NOIDA METRO RAIL CORPORATION LIMITED

CONTRACT NO: NMRC/Projects/NGNEDDC/2025/415

Contract NGNEDDC: Detail Design Consultant (DDC) for Civil, Architectural and E&M works including Traction works for Elevated Sections of Extension Projects of Aqua Line from Noida Sec-51 to Knowledge Park-V, Noida Sec-142 to Botanical Garden & Depot Station to Boraki including augmentation of existing depot and RSS works (31.595 km).

VOLUME-5
STANDARD DOCUMENTS

PART I - OUTLINE DESIGN CRITERIA - RAILWAY GEOMETRY, BRIDGES AND VIADUCTS
PART II - OUTLINE DESIGN CRITERIA - GEO-TECHNICAL, FOUNDATION AND RAILWAY FORMATION WORKS
PART III - GENERAL PLANNING CRITERIA
PART IV - BUILDING SERVICES
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PART VI - DESIGN CRITERIA (DEPOTS, YARDS AND WORKSHOPS)

NOIDA METRO RAIL CORPORATION LTD.
Block-III, 3rd Floor, Ganga Shopping Complex,
Sector-29, Noida -201301,
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OUTLINE DESIGN CRITERIA

RAILWAY GEOMETRY, BRIDGES AND VIADUCTS

Section D1 - GENERAL, CODES AND STANDARDS

D1. 1 Purpose and Scope

D1.1.1. The Outline Design Specifications hereto provide minimum standards that are to govern the Design of the Permanent Works.

D1.1.2. The Outline Design Specifications shall be read in conjunction with the Outline Construction Specifications where ever appropriate.

D1.1.3. The design and construction of the Permanent Works shall comply with codes of practice and standards current at the time of submission of Tender Documents. Regulations made and requirements issued by the Government of India and by relevant utility authorities shall be followed and specified.

D1.1.4. Alternative or additional codes, standards and specifications proposed by the DDC shall be internationally recognized codes and shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional body or organization, subject to being, in the opinion of the Engineer, suitable for incorporation or reference into the Specifications.

D1. 2 Codes and Standards

Design and loading requirements for the structures shall be not less than the following Indian Standards and Codes of Practice, together with all applicable amendments.

Where other standards and codes of practice are referred to in the text of other Appendices then the designer is expected to apply those Standards and Codes of Practice unless the designer can show that an economic case exists for use of an Indian Standard. However, preferences of codes will be as follows: –

1) IRS - Where any structures supporting railway tracks.
2) IRC
3) IS
4) BS
5) AASTO

D1. 3 Indian Railway Standards (IRS)

IRS - Bridge Rules for loading (Ministry of Railways)

IRS - Code of practice for steel bridges.

IRS- Code of practice for plain, reinforced and pre-stressed concrete for general Bridge construction. Second Revision – 1997.

IRS- Code of practice for the design of substructures and foundation of bridges

D1. 4 Indian Roads Congress Standards (IRC)

IRC 5:	1985	Standard Specifications and Code of Practice for Road Bridges, Section I - General Features of Design
IRC 6:	2000	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses
IRC 10:	1961	Recommended Practice for Borrow pits for Road Embankments Constructed by Manual Operation
IRC 11:	1962	Recommended practice for the design of layout of cycle tracks
IRC 18:	1985	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete)
IRC 19:	1977	Standard Specifications and code of Practice for Water Bound Macadam
IRC 21:	1987	Standard Specifications and Code of Practice for Road Bridges Section III–Cement Concrete (Plain and Reinforced)
IRC 22:	1986	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction
IRC 24:	1967	Standard Specifications and Code of practice for Road Bridges, Section V – Steel Road Bridges
IRC 36:	1970	Recommended Practice for the Construction of Earth Embankments for Road Works
IRC 37:	1984	Guidelines for the Design of Flexible Pavement
IRC 45:	1972	Recommendations for Estimating the Resistance of Soil below the maximum Scour Level in the Design of Well Foundations of Bridges
IRC 48:	1972	Tentative Specifications for Bituminous Surface Dressing Using Pre-Coated Aggregates
IRC 75:	1979	Guidelines for the Design of High Embankments
IRC 78:	2000	Standard Specifications and Code of Practice for Road Bridges, Section VII (Parts 1 and 2), Foundations and Substructure
IRC 83:	1987	Standard Specifications and code of practice for Road Bridges, Section IX - Bearings Part I & II: Bearings (Metallic and Elastomeric)
IRC 87:	1984	Guidelines for the Design and Erection of False Work for Road Bridges
IRC 89:	1997	Guidelines for Design and Construction of River Training and Control Works for Road Bridges

IRC: SP 11	1988	Handbook of Quality Control for Construction of Roads and Runaways

D1. 5 IS: Codes

National Building Code

SP 7:	1983	Bureau of Indian Standards**.**
IS 73:	1992	Paving Bitumen
IS 150:	1950	Ready mixed paint brushing, finishing stoving for enamel colour as required
IS 205:	1992	Non-ferrous metal Butt Hinges
IS 206:	1992	Tee and strap hinges
IS 207:	1964	Gate and shutter hooks and eyes
IS 208:	1987	Door handles
IS 210:	1993	Grey iron castings
IS 215:	1995	Road tar
IS 217:	1988	Cutback Bitumen
IS 269:	1989	33 grade Ordinary Portland Cement.
IS 278:	1978	Galvanized steel barbed wire for fencing
IS 280:	1978	Mild Steel wire for general engineering Purposes
IS 281:	1991	Mild Steel sliding door bolts for use with Padlocks
IS 362:	1991	Parliament hinges
IS 363:	1993	Hasps and staples
IS 383:	1970	Coarse and fine aggregates from natural Sources for concrete
IS 432:	1982	Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement
	(Part 1)	Mild steel and medium tensile steel bars
	(Part 2)	Hard-drawn steel wire
IS 453:	1993	Double-acting Spring hinges
IS 455:	1989	Portland slag cement
IS 456:	2000	Code of practice for plain and reinforced concrete
IS 457:	1957	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures

IS 458:	1988	Precast concrete pipes (with and without reinforcement)
IS 459:	1992	Corrugated and semi-corrugated asbestos cement sheets
IS 460:	1985	Test sieves
IS 516:	1959	Method of test for strength of concrete
IS 650:	1991	Standard sand for testing cement
IS 733:	1983	Wrought aluminum and aluminum alloy bars, rods and sections for general engineering
IS 737	1986	Wrought aluminum and aluminum alloy sheet and strip for general engineering purposes
IS 771	1979	Glazed fire-clay sanitary appliances
	(Part 1)	General requirements
	(Part 2)	Specific requirements of Kitchen and laboratory sinks
	(Part 3/Sec. 1)	Specific requirements of Urinals - Slab Urinals
	(Part 3/Sec. 2)	Specific requirements of Urinals - Stall Urinals
IS 774:	1984	Flushing cistern for water closets and urinals
IS 775:	1970	Cast iron brackets and supports for wash basins and sinks
IS 777:	1988	Glazed earthenware wall tiles
IS 778:	1984	Copper Alloy gate, globe and check valves for water works purposes
IS 779:	1994	Water meters
IS 780:	1984	Sluice valves for water works purposes (50 to 300 mm size)
IS 781:	1984	Cast copper alloy screw down bib taps and stop valves for water services
IS 783:	1985	Code of practice for laying of concrete pipes
IS 800:	1984	Code of practice for general construction in steel
IS 814:	1991	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel

IS 875:	1987	Code of practice for design loads (other than earthquake) for buildings and structures
IS 883:	1994	Code of practice for design of structural timber in building
IS 909:	1992	Under-ground fire hydrant, sluice valve type
IS 1003:		Timber paneled and glazed shutters
(Part 1)	1991	Door shutters
(Part 2)	1994	Window and ventilator shutters
IS 1030:	1989	Carbon steel castings for general engineering purposes
IS 1038:	1983	Steel doors, windows and ventilators
IS 1077:	1992	Common burnt, clay building bricks
IS 1080:	1986	Design and construction of shallow foundation in soil (other than raft ring and shell)
IS 1161:	1979	Steel tubes for structural purposes
IS 1195:	1978	Bitumen mastic for flooring
IS 1230:	1979	Cast iron rainwater pipes and fittings
IS 1237:	1980	Cement concrete flooring tiles
IS 1239:	1990	Mild steel tubes, tubular and other wrought steel fittings
	(Part 1)	Mild steel tubes
	(Part 2)	Mild steel tubular and other wrought steel pipe fittings
IS 1322:	1993	Bitumen felts for water proofing and damp-proofing
IS 1341:	1992	Steel butt hinges
IS 1343:	1980	Code of practice for Pre-stressed Concrete
IS 1346:	1991	Code of practice Waterproofing of roofs with bitumen felts
IS 1458:	1965	Railway bronze ingots and casting

IS 1489:	1991	Portland Pozzolana Cement.
IS 1536:	1989	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage
IS 1537:	1976	Vertically cast-iron pressure pipes for water, gas and sewage
IS 1538:	1993	Cast iron fittings for pressure pipes for water, gas and sewage
IS 1566:	1982	Hard-drawn steel wire fabric for concrete reinforcement
IS 1592:	1989	Asbestos cement pressure pipes
IS 1703:	1989	Copper alloy float values (horizontal plunger type) for water supply fittings
IS 1726:	1991	Cast iron manhole covers and frames
IS 1729:	1979	Sand cast iron spigot and socket soil waste and ventilating pipes, fitting and accessories
	1989	Dimensions for round and square steel bars for structural and general engineering purposes
IS 1785:	1983	Plain hard-drawn steel wire for prestressed concrete
	(Part 1)	Cold-drawn stress – relieved wire
	(Part 2)	As drawn wire
IS 1786:	1985	High strength deformed steel bars and wires for concrete reinforcement.
IS 1791:	1985	Batch type concrete mixers
IS 1795:	1982	Specifications for pillar taps for water supply purposes
IS 1834:	1984	Hot applied sealing compound for joint in concrete
IS 1838:	1983	Pre-formed fillers for expansion joint in concrete pavements and structures (non-extruding and
	(Part 1)	Bitumen impregnated fiber
IS 1888:	1982	Method of load tests on soils
IS 1892:	1979	Code of practice for sub surface investigations for foundations

IS 1893: Part-I	2001	Criteria for earthquake resistant design of structures
IS 1904	1986	Design and construction of foundations in soils General Requirements
IS1905:	1987	Code of practice for Structural use of un reinforced Masonry
IS 1948:	1961	Aluminum doors, windows and ventilators
IS 1949:	1961	Aluminum windows for industrial buildings
IS 1977:	1976	Low Tensile Structural steel
IS 2004:	1991	Carbon steel forgings for general engineering purposes
IS 2062:	1992	Steel for general structural purposes
IS 2074:	1992	Ready mixed paint, air-drying, red oxide-zinc chrome, priming
IS 2090:	1983	High tensile steel bars used in prestressed concrete
IS 2114:	1984	Code of practice for laying in-situ terrazzo floor finish
IS 2116:	1980	Sand for masonry mortars
IS 2119:	1980	Code of practice for construction of brick-cum-concrete composite
IS 2202:	1991	Wooden flush door shutters
IS 2326:	1987	Automatic flushing cisterns for urinals
IS 2386:	1963	Methods of test for aggregates for concrete
	(Part 1)	Particle size and shape
	(Part 2)	Estimation of deleterious materials and organic impurities
	(Part 3)	Specific gravity, density, voids, absorption and bulking
	(Part 4)	Mechanical properties
	(Part 5)	Soundness
	(Part 6)	Measuring mortar making properties of fine aggregates

