

POWER GRID COMPANY OF BANGLADESH LIMITED
Design, Supply, Installation, Testing & Commissioning of 230/132 kV and 132/33 kV Substations, Northern
Zone, on Turnkey Basis Contract No. PGCB/KfW/2012.66.436/NZSS
BMZ No. 2012 66 436
Transmission System Improvement Western Zone
ICB No. PGCB/KfW/2012.66.436

Addendum No. 1

Volume 1 of 3

1. Section-III; Evaluation and Qualification Criteria.

- i) Clause No: - 2.7, Manufacturers/Subcontractors, Page III-13 to Page III-15 have been replaced by revised pages, Page III-13(Rev-1) to Page III-15(Rev-1).

Revised Pages, Page III-13(rev.1) to Page III-15(rev.1) are attached herewith in **Annexure-1**.

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1. Section – 5, Protection, Metering and Control

- i) Clause No – 5.20, Sub-clause – 5.20.1, Scope of Supply, the last line of the third paragraph is replaced with the following:

"It shall include communication gateway to NLDC(two (2) communication gateway for 230/132kV substation and one (1) communication gateway for 132/33kV substation), inter-baybus, intelligent electronic devices (IED) for bay control and protection as shown in the enclosed general system architecture drawing."

Consequently, the concern Page No:- 142 is replaced by Page No:- 142 (Rev-1) which is attached herewith as **Annexure – 2**.

2. Section-11, Supporting Structures for outdoor equipment has been revised.

Cosequently, page no:- 209 to page no:- 218 have been replaced with page no:- 209 (Rev-1) to page no:- 218(Rev-1) respectively which are attached herewith as **Annexure - 3**.

3. Section-12, Buildings and Civil engineering has been revised.

Cosequently, page no:- 219 to page no:- 251 have been replaced with page no:- 219(Rev-1) to page no:- 251(Rev-1) respectively which are attached herewith as **Annexure - 4**.

4. Section-17, Bid Drawings, General Drawings

- i) The drawing having title "SINGLE LINE DIAGRAM FOR 110V & 48V DC DISTRIBUTION" with drawing number "PGCB/KfW/2012.66.436/SSNZ/7.1" has been revised and repaced with a drawing having drawing number "PGCB/KfW/2012.66.436/SSNZ/7.1 (Rev-1)"
- ii) The drawing having title "Telecommunication System-Block Diagram" with drawing number "PGCB/KfW/2012.66.436/SSNZ/8.2" is replaced with the following drawing:-



"A Typical Communication Schematic Diagram for Grid Substation, Drawing No:- PGCB/KfW/2012.66.436/SSNZ/8.2(Rev-1)".

- iii) The drawing having title "132kV Substation Property Line, Boundary Line and Security Wall" with drawing number "PGCB/KfW/2012.66.436/SSNZ/9.6" is replaced with the following drawing:-

"Boundary Wall or Security Wall, Drawing No:- PGCB/KfW/2012.66.436/SSNZ/9.6(Rev-1)".

- iv) The following drawings have been added:-

"Typical sectional details of property marking with continuous grade beam and column for substations", drawing no: - PGCB/KfW/2012.66.436/SSNZ/10.0

"Relative level of switchyard and different structures", drawing no:- PGCB/KfW/2012.66.436/SSNZ/10.1

"Internal Road Section", drawing no:- PGCB/KfW/2012.66.436/SSNZ/10.2

Consequently the sub-clause 17.2, List of bid drawings has been revised.

Revised Page No: 331 (Rev-1), 332(Rev-1), revised drawings and newly added drawings are all attached herewith as **Annexure – 5**.

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1. Schedule A : Introduction and Preamble to the Price and Technical Schedules

Fire protection system for three phase 50/75MVA transformer against Bangura and Mithapukur 132/33kV Substation shall be Nitrogen Injection Fire Protection System (NIFPS).

Consequently, Page 10 and Page 16 have been replaced with Page 10(Rev-1) and Page 16(Rev-1) which are attached herewith as **Annexure – 6**.

2. Schedule of Rates & Prices:

- i) The description of item no – L1.X of price schedule no 4 against Bangura substation has been replaced with the following:-

"Land development of complete switchyard area by cutting, land filling, compacting up to a suitable level including slope protection.

Approximate total area of the substation is 5 acres and additional land between S/s site and adjacent Highway = 0.9 acre".

Consequently, page B-57 of price schedule 4 has been replaced with page no B-57 (Rev-1) with is attached herewith as **Annexure - 7**.

- ii) The following sub item has been added in Price Schedule 4: Installation and Other Services under item no L2.X against Rajshahi, Bangura and Mithapukur substation:-
Sub-item No: - 12, Property Line Demarcation for Rajshahi Substation, sub-item no: - 18 Property Line Demarcation for 132/33kV Bangura Substation and 132/33kV Mithapukur Substation.

Consequently, Page No- B-54, B-58 & B-65 of Schedule - 4 are replaced by Page No- B-54(Rev-1), B-58(Rev-1) & B-65(Rev-1) respectively with are attached herewith as **Annexure - 8**.

- iii) The VA rating of the first core of all current transformers shall be 10 VA except the current transformers adjacent to auxiliary transformer.

Consequently page no: -B-1, B-6, B-8, B-9, B-13, B-14, B-17, B-18, B-23, B-24 of Schedule – 1 and page no: - B-27, B-32, B-34, B-35, B-39, B-40, B-43, B-44, B-48, B-49 of Schedule – 2 are replaced with page no:- B-1(Rev-1), B-6(Rev-1), B-8(Rev-1), B-9(Rev-1), B-13(Rev-1), B-14(Rev-1), B-17(Rev-1), B-18(Rev-1), B-23(Rev-1), B-24(Rev-1) of Schedule – 1 and page no: - B-27(Rev-1), B-32(Rev-1), B-34(Rev-1), B-35(Rev-1), B-39(Rev-1), B-40(Rev-1), B-43(Rev-1), B-44(Rev-1), B-48(Rev-1), B-49(Rev-1) of Schedule – 2 which are attached herewith as **Annexure - 9**.

- iv) Fire protection system for three phase 50/75MVA transformer against Bangura and Mithapukur 132/33kV Substation shall be Nitrogen Injection Fire Protection System (NIFPS).

Consequently, Page: B-10 & Page: B-19 of Price Schedule-1 and Page: B-36 & Page: B-45 of Price Schedule-2 have been replaced with Page: B-10(Rev-1) & Page: B-19(Rev-1) of Price Schedule-1 and Page: B-36(Rev-1) & Page: B-45(Rev-1) of Price Schedule-2 which are attached herewith as **Annexure – 10**.



2.7 Manufacturers/Subcontractors

Manufacturers/Subcontractors for the following major items of supply or services must meet the minimum criteria listed herein for that item. Failure to comply with this requirement may result in rejection of the Subcontractor and may result in rejection of the bid.

List of minimum required Type test reports can be found in Volume 1, Section 6, Employer's requirements

No.	Equipment	Minimum Criteria
1.	Power Transformer (230/132kV)	- At least last ten (10) years of experience in manufacturing minimum 220/110 kV or higher rating power transformers, with the equipment in satisfactory service for a minimum of three (3) years as on the date of bid opening. - Minimum average delivery over the last 3 years of the ten (10) 220/X kV or higher rating power transformers - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening. - Implemented ISO 9001 - Type test reports as mentioned in the clause 1.2.5 of section-6 of volume 1 of 3 of the bidding document for similar power transformers, three-phase, with on-load tap changer and a minimum rating 220/110 kV, 225 MVA - Technical data sheets, drawings, wiring diagrams, catalogues and other technical documents
2.	Circuit Breaker	- At least last fifteen (15) years of experience in manufacturing minimum 220 kV or higher rating circuit breakers, with the equipment in satisfactory service for a minimum of three (3) years as on the date of bid opening - Minimum average delivery over the last 3 years of hundred (100) 110 kV or higher rating circuit breakers - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening - Implemented ISO 9001 - Type test reports as mentioned in the clause 1.2.5 of section-6 of volume 1 of 3 of the bidding document for each type. - Technical data sheets, drawings, wiring diagrams, catalogues and other technical documents
3.	Disconnect Switch	- At least last ten (10) years of experience in manufacturing minimum 220 kV or higher rating disconnectors, with the equipment in satisfactory service for a minimum of three (3) years as on the date of bid opening. - The minimum average delivery over the last 3 years of hundred (100) 110 kV or higher rating disconnectors - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's Reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening - Implemented ISO 9001 - Type test reports as mentioned in the clause 1.2.5 of section-6 of volume 1 of 3 of the bidding document for each type. - Technical data sheets, drawings, wiring diagrams, catalogues and other technical documents

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No.	Equipment	Minimum Criteria
4.	Instrument Transformers	- At least last ten (10) years of experience in manufacturing minimum 220 kV or higher rating Instrument transformers, with the equipment in satisfactory service for a minimum of three (3) years on the date of bid opening - Minimum average delivery over the last 3 years of hundred (100) 110 kV or higher rating instrument transformers - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening - Implemented ISO 9001 - Type test reports as mentioned in the clause 1.2.5 of section-6 of volume 1 of 3 of the bidding document for each type. - Technical data sheets, drawings, wiring diagrams, catalogues and other technical documents
5.	Surge Arrester	- At least last ten (10) years of experience in manufacturing minimum 220 kV or higher rating surge arresters, with the equipment in satisfactory service for a minimum of three (3) years on the date of bid opening. - Minimum average delivery over the last 3 years of hundred (100) 110 kV or higher rating surge arresters - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening. - Implemented ISO 9001 - Type test reports as mentioned in the clause 1.2.5 of section-6 of volume 1 of 3 of the bidding document for each type. - Technical data sheets, drawings, catalogues and other technical documents
6.	Substation Automation system	- At least last five(5) years of experience in manufacturing high-voltage substation automation systems, as per IEC 61850 standard, with the equipment in satisfactory service for a minimum of three (3) years on the date of bid opening - Minimum average delivery over the last 3 years of ten (10) complete substation automation systems, as per IEC 61850 standard - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening - Implemented ISO 9001 - Type test reports as mentioned in the clause 1.2.5 of section-6 of volume 1 of 3 of the bidding document. - Technical data sheets, drawings, block diagrams, wiring diagrams, catalogues and other technical documents
7.	Protection Relay	- At least last five(5) years of experience in manufacturing protection relays, as per IEC 61850 standard, with the equipment in satisfactory service for a minimum of three (3) years on the date of bid opening - Minimum average delivery over the last 3 years of hundred(100) relays, as per IEC 61850 standard - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening

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No.	Equipment	Minimum Criteria
		- Implemented ISO 9001 - Type test reports as mentioned in the clause 1.2.5 of section-6 of volume 1 of 3 of the bidding document. - Technical data sheets, drawings, block diagrams, wiring diagrams, catalogues and other technical documents
8.	Communication Equipment	- At least last ten (10) years of experience in manufacturing communication equipment, with the equipment in satisfactory service for a minimum of three (3) years on the date of bid opening - Minimum average delivery over the last 3 years of ten (10) complete substation communication equipment - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening - Implemented ISO 9001 - Type test reports - Technical data sheets, drawings, block diagrams, wiring diagrams, catalogues and other technical documents
9.	DFDR	- At least last ten (10) years of experience in manufacturing DFDR for high voltage substations, with the equipment in satisfactory service for a minimum of three (3) years on the date of bid opening. - Minimum average delivery over the last 3 years of ten (10) DFDR - Manufacturer's authorization letter, with confirmation of experience and satisfactory operation of the offered equipment and Manufacturer's reference list - At least one evidence from end users for satisfactory service of equipment for a minimum of three (3) years on the date of bid opening - Implemented ISO 9001 - Type test reports - Technical data sheets, drawings, block diagrams, wiring diagrams, catalogues and other technical documents
10	Electrical Works Subcontractor	- At least last five (5) years of experience in installation of high voltage substations, rated voltage 110 kV or higher. - At least one contract for the installation of a new substation with 110/X kV or higher rated voltage, of minimum two HV bays and one power transformer, in last three (3) years - Subcontractor's reference list and end user's letters Note: Evidence of the above experience shall be submitted in the bid. It shall be on the user's letterhead, indicating address, telephone and fax numbers of the user. It shall include name of the project, name of the employer, description of the work, commissioning date and contract amount.
11	Civil Works Subcontractor	- At least last five (5) years of experience in civil works for installation of high voltage substations with rated voltages of 110 kV or higher - At least one contract for civil works for the installation of new substations of 110/X kV or higher rated voltage, of minimum two HV bays and one power transformer in the last three (3) years - Subcontractor's reference list and end user's letters Note: Evidence of the above experience shall be submitted in the bid. It shall be on the user's letterhead, indicating address, telephone and fax numbers of the user. It shall include name of the project, name of the employer, description of the work, commissioning date and contract amount.

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5.18 Tripping Relays

All tripping relays, where specified, shall be of high-speed (less than 10 ms), high-burden, heavy-duty (larger than 150W) type and shall be suitable for panel mounting. Relays shall comply with the requirements of Clause 5.13.9.

5.19 Protection Settings

Relay settings with calculation for all unit-type protective schemes and shall be submitted to the Engineer and Employer prior to commissioning of any plant for approval. Settings shall also be provided for those relays and other equipment provided under this section of the contract which do not require an intimate knowledge of existing relay settings e.g. circuit breaker fail relays. Detailed calculations shall be provided supporting all recommended settings.

Any additional information needed by Contractors should be requested.

5.20 Substation Automation System

5.20.1 Scope of Supply

This specification covers the design, manufacture, inspection, testing at the Manufacturer's works, erection and commissioning of a substation automation system, as shown in drawing of this technical specifications & described in the following sections, to control and operate the 230 kV & 132 kV grid substation.

