repair sleeves. Repairing of conductor surface shall be done only in case of minor damage, scuff marks etc. keeping in view both electrical and mechanical safe requirements. The final conductor surface shall be clean smooth and without any projections, sharp points, cuts, abrasions etc.
- d) Conductor splices shall be so made that they do not crack or get damaged in the stringing operation. The contractor shall use only such equipment/methods during conductor stringing which ensures complete compliance in this regard.
- e) Derricks shall be used where roads, rivers, channels, telecommunication or overhead power lines, railway lines, fences or walls have to be crossed during stringing operations. It shall be seen that normal services are not interrupted or damage caused to property. Shut down shall be obtained when working at crossing of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor, earth-wire and accessories in the field.

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

- f) The sequence of running out shall be from top to downwards i.e. the earthwire shall be run out first, followed by the conductors in succession. Unbalances of loads on towers shall be avoided as far as possible.

7. STRINGING OF CONDUCTOR AND EARTHWIRE

- I) The stringing of the conductor shall be done by standard stringing method.
- II) After being pulled the conductor/ earthwire shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.
- III) Conductor creep is to be compensated by over tensioning the conductor at appropriate temperature for which calculations are to be submitted by the contractor for Owner's approval.

IV) Jointing

- a) All the joints on the conductor and earthwire shall be of compression type, in accordance with the recommendations of the manufacturer for which all necessary tools and equipment like compressors, dies, processes etc. shall have to be arranged by the Contractor. Each part of the joint shall be cleaned by wire brush to make it free of rust or dirt etc. and properly greased with anti-corrosive compound if required, and as recommended by the contractor before the final compression is done with the compressors.
- b) All joints or splices shall be made at least 30 meters away from the structures. No joints or splices shall be made in spans crossing over main road, railways, small rivers with tension spans. During compression or splicing operation the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After pressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.
- c) During stringing of conductor to avoid any damage to the joint, the Contractor shall use a suitable protector with mid span compression joints in case joints are to be passed over pulley blocks/aerial rollers. The size of the groove of the pulley shall be such that the joint along with protection can be passed over it smoothly

8. SAGGING-IN-OPERATION

- I) The conductor shall be pulled upto the desired sag and left in running blocks for atleast one hour after which the sag shall be re-checked and adjusted, if necessary before transferring the conductor from the running blocks to the suspension clamps. The conductors shall be clamped within 36 hours of sagging in.
- II) The sag will be checked in the first and the last span of the section in case of sections upto eight spans and in one intermediate span also for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

- III) The running blocks, when suspended from the transmission structure for sagging shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured,
- IV) At sharp vertical angles, the sags and tensions shall be checked on both sides of the angle, the conductor and earthwire shall be checked on the running blocks for equality of tension on both sides. The suspension insulator assemblies will normally assume vertical positions when the conductor is clamped.
- V) Tensioning and sagging operations shall be carried out in calm weather when rapid changes in temperatures are not likely to occur.

VI) Tensioning and Sagging of Conductors and Earthwire

The tensioning and sagging shall be done in accordance with the approved stringing charts before the conductors and earthwire are finally attached to the tower through the earthwire clamps for the earthwire and insulator strings for the conductor. The 'Initial' stringing chart shall be used for the conductor and 'final' stringing chart for earth-wire should be employed for this purpose. Dynamometers shall be employed for measuring tension in the conductor and earthwire. The dynamometers employed shall be periodically checked and calibrated with the standard dynamometer.

VII) Clipping In

- a) Clipping of the conductors in positions shall be done in accordance with the recommendations of the manufacturer. Conductor shall be fitted with armour rods where it is made to pass through suspension clamps.
- b) The jumpers at the section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements and shall match the jumper drops shown in the tower drawings.
- c) Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

VIII) Fixing of Conductor and Earthwire Accessories

Vibration dampers for conductor and earthwire and other conductor and earthwire accessories shall be installed by the Contractor as per the design requirement and respective manufacturer's instructions within 24 hours of the conductor/earthwire clamping. While installing the conductor and earthwire accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and no damage shall occur to any part of the accessories.

9. REPLACEMENT

If any replacements are to be effected after stringing and tensioning or during maintenance, leg members and bracings shall not be removed without reducing the tension on the tower with

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

proper guying or releasing the conductor. If the replacement of cross arms becomes necessary after stringing, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys as suspension points.

