



**BHARAT HEAVY ELECTRICALS LIMITED**  
TRANSMISSION BUSINESS ENGINEERING MANAGEMENT , NEW DELHI.

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CUSTOMER	<b>UPPTCL</b>				
PROJECT	<b>EXTENSION OF 765/400 KV S/S AT BARA IN ALLAHABAD,U.P</b>				

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## **SECTION - 1**

SCOPE, SPECIFIC TECHNICAL REQUIREMENT,  
SPECIAL CONDITION OF CIVIL WORKS &  
QUANTITIES

## **SECTION - 1**

### **SCOPE, SPECIFIC TECHNICAL REQUIREMENTS** **SPECIAL CONDITIONS FOR CIVIL WORKS & QUANTITIES**

#### **1.1.0 SCOPE**

1.1.1 The scope of work under this specification is Civil Works for Extension of 765/400kV Sub Station at Bara in Allahabad distt., of U.P executed by Bharat Heavy Electricals Ltd. The Customer is U.P. Power Transmission Corporation Limited.

1.1.2 The Civil Works shall generally include, *but not limited to*, following:

- (i) Site surfacing.
- (ii) Tower Foundations
- (iii) Equipment foundations.
- (iv) Cable trenches including precast covers & cable trench crossings.
- (v) Fencing
- (vi) Gravel spreading and relaying existing gravel.
- (vii) Drainage work.
- (viii) Road work.
- (ix) Any other work required for the project.

1.1.3 The works to be performed in the above construction includes preparation of bar bending schedules, based on the drawings released for construction and getting the same approved by the Engineer-in-charge plus the execution of the work including providing of all labour, supervision, materials, scaffolding, power, fuel, construction equipments, tools and plants, supplies, transportation, all incidental items necessary for successful completion of the work including contractor's supervision and in strict accordance with the drawings and specifications and with inspection and testing standards. The nature of work shall generally involve excavation in all type of soil and rock including dewatering, shoring, strutting, and filling under and around structures, backfilling with available excavated or borrowed earth around completed structures, cable trenches with covers, disposal of surplus soil, formwork, providing necessary steel embedments and other inserts, drainage work, stone spreading (including antiweed treatment), fencing, surface dressing, concreting, brickwork, plastering as per technical specifications and other works in switchyard all complete as per detailed specification, drawings and directions of Engineer-in-charge.

#### **1.2.0 SPECIFIC TECHNICAL REQUIREMENT**

1.2.1 The specific technical requirements for the execution of civil works shall be as per Customer Technical Specification/IS code. In case of any conflict between Indian Standard Code and Technical Specifications, the provisions of Technical Specification shall prevail.

### 1.3.0 SPECIAL CONDITIONS FOR CIVIL WORKS

- i. All civil work shall be executed as per approved / released for construction drawings.
- ii. All Drawings for electrical lighting work including Conduit layout, wiring diagram etc. for stores shall be prepared by contractor and submitted to Engineer in charge for approval.
- iii. Mode of measurement for civil works shall be as per customer technical specifications.
- iv. All centering, shuttering and scaffolding shall be arranged by the contractor. Form work used should be of good quality and no honeycombing in concrete will be allowed.
- v. The materials such as brick, sand, coarse sand, stone aggregate etc. shall be as per relevant IS code and prior source approval of the same has to be taken from customer. Regular testing of materials shall be done by the contractor from approved laboratory at his own cost.
- vi. Centre-line pillars, benchmarks pillars and level pillars in brick work shall be constructed by the contractor at various places as per direction of Engineer-in-Charge, at his own cost.
- vii. Portland cement of approved make from the customer shall be used by the contractor in construction of substation. Test certificates shall be submitted before use.
- viii. Reinforcement steel bars conforming to IS: 1786-1979 of approved manufacturers from the customer shall be used in construction works. Test certificates shall be submitted before use.
- ix. Structural steel section as approved by the customer shall be used. Test certificates shall be submitted before use.
- x. Contractor shall arrange Concrete mixture for mixing of all grades of cement concrete at his own cost. For compaction of concrete suitable vibrators shall be arranged and used by the contractor at his own cost.
- xi. The contractor will make his own arrangements for electricity / water required for construction of substation. Nothing shall be paid on this account.
- xii. The contractor will arrange for temporary stores and site office at the site of work at his own cost.
- xiii. The water fit for drinking shall be used in construction works.
- xiv. Suitable templates made of MS angles and MS channels for grouting of bolts shall be arranged by the contractor at his own cost. Drawings for templates shall be prepared by contractor and submitted to Engineer in charge for approval before use. No tolerance is allowed in grouting of bolts.
- xv. Regular Testing of construction work/material as per approved FQP or direction of Engineer-in-Charge shall be carried by contractor at his own cost from approved laboratory and results shall be submitted to Engineer incharge.
- xvi. All civil work shall be carried out as per UPPWD/UPPTCL specification/Relevant IS codes.
- xvii. **No extra item shall be executed / started by the Contractor without written permission, failing which the Contractor shall be responsible for any expenditure incurred or risk involved as such. Contractor is strictly prohibited to start extra items without written permission by Engineer Incharge. Any violation of this clause will mean breach of the contract.**
- xviii. Concrete of RCC slab shall be smooth finished & no extra payment shall be made on this account.

**1.3.0 BILL OF QUANTITIES**

- 1.4.1 The Bill of Quantity shall be as per pages from 1.4 to 1.9
- 1.4.2 The quantities indicated in the 'Bill of Quantity' are indicative and can vary to any extent. Contractor shall not be entitled for any claim for any such variation in the quantities.
- 1.4.3 The provision of Bill of Quantity, specifications and drawings shall be read in conjunction with each other and in case of conflict amongst them, the clarification shall be obtained from the Engineer-in-charge whose decision shall be final and binding.

**BILL OF QUANTITY CUM PRICE SCHEDULE**  
**CIVIL WORK FOR EXTENSION OF 765/400kV S/S AT BARA IN ALLAHABAD U.P**

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S.N	Item	Quantity	Unit	Unit Rate	Amount
1	Earth work in excavation by mechanical means (hydraulic excavator)/manual means over areas (exceeding 30cm in depth, 1.5m width as well as 10sqm on plan ) including getting out and disposal of excavated earth lead upto 50m and lift upto 1.5m as directed by Engineer in charge.				
a	Ordinary rock	550	cum	221.05	121578
b	Hard rock (requiring blasting)	100	cum	389.50	38950
c	Hard rock (blasting prohibited)	1100	cum	619.80	681780
2	Excavation in foundation in <b>ordinary soil</b> (Loam Clay or Sand) including lift upto 1.5m and lead upto 30m & including backfilling, watering, ramming (compaction) of excavated earth into the trenches or into the space between the building and sides of the foundation work.	250	cum	127.20	31800
3	<b>Add to Earth work item</b> (SI No. 1 to 2) for every additional 1.5M lift or part thereof within the switchyard area.	1200	cum	19.20	23040
4	<b>Sand filling</b> in plinth including supply of necessary quantity of sand from outside the UPPCL premises including watering, dressing etc. rate to include cost of all materials, labour and T&P etc. required for proper completion of work	500	cum	884.00	442000
5	<b>Clearing jungle</b> including of rooting of rank vegetations grass, bush, wood, tree and sapling of girth up to 30 cm measured at height of 1.0 m above ground level and removal of rubbish up to a distance 50 m outside the periphery of UPPCL Area.	5000	sqm	5.60	28000
6	<b>Earth filling</b> under floors and substation area including cost of earth when obtained from outside UPPCL area including its carriage, watering and compacting in to 20 cm layers and dressing of earth etc. complete.	1500	cum	322.40	483600
7	Concrete with 4 cm gauge 1st class brick ballast class 150mm coarse sand and cement in proportion of <b>12:6:1</b> in foundation and under floors including supply of all materials, labour & T&P etc. complete	20	cum	4309.60	86192
8	Concrete with 4cm gauge class-1 brick ballast (class 150mm) coarse sand (F.M 1.8 to 2.5) & cement in proportion of <b>8:4:1</b> in foundation & under floors including supply of all materials, labour & T&P etc. complete.	145	cum	4635.20	672104
9	Concrete with 4cm gauge stone ballast, coarse sand (F.M. 1.8 to 2.5) and cement in proportion of <b>8:4:1</b> in foundation & under floors including supply of all materials, labour & T&P etc. complete.	225	cum	5876.80	1322280
10	Concreting of <b>40mm thick RCC trench cover</b> in MS frame work (to be fabricated under other items of work ) with CC 1:1.5:3 in cement , Coarse sand with 2cm gauge graded hard stone ballast with 3mm thick floating coat of neat cement finish on top of cover complete with supply of all material labour T&P etc required for proper completion of work complete excluding cost of frame.	75	sqm	320.00	24000

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S.N	Item	Quantity	Unit	Unit Rate	Amount
11	Cement concrete with 2cm gauge approved hard stone ballast, coarse sand (F.M. 1.8 to 2.5) and cement in proportion of <b>4:2:1</b> including supply of all materials, labour,side shuttering if required and T&P etc. required for proper completion of work.	10	cum	6286.40	62864
12	Cement concrete with 2cm gauge approved hard stone ballast, coarse sand (F.M. 1.8 to 2.5) and cement in proportion of 3:1.5:1. including supply of all materials, labour,side shuttering if required and T&P etc. required for proper completion of work.	20	cum	7060.80	141216
13	RCC work with cement approved coarse sand (F.M. 1.8 to 2.5) and 2 cm gauge graded approved hard stone ballast like grainite, quartzite etc from Dalla, Jhansi or other quarries and approved coarse sand in proportion 1:1.5:3 in <b>slab</b> , excluding supply of reinforcement & its bending but including its fixing and binding the same with binding wire, including cost of all other materials labour and T&P .	10	cum	9379.20	93792
14	Supplying and filling stone ballasts in chilling tank complete including supply of all materials, labour and tools and plants etc. required for proper completion.(Voides 30 % shall be deducted during measurement).	50	cum	1898.40	94920
15	RCC work with cement approved coarse sand (F.M. 1.8 to 2.5) and 2 cm gauge graded approved hard stone ballast like grainite, quartzite etc from Dalla, Jhansi or other quarries and approved coarse sand in proportion 1:1.5:3 in <b>lighter beams i.e. having span upto 6m</b> , excluding supply of reinforcement & its bending but including its fixing and binding the same with binding wire, including cost of all other materials labour and T&P .	10	cum	10160.00	101600
16	RCC work with cement approved coarse sand (F.M. 1.8 to 2.5) and 2 cm gauge graded approved hard stone ballast like grainite, quartzite etc from Dalla, Jhansi or other quarries in proportion 1:1.5:3 in <b>raft foundation and footings</b> , excluding supply of reinforcement & its bending but including its fixing and binding the same with binding wire, including cost of all other materials labour and T&P.	800	cum	7784.00	6227200
17	Same as above item no. 16 in RCC <b>pile caping, gantry walls/column foundations and RCC pedestals</b> but in the proportion 1:1.5:3.	20	cum	8034.40	160688
18	Same as above item no. 16 but in R.C.C. <b>T Beam slab, walls, and R.C.C. column</b> . (above FGL)	400	cum	10327.20	4130880
19	<b>First class brick</b> (class-150)work in 1:6 cement and coarse sand (F.M. 1.8 to 2.5) mortar in <b>foundation and plinth</b> including supply of all materials, labour & T&P etc. required for proper completion of work.	150	cum	4612.00	691800
20	Same as item no. 19 but in <b>superstructure</b> ,thickness of wall not to be less then 1 brick (230mm)thick including supply of all materials, labour & T&P etc. required for proper completion of work.	90	cum	5109.60	459864
21	First class brick work(class 150) in 1:4 cement and coarse sand (FM 1.8 to 2.5) mortar in <b>foundation and plinth</b> including cost of all materials, labour and T&P etc. required for proper completion of work	250	cum	4739.20	1184800