	(Part 7)	Alkali – aggregate reactivity
	(Part 8)	Petrographic examination
IS 2430: 1969		Methods of sampling of aggregate for concrete
IS 2548: 1996		Plastic seats and covers for water closets
IS 2556 - 1994/95		Vitreous sanitary appliances
	(Part 1)	General requirements
	(Part 2)	Wash-down water closets
	(Part 3)	Squatting pans
	(Part 4)	Wash-basins
	(Part 5)	Laboratory sinks
	(Part 6)	Urinals and Partition plates
	(Part 7)	Accessories for sanitary appliances
	(Part 8)	Pedestal close coupled wash-down and symphonic water closets
	(Part 9)	Pedestal type bidets
	(Part 14)	Integrated squatting pans
	(Part 15)	Universal water closets
IS 2681: 1993		Non-ferrous metal sliding door bolts (aldrops) for use with padlocks
IS 2690: 1993		Burnt - clay for flat terracing Tiles
IS 2692: 1989		Ferrules for water services
IS 2720		Methods of Tests for Soils
IS 2751:	1979	Recommended practice for welding of mild steel plain and deformed bars used for reinforced construction
IS 2906:	1984	Specification for sluice valves for water works purposes (350 to1200 mm size)

IS 2911:	1979	Code of practice for design and construction of pile foundations
	(Part 1)	Concrete piles
	Section 1	Driven cast –in-situ concrete piles
	Section 2	Bored cast-in-situ concrete piles
	Section 3	Driven precast concrete piles
	Section 4	Bored precast concrete piles
	(Part 3)	Under-reamed piles
	(Part 4)	Load test on piles
IS 2950:	1981	Code of practice for design and construction of raft foundations
IS 3370:	1965	Code of practice for concrete structures for the storage of liquids
IS 3564:	1995	Hydraulically regulated door closers
IS 3812:	1981	Fly ash for use as pozzolanas and admixture
IS 3847:	1992	Mortice night latches
IS 3955:	1967	Code of practice for design and construction of well foundations
IS 3989:	1984	Centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and
IS 4082:	1996	Recommendations on stacking and storage of construction materials and components at site
IS 4138:	1977	Safety code for working in compressed air
IS 4326:	1993	Earthquake resistant design and construction of buildings – code of practice
IS 4656:	1968	Form vibrators for concrete
IS 4736:	1986	Hot-dip zinc coatings on mild steel tubes
IS 4826:	1979	Hot-dipped galvanized coatings on round steel wires
IS 4925:	1968	Concrete batching and mixing plant

IS 4926:	1976	Ready mixed concrete
IS 4968:	1976	Method for sub surface sounding for soils
IS 5525:	1969	Recommendations for detailing of reinforcement in reinforced concrete works
IS 5529:	1985	Code of practice for in-situ permeability tests
IS 5640:	1970	Method of test for determining aggregate impact value of soft coarse aggregate
IS 5816:	1970	Method of test for splitting tensile strength of concrete cylinders
IS 5889:	1994	Vibratory plate compactor
IS 5892:	1970	Concrete transit mixers and agitators
IS 6003:	1983	Specification for indented wire for prestressed concrete
IS 6006:	1983	Specification for uncoated stress relieved strands for prestressed concrete
IS 6051:	1970	Code for designation of aluminum and its alloys
IS 6248:	1979	Specification for metal rolling shutters and rolling grills
IS 6403:	1981	Code of practice for determination of bearing capacity of shallow foundations
IS 6603:	1972	Stainless steel bars and flats
IS 6760:	1972	Slotted countersunk head wood screws
IS 6911:	1992	Stainless steel plate, sheet and strip
IS 7181:	1986	Horizontally cast iron double flanged pipes for water, gas and sewage
IS 7196:	1974	Hold fast
IS 7205:	1974	Safety code for erection of structural steel work
IS 7231:	1984	Specifications for plastic flushing cisterns for water closets and urinals
IS 7273:	1974	Method of testing fusion-welded joints in aluminum and aluminum alloys
IS 7293:	1974	Safety code for working with construction machinery

IS 7320:	1974	Concrete slump test apparatus
IS 7534:	1985	Sliding locking bolts for use with padlocks
IS 7861:	1975	Code of practice for extreme weather concreting
	(Part 1)	For Hot Weather concreting
	(Part 2)	For Cold Weather concreting
IS 7969:	1975	Safety code for handling and storage of building materials
IS 8009	1976	Calculation of settlement of foundations
IS 8041:	1990	Rapid – hardening Portland cement
IS 8112:	1989	43 grade ordinary Portland cement
IS 8142:	1994	Method of test for determining setting time of concrete by penetration resistance
IS 8500:	1991	Structural steel-micro alloyed (medium and high strength qualities)
IS 9013:	1978	Method of making, curing and determining compressive strength of accelerated cured concrete
IS 9103:	1979	Admixtures for concrete
IS 9284:	1979	Method of test for abrasion resistance of concrete
IS 9417:	1989	Recommendations for welding cold worked bars for reinforced concrete construction
IS 9595:	1996	Recommendations for metal arc welding of carbon and carbon manganese steels
IS 9762:	1994	Polyethylene floats (spherical) for float valves
IS 10262:	1982	Recommended guidelines for concrete mix design
IS 10379:	1982	Code of practice for field control of moisture and compaction of soils for embankment and subgrade
IS 12269	1987	53 grade ordinary Portland cement
IS 12894:	1990	Fly ash lime bricks
IS 13630:	1994	Ceramic tiles – methods of tests

IS 13920	1993	Ductile detailing of Reinforced Concrete Structures subjected to Seismic Forces
		Foreign Standards
ASTM D-297		Methods for Rubber Products - Chemical Analysis
ASTM D-395		Compression set of vulcanized rubber
ASTM D-412		Tension testing of vulcanized rubber
ASTM D-429		Adhesion of vulcanized rubber to metal
ASTM D-573		Accelerated ageing of vulcanized rubber by the oven method
ASTM D-624		Tear resistance of vulcanized rubber
ASTM D-797		Young's Modulus in flexure of elastomer at normal and subnormal temperature
ASTM D-1149		Accelerated Ozone cracking of vulcanized rubber
ASTM D-1559		Test for resistance to plastic flow of bituminous mixtures using Marshall apparatus
ASTM D-2166		Test methods for Unconfined Compressive strength of Cohesive Soils
ASTM D-2172		Extraction, quantitative, of bitumen from bituminous paving mixtures
ASTM D-2434		Test methods for permeability of Granular Soils
ASTM D-2240		Indentation hardness of rubber and plastic by means of a Durometer
ASTM D-3080		Method for Direct Shear Test of Soils under Consolidated Drained Condition
ASTM E-11		Specification for wire cloth sieve for testing purposes
AASHTO DM 57-80		Materials for embankments and subgrade
AASHTO DM 147-67		Materials for aggregate and soil (1980) base and surface courses
AASHTO DM 282-80		Joints sealments, not poured, elastomeric type, (ASTM : D 3406) for Portland cement cure rate pavements
BS 410:	1986	Specification for test sieves
BS 812:		Testing aggregates
BS 1154:	1992	Specification for natural rubber compounds

BS 1377:	1990	Methods of test for soils for Civil Engineering purposes
BS 5400:Part 4.	1990	Code of Practice for Design of Concrete Bridges.
BS 5930	1981	Code of Practice for Site Investigations
BS 5950		Structural use of Steel work in Buildings
BS 6177	1982	Guide to selection and Use of Elastomeric Bearings for Vibration Isolation in Buildings
BS 8007	1987	Code of Practice forDesign of Concrete Structures for Retaining Aqueous Liquids
BS 8110 Parts I and II		Structural use of Concrete
Part 9. Section 9.1		Code of Practice for Design of Bridge Bearings

Other Publications

Indian Standard Hand Book on Steel sections Part I

Indian Railways Manual on Design and Construction of well and pile foundations.

UIC/772 – R The International Union of Railways Publication.

IEC International Electromechanical Commission

Section D2 - GEOMETRIC DESIGN CRITERIA FOR RAILWAY ALIGNMENT

D2. 1 Criteria

D2 1.1. The horizontal and vertical alignments of the railway are given in the Drawings provided by the Employer.

D2 1.2. The DDC shall design the civil engineering works to these alignments. However, subject to the provisions of the Contract, minor changes to the given alignments may be made, where clear benefits can be demonstrated, and in order to suit the specific characteristics of his design.

D2 1.3. The railway alignment design shall comply with the requirements of the following Clauses D2.2 to D2.8.

D2. 2 Horizontal Alignment

D2 2.1. The limits for radii for horizontal circular curves shall be as follows : Minimum radius: (as per the alignment)

- running track : 120 metres
- within depots : 120 metres

D2 2.2. Whenever possible the track shall be straight throughout the length of the stations. The presence of external restrains may necessitate limited encroachment of transition curves at station ends but this shall be avoided whenever possible. Where encroachment is unavoidable this shall be limited such that the vehicle throw does not affect the platform nosing clearance.

D2 2.3. Circular curve radii shall be selected to be the maximum practicable. The radius selected for any particular curve shall not be so large as to unnecessarily impose more severe curvature of the track at either end of that curve.

D2 2.4. The combination of circular curves and their related transition curves shall be chosen such that the length of pure circular arc between transitions is not less than the following :

- Desirable minimum 50 metres
- Absolute minimum 25 metres

D2 2.5. For any consecutive circular curves with opposite direction of curvature the length of straight track between the ends of the curves or of the transitions where these are required shall be not less than:

- Desirable minimum 25 metres
- Absolute minimum 15 metres

When it is not possible to provide a straight portion of 15m, no straight portion shall be provided and the transitions extended accordingly. The rate of change of cant and versine over both transitions shall be kept the same in such cases.

D2. 3 Cant and Speed

D2 3.1. The curve speed cant relationship shall be based on the following equations:

Equilibrium cant $E = \frac{11.82 \times Ve^2}{}$ (Standard Gauge)

$$E = \frac{13.78 \times Ve^2}{R} \text{ (Broad gauge)}$$

Maximum permissible speed $Vm = 0.29 [R (E_a+D)]^{0.5}$ (Standard Gauge)

$$Vm = 0.27 [R (E_a+D)]^{0.5} \text{ (Broad gauge)}$$

Where R = horizontal curve radius in metres.

Vm = maximum permissible speed in kilometres per hour.

V_e = equilibrium speed in kilometres per hour.

E = equilibrium cant in millimetres.

E_a = actual applied cant in millimetres.

D = maximum allowable deficiency of cant in millimetres.

D2 3.2. The maximum allowable applied cant for ballasted and ballastless track shall be :

	Absolute Maximum	**Desirable Maximum**
Standard gauge	125mm	110 mm
Broad gauge	150 mm	125 mm

D2 3.3. The deficiency of cant shall be limited to:

(i)	Maximum allowable deficiency of cant on plain line for CWR and jointed track	100 mm
(ii)	Maximum allowable deficiency of cant on turnouts and crossings of CWR and jointed track	75 mm
(iii)	Limit of negative cant on switches and crossings for CWR and jointed track	75 mm

D2 3.4. The track shall be designed on the basis of maximum line speeds. These will be:

Curve Radius (m)	**Max. Speed (km/hr) Broad Gauge**	**Max. Speed (kmph) Standard Gauge**
200	60	60
250	65	65
300	75	75
350	80	80
400	80	80
>450	80	80

The table is based on cant up to 150mm and cant deficiency of up to 100mm where required. However, subject to the provisions of the contract, speed restrictions may be introduced where this is dictated by external constraints and operational requirements.

D2 3.5. Applied cant shall be specified to the nearest millimetre for concrete track and to the nearest 5 mm for ballasted track.

D2 3.6. Track at terminus stations shall continue past the end of the platforms by 25 metres where stabling or refuge tracks are not required.

D2. 4 Transition Curves

D2 4.1. In general for all running and depot lines transition curves shall be provided wherever possible between a circular curve and adjoining straight, between the different radii of a compound curve and at the adjoining ends of circular curves forming reverse curves. Transition curves are not required in sidings.