This describes the facilities required to provide the control of plant and system within a substation and outlines the facilities to be provided on site, interface requirements and performance criteria.

The substation automation system (SAS) shall comprise full station and bay protection as well as control, monitoring and communication functions; it shall provide all functions required for the safe and reliable operation based on IEC 61850 standards. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package, and shall perform the necessary system control and data acquisition functions. It shall include communication gateway to NLDC (two (2) communication gateway for 230/132kV substation and one (1) communication gateway for 132/33kV substation), inter-baybus, intelligent electronic devices (IED) for bay control and protection as shown in the enclosed general system architecture drawing.

The communication gateway shall secure control from and information flow to remote network control centres. The inter-bay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directly connected to the instrument transformer and trip/close coils in the switchgear without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Employer.

The Contractor will have the option to choose different types of communication networks for the bay level and the process level based on IEC 61850. However, network topology and access mode shall



11. Supporting Structures for Outdoor Equipment

11.1 Scope

Where specified structures shall be provided under this contract for supporting the conductors, busbars, insulators, isolating switches, circuit breakers, current and voltage transformers, surge arresters, line traps, coupling capacitors, sealing ends or cable boxes and cables where necessary and other items of plant generally as shown on the relevant drawings. Facilities shall also be provided where specified for the termination of the incoming transmission lines.

All structure designs shall be such as to facilitate inspection, painting, maintenance, repairs and operation with the continuity of supply being the prime consideration.

11.2 Structure Arrangement

The arrangement of the high level structures supporting conductors and/or busbars shall be either lattice structures primarily composed of angle sections, or low visual impact A-frame type structures primarily composed of welded hollow or composite sections. Angle, hollow or composite sections shall be either steel or aluminium as specified. For lattice structures a fully triangulated system of bracings shall preferably be adopted. For A-frame structures the primary connections between major components shall be bolted, for ease of transportation and erection.

Low level support structures shall be either lattice structures primarily composed of angle sections or 'moment' type structures primarily composed of welded hollow or composite sections.

The design and arrangement of supporting structures shall be subject to approval by the Engineer.

The type of arrangement of high-level structures and acceptable materials for both high and low level structures shall be as specified in the Schedule of Technical Requirements.

11.3 Design

11.3.1 General

The supporting structures shall be designed to ensure that the specified minimum phase, earth and section clearances are maintained under all conditions. Where applicable special attention shall be paid to the design of the line termination structures to ensure minimum phase clearance is obtained for the complete range of angles of entry specified.

The strength and rigidity of structures shall be such that the alignment of the equipment which they carry shall not be affected by the static and dynamic loads to which the structures are subjected.

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The assumptions made in the overall structural design especially in the load transfer between the gantry beam and column shall be adequately reflected in the design and detailing of the beam-column connection.

11.3.2 Assumed Loading Combinations

The supporting structures shall be designed to resist the ultimate applied loading, determined in accordance with the following load combinations:

Load Combination 1 - Design Wind, Coincident Temperature, (Ice)

- (a) The wind pressure specified in Table 11-1 below applied to the projected area of all conductors and electrical equipment;
- (b) The wind pressure specified in the Schedule of Technical Requirements applied to the projected area of all members of the windward face of structure;
- (c) Where appropriate the conductor and/or earthwire tensions or busbar forces, including due allowance for both horizontal and vertical deviations / inclinations;
- (d) Self weight of the equipment and structure;
- (e) When stated in the Schedule of Technical Requirements the effects of the specified radial ice thickness shall be taken into account in the determination of the wind area of the conductor, earthwire, busbar, electrical equipment and the supporting structure, the conductor and earthwire tensions and the self-weight of the equipment and the structure.

The wind directions considered shall include transverse, longitudinal and if appropriate 45° to the major axis of the structure.

Load Combination 2 - Still Air, Short Circuit, Minimum Temperature or Maximum Operating Temperature

- (a) Conductor and/or earthwire tensions or busbar forces including the dynamic affects calculated in accordance with IEC 865-1.
- (b) Self weight of the equipment and structure;

Load Combination 3 - Still Air, Seismic, Coincident Temperature (Ice)

- (a) Conductor and/or earthwire tensions or busbar forces;
- (b) Seismic forces;
- (c) Self weight of the equipment and structure;
- (d) When stated in the Schedule of Requirements the effects of the specified radial ice thickness.

Seismic forces shall be applied as a static horizontal force transversely and alternatively longitudinally to the major axis of the structure, and shall be equal in value to the seismic coefficient stated in the Schedule of Technical Particulars multiplied by the self-weight of the conductor, earthwire, busbar, electrical equipment and structure, and applied at the centre of gravity of the equipment and structure as appropriate.



Load Combination 4 - Still Air, Erection, Coincident Temperature

- (a) Conductor and/or earthwire tensions or busbar forces;
 (b) Self weight of the equipment and structure.

For erection conditions any one complete phase conductor bundle or busbar or earthwire shall be assumed not to be erected in any one span.

For the purposes of design all high level structures shall be considered as terminal structures. For multi-bay continuous structures, central columns shall be designed for the most onerous condition of adjacent bays being loaded or unloaded.

Table 11-1: Wind Pressures

Line Description							
1.	Structure Arrangement [clause 11.2]						
	- High Level - Low Level - Primary Material		- Lattice or A-Frame - Lattice or Moment - Steel				
2.	Load Combination 1 [clause 11.3.2]			Structures only		Structures, Busbars, etc.	
	Wind pressure at above G.L. q_{ref}	kN/m ²	3.54		1.21		
	Coincident temperature	°C	5				
	Radial ice thickness	mm	0				
	Density of ice	kg/m ³	-				
	Load combination 2						
	Minimum temperature	°C	5				
	Maximum operating temperature	°C	80				
	Load combination 3						
	Seismic coefficient	g	0.1				
	Coincidence temperature	°C	5				
3.	Line Termination Structure [clause 11.3.3]			400kV Phase	230kV Phase	132kV Phase	Earthwire
	Number of sub-conductors			2	2	2	-
	Maximum working tension per sub-conductor		kN	20	10	7	4.5
	Radial ice thickness		mm	0	0	0	0
	Maximum downlead span		m	75	75	75	75
	Maximum angle of entry	Horizontal	deg.	45	45	45	45
		Vertical	deg.	30	30	30	30
	Low duty tension set	Wind area	m ²	0.7	0.7	0.7	-
		Mass	kg	100	100	100	-
4.	Partial Load Factors [clause 11.3.4]						

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Line Description				
	Load combination		Steel	Aluminium
	• 1		1.35	n.a.
	• 2		1.0	n.a.
	• 3		1.0	n.a.
	• 4		1.5	n.a.
5.	Safety and Access Requirements [clause 11.3.7]		High Level	Low Level
	Step bolts		Yes	No
	Ladders:		Yes	No
	• Cage protection		No	No
	• Fall arrest system		No	No
6.	Partial Material Factors [clause 11.3.8]			
	Steel		0.85	
	Aluminium		-	
	Foundations		0.76	
7.	Minimum Member Thickness** [clause 11.3.8]		Steel	Aluminium
	Main member	mm	6.0	n.a.
	Other bracing members	mm	5.0	n.a.
	Secondary (redundant) members	mm	5.0	n.a.
	Plates	mm	6.0	n.a.
	Bolt diameters	mm	16.0	n.a.
	**Minimum thickness specified shall apply to both hot rolled and hollow sections			
8.	Protective treatment (clause 11.6)			
	Galvanising thickness	µm	85	n.a.
	Protection procedure		BS 729	no

11.3.3 Line Termination Structures

For details of the incoming transmission line phase conductor and earthwire details, and angles of entry reference should be made to the Schedule of Technical Requirements.

11.3.4 Partial Load Factors

The partial load factors to be applied to the loading combinations determined in accordance with Clause 11.3.2 shall be as specified in the Schedule of Technical Requirements.



11.3.5 Wind Loading

The reference wind pressure to be adopted for the design of the outdoor supporting structures shall be based upon the value specified in the Schedule of Technical Requirements. The reference wind pressure q_{ref} N/m² at a height of 10m above ground level shall be subjected to variation for height and shape of the structure or equipment under consideration to give the total wind load.

The total wind load on the structure or equipment surface shall be determined from the expression:

The total wind load on the structure or equipment surface shall be determined from the expression:

$$F_w = q_{ref} \left(\frac{H}{10} \right)^{0.2} C_{shp} W_A$$

Where

F_w = The calculated total wind load on the structure or equipment:
 q_{ref} = reference wind pressure
 H = Height to top of the panel under consideration
 C_{shp} = aerodynamic shape factor
 W_A = windward face area of the structure or equipment

The aerodynamic shape factor C_{shp} shall be as specified:

• Flexible conductors	1.0	
• Earthwires	.2	
• Tubular busbars $Re < 4.1 \times 10^5$	1.2	[1]
• $4.1 \times 10^5 < Re < 8.2 \times 10^5$	0.6	
• Support insulators, porcelain for apparatus or cap & pin insulator strings	1.2	[2]
• Flat truss structures consisting of profiles	1.6	
• Square & rectangular lattice towers & supports consisting of profiles	2.8	
• Sharp edged structures & components other than above	2.0	
• Flat truss structures consisting of tubes	1.2	
• Square & rectangular lattice towers & supports consisting of tubes	2.1	

Notes: [1] Re = Reynolds Number [2] Based on external diameter of insulator.

11.3.6 Equipment and Conductor Terminations

All supporting structures shall be provided with such holes, bolts and fittings as may be necessary to accommodate insulators, isolating switches and other equipment provided under the Contract.

Where incoming transmission lines and/or conductors and/or earthwires are terminated at structures with tension sets, approved shackle or swivel attachments shall be provided. To facilitate maintenance and erection, additional attachment points shall be provided adjacent to the main termination attachment. The supply and connection of the incoming transmission line will be undertaken under a separate contract.

Structures required to support cable sealing ends shall be provided with arrangements for supporting the cables. Attachment holes for the connection of earthwire bonds shall be provided adjacent to the earthwire attachment point. Attachment holes for the connection of the substation earthing grid shall

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be provided on the vertical face of the structure, approximately 300mm above the top of concrete. Foundation holding-down bolts shall not be used for the attachment of earth connections.

11.3.7 Safety and Access Requirements

To facilitate safe inspection and maintenance all supporting structures which cannot be maintained from ground level shall be provided with climbing facilities, inter-circuit screens, guards etc. in appropriate positions as agreed with the Engineer.

All members inclined at 40° or less to the horizontal, shall be designed to resist a mid-point load of 1.5 kN, with no other loading being considered.

Where specified step bolts of an approved type shall be fitted to supporting structures at not more than 450 mm centres starting as near as practicable to the base and continuing to within 1m below the top of the structure. It shall be noted on the erection drawings that all step bolts are to be removed after construction for a distance of 2.0m above ground level. Adequate clearance shall be provided between the step bolts and any obstructions which might interfere with their use. Step bolts shall not be less than 16mm diameter, project not less than 150mm, and be fixed with nut, washer and nut.

Where specified ladders of an approved type generally in accordance with the requirements of BS 4211, 450mm wide and 350mm rung spacing shall be fitted to supporting structures. They shall be incorporated into the structure either integrally or separately. Where specified cage protection or fall arrest systems shall be fitted to the ladder. Means shall be provided to prevent unauthorised access of ladders.

Inter-circuit screens shall be provided where necessary to prevent access between adjacent circuits on multi-bay structures. Inter-circuit screens shall be fabricated from a 50mm x 50mm mesh formed from 3mm diameter galvanised steel wire.

All structures shall be fitted with identification/notice plates as appropriate.

11.3.8 Structural Design

The allowable ultimate unit stresses used in the determination of the nominal member strength of supporting structures shall be based on the following:

Lattice steel structures	ANSI/ASCE 10-97
Steel A frame or moment structures	BS 5950
Aluminium structures	BS 8118: Part I

Partial factors to be applied to member nominal strength determined in accordance with the above stated codes shall be as specified in the Schedule of Technical Requirements. For ANSI/ASCE 10-97 the appropriate reference stress levels shall be based on the values specified in BS 5950.

The maximum allowable slenderness ratios shall not exceed the following:

Steel Aluminium

- For column or support leg members, beam chords 120
- For other load bearing compression members 200



- For secondary (redundant bracings) 250
- For tension only members 350

Members shall be of such shape, size and length to preclude damage or failure from vibration or stress reversal, including the detailing of connections.

Minimum member thickness and diameter of bolts shall be as specified in the Schedule of Technical Requirements

Holding down bolts shall be used to connect the structures to their foundations. The design of holding down bolts shall make adequate provision for combined axial and shear forces.

The nuts of all bolts attaching conductors, busbars or earthwire tension sets etc., shall be locked with a locknut. No screwed threads shall form part of a shearing plane between members, and bolts shall not project more than 10mm beyond the nut.

11.3.9 Design Submissions

The Contractor shall submit all design calculations, drawings and method statements as required. All sets of calculations shall be complete, bound, properly titled and given a unique drawing number. An agreed system of identification of the structure design reference, fabrication drawings and substation general arrangement drawings shall be used.

Calculations shall contain a Design Information sheet, derivation of all applied loadings including sag and tension and dynamic tension calculations, the design load for each member group under the critical loading case, member size, slenderness ratio, allowable load, end connection detail and foundation load schedule. Codes or standard references should be quoted and where computer programs are used, a full explanation in the English language shall be provided to assist the Engineer's approval of the calculation. Soft copy of design calculations, executable files etc. to be delivered with submission.

11.4 Materials

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate and shall be suitable for all usual fabrication processes including hot and cold working within the specified ranges. The Contractor must take due cognisance of the minimum ambient temperature, quality of steel, charpy impact value and stress relieving.