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S.N	Item	Quantity	Unit	Unit Rate	Amount
22	Same as item no. 21 but in <b>superstructure</b> ,thickness of wall not to be less then 1 brick (230mm)thick including supply of all materials, labour and T&P etc. required for proper completion of work.	70	cum	5236.80	366576
23	<b>Mild Steel or Iron work</b> in heavy sizes such as trusses built up gates, door frames, record, racks roof work gates,gratings,structure for supporting grating,plates,inserts and embedments etc. wrought to required form including holes rivetting or welding where necessary and also fixing in proper position and alignment including priming, cost of all materials supplied by contractor.	68	MT	61240.80	4164374
24	Steel reinforcement -Cold twisted bars /TMT- Fe 500 (To be procured from SAIL,TISCO,IISCO, JINDAL STEEL and RINL only)				
a	Including supply, straightening, cutting and bending, binding (i/c cost of binding wire), placing in position, etc., all labour & material, complete.	5	MT	54353.60	271768
b	Excluding supply but including straightning, cutting, bending, binding (i/c cost of binding wire), placing in position, etc., all labour & material, complete incl unloading & storage. (Reinforcement steel shall be supplied by BHEL free of cost)	55	MT	15698.40	863412
25	Fixing and grouting bolts upto 28mm to 56mm dia in proper alignment level and setout with help of a template complete including supply of all labour & T&P etc. required for proper completion of the work.(labour rates only) .	50	No.	44.80	2240
26	Fixing and grouting GI Anchor bolt upto 25mm dia. in proper alignment level and set out with the help of a template including supply of all labour T&P etc. reqd. for proper completion of the work.	550	No.	34.40	18920
27	Providing M.S. Frames work for R.C.C. Trench covers and edging with M.S. Angles including cutting, bending,welding and priming of <b>MS Angle</b> & cutting and welding of MS bars for reinforcement & lifting hooks as per approved design. The rate is including cost of all labour, materials etc. as required for proper completion of the work.	10	MT	58054.40	580544
28	<b>Fixing grouting of trench edging</b> in proper level and alignment including cost of all labour and T&P etc required for proper completion of the work but excluding cost of C.C	150	RM	9.60	1440
29	Grouting of 90/105 lbs M.S. rail including cost of all materials, labour & T&P for fixing of rail in proper alignment, level and position in transformer plinth foundation etc. as per direction of Eng I/C. (Rail to be supplied by the dept.)(labour rates only) .	20	RM	396.00	7920
30	S/F in position 90 lbs <b>M.S. Rail</b> for transformer plinth including cost of all labour, material and T&P etc. required for proper completion of the work.	70	RM	2796.00	195720
31	S/F in position 105 lbs <b>M.S. Rail</b> for transformer plinth including cost of all labour, material and T&P etc. required for proper completion of the work.	300	RM	3183.20	954960
32	Grouting of vertical or inclined post of pale/chain/security fencing in true level, alignment and in plumb or inclination as required, including cost of all labour, materials and T&P required for proper completion of work. (Post and concrete for grouting shall be measured separately)	20	No.	38.40	768



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S.N	Item	Quantity	Unit	Unit Rate	Amount
33	S/F 50x50mm, 8 gauge <b>G.I. chain link fencing</b> 1.8 M high including fixing to vertical posts, horizontal runners with 10mm dia. 40mm long bolts, nuts and washers complete with all material, labour and T&P etc. required for proper completion of work. Chain link of 8 gauge shall be galvanized by hot dipped method as per relevant IS Code. (Excluding cost of vertical posts and horizontal runners)	100	sqm	595.20	59520
34	Fixing of <b>cable trench racks</b> in proper position and alignment including cost of all labour, material and T&P etc. required for proper completion of the work (Labour rate only).	300	No.	7.20	2160
35	Fixing of template in position level and alignment for grouting of Anchor bolt in <b>main gantry</b> (labour rate only).	5	No.	181.60	908
36	Fixing of template in <b>Auxiliary Structure</b> for grouting of Anchor bolt in column of foundation. (labour rate only).	200	No.	115.20	23040
37	Fabrication of template for <b>main gantry foundation</b> including cost of all labour, and T&P etc. required for proper completion of the work. Steel shall be arranged by contractor free of cost. This template shall be property of contractor.	3	No.	676.00	2028
38	Same as above item no. 37 but for <b>auxiliary foundations</b> .	20	No.	340.00	6800
39	<b>12 mm thick plaster</b> with cement mortar consisting of 1 cement & 4 part of approved coarse sand of 2.5 fineness modulus over brick work minimum thickness not to be less than 10mm including supply of all materials, labour & T&P etc. required for proper completion of work.	700	sqm	167.20	117040
40	Providing (12x15) mm section groove in plaster including all material, labour and T&P etc. required for proper completion of the work.	300	RM	9.60	2880
41	<b>6 mm. thick plaster</b> with 1:3 cement & coarse sand including labour, materials & T&P etc. required for proper completion of the work.	1500	SQM	137.60	206400
42	Champering the edge of concrete in auxiliary structure, of size 25 mm wide in triangular section including all materials, labour & T&P etc complete.	50	RM	6.40	320
43	<b>3mm thick floating coat</b> of neat cement finish including supply of all materials, labour & T&P etc. required for proper completion of work. (cement consumption 0.044bag/sqm).	700	SQM	14.40	10080
44	<b>2.5 cm thick 1:2:4 plain cement concrete floor</b> with cement approved coarse sand and 2cm graded stone ballast laid in panel finished with 3mm floating coat of neat cement as specified and removing any overlapping mortar at the joints of the panel if any and giving them a uniform finish including supply of all materials, labour and T&P etc. required for proper completion of work (Base CC shall be paid separately)	50	sqm	228.80	11440
45	Same as above item no. 44 but for 4 cm thick. (Base CC shall be paid separately)	50	sqm	378.40	18920
46	First class <b>bricks on edge</b> floor laid dry, joints sand filled, including preparation of base to proper slope and its ramming including supply of all material, labour & T&P etc. required for proper completion of the work.	50	sqm	441.60	22080
47	Straight over burnt bricks on <b>edge floor laid dry</b> , joints sand filled, including preparation of base to proper slope and its ramming including supply of all material labour & T&P etc. required for proper completion of the work.	50	sqm	446.40	22320

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S.N	Item	Quantity	Unit	Unit Rate	Amount
48	First class brick on edge floor-laid in cement mortar consisting of one part of cement and six parts of coarse sand and pointed with cement mortar 1:2 over and including all materials, labour, T&P etc.required for proper completion of work.	50	sqm	566.40	28320
49	Painting and varnishing on new wood, or new iron work with one coat of ready mixed priming paint and two coats of approved ready mixed paint (Luxol or equivalent brand or varnish) including supply of all materials, labour &T&P etc. required for proper completion of work.	1250	sqm	82.40	103000
50	Dismantling brick work or stone work in lime or cement mortar and including stacking of materials as directed by the Engineer-in-charge within a distance of 60 metres.	25	cum	372.80	9320
51	Dismantling reinforced cement concrete or reinforced brick work, including stacking of dismantled materials as directed by the Engineer-Incharge within a distance of 60 metres.	50	cum	834.40	41720
52	Laying cement <b>concrete road slab</b> consisting of 1 part cement 1½part approved coarse sand and 3 part approved 20mm down graded stone aggregate over prepared sub grade after its rectification and bringing it to proper camber and shape and making good to the satisfaction of E/I including cost of all materials, labour and T&P etc. required for proper completion of the work.	200	cum	6855.20	1371040
53	Filling of 20 mm. wide 100/150 mm. deep joint with coarse sand and saw dust mixed with hot bitumen etc. complete including supply of all materials, labour and T&P etc. required for proper completion of the work.	800	RM	36.00	28800
54	Providing and laying 300 mm non-pressure <b>NP3</b> class RCC pipes with collars with stiff mixture of cement mortar in the proportion 1:2 (1-Cement, 2-Coarse sand) including testing of joints including cost of all material, labour, T&P etc. required for proper completion of the work.	30	RM	1149.60	34488
55	Providing and laying 600 mm non-pressure <b>NP3</b> class RCC pipes with collars with stiff mixture of cement mortar in the proportion 1:2 (1-Cement, 2-Coarse sand) including testing of joints including cost of all material, labour, T&P etc. required for proper completion of the work.	45	RM	2557.60	115092
56	Placing of trench covers of all size in proper position including transportation from different places within the S/S area including supply of all materials, labour and T&P etc. required for proper completion of work.	200	No.	7.20	1440
57	Cartage of ballast,rock,kankar,coal grit or sand etc. including loading, unloading and spreading				
a	Upto 1st kM	400	cum	98.40	39360
b	Upto 3rd kM	800	cum	117.60	94080
58	Providing and laying stone aggregate in switch yard areas as per Technical specification SECTION VII ' Substation Civil Works-037806-41ES-1100 CLAUSE 3.4' all complete as per direction of Engineer in Charge. (The rate shall be inclusive of all materials, labour, loading, unloading but excluding micro leveling, dressing & antiweed treatment. PCC, if required, shall be paid seperately under respective item. )	975	cum	1617.00	1576575
59	Same as above item 58 excluding Supply of stone aggregates, but including removal of existing laid gravel, stacking, washing and relaying but excluding micro leveling, dressing & antiweed treatment. PCC, if required, shall be paid seperately under respective item.	1442	cum	807.90	1164992

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S.N	Item	Quantity	Unit	Unit Rate	Amount
60	Antiweed treatment in switchyard area including micro leveling, dressing etc as per Technical Specification.	7850	sqm	12.80	100480
	<b>TOTAL (RS.)</b>				29948233

**NOTE:**

- 1 Mode of measurement for civil works shall be as per customer technical specification.
- 2 The Rate of RCC/CC items includes the cost of form work ( Centering, shuttering and scaffolding) and no additional payment shall be made for form work
- 3 For excavation nothing extra shall be payable for slope,shoring,strutting etc. irrespective of whatever is provided. However the contractor shall maintain the required slope and working space as per the safety /statutory requirement and its cost is deemed to be included in the quoted rate. The overlaped portion in the case of adjacent foundation shall be paid once.

## **SECTION - 2**

STANDARD TECHNICAL SPECIFICATION  
(N.A.)

## **SECTION - 3**

ENCLOSURES TO THE SPECIFICATION

(a) Customer Technical Specification



**INSTALLATION AND COMMISSIONING OF 1500MVA ICT-II  
ALONG WITH COMPLETION OF ASSOCIATED 765 & 400KV  
TRANSFORMER BAYS AT EXISTING 765/400KV SUBSTATION,  
BARA TPS (U.P.)**

**Technical Specification  
Substation Civil works  
037806-41ES-1100**

## **1 GENERAL**

### **1.1 Objective**

This specification outlines the Standard Technical Requirements for the construction work of Installation and commissioning of 01 no. 765/400kV 1500MVA Transformer along with completion of associated 765 & 400kV Transformer bays civil works at existing 765/400kV Substation, Bara TPS by the Uttar Pradesh Power Transmission Corporation Ltd. (UPPTCL), Uttar Pradesh, India.

The Contractor shall ensure that the civil works of the 765/400 kV substation shall be compatible with the Project requirements.

The Contractor shall prepare and present the required documents for Engineer's review as described later in this document or elsewhere in the Contract documents.

This technical specification shall be read in conjunction with the General Technical Requirements.

In the case of any discordance or conflict between the documents, the decision of Engineer in charge shall be final.

### **1.2 Scope of Works**

The Contractor shall design and build all works necessary for the construction of the bays. The electrical layout drawings enclosed within the specifications shall be used as a reference to identify all the civil works needed to provide a completely functional installation. Namely (not limitative):

- Earth works to make the substation land suitable for installation of supporting structures and equipment; for erection of the main control building and other ancillary buildings, with drainage to evacuate water in all conditions and of sufficient size to allow access to maintenance equipment, and levelling, filling and gravelling the switchyard area;
- Compaction test and report for filling and graveling material;
- Security fence along the perimeter of the substation;
- Foundations and anchor bolts for equipment pedestals, bus supports and gantry structures for incoming lines and strain busses;
- Cable concrete trenches and embedded ducts with pulling stations and cable pits;  
Road and switchyard internal circulation ways;
- Drainage network, including perimeter trenches, switchyard internal sub soil drainage trenches and pipes;
- Power transformers oil containment basins, with oil/water separator;
- Office and accommodation facilities for Purchaser and/or Engineer (where specified); and
- Culvert and other work to reach the sub-station.
- Other related works to make a complete installation.

In addition to the previously mentioned permanent installation, the Contractor shall provide all necessary provisional facilities to perform his works such as storage areas, water and electricity supply, communications, site office, accommodation facilities for his personnel, workshops, etc.

When there is no availability of power or water, the Contractor shall provide a diesel generator with fuel and transport water for use by his personnel and for construction purpose. Contractor may use the access road available in the substation for transportation of the equipment. However the access road shall not be damaged in any way and shall be repaired at his own cost if damaged due to

transportation of equipment.

### **1.3 Standards and Codes**

The ACI and ASTM standards latest release are given as reference for constructions or for the quality of material. Indian Standards Code for Civil Work is also applicable.

The Contractor may propose to the Engineer equivalent standards from recognized international organizations.

In case of any conflict with the referred standards and codes, the following order of priority shall be observed:

- a) Contract clauses;
- b) Construction code or regulation of country;
- c) Standard ACI; and
- d) Standard ASTM.