D2 4.2. Transition curves shall be in the form of cubic parabolas or clothoid spirals for which the equations are :

a) **Cubic Parabolas**

i. $$y = \frac{d^3}{6RL}$$

ii. $$A = \frac{d^2}{2RL}$$

iii. $$S = \frac{L^2}{24R}$$

b) Clothoid spiral

$$S = \frac{L^2}{24R} - \frac{L^4}{2688R^3}$$

Where L = length of transition

R = radius of circular curve

S = shift

y = offset from tangent

d = distance along transition

A = deviation angle of transition

D2 4.3. The cant gradient or cant deficiency gradient shall be subject to the following limits:

(i)Absolute maximum = 1 : 500

(ii) Preferred = 1 : 750

D2 4.4. The rate of change of cant or cant deficiency shall be limited to:

(i)Absolute maximum = 55 mm/sec.

(ii) Desirable maximum = 35 mm/sec

Transition curves will not normally be required between different radii of a compound curve where the change of radius of curvature does not exceed 15% of the smaller radius and provided that the cant deficiency and/or cant excess criteria are not exceeded for either curve.

Where a compound curve is employed with a change of radius greater than 15% of the smaller radius, or where the cant deficiency or cant excess criteria necessitates a change in cant between the circular curves, a suitable transition curve shall be interposed between the two parts of the curve. The length of such a transition shall be equal to the difference between the required transition lengths at each end of the curve.

When the actual shift of any calculated transition curve would be less than 10mm the actual transition curve may be omitted. In this case, the required change of cant shall take place over the calculated length of the transition, or 15 m which ever is the greater, and in the same location as if the transition had been provided.

D2. 5 Vertical Alignment

D2 5.1. Vertical curves shall wherever possible be positioned such that coincidence with horizontal transitions is avoided. Where such coincidence is unavoidable the largest practicable vertical curve radius shall be employed.

D2 5.2. Vertical curves shall, for each location, be selected on the basis of the largest practicable vertical curve radius subject to the following limit :

Minimum desirable radius 2500 m

D2 5.3. The length of constant grade between consecutive vertical curves shall be as follows:
i) Desirable minimum 50 m
(ii) Absolute minimum 25 m

D2 5.4. At point and crossing work vertical curves shall not coincide with any part of the overall length of switches or of cast crossings. At other point and crossing work vertical curves shall be avoided whenever possible. Where they cannot be avoided the vertical curve radius shall be 3000 m or more

D2 5.5. At station ends the tangent point of the vertical curve shall be permitted to encroach within the length of the platform to a limited extent. This length of encroachment shall be such that the vertical offset of the curve from the station gradient at the platform end shall not exceed 15mm.

D2. 6 Gradients

D2 6.1. The limits for gradients shall be as follows :

- For running lines the desirable maximum gradient shall be 3% and where unavoidable shall be 4%. Where gradients of 1% or less are used they may be unrestricted in length. Gradients above 3.0% shall be kept as short as possible.
- At stations the track shall be level or of constant gradient not steeper than 0.2% throughout the platform length except for the limited lengths of vertical curves as specified in Clause D2.5.5 above.
- A drainage gradient shall be provided for all viaducts, other than at stations, as

follows :

- Desirable minimum 0.5%
- Absolute minimum 0.25%
- Sidings shall be level or shall fall away from the main line switch at a gradient not exceeding 0.25%. Train berths shall be level or shall fall towards the buffer stops at a gradient not exceeding 0.25%.

D2. 7 Levels

D2 7.1. All levels shall be quoted in metres correct to three decimal places and shall be above mean sea level (MSL).

D2 7.2. Rail level on canted track will refer to the level of the running edge of the lower rail.

D2. 8 Points and Crossing Work

D2 8.1. General

Whenever possible points and crossing work shall not coincide with vertically or horizontally curved track.

Where it is not possible to avoid coincidence with vertical curves the switches and stock rails shall not be laid on vertical curves.

Points and crossing work shall not coincide with horizontal transitions.

No part of the switches, switch operating gear or crossing nose shall be over a structural movement joint.

D2 8.2. D2.8.2 Scissors Crossovers

Scissors crossovers shall be based on a transitioned crossover with vertical rails.

The switch points and turnout radius shall be standard UIC or approved equivalent, designed to accommodate a minimum operational speed of 40 km/hr.

D2 8.3. D2.8.3 Turnouts

Turnouts shall be based on a transitioned turnout with vertical rails.

The speed through the turnout shall be 50 km/hr.

Operational speed in the Depot shall be 20 km/hr.

D2 8.4. Trackwork Requirement :

The Contractor shall design the viaduct structures in accordance with track work requirements. All the structural elements of the viaducts including the locations of expansion joints shall be designed so that they will not interfere with the operation of the track work requirement and turnouts and crossovers.

Section D3 - RAILWAY DESIGN REQUIREMENTS

D 3.1. General

D3.1.1. The Railway Envelope is defined as the extent of works to be constructed to allow installation and operation of the railway equipment.

D3.1.2. The DDC shall be responsible for the design, of a first stage primary concrete. Others will undertake the design of the secondary concrete, trackslabs and trackwork under contracts with the NMRC. A fundamental obligation of the DDC is to co-ordinate and co-operate with the Trackwork DDC and Contractor so that the design of all components of the railway are compatible.

D3.1.3. The design of all railway operating equipment, including signals and signalling cables, the traction power electrification equipment, electrical cables, electrical and mechanical equipment, telecommunication links, etc. that are required for the railway will be undertaken by others under contracts with the Employer. Similar co-ordination and co-operation obligations as expressed in Clause D3.1.2 above apply.

D3.1.4. The DDC shall include in the civil works blind holes, plinths, trenches etc. as required by the Systemwide Contractors. The Systemwide Contractors will supply and fit brackets, nuts and bolts and other fixings for the support of its equipment. The extent and detail of such provisions are to be determined by the DDC making due enquiries, through design co-ordination, from Contractors engaged to provide railway-operating equipment and from the Trackwork DDC. Some details of the likely fixing to be provided are given below but it is stressed that this information may not be complete or comprehensive for the DDC.

D3.1.5. The DDC shall be responsible for co-ordinating his design with other DDCs and with the Employer's Representative and for ensuring that the design incorporates such fixings as are required in order to avoid any necessity for contractors to drill, weld, burn or cut any part of a structure.

D3.1.6. Telecommunication

DDC shall allow for mounting plates or other agreed fixings for the lineside telephones and associated cables at spacings to be determined by the Systemwide Contractors.

D3.1.7. Setting out

The DDC shall provide permanent survey monuments and shall provide full details of co-ordinates and levels to the Track work DDC.

D3.1.8. Second pour concrete

The Trackwork Contractor will carry out the second pour concrete for the trackwork. In this regard, the DDC shall include design of starter bars in the primary concrete pour to facilitate anchorage of the second pour concrete if so required. The DDC shall co-ordinate with the Trackwork DDC as to the size and location of the starter bars. The DDC shall design drainage pipes, channels and catch basins to be in the first pour concrete.

D 3.2. Stray Current Corrosion Control

D3.2.1. The DDC shall incorporate into his design precautions to minimise stray current corrosion caused by DC traction power returns through the rails. These requirements do not apply to traction power at 25 kV 50 Hz..

D3.2.2. The Trackwork DDC will design electrical insulation of the Trackwork.

D3.2.3. The DDC's design shall include throughout in situ concrete structures in the vicinity of return rails a longitudinal, continuous, low resistance, electrical path. The DDC shall allow for sufficient longitudinal reinforcement to be electrically bonded, to form an effective stray current interception and collection path.

D3.2.4. The continuous electrical path shall be provided by ensuring full and reliable electrical connection throughout the structure.

D3.2.5. The electrically continuous path shall be provided through the steel reinforcement either by continuous welding of structural reinforcement or by the provision of additional welded mesh reinforcement. Where welded structural reinforcement is used to form a grid, welded cross-connections shall be at a minimum spacing of :

(a) for longitudinal bars, 600 mm measured in the transverse direction;

(b) for transverse bars, 6 m measured in the longitudinal direction.

D3.2.6. The DDC shall make provision for the monitoring of this continuous electrical path during construction and the DDC will be required to demonstrate to the Engineer during construction that the required electrical resistance has been achieved.

D3.2.7. The continuous electrical path will be made approximately in 100 metre sections. At these sections the DDC shall include in the design, terminals as required from the continuous electrical path through the structures to external connections. The terminals shall be suitable for the connection of 70 mm^2 copper cable. At each connection, four such terminals shall be provided, two of which shall be kept as spares and suitably protected. Similar terminals, spare terminals and connections shall be provided over any joint of the structure.

D3.2.8. General requirements for earthing and bonding the structures are to be determined in liaison with the Systemwide Contractor.

D3.2.9. Cross bonding of the running rails, stray current return cabling etc. will be carried out by the Systemwide Contractor.

D3.2.10. The DDC shall take account in his design of the fact that the Contract will be integrated with others in the Project in respect of the control of stray currents, and may therefore carry stray currents arising from any foreseeable operating condition of the Project.

D 3.3. Railway Cross Sections and Structure Gauges

D3.3.1. The Kinematic Envelope for the rolling stock of the railway and Structure Gauges for straight and curved track will be provided after finalisation of contract.

D3.3.2. The DDC shall ensure that the proposed size of structure is adequate to contain the equipment, required under Clause D3.1 above, outside the Structure Gauge.

D 3.4. Clearances

Structures shall not infringe the clearances specified. See also Clause D3.3.2 above.

Section D4 - DESIGN LIFE AND SERVICEABILITY

D 4.1. General

Clauses D4.2 to D4.6 below define the design life and serviceability requirements for the various elements of the structures.

The design life of a structure is that period for which it is designed to fulfil its intended function when inspected and maintained in accordance with agreed procedures. The assumption of a design life for a structure or component does not necessarily mean that the structure will no longer be fit for its purpose at the end of that period. Neither will it necessarily continue to be serviceable for that length of time without adequate and regular inspection and routine maintenance.

All Design Life criteria shall be confirmed.

D 4.2. Civil Engineering Structures

The design life of all civil engineering structures shall be a minimum of 100 years unless otherwise specified or agreed.

D 4.3. Building Structures

The design shall be a minimum of 50 years unless otherwise specified or agreed.

D 4.4. Bridge Bearings and Movement Joints

Bridge bearings and movement joints shall have a minimum design life of 50 years apart from minor components that can be replaced without complete removal and without interruption to traffic. Such components shall have a service life of 20 years.

D 4.5. Serviceability of Civil Engineering and Building Works

D4.5.1. The design shall include the effects of surface water conditions with the following return periods :

(a) 10 years, with a factor of safety of 1.4;

(b) worst predicted, with a factor of safety of 1.1.

D4.5.2. Paint systems for steelwork shall ensure a minimum life of 15 years for primer coat and 5 years for top coat before maintenance painting is required.

D4.5.3. The corrosion protection of non-structural steel items shall be appropriate to the accessibility of the item for inspection and maintenance.

D 4.6. Serviceability of Mechanical and Electrical Equipment

Serviceability of electrical and mechanical equipment to be designed under this Contract shall be provided to the Employer's Representative.

Section D5 - LOADS AND REQUIREMENTS

RAILWAY LIVE LOADS

D 5.1. General

The railway loading applied to structures on the Project shall be in accordance with attached axle configuration of modern rolling stock except as detailed below. Dead loads shall be used that are in accordance with IRS Bridge Rules and IS 456 (for buildings) and IS 1911 for unit weights of materials.

D 5.2. Nominal Loads

For the purpose of computing stresses and deformations, the following loads and consequential effects shall be taken into account as applicable.

- Dead loads DL
- Super Imposed Dead loads SIDL
- Live loads LL
- Dynamic effects DI
- Forces due to curvature or eccentricity of track CF
- Temperature effects T
- Frictional resistance of expansion bearings
- Longitudinal forces LF
- Long welded rail forces LR
- Racking forces RF
- Forces on parapets
- Wind pressure effect WL
- Forces and effect due to earthquake EQ
- Erection forces and effects DEL
- Buoyancy B
- Differential settlement DS

D 5.3. Loading Combinations

The various combinations of loads and forces to which components of the structures can be subjected are given in the Table 12 of IRS CBC. Each component of the structure shall be designed/checked for all applicable combinations of these loads and forces. They shall resist the effect of the worst combination. The allowable unit stress in a member subjected to a particular combination loading shall not exceed the percentage indicated below against the respective combination.