The quality of finished steel shall be in accordance with BS EN 10163. All steel shall be free from blisters, scale, lamination, segregation's and other defects. There shall be no rolling laps at toes of angles or rolled in mill scale.

Hot rolled steel plate 3mm thick or above shall be in accordance with the requirements of BS EN 10029.

Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190 and shall be threaded ISO Metric

Course Pitch to BS 3643: Part 2, Tolerance Class 7H/8g. Only one grade of steel shall be used per bolt diameter. Washers shall be in accordance with BS 4320 Grade E and BS 4464 Type B as appro-

priate.

Consumables used in metal arc welding shall be in accordance with the relevant standard.

All materials for aluminium structures shall be in accordance with BS 8118: Part 2.

11.5 Workmanship

The Contractor shall submit panel assembly (fabrication) drawings which shall show all materials in place, complete with all fabrication and connection details. A complete tabulation listing all pieces, bolts, nuts, washers etc. shall also be shown on the drawings. The Contractor shall make changes to the fabrication details which the Engineer determines necessary to make the finished structure conform to the requirements and intent of the specification.

The Contractor shall submit a detailed Method Statement of his proposed fabrication procedures including quality control procedures to ensure satisfactory assembly and erection, interchangeability of similar members, accuracy of dimensions, position and alignment of holes.

All welding shall be carried in accordance with BS 5135 for steel structures and BS 8118 Part 2 for aluminium structures. All members shall be stamped on before galvanising or other protective coatings, using characters 10mm high and shall be clearly legible after galvanising.

11.6 Protective Treatment

Unless otherwise specified after fabrication, all structural steelwork, including bolts, nuts and washers shall be hot dipped galvanised to meet the requirements of BS 729. Bolt threads shall be cleaned of surplus spelter by spinning or brushing. Dies shall not be used for cleaning threads other than on nuts. Nuts shall be galvanised and tapped 0.4mm oversize and threads shall be oiled.

Excessively thick or brittle coatings due to high levels of silicon or phosphorous in steel, which may result in an increased risk of coating damage and/or other features that make the final product non-fit-for purpose shall be cause for rejection. Protective treatment for aluminium shall be in accordance with the requirements of BS 8118.

Galvanising thickness and aluminium protection procedure shall be as specified in the Schedule of Technical Requirements

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11.7 Quality Control

11.7.1 General

Routine tests on raw materials and fabricated individual members shall be undertaken in accordance with BS EN 10025, BS EN 10210 and BS 8118 as appropriate.

All steel ex-mills or received from merchant's stock shall be marked to identify the cast or casts from which it was rolled in accordance with Section 9 of BS EN 10025 and Section 10 of BS 102 10, and shall be covered by the appropriate (mill) certificate. The optional impact test BS EN 10210 option 1.6 for quality JO is required.

The material grades or alloy categories of individual pieces of steel/aluminium shall be capable of positive identification at all stages of the fabrication process.

Bolts and nuts shall be covered by the appropriate test certificate to prove compliance with BS 4190.

11.7.2 Welding

Unless specified to the contrary all structural welds shall be undertaken using approved welding procedures in accordance with BS EN 288. All welders shall be tested to the requirements of BS EN 287.

All welding shall be subject to a non-destructive testing (NDT) programme, which shall include visual, ultrasonic and magnetic particle testing as appropriate. Visual inspection shall be in accordance with BS 5289, ultrasonic to BS 3923 and magnetic particle to BS 6072. Acceptance criteria shall be in accordance with BS 5135, except for porosity and BS 8118: Part 2. All welds especially butt welds must be continuous to ensure a pickle-tight connection when galvanised.

The Contractor's NDT programme shall be submitted to the Engineer for approval prior to the commencement of fabrication.

11.7.3 Check Erection

Prototype structures shall be check erected in order to verify the accuracy of detailing and fabrication.

The degree of check erection shall be sufficient to verify not only the main structure, but all auxiliary steelwork. Sufficient blocking and support shall be provided to prevent distortion and overstressing of members to ensure proper fit. Assembly shall be accomplished without extraordinary effort to align bolt holes, or to force pieces into position. Bolt holes shall not be reamed or enlarged. Any damage to protective coatings during check erection if the check erection is undertaken on coated structures, shall be recoated at the fabricator's cost.

11.7.4 Galvanising

Tests on galvanised members and components shall be carried out at the works to ensure compliance with the requirements of BS 729.



11.7.5 Tolerances

The fabrication tolerances after galvanising for steel members, which are not to be considered cumulative shall be as follows:

- | | | |
|----|--|------------------|
| a) | On linear dimensions of nominal sections as per BS 4, BS 4848, BS EN 10024, BS EN 10034 & BS EN 10056-2. | |
| b) | On overall length of member | ± 1 mm |
| c) | On centres of holes | ± 1 mm |
| d) | On groups of holes | ± 2 mm |
| e) | On back-gauges | ± 1 mm |
| f) | On corresponding holes in opposite faces of a member | ± 1 mm |
| g) | On specified hole diameter on the punch side (in the black),
or when drilled | ± 0.3%
- 0 mm |
| h) | Taper on the punched holes as measured between the specified hole diameter
on the punch side and the hole diameter on the die's side (in the black) | ± 1.0 mm |
| i) | On specified bends, open and closed flanges | ± 0.02% |

The permitted tolerances for straightness after galvanising shall not exceed an offset of 1: 1000.

Tolerances for aluminium structures shall be in accordance with BS 8118: **Part 2**.

11.8 Erection

The Contractor shall when requested provide the Engineer with a Method Statement detailing his proposed erection methods. Due cognisance shall be taken of the relevant parts of BS 5531 and current health and safety legislation.

All structural members stored on site shall be kept clear of the ground where possible. Contact with substances likely to attack the protective coatings shall be avoided and all members kept in a clean and tidy condition. Care shall be taken to prevent damage/deterioration of any protective coating during transportation, storage and erection. Unless otherwise agreed damaged members shall be replaced. The renovation of damaged areas of protective coatings shall be carried out using techniques agreed with the Engineer.

The Contractor shall ensure that the structures are not strained or damaged in any way during erection. Structures shall be erected vertically within a tolerance at the top, or the centre of the beam of 0.5% of the overall structure height before equipment installation or conductor/busbar stringing.



12. Buildings and Civil Engineering Works

12.1 General

This section covers all earth work, foundations and buildings associated with the project together with roads, surfacing, cable trenches and tunnels, boundary walls, guard houses, foul and storm drainage and water supply.

12.1.1 Scope of Work

The work includes the design, detailing, construction and maintenance of the following:

1. performance of site investigation
2. foundations for all equipment to be installed in outdoor switchyards, control buildings, indoor switchgear and any other building required for the project
3. complete buildings consisting of structural reinforced concrete frames, brick walls, concrete roof and floor slabs.
4. roadways generally within sites, surfacing the entire area within site boundary and surface water drainage.
5. cable trenches, cable tunnels, cable ducts and pipe ducts

Included in the scope of work is the detailing, construction and maintenance of the following items which shall generally be constructed to the Employer's standards but full working drawings shall be prepared by the Contractor:

- a. guardhouses
- b. boundary walls and entrance gates
- c. septic tank and soak way
- d. underground water tank where water supply pressure is low
- e. water supply tube well (Minimum depth of the well is 20m)
- f. underground water storage tank.
- g. the existing 132kV control building floor shall be renovated by using homogeneous floor tiles and as per this section clause no. 12.3.8

Guardhouse, as stated in item (a) shall be designed as per enclosed drawing.

Boundary wall and entrance gate stated in item (b) shall be designed as per enclosed drawings.

Drawing and design of septic tank and soak way item (c) above, shall be prepared by the Contractor as per requirement of clause 12.3.3 and shall be finalized during detailed Engineering.

The Bidder shall state which approved local building Contractor(s) he proposes to employ to carry out the work.



12.1.2 Contractor to Satisfy himself as to all Conditions

The Contractor shall assess:

- a. access conditions at all sites, plus ground conditions and ground bearing capacity
- b. transport costs, materials costs and restrictions of availability of supply of materials locally
- c. importation restrictions and delay due to customs controls
- d. restrictions imposed by existing equipment on sequence of construction, access etc.
- e. restrictions caused by cable laying and overhead line Contractors
- f. ground conditions and temporary works required to provide support during excavation

12.1.3 Way Leaves, Land Purchase and Planning Permission

The Employer will be responsible for the purchase of all land within the permanent site boundary and the purchase of all land required to the base of the fill of any batter slopes. The Employer will also be responsible for obtaining land to provide a permanent single access to each site from a nearby road or waterway.

The Contractor shall perform the land development of the planned area. The substation location should be filled up and elevated above ground at least to the same level as the main road, so land back filling shall be performed and all cost shall be included in the Contract price. Elevation of the substation should take into consideration also the expected higher flood level, which is an impact of the climate change.

During the construction period the Contractor shall be responsible for maintaining this access in a reasonable condition by reinstating damage caused by his construction traffic and Employer traffic. The Contractor shall provide durable surface to access road.

Should the Contractor require more than one single access to a site or require additional land for construction activities outside the permanent site boundary, he shall be responsible for the purchase or way leave of the required land.

The Employer will be responsible for applying for planning permission. The Contractor shall be responsible for completing the approved site survey and the approved site layout plan, together with the approved architectural elevations of all facades of any buildings, by the key date given in the programme for each site so that the Employer may use these drawings to apply for planning permission.

12.1.4 Site Survey Drawings

For each site the Contractor shall prepare a survey at 1:200 scale showing existing ground levels on a minimum 10 metre grid and details of all features above and below the ground within the site boundary and up to 15 metres beyond it by the key date stated in the programme. Levels shall be related to bench marks clearly indicated on the plan. The plan shall be submit to approval by the Engineer and the agreed substation building floor levels shall be given on each site plan.

The Contractor shall propose the building floor level to the Engineer. It shall generally be at least 300mm above the crown of the adjacent substation internal road.



12.1.5 Earth Works

Cut and fill where required shall be carried out by the Contractor. Source of fill material shall be planned and approved by the Employer. The Contractor shall be responsible for providing a level or uniform sloping site to suit his substation layout design. The final ground level shall be stated on the site survey plan to be prepared by the Contractor. Final ground level (FGL) shall be at least 500mm higher than adjacent public road or highest flood level whichever is greater.

Earth works to make the substation land suitable for installation of supporting structures and equipment, for extinction of the control building and related dependencies, with drainage to evacuate water in all conditions and of sufficient size to allow access to maintenance equipment and gravelling of switchyard surface.

Access road and switchyard internal circulation ways shall be extended. Extend drainage network made of perimeter trenches, switchyard internal sub soil drainage trenches or pipes.

All fill shall be compacted in layers not exceeding 150mm deep to a minimum of 90% optimum density as defined by the Proctor Test.

12.1.6 Engineer's and Employer's Accommodation/Surveying Equipment

On each major site the Contractor shall provide an office of approx. size 5 x 6m equipped with desk, 2 chairs, light and fan for the sole use of the Engineer and his inspectors. Similar facilities are to be provided for the Employer.

The Contractor shall also provide in the Engineer's site office one set of personal computer. The PC shall be fully equipped with all peripherals.

The Contractor shall loan his surveying instruments to the Engineer and his staff when required. Instrument checks shall be carried out at monthly intervals.

12.1.7 Programme

The Contractor's programme shall at Bid stage define the following key dates for each site. Where drawings are to be submitted for approval, they shall be submitted at least 6 weeks before the key dates to allow for the Engineer to comment and his comments to be incorporated in the drawings:

6. Issue of approved site survey drawing complete with soil levels and floor levels
7. Issue of approved electrical layout drawings
8. Completion of site investigation field work
9. Issue of approved Site Investigation Final report
10. Completion of loading tests on a foundation on each fill site and any other site where settlement is likely to be a problem
11. Issue of approved drawings required for planning permission
12. Issue of a full complete set of civil building drawings
13. Construction start date
14. Date access will be given for:
 - a) Installation of equipment in buildings
 - b) Installation of outdoor plant



15. Construction finish date

The Contractor's programme shall outline the number of sites he proposes to build at any time and shall show the order of completion of sites and how crews will move from site to site. This information shall be used to establish the number of expatriate site supervisors required.

The drawing programme shall ensure that complete set of approved civil building drawings will be issued at least 21 days before construction start at any site, in accordance with the Project Requirements in Schedule A of Volume 3 of 3.

The Construction programme shall be expressed in an 'S' curve for the whole project, with the percentage (of the total value of work in the schedules) given for each site each month. The overall percentage completion of the project each month shall also be given.

12.1.8 Monthly Progress Certificates/Progress Reports

In accordance with the Project Requirements in Volume I the Contractor shall submit agreed progress certificates for each site before the seventh day of the next month. These certificates shall state the percentage completion of each item in the schedules and shall state the overall percentage completion of each site and that site's contribution to overall project percentage completion. An updated 'S' curve shall be submitted with the progress certificates.

In addition, the Contractor shall provide a monthly

- Environmental and Social and Compensation Inspection Report
- Health & Safety Report

12.1.9 Temporary Facilities

The Contractor shall provide all temporary buildings, workshops, cement and lime stores and latrines required for his use. The Contractor shall agree the location of these buildings with the Engineer, after submitting a drawing showing their proposed location.

12.1.10 Site Supervision

Although the civil and building works may be let as a sub-contract to an approved local Contractor, the main Contractor shall ensure that an expatriate supervisor in his direct employ is continuously available at each site during construction. This supervisor shall have at least a working command of spoken English and be able to read, understand and discuss specifications and drawings.

The Contractor shall notify the Employer and Engineer in writing of every concrete pour and foundation casting the day before the work starts.

12.1.11 Designs and Drawings

The Contractor shall obtain the Engineer's approval for the use of all design codes and standards before design work starts. All design and drawing work shall be completed in the Contractor's own country, in direct coordination with the electrical plant design.