In addition to the above-mentioned international standards, Contractor shall also comply with the Indian Standard Codes for the followings:

- Structures and foundations
- Concrete works
- Form works
- Earthworks
- Roads and pavements
- Fences and gates
- Steel reinforcement



**I.S. CODE: reference of statement of 765 kV S/S Civil Work specification with respect to American Code**

4.1.1	ASTM A760/A760M	IS : 1537 - 1960
	C-117	AS PER RELEVANT I.S CODE
	C-136	AS PER RELEVANT I.S CODE
	D-698	IS : 2720 : PART (VII) - 1985
	D-4254	IS : 2720 : PART I-VII - 1985
4.9	ACTM C-14 M	AS PER RELEVANT I.S CODE
5.1.1	ACI 301	IS : 456 - 2000
	ACI 305	IS : 7861 (PART-I)AND PART - II
	ACI 318	IS : 456 - 2000
	ASTM A A-36/A36 M	AS PER RELEVANT I.S CODE
	A153	IS : 278 -1978
	A 185	IS : 1786 - 2008
	A 615/A 615 M	IS : 42 PART – I 1982
	C-33	IS : 383 - 1970
	C-39	IS : 515
5.1.4	C-207	IS 9/03 - 1999
	C-494	IS : 456 – 2000 CLAUSE 8.2.4.1, 8.2.5.2, 8.2.2.4
	D-698	IS : 516 – 1959 AND is ; 1199
	ACI 301	IS : 4082 – 2000
	ACI 305	IS : 456 – 2000 CLAUSE 8.2.2.1, 35.3.2
	ASTM C-33	IS : 383 – 1970 (REAFFIRMED 2002)
	ASTM A 615/A 615 M GRADE 400	IS : 1786– 2008
	ASTM A 185	IS : 1786– 2008
	ACI 318	IS : 456– 2000 CLAUSE 9.1
	ASTM C-39	IS : 456– 2000
6.4	ASTM D-1597	AS PER RELEVANT I.S CODE
	ASTM D-2027	AS PER RELEVANT I.S CODE
	ASTM C-128	AS PER RELEVANT I.S CODE
	ASTM D-4469	AS PER RELEVANT I.S CODE
	ANSI/ACI 7	IS : 875 (PART I-IV) AND IS : 1893
	A - 307	AS PER RELEVANT I.S CODE
	A - 490	IS : 3757
	C - 991	IS : 7193 - 1994

#### **1.4 Works Programme**

The Contractor shall prepare and submit a Works Programme in compliance with Sub-Clause 8.3 of the Particular Conditions of Contract. The program shall be updated and kept current throughout the duration of the Contract, and will be used by the Engineer to monitor the progress, identify deviations and determine corrective action in conjunction with the Contractor.

#### **1.5 Safety Measures**

The Contractor shall implement a safety program for his personnel in accordance to safety regulations applicable in India and meeting sound construction industry standards.

The Contractor shall comply with Sub-Clause 6.7 of the Conditions of Contract. In particular, the

Contractor shall designate an officer in charge of safety who has the training and experience, as well as the necessary equipment, to meet emergency situations. This officer will have the authority to stop the work at any time, if he judges that safety of personnel is compromised, or the method or equipment employed to perform the work is risk prone, and stop any individual who does not comply with safety rules.

#### **1.5.1 Safety Programme**

Within two months from the contract award, the Contractor shall present a safety programme for the Engineer's review and acceptance; among others, the plan shall cover the following aspects:

- Name of safety officer and proof of adequate training;
- Safety rules for Contractor's personnel and visitors;
- Means for fast transportation of injured personnel;
- Hygiene on site of works (potable water supply, clean facilities, etc.);
- Prevention measures against accidental electrical shock;
- First aid measures on site;
- Accessibility to nearby hospital and clinic at any time with arrangement for standby medical personnel; and
- Supply to personnel of security hats, boots and glasses.

#### **1.5.2 Prevention of Accidents**

All Contractor's personnel shall be identified properly to control their access to the work sites. Unauthorized persons shall be prevented to enter the premises. Identification cards shall also be issued to the Engineer and his representatives.

Among others, the following measures shall be implemented:

- At least one out of every 30 workers must be trained to impart first aid and have, readily available, a suitable first-aid kit;
- Any worker responsible for operating electrical equipment shall be trained to disconnect power and attend to any worker jolted by electric current;
- No worker shall be allowed to manually handle loads exceeding 50 kg;
- All tools shall be provided with hardwood handle, avoid loose parts or cutting edges;
- Cutting tools shall come with an adequate handle, safety lock and storing case;
- Wrenches shall have a lever of convenient length to avoid the use of tube extension;
- Handling conductors or metallic cables close to energised lines or substation bus shall be strictly avoided; and
- Ladders shall be safe, preferably metallic.

#### **1.5.3 Work in Energized Area**

When the work involves modifying or extending an existing substation, where the workers will access energized areas of the switchyard, the Contractor shall present to the Engineer a detailed work plan where the Contractor explains the method he will be using to perform each operation. The Engineer will coordinate with the substation operator to obtain the permit for the Contractor to access the area and, when necessary, to put the corresponding section of the switchyard out of service. Work on energized parts is strictly prohibited.

The Contractor shall be responsible to implement safety measures when operating in energised surroundings. Such measures may include use of temporary barriers with padlocks, warning signs, grounding tools, coloured tape to limit the zone, etc.

These measures shall be agreed with the Engineer and the operator of the substation as well as Lucknow Remote Despatch Center is so required.

The detailed work plan shall also address, at least, the following issues:

- Safety rules:
  - Identification of each electrical isolating point in the area;
  - Request for temporary shutdown of the equipment;
  - Setting out of protected zone;
  - Shutting down the equipment (with installation of barriers, padlocks, signs, etc.);
  - Issue work permits to authorized personnel;
  - Definition of work safe zone (apprise all involved of safety measures, identification of dangerous points, etc.);
  - Instructions to personnel;
  - Ensure continual presence of person in charge of works;
  - Instructions for interrupting the work, if necessary;
  - Test on completion of the work in protected zone;
  - End of work and leaving work zone;
  - Dismantling the protection measures;
  - End of work notification.
- Work rules (authorizations, self-protection, interface with operator);
- Training of personnel; and
- Control of safety equipment.

## **1.6 Materials**

All material used for the Work shall be **new and of first class quality** and shall comply with this Specification. The material delivered in containers, boxes or barrels shall come to the site of work in their original packing and sealed. The **cement (PPC) conforming to corresponding IS 1489 part-1** shall be delivered in PVC or hard paper bags and stored at site in shelter previously prepared conforming to Indian Standards. The bulk products such as aggregate for concrete and stone shall be delivered by trucks and stored at the site conforming to Indian Standards.

The Engineer may reject any material that, in his opinion, is not of good quality or not compliant with the Specification.

## **1.7 Quality Control During Performances of Work**

The Contractor shall implement a quality control program for the performance of the work. This program shall be based on the principles of ISO 9001 standard.

The program, to be submitted to the Engineer for review and acceptance prior to work commencement, shall address, among others, the following issues:

- Q.A. organization chart;
- Level of authority and competence of quality control personnel;
- Control of materials;
- Test facilities, tools and instruments;
- Follow-up and inspection of each piece of work in accordance with the Drawings;
- Non conformance report and corrective measures;
- Q.A. log book; and
- Control of documentation at site.

The Contractor shall maintain the following Q.A. records at Site (as a minimum requirement) which can be reviewed by the Engineer at any time:

- Files with verification forms and test results for the materials used for the Works. The various steps of compulsory inspection, defined for each element of work, shall be submitted to the Engineer for approval;
- Non-conformance report (NCR) files: These reports will be kept current until satisfactory corrective measures have been implemented. A periodic review of NCR reports shall be performed with the Engineer to appraise the degree of quality of the work performed by the Contractor. The Contractor shall keep a rigorous follow-up of all NCR reports;
- “As-built” drawings: the Contractor shall keep at Site an updated, “as-built”, marked-up copy of each, available for inspection by the Engineer. Any substantial deviation from the original construction drawings shall be documented by generating an NCR for which the Contractor shall be asked to provide explanation and justification;
- The marked-up drawings will then be used by the Contractor to prepare the final “as-built” drawings that will be handed to the Engineer on completion; and
- The resident Contractor’s representative shall be responsible for the implementation of the quality assurance program at site and for keeping the corresponding records.

## **1.8 Environment protection**

The Contractor shall implement a program for environment protection during the works. This program shall be based on the principles of ISO 14001 standard.

The program, to be submitted to the Engineer for review and acceptance prior to work commencement.

## **2 SITE FACILITIES AND PRELIMINARY WORKS**

### **2.1 Office and Storage**

The Contractor shall provide, among others, the following facilities at Site:

- Contractor’s site office with, with adequate facilities for joint meetings with the Engineer and the Engineer;
- Accommodation for Contractor’s personnel;
- Storage sheds for Permanent Works (materials and equipment). Where required, air conditioning and ventilation shall be provided;
- Storage sheds for Contractor’s equipment and materials;
- Electrical and mechanical workshops;

- Material control laboratory, fully equipped;
- Canteen facilities for site personnel;
- First-aid facilities;
- Provision, servicing and maintenance of site facilities for Engineer's personnel, as specified;
- Open areas for storage;
- Security fence;
- Water and power supply;
- Temporary sewage and disposal system;
- Fire fighting equipment; and
- Others, as required.

Contractor's facilities may include mobile units. Use of empty containers will be allowed, provided these are suitably adapted for the intended purposes.

The Engineer may refuse the facilities of the Contractor if he judges they are not convenient and acceptable.

## **2.2 Mobilizing and Demobilizing**

The Contractor shall be responsible to transport and install all site facilities, Temporary Works and Contractor's equipment, as required for the Works. Upon completion of the Works, the Contractor shall remove the same and leave the Site clean and unencumbered, to the Engineer's approval.

## **2.3 Sign Board**

The Contractor shall install a project sign board. Wording, size and location of the sign board shall be as approved by the Engineer.

### **2.3.1 Testing**

All field and laboratory tests shall be performed in accordance with the standards.

All laboratory tests shall be carried out in an approved laboratory. American, British or Indian Standards shall be used.

### **2.3.2 Field Tests**

The following field tests shall be required:

- a) For buildings and equipment support foundations:
  - i) Subsoil strata by means of boring;
  - ii) Standard penetration test;
  - iii) Dutch cone penetrometer test and/or shear vane test; and
  - iv) Plate bearing test.
- b) For roads:
  - i) In-situ density of sub-grade; and
  - ii) Plate bearing test of sub-grade.

- c) For Earthing
  - i) Soil resistivity measurement and analysis
- d) For Piling Work
 

Pile load test shall be carried out as per relevant IS code norms for compression, tension & deflection prior commencing the piling.

### **2.3.3 Laboratory Test**

The following laboratory tests are required:

- a) For buildings:
  - i) Particle size distribution test;
  - ii) Consolidation tests to determine parameters of settlement analysis; and
  - iii) Triaxial test, unconfined compression.
- b) For roads:
  - i) Dry density/moisture content determination on sub-grade and borrowed pit materials;
  - ii) California Bearing Ratio tests on sub-grade and borrowed pit materials;
  - iii) Particle size distribution tests on sub-grade and borrowed pit materials; and
  - iv) Miscellaneous tests as specified by the Engineer.
- c) For equipment support foundations:
 

The same as for building.

It is the Contractor's responsibility to visit the site of the Works and familiarise himself with the extent of the soil investigation program.

## **2.4 Engineer's Site Office**

The Contractor shall provide for the exclusive use of the Engineer one Portacabin office at site. They shall be located according to the engineer's request and shall be available upon arrival of the Contractor's staff at site. The office shall be fully equipped and shall comprise at least:

1. Air-conditioner;
2. Toilet, shower, hand wash basin with hot & cold water supply;
3. Adequate office furniture, i.e. 1 lockable desk, 1 chair, 1 filing cabinet, 1 Almirah and 6 visitor chair & lighting;
4. Electricity supply on a 24-hour basis; and
5. Telephone, fax and Internet connections (high speed wire-less modem and broadband at site office)

The offices shall be cleaned daily by the Contractor and kept in good condition.

The Contractor shall also provide in the Engineer's site office one set of personal (desk top) computer (Intel Pentium 3.2 GHz MMX 4 GB RAM, CD-ROM with DVD-CD-Writer 32 speed/full multimedia, 1.44 FD, 500 HDD, VC MATROX G450, plasma 19" monitor; all to be compatibles), HP Deskjet 1220 C printer and 650 VA UPS, APC make. The PC shall be fully equipped with all peripherals. A scanner and photocopying machine with an automatic document feeder (Sharp,

Minolta and Rank Xerox make them) shall also be available. One computer operator/typist with adequate speed in Hindi & English typing shall be provided by the Contractor at the site office on an eight-hour daily basis.

The Engineer's office shall be equipped with a phone, a fax machine and radio communication facilities operating on Contractor's frequency range.

### **3 EARTHWORKS**

#### **3.1 General**

Earthwork consists of all measures required to clear and prepare substation sites and access roads as shown on the Drawings and as specified herein.

Work consists of the following:

- Clear, grub and remove vegetation and debris;
- Strip and remove top soil;
- Grade site to elevations shown on drawings;
- Supply, place and compact common fill;
- Supply, place and compact 300mm other types of fill;
- Supply and spread 300 mm layer of crushed stone; and
- Excavate and shape ditches.