The loading combinations indicated are not exhaustive. DDC shall analyse the effects of any other combination as deemed appropriate.

D 5.4. Design Loads

Design shall include the effects of:

Static Loading: These shall consist of loads due to:

- Track: Load due to 60 Kg (UIC) rails and guard rail and fittings
- Track bed: RCC blocks or concrete pour or precast slabs in RCC with inserts and fittings in case of ballastless track (minimum 197 mm thick) or PSC sleepers over 250/300 mm of ballast for ballasted track.
- Other loads: As per Indian Railway Standards (IRS) and Bureau of Indian Standards (BIS) Fatigue Loading:

The nominal loading for the design of members in accordance with BS 5400: Part 10 shall comprise trains with eight individual cars each having four axles, the axle loads and vehicle lengths will be provided by the Rolling Stock Consultant. The fatigue loading shall be applied in accordance with the requirements of BS 5400: Part 10 Clause 9.3.3 in conjunction with the following projected annual tonnage's of rail traffic per track. Clause 9.3.4 of BS 5400: Part 10 shall not be applied.

Dynamic Loading:

The static and fatigue loading given in above shall be multiplied by an appropriate dynamic factor as per IRS Bridge Rules.

Dynamic loading shall not be applied to piles, pile caps, centrifugal loads or braking/traction loads.

Longitudinal Loads:

Longitudinal forces of 20% axle load for tractive and 18% for the axle load for braking for the modern rolling stock

When a structure carries two tracks, both tracks shall be considered to be occupied simultaneously. Traction forces shall act on one track and braking forces acting on the other, with both acting in the same direction to produce the worst loading condition.

Longitudinal forces acting on the track shall be considered to be dispersed through the track before being transmitted to the substructure. This shall be calculated based on IRS Bridge Rules, IS Codes and relevant BS Codes.

Provision shall be made for effect of horizontal and longitudinal forces in the rail, especially in the girders with ballastless deck.

Additional permissible stresses while considering this contingency will be proposed by the DDC for review by the Employer’s Representative. Forces shall be calculated for continuous welded rail with a concrete structure interaction resulting from temperature differential of rail and concrete.

Longitudinal forces shall consider the effects on stability and safety arising from a broken rail in ballastless track.

Centrifugal load:

Train Derailment Load: Check for derailment loads shall be made as per IRS Bridge Rules.

Overhead Line Equipment (OLE) Loadings:

Viaducts and bridges under the tracks will be designed for OLE loading on both tracks, with OLE masts located on sides on footpaths.

D 5.5. Wind Loading

The viaduct structure shall be designed for wind loading as per IS 875.

However, a bridge shall not be considered to be carrying any live load when the wind pressure at deck level exceeds 150 kg/m2. Wind load shall be taken as 400-kg/metre length of train in transverse direction and 90-kg/metre length in longitudinal direction. These are computed for length of train as seen in elevation normal to longitudinal axis. The transverse load will be applied to train as concentrated at axle locations at a height of 3.2 m or at C.G. of projected area of the vehicle as accepted by the Employer's Representative above top of lowest rail and normal to track. The horizontal force component transmitted to rails and superstructure by an axle will be treated as a concentrated load at rail having direct wheel flange to railhead contact.

D 5.6. Temperature Loading

D5.6.1. Overall temperature and differential temperature effects shall be determined as per provisions of IRS or IRC Codes.

D 5.7. Seismic Loading

Seismic effects shall be considered on all structures, as per provision of IRS or IRC, except culverts consistent with a horizontal acceleration of 0.07g and will be considered to act in any horizontal direction and 0.0375g in vertical direction. It is also required to check the structures for seismic forces as per IS:1893:2001.

D 5.8. Erection Forces and Effects

The weight of all permanent and temporary materials together with all other forces and effects which can operate on any part of structure during erection shall be taken into account. Allowance shall be made in the design for stresses caused in any member during erection. For extra allowance in permissible stresses when erection forces are also considered, Clause 1.3 may be seen.

D 5.9. D5.9. Shrinkage and Creep

Provision shall be made for the effects of shrinkage and creep of the concrete in the structure as per relevant codes.

D 5.10. Differential Settlement

Consideration of the forces resulting from differential settlement shall be made where the nature of the chosen foundation system and the ground conditions indicate that such a condition may arise but not more than:

- 12 mm Long Term Settlement
- 6 mm Short Term Settlement

D 5.11. Noise Abatement

Allowable Range of Noise Levels:

Generally, the allowable range of noise levels for different land uses are:

- Residential 50 – 70 dba
- Business & Commercial 75 dba
- Hospitals 60 dba

- Rural 45 - 50 dba

Provision of Noise Barriers:

Structures shall be designed to reduce noise to locally acceptable levels by provision of low vibration track forms, resilient base plates and also design of parapet walls and treatment of their track side surfaces. They can be supplemented by providing sound elimination material on sides of the viaduct superstructures. But in many locations, existing noise level itself may be much higher at 1.0 to 1.2 metres above walkway level. Noise barriers may be required in some lengths of viaducts and bridges passing through sensitive residential or hospital zones. The choice of type and their disposition along the parapet/railing is also closely related to aesthetics of the structure.

Section D6 - LIVE LOADS IN STATIONS

D. 6

D 6.1 Live Loads:

Live loads shall generally follow the requirements of IS 875, except where the loadings given below are more severe.

Platforms and Ticket Hall	5.0kN/m^2, or a concentrated load of 15kN on a square area of 300mm side, whichever is more onerous.
Staff Rooms, Toilets, Offices	3.0kN/m^2
Store Rooms	5.0kN/m^2
Plant Room	According to self-weight of machines

Circulation space within:-

(i) Control rooms 3.0kN/m^2

(ii) Plant rooms 5.0kN/m^2

D6.2 Loads due to Equipment

Self weight of various equipment listed below shall be considered

	Equipment
1.	24 kV Switch board (1 No./substation)
2.	380 V Switch board (No. according to design)
3.	AC Switch board (1 No.)
4.	Aux. Services Transformers (Accord. Employer's Requirements)
5.	Inverter (1 No. if installed) and Batteries

Note :

1. The design of the station structure shall take into account the dimensions and weights of the actual equipment to be used.

2. 2. In the design of the station structure due account shall be taken of all loadings resulting from the method and route to be taken for the installation and subsequent removal and replacement of the various items of plant and equipment

Section D7 - ELEVATED STRUCTURES

STRUCTURAL SYSTEM AND ARTICULATION

D 7.1. General

Viaducts and bridges form the predominant components of the NMRC'S on the Rail Corridor. The form, dimensions and design requires special consideration to resolve structural suitability, economy and aesthetics concerns. Viaducts for the corridor shall be generally twin C girder system, having all the required support system for cabling, OHE and the railway tracks, is the economical solution under normal circumstances.

Consideration shall be given to include in the design the following requirements:

- Long welded rails with track centres at 4.60m and suitable for kinematic profile of Standard Gauge schedule of dimensions of NMRC.
- The track shall be ballastless construction on the elevated segments

D 7.2. Railway Requirements

D7.2.1. Provision for emergency evacuation shall be provided along the railway for the full length of the structure. Routes assigned for emergency evacuation shall be designed for footway loading in accordance with the requirements stated herein.

D7.2.2. D7.2.2 The DDC shall note that there is a requirement to provide touch potential protection to passengers on the platforms. The design shall therefore include for a width of 2.5 metres from the platform edge to be insulated from ground earth by insertion of PVC and/or other insulating compounds. Metalwork railings etc. shall be kept a minimum of 2.5 metres from the platform edge unless similarly insulated.

D7.2.3. Parapets

Parapets shall be provided on both sides of all viaducts for the full length of the structure. They shall be designed to act as the support structure to the railway cabling as appropriate. Parapets shall be designed to resist a horizontal and a vertical force each of 150kg/m applied simultaneously to the top of railing or parapet

Parapets shall be provided for all transition structures to protect the guideway from intrusion by trespassers, vandals and road vehicles.

Parapets shall be designed to function as Noise

Containment Barriers. Parapets shall be designed to cater

the forces of OHE (if any).

D 7.3. Vertical Alignment

D7.3.1. Profile grade:

The superstructure shall be so designed that, when subject to dead load only, the rail level would be above the theoretical vertical profile of the system by an amount equal to permissible LL deflection for the structure.

Provision for super-elevation shall be made preferably as part of the track structure over the deck. The dead load is to be considered at such locations.

D7.3.2. Camber

The superstructure deck, including the soffit of any overhead structure above the deck,shall be cambered so as to compensate for the combined effect of:

- vertical curvature, if any;
- dead load deflection; and
- permissible live load plus-impact deflection as accepted by the Employer's Representative.

D7.3.3. Span/Depth ratios

Length-to-depth ratio should as far as possible be restricted to:

- Reinforced concrete member- 10
- Pre-stressed concrete member:
- Composite members - 16- Desirable 12

In Box girders these ratios shall be further subject to stipulations made with regard to internal dimensions required for inspection and future pre-stressing.

Desirable Minimum thickness of any RC member

- Deck - 200 mm
- Web of T-beam - 250 mm
- Web of prestressed girders - 150 + d
- If there are 2 cables at any level - 150+3d

(where d is the diameter of the cable duct.)

Box Girders: minimum member thickness:

- Deck slab - 200 mm
- Bottom flange - 300 mm
- Web - 250 mm
- or as required by IRS Concrete Bridge Code whichever is the greater thickness

In an aggressive environment, an additional thickness of 10 to 20 mm shall be used.

D7.3.4. Typical pier locations are shown on the drawings. Where topographical or service utility restraints dictate use of longer/continuous spans, pier locations may be adjusted to suit the proposed span lengths.

D7.3.4.1. The Consultant shall provide, by suitable choice of span lengths, a sufficiently stiff deck and supporting sub-structure to resist loading as defined in Clauses D5.1 to D5.8 above. Static and dynamic rail live load responses, at essential movement joint locations, shall be in compliance with the Employer's Requirements.

D7.3.4.2. Halving joints shall not be used unless absolutely essential.

D7.3.4.3. The design of the Permanent Works shall comply with the railway noise requirements detailed in Clause D5.11.

D7.3.4.4. Rail/Structural interaction analysis due to continuous welded rail with direct fixation or structure shall be performed in accordance with proven international practice.

D7.3.4.5. Approach slabs of sufficient sizes shall be provided between abutments and at-grade

An approach slab shall be provided in rear of all abutment of elevated structures and bridges. This should not be less than 6 m in length nor be less than the length computed from the formula:

$L = 1.5\ h \tan(45^o - Ø/2)$

Where h = Depth from bottom of slab to bottom of abutment (top of footing)

Ø = Angle of internal friction of backfill soil in degrees

Slab shall be designed assuming that it does not receive any support from the backfill for a distance of not less than 4.0 m nor less than $h \tan(45^o - Ø/2)$ from back of abutment.

D 7.4. Design Considerations

D7.4.1. Vibration and Deflection Limitations

The amplitude and frequency of vibrations of the viaduct and station structure shall be limited to international standards.

The overall deflection as specified elsewhere in the contract for elevated structure will be limited taking into consideration the effect of vibration in addition to other considerations.

Suitable provisions shall be provided at the ends of beams and jacking pads on pier caps shall be provided to allow for replacement of bearings and for any repairs during service.

Provision should be made for adequate fixtures of the superstructure to the

substructure, if any loading or loading combination increased by 100% of live load plus impact is likely to cause uplift of any support.

D7.4.2. Design Procedures

Reinforced and Pre-stressed concrete members of elevated structures shall be designed in conformity with the provisions of IRS and IRC Codes.