The Contractor shall supply one copy of all of codes for the Engineer in Dhaka. If non-English equiva-



lent National codes are adopted, the Contractor shall supply English translations of these Codes to the Engineer.

One copy of calculations shall be submitted together with drawings. To avoid possible misunderstandings, calculations will not be approved separately from drawings.

The Contractor shall generally submit a complete set of drawings for each substation for approval after initially getting the electrical layout of each substation approved. Where possible, drawings shall be standardized and general drawings (00) issued covering several sites.

For each substation the Contractor shall provide a co-ordination plan at scale 1:200 showing bus bar sizes, structure types, foundation types, cable trenches, roads, ducts, buildings, boundary walls, earthing, drainage and all services in this Contract.

12.2 References

12.2.1 General

The design and construction shall conform to the latest edition of the relevant Codes and Standards. Any proposed substitution for the listed Standards by an equivalent Standard will be subject to approval by the Engineer. Relevant Standards include, but are not limited to, those listed in subsection 2.2 below.

12.2.2 Design and Construction Standards

- BS12 Portland Cement
- BS EN 124 Gully and Manhole tops for vehicular and pedestrian areas
- BS 812 Testing aggregates
- BS 882 Aggregates from natural sources for concrete
- BS 1377 Methods of test for soils for civil engineering purposes
- BS 1722: Part 10 Anti-intruder fences
- BS 1881 Testing concrete
- BS 2853 Design and testing of overhead runway beams
- BS 3148 Methods of test for water for making concrete
- BS 3921 Clay bricks
- BS 4449 Steel bars for the reinforcement of concrete
- BS 5262 External renderings
- BS 5395 Stairs, ladders and walkways
- BS 5572 Sanitary pipework
- BS 5628 Code of practice for use of masonry
- BS 5930 Code of practice for site investigations
- BS 6031 Code of practice for earthworks
- BS 6367 Code of practice for drainage of roofs and paved areas
- BS 6399: Part 1 Code of practice for dead and imposed loads
- BS 6399: Part 2 Code of practice for wind loads
- BS 6465 Sanitary installations
- BS 6651 Code of practice for protection of structures against lightning
- BS 6700 Design, installation, testing and maintenance of services supplying water for



- BS 8004 domestic use
- BS 8005 Code of practice for foundations
- BS 8100 Sewerage
- BS 8102 Lattice towers and masts
- BS 8102 Code of practice for protection of structures against water from the ground
- BS 8110 Structural use of concrete
- BS 8206 Lighting for buildings
- BS 8215 Code of practice for design and installation of damp-proof courses in masonry
- BS 8290 Suspended ceilings
- BS 8301 Code of practice for building drainage

12.3 Design

12.3.1 Architectural and Structural Requirements of Buildings

All new buildings shall be designed to be architecturally pleasing in appearance and to withstand the tropical climate with minimal maintenance.

Architectural elevations of all elevations of buildings shall be agreed before other detail plans are prepared.

Air conditioning units shall be provided in rooms listed in Section 13. Air conditioned rooms shall have a false ceiling such that the overall thermal transmittance of the roof shall be below 0.45 Watts/m²°C.

The false ceiling shall be made from non-combustible materials, and shall be easily removable to provide easy access to small power cables.

All buildings shall be reinforced by a reinforced concrete frame which shall be capable of resisting a horizontal earthquake force of 0.1G.

Main control building shall be of two storey. First storey is cable basement. Second storey shall be designed to have at least 3.5 metres high with an imposed load of 2.5 kN/m² floor loading. An external concrete open staircase shall be provided. The roof shall be a flat in situ concrete slab designed for 2.5 kN/m² live load and a fixed ladder of galvanised steel shall be provided up to the roof.

The roof shall be waterproofed with lime terracing 2:2:7 lime, shurki (powdered brick) and brick chips 0.75" down, which shall be beaten in accordance with local practice. The entire roof area shall be laid in one continuous operation. The minimum compacted thickness of terracing shall be 25mm at the low points of the roof with a 1: 150 slope to those points formed by a layer of terracing of increasing thickness. Once laid, the terracing shall be covered with a layer of bitumen emulsion and the edge of the terracing shall be protected against erosion into the downpipes. Downpipes shall be 100mm diameter uPVC pipe placed outside the wall but shall be enclosed in a facing brick buttress. There shall be at least one downpipe per 100m² of roof. The Contractor shall guarantee the roof against leaks for a period of 5 years from the Taking Over Certificate date. The roof shall project at least 450mm beyond the face of all walls to form a sunshade and rain shelter to the walls below. The upper surface of this projection shall be sloped and a drip provided.

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The main entrance to all buildings shall be shaded, either by a projection of the roof over the entrance veranda or by a separate roof at a lower level. This area of roof shall also be lime terraced and drained by rainwater pipes.

The roof parapet wall shall be about 0.8 metre high with an in situ concrete coping with DPC below it. Where facing bricks are used below the roof level, they shall also be used above roof level. An architectural feature shall be provided by panels of open decorative blockwork (Mirpur ceramics or similar approved) to ensure good air circulation over the roof. Air bricks shall be provided at 750 mm centres in solid portions of parapet wall.

The head of each downpipe shall be fitted with an enlarged hopper and purpose made cast iron grill set into a recess in the roof projection.

Window openings shall be fitted with protruding concrete sunshades above and at the sides of the openings.

All external walls shall be 230mm first class brickwork plus a 50mm thick layer of Mirpur Ceramics facing bricks or similar approved, or rendered with cement render and painted as required by the architectural plan. The internal walls shall also be generally of 105mm thick first class brickwork. Internal walls shall all be rendered and receive one sealer coat plus two finishing coats of emulsion paint. All brickwork shall be tied into the concrete frame by galvanised ties. Externally, rendered walls shall receive primer plus two finishing coats of PEP acrylic external quality paint or similar approved. At least two air bricks shall be provided to each room in which staff work/rest.

Particular attention must be given in the design of buildings and layouts to fire prevention and safety of personnel at all times. Buildings housing switchgear and control equipment shall be designed as far as practicable to exclude pollution under all likely weather conditions. Fire-proof or flame-retarding materials are to be used for floor, wall and ceiling finishes. Where areas are designed as having a fire resistance rating then materials shall be shown to have passed approved standard tests for that class of fire resistance.

The height of control rooms shall provide about 1 metre clearance over the top of the cabinets to the underside of the false ceiling. In the switchgear rooms, about 1 metre clearance shall be provided over the switchgear to the underside of the roof slab but the Contractor shall provide a greater clearance if it is required to remove equipment. The clearance may be reduced below downstand beams provided no equipment is required to be removed from the top of the switchgear. All rooms in any building shall be one height.

Rooms shall have walls and roof slabs adequately insulated. Maximum thermal transmittance values for all rooms shall be 0.7 watts/m²/°C for walls and 0.57 for roofs. Air conditioning units shall be provided in rooms listed in Section 13. Air-conditioned rooms shall have a false ceiling such that the overall thermal transmittance of the roof shall be below 0.45 Watts/m²/°C. The false ceiling shall be made from non-combustible materials, and shall be easily removable to provide easy access to small power cables. Suspended ceilings, with acoustic tiling and incorporating lighting and air-conditioning fixtures shall be used in corridors, offices, control room and SCADA rooms of the buildings and as per schedule of finishes

All structures shall be designed to carry the loads imposed by the structure itself, together with live loads in accordance with an approved standard or code of practice. The roof shall be designed for 2.5 kN/m² live load.



All doors opening outwards from the buildings shall be provided with panic latches or bolts which override any locking device, for escape in the event of fire. All doors shall be provided with overhead door closures of adequate capacity. Door labels incorporating electrical hazard warning in Bangla and English shall be fixed to each entry door. Vision panels shall be provided to frequently used doors. Window openings shall be fitted with protruding concrete sunshades above and at the sides of the openings.

Float operated submersible pump of capacity 25 cum/hour at a head of 8 meters to be provided for sump of basements. The pumps shall be fixed in all respect ready for operation and discharge into storm water drainage system.

The domestic water supply system shall include all plumbing, underground pipework, high and low level storage tanks, valves, fittings and pumps (including the provision of a standby pump) for the provision of a pressurized water supply system for the static water tank and all buildings within the compounds.

On completion of the installation and prior to putting to use, the system shall be sterilized in accordance with an approved Code of Practice.

The Contractor shall be responsible for the provision and installation of a water supply serving the substation buildings. Every cistern, sink, basin, etc., shall be provided with as stop-cock in the supply pipe adjacent to the fitting. Each basin, sink and shower unit is to be provided with both hot and cold water. Provision shall be made for connection to the drinking water supply.

Toilets shall be provided with 1 no. western type WC, 1 no. Asiatic, type WC, 1 no. wash-hand basin, and 1 no. wall mounted mirror. All necessary fittings and accessories shall be provided.

Battery rooms shall be supplied with sink and drainer.

Control buildings housing switchgear and control equipment shall include a cable basement to facilitate connection to the equipment. Basements shall be constructed so as to protect the building substructure from water in accordance with BS 8102.

12.3.2 Ground Conditions, Foundations and Site Investigation

(a) Fill Sites

Site filling shall be carried out by the Contractor. Mechanical compaction of earth or sand in 150mm layers including leveling, watering and consolidation each layer with chain dozer, grader, roller etc. to achieve minimum dry density of 90% with optimum moisture content (modified proctor test) up to finished level all complete and accepted by the engineer subject to submission of the method statement.

On every fill site the Contractor shall prove that his switchyard foundation will not suffer settlement greater than 20 mm by constructing a foundation and load testing this to twice the design bearing pressure for a minimum of 20 days.

The bearing capacity of proposed soil level for outdoor equipment shall be checked by the Plate Bearing Test. The Contractor will be provided by the Employer with a survey of soil levels prior to filling. The Contractor shall impose the site layout on the survey to check for uneven depth of fill below any foundation and where uneven depth of fill exists his foundation proposals shall restrict final differential settlement to a 1 in 400 slope.



If a fill site has not been exposed to one wet season before foundation work starts, the Contractor shall flood the site to a depth of 50mm for 10 days. (Not required on hydraulic fill sites). This requirement is because silty sands will generally compact to a denser condition on first time flooding.

On all fill sites the Contractor shall pipe rainwater from down pipes down to paddy level and shall prevent water ponding in open foundations and backfill all foundations as soon as possible.

The Contractor shall monitor settlement of the fill (by placing concrete posts 50 x 50 x 750mm deep on a 10 metre grid and taking readings) at 30 day intervals from the time he is given access to each fill site.

When a fill site is handed over to the Contractor, the Contractor shall become responsible for maintaining the entirety of the fill in good condition, including all better slopes.

(b) Unfilled Sites

Original delta levels are generally below road level. Therefore most sites are historically fill sites but fill settlement can sensibly be considered complete, where fill is over 3 years old.

(c) Site Investigation

Detailed methodology for subsoil investigation shall be submitted before implementing the subsoil investigation. All laboratory tests shall be done at the test facility approved by the Employer.

The Contractor may appoint a Subcontractor to carry out the site investigation but all work and all lab work shall be witnessed by one of his own staff who shall countersign all recorded data.

Boreholes shall be taken on a 25 metre grid with at least three additional boreholes beside each building. Additional boreholes may also be required where uneven fill depth is encountered.

The number and location of boreholes shall be approved with the site survey drawing showing existing ground levels specified in the section 12.1.4. The boreholes shall be located to an accuracy of + 0.5m and shall be located to site layout considering existing obstacles at the field.

Boreholes shall be a minimum of 20 metres depth or twice building footing width, whichever is greater.

All boreholes shall be backfilled with compacted sand.

Borehole log together with a summary of all required laboratory tests is required to be prepared. Soil test locations are required to be indicated on the geographical map.

In each borehole the following tests shall be carried out:

- Standard penetration tests at 1.0 metre intervals.
- Undisturbed samples shall be taken at around 2.0 metres depth and 3.0 metres depth and tested by unconfined compression tests.
- One-dimensional consolidation tests shall also be carried out on undisturbed samples taken at 2, 3 and 4 metres depth. The samples shall be saturated and the range of applied pressure shall fully reflect the in situ conditions. Graphs showing void ratio (e) and applied pressure shall be submitted along with the coefficient of compressibility for the range of loading anticipated. M_v shall be given in m^2/MN and shall be recorded at each stress increment. The coefficient of consolidation, c_v , shall be



given in m²/year.

- Particle size analysis shall be carried out for each stratum and specific gravity, moisture content, liquid limit and plastic limit determined.
- Ground water level shall be determined by dipping the boreholes. Where collapse of the boreholes occurs, casing shall be used and left in until the water level remains constant for two days.
- In cohesive soils a vane tests to BS 1377: Part 9 shall be carried out at three different depths. The Contractor shall check the sensitivity of soil and ground water at each site to concrete and take all measures necessary to ensure the long term durability of concrete.

(d) Site Investigation Report

The site investigation and analysis of the data in a final report giving full details of foundation proposals shall be completed at each site by the programmed date. During site investigation, Geographical map shall be prepared indicating the locations of soil test.

The report shall be submitted by the key date at each site given in the programme. The Contractor shall submit 2 copies of the report to the Engineer. The report shall propose full details of foundations and loading thereon and shall provide estimates of likely settlements and differential settlements. The report shall be the work of the Contractor's own foundation engineers.

If the Contractor uses a local site investigation Contractor, he shall appoint one of his own staff to oversee the entire operation and each piece of data shall be countersigned by this person.

Where estimated settlement exceeds 25mm, the Contractor shall construct one foundation at an early stage and test load this foundation to confirm settlement predictions.

(e) Foundations

Regardless of the result of soil investigation report, the foundations of main control building, gantry tower/column, power transformer and boundary wall shall be provided with piles.