##### **3.1.1 Codes and Standards**

Publications listed below form part of this specification to the extent specified in this sections:

##### **American Society for Testing and Materials (ASTM)**

A760/A760M	Standard Specification for Corrugated Steel Pipe, Metallic – Coated for Sewers and Drains.
C117	Standard Test Method for Material Finer than 75 $\mu\text{m}$ (No. 200) Sieve in Mineral Aggregates by Washing.
C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
D698	Standards Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft <sup>3</sup> (600 kN-m/m <sup>3</sup> )).
D4254	Standard Test method for Minimum Index Density and Unit Weight of Soils and Calculations of Relative Density.

The Contractor may propose to the Engineer equivalent standards from recognized international organizations.

##### **3.1.2 Submittals**

Submit details of the sources and types of all borrowed materials used in this section.

Submit results of test required to show compliance of material with the specification.

Submit results of field compaction tests, on common and other type of fill.

### **3.1.3 Special Care**

#### **d) Regulations;**

Shore and brace excavations, protect slopes and banks, and perform all work in accordance with local regulations in the Country where the job site is located.

Blasting will be allowed only with the approval of the Engineer and all appropriate authorities, and shall be in strict accordance with government regulations. Maximum precautions shall be taken for protection of personnel and property. The Contractor shall be responsible for obtaining all necessary approvals and permits. Permission to blast shall not be assumed to be automatic and, where approval and permits are not granted, no claims will be considered for additional costs or delays.

The Contractor shall assign an experienced blasting specialist to supervise all blasting operations. The blasting specialist shall be experienced in the use of explosives for foundation excavations. His qualifications shall be submitted to the Engineer for acceptance.

#### **e) Tests and Inspections;**

Testing of materials, compaction of backfill and fill will be carried out by testing laboratory designated by the Contractor and approved by the Engineer.

Do not begin backfilling or filling operations until all the required material shall be approved by the Engineer.

Not later than 48 hours before backfilling or filling with approved material, notify Engineer so that compaction tests can be witnessed.

Before commencing work, conduct surveys on conditions of existing buildings, trees and other plants, lawns, fencing, service poles, wires, rail tracks and paving, survey bench marks and monuments which may be affected by work.

#### **f) Buried Services;**

Before commencing work, establish the location of all buried services on and adjacent to the Site.

Arrange with the appropriate authority for relocation of buried services that interfere with the execution of the work. Pay costs of relocating services.

Remove obsolete buried services within two (2) metres of foundations. Cap cut-offs.

#### **g) Protection;**

Keep excavations clean, free of standing water and loose soil.

Where soil is subject to significant volume change due to change in moisture content, cover and protect, as per Engineer's approval.

Protect natural and man-made features required to remain undisturbed. Unless otherwise indicated or located in an area to be occupied by new construction, protect existing trees from damage.

Protect buried services that are required to remain undisturbed.

### **3.1.4 Materials**

#### **a) Common Fill;**



Selected material from excavation or other sources, approved by the Engineer for use intended, free from rocks larger than 1/3<sup>th</sup> of compacted layer thickness and bigger than 150 mm, cinders, ashes, organic inclusions such as leaves, wood, loam or other deleterious material and capable of being compacted as specified in this section.

b) Other Type of Fill;

Crushed, pit run or screened stone, gravel or sand consisting of hard durable particles free from clay lumps, cementation, organic material and other deleterious material.

Gradations to be within limits specified when tested to ASTM C136 and ASTM C117.

Sieve Designation	% Passing
150	100
26.5	50 – 100
4.75	20 – 55
1.18	10 – 40
0.3	5 – 25
0.075	0 – 10

c) Crushed Stone;

Crushed or screened stone, consisting of hard durable particles free from organic or other deleterious materials.

Gradations to be within the limits specified when tested to ASTM C136 and C117.

Sieve Designation	% Passing
19 (20mm sieve)	100
16 (0.075mm sieve)	0 – 5

d) Culverts.

Corrugated Steel Pipe, Type 1, Zinc-coated, conforming to ASTM A760/A760M with 68mm x 13mm corrugations, complete with coupling bands. The Contractor may propose equivalent armoured concrete pipes or box type culvert which suitable as per site condition.

### 3.2 Preparation of Surface

#### 3.2.1 Clearing and Grubbing

Remove trees, stumps, logs, brush, shrubs, bushes, vines, undergrowth, rotten wood, dead plant material, exposed boulders and debris within areas designated to be graded.

Remove stumps and tree roots below footings, slabs, paving and to one (1.0) m below finished grade elsewhere.

Dispose of cleared and grubbed material off site to disposal areas acceptable to the Engineer and

the authority having jurisdiction.

### **3.2.2 Stripping**

Strip topsoil over areas to be covered by new construction and over areas where grade changes are required so that excavated material may be stockpiled without covering topsoil. Dispose of topsoil off site as per Engineer's instructions and in accordance with local authority's regulations.

### **3.2.3 Preparation of Sub-Grade**

Prior to placing any fill, remove all organic matter or debris from sub-grade and remove by surface grading all ruts, hummocks and other uneven surfaces.

Where sub-grade has been softened or washed out by water, remove all damaged material and replace with undamaged fill of the same class and compact as specified in clause below.

## **3.3 Earth Movement**

### **3.3.1 Excavation**

Excavate to grades as required to accommodate the works.

Unsuitable materials including organic matter and debris below grade or foundation elevation shall be removed from the site and disposed of at location acceptable to all regulating agencies. The acquisition of off-site disposal areas shall be the responsibility of the Contractor.

Excavated material suitable for common fill shall be stockpiled for future use.

Ensure that all sides of open excavations are maintained in a safe and stable condition by shoring or adequate side slopes.

### **3.3.2 Dewatering**

Ensure that all work areas and excavations are kept free of water during construction.

### **3.3.3 Fill and compaction**

#### **a) Filling;**

After sub-grade preparation has been approved, spread approved fill material in layers not exceeding 150 mm in uncompacted thickness. Do not place, spread or roll and fill material when moisture content is unsuitable for compaction.

#### **b) Moisture conditioning;**

Water or aerate the fill material as necessary and thoroughly mix to obtain a moisture content, which will permit proper compaction.

#### **c) Compaction;**

Compact each soil layer to at least the minimum density specified. Repeat compaction process until grade is attained.

#### **d) Minimum density;**

Fill 98% maximum dry density as determined by ASTM D698 or 70% relative density as determined by ASTM D4254.

e) **Field Quality Control;**

Perform compacting test on fill.

Perform at least one density test for each 50 m<sup>3</sup> or portion of each classification of fill placed and not less than two (2) tests during one shift.

**3.4 Grading**

Perform all rough and finish grading required to accommodate the works. The finished surfaces shall have a slight slope for the water to flow naturally towards the drains.

Use all means necessary to prevent erosion of graded areas during construction.

**3.5 Over - Excavation**

Over – excavation of sub-grade and trenching shall be backfilled with common fill compacted in accordance with clause above.

**3.6 Culvert Installation**

If required install culverts as per Contractor's design approved by the Engineer. Ensure backfill is placed under pipe haunches and compacted as specified. Material for pipe bedding must not contain any rocks greater than 75 mm diameter.

**3.7 Crushed Stone Cover**

Spread an even layer of Crushed Stone 300 mm thick over the entire substation area plus 1.0 m outside the fence over 150 mm thick PCC 1:4:8. Do not start this work until installation of equipment and underground work is completed and site surface is levelled. Obtain Engineer's approval before crushed stone is levelled. Do not compact crushed stone.

**3.8 Site Drainage**

Adequate site drainage system shall be provided by the Contractor. The Contractor shall obtain rainfall data and design the storm water drainage system, (culverts, ditches, drains, etc.) to accommodate the most intense rainfall that is likely to occur over the catchment area in a one hour period on an average of once per ten years. The surfaces of the site shall be sloped to prevent the stagnation of water.

The maximum velocity for pipe drains and open drains shall be limited to 2.4 m/sec and 1.8 m/sec respectively. However, minimum velocity for self-cleansing of 0.6 m/sec shall be ensured. Longitudinal bed slope not milder than 1 in 1000 shall be provided.

Reinforced concrete pipes shall be pre-cast and manufactured in accordance with the requirements of ASTM C14M, or applicable Indian Standards.

Adequate protection shall be given to site surfaces, roads, ditches, culverts, etc., to prevent erosion of material by wind and water.

The drainage system shall be adequate without the use of cable/pipe trenches.

All pipes shall be clearly marked as to class and shall be of the class required for the depth of backfill and surcharge loading. Manholes shall be provided at every 30 m interval, at connection points and at every change of alignment.

For open trapezoidal drains, if provided, cast-in-situ PCC lining of minimum M15 grade on sides and

bottom shall be provided. The thickness of lining shall be minimum 100 mm or as per design considerations whichever is higher.

In general, all plant effluent drainage shall be through buried concrete pipes and all storm water drainage shall be through open drains/pipe drains. Open storm water drains shall be provided on both sides of the roads and shall be designed to drain the road surface as well as all the free and covered areas, etc.

Pipe drains shall be connected through manholes at an interval of max. 30 m. Plant effluents shall be suitably treated by the Contractor to meet all the prevalent statutory requirements and local pollution control norms.

Invert level of the drainage pipe shall be decided in such a way that the water can easily be discharged above the High Flood Level (HFL) outside plant boundary at suitable location and approved by the Engineer. Pumping of drainage water (if required) shall be provided by Contractor.

All the trench entry in the control room shall be through respective header.

Rainwater drainage and foul sewerage system shall be kept completely separate. No foul drainage must be led into the rainwater system under any circumstances and rainwater where it is collected shall not be piped into the foul sewers.

All internal site drainage system, including the final connection/disposal to Engineer acceptance points shall be part of the Contractor's scope including all required civil work, mechanical and electrical systems. The Contractor shall connect his drain(s) at one or more points.

The precast manholes shall be preferred against cast-in-situ type. The drainage scheme may either employ open drain system or underground pipe system or a combination of both. A manhole shall be provided at every turn or 100m, whichever is less, corner in case of underground type in addition to the normal requirement.

Suitable pumping arrangement shall be provided by the Contractor to pump out the water from sump to the open channel; automatic float valve type pump shall be provided and installed by the Contractor.

## **4 FOUNDATIONS AND CONCRETE WORKS**

### **4.1 General**

Substation foundations shall mean foundations for substation structures, electrical equipment, fence and include cable trenches and covers.

Work of this section consists of all measures and materials required to design, supply, detail, test and install substation foundations as specified herein and includes the following:

- Geotechnical investigation;
- Foundations for substation steel structures and buildings;
- Foundations for substation electrical equipment;
- Foundations for substation fences;
- Foundations for switchyard lighting poles; and
- Substation cable trenches and covers.

No materials will be supplied by the Engineer for inclusion in the work.

#### **4.1.1 Codes and Standards**

Publications listed below form part of this specification to the extent specified in this section:

##### **American Concrete Institute (ACI)**

- 301            Specification for Structural Concrete
- 305            Hot Weather Concreting
- 318            Building Code Requirements for Reinforced Concrete and Commentary

##### **American Society for Testing and Materials (ASTM)**

- A36/A36M    Standard Specification for carbon structural steel
- A153           Standard Specification for Zinc Coating (Hot Dip) on Iron and steel hardware
- A185           Standard Specification for welded wire fabric, plain, for concrete reinforcement
- A615/A615M   Standard Specification for deformed and plain billet steel bars for concrete reinforcement
- C33            Standard Specification for concrete aggregates
- C39            Standard Test method for compressive strength of cylindrical concrete specimens
- C260           Standard Specification for Air-entraining admixture for concrete
- C494           Standard specification for chemical admixtures for concrete
- D698           Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>)).
- D2103           Standard Specification for Polyethylene film and sheeting
- D4254           Standard Test methods for minimum index density and Unit Weight of soils and calculation of relative density

##### **Institute of Electrical and Electronic Engineers (IEEE)**

- IEEE 980      Guide for containment and control of oil spills in substations.

The Contractor may propose to the Engineer equivalent standards from a recognized international organization.

#### **4.1.2 Submittals**

Submit the following:

Submit items a) and b) prior to the final design of foundations.

- a)      Proposed geotechnical investigation program;

A full description of the Contractor's proposed soil investigation program and tests to be carried out.

The equipment to be used and procedures to be adopted for the soil investigation.

b) Geotechnical report;

A complete geotechnical report for the substation sites that shall compare the design parameters specified herein with parameters based on the results of the investigations undertaken by the Contractor.

Recommendations for foundation types and design parameters if the foundations designed to the parameters specified herein are inadequate.

c) Design calculations;

Final detail design calculations which shall clearly show the calculations and design method for all proposed foundations and concrete structures and all ground conditions. Include with the design the applied loads, actual and allowable stresses, overload factors, soil parameter and any other pertinent information.

d) Drawings;

Construction drawings, complete in all respects.

e) Test certificates;

Certified test certificates showing compliance of materials to references listed in 5.1.1.

f) Reinforcing steel;

Specification for grades of steel used.

g) Material tests;

Source and description of material to be used as common fill.