D7.4.3. Method of Construction

Stresses in partially completed structures shall be analysed for appropriate critical conditions at various stages of the construction.

Any restriction on the construction operations resulting from the design assumptions shall be clearly specified on the contract drawings and specifications. Conversely, advantage may be taken by the designer of specified construction procedures or sequences to effect a more favourable distribution of loads or stresses.

D7.4.4. Movement/Expansion Joints

Movement/expansion joints and other necessary measures to control shrinkage and thermal effects shall be incorporated in the structural design so that the performance of architectural finishes or of any services are not adversely affected during normal working conditions.

Movement/expansion joints shall be designed to be easily maintained and replaceable.

D7.4.5. Design Surface Crack Width

For the serviceability limit state of cracking:

- Design surface crack width of reinforced concrete viaduct structures shall not exceed the values given in Table 10 of CBC-1997 (Correction slip No.1 dated 26.04.2000).
- Pre-stressed concrete viaduct structures shall be designed as per provisions of IRS and IRC Codes.
- Design surface crack width of reinforced concrete station structures exposed to weather shall not exceed the values given in Table 10 of CBC-1997 (Correction slip No.1 dated 26.04.2000).
- Pre-stressed concrete station structures that are exposed to the weather shall be designed as per IRS/IRC or other relevant codes. Structural elements that are fully protected from the weather may be designed as class 2.
- All aqueous liquid retaining structures and basements shall be designed to the requirements of BS 8007 unless otherwise varied by this specification.

D7.4.6. Temperature Effects

Temperature effects shall be taken into account in accordance with the requirements of IRS or BIS, where applicable.

The difference between maximum and minimum effective temperature shall be taken as 35°C.

D7.4.7. Not Used.

D7.4.8. Structural Members with Bearings

Consideration shall be given for the easy maintenance and replacement of viaduct and station bearings.

The minimum clearance between structural members separated by bearings shall be as follows:

- Precast Viaduct Beam/Cross Head : 150 mm
- In-Situ Viaduct Beam/Column : 250 mm
- Precast station Beam/Corbel : 175 mm

These are absolute minimum values and the requirement for easy maintenance and replacement of bearings shall prevail.

D7.4.9. Thermal Rail Forces

Provision shall be made for horizontal transverse and longitudinal forces due to temperature variation in rail. The forces shall be applied in a horizontal plane at the top of low rail as follows:

(1) Transverse Force. The transverse force (T) per linear metre of structure per rail shall be determined by the following formula:

$$T = \frac{650}{R} \text{ kN}$$

Where; R = radius of rail curvature in metres.

(2) Longitudinal Force. A longitudinal force shall be applied in accordance with Indian Standards.

D7.4.10. Access To Voids

Continuous access between the deck voids shall be provided wherever possible. An easily removable, watertight manhole access to deck voids shall be provided in every span.

D7.4.11. Pre-stressed Concrete

Non-shrink grout shall be used for grouting of post-tensioned tendon ducts.

Pre-stressing anchorages shall be detailed such that they are easily

accessible for inspection and maintenance. The detailing shall also prevent the accumulation of water and dirt around the anchorage.

All assumptions made in the determination of the design pre-stress loads, e.g. curvature, friction, cross section and mechanical properties of strand and concrete shall be clearly stated on the drawings.

D7.4.12. Bearings

D7.4.12.1. In the selection of the bearing layout in viaducts and elevated stations, consideration shall be given to their performance in relation to the supporting structures, economy as well as maintenance and replacement of the bearings.

D7.4.12.2. Due care must be taken to ensure that no pair of bearings act against one another in service conditions to the detriment of the structure and to the bearings themselves.

A suitable bearing layout for the viaduct could be the 3-bearing system.

D7.4.12.3. Design Life

Bearings and their installations shall be designed to be compatible with the design life of the viaduct and the elevated stations.

Whenever the expected design life of the bearings is significantly less than that of the structure, provision shall be made for the removal and replacement of the whole or parts of the bearings.

D7.4.12.4. Type of Bearings

Bearings for the viaducts would preferably be Elastomeric Bearings, but types used by NMRC under similar applications will be acceptable.

For the elevated stations, elastomeric bearings or POT/PTFE would be acceptable. Where necessary and with the Engineer's prior acceptance, vibration-reducing bearings shall be specified for the elevated stations.

The type of bearings and their installations to be adopted shall be such that they satisfy the requirements for their design life as stipulated in IRC-83 or UIC-772R.

D7.4.12.5. Bearing Design

Unless otherwise specified, bearings shall be designed in accordance with the requirements of IRC Codes or UIC.772R
Bearings for viaducts and elevated stations shall be designed to allow for the following movements:

- Thermal expansion and contraction: An ambient range varying between 2°C to 47 °C should be considered for Noida-Greater Noida
- Shrinkage of concrete

- Creep in concrete
- Elastic shortening under prestress
- Displacements of structure under load:
- Differential settlement between viaduct piers shall be considered.
- Rotation and sway of columns and crossheads under the worst load combination including the effects of temporary loads during construction shall be considered.

Schedule listing the performance requirements for each type of bearings for viaduct and elevated stations shall be incorporated in the drawings. The schedule shall indicate the following:

- Dead load to be supported (SLS and ULS)
- Maximum and minimum vertical live load to be supported (SLS andULS)
- Horizontal forces to be resisted (SLS and ULS)
- Rotation capacity required
- Translation capacity required (both reversible and irreversible). In the case of in-situ viaducts, the amount of pre-setting required for the bearings should be clearly indicated.

Calculations for movements of bearings shall take into account the variability of materials and conditions that the structure is expected to encounter during its design life.

In the above ULS and SLS mean Ultimate Limit State and Serviceability Limit
State respectively as defined by IRS Concrete Bridge Code-1997.

Design of the bearings, derailment loads requirements specified in IRS Bridge Rules shall be taken into consideration. The corresponding viaduct rotation under derailment loads shall be controlled to minimise damage to the viaduct elements.

In the design of the bearings to resist lateral loads, friction between the bearing and mortar shall be ignored.

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Mortar bedding composing of sand and either cement, polyester resin or epoxy resin shall have a crushing strength of at least twice the average contact stress. In the choice of bedding due consideration shall be given to the future removal and replacement of the bearing without damage to bedding or to the structural elements bonded to it.

Shear studs or bolts shall be provided to secure the bearing top and bottom plates to the structure. The shear studs or bolts shall be designed in accordance with international practice.

The fixing method to be adopted shall be such that it is convenient and possible to replace the bearings at some future date.

The designer shall ensure that the bearings can be produced to satisfy the design requirements; and that the space allowed for in the overall design is sufficient to accommodate the bearings and enable them to be inspected, maintained and replaced when required.

D 7.5. Highway Clearances

The vertical and horizontal highway clearances required to structures shall generally be in accordance with the requirements described below.

D7.5.1. Vertical Clearances

The minimum clearance between the elevated structures and highways, railways, utility lines and other structures and property should be greater by a minimum of 250 mm on those prescribed by the agencies involved. The minimum vertical clearance below the bottom of the structure for any highway/road passing below will be 5.5 metres as prevailing presently. In case of minor roads/streets a lower clearance may be adopted with specific approval of the agency owning and/or maintaining the road/street.

D7.5.2. Horizontal Clearances

The clear span over the roads passing below the viaduct/bridge shall be determined after evaluation of present and future needs.

Protection shall be necessary for piers against accidental impact from road vehicles on a case by case basis. IRC-6-2000 shall be applied.

For supports located in the median or adjoining major roads where heavy goods vehicles pass at high speed and where adequate clearances are not available, the foundations and piers shall be designed for an impact force of 100t at a height of 1.2 m above road level in the direction of traffic. Higher permissible stresses shall be considered. The approach to the pier shall also be protected by non-mountable kerb and sand filling.

Where clearances are available and a suitably designed safety barrier can be provided, the pier shall not be checked for 100t impact force. The protection afforded should be such that when a car of 1.5t weight strikes the barrier at 110 kph and at an angle of 20^{o}, the wheels of the car will only just reach the pier. The clearance between the pier and safety barrier shall be 0.6 m or more, and the safety barrier shall be a guardrail or crash barrier, mounted on posts to form a free standing rail barrier.

D 7.6. Viaduct Deck Furniture, Drainage and Waterproofing

Viaduct deck furniture, drainage and waterproofing system shall be designed for all effects and requirements of the railway as per IRS/IRC

Codes.

Cast-in drains shall be used, provided with rodding eyes at every bend. Runoff on viaduct structures and bridges shall be collected through surface drains that shall lead to down drains at the support columns. The down drains shall be connected to a drainage system which shall consist of collection header pipe and manholes which shall discharge to the nearest suitable drainage system. Silt removal shall be provided where necessary.

D 7.7. System wide Requirements

D7.7.1. Systemwide requirements must be considered in the development of the structural design. Such consideration shall include:

- The incorporation of a stray current corrosion control system
- The incorporation of an adequate water drainage system
- The necessary design of reinforcement in plinth and deck so as to avoid interference with and attenuation of the signalling circuits
- Special care taken with the location of gullies in points and crossing areas.
- Provision for future pre-stressing of cable/strands as per IRS code shall be made for all pre-stressed concrete members (External pre-stressing) as indicated in the conceptual drawings.

D7.7.2. Systemwide details are liable to changes as the requirements of various contracts become known and their designs are developed. The DDC shall be responsible for incorporating all Systemwide requirements as they become available.

D7.7.3. All details provided to meet Systemwide requirements shall be subject to the acceptance by the Employer's Representative.

NOIDA METRO RAIL CORPORATION LIMITED

CONTRACT NO: NMRC/Projects/NGNEDDC/2025/415

Contract NGNEDDC: Detail Design Consultant (DDC) for Civil, Architectural and E&M works including Traction works for Elevated Sections of Extension Projects of Aqua Line from Noida Sec-51 to Knowledge Park-V, Noida Sec-142 to Botanical Garden & Depot Station to Boraki including augmentation of existing depot and RSS works (31.595 km).

VOLUME-5
STANDARD DOCUMENTS

PART II - OUTLINE DESIGN CRITERIA - GEO-TECHNICAL, FOUNDATION AND RAILWAY FORMATION WORKS

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CONTRACT NO: NGNDD01

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CONTRACT No. NGNDD01

OUTLINE DESIGN CRITERIA

GEOTECHNICAL, FOUNDATION AND RAILWAY FORMATION WORKS Section E1 – GENERAL, STANDARDS AND CODES

E1.1. Purpose and Scope

The purpose of this chapter of these Design Criteria is to establish the minimum requirements for geotechnical site investigations, studies, analyses, and preparation of geotechnical reports and design and construction recommendations for earthwork, foundations, structure, and substructure design for the `Noida Extension Metro Corridor'.

The Criteria in this Appendix apply to all phases of geotechnical site investigations, studies, analyses, reports and recommendations.

"Geotechnical works" shall mean foundations, earthworks, deep excavations, slopes, embankments and earth retaining structures. It shall also include dewatering, and any ground related activities in soil and rock.

The NMRC will make available to the DDC, for information only the Geotechnical Investigation Report prepared earlier. This shall be supplemented as necessary by additional boreholes as required by the DDC in consultation with NMRC under provisional sum.

E1.2. Codes, Standards, and Regulations

The principal standards listed below shall be complied with, superseded, or amended by these Criteria.

The version of the standards, codes, and regulations shall be the latest version.

Indian Standards

SP 36 (Part 1):	Compendium of Indian Standards on Soil Engineering (Laboratory Testing)
SP 36 (Part 2) :	Compendium of Indian Standards on Soil Engineering (Field Testing)
IS 1080 :	1986, Code of Practice for Design and Construction of Shallow Foundations on Soils.
IS 1200 : (Part 1) :	1992, Methodology of measurement of Building and Civil Engineering Works.

IS 2386: (Part 1 to Part 8)1963, Methods of Test for Aggregates for Concrete.