Piles shall generally be cast-in-situ reinforced concrete piles complying with BS 8004. Pre-cast concrete pile may be used upon approval of employer's engineer.

Foundation type for other structures such as equipment structures, switchyard panel room, guard house, sentry post etc shall be either of spread footing or pile foundation depending on detailed soil investigation.

The minimum depth of all foundations shall be:

- | | |
|---|-------|
| a) Transformer bases and bund | 1.0 m |
| b) All other switchyard foundations | 1.1 m |
| c) Control building foundations,
including all wall foundations
and internal wall foundations | 1.5 m |
| d) Boundary wall foundations | 1.1 m |



All formations shall be hand rammed or mechanically compacted before placing 70mm minimum thickness of Class B concrete blinding, within 24 hours of bottoming excavation, which blinding shall project 300mm minimum distance beyond all footings. Each footing shall be inspected by the Engineer. Where soil condition is poor (on fill sites or already filled sites) or where the Contractor leaves foundations exposed and soil conditions deteriorate, one of the following measures shall be carried out as agreed with the Engineer:

- i) Blinding depth and projection shall be increased
- ii) Soft soil shall be removed and replaced with compacted viti sand with the top 200mm consisting of viti sand and brick chips.

The cost of this work shall be borne by the Contractor.

The Contractor shall propose the allowable bearing pressure for all foundations based on soil strength parameters only and shall not be increased while wind loads exceeds 25% of dead load as well as shall not exceed 125kN/m². Between column footings all walls, including all internal walls, shall be provided with a reinforced concrete strip footing of minimum dimension 800mm wide by 250mm deep placed at the same level as column footings and linked structurally to the footings. In addition column footings shall be tied at foundation level and also floor level by beams to every adjacent column in both orthogonal directions.

These beams shall be designed to resist 1 in 200 differential settlements without distress and shall be capable of resisting the earthquake load of 0.1G.

The deepest parts of any foundations shall be completed first. All foundations shall be completed and backfilled, including all cable tunnel and cable trench work inside buildings, before walls are raised above floor levels. All other foundations shall be backfilled within 7 days of completing concreting.

All exposed concrete and the outer surfaces of cable trenches and cable tunnels shall receive two coats of bitumen mastic paint before backfilling to reduce ingress of water. The Concrete surface shall be ground smooth and all air holes etc. filled (rubbed down with a cement slurry) before painting.

The Contractor shall monitor settlement of all foundations each month and report this settlement to the Engineer until settlement has reduced to less than 1.5mm in 3 months.

The tops of all foundations shall terminate 200mm. above site average finished surface level for new Substation & for existing substation the level should be as per existing. All exposed edges shall have 20 mm x 20 mm. chamfers.

Excavation shall only be carried out when the ground water table is at least 1000mm below foundation level. The excavation shall be kept dry during the construction period by providing sumps and pumps as required. During the rain season, shelters shall be erected over all open excavations.

Any over excavation shall be filled with Class B concrete.

All backfill shall be compacted to 95% maximum dry density as defined by BS 1377 test method, part 4, 2.5 kg rammer.

Before starting foundation work the Contractor shall clear all sites of trees, tree roots, shrubs, debris, surplus soil, and any buildings.

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Foundations shall be designed to resist uplift, assuming the water table is at ground level and the weight of soil resting on a foundation is that included within a 15° frustum.

One working pile from main control building, one working pile from power transformer foundation, one working pile from gantry column/tower foundation of each switchyard chosen by the Engineer shall be load tested at each site to 150% of design load in accordance with BS 8004.

12.3.3 Drainage

The entire surface within boundary walls shall be of uniform sloping site, sloping at 1 in 150 minimum slopes to open channels around the entire perimeter. These channels shall be designed for a rainfall intensity of 60mm per hour. Outside the boundary wall the Contractor shall be responsible for drainage up to 20 metres from the wall and will at some sites need to construct outlets with suitable erosion protection down to paddy level.

The concrete wall of cable trenches shall project at least 70mm. above brick paving level to prevent run off entering the cable trench. The floors of all cable trenches/tunnels shall be sloped to soakway as described in 12.3.16.

The cable trenches will thus form barriers to surface water drainage. If the cut-off area exceeds 30 m² it shall be drained by a 200mm minimum diameter concrete pipe to the boundary drain. The Contractor's drainage design shall avoid all ponded water to avoid forming a mosquito breeding ground.

All drainage pipework within buildings shall be ductile iron, generally of 100mm diameter. Floor drains shall be placed in each battery room and toilet.

External pipework shall be 150mm. minimum diameter concrete pipes at a minimum depth of invert of 700mm. Where pipes, including existing pipes alongside site, are less than 400mm above adjacent foundations they shall be surrounded in concrete. Where required, drainage pipes shall be kept below cables, allowing 1.1 m cover to top of pipes.

Manholes shall be of brick construction with 600mm. x 600mm clear openings and airtight ductile iron covers to BS EN 124. Manholes shall be located at each change of direction. Minimum fall on all pipe-lines shall be 1 in 80. Manholes shall not be located in roads.

The Contractor shall be responsible for all negotiations with local authority WASA where a connection to a public sewer is proposed. Where high water levels in public sewers may cause effluent to back up into a site, non-return valves shall be fitted. The Contractor shall provide all protection required to existing sewers and shall deepen foundations, including boundary wall foundations, where required to ensure all foundations are below adjacent sewers. The Contractor shall draw longitudinal sections of all pipelines.

Each control building shall be provided with a **septic tank** designed for 10 users and a soak away of open brick construction 11m deep by 2.2m diameter filled with broken bricks. The septic tank shall be located at least 15 metres from buildings. Other buildings shall have septic tanks designed for the required number of users. All foul drains shall be vented by a vent pipe to above roof level. The inner surface of all manholes and septic tanks shall be painted with 2 coats of bitumen mastic paint to protect it against sulphate attack. The septic tank shall have access holes directly over the inlet pipes and outlet pipes. Where public sewers exist alongside a site, the Contractor shall connect directly to the foul sewer, provided effluent from the sewer is treated.



The Contractor shall construct the drainage first to ensure that at no stage is rainwater ponded on any part of the site. All rainwater shall be able to run off the site or shall be immediately pumped off site by the Contractor. The Contractor shall complete all necessary drains before casting any roof and large concrete area which will create large run off. The condensate drains for the air conditioning shall also be connected to the drainage. Two vents of minimum height 2.2m shall be provided on each septic tank.

If a town's water supply is unreliable, the roof rain water shall be collected in an underground tank of standard Employer's design. Scope of this work shall be agreed at Bid stage.

12.3.4 Surfacing

For the whole of the switchyard outdoor equipment area the ground shall be surfaced with gravel or other readily available local stone as approved by the Engineer. The switchyard surfacing shall be clean, thoroughly washed when necessary, and free from clay, soil or contaminating material and shall be graded from 20 - 45mm, laid and lightly compacted to a finished thickness of 175mm. Below the gravel layer there shall be a 75mm brick layer with cement mortar (1:6).

The substation plot, outside of the designated switchgear equipment areas, shall be turfed. Turf shall be of good quality, free from weeds and shall be a minimum of 40mm thick. Samples of the turf which is proposed to use shall be submitted to the Engineer for his approval. The turfs shall be laid to even surfaces on a bed of vegetable soil, which shall be raked and consolidated to provide a suitable bed.

On sloping surfaces the Contractor shall provide and fix wooden pegs to retain turfs.

All areas to be surfaced shall first be treated with a total weed killer in accordance with the Manufacturer's instructions. Weed killer shall only be applied in dry weather when there is no risk of it being washed out to adjacent agricultural areas.

12.3.5 Roads

All roads within the site boundary shall be provided by the Contractor, plus access road outside the site boundary to connect to any adjacent public road or waterway. The extent of roads required is shown approximately on Bid drawings but the scope of the work may change.

The road surface shall be finished by concrete paving or equivalent. All roads shall be of reinforced slabs of approximately 25 cm thickness fitted with construction joints. Paving schedule and methodology shall be approved by the Employer.

Road layout shall generally permit vehicles to turn easily to avoid having to reverse out. Road layout shall be designed by the Contractor. The Contractor's Liability for roads outside the site shall be as stated in the Project Requirements of Volume 1.

The width of access road from outside the site boundary to connect to any adjacent public road shall be 6 meters. All roads within the site boundary shall be generally 6 metres wide between the outer edges of kerbs for main road and 3 meters wide for sub road.



The road edge shall be formed by a flush Class B concrete kerb 250mm wide by 300mm deep, placed over one layer of bricks laid flat. The road shall be a Class A concrete slab 150mm deep with 1:50 cross fall and stiff broom concrete finish reinforced with 8mm bars at 200mm centres longitudinally and 8mm bars at 200mm centres transversely placed 60mm below the upper surface. Expansion and contraction joints shall be detailed on site plans. Expansion joints shall have oil resisting grade polysulphide sealant. Below the slab shall be a layer of polythene 0.5mm thick laid over a layer of 150mm thick base course consisting of sand-khoa consolidation with 50mm down graded picked jhama and best quality local sand (F.M 1.2 minimum) mixing in (2:1) (khoa:sand) proportion to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test). If the soil is clay a 75mm drainage layer of broken bricks shall additionally be placed over the soil.

The radius of the road edge at comers shall not be less than 3 metres and 1.2 metres either side of the road shall be kept clear of obstacles. Bollards or raised kerbs shall be provided where required to protect items alongside a road from vehicles. Ducts shall be provided below roads for all services in this Contract and for all future services.

Where mortar designations are referred to see BS 5628 Mortar designation iv is 1 cement: 2 Lime: 8 to 9 sand.

At each new substation site a two bay hard standing car port, complete with sun shades, is to be provided adjacent to the control building.

12.3.6 Water Supply

The Contractor shall be responsible for providing a water supply both for construction and for operation of the completed sites. If a town's water supply is not available, the Contractor shall install a tube well of 40mm minimum diameter and 100m minimum depth but in that case guideline specified by WHO for drinking water is required to be satisfied. The Contractor shall supply and commission power supplies and all pumps required by tube wells.

If a town's water supply is available, the Contractor shall be responsible for making all necessary arrangements with WASA to connect a supply. If the pressure in the supply is inadequate to supply the roof tank continuously, the Contractor shall install an 1800 litre low level tank and pumps. This tank shall be below ground with a 200mm minimum air void around the tank to protect it from contamination. The pump control panel shall be located in the building. Water levels shall be controlled by float switches but the panel shall provide also for manual operation.

The supply shall be connected to an 1800 litre roof tank of 16 gauge galvanised steel plate with a lid secured by bolts. The tank shall be raised 400mm clear of the line terracing on four brick piers of minimum 350mm square. All supplies in buildings shall be fed from the roof tank. The supply to the tank shall have a valve at waist height. The tank shall have an overflow returning to the location of this valve. No pipes shall pass through the roof directly over any room. Pipework shall be routed up the outside of the building and return pipes shall return down the outside of the building before entering through the wall. Pipework shall be galvanised steel secured by clamps at 1-5 metre intervals and painted with alkyd paint to match walls.



12.3.7 Plumbing and Sanitary Fittings

The Contractor shall prepare a drawing of all plumbing and building drainage for each building. Sanitary fittings and plumbing materials shall generally be of approved local manufacture.

Every tap and cistern shall have stop cocks in the supply pipe. One external tap shall be provided on each building. Battery rooms shall be provided with a stainless steel sink of approximate dimensions 900 x 600 x 200mm with a draining board to one side. The battery room floor drain shall be connected to the foul drainage. All floor drains shall have P traps.

Mirrors shall be installed over toilet wash basins. Care shall be taken in orientation of toilets to avoid offending religious sensitivities. Toilets shall generally be orientated North South where possible. Each shower shall have a wall on two sides and a porcelain shower tray sunk into the floor. No hot water is required in any control building. Soap dishes shall be provided beside each shower.

Only foul water from WC pans shall be connected to septic tanks. All other water shall flow to surface water drains.

12.3.8 Control Building Floors

All topsoil containing roots shall be removed and the in situ soil compacted before placing backfill. All backfill, including the backfill to column footings, below the floor shall be sand but around the perimeter walls a band of broken brick 600mm wide shall be placed with drain holes placed in the walls at 2.5 metre centres. The floor and all cable trenches shall be made of Class A concrete. The floor slab shall have a minimum 125mm reinforced concrete Class A thickness and it shall rest on the fill. Below the slab shall be placed a layer of polythene 0.5mm and a layer of compacted broken bricks at least 75mm deep, hand rammed to a smooth upper surface.

The floor/equipment layout shall minimise the number of cable trenches over which station staff have to walk. Where power cables traverse a building to reach a switchgear room on the far side they shall generally be contained within a dedicated cable basement or cable tunnel.

All sand backfill shall be compacted to 95% optimum density and shall be tested. The fill within a building, above ground level, shall not be placed until all backfill outside the building is completed.

Main control building shall have a ramp at a slope of approximately 1 in 7.5, of 1.5m minimum width with a Concrete Class A slab of min depth 125mm with a stiff brush concrete surface finish, or other agreed non slip surface.

All floor rooms shall have homogeneous floor tiles. Verandas and internal stair shall also have homogeneous floor tiles. External stair shall have marble tiles as approved by the employer. Verandas shall have a minimum 1: 50 slope to shed rainwater away from buildings. 150mm high skirting shall be installed beside each wall. Concrete floors and steps shall also be treated with 3 coats of Lithurin or other approved concrete dust proofer.

If floor tiles are not adequately durable to withstand switchgear movement when rolled out to the maintenance position, then galvanized steel chequered plates shall be inserted in the floor to resist the abrasion from switchgear wheels.