Source and gradation of materials to be used as other types of fill.

h) Concrete;

Concrete mix design and trial mix results including the sources, description and tests of all ingredients.

Test results of samples of water and aggregate from each source used.

i) Concrete field test;

Reports on all tests carried out on concrete test specimens taken in the field during construction. These shall include, but not be limited to, compression tests, slump tests and air content tests.

j) Field compaction tests.

Result of tests on compaction of fill.

#### **4.1.3 Special Care**

a) Soil report;

The Contractor is responsible for making the necessary soil investigation.

The Contractor shall inquire with the Engineer for any available information, especially when the project consists in extending an existing facility.

b) Source Quality Control;

Materials supplied by manufacturer's name and classification shall be so identified by the manufacturer.

Bar reinforcement procured for works shall be separated and tagged according to mill test identification numbers.

c) Allowable tolerances;

- Foundations;

- Foundation centre lines between two constructions within  $\pm 5$  mm from theoretical centre lines shown on the drawings; and
- Top of foundations  $\pm 5$  mm from elevations shown on drawings.

- Anchor Bolts;

- 3 mm centre-to-centre of any two bolts within an anchor bolt group where an anchor bolt group is defined as the set of anchor bolts which receives a single fabricated steel-shipping piece;
- 5 mm centre-to-centre of adjacent anchor bolt groups;
- Maximum accumulation of 5 mm per 30 m along the established column line of multiple anchor bolt groups but not to exceed a total of 25 mm. The established column line is the actual field line most representative of the centres of the as-built anchor bolt groups along a line of columns; and
- 5 mm from the centre of any anchor bolt group to the established column line through that group.

d) Product delivery and handling of concrete products;

Portland cement, concrete aggregate and concrete admixtures shall be handled and stored in accordance with the applicable standards of ACI 301 and Indian Standards.

e) Hot weather requirements for concrete work;

Hot weather requirements shall apply when daily mean ambient temperature is 27°C or above. Procedures shall be adhered to as outlined in Indian Standard 7861.

f) Sulphates and chlorides;

At locations where the concentration of chlorides or sulphates in soil exceeds 0.1% or in ground water exceeds 150 ppm, apply to the full concrete surfaces in contact with soil one of the following treatments:

- Two coats of emulsified asphalt;
- Two coats of unfilled cutback asphalt; and
- Two coats of unfilled cutback tar.

In addition, provide at the base of footings a layer of blinding concrete with a minimum

thickness of 75 mm.

#### **4.1.4 Materials**

a) Concrete;

Materials for concrete work shall conform to all requirements of ACI 301, Specification for Structural Concrete, except as modified by the following supplemental requirements:

- The following admixtures may be used:
  - Air entraining admixtures to ASTM C260;
  - Concrete shall conform to ASTM C450:
    - Type I cement with tricalcium aluminate ( $C_3A$ ) content between 6% to 8% %, higher tricalcium alumina content shall be prohibited, or;
    - Type II cement.
  - Chloride and sulphate content of aggregates shall be limited to 0.2% by dry weight;
  - Fine and coarse aggregates shall be normal weight and from local sources agreed by the Engineer, capable of delivering supplies of consistent quality in accordance with ASTM C33;
  - Water used in mixing concrete and water used for curing shall be clear and free from chlorides, organic matters and other impurities not suitable for concrete as specified in ACI 301.

*The use of all admixtures will be subject to the agreement of the Engineer.*

- Plain bars are not permitted for reinforcement;
- Proprietary materials for repair of surface defects will only be permitted if the use of the proposed materials is agreed to by the Engineer;
- Damp-proofing shall be installed below control building slabs and shall consist of 0.20 mm minimum thickness polyethylene to ASTM D2103 or 20 kg (45 lb) roll roofing; and
- Concrete shall have a minimum compressive strength of 20 MPa at 28 days unless shown otherwise in the drawings.

b) Reinforcement;

Bar reinforcement, deformed bars conforming to ASTM A615/A615M grade 400. Reinforcing fabric conforming to ASTM A185.

c) Grout;

Pre-mixed cement based, non-ferrous, non-shrink.

d) Anchor bolts;

Steel conforming to ASTM A36/A36M.

e) Grating;

Standards galvanized steel bar grating with bearing bars at 30 mm c/c cross bars at 100 mm c/c.

f) Miscellaneous steel;



Miscellaneous and embedded steel conforming to ASTM A36/A36M.

g) Joint filler;

Oil resistant closed cell PVC foam, rigid grade.

h) Joint sealant;

Oil resistant pourable polyurethane.

i) Backfill;

Common fill as specified in **Section 4**. Backfill from any source shall be subject to the agreement of the Engineer.

j) Other type of fill.

Other type of fill as specified in Section 4 agreed by Engineer.

#### **4.1.5 Design**

a) General;

Foundations may be reinforced concrete rafts, spread footings or augured caissons, at the discretion of the Contractor.

Design reinforced concrete in accordance with ACI 318 except as otherwise specified. Clauses forming this specification and related clauses contained in ACI 318 shall be read together.

Dimensions of all foundations shall be determined from the most critical combination of foundation down thrust, uplift overturning moments and horizontal shears in both transverse and longitudinal directions.

For spread type foundation design, all overturning moments, vertical and horizontal loads shall be resisted by vertical bearing pressures and no passive lateral resistance of the soil shall be considered.

The height of the water table shall be taken into account when designing foundations.

Ensure settlement under any long term loading condition does not exceed 25 mm.

b) Soil parameters;

The design shall be based on the results of geotechnical investigation performed by the Contractor and accepted by the Engineer.

For rock foundations, they shall extend to the rock surface and if necessary make use of rock anchors. In the case of lightly loaded foundations, other type of fill may be placed between the base of the foundation and the rock surface.

All foundations are to extend at least 1.0 m below sub grade and are to be placed on a 300 mm layer of other type of fill.

c) Loading;

- Wind loading:

Wind loading shall be the same as for the metal structure technical specification (refer to document 017806-41ES-1300).

- Steel structure loading:

Load transmitted to foundations by the steel structures shall be determined by the Contractor from calculations performed for design of the steel structures (refer to document 017806-41ES-1300).

- Equipment loading:

Refer to document 017806-41ES-1300.

- Loading combinations:

Refer to document 017806-41ES-1300.

- Factors of safety:

The factors of safety below shall be applied to the specified loads to factored loads:

Condition	Factor of Safety
Overturning or uplift	1.5
Foundation concrete and reinforcing design	1.5
Soil bearing pressures	1.0*

\*The factor of safety is included in the allowable bearing pressures.

Seismic loading: The values related to seismic requirements are given in the General Technical Requirements 017806-47ES-0200.

d) Cable trenches;

Cable trenches shall be designed for multilevel cable arrangement to separate the LV power cables from the LV control cables and between segregated redundant circuit cables. The trenches shall be provided with suitable wall mounted supports for cables to lay on spacing between supports shall not exceed 500 mm. No cable shall be allowed to lay directly on the bottom of the trenches such that water can flow freely to the drainage points.

Adequate drainage shall be provided to prevent water from accumulating in the trenches at any time. The size of the trenches shall be calculated such as to include the amount of cables for the ultimate substation arrangement plus 20% spare capacity as a maximum.

The cables trenches network shall include cable pits located in strategic points to allow grouping and routing of cables from different sectors of the substation.

The size of the pits shall be sufficient to allow entry of personnel and proper arrangement of cables. The pit shall be provided with convenient cable trays and water drainage.

Cable trenches and pits shall be with steel reinforced concrete cover pieces capable to support the weight of a maintenance vehicle. The cover piece's weight shall be limited to allow handling by one or two men.

The MV cables will be routed through buried ducts imbedded in concrete. Proper access boxes shall be given to allow pulling the cables inside the ducts. The boxes shall be located in such locations as to avoid excessive pulling tension on the cables. The cable shall not

have more than one bend between two boxes or more than 100 m length of duct.

Foundations for the switchyard lighting poles shall be in accordance with the design criteria indicated in the technical specifications for Structural Supports for Equipment 017806-41ES-1300 and Junction Boxes & Lighting Fixtures 017806-47ES-7700.

#### **4.1.6 Fabrication and Manufacture**

- Reinforcing steel;  
Make bends in reinforcement to shapes shown on the drawings and bar schedule. Make bends around mandrels to achieve the specified bending radii. Report to Engineer any tendency of the bends to crack. Discard bars with cracks or splits.
- Anchor bolts;  
Galvanize anchor bolts to ASTM A153 for at least the projection plus 150 mm.  
Supply anchor bolts with levelling nuts and lock nuts. Nuts shall run freely on threads.

#### **4.2 Construction**

- a) Templates;  
Use rigid steel templates for accurately positioning and maintain anchor bolts to the specified dimensional tolerances during installation, backfilling and concrete setting periods.
- b) Excavation;  
Perform all excavations and dewatering required to construct the foundations.  
  
Set the base of the foundations within the specified allowable tolerances to the depth shown on the construction drawings or as specified by the Engineer.  
  
Fill any over-excavations under foundations with concrete.
- c) Backfill;  
  
Do not begin backfilling until material has been approved by the Engineer. Do not backfill without agreement of Engineer.  
  
Backfill foundations using common fill in 150 mm layers before compaction.  
  
Compact to 98% maximum dry density as determined by ASTM D698 or 70% of relative density as determined by ASTM D4254.  
  
Backfill shall be placed only in dry excavated holes or in holes kept dry by dewatering. Under no circumstances shall backfill be placed in an excavation where water is present.
- d) Concrete;
  - Anchor bolts position;  
Inspect installation of anchor bolts before and immediately after placing concrete and correct immediately where these have been inadvertently cast out of true position.
  - Execution;  
Concrete work shall conform to all requirements of ACI 301, Specifications for Structural Concrete, except as modified by the supplemental requirements below:

- The use of earth cuts for forms will be permitted provided adequate cover is maintained for reinforcement;
- Provide a 25 mm x 25 mm chamfer on external corners and edges of concrete exposed to view. Do not chamfer interior edge of cable trench walls;
- Testing will be carried out as specified in Section 5.4 Field Quality Control;
- Do not disturb formwork until concrete has hardened adequately;
- Welding of reinforcement will not be permitted;
- Placement of concrete under water will not be permitted; and
- Damp-proofing below control building slabs shall be lapped no less than 200 mm at joints.

e) Concrete Formwork;

All formwork shall be of approved design, rigidly constructed of approved materials, adapted in all respects to the several structures, to the required finishes, and shall be of sufficient strength to withstand the pressure of the wet concrete without distortion.

The formwork (roof, beams, etc) shall be constructed with cambers, as is necessary to produce the finished structures to the correct levels and profiles.

Timber for formwork to surfaces of concrete which will be exposed to view in the finished work shall be sound, well seasoned, wrought and free from loose knots and shall be maintained so that such concrete surfaces are smooth, true and free from blemishes. Well-seasoned, rough timber or other suitable material may be used for unexposed surfaces of concrete.

Bolts or other internal spaces intended to be recovered shall be fixed so they can be easily removed when the formwork is stripped and the hole remaining after concreting shall be filled with fine concrete or plastic stubs. No part of any metal tie or spacer remaining permanently embedded in the concrete shall be closer than 20 mm from the finished surface of the concrete.

All pipes, bolts, steelwork and other fixings that are required to be built in or through any concrete element shall be firmly fixed in the formwork, which shall be neatly cut and fitted to suit, joints being caulked where necessary to prevent the escape of grout. Likewise, cores and other devices used for forming openings, holes, pockets, chases, etc., shall be fixed to the formwork prior to the wet concrete reaching their level.

The inner surfaces of the formwork shall be treated with a coat of approved material by the Engineer. The use of motor oil is prohibited. Before pouring the concrete, all formwork shall be cleaned to remove dirt, shavings, and sawdust and must be inspected and approved by the Engineer.

No formwork shall be removed without the approval of the Engineer but such approval shall in no way relieve the Contractor of any of his contractual responsibilities.

The removal of the formwork shall be carried out carefully so as to avoid damaging the concrete. No overloading nor any earth, water or other weight or pressure shall be applied to any part of a structure until permission is given by the Engineer.

Stripping times for all formwork shall be agreed by the Engineer from time to time and shall take into consideration the nature of the work and the current climatic conditions.

Typical stripping times of formwork:

Walls, columns and vertical faces of all structural members:	24 – 48 hours
Slabs:	3 days
Beams:	7 days (side: 3days)
Props under slabs:	

- Spanning up to 4.5 m 7 days
- Spanning over to 4.5 m 14 days

Props under beams:

- Spanning up to 6 m 14 days
- Spanning over to 6 m 21 days

According to Indian Standards IS 456 – 1981.