IS 2720: Methods of Tests for Soils.

IS 2911: (Part 1) 1979, Code of Practice for Design and Construction of Pile Foundations.

IS 3067 : 1988, Code of Practice for General Design Details and Preparatory Work for Damp-Proofing and waterproofing of Buildings

British Standards Institution

BS 812 : 1985/1988, Testing Aggregates (Parts 117 to 119).

BS 1377 : 1990, Methods of Test for Civil Engineering Purposes (Parts 1 to 9).

BS 5930 : 1981, Code of Practice for Site Investigations.

BS 6031 : 1981, Code of Practice for Earthworks.

BS 6349 : 1991, Code of Practice for Dredging and Land Reclamation.

BS 8000 : Part 4 : 1989, Code of Practice for Waterproofing.

BS 8000 : Part 5 : 1989, Code of Practice for Below Ground Drainage.

BS 8002 : 1994, Code of Practice for Earth Retaining Structures.

BS 8004 : 1986, Code of Practice for Foundations.

BS 8081 : 1989, Code of Practice for Ground Anchorages.

Standard Method of Measurement for Civil Engineering Works, Edition 1, 4/92.

Others

American Society for Testing and Materials (ASTM), Section 4 : Construction,
Volume 04.08 : Soil and Rock I, and Volume 04.09 : Soil and Rock II, 1995.

International Society for Rock Mechanics (ISRM), Suggested Test Methods, (various dates).

GEOTECHNICAL DATA

E1.3. A safety factor of not less than 2.5 should be adopted as the test load for a single pile and a safety factor of not less than 2.0 shall be adopted when considering pile and pile group capacities. A safety factor of at least 1.75 for a single pile and at least 1.5 for group piles shall be adopted when the negative skin friction (which results from downward movement of adjacent soil relative to the pile caused by dewatering and/or the placement of fill) is considered.

E1.4. In his design the DDC shall take adequate measures to minimise the amount of local differential settlement of road surfaces around below ground level works.

E1.5. The slopes of all permanent cuttings and excavations shall be so designed that they are capable of supporting vegetation and shall be stabilised where necessary. In particular, soil slopes shall be hydroseeded or turfed.

E1.6. Piles and Pile Caps

Preliminary geo-technical investigations indicate that piled foundations will be required for elevated structures. Spread foundations shall also be considered if these can be justified on cost, time and geo-technical parameters. For major bridges and culverts, the type of foundation shall depend on soil and site conditions, and, where the MRTS alignment is close to the Northern Railway line, the foundation design of the adjacent structure.

Section E2 – SITE INVESTIGATIONS AND LABORATORY INVESTIGATIONS

SITE INVESTIGATIONS

E2.1 General Conditions

Subsurface Conditions

Regional engineering geology aspects for the area of the Rail alignments are generally documented by the Geological Survey of India.

Seismic conditions

Detailed, seismic loading and ground-acceleration criteria are discussed under Structural, of these Design Criteria. Consideration of design-level seismic forces in the design of temporary structures is generally not required, except that such designs shall ensure public safety and cause no loss or damage to adjacent projects or properties.

The effects of the design seismic event on the stability of slopes and on the potential for liquefaction of soils shall be taken into account in the design.

E2.2 Investigation Requirements

Existing information shall be supplemented with project-specific site investigations (SI). The intent and objectives of the SI shall be to collect all pertinent and reliable data and information required to produce a safe and economic design and to meet tender and construction requirements.

For the purpose of these Criteria, the term SI shall be considered to include, but not be limited to, the following.

- Compiling and reviewing pertinent existing geologic data.
- Compiling and reviewing pertinent existing geotechnical data from adjacent projects.
- Compiling and reviewing pertinent existing foundation, structure, substructure, and related data from adjacent projects.
- Performing a detailed field reconnaissance.
- Performing ground investigations under provisional sum.

E2.3 Investigation Methods

E2.3.1. Geologic Studies

Geologic studies shall include, but not be limited to, a review of pertinent and existing literature, aerial photographs, and remote-sensing data; a detailed field reconnaissance of the site; and preparation of project-specific maps and cross- sections.

Project-specific geologic maps shall be prepared at about 1:5,000 scale, and geologic cross-sections shall be prepared at about 1:5,000 scale, both horizontal and vertical. Suitable base maps for geologic maps shall be utilised.

Section E3 – FOUNDATIONS

E3.1 Introduction

Foundation depth shall be governed by two factors viz. safe bearing pressure on founding soil and adequate embedment/grip for the foundation structure after allowing for deepest possible scour around the foundation.

In case of continuous structures no settlement is normally permitted. However design should cater for possible settlement as specified above or in accordance with accepted International practice for Railway bridges. Possible settlement, if any, during replacement of bearing under continuous spans also should be completed and limited to permissible limits.

E3.2 Foundation Design Loads, Forces and Stresses

E3.2.1. Ground/Structure Interaction

The effects of foundation settlements on the structures shall be allowed for in the design.

The calculated differential settlement for serviceability Limit State (SLS) between adjacent viaduct piers shall not be greater than 1/1200 times the span or as specified in Clause D5.10.

In the selection of the structural framework for elevated stations, careful consideration shall be given to the isolation or reduction of vibration transmitted from viaduct to the station structure. Complete isolation, if practical, is preferred.

E3.2.2. Earth Pressure

Substructure elements of the bridges/elevated structures, shall be designed to withstand earth pressures in accordance with provisions in IRS Code of Practice for Design of Substructures and Foundations. When Highway, Railway or MRTS system traffic can come within a distance from the top of the structure equal to one- half its height, the applicable load surcharge as specified in respective code shall be adopted. For MRTS loadings the surcharge effect of trains shall be equal to 1.18 tonne/sq.metre.

E3.2.3. Live Loads

The worst of 4 loading conditions shall be considered:

- when only one span is loaded (which would cause an eccentricity effect); or
- when both spans are fully loaded; or
- when both spans on one line loaded with no traffic on other end; or
- when only one girder on one span only is loaded.

In case of well/caisson foundations only such proportion of live load which exceeds 15% of dead load after deducting buoyancy need be considered.

E3.2.4. Buoyancy

The effect of buoyancy shall be considered in the design of substructure (including piling and wells).

E3.2.5. Stream Force

All piers and other portions of structures subject to the force of flowing water shall be designed to resist the maximum forces induced therefrom in accordance with the design flood in accordance with design codes.

E3.3 Load Combinations

All footings shall be designed to keep the soil pressures within safe bearing values and to keep the pressure as uniform as possible. In addition the footings shall be proportioned in such a way that:

Load Combination (See also D5.1)	Applicable Condition
Spread Foundation	
Under Combination I loading	Resultant to fall within middle third of base (in Either direction)
Under Combination II loading	Resultant to fall within 42% of base (in either Direction) and maximum Toe pressure not to Exceed 125% of Allowable Bearing Pressure
Under Combination III loading	Resultant to fall within 44% of base (in either Direction) and maximum Toe pressure not to Exceed 133% of allowable bearing pressure.
Footing on Rock –Under Combination I loading	Resultant to fall within 55% of base(in either Direction) and maximum toe Pressure not to exceed allowable bearing pressure
Pile Foundation	
Under Combination I loading	Load on any pile not to exceed its safe load capacity and Uplift force not Exceeding 5% of safe load capacity of pile.
Under Combination II Loading	Load on any pile not to exceed its safe load capacity by more than 25% and Uplift force not exceeding30% of safe Load capacity of pile

Under Combination III loading	Load on any pile not to exceed its safe load capacity by more than 33% and Uplift force not exceeding 40% of safe load capacity of pile

When footings are to be constructed on uneven and/or smooth rock surfaces, the rock surface shall be notched and benched as necessary. In case of shallow foundation, it should be checked for uplift and overturning effects and if found unstable it should be anchored by rock anchors. Shear anchors in form of old light gauge rails or end split rod dowels taken sufficiently deep (at least 0.6 m) into bed rock shall be provided.

BELOW GROUND STRUCTURES

E3.4 General Principles

The designs provided under this Clause shall also satisfy the requirements of Clause foundations to elevated structures.

E3.4.1. The DDC shall use design methods for the analysis of the below ground structures that take account of:

- The method of construction, including temporary works.
- The ground/structure interaction, including the effects of temporary works.
- Ground pressure redistribution and bending moment redistribution.
- Short and long term heave and settlement.
- Groundwater loading, backfill, temperature and other imposed loadings such as surcharge and highway loadings.

E3.4.2. For the purpose of assessing ground pressures the walls of the covered approach shall be considered as either free ended or propped cantilevers as appropriate for the proposed roof slab connection. In either case the ground pressure shall be taken as the at rest value.

E3.5 Types of Construction

E3.5.1. The method of construction for the below ground structure shall take into account the following :

- The geology along the length of the approach structure.
- The hydrogeology and ground permeabilities of the site.
- The maximum depth of construction required.
- Control over heave and instability of the base of the excavation.
- The methods by which the completed structure shall be secured against flotation.
- The method for waterproofing the completed structure.

E3.5.2. The following methods of construction may be used either individually or in combination depending upon the particular

requirements of the location, size and type of structure. The list is not considered to be exhaustive.

(i) Diaphragm Walling

Particular attention shall be paid to the stability of the reinforcement cage during placing, methods for forming and locating box-outs, waterproofing of the vertical panel joints and support of the walls during excavation.

(ii) Secant Piling

Particular attention shall be paid to the formation of piles to ensure their integrity and water tightness, and to the support of the completed walls during excavation.

(iii) Soldier Piles and Lagging

Particular attention shall be paid to ensuring that the lagging is providing proper support to the ground, and that the wall is adequately supported during excavation.

(iv) Steel Sheet Piling

Particular attention shall be paid to adequately supporting the walls during excavation and to ensuring that water leakage will not be such that loss of ground or significant groundwater draw down will occur.

(v) Precast concrete panels.

E3.5.3. In all cases the need to support existing services adequately across or near to the excavation shall be taken into account.

E3.6 Flotation

The DDC shall include in the design of the below ground structure suitable methods for countering the uplift due to displaced water.

E3.7 Base Heave/Boiling

E3.7.1. The excavation during construction for below ground structures shall be checked for base heave/boiling.

E3.7.2. The completed subways shall be checked against base heave. E3.7.3 Differential heave and settlement shall be considered.

SHALLOW FOUNDATIONS

E3.8 Types, Applications, and General Methods of Analyses

Shallow foundations shall include spread footings for isolated columns, combined footings that support the loads from more than one structural unit, strip footings for walls, and foundation mats or rafts that support an entire structure or loaded area. Shallow foundations may be used where sufficient depth of competent bearing stratum occurs at the foundation's bearing level, and where the following statements are true.

- No highly compressible deposits are present below.

- The calculated foundation settlements are acceptable.
- Existing foundations and slopes shall not be adversely affected.

Methods for shallow-foundation analyses shall be based on recognised standard formulations. All design formulations, parameters, and assumptions shall be presented and accounted for in the analyses.

E3.9 Factors of Safety and Allowable bearing Intensities

Allowable, bearing-pressures shall be based on the calculated ultimate bearing capacities after applying a minimum factor of safety of 3.0 to the overall capacity. Increases in static load capacity of one-third may be allowed for short-term, transient-loading conditions. Requirements shall be satisfied for allowable, bearing pressures based on material type, relative compaction, strength, and other classifications addressed in applicable government publications and standards. The computation for bearing capacity shall be in accordance with IS 6403 or equivalent.

Spread foundations shall be proportioned to keep the maximum imposed soil pressure within the allowable levels and to minimise differential settlement. The design shall ensure that the resultant of the vertical, soil-pressure diagram falls within the middle one-third of either of the plan dimensions of the foundation.

E3.10 Settlements

The total or differential settlements of the chosen foundation system and the site- specific ground conditions shall be demonstrated not to have a significant influence on either the structure as a whole or on individual or groups of elements in the structure. This is particularly important for structures constructed in reclamation areas.