10. FINAL CHECKING TESTING AND COMMISSIONING

After completion of the works, final checking of the line shall be done by the Contractor to ensure that all the foundation works, tower erection, and stringing have been done strictly according to the specifications and as approved by the Owner. All the works shall be thoroughly inspected keeping in view of the following main points:

- a) Sufficient backfilled earth is lying over each foundation pit and it is adequately compacted.
- b) Concrete chimneys and their copings are in good finally shaped conditions.
- c) All the tower members are correctly used, strictly according to final approved drawing and are free of any defect or damage, whatsoever.
- d) All bolts are properly tightened and punched/tack welded.
- e) The stringing of the conductors and earthwire has been done as per the approved sag and tension charts and desired clearances are clearly available.
- f) All conductor and earthwire accessories are properly installed.
- g) All other requirements to complete the work like fixing of danger plate, phase plate, number plate, anti climbing device etc., are properly installed.
- h) Wherever required it should be ensured that revetment is provided.
- i) The insulation of line as a whole is tested by the Contractor by providing his own equipment, labour etc. to the satisfaction of the Owner.
- j) All towers are properly grounded.
- k) The line is tested satisfactorily for commissioning purpose.

11. TRANSMISSION LINE MATERIAL

I) GENERAL

- a) All the equipment shall be of the latest design and conform to the best modern practice adopted in the extra high voltage field. The Bidder shall offer only such equipment as guaranteed by him to be

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

satisfactory and suitable for 220 kV AC transmission with twin/ single conductor and will give continued good performance.

- b) The design, manufacturing process and quality control of all the materials shall be such as to give maximum factor of safety, maximum possible working load, highest mobility, elimination of sharp edges and a good finish.
- c) All ferrous parts shall be hot dip galvanised, after all machining has been completed, nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electrogalvanised. The bolt threads shall be undercut to take care of increase in diameter due to galvanising . Galvanising shall be done in accordance with IS: 2629. Fasteners shall withstand four dips while spring washers shall withstand three dips. Other galvanised materials shall be guaranteed to withstand at least six dips each lasting one minute under the standard preece tests for galvanising.
- d) The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continues and free from imperfection such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanising shall be of grade Zn. 99.95 as per IS:209.

II) EARTHWIRE

- a) The galvanised steel earthwire shall generally conform to the specification of ACSR core wire as mentioned in IS 398 (Part-II)-1976 except where otherwise specified herein.
- b) Parameters of the earthwire – As per attached annexure

III) CONDUCTOR

- c) The conductor shall be Aluminium Core Steel Reinforced (ACSR) type. The conductor shall confirm to IS: 398 (Part-II) except where otherwise specified herein.
- d) Parameters of the conductor – As per attached annexure

IV) CONDUCTOR ACCESSORIES

A) Mid Span Compression Joint for Conductor

As per details given in IS: 2121 Part-2.

B) Repair Sleeve

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be of rounded that the conductor strands are not damaged during installation.

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

- a) The Bidder shall clearly specify the before and after compression dimensions of the mid span compression joint and repair sleeve for owner's review. The compression pressure shall also be indicated by the Bidder.

C) Vibration Damper for conductor and Earthwire

- a) Vibration dampers of 4 R-Stock bridge type with four (4) different resonance spread within the specified aeolian frequency bandwidth shall be used at all suspension and tension points on each span to damp out the Aeolean vibrations of the conductors to the specified level as mentioned hereinafter. Two dampers minimum on each side per conductor/earthwire shall be used at tension points and one damper minimum on each side per conductor at suspension points for ruling design span.
- b) The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6 or equivalent.
- c) The messenger cable shall be made of high strength galvanised steel/stainless steel with a minimum strength of 135 kg/mm². It shall be of pre-formed and post-formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS: 4826-1979 for heavily coated wires.
- d) The manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 KN and 5KN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
- e) The vibration damper for conductor shall not have magnetic power loss more than 0.5 watt at 350 Amps at 50 Hz alternating current.
- f) The vibration analysis of the system, with and without damper and dynamic characteristics of the damper shall have to be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the systems area follows:

D) EARTHWIRE ACCESSORIES

a) Mid Span Compression Joint for Earthwire

It shall be used for joining two lengths of earthwire. The joint shall be made of mild steel. The steel sleeve should not crack or fail during compression in it or service period. The Brinell Hardness of steel should not exceed 200. The steel sleeve shall be hot dip galvanised. The joints shall not permit slipping off, damage to, or failure of the complete earthwire or any part thereof at a load not less than 95% of the ultimate tensile strength of the earthwire. The joint shall have resistivity less than 75% of resistivity of equivalent length of earthwire. The dimensions and the dimensional tolerance of the joint shall be as given below:

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6	
CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL
	Rev - 00

Item	Dimensions before compression		Dimension after compression		
	Inner Dia.	Outer Dia.	Length	Corner to Corner width	Face to face width
	(mm)	(mm)	(mm)	(mm)	(mm)
Al. sleeve	22±0.5	30±0.5	315±5	29.4±0.5	25±0.5
Steel sleeve	10±0.2	21±0.5	230±5	20.2±0.5	17.5±0.5

E) Vibration Damper For Earthwire

Refer Clause IV C detailed above.