### **4.3 Field Quality Control**

#### **4.3.1 Concrete**

a) General;

Obtain Engineer's agreement of all work to be covered by concrete before placing concrete and all equipment to be used during concrete work. Give to the Engineer 24 hours' notice of intention to place concrete for each placement.

b) Trial concrete mix;

Concrete mix design facility shall be provided at site and got approved from the reputed institutes s.a. IIT or NIIT. A minimum of 30 days prior to the commencement of concreting operations, the Contractor shall prepare a trial concrete mix consisting of the mixing water, aggregates, cement and batching procedure to be used during construction. The materials shall be mixed according to the Contractor's design; compressive strength tests shall be carried out by the Contractor on the concrete in accordance with ASTM C39. A sufficient number of concrete specimens shall be tested to give an accurate statistical indication of the sufficiency of the mix design and batching process.

A trial concrete mix shall be required for each change in mix design or on the arrival of new lot of materials.

The Contractor shall advise the Engineer a minimum of seven (7) days prior to the date of the trial mix. The trial mix and the compression tests must be witnessed by the Engineer. Results of the concrete compression tests shall be made available to the Engineer immediately upon completion of the tests.

c) Sampling and testing;

The Contractor shall perform all testing in accordance with ACI 301 Chapter 16, Testing.

The Engineer may require that not more than 5% of all testing be carried out by an independent local testing laboratory appointed by the Engineer.

Where required by the Engineer, cores at least 50 mm in diameter shall be obtained and tested.

The Contractor shall perform one slump test and one air content test on each specimen of concrete taken for compression tests.

At least one compression test shall be performed for each 75 m<sup>3</sup> or for each portion of concrete placed in any one day, but not less than one specimen per footing.

#### **4.3.2 Reinforcement**

Notify Engineer on completion of reinforcement installation and obtain his agreement for reinforcement installation before covering up work with formwork or concrete.

#### **4.3.3 Formwork**

Notify Engineer on completion of formwork erection and fixing of the items specified herein. Obtain agreement before placing concrete.

#### **4.3.4 Protective Coatings**

Notify Engineer on completion applying protective coatings. Obtain agreement before backfilling.

#### **4.3.5 Backfill**

Perform compaction tests on common fill and other type of fill. Perform at least one test per foundation and per each classification of material.

#### **4.3.6 Grouting**

Grout under structure base plates after structures are plumbed and levelled.

Mix and place grout in accordance with manufacturer's written instructions.

### **4.4 Adjust and Clean**

#### **4.4.1 Cleaning**

On completion of works, leave concrete surfaces exposed to view as clean as when first finished.

#### **4.4.2 Backfill**

Check that no backfill has settled below general ground level. Fill depressions over excavation and holes.

#### **4.4.3 Protection of Concrete in Contact with Soil**

The type of cement to be used shall be determined by the pH value of the soil and by the concentration of sulphates as follows:

- Portland Pozzolana Cement pH > 6
- Sulphate Resisting Cement pH > 5
- Super-sulphated Cement pH > 3.5

Sulphate-resisting or super-sulphated cement shall be used in all foundations where the concentration of sulphates (expressed as SO<sub>3</sub>) exceeds 0.5% in the soil or exceeds 120 parts per 100 000 in the ground water.

Where the concentration of sulphates exceeds 2.0% weight in the soil or exceeds 500 parts per

100 000 in the ground water, sulphate-resisting or super-sulphated cement shall be used and, in addition, an impermeable protective barrier as outlined in a) and b) hereafter shall be inserted between concrete and soil.

The onus will be on the Contractor to satisfy the Engineer that either or both of the above protective measures may be omitted at any site location.

- a) A continuous layer hydroisolating or other approved material shall be interposed between the soil and the concrete, and adequate precautions shall be taken to ensure that this layer is not torn or punctured while concrete is being placed.

Concrete blinding to all foundations shall be placed in two 50 mm layers of lean concrete. A layer of polythene sheeting shall be placed under the blinding and the two layers of blinding shall be separated by a further layer of polythene.

A layer of approved bitumastic material approximately 1.5 mm thick shall be placed on top of the blinding under the structural concrete and shall be carried up the sides of all foundations to a level of 300 mm above ground level. The polythene shall be lapped with the bitumastic material on all vertical faces.

Backfill material shall be to the approval of the Engineer and a 12 mm layer of inert material such as cork or other approved, shall be used to protect the vertical impervious layer if there are large or sharp particles in the backfill material

- b) For pile foundation, concrete blinding to all pile caps shall be placed in two 50 mm layers of lean concrete. A layer of "Visqueen 1000" polythene sheeting shall be placed under the blinding.

A layer of approved bitumastic material approximately 1.5 mm thick shall be placed between the two layers of blinding and shall be carried up the sides of all pile caps, bases, beam walls, etc. to a level of 300 mm above ground level. This material shall be lapped on all vertical faces. It shall also be lapped onto the sacrificial mild steel casing to maintain full continuity of the groundworks protection.

Back fill material shall be to the approval of the Engineer and a 12 mm layer of inert material such as cork or other shall be used to protect the vertical impervious layer if there are large or sharp particles in the backfill material.

Type of cement used in the construction work shall be depend upon the pH value and sulphate content only as determined in the soil test report and OPC shall be replaced by the suitable type of cement after engineer approval.

## **5 ROADS AND PAVED AREAS**

### **5.1 General**

Road geometry shall be in accordance with American Association of State Highways and Transportation Officials (ASHTO), Indian Standards or equivalent.

The Contractor shall design and construct roads including parking areas and turning bays with concrete surfacing for access roads within the substation and the parking areas.

As far as is practicable excavated material shall be used in the construction of road embankments, or for refill of road excavation below formation.

Surplus material not required for the Works shall be disposed of in approved disposal areas.

## **5.2 Road Base and Sub-Base Construction**

### **a) Preparation of Formation;**

The preparation of formation shall be carried out only after completion of all subgrade drainage, piped drains, services and ducts or any other drainage work that might affect the pavement works, and such preparation shall be carried out immediately prior to the laying of the sub-base, or the road base where no sub-base is required.

The surface of the formation shall be substantially uniform in density throughout its entire width and shall conform to the density requirements for compaction. It shall be trimmed to conform to the lines, cambers, grades and typical cross-sections shown on the approved Drawings. Where ruts or other objectionable irregularities occur as a result of construction traffic or other causes, the Contractor shall reshape and recompact the formation to the required density before the sub-base or base is placed.

The surface of the subgrade before the construction of the sub-base shall be within 20 mm of the correct levels.

### **b) Base and Sub-base**

The thickness of the base and sub-base shall be determined by the Contractor from subgrade strength tests and submitted to the Engineer for approval.

Base and sub-base materials shall be approved on the basis of strength tests and shall comply with the following conditions:

- The base shall have:
  - a minimum thickness of 150 mm;
  - a minimum four day soaked California Bearing Ratio Test value of eighty (80) percent at a density of ninety five (95) percent of the maximum dry density as defined in ASTM D1557 with moisture content not greater than ninety (90) percent of optimum moisture content (4.5 kg rammer method);
  - a maximum plasticity index of 6;
  - a liquid limit not greater than 25; and
  - a maximum lineal shrinkage of 4 for material passing 0.475 mm ASTM sieve.
- Base material shall be well graded and in accordance with Table 3 of Road Note 31, 37.5 mm nominal size natural gravel or Table 4 for all-in crushed stone base material with one hundred (100) percent material passing the 37.5 mm BS sieve; and
- The sub-base shall have:
  - a minimum four day soaked California Bearing Ratio Test value of twenty five (25) percent; and
  - a maximum plasticity index of 12.

Base and sub-base construction may be of in-situ or imported material as proposed by the Contractor and approved by the Engineer. Imported material shall be spread evenly over the whole width of the formation required prior to construction.

Construction of base and sub-base layers shall comprise sufficient scarifying, pulverising, even mixing with water, shaping and compacting to produce a dry density of the treated material for the total depth of the layer not less than ninety five (95) percent of the maximum dry density as defined in ASTM D1557 with moisture content not greater than ninety (90) percent of optimum moisture



content. If the moisture content is too low for satisfactory compaction, moisture shall be added.

Unless otherwise approved, base and sub-base construction shall be carried out in layers not exceeding 150 mm each in compacted depth. All material shall be placed and spread evenly to the full width of the roadbed. Each layer shall be compacted to the required density before the next layer is placed. Care shall be taken to prevent segregation of the material into the coarse and fine fractions. Segregated surface areas of a base constructed or base material contaminated to such an extent that it no longer complies with the requirements of this Technical Specification shall be removed and replaced with well graded and satisfactory material.

The surface of the base and sub-base shall be well drained at all times.

Compaction shall be completed as soon as possible after each layer has been spread and shaped satisfactorily. Each layer shall be thoroughly compacted with suitable compaction equipment.

The finished base and sub-base surface shall be even, free from irregularities, loose material or fines and true to cross-section, line and level. The finished base surface shall not show any departure from the true surface of more than 12 mm in any length of 3 m in either the longitudinal or transverse direction. Correction shall be by loosening, adding or removing material, reshaping and recompaction.

### **5.3 Checking of Pavement Layers**

The Contractor shall test the compaction of the base and sub-base where directed by the Engineer. The frequency of such testing shall be not less than two (2) tests in any 100 m length of road for each layer of sub-base and base material. In addition the Contractor shall check the thickness of the base and sub-base with not less than five measurements made in any 100 m length of road. The average thickness of the sub-base shall not be less than the required thickness and no single measurement shall be less than ninety (90) percent thereof. The Contractor shall rectify any area of the work where tests fail to meet the requirements of the Technical Specification and shall re-test where directed by the Engineer.

### **5.4 Roads**

This shall consist of the following

- a) Subgrade  
It shall be well compacted and tested before laying subgrade and will be strengthened as per site condition.
- b) Sub grade
  - i) It shall consist of at least three layer of ready mixed W.B.M.. Thickness of each layer shall be min 100mm and will be checked according to the CBR.
  - ii) A 150mm layer of cement concrete with 25mm crushed stone coarse sand and cement in proportion of 4:2:1
- c) Design Mix M25 or M30 Cement concrete with design reinforcement only shall be used in top layer.
- d) Joints of 50mm wide in full depth shall be provided at interval of 4 meter and shall be filled with approved filler material.
- e) Side toe wall 230mm thick in brick work 1:6 shall also be provided along road side.

- f) All Road of switchyard have footpath on both side of road, shall be 1meter wide will be provided with interlocking tile over the minimum 500 mm thick layer of sand.

### **5.5 Interlocking Paving Blocks**

Road to be paved with interlocking concrete blocks shall be excavated and replaced with 500 mm depth of compacted material at the exact levels and falls required for the finished work.

If parts of the base are found to be unstable, the Contractor shall excavate further to a firm bed and fill with layers of fine crushed rock or aggregate, thoroughly compacted. The upper surface of the base shall reflect the exact profile, fall or contour of the final paving as irregularities shall not be compensated for by varying the depth of sand bedding.

A stable edge shall be provided to retain the paving units and sand bedding by means of precast concrete edging unit or kerbs set in-situ concrete.

The sand bedding shall be a fine, well graded sand in a dry to moist condition and laid to a compacted thickness of 500 mm.

Samples of the Interlocking paving blocks 80mm thick are to be submitted to the Engineer for his approval. No orders shall be placed with the manufacturers until the Engineer's approval has been given. The thickness of the paving block will vary  $\pm 2$ mm.

The paving blocks shall be laid in accordance with the manufacturer's instructions and shall be compacted at completion of each day's work.

### **5.6 Concrete Paving Slabs**

Areas to be paved with concrete paving slabs shall be excavated and replaced with 300 mm depth of compacted material at the exact levels and falls required for the finished work. If parts of the base are found to be unsuitable, the Contractor shall excavate further to a firm bed and fill with layers of fine crushed rock or aggregate, thoroughly compacted. The upper surface of the base shall reflect the exact profile, fall or contour of the final paving as irregularities shall not be compensated for by varying the depth of sand bedding.

Samples of the paving slabs are to be submitted to the Engineer for his approval. No orders shall be placed with the manufacturers until the Engineer's approval has been given.

The paving slabs shall be laid in accordance with the manufacturers instructions.

### **5.7 Pre-cast Concrete Kerbs, Channels, Edging and Quadrants**

All kerbs, channels edging and quadrants shall be made of precast concrete, and shall comply with the requirements of BS 7263. Colour, finish and sections shall be agreed on site with the Engineer and samples provided for approval.

Pre-cast concrete kerbs, channels, edgings and quadrants shall be laid and bedded in layer of 1 to 3 cements/sand mortar, not less than 10 mm and not more than 40 mm thick onto concrete or road base. Kerbs shall be backed with lean mix concrete. In general circulation areas, kerbs shall be placed on top of the surfacing, and pinned in position using steel pins to delineate roadways.

For radius of 12 m or less, kerbs of appropriate radius shall be used. Any unit of kerb, channel, edging or quadrant deviating more than 3 mm on 3 m, from line and level shall be made good by lifting and relaying.