The design of any temporary, ground-support wall (prior to dewatering and excavation) shall include provisions to limit settlement in the adjacent structures or ground to 25mm maximum. The design shall also include provisions to limit angular distortions in adjacent structures to 1:2,000 maximum

The chosen foundation system or form of construction shall be demonstrated not to result in settlement of adjacent structures and properties exceeding the values above. In particular, such structures shall be capable of withstanding these deformations either with or without building-protection measures.

In addition, the requirements for tolerable settlements addressed in applicable government publications and standards shall be satisfied.

DEEP FOUNDATIONS

E3.11 Types and Applications

Deep foundations can generally be classified as follows: driven, displacement elements (large displacement, small displacement) and drilled, cast-in-place, replacement elements.

Driven, displacement elements includes the following.

- Precast prestressed concrete piles (solid sections, cylinder sections).
- Open- and closed-end steel pipe sections.
- Steel H-sections.
- Special sections (Franki piles, Monotube piles, step-tapered piles, PIP piles).

Drilled, cast-in-place, replacement elements includes the following.

- Machine-excavated piers.
- Hand-excavated caissons.
- Barrettes.
- Minipiles.

Deep foundation elements shall be used where bearing capacity or settlement considerations, or both, render shallow foundations unsuitable, or where it is necessary to span foundation loads over existing structures.

E3.12 General Methods of Analyses

Analytical methods include evaluations of axial and lateral capacities, including determinations based on presumptive, simplified rational methods based on total and effective stress analyses, numerical methods, and semi-empirical correlations with in-situ test results. Driveability analyses (wave equation analyses) shall also be performed for driven foundation elements.
Corrosion considerations with respect to deep foundations shall be according to IS 2911 and IS 2720.

E3.13 Factors of Safety and Allowable Capacities

Allowable capacities shall be based on the ultimate capacities after applying appropriate factors of safety. The ultimate pile capacity can be derived from shaft resistance, end bearing, or a combination of both. Capacities shall consider both the strength of the subsurface bearing materials and the allowable structural stresses in the pile materials (steel, concrete). Increases in static axial compressive capacity of one-third may be allowed for short-term intermittent-loading conditions.

For foundation elements under static, axial compressive loads, a minimum, global factor of safety of between 2.0 and 3.0 shall be applied to the ultimate pile capacity. A minimum factor of safety of between 2.0 and 2.5 shall be applied to the ultimate shaft resistance, and a minimum factor of safety of 3.0 shall be applied to the ultimate end bearing.

For foundation elements under static, axial tensile loads, a minimum factor of safety of between 2.5 and 3.0 shall be applied to the ultimate shaft resistance.

Lower-bound minimum factors of safety for axially-loaded foundation elements may be applied if validated by comprehensive load testing. However, in no cases shall minimum factors of safety for axial-loaded foundation elements be less than 2.0.

For vertical foundation elements under lateral load, load-carrying capacity will normally be governed by limiting lateral-deflection requirements, and the moment or shear capacity, or both, of the structural members.

E3.14 Settlements

See Sub-Section E3.10

E3.15 Negative Skin Friction

The design of deep foundations shall include the effects of negative skin friction or downdraw, which may result from settlement of surrounding compressible soils at built-up (fill) sites, from subsidence caused by construction dewatering, or from particular methods of foundation installation. Even with extensive pre-treatment of reclaimed areas, deep foundations and other structural elements constructed in these areas may be subject to negative skin friction loads caused by settlement of the fill and the underlying soft material should be accounted for also.

Unless otherwise accepted, negative skin friction shall be considered as a permanent load on the structural elements and shall be determined from the settlement profile of the relevant strata.

Proposals for bitumen or slip coats applied to these elements, or other appropriate methods to reduce the effects of negative skin friction or other adverse soil conditions may be submitted for acceptance.

E3.16 Group Effects

The design of deep foundations shall include group effects that may reduce the calculated single element axial and lateral capacities and increase the calculated single element deformation.

E3.17 Testing Programme for Deep Foundations

The design shall include the details of a deep foundation load-and-integrity testing programme generally in accordance with IS 2911 (Part 4). Provisions shall be made for the following tests.

Static Load Tests. Compression load tests; uplift load tests; lateral load tests, for all deep foundation types to validate design capacities. Static load testing may be expanded here to include test methods, using Osterberg-type load cells, in which the test load is applied to the base of the foundation element.

Dynamic Load Tests. Pile Driving Analyser; Case Pile Wave Analysis Program (CAPWAP) method; Statnamic-type tests, may be used to supplement, but not replace, static load tests.

Provisions for non-destructive integrity testing (seismic testing, nuclear probes) shall also be included in the testing programme. Testing methods for deep foundations shall be generally according to IS 2911 (Part 4).

For driven, displacement elements, the programme shall include the details of a preproduction, probe, pile programme to be conducted with load testing to determine driving conditions and to confirm installation methods.

Section E4 – RETAINING WALLS AND ABUTMENTS

GENERAL

E4.1 Types, Applications, and General Methods of Analyses

The Criteria set forth in this section governs the design of retaining walls, abutments, and wing walls for viaduct, bridge, and crossing structures. Retaining structures shall be designed to resist earth pressures, hydrostatic pressures, seismic loads, and lateral loads due to surcharge, such as those imposed by highway or railway traffic. Analyses shall consider foundation bearing capacity, stability against base sliding and overturning, and slope stability (resistance against both local instabilities of the back slope area and global slope instabilities that involve the entire wall structure). Settlement of the wall and backfill, and tilting shall also be considered. Retaining walls and abutments may be supported on either shallow or deep foundations.

E4.2 Definitions

Load Factors.

Typically applied to surcharge loads and to material properties, such as unit weights, base friction angles, drained and undrained shear strengths (soils), and compressive strengths (rock). For drainage considerations, an appropriate load factor is also applied to permeability values of granular filters and backfill drainage materials. Load Factors are also known as factors of safety.

Loading Conditions.

Earth pressures and lateral loads due to surcharge shall be based on soil and rock parameters determined from interpretations of ground investigation and laboratory test data and from information related to the state of stress of the backfill. The methods and sequence of backfilling and the effects of compaction shall be considered. Saturated unit weights of soils shall be used to determine earth pressures. A reduction in the saturated unit weight shall be considered only where it can clearly be demonstrated that the backfill soil/rock is and will remain well-drained.

E4.3 Methods of Support

Retaining walls, abutments, and wing walls may include the following.

- Gravity and semi-gravity walls where stability is derived from the dead weight of the structure itself.
- Counterfort and cantilever walls where stability is derived from the dead weight of the wall and of soil engaged by the geometry of the wall.
- Tieback walls where stability is derived from the tensile capacities of tiebacks/anchors.

- "Reinforced earth"-type walls (including reinforced fill structures) where stability is derived from the composite action of the wall facing and backfill, which is reinforced with closely-spaced, small reinforcing elements.
- Crib walls and gabion walls (which may be considered where maximum vertical height measured from toe of wall will not exceed 7m, and where surcharge loading is not present).

E4.4 Load Factors

The partial-load-factor method of applying different load factors (factors of safety) for loading and for material properties shall be used. Loading conditions, such as wall weights, backfill soil/rock, water, and seismic loads, are typically unfactored (load factor of 1.0). Load factors shall be recommended by the Designer.

E4.5 Drainage and Waterproofing Considerations

Retaining wall designs shall provide both effective measures to prevent saturation of backfill soil/rock and to provide effective drainage of backfill soil/rock at all times, including during design flood conditions. If possible, where the retaining structure is impermeable, drainage blankets and toe drains shall be provided to allow drainage and dissipation of water pressures.

Section E5 - SLOPES

E5.1 Typical Slopes

Typically, cut slopes in rock shall not be steeper than 3 horizontal to 10 vertical, with a minimum 4m-wide bench at least every 15m vertical interval. Typically, cut slopes in highly weathered rock of and compact alluvial deposits shall not be steeper than
1.5 horizontal to 1.0 vertical, with a minimum 1.5m-wide bench at least every 7.5m vertical interval. Typically, fill slopes shall not be steeper than 2.0 horizontal to 1.0 vertical.
The typical slopes cited above are provided as guidelines. Actual slope designs shall be based on the results of recognised, analytical methods.

E5.2 General Methods of Analyses

E5.2.1. Soil Slopes

Geometries of slopes in soils shall be determined analytically, generally using non- circular calculation methods, such as the Simplified Janbu method. Depending on soil type/composition, infinite slope, sliding block, or Bishop circular analyses may be used where more appropriate. Where high-quality subsurface data are available, or when back-analyses of a failed slope are being carried out the Rigorous Janbu, Morgenstern-Price or Sarma's methods may be appropriate.

E5.2.2. Rock Slopes

Geometries of slopes in rock, including completely to highly weathered rock with controlling remnant rock jointing or other structure, shall be determined analytically, generally using stereographic projection or vector methods. Slope geometries shall be analysed for planar sliding along individual joints, block sliding along joint set combinations, and toppling.

E5.3 Methods of Support

Typical methods of support include mechanical restraint involving walls, temporary and permanent ground anchors, soil nailing, and rock bolting. Passive methods involving internal drainage of slopes (horizontal drains or weepholes) shall be considered in design and construction to improve stability by dissipating driving water forces.

E5.4 Factors of Safety

Factors of safety for slopes shall be at least 1.5 and 1.2 for the short term and long term case respectively.

E5.5 Drainage and Erosion-protection Considerations

All slopes shall be provided with surface drainage and erosion-protection systems based on acceptable soil loss, topography and hydrology. Typically, slope drainage shall be provided by a series of interconnected

channels at the top of the slope, along intermediate benches, and at the toe of the slope that intercept runoff and convey it to discharge points beyond the slope. Drainage channels shall typically be concrete-lined U-channels, or half-round channels.

Rigid surface protection such as shotcrete/gunite, with/without welded-wire fabric or fibre reinforcement shall be provided for all exposed soil slopes. Weepholes penetrating the surface protection shall be provided to prevent build-up of water pressures. Typically, 50mm diameter weepholes at 1.2m centres each way shall be provided.

Vegetative protection shall be limited to relatively flat slopes with low relief that are capable of supporting vegetation and that have adequate stability under saturated conditions.

NOIDA METRO RAIL CORPORATION LIMITED

CONTRACT NO: NMRC/Projects/NGNEDDC/2025/415

Contract NGNEDDC: Detail Design Consultant (DDC) for Civil, Architectural and E&M works including Traction works for Elevated Sections of Extension Projects of Aqua Line from Noida Sec-51 to Knowledge Park-V, Noida Sec-142 to Botanical Garden & Depot Station to Boraki including augmentation of existing depot and RSS works (31.595 km).

VOLUME-5
STANDARD DOCUMENTS

PART III – GENERAL PLANNING CRITERIA

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CONTRACT No. NGNEDDC

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Section G
GENERAL PLANNING AND DESIGN REQUIREMENTS

G 1. PURPOSE AND SCOPE

The purpose of this Appendix is to include other criteria and requirements not included elsewhere that are necessary for the full development

G 2. SITE DESIGN

G 2.1. Principles and Standards

This section lists the main principles and standards for urban design, site design, and landscaping at stations. This includes basic design principles, vehicular and pedestrian circulation, and parking. Circulation patterns for traffic within station sites and on approaching streets shall be determined on a site specific basis for each station site. Three conditions shall always be considered:

- Integration of stations and associated property development with the existing urban fabric, respect for local traditions, where applicable, and minimising visual intrusion into the urban landscape are important NMRC goals.
- Separation of traffic modes to allow convenient, safe, and rapid access to and from NMRC facilities.
- Accommodation of passenger design loads for NMRC traffic.

G 2.2. Access Modes

NMRC passengers will arrive at and depart from the stations via five basic modes of transport. In order of priority for station access, these transport modes are as follows:

- Pedestrian Walk-in;
- Scooter and Cycle with parking;
- Bus;
- Taxi, Auto-Rickshaw, Cycle-Rickshaw and Car Drop-off;
- Automobile with Station Parking.