12.3.9 Cable Basement

Below ground level basements to buildings shall be of waterproof construction; designed and constructed in reinforced concrete to BS 8007 and BS 8102 [Type C (Drained protection)]. The external walls and base slab shall be a minimum 200mm and 300mm thick respectively. The design shall assume that the ground water table is at ground water level.

The walls and floor of the basement shall have a drained cavity with ventilation provided. The cavity shall drain to a sump, equipped with one hand operated and one electric pump, to facilitate the removal of water. The electric pump shall be of the submersible type with automatic control by float switches. The hand driven pump shall be rotary action and valve less giving smooth non-pulsating flow.

The basement shall be provided with air extraction equipment, 100% standby equipment to give uninterrupted ventilation, sufficient to change the air 6 times per hour. Air supply and exhaust shall be from within the building at ground floor level in a protected location and shall not connect directly to the outside. The stairs leading to the basement shall be enclosed with, from ground level and at basement floor level, entry through security door sets. Sufficient air ducting shall be provided to ensure adequate ventilation to the basement even if the extract fans cease to operate.

The basement shall be equipped with lighting and small power.

Where cables enter the building all ducts and trenches shall be sealed; the ends of all ducts entering trenches shall be bell-mouthed. The floor shall be screened, the walls finished as per the schedule of finishes.

12.3.10 Battery Room Floors

Battery rooms shall have a concrete floor sloping to floor drain. The concrete surface shall be treated with Nitocote epoxy resin coating (Nitoflor primer plus two coats of Nitocote in accordance with Manufacturer's instructions), or similar approved material, to ensure resistance to battery electrolyte. There shall be no cable trenches in battery rooms. Cable entrances through the floor shall be protected by a raised plinth 50mm high around the opening with the annulus around the cable sealed after installation. The door of the battery room will open outside the room.

12.3.11 Control Room Floors

Control rooms where specified in the bid drawings shall have a raised floor (Multi access floor). The Contractor shall submit the drawings showing required details for construction of raised floor for approval by the Employer's representatives.

The raised floor shall be made of poly-urethane material having functions of fire resistance, waterproof and soundproof. Each panel of raised floor shall be installed on the structure frame. The floor material shall have function to easily accommodate cables, communication wiring, etc. on its lower part. The floor material shall include the shock-absorbing material and finishing stuff.

Panel elements shall be produced without fading or peeling on the finishing stuffs and trim by the injection moulding of finishing stuff with panel elements at the same time. By the injection moulding, the panel's thickness and the other standard (width, length, thickness, opposite angle, right angle, flatness



angle, etc.) should be precise.

Pedestal elements shall have the function of support for the panel element of raised floor material.

Shock-absorbing material shall be installed on the top of pedestal elements and prevent any vibration or impact of the panel elements.

The materials for raised floor shall be as shown below or similar. The details should be approved by the Employer.

- Panel stuff: polyurethane
- Panel dimension: 600 x 600 ± 0.5mm (including finishing stuff, trim)
- Panel thickness: 40 ± 0.5mm (including finishing stuff)
- Panel inside core: particle board 35mm
- Panel frame: width 3mm poly-urethane
- Finishing stuff: anti-static laminate tile
- Under structure: zinc electric galvanizing
- Central concentrated load transformation: less than 2.5 mm with 4,900 N

The materials should be kept on the well-ventilated places against rain and direct ray of light. When transporting and handling the stuffs, the handler should be alert not to be damaged. The damaged materials have to be taken out. The finishes of stuff have to be stuck in the panel element.

The floor surface must be dry before construction; also the impurities like dirt and other obstruction should be removed. The under-structures (Pedestal set) are installed at intervals of 600mm from the starting point of construction like radial shape. At this time, the under-structure is fixed strongly on the floor surface by using an adhesive. When each supporting structure is connected to the frame (stringer), the levelling work shall be done together. Horizontal angle shall be checked again after the construction is finished.

Panel lifter and other accessories necessary for maintenance shall be provided by the Contractor.

12.3.12 Site Clearance, Obstructions and Adjacent Structures

The Contractor shall be responsible for clearance of:

- (1) Trees, shrubs and any vegetation including the extraction of all roots and compaction of backfill where roots have been extracted.
- (2) The removal of all buildings, sheds or any other structures above or below ground including the removal of any septic tanks, drains or other underground services.
- (3) The removal of any existing surfacing, roads, foundations or any other obstruction.

All material cleared away by the Contractor shall be the property of the Employer and shall be removed by the Contractor to a site in the Project area upon instructions of the Employer. The Employer may remove any buildings or structures himself from sites before the commencement of site works.

Where an existing service, existing equipment or adjacent building is to be retained, the Contractor shall take all necessary measures to protect the item concerned from damage and shall be responsible for ensuring that no movement of foundations occurs during or after completion of construction.



Any existing electrical equipment/cables which have to be modified or repositioned shall be included in the works at no extra cost. Any buried gas or water main services which require to be diverted shall be deviated by the Employer at his cost. However, where it is possible to retain these existing services and build new structures around them, the Contractor shall take all necessary measures to build in the service at no extra cost.

12.3.13 Guard Houses, Boundary Walls, Fences and Entrance Gates

The guard house serves for control of entrance. The gatekeeper shall be able to watch the area before and behind the guard house. The guard house shall be provided with water supply and toilet. Small power and lighting facilities are to be provided in the Guard House.

The contract has to construct property demarcation structure as per drawing attached with this document immediately after the taking possession of the site. Concrete boundary wall and main entrance gate to be constructed as per employer's requirement. The Contractor shall base his design of boundary walls and entrance gates according to the attached drawing and to be approved by the employer.

The Contractor shall erect a permanent fence 1.5m high around the switchyard as described in the substation layout drawing in accordance with BS 1722 part 10 or similar approved.

12.3.14 Windows

Even natural light shall be provided by windows to illuminate all areas of buildings. Window area shall be about 6% of floor area to limit solar heat gain. Tops of windows shall generally be below 2.25 metres from floor level but toilet windows may be higher. The bottom of windows shall be generally at least 0.75 metres above floor level to provide good protection to staff. Each window shall be provided with a sunshade projecting about 500mm from the wall above and at the upper sides of the window. Few windows shall be placed on south facing walls. Windows shall be spaced to give a wide view of the switchyard.

Windows shall have single glazing with 6mm thick glass, reinforced with wire mesh where windows are placed in or over doors.

Window frames shall be anodised aluminium.

Glass panels shall be placed over doors to provide natural light to internal corridors and rooms where required.

External sills shall have a sloping tile or similar detail with drip.

The Contractor shall prepare a window schedule for each building.

The schedule shall clearly indicate both fixed and opening windows.

The Control and Switchgear rooms in particular shall have opening windows to allow adequate ventilation.

Guard Houses are to include for opening windows with burglar bars and shutters.



12.3.15 Doors

Main entrance door to first floor, Internal doors and door frames shall be anodised aluminium. Door for main entrance to ground floor cable basement and roof door and door frames shall be made of steel. A collapsible gate to be provided at the entrance of internal stair case.

The minimum size of the openings for doors shall be 1500mm wide for double doors and 1000 mm wide for single doors. Door height shall generally be 2250mm but switchgear. All door sizes and widths shall be adequate to get in and get out all equipment and future equipment.

All external doors shall have weather boards, hydraulic closers and cabin hooks to hold the door open.

External doors shall open inwards, except for switchgear room doors which must open outwards and be fitted with panic release latches.

Each door leaf shall have three 150 mm heavy iron hinges equally spaced. Door furniture shall be of approved local manufacture and shall generally be of brass. All corridor doors, external doors and rest room (toilet) doors shall be fitted with hydraulic closers. Door stops shall be fitted where required. Door frames shall generally be set 200 mm off a wall junction to enable the door to open fully through 90°.

All external doors shall be shaded by either the roof canopy or a separate pre-cast concrete canopy over the top and the upper sides of a door.

The Contractor shall prepare a schedule of all doors and all door furniture for each building.

12.3.16 Brickwork

Brickwork shall be designed to BS 5628. External panels of brickwork shall be checked for wind pressure calculated in accordance with BS 6399 for a wind speed of 160 kph 3 second gust.

Bricks shall be first class bricks from approved Manufacturers. 10 bricks shall be tested in accordance with BS 3921 to determine water absorption and crushing strength, which shall exceed 20N/mm². Mortar shall generally be of Mortar designation (iii), 1: 1: 5 to 6. cement, lime, sand.

All brick panels shall be tied to the concrete frame with galvanised ties of approved design. Ties shall be painted with bituminous paint.

Facing bricks shall be of approved quality and size ceramic bricks. Facing bricks shall be tied back to the main wall. External walls shall be 230mm thick brickwork, rendered internally and clad externally with facing bricks or rendered as required by the architectural plan.

Bricks shall be compacted down onto a full bed of mortar. Vertical joints shall be completely filled with mortar. Joints shall be raked out about 10mm deep where walls are to be rendered.

Brick walls shall be constructed so that tops of all meeting walls are about the same level with maximum variation of 0.75m. Only 18 courses per day shall be laid. New work shall be protected from sunlight and drying winds for 4 days.



Lime and cement for all brickwork shall be stored in a dry building with a raised dry floor. Reinforcement by mild steel rods shall be provided where required by the design. Additionally openings over 500mm. wide shall be reinforced for 2 courses above and below the opening, two 6mm. bars per course extending 900mm beyond the opening both sides where possible.

All exposed brickwork shall be rendered and painted where not faced with facing bricks.

12.3.17 Expansion Joints, Joint Fillers and Sealants

Expansion joints shall be placed in floors beside all ground floor walls. All filler board shall be bitumen bound fibre board. Any expansion joints on roofs shall be raised and protected by a metal flashing.

All expansion joints shall be sealed by polysulphide sealants, applied in accordance with the Manufacturer's instructions. Sealants shall be oil resisting grade where required. Sealant colours shall match or blend with adjacent wall colours.

12.3.18 Cable Trenches in Switchyards

Cable trench sizes shall be standardised. Layout drawings shall be submitted for each substation showing layout and size of trenches. No trench shall cross a road; power cables shall be placed in ducts of minimum 150mm diameter with bell-mouthed ends. Ducts shall extend 1500mm minimum beyond the edge of roads. Spare ducts shall be installed for likely future development.

Floors and walls of trenches shall be constructed of Class A reinforced concrete of minimum 150mm thickness, with the external surface painted with two coats of bitumen mastic paint. Walls and covers shall protrude at least 70mm above site finish level and the top of the wall shall be flat with no rebate.

Floors shall be sloped at 1: 150 minimum slopes to brick soak ways placed below the trench at low points; the volume of each soak away shall be 2.5m³ per 150m² of trench.

Covers shall be of reinforced concrete Class A. Each cover weighs less than 55 kg. The minimum depth shall be 70mm, with down stand ribs along each side providing a minimum overall depth of 100mm. The ends of the cover shall overhang the wall by 15mm and in the centre of each end there shall be a hand hole of minimum size 100mm by 20mm high. This hole shall allow air to ventilate the trench so that heat built up in the trench shall be reduced. No gaps larger than 5mm shall be left between adjacent covers so that the cables are always shaded. Cover slabs shall sit squarely and uniformly on the trench walls without the need for bedding or shims. Because portable fire extinguishers will be rolled over and along trenches, each cover shall be capable of resisting a 250kg point load at mid span. The Contractor shall provide ramps up to the edge of covers in several locations, as agreed on site, to enable the wheeled extinguisher to mount the covers. Longitudinal edges may be inclined at 10° to the vertical, thus creating a larger gap at the bottom of adjacent slabs, again to reduce heat build-up. The upper surface of covers shall have a stiff broom non slip concrete finish. All sharp edges shall be stoned smooth. Outer edges shall be chamfered.

Longitudinal fire separation walls and transverse fire separation walls as required by the cable section, may be of brick or reinforced concrete.



12.3.19 Cable Trenches in Buildings

The base and walls of the trench shall be of reinforced Class A concrete of minimum thickness 110mm with the outside face painted with 2 coats of bitumen mastic paint. Cable trays may be supported by Unistrut P3300 inserts, or similar approved or drilled anchor bolts.

The building layout shall minimise trench lengths. Where power cables pass through a building to reach the far side, this shall generally be in a tunnel section. The Contractor shall be responsible for providing all trenches and ducts in a building, including ducts for outgoing power cables up to the site boundary and including any pulling pits required.

Trench covers shall be sheets of checkered plate or similar approved, consisting of wood fibres impregnated and compacted in synthetic resin, or a computer flooring composite board.

The weight of each cover shall be restricted to about 30 kg. The upper surface shall be non-slip. Deflection shall be limited to 1/250 of span under a load of 3kN/m². Only one thickness of board shall be used to standardize the edge support detail. The recess to receive the cover shall be protected by steel or brass on the vertical edge and bedding surface. Covers shall fit snugly around all cables. Where cables enter the building, all ducts/trenches shall be sealed. Fire/oil barriers shall be required to separate hazardous equipment. The ends of all ducts entering trenches shall be bell-mouthed.

Any beams used to support large span covers shall be removable. All metal work shall be painted as specified in the paint section.

All covers shall bed down evenly. Full detailed fabrication drawings shall be provided for all covers.

12.3.20 Rainwater Pipes

Down pipes shall be 100mm minimum diameter placed on the outside of walls but enclosed in a brick buttress of facing bricks. One downpipe shall be provided for each 100m² of roof area. The head of the downpipe shall be enlarged to 200mm diameter and a purpose made cast iron grill provided over the head. This grill shall be sited in a recess in the roof slab projection.

The foot of the pipe shall have a 90° bend and water shall be discharged into either:

- i) a small open channel conveying the water to the boundary channel
- ii) a pipeline conveying the water off the site. Rainwater shall not be connected to the septic tank or allowed to discharge directly onto switchyard paving.