## **5.8 Carriageway Markings**

The material for markings shall be hot applied "Sprayplastic" complying with the requirements of BS 3262, as manufactured by Prismo Universal Limited, or similar approved for use in the prevailing environment.

Carriageway markings shall only be applied to surfaces which are clean and dry. Where owing to the action of traffic or otherwise, the pavement has become polished before the application of road markings, at the direction of the Engineer a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's instructions. Markings shall be free from raggedness at their edges and shall be uniform and free from streaks.

"Ballotini" is to be incorporated at 18% to 22% by weight of total mix and also to be applied to the surface of the markings at the rate of 400 to 500 g/m<sup>2</sup>.

The laid thickness of the markings shall be 1.5 ± 0.5 mm measured in accordance with Appendix H of BS 3262.

The Contractor shall state the maximum safe heating temperature, the temperature range of the apparatus and the method of laying to be used.

### **5.8.1 Masonry Works**

- **Bricks, Pre-cast and solid blocks;**

Pre-cast concrete blocks shall be prohibited. Where described or otherwise ordered, solid blocks shall be used. All blocks must have a compressive strength not less than 5 N/mm<sup>2</sup>. The average of 3 tests shall exceed 6 N/mm<sup>2</sup> (referred to product of total length and width).

The bricks used in the switchyard shall be Class 150 and comply with the corresponding IS codes. Surfaces of bricks that are not to be rendered or plastered shall be smooth; otherwise, surfaces shall be such as to provide a good base for the application of the finish specified. Brick work shall be checked randomly and brick of every lot shall be tested for its strength and water absorption. As per IS water absorption of class 150 brick will be 10%. The brick work checked with 1m long wooden rod and in 1m it shall contains 13 layers of bricks with cement mortar.

Standard size brick shall be used whenever possible, and every care shall be taken to ensure that the perpendiculars are truly plumbed to ensure vertical alignment, in alternate course. Walls and partitions of the same thickness shall be bonded to one another (angles and junctions). Partitions at junctions with walls of greater thickness or concrete columns shall be tied to those walls with mild steel bars of the appropriate sizes and shapes.

Jointing of brick walls shall be carried out as the work proceeds and fair surfaces work shall be flush pointed with mortar of the consistency herein specified. Joints on surfaces of brick walls which are to be rendered, plastered or tiled, shall be raked out at a depth of 5 mm. For tests procedure and test equipment, refer to Clause 5.4 above.

The masonry works shall not start without the Engineer's written approval.

### **5.8.2 Plastering Works**

- **Rendering – External and Internal;**

Surfaces that are to be rendered shall be brushed down to remove any loose material and dust; joints of block work shall be raked out to a depth of 5 mm. A spatter-dash coat of 1:4 cement mortar, mixed with sufficient water to give the consistency of a thick slurry, shall then be dashed on to the

previously damped surface (inside and outside) to provide a thin rough coating, which shall be allowed to harden before rendering is applied.

External plastering shall be applied in two coats. The first or straightening coat of 1:4 cement-mortars shall be supplied to a thickness of 15 mm, and when it has commenced to dry and harden, it shall be combed to provide a key. The final coat shall be 12 mm thick and shall be rubbed down to a smooth surface. The complete thickness of the external plaster shall be not less than 15 mm after two coat at any place..

Internal plastering shall also be applied in two coats. The first or straightening coat of 1:4 out of cement plaster shall be applied to a thickness of 15 mm. The final coat out of cement plaster shall be 12 mm thick and shall be rubbed down to a smooth surface.

The complete thickness of the plaster shall not be less than 15 mm.

All plaster edges of doors and windows shall be protected by cover angles of Anodized Aluminium.

### **5.8.3 Paints and Painting**

All paints shall be of approved makes and colours and suitable for the prevailing climate at the site.

Special purpose paint shall be of a make with a proven record of resistance to the particular conditions at site.

All paints shall be applied to dry surfaces, to metal and timber surfaces, and shall be applied by brush and well worked into the material. Other methods of application will be considered for painting plastered or concrete surfaces and the like.

#### **a) Painting Steelwork (non galvanized steel) on Site;**

Structural steelwork shall, before delivery and erection, be treated as specified in the drawings approved by the Engineer. After erection, at a time to be agreed with the Engineer, steelwork not encased in concrete shall be cleaned, including the complete removal of any rust which may have developed, the shop coat of red lead made good, and the steelwork immediately given a second coat of red lead paint. Painting shall consist of two undercoats and one finishing gloss coat, all of oil based paints. Steelwork surfaces to be encased or covered with concrete shall be free from all loose rust and reasonably clean when the concrete is poured or placed. During site erection of steelwork, surfaces that are in contact shall receive their second coat of red lead paint immediately before erection so that the surfaces are brought together wet. All surfaces of steelwork which will be finally accessible for painting (e.g. stanchion surfaces adjacent to walls) shall be given two coats of approved bituminous paint in lieu of the treatment specified above.

#### **b) Painting Rainwater Pipes;**

These shall be delivered coated internally and externally as specified. Thereafter, they shall be given externally two undercoats and one gloss finishing coat, all of oil based paints.

#### **c) Painting Timber;**

Generally, only softwood will require painting. After all specified treatment, joinery and finished woodwork shall be knotted, stopped and primed and then given two under-coats and one gloss finishing coat, all of oil based paints.

Surfaces shall be rubbed down as necessary between coats.

Pre-painting treatment shall be applied prior to painting.

d) Painting Concrete;

Where required concrete surfaces shall be cleaned down, primed one coat, then given one undercoat and one finishing coat of plastic paint (inside). Outside surface shall be with mineral paint only, which achieves silication effect between paint and mineral base. Coating systems shall be approved by the Engineer. Repair paint, however, shall be of the same type as existing.

e) Painting Plastered Surfaces;

These shall be cleaned down, sized or sealed and then primed and given two coats of washable oil or emulsion paint.

f) Painting Plaster – board and Ceiling boards;

If required, these shall be cleaned down, sealed and painted in accordance with the manufacturer's recommendations.

g) Painting Battery Room;

All painting works inside the battery room (including door and window) shall be executed with acid resistant paint.

#### **5.8.4 Cable Trenches**

The low-voltage AC and DC cables, along with the control cable, shall be laid in trenches separate from those for high-voltage cables.

Cables trenches should be covered by means of precast or gratings or chequered plates, as approved by the Engineer. As min resale value of precast cover may be preferred over other type cover.

Trenches of Control room/bay control room/other building must have the galvanized chequered plate covers.

All cable entries to the substation building are to be waterproof. Cable entry sealing works shall be executed with lightweight concrete and/or non-combustible sealing foam. This detail and the choice of sealing materials will, in any case, be subject to Engineer's approval. For future extensions, the building shall be equipped with empty entries closed by waterproof locking. The number and the position of these entries shall be determined in coordination with the Engineer.

The number of the additional entries will be sufficient to allow for expansion to substation's ultimate configuration.

Covered inspection manholes shall be provided for outside accessibility.

The work shall include all fixtures and necessary materials for the installation of the switchgear and control panels and other auxiliary equipment.

Cables of different voltage levels shall be installed on separate cable trays.

All cables traces for control cables, which are placed inside HV cable trenches, shall be executed in fire-protected way by use of mineral-fibre armed panels of non-organic material.

Use of asbestos materials will not be accepted. The panels shall have a thickness of 200 mm and shall be resistant against humidity, water and rotting (promatect-panels or equivalent).

### 5.8.5 Power Requirement

An underground electric cable shall be laid from the substation AC Sub-Distribution Board to a the pump motors. Engineer's standards of underground installation must be observed. All necessary power distribution accessories shall be supplied and installed.

### 5.8.6 Availability, Servicing and Ruggedness

All equipment, machinery and their components must be available and serviceable in India. All exposed equipment and machinery shall be weather proof. All the pumps, including the submersible pump, shall be WORTHINGTON/SIMPSON/JACUZZI brand or approved equivalent, sold and serviceable by a reputable company in India.

### 5.8.7 Codes and Standards

Publications listed below form part of this specification to the extent specified in this section:

#### American Society of Civil Engineers (ACE)

ANSI/ACE 7      Minimum Design Loads for Buildings and Other Structures

#### American Society for Testing and Materials (ASTM)

A36/A36M	Standard Specification for Carbon Structural Steel
A123	Standard Specification for Zinc (Hot-dip Galvanized) Coatings on Iron and Steel Products
A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
A490	Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength
A653/A653M	Standard Specification for Steel Zinc-Coated (Galvanized) or Zinc-Iron Alloy-coated (galvanized) by the Hot Dip Process
C991	Standard Specification for Flexible Glass Fiber Insulation for Metal Buildings.

#### Metal Building System Manual

Low Rise Building Systems Manual

The Contractor may propose to the Engineer equivalent standards from recognized international organizations.

### 5.8.8 Design Requirements

#### a) Design Loads:

- Wind load:                      Pressures resulting from wind as specified in 017806-41ES-1300
- Roof live load:                0.50 kN/m<sup>2</sup>
- Seismic Loads:                The values related to seismic requirements are given in the General Technical Requirements 017806-47ES-0200.

Apply loading in accordance with ANSI/ACE 7

- b) Design building to allow for thermal movement of component materials caused by ambient temperature range of 60°C without causing buckling, failure of joint seals, undue stress on fasteners or other detrimental effects;
- c) Design insulation to maintain specified interior temperature with cooling units provided;
- d) Ensure building is watertight;
- e) Provide for positive drainage of condensation occurring within wall construction and water entering at joints to exterior face of wall;
- f) Design building enclosure elements to accommodate, by expansion joints, movement in wall and structural movements without permanent distortion, damage to in-fills, racking of joints, breakage of seals, water penetration or glass breakage;
- g) Design foundations;
- h) Design, assemble and secure building elements to building frame to ensure stresses in sealants and seals are within sealant manufacturer's recommendations;
- i) Design building assembly to permit easy replacement of components;
- j) Allow for ceiling, piping, conduit, control panels and other interior dead loads imposed on these structures;
- k) Building interior environment shall be air conditioned, thermostatically controlled to maintain a maximum temperature of 25 °C, with relative humidity of 60% ± 5 %;
- l) Building interior ventilation shall achieve six (6) air changes per hour;
- m) Building lighting; and
- n) Doors to sizes and location indicated, insulated, weather-stripped.

#### **5.8.9 Performance Requirements**

- a) Maximum deflection for roofing under full, specified live load – 1/180 of clear span;
- b) Maximum deflection for exterior cladding under full, specified, exterior wind induced loads – 1/90 of clear span;
- c) Maintain the following tolerances for building structure and enclosure elements:
  - Maximum variation from plane or location shown on shop drawings – 1 mm/1 m of length and up to 1 mm/5 m maximum; and
  - Maximum offset from true alignment between two adjacent members abutting end-to-end in line – 0.75 mm.

#### **5.8.10 Shop Drawings**

- a) Submit shop drawings in accordance with general technical requirements;
- b) Indicate plans and grid lines, structural members and connection details, bearing and anchorage details (roof cladding, wall cladding), framed openings, accessories, schedule of

materials and finishes, camber and loadings, fasteners and welds;

- c) Indicate detailed description of mechanical, electrical and other systems in work;
- d) Submit erection drawings for approval before construction; and
- e) Indicate erection dimensions and methods.

#### **5.8.11 Materials**

- a) Structure steel: shall conform to ASTM A36;
- b) Bolts and Nuts: bolts and nuts shall conform to ASTM A325 or A490;
- c) Cladding:
  - General: wall and roof shall be pre-painted, double skin insulated, metal cladding;
  - Exterior Sheets: exterior cladding shall be preformed metal panels fabricated from steel sheet conforming to ASTM A653 Grade A, with a fine coating designation Z 275. Thickness to satisfy design requirements;
  - Interior Liner: interior liner sheets shall be preformed metal panels fabricated from steel sheet conforming to ASTM A653 Grade A, minimum base steel, nominal thickness 0.46 mm, with a fine coating designation Z 275;
  - Finish Coating: the exterior sheets and interior liner shall have the manufacturer's standard enamel coating on both faces; and
  - Colour: colours will be selected by Engineer from manufacturers' standard colours.
- d) Insulation: insulation shall be glass fiber conforming to ASTM C 991;
- e) Sub Girts: channels or Z-bars sub girts shall be zinc-coated steel with minimum thickness of 1.22 mm;
- f) Fasteners: fasteners shall be stainless steel, minimum 6 mm diameter. Washers shall be stainless steel with bonded neoprene. Heads of fasteners shall match colour of panels;
- g) Metal Closures, Flashings and Copings: closures, flashings and copings shall be the same colour, thickness and material as panels;
- h) Sealants: joint sealant shall be acrylic sealant for gun application. Only approved sealants shall be used. Sealant colours shall match adjoining paint colour of sheets;
- i) Adhesives: tape sealant shall be poly-isobutylene compound tape, not less than 3 mm thick x 12 mm wide with release paper backing;
- j) Reinforcement for Small Openings: reinforcement for small openings with perimeter lengths less than 3 m shall be of structural quality steel angles, complying with ASTM A 36, galvanized to ASTM A 123; and
- k) Closure Strips: closure strips shall be PVC, cut or pre-moulded to match the corrugations of panels specified.