F) Flexible Copper Bond: As detailed in IS: 2121 part3.

G) Suspension Clamp for Earthwire: As Detailed in IS: 2121 Part3

- a) At all suspension towers, suitable suspension clamp shall be used to support the earthwire of 7/3.15 mm size, the clamp shall be of either free-centre type or trunion type and shall provide adequate area of support to the earthwire.
- b) The total drop of the suspension assembly from the center point of the attachment to the centre point of the Earthwire shall not exceed 150 mm. The complete assembly shall be guaranteed for slip strength of not less than 9 kN and not more than 14 kN. The breaking strength of the assembly shall not be less than 25 kN.
- c)]The clamping piece and the clamp body shall be clamped by at least two U-bolts of size not less than 10 mm diameter having one nut and 3 mm thick lock nut with washer on each of its limbs. Suspension clamps shall be provided with inverted type U-bolts. One limb of the Ubolt shall be long enough to accommodate the lug of the flexible copper bond.

H) Tension Clamp for Earthwire

The details shall be as per IS: 2121 part-3. Only Compression type tension clamp shall be used to hold galvanised steel earthwire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates.

I) HARDWARE FITTINGS

Drawings attached for reference.

J) INSULATOR

Drawings attached for reference.

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

12. TOWER ACCESSORIES

I) STEP BOLTS & LADDERS

Each tower shall be provided with step bolts of not less than 16mm diameter and 175 mm long, spaced not more than 450mm apart and extending from about 3.5 meters above the ground level to the top of the tower. Step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. For special structures, where the height of the super structure exceeds 50 meters, ladders along with protection rings shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 3.5 m to 30 m height of super structure step bolts shall be provided. Suitable railing for access from step bolts to the ladder and from the ladder to each cross arm tip and the groundwire support shall be fixed on tower by using countersunk bolts.

II) ANTI-CLIMBING DEVICE

Barbed wire type anti-climbing device shall be provided and installed by the Contractor for all towers. The height of the anti-climbing device should be provided approximately 3m above ground level. The barbed wire shall conform to IS-278-1978. The barbed wires shall be given chromating dip as per procedure laid down in IS: 1340-1959.

A) Danger plate, Number plates, Circuit Plate, Phase plate & Bird Guards.

Danger, Number Plates, Phase Plates & Bird Guards shall be provided and installed by the Contractor:

- Each tower shall be fitted with a number plate, and danger plate. Each tension tower shall be provided with a set of phase plates also. The arrangement for fixing these accessories shall not be more than 4.5m above the ground level.
- The letters, figures and the conventional skull and bones of data plates shall conform to IS: 2551-1963 and shall be in a single red on the front of the plate.
- The corners of the number and danger plate shall be rounded off to remove sharp edges.
- To prevent birds from perching immediately above the suspension insulator strings and thus fouling it with droppings suitable birdguards shall be provided at cross arm tips of all suspension towers. The arrangement shall conform to IS: 5613 part-2/Sec-I.

13. TOWER EARTHING

The footing resistance of all towers shall be measured by the Contractor in dry weather after tower erection but before the stringing of earthwire. All the towers are to be earthed. In no case tower footing resistance shall exceed 10 ohms. Pipe type earthing and counterpoise type earthing wherever required shall be provided in accordance with the stipulations made in IS: 3043-1987 and IS: 5613 (part-II/

PROJECTS : 400/220kV Switchyard- RTPP Stage-IV Unit#6 CUSTOMER: APGENCO, Hyderabad	
Section-2: ETC OF 220kV DC Transmission Line	Doc. No .TB-344-316-001TL Rev - 00

Section-2) 1985. The details for pipe and counterpoise type earthing are given in drawing enclosed with the specification.

14. TESTS FOR TL. LINE MATERIAL

The materials shall conform to all the type tests as per relevant standards. The acceptance, routine tests and tests during manufacture shall be carried out on the line material as per relevant standards.