12.3.21 Switchyard Foundations

The tops of all foundations shall be set at the same level, which shall be raised above the general switchyard level for the purpose of preventing surface water coming into contact with the equipment structures and holding-down bolts. The distance between the general surface level and the top of foundations shall be at least 200mm. All exposed concrete surfaces shall be painted with an acrylic weatherproofed or bituminous paint, and flat areas shall be sloped to shed water. No base shall permit ponding of water in any way, and free drainage shall also be possible from all areas inside any grouting.



Bases shall generally be of Class A reinforced concrete.

Bases shall have all recesses for cables and earthing detailed on drawings. The drawings shall clearly show the orientation of each base and the location of all recesses. Where new foundations are adjacent to existing foundations; the Contractor shall be responsible for verifying the extent of the existing foundation and ensuring its stability.

For anchorage design of switchyard foundations shear force, vertical accelerations, overturning moments and torsion due to mass eccentricities of the equipment for the earthquake load of 0.2G are required to be considered. Mild steel ductile bolts and headed studs cast-in-place anchor bolts shall be used. Thick plate washer is required to be welded to the equipment base plate. Normal washer shall be used under a nut in all cases.

12.3.22 Transformer Bases

The transformer base, together with its surrounding bund shall form a raft to distribute the load from the transformer over the entire area within the bund wall. The bund shall extend at least 700mm beyond any part of the transformer and its radiators. The level of the top of the bund and the skids shall be 200mm above general switchyard level. Skids shall extend to the edge of the bund.

50mm below the top of the wall shall be placed a layer of stone 225mm deep set on a galvanised grill painted with two coats of bitumen mastic paint. The volume of the bund below the stone shall equal 125% of the total volume of oil in the transformer and its radiators.

Rainwater will tend to collect in the bund. To evacuate rainwater a fixed submersible pump controlled by sensors and switches (Aqua Sentry or equal) shall be provided at each bund with power supplies and drainage manhole conveniently located. The bund water control system shall differentiate between water and oil to ensure that the pump will not be activated while oil is present in the bund.

The transformer base and the bund shall be founded a minimum 1.0 metres below average switchyard finished level.

Below the skids the walls shall be at least 600mm wide. Piers shall be provided below the jacking points. Each base shall be provided with two galvanised steel removable pulling posts on the other side of the access road to the bund and also at the back of the transformer bund.

The entire concrete surface of the bund and the transformer base which is not buried shall receive two coats of bitumen mastic paint. Skids shall receive 3 coats of bitumen mastic paint before being cast in. A carriage way shall be provided with rail connected with all transformer bases.

Transformers shall be anchored to resist the earthquake load of 0.1G.

12.3.23 Blast Walls

The Contractor shall construct blast walls to reduce the risk of fire spreading from each three phase transformer unit to an adjacent transformer unit or control building. Blast walls shall also be constructed to resist impact forces causing from a transformer explosion damaging adjacent equipment.



The width of the blast walls for transformers shall be 500mm higher than the tops of transformer or same height of the tops of the HV bushing and 300mm wider at both sides than the width of transformer. The thickness of blast walls shall be 200mm minimum.

The wall may be constructed in Class A reinforced concrete with all exposed edges chamfered.

12.3.24 Paints and Painting

All paints shall be of approved makes and colours and proven suitability for the prevailing climate and shall be approved by the Engineer. All surfaces for painting shall be cleaned down prior to being painted and rubbed down to a smooth finish.

All externally exposed concrete and render of the control buildings, boundary walls, blast walls and guard posts shall be painted with a fungicide, Snowcem primer and two coats of Snowcem. All exposed facing bricks and Snowcem painted surfaces shall be treated with one coat of clear silicone (5%) water proofing solution.

All exposed parts of foundations, the outer faces of cable trenches and cable tunnels shall be painted with two coats of bitumen mastic paint.

All ungalvanized metalwork shall receive two coats of red oxide paint at least 4 days before installation and shall receive two finishing coats of paint after installation, each coat being of different colour. Surface preparation before painting shall be SA 2.5 or an agreed rust convertor acid shall be used. All galvanized steel, including all brick ties, boundary wall wire supports, crane beams, and baseplates and holding down bolts and concrete plinths shall receive two coats of bitumen mastic paint. Galvanized steel shall not be painted until the surface has weathered.

Internal walls when fully dry shall have the surface rubbed down with sandpaper and be painted with a sealer and 2 finishing coats of plastic emulsion paint before equipment is installed. A further finishing coat shall be applied after completion of installation.

One day shall be allowed for drying of each coat before the next coat is applied. The interior of all septic tanks and manholes carrying foul sewage shall receive two coats of bitumen mastic paint.

12.3.25 Furniture

The Contractor shall supply a complete set of tables, chairs, stools, desks, benches, storage shelves and drawing cabinets as described in the Project Requirements, Volume I with layout top, for drawing examination, lockable cabinets for spares and test equipment and key boxes in each control building.

These shall generally be of steel of local manufacture and shall be of robust durable construction. In each rest room (toilet) two couches, approximately 900mm wide by 1900mm long with back rests against the wall, shall be provided.

The full details and specification of these materials shall be agreed before purchase. The Contractor shall arrange for a list of items to be handed over to the Employer, who will sign for receipt of a complete set as stated on the list.

Furniture shall be provided for new substations only.

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12.3.26 Concrete

Only two grades of concrete shall be used. Class A shall be used for all structural work, piling and for all foundations which are not unreinforced massive blocks. Class B concrete shall be used for blinding, pipe surround and unreinforced or nominally reinforced concrete. Road slabs and floor slabs shall all be reinforced Class A concrete.

	Class A	Class B
Minimum cement content	360 kg/m ³	170 kg/m ³
Maximum water/cement ratio	0.55	-
Coarse aggregate type	broken stone	Jhama brick
Max. coarse aggregate size	200 mm (40 mm piling)	25 mm
Method of batching	volume batching	volume batching
Minimum characteristic of trial:		
• Mix at 28 days	30 N/mm ²	-
• Minimum characteristic strength of trial mix at 7 days	14 N/mm ²	-
• Minimum characteristic strength of workscubes at 28 days	20 N/mm ²	-
Slump range (minimum / maximum)	30 mm / 100 mm	min. 50 mm
Slump for concrete placed below water in piling (minimum / maximum)	150 mm / 200 mm	

It should be noted that minimum specified cement content will produce significantly stronger concrete.

The Contractor's design shall be based on a 28 day crushing strength of 30N/mm². Design shall be in accordance with this Contract and BS 8110 or other agreed standard.

Minimum cover to rebar shall be 60mm where concrete is in contact with backfilled soil against a shuttered face, 100mm where concrete is cast against soil, and 30mm for all above ground concrete. In detailing bars which traverse a member, a reduction of 5mm shall be made for a bent bar and 10mm for a straight bar to ensure adequate cover. Exposed ends of sunshades and roof projection shall have 70mm minimum cover.

All concrete design shall ensure easy access for vibrators of 50mm. minimum diameter. Because of the slowness of concreting using local methods of transport, congested reinforcement details and shapes which are difficult to concrete should not be used. The location of all cold joints shall be agreed in writing with the Engineer and all joint surfaces shall be scabbled. All joints shall be horizontal or formed against vertical stop ends. All cold joints shall be indicated on drawings. Roof slabs shall generally be cast in one continuous operation.

12.3.27 Concrete Reinforcement

The Contractor may use locally available mild steel bars from approved sources or import steel bars to any agreed standard. No bar or stirrup shall be smaller than 6mm diameter to ensure adequate rigidity during concreting.

If locally purchased bars are used, bending tests and tensile tests shall be carried out to ensure the bars meet the design standard adopted and weight per unit length shall be tested regularly.

Bar bending lists shall generally be shown on drawings, where possible with a diagrammatic representation of each bar to ensure clarity and ease site communication. The Engineer will not systematically check the accuracy of every bar on bar lists when approving drawings. The Contractor shall therefore arrange to check all bar lists. Drawings shall detail all chairs and ties and include these on bar lists.

Bars shall be tied at every intersection and the ends of tie wire bent away from concrete surfaces.

Anti-crack bars shall be provided at changes in slab or wall thickness and at the corners of every rectangular opening.

12.3.28 External Render

All brickwork which is not faced with facing bricks shall be rendered. Concrete columns and walls shall be rendered and painted in accordance with BS 5262 with a 3mm spatter dash coat a 12mm undercoat followed by a 9mm finishing coat. Surface preparation shall be as described in BS 5262. Joints shall be provided in all render where brickwork panels abut concrete columns and grade beams, as required by BS 5262.

A mix type II or III shall generally be used. The finishing coat shall be weaker than the undercoat.

The tops of all foundation blocks and all protruding concrete foundations shall also be rendered where required by the Engineer.

PVA Bonding agents shall not be used because of the risk of early drying in the tropics. All concrete surfaces to be rendered shall have the entire surface scabbled and brushed with a stiff brush to remove all loose material. The surface of the undercoat shall be roughened to ensure bonding of the finishing coat.

All render once completed shall be kept continuously damp for 10 days, after which it shall be treated with a fungicide. Any existing backgrounds shall be treated with a fungicide and all growth cleaned after 5 days of contact with the fungicide.

12.3.29 Goalposts

In each outdoor switchyard with live conductors crossing roads the Contractor shall erect a permanent goalpost at the edge of the danger area with red and white metal warning boards hanging down from the goalpost to warn high vehicles of the overhead danger. This structure shall conform and match those supporting structures in Section 12 of this Contract for the high voltage switchgear.

12.3.30 Lifting Beams

In two storey control buildings a galvanised steel lifting beam shall be provided for hoisting equipment to all upper floors. The beam shall be fixed permanently in place and shall project the required distance from the building to lift the largest equipment from road transport. Beams shall be designed in accordance with BS 2853 and deflection shall be limited to 1/900th of span. An approved (Morris of Loughborough 190 Series with Morris 164 travelling trolley or similar approved) hand chain hoist with hand geared travel and travelling trolley of capacity to suit the heaviest equipment or future equipment shall be provided on each beam. The chains shall reach to lorry level and provision shall be made to



hang up the chains to one side when not in use.

Inward opening doors shall close around the beam and be shaped to a close fit.

12.3.31 Stairs

Two storey buildings have an external staircase, which shall have a minimum clear width of 1.8 metre with a maximum slope of 30°, all detailed in accordance with BS 5395. External staircases shall not be enclosed but shall be completely protected against rain by roof projections. Steps of stair shall be open with non-slip nosing. At least 900mm high stainless steel railing shall be provided alongside each flight of stairs.

All roofs which are not accessible by stairs shall be provided with a galvanised steel fixed ladder.

12.4 Concrete Workmanship

12.4.1 General

At all stages in the production, mixing, placing and curing of concrete, the work will be inspected by the Engineer's representative. If any material, dimension or practice is not at least equal to the standards set out herein, it shall be rejected and alternatives compliant with the said standards, and in addition to the satisfaction of the Engineer, shall be implemented.

12.4.2 Aggregates

Coarse aggregate shall be capable of passing through a 20mm sieve and be retained on a 5mm sieve. Fine aggregate shall be not larger than 5mm and not smaller than 0.06mm and shall be sharp in texture.

All aggregates shall be free of harmful quantities of organic impurities, clay, silt, salt or unsound particles. The amount of clay, silt and fine dust present in aggregate, whether as coatings or separate particles, may not be more than:

- 15% by weight in crushed sand
- 3% by weight in natural or crushed gravel sand
- 1% by weight in coarse aggregate.

If the Engineer considers that any aggregate which the Contractor proposes to use contains an excess of fine particles or any harmful substances, the Contractor shall either replace the aggregate or, at his option and entirely at his expense, institute a series of approved tests at an approved laboratory to determine the nature and extent of the fine particles and harmful substances. Following receipt by the Engineer of the results of the analysis and tests, he will advise the Contractor in writing whether the proposed aggregate may or may not be used. The Engineer's decision in this respect shall be final.

Tests to determine the extent of impurities or fine particles shall include (but shall not be restricted to) the relevant tests specified in BS 882:1992, ASTM. C40-79 (Colorimetric test) and ASTM. C33-82.



12.4.3 Sampling

At least four weeks before he envisages first receiving aggregate from any source the Contractor, in the presence of the Engineer, shall obtain samples for testing. Samples shall be taken in accordance with the procedure quantities laid down in BS 812 and shall be subjected to those tests which the Engineer considers necessary to demonstrate the soundness of the material.

Such tests shall be carried out in an approved manner at the Contractor's expense and may include the manufacture, both in the laboratory and at site, of test cubes or cylinders to determine crushing strength.

12.4.4 Grading

The Contractor shall ensure that his offer includes the full cost of obtaining and transporting suitably graded stone aggregates to site.

Grading of aggregates should, together with the required minimum cement content and water cement ratio, ensure adequate durability, density and characteristic strength of the finished concrete. The

Contractor shall submit in writing to the Engineer the make-up of the mix he proposes to use, together with the grading analysis for the particular material and any details concerning his or others' experience with the use of aggregate obtained from the same source.

12.4.5 Cement

Ordinary Portland Cement or Portland Composite Cement shall be used in structural concrete. Ordinary Portland Cement shall comply with BS 12 while Portland Composite Cement shall comply with BS EN 197-1. The Contractor may obtain cement, bagged or in bulk, from any approved source in Bangladesh but shall always submit sufficient samples from each delivery, as required by the Engineer, to ensure that all cement complies with the minimum requirements of BS 12. All cement shall be stored in a weather tight shed at least 300mm off the floor. Regular checks shall be made on the weight of cement in each bag.

12.4.6 Water

All water used in the preparation of concrete for foundations shall be clean, fit for drinking and free from all earth, vegetable matter and alkaline substances, whether in solution or in suspension, and shall comply with BS 3148.