#### **5.9 Execution**

##### **5.9.1 Erection**



Perform pre-fabricated metal building work to NBMA Low Rise Building Systems Manual.

Erect building structure and enclosure elements.

### **5.9.2 Cleaning**

Remove excess sealant by moderate use of mineral spirits or other solvent acceptable by sealant manufacturer,

Clean all surfaces.

### **5.9.3 Protection**

Provide protection to finished surfaces with strippable coatings, strippable wrappers, plywood or sheet materials as required before acceptance of work.

## **6 FENCES**

### **6.1 General**

Fencing of land property and facilities shall meet the following minimum requirements:

<b>Fence</b>	<b>Height</b>	<b>Top rail</b>	<b>Brace posts</b>	<b>Support arms</b>	<b>Strands</b>	<b>Concrete anchor</b>
Property	2135	no	no	1	3	no
Facility	2440	no	no	2	6	yes

All fencing components except concrete and asphalt felt shall be hot-dip galvanized in accordance with the relevant ASTM specification.

Warning signs "Danger High Voltage with Bone and Skull" and "Danger High Voltage Keep Away" shall be installed on each side of the fence and at the gates.

#### **6.1.1 Codes and Standards**

Publications listed below from part of this specification to the extent specified in this section. The Contractor may propose equivalent standards from recognized international organizations.

#### American Society for Testing Materials (ASTM)

A53	Standard Specification for Pipe, steel, black and hot dipped, zinc-coated, welded and seamless.
A90	Standard Test method for weight (Mass) of coating on Iron and Steel articles with zinc or zinc-alloy coatings.
A153	Standard Specification for zinc coating (hot dip) on iron and steel hardware.
A653	Standard Specification for Steel sheet, zinc-coated (galvanized) or zinc-iron alloy-coated (galvanized) by the hot-dip process.
A824	Standard Specification for metallic-coated steel, marcelled tension wire for use with chain link fence.
A585	Standard Specification for Aluminium – coated steel barbed wire

F626 Standard Specification for Fence Fittings.

F1183 Standard Specification for aluminium alloy chain link fence fabric.

### 6.1.2 Submittals

Submit shop drawings to indicate dimensions and details of fence and location of posts, braces and turnbuckles. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

## 6.2 Materials

### 6.2.1 Fabric

The fence fabric shall be 50 mm diameter diamond mesh in accordance with ASTM A392 and galvanized before or after weaving for Class 1 or Class 2 coatings. Roll diffing is not acceptable. It shall be supplied in standard lengths of roll of 150 m.

The fencing fabric shall be attached to the tension wire by means of clip or tie wires spaced at intervals not exceeding 300 mm.

Attachment of fence fabric to the line posts shall not exceed 355 mm of centres. Tie knots shall be made on the security side of the fence.

### 6.2.2 Chain Link

The chain link fence consists of 2.4 m high woven fabric supported by tubular posts. The gauge of chain link should be of 8 SWG and 50x50 mm.

- Aluminium alloy to ASTM F1183;
- Top selvage – twisted and barbed;
- Bottom selvage – knuckled;
- Wire diameter – 3.76 mm (9 gauge);
- Mesh size – 50 mm; and
- Height of fabric – 2.4 m.

Rolls of chain link fabric shall be joined by weaving a single strand into the ends of the rolls to form a continuous mess pattern.

### 6.2.3 Posts

Posts shall be circular seamless and hot-dipped galvanized steel pipe, schedule 40, conforming to ASTM A53, Grade A, Type S, and shall meet the following minimum requirements:

Classification	OD (mm)	ID (mm)	T (mm)	Wt (kg/m)
Rail (Top and Brace)	42.2	32.0	3.56	3.40
Line Post	60.3	50.8	3.91	5.50
End, Corner and Pull Post	73.0	63.5	5.16	8.70
Single Gate	73.0	63.5	5.16	8.70
Double Gate	101.60	89.0	5.74	13.60

Legend:

OD = Outside diameter

ID = Inside diameter

T = Wall thickness

Wt = Unit weight of steel pipe

For the purpose of this specification, the following terminology applies:

- Terminal post means gate, end or corner post;
- Corner post means any post at which the direction of the fence changes; and
- Line post means any intermediate post between terminal posts.

Line posts shall be installed as line posts at 100 m centres of uninterrupted fencing runs.

Terminal posts shall be installed at the beginning and end of each continuous length of fence and at abrupt changes in vertical and horizontal alignments for all types of fence.

All posts shall be equally spaced at intervals of not more than 3 m on centres in the line of the fence.

All posts shall be provided with the necessary holes, drilled for the appropriate fittings.

All posts shall be equipped with water excluding top caps or extension arms.

All posts shall be plumbed with tops properly aligned.

The tensile and yield strength shall not be less than 330 Mpa & 205 Mpa respectively.

#### **6.2.4 Concrete Mix**

Concrete mix as shall be as specified in Section 5 “Foundations and Concrete Works”.

- Nominal coarse aggregate size – 20 mm; and
- Compressive strength – 20 MPa minimum at 28 days.

#### **6.2.5 Accessories**

Bottom tension wire to ASTM A824, single strand, aluminium-coated steel wire, 4.5 mm diameter;

Posts, braces and rails to ASTM A53, butt welded, schedule 40, galvanized steel pipe;

Tie wire fasteners, aluminium alloy wire, single strand;

Tension bar to ASTM A653, 5 x 20 mm minimum galvanized steel;

Fittings and hardware shall comply to ASTM F626, cast aluminium alloy, galvanized steel or malleable or ductile cast iron.

Post caps to provide waterproof fit, to fasten securely over posts and to carry top rail;

Barbed wire, 2.50 mm diameter, aluminium-coated steel wire to ASTM A585, for-points barbs, 125 mm spacing.

610 g/m<sup>2</sup> minimum galvanizing for pipes to ASTM A90 for pipes.

610 g/m<sup>2</sup> minimum galvanizing for other ferrous fittings including barbed wire to ASTM A153;

Galvanization and coating thickness not less than 30 microns;

Aluminium coating for barbed wire is as per ASTM A585.

### **6.3 Installation**

#### **6.3.1 Grading**

Remove debris and ground surface irregularities along perimeter fence shall be machine graded as required to obtain Clearance below the bottom from the fence shall not exceed 25 mm. Clearance between bottoms of fence and crushed stone cover of 30 mm to 50 mm.

The plan and profile of each reach of fence between corner posts or between corner posts and gate posts, shall be straight. The Contractor shall grade ground surface as required to achieve the straight profiles before each reach of fence is installed.

#### **6.3.2 Excavation**

Excavation for fence posts foundation shall not be started unless final grading is completed prior to excavation.

The Contractor shall verify from the Employer the location of underground utilities that may exists in the area.

Excavate of drill holes for posts footings with all necessary precautions to insure that any underground utility in the area will not be damaged.

Holes shall have a diameter of not less than 250 mm for line posts and 300 mm for corner posts, end and terminal or pull posts and gate posts. Depth of holes shall be not less than 1000 mm.

Where posts are set in earth, concrete foundations 100 mm deep shall be provided. If sound bedrock is encountered, post excavation shall be at least 600 mm into the rock and the diameter of the hole shall be a minimum of 25 mm greater than the cross section of the post. Non-shrink grout shall be used to fill the void.

#### **6.3.3 Grounding**

A perimeter ground conductor shall be laid which follows the fence line and the gate in any position (open or close) at a distance of 0.5 – 1.5 m beyond (outside) the fencing. The perimeter ground conductor and the fence then shall be bonded electrically at corner posts, gateposts and every alternate line post. The gates shall be bonded to the gateposts with a flexible copper cable or braid.

The barbed wire on the top of the fence shall be bonded to the grounding grid at every 21 meter intervals.

#### **6.3.4 Erection**

- a) Erect fence along lines as indicated on construction drawings;
- b) Excavate line-post holes 1000 mm deep x 300 mm diameter. Excavate terminal-post holes 1100 mm deep x 400 mm diameter. Use excavation methods approved by Engineer;
- c) Space line posts 3 m apart measured parallel to ground surface;
- d) Install corner post where change in alignment exceeds 10 degrees;
- e) Install end posts at end of fence and at buildings. Install gate posts on both sides of gate openings;
- f) Form top 300 mm of post holes. Place concrete in post holes, then embed posts into concrete to minimum 900 mm depth. Extend concrete 50 mm above crushed stone cover and slope to drain away from posts. Brace to hold posts in plumb position and true to alignment and elevation until concrete has set;
- g) Do not install fence fabric until concrete has cured a minimum of five days;

- h) Brace terminal posts with pipe compression braces between the terminal and closest line post, located midway between the top rail and the ground surface, and a tension brace consisting of a steel rod and turnbuckle from the end of the compression brace at the line post to the bottom of the terminal post. Brace corner posts in both directions;
- i) Install overhang tops and caps with overhang on outside of substation;
- j) Install top rail between posts and fasten securely to posts and secure waterproof caps and overhang tops;
- k) Install bottom tension wire, stretch tightly and fasten securely to end, corner, gate and straining posts with turnbuckles and tension bar bands;
- l) Lay out fence fabric. Stretch tightly to tension recommended by manufacturer and fasten to end, corner, gate and straining posts with tension bar secured to post with tension bar bands spaced at 300 mm intervals. Knuckled selvage at bottom; twisted selvage at top;
- m) Install fabric on outside of line posts. Secure fabric to top rails, line posts and bottom tension wire with tie wires at 450 mm intervals. Give tie wires minimum two twists;
- n) Install barbed wire strands and clip securely to lugs of each projection;
- o) Install grounding as per specification (017806-47ES-7400); and
- p) Fill all depressions to maintain specified clearance between bottom of fence and crushed stone cover. Ensure no gaps are greater than 50 mm.

### **6.3.5 Cleaning**

Clean and trim areas disturbed by operations. Dispose of surplus material as directed by Employer.

## **7 TRANSFORMER FOUNDATIONS AND OIL/WATER BASINS**

Transformer foundation shall be constructed in reinforced concrete and piled if necessary. An oil drainage pit filled with 25 to 50 mm crushed stones shall be provided around each transformer from which oil shall be drained to a common tank (the oil recovery pit), which shall be equipped with an oil separator. The oil catchment basin dimension shall be large enough to ensure oil drop within it.

Oil pits and oil recovery pit shall be constructed as reinforced concrete tanks and shall be adequately sealed to prevent oil from seeping into the sub-strata. They shall be painted with an oil-resistant paint. The oil recovery pit shall have access and sump to facilitate clearing and removal of oil. The oil pit capacity shall be 1.2 times the oil volume of the largest transformer and shall be designed to hold 50% of its capacity within filled gravel. The pits shall, in all respects, conform with the requirements of NFPA 329 or equivalent standards.

Concrete ducts fitted with removable covers and pipe ducts as required shall be provided for cables to the transformer. These shall be adequately sealed to prevent ingress and escape of oil or water.

Containment shall extend at least 1500 mm past oil containing parts of transformers. The basin shall be filled with fire extinguishing crushed stone. The oil capacity of the basin shall be calculated by subtracting the volume occupied by the crushed stone.

An oil/water separator tank shall be provided and connected to each containment basin of the substation. The design of the oil containment basin and separator tank shall be compliant with the IEEE 980 Standard.

In case of small apparatus (such as earthing reactors) containing less than 5000 l of oil, the basin

can be connected to any separator tank used for large apparatus provided it is located within reasonable reach.

## **8 FIRE PROTECTION WALLS FOR TRANSFORMERS**

### **8.1.1 Application Criteria**

If the free distance between building, and the transformers is less than 10 m, a fire wall shall be erected between the building and the equipment, or otherwise the building walls shall be fire resistant. Also fire reinforced concrete walls shall be provided between power transformers to prevent the adjacent transformers in case of fire on the transformer.

### **8.1.2 Fire Resistance**

The firewall shall have a minimum fire resistance of 3 hours. The fire walls shall be designed in order to protect against the effects of radiant heat and flying debris from an adjacent fire.

### **8.1.3 Mechanical Resistance**

The fire wall shall have the mechanical resistance to withstand local atmospheric conditions. If this wall shall serve as a support for equipment such as insulators etc., its mechanical rigidity must then be increased.

Connecting the walls by steel or other structures which may produce a reversing torque if overheated shall be avoided.

### **8.1.4 Dimensions**

The firewall shall extend at least 1 m on each side of the transformers and at least 600 mm above the conservator tank or safety vent. These dimensions might be reduced in special cases, where there is lack of space. A minimum of 2 meters clearance shall be provided between the equipment e.g. transformers and the firewalls.

The building walls, which act as firewalls, shall extend at least 1 m above the roof in order to protect it.

### **8.1.5 Materials**

The firewall shall be made of reinforced concrete (M-30 grade).