12.4.7 Reinforcing

Where reinforcing is specified in any foundation design, it shall comply with BS 4449 or an approved similar standard. Before any reinforcing is used, the Contractor shall provide the Engineer with a certified mill certificate, verifying its grade and quality, and proof test such samples as the Engineer considers necessary. All reinforcement shall be clean and free from loose mill scale, dust, loose rust and paint, oil or any other coating which in the opinion of the Engineer may destroy or reduce bond.

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12.4.8 Storage

The Contractor shall ensure that all the materials he provides for the preparation of concrete shall be stored in a manner which prevents contamination by dust, clay, water or any other harmful material. Heaps of coarse and fine aggregate shall be separated by at least one metre. Where aggregate is tipped directly onto the ground, the bottom 20cm of the heaps shall not be used.

Bagged cement shall be protected from rain, mixing water or damp soil during storage/transport. Cement from accidentally split or damaged bags shall not be used.

Where the Engineer considers it necessary, special precautions shall be taken to ensure that aggregate stored on site shall remain dust free. Such precautions may include the bagging of aggregate at the pit if sites are adjacent to dusty roads or if heavy rain is liable to wash out fine material or saturate the aggregate to an extent which might influence the water content of a mix.

Where the Contractor establishes central depots for receiving cement prior to despatch to individual sites, he shall ensure that the cement storage areas are sufficiently raised above the surrounding ground to prevent contamination of the cement by surface water. The material from which storage plinths are made shall be approved by the Engineer.

12.4.9 Design Mix

Prior to ordering any aggregate the Contractor shall inform the Engineer of the source(s) of his aggregates and deliver samples to the Engineer. The Contractor will authorise at an approved laboratory tests to show the sieve analyses, relative densities, moisture content of the samples of aggregate from each source. At least four test specimens of concrete shall be mixed at an approved laboratory and tested after 7 and 28 days.

Depending on the moisture content of the samples of aggregate the Contractor will report to the Engineer on the expected water/cement ratio and the aggregate/cement ratio of concrete to be produced on site.

Following the successful testing of the laboratory samples the Contractor shall make trial mixes at site (from which he will take at least 4 test specimens) using the proportions advised to the Engineer (and in the presence of the Engineer) and using the equipment he intends to use in the normal day to day manufacturing of concrete. The minimum 28 day crushing strength of any such test specimen shall be not less than 20.7 N/mm².

After successful testing of the test specimens made at site, the Engineer may then approve the source(s) of aggregate and the mix design.

No changes to the approved mix design will be permitted unless the type or source of aggregate differs from those already tested, in which case further tests at both the laboratory and at site will be made.

Any concrete placed which does not conform to the approved mix designs, shall be removed and replaced by the Contractor at his own cost.



12.4.10 Mixing and Placing of Concrete

Proportions of aggregates and cement and the quantity of water for each batch of concrete shall be closely monitored by an experienced mixer operator. Aggregate shall preferably be weight batched but, where this is not possible, volume batching shall be permitted, provided that the net volumes of the loading equipment are approved by the Engineer. Containers for measuring quantities of water shall be clearly marked and only approved quantities of water shall be used in the manufacture of concrete.

Mechanical mixers shall be in good condition and well maintained. After loading, the constituent parts of the concrete shall be mixed together for a period of not less than two minutes or 30 revolutions of the barrel, whichever is the greater. For mixers with a capacity greater than 1.5m³ these periods may be increased if the Engineer so requires.

When the constituents are adequately mixed, the fresh concrete shall be discharged from the mixer and placed in the foundation with the minimum of delay. Chutes shall be used to ensure that fresh concrete is not dropped by more than 1.5 metres.

No concrete shall be placed until all form work, installation of parts to be embedded, and preparation of surfaces involved in the placing have been approved. No concrete shall be placed in or through water, except with the written permission of the Engineer, and the method of depositing such concrete shall be approved by the Engineer.

Concrete shall not be placed in running water and shall not be subjected to the action of running water until after the concrete has hardened for seven days. All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, mud or other foreign material, shall be cleaned of all such refuse before the surrounding or adjacent concrete is placed. Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud and other foreign matter. The surfaces of concrete which have set, and against which new concrete is to be poured, shall be thoroughly cleaned to remove all foreign material and laitance, and be saturated with water immediately before placing concrete. Concrete shall be deposited continuously and as rapidly as possible until the unit being poured is complete. If for any reason the work is stopped before completing the unit of operation, a construction joint shall be installed in accordance with the instructions of the Engineer. Concrete shall be so deposited as to maintain, until the completion of a unit, a plastic surface approximately horizontal.

The method and equipment used for transporting concrete shall be such that concrete having the required composition and consistency will be delivered as near as practical to its final position without segregation or loss of slump. All concrete mixing and placing equipment and methods shall be subject to approval by the Engineer. Concrete placement will not be permitted when, in the opinion of the Engineer, weather conditions or other pertinent factors prevent proper placement and consolidation.

Bidders are reminded that, as a minimum standard, the following series of inspections should be carried out by the Contractor before concreting can begin:

- 1 Formwork coated with mould oil and correct in type, quantity and condition
- 2 Centre lines of template to coincide at the centre peg
- 3 Formwork to be well strutted and correctly located
- 4 Vibrator to be in working order
- 5 Mixer to be in working order



- 6 There is provision to maintain continuous mixing and pouring, by hand if necessary, in the event of a mixer breaking down
- 7 Where necessary, re-bar is on site ready bent and complete with tie wire, stirrups and concrete or plastic preformed spacer packs
- 8 A reliable level is at hand
- 9 There is sufficient aggregate, cement and water to complete the pour
- 10 Excavations are safe and not cluttered around the top edges
- 11 The mixer barrel is clean, and the paddles are complete and in place and the barrel will rotate at the speed specified by the Manufacturer
- 12 A suitable chute is in place
- 13 Both an air thermometer and concrete thermometer are on site
- 14 There is a large quantity of hessian sacking at hand

Where any of the above items are not complied with, the Engineer may suspend concreting pending their implementation.

12.4.11 Testing of Concrete

Samples shall be taken and tested in accordance with BS 1881. Testing shall be carried out by an approved laboratory, who shall arrange to immediately notify the Contractor and the Employer in writing of any cube failure. Failed cubes shall be kept for reference.

Concrete for the test specimens shall be taken at the point of deposit. To ensure that the specimens are representative of the concrete, a number of samples shall be taken from different points. Each sample shall be large enough to make one test specimen and shall be taken from one point in the work.

The tests specimens shall be stored at the site at a place free from vibration, under damp sacks for 24 hours $\pm$ 1/2 hour, after which time they shall be removed from the moulds, marked and stored in water at a temperature of 10° to 21°C until the test date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in damp sand or other suitable damp material, and shall reach the laboratory at least 24 hours before test. On arrival at the laboratory, they shall be similarly stored in water until the date of the test.

One compression plate of the testing machine shall be provided with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the plate. Test specimens shall be placed in the machine in such a manner that the load is applied to the sides of the specimen as cast.

Cube strengths for concrete are to be not less than 14.8N/mm² within seven days after mixing and 20.7N/mm² within 28 days after mixing.

One cube shall be tested at 7 days to obtain an indication of the concrete strength. The remaining three cubes shall be tested at 28 days and the average of their strengths shall be calculated. Should the average of the cube strengths fall below the specified 28 days cube strength, the Engineer may order the affected concrete to be removed and replaced at the Contractor's expense, or the Engineer may allow the Contractor to take a cylinder for further testing in accordance with BS 1881, if Schmidt Hammer readings indicate below strength concrete.

The diameter of the cylinder shall be not less than three times the size of the maximum aggregate and



its length will be at least double the diameter, after allowing for preparation and facing prior to the test.

Both a report and compression test will be completed for the sample in accordance with BS 1881. Only one such test will be permitted from any one sample and if the crushing strength of the sample is in excess of that required by the design the Engineer may, after the Contractor has made suitable repairs to the part disturbed by taking the sample, accept the concrete.

In addition to cube sampling, 30% of concrete pours shall be tested by Schmidt Hammer. The Contractor is to pay for all remedial work and testing. Readings shall be taken at locations agreed with the Engineer and shall be witnessed by the Engineer. At least 15 readings shall be taken such that, after discarding the highest and lowest, some 12 readings remain from which the mean shall be calculated.

Readings shall be restricted to the middle third of a beam, slab or column and shall not be closer than 50mm to an edge or closer than 50mm. to any other readings. Immediately on completion of hammer testing, the concrete surface shall be painted to seal it with two coats of snowcem primer.

12.4.12 Formwork

Formwork shall conform to the shape, lines and dimensions of the concrete as called for on the Plans and shall be sufficiently strong to carry the dead weight of the concrete without undue deflection or bulging, and sufficiently tight to prevent leakage of mortar. It shall be properly braced and tied together so as to maintain position and shape. Members used in forms at exposed surfaces shall be dressed to uniform thickness and shall be free from loose knots or other defects. Joints in forms shall be horizontal or vertical. At all unexposed surfaces and rough work, undressed timber may be used. Timber re-used in shutters shall have nails withdrawn and surfaces to be in contact with concrete thoroughly cleaned before being reused. Formwork shall not be disturbed until a minimum of 48 hours has passed from time of placement and concrete has hardened sufficiently to support any construction loads that may be imposed when stripping forms, metal wedges or tools shall not be used to pry panels loose. If wedging is necessary, it shall be done with wood wedges lightly tapped to break adhesion.

All columns and beams will have exposed edges chamfered 20 mm x 20mm.

12.4.13 Reinforcing Steel

Steel reinforcing bars shall be positioned in the concrete at the places shown on the drawings, or where reasonably directed by the Engineer.

Before reinforcing bars are placed in position, surfaces shall be cleaned of heavy flaky rust, loose mill scale, dirt, grease and all foreign matter. Once in position, reinforcing bars shall be maintained in a clean condition until they are completely embedded in concrete. Reinforcing bars shall have at least the minimum concrete cover shown on the drawings. Reinforcing bars shall be accurately placed and secured in position, such that they will not move during placing of concrete. Precast concrete block spacers may be used for supporting reinforcing bars.



12.4.14 Consolidation of Concrete

Concrete shall be consolidated to maximum practical density, without segregation, by vibration so that it is free from pockets of coarse aggregate and closes against all surfaces and embedded materials. Vibration of concrete in structures shall be by electric or pneumatic-driven immersion type vibrators of 50mm minimum diameter, operating at speeds of at least 8,000rpm when immersed in concrete. The vibrator shall be inserted vertically at close enough intervals so that the zones of influence overlap.

The vibrator shall be inserted to the full depth of the layer being treated and withdrawn slowly. When concrete is being placed in layers, the tip of the vibrator shall extend approximately 100mm. into the underlying layer. Vibrators shall not be used to move concrete horizontally. Care shall be exercised to avoid over-vibration of the concrete and direct contact between the vibrator and reinforcing shall be avoided.

12.4.15 Curing of Concrete

For foundations where excavations are to be backfilled immediately following the striking of shutters, the concrete is to be thoroughly wetted before backfilling commences. Where shutters are to be struck and backfilling of the excavation is not to take place immediately, the concrete is to be covered with wetted hessian sacking and be enclosed in polythene sheeting to avoid rapid drying of the concrete.

12.4.16 Hot Weather Concreting

In hot weather the following additional precautions shall be taken.

- (a) In hot weather suitable means shall be provided to shield the aggregate stockpiles from the direct rays of the sun or to cool the mixing water/aggregates to ensure that the temperature of the concrete when deposited shall not exceed 32°C.
- (b) In hot dry weather suitable means shall be provided to avoid premature stiffening of concrete placed in contact with hot dry surfaces. Where necessary the surfaces, including reinforcement, against which the concrete is to be placed shall be shielded from the rays of the sun and shall be sprayed with water to prevent excessive absorption by the surfaces of water from the final concrete.

12.5 Workmanship of all Other Materials

This specification only describes concrete work in detail. All other materials workmanship shall be in accordance with an agreed standard. Before starting any new item of work the Contractor shall submit samples of the materials to the Engineer for approval in writing and the method of installation shall also be approved. The first item of any type to be installed shall be inspected and checked in detail by the Engineer before other items are constructed.



12.6 Fire Extinguisher

12.6.1 Control Room/Communication Room/Battery Rooms

These rooms shall be protected by a portable CO₂ fire extinguisher system. The system shall consist of all equipment required for directing the CO₂ gas discharge at a fire including, but not limited to, CO₂ cylinders and necessary piping, a flexible hose along with a jet nozzle. The effective reach of CO₂ gas jet release shall be sufficient to fight small fires that could develop in a control room area. Fire extinguishers shall be placed at strategic locations as per instruction of project engineer. The quantity of extinguisher at each new substation are given in Table-1.

12.6.2 Cable Room/Outdoor Switchyard

These areas shall be protected by a portable dry-type ABC powder fire extinguisher system. The system shall consist of all equipment required for directing the dry ABC powder discharge at a fire including, but not limited to, a wheel carriage(only for 15kg capacity) loaded with portable cylinders and necessary piping and a flexible hose along with a jet nozzle and pressure gauge. The extinguisher material shall be non-explosive, non-hazardous, non-corrosive, non-toxic. The effective reach of jet release shall be sufficient to fight small fires that could develop in an outdoor switchyard, cable room and storeroom area. Fire extinguishers shall be placed at strategic locations as per the instructions of the Project Engineer. In addition, sand buckets shall also be provided, with a metal frame for hanging buckets and shall be placed at locations directed by project engineer. The quantities of extinguishers at each new substation are given in the table below:

Type, characteristics	Quantity
CO ₂ type, 5 kg	5 sets
CO ₂ type, 3 kg	5 sets
ABC dry powder type, 5 kg	5 sets
ABC dry powder type, 15 kg, including wheel carriage	4 sets
Sand bucket, with metal frame, with all accessories	2 sets

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