G 2.3. General Site Circulation Parameters

Pedestrian Link.

Entrances shall cater to the pedestrian. In most cases, the station will be tied by a pedestrian link to the podium level of adjacent development.

Various ground circulation systems will be located below the level of the pedestrian podium.

Entrance Conditions.

An entrance shall be visible from the bus-loading area, if possible, and at a minimum shall be easily accessible from the loading area. Covered access from the vehicle drop-off areas to the station entrance shall be provided. In most cases this will be provided by the podium level above the station. Where there is insufficient buildingstructure to cover the area, an additional canopy shall be considered. Property Development.

Station and property development circulation shall be separated. Orientation.

Site circulation layouts shall be simple and direct, allowing easy orientation for drivers and facilitating the movement of pedestrians.

Parking Layout.

Station parking areas shall be laid out so that queuing for parking will not obstruct bus circulation or automobile and taxi drop-off areas.

Intersections.

Where conditions permit, roadways shall be one-way circulation, with turning loops eliminating intersections within the site.

Sightlines.

Sightlines at merges or intersections shall be left clear.

G 2.4. **Pedestrian Access**

From Adjacent Streets

Direct and safe approaches for pedestrians shall be provided into the station area from all adjacent streets.

Crossing Traffic

Right-of-Way. Pedestrians shall have the right-of-way over vehicles at crossings of internal roadways.

Visibility

Pedestrian crossings shall have good visibility for both pedestrians and drivers. Refuge Area.

Pedestrian crossings at streets wider than four traffic lanes shall have a refuge area in the median.

Path Direction.

A pedestrian’s path from a parking stall to the station entrance shall be as direct as possible. Where possible, the use of natural light shall serve to

identify this route. The coefficient of directness, i.e., length of path divided by straight line distance, shall not exceed 1 in 4, preferably 1 in 2.

Kerb Cuts

At all pedestrain crossings, kerb cuts shall be provided for Persons with Special Needs. All kerb cuts shall be marked with signs.

Markings

Pedestrian crossings shall be emphasised with textured pavement or crosswalk markings. Where major pedestrian paths cross roadways, the paving material, or a material of similar colour, shall be carried across the roadway to emphasise the pedestrian right-of-way.

Number of Crossings.

The parking pattern shall be designed to allow pedestrians to walk toward the station with a minimum of traffic crossings.

Minimum Dimensions.

Minimum dimensions of pedestrian walkways and crosswalks shall comply with Indian Road Congress(IRC) requirements.

Pedestrian Parapets and Missile Screens

All structures, including podium areas, parking structures, roof terraces, and walkways that cross over railway tracks, shall have solid parapets 1500mm high. The parapets shall be designed to prevent persons from walking or standing on top of them, including protection to the ends to deny access. Lightweight missile screens above parapets shall be provided to a combined height of 3000mm minimum above finish floor level to prevent articles from being thrown directly onto the track.

G 2.5. **Vehicular Access**

Traffic Distribution.

Vehicular entrances shall be located to distribute traffic loads evenly over the site. Entrance Location.

Vehicles shall enter from secondary roads, where possible, with provision for sufficient waiting and stacking space.

Separation of Types.

Entrance and exits from station parking shall be separated, where possible, from those of bus and auto drop-offs.

Number of Entrances.

The number of vehicular entrances along any one street shall be kept to a minimum. Turning Lanes.

Where required for traffic mitigation, turn lanes shall be provided for

entering or exiting vehicles. Left turns into and out of the station are preferable to right turns.

Emergency Vehicle Access.

Emergency vehicle access shall be provided to all building structures, especially the station entrances. Station access roads and parking lot perimeter roads shall accommodate emergency vehicles including fire trucks.

Auto Drop-off

A drop-off and pick-up zone, preferably with boarding on the left hand side, is required adjacent to the main entrance of the station. This area shall be sheltered, in most cases, by the station or the podium of the property development. A kerb cut shall be provided within or adjacent to this area for Persons with Special Needs. The location of the kerb cut shall be marked with signs.

Where site area permits, a parking area for persons waiting to pick up passengers shall be conveniently located close to the pick-up zone. This parking area shall provide good visibility of the station exit and shall permit convenient re-circulation of Vehicles.

G 2.6. **Station Parking**

Locations.

Parking shall be provided at some stations. Space will generally be provided in structured garages. Where space permits, parking may also be provided at ground level.

Aisle Direction.

The direction of the parking aisles shall be determined by the needs of both the pedestrians and the vehicles. In most cases, the aisles shall be perpendicular to the station entrance. Where site conditions dictate parallel aisles, provision shall be made for pedestrians to cross the parking row.

Angle of Parking.

Standard 90° parking is preferred. Wheel Stops.

Wheel stops within each parking space shall not be used as they are a maintenance problem.

Landscaping.

Where station parking is provided at-grade, landscaping shall be used to sub-divide the parking area and to provide shade.

Payment.

Parking shall be on a pay per entry basis. Entrance and exit gates shall be operated by means of a card validated at the parking shroff. Details of

payment for and management of parking areas shall be determined at a later date.

Special Needs Parking.

Parking designated for Persons with Special Needs shall be located as close to the station entrance as possible. Roadway crossings from these spaces to the station entrance shall be kept to a minimum.

Numbering.

All public parking places shall be numbered.

G 2.7. **Taxi and Bus Lay-Bys**

Bus lay-bys shall be provided at stations to facilitate passenger transfers to bus transport in the event of emergency or train failure. Additional bus lay-bys shall be designed to suit site specific requirements and demand forecasts.

G 2.8. **Pedestrian Ways and Overpasses**

Walkway, stair, and escalator space requirements shall be based on Level of Service “C” as described in Pedestrian Planning and Design, John J. Fruin, original copyright 1971.

G 2.9. **Cycle Facilities**

Cycle facilities shall be provided at selected stations. Stations most suited for cycle facilities include those in areas of low-density development and those adjacent to existing or planned cycle tracks. A list of selected station locations will be developed during the Technical Studies phase. Cycle facilities shall conform to the criteria given below.

- Connections to Community. Cycle tracks shall be designed to provide a direct, convenient connection between the station and any existing or proposed bike routes throughout the community.
- Vehicle/Cycle Interface. Cycle track design shall avoid any undue conflicts of cycles with motor vehicles moving parallel to the cycle track, turning across the cycle track, or crossing the cycle track at street intersections.
- Safety. Cycle tracks shall be designed to promote public safety. Cycle tracks that are near steps or kerbs or are hidden from public view shall be avoided.
- Cycle Track Configuration. At stations, cycle tracks shall be designed to pass through an uninterrupted corridor with access to station cycle-parking facilities.
- Pedestrian/Cycle Interface. Cycle-parking facilities shall be located out of the way of pedestrian walkways. They shall be detectable to the

visually impaired by means of paving, kerbs, or railings, and shall be within view of station entrances.

- Equipment. Short-term cycle parking shall consist of a securing device that allows the two wheels and frame to be locked. Cycle racks shall not be placed on pedestrain walkways.

G 3. LANDSCAPING

G 3.1. Railway Alignment

The design shall provide for suitable landscaping and introduction of appropriate vegetation along the route of the viaduct to improve the aesthetic appearance of the structures. It shall also confirm to the master plan recommendations.

The design shall specify shrubs, trees and ground cover, suitable to their location and the city environment to be provided within the full length of the central median to improve and soften the impact of the structure on the city scene after completion of construction.

The design shall provide for watering points at appropriate centres along the median to enable plantings along this strip to be properly maintained.

G 3.2. Station Areas

The design shall include in the station design for the provision of appropriate planting to enhance and soften the appearance of the station box and the approach structures.

Landscaping and external works around station entrances and inter-change facilities to be included in the tender documents shall include:

- Standard Schedule Formats
- Typical Landscaping Details
- Fencing, Barriers and Bollards
- Site Fixtures, Furnishings and Equipment

G 3.3. Irrigation

The purpose of the following criteria is to provide efficient water use through proper design and management of landscape irrigation. Landscape irrigation systems shall conform to local codes and policies of the communities in which NMRC facilities are located.

Co-ordination with Plant Material.

Irrigation systems shall be organised so that non-drought-tolerant planting shall be watered separately from the rest of the landscaping.

Location.

Sprinklers and sprays shall not be used in areas less than 2500mm wide. Drip and bubbler devices shall be used with the minimum flow rate necessary to water plant materials.

Slope Conditions.

Sprinkler heads on slopes exceeding 15% or on slopes exceeding 10% within 3000mm of hardscape areas shall be calibrated to prevent excess runoff.

Valves and Circuits.

Valves and circuits shall be separated based on water use. Trees.

Drip or bubbler irrigation systems shall be required for trees. Sprinkler Heads.

Sprinkler heads shall have matched precipitation rates within each control valve circuit. Sprinkler head spacing shall be designed for head-to-head coverage

Check Values.

Serviceable check valves shall be required where elevation differential may cause low head drainage.

Runoff.

Irrigation systems shall be designed for minimum runoff and overspray to non-irrigated areas.

Programming.

All irrigation systems shall be equipped with a controller capable of dual or multiple programming. Controllers must have multiple-cycle start capacity and a flexible calendar program.

Control.

All irrigation systems shall be controlled by a central computer. Irrigation Schedule.

Every controller shall have an irrigation schedule attached for maintenance personnel to follow. Irrigation schedule shall reflect time of year and plant maturity.

Water Budget.

Plans shall include a water budget that includes the following:

- Estimated annual water use (in litres) and area irrigated (in square metres);
- Precipitation rates for each valve circuit;
- Monthly irrigation schedule for plant establishment period and the first year thereafter.

Vacuum Breakers.

All vacuum breakers and controllers shall be located to eliminate the need for corrective screening.

Quick-Disconnect Valves.

In parking, podium, and plaza areas, quick-disconnect valves shall be provided for washing pavement and watering trees in pockets.

Rain Detection.

Rain shutoff devices with automatic controller and automatic moisture sensors shall be used. Precipitation rates for a given circuit shall not exceed soil absorption rates.

G 4. UTILITIES

G 4.1. The DDC is responsible for determining the extent of existing services in the area of the Works, and for planning, in co-ordination with Utility Agencies the relocations and diversions of the services to enable the Permanent Works to be carried out. The DDC will follow the requirements of the Utility Agencies for relocation or diversion of their services.

If the DDC is required to relocate or divert any utility to a higher standard or capacity than the existing system, the DDC will advise the Employer's Representative.

G 4.2. The DDC will note that in addition to any liaison with the Utility Agencies regarding diversion works, any works which will affect the operation of the Highway will have to follow the appropriate procedures as laid down by the Noida-Greater Noida authorities and/or the highway authority in this respect.

G 5. ACCESS FOR INSPECTION AND MAINTENANCE

The design shall incorporate suitable access provisions for the inspection and maintenance of all structures and equipment.

This will include provision for inspection of structural and non-structural elements within the station structures. Any bearings shall be accessible for inspection and, where necessary, replacement. Half joints in structures should be avoided where possible.

G 6. ENVIRONMENTAL REQUIREMENTS

G 6.1. General

The DDC shall note the requirements in respect of the Environmental Protection Requirements to be applied to the Works.

G 6.2. Noise

The design of the Permanent Works shall minimise noise emission due to

operation of the railway, and shall comply in full with the following requirements:

(a) The design of all parts, including non-structural parts, of the structures shall minimise as far as practicable the radiation of noise due to vibration caused by the passage of trains. Particular attention shall be paid to the minimisation of noise at the low end of the acoustic frequency spectrum.

(b) Walls and slabs intended to contain airborne noise from the railway shall be of concrete of 200 mm minimum thickness or shall be purpose-made, non- combustible, vibration absorbing/damping GRC panels or similar construction.

G 7. SECURITY REQUIREMENTS

G 7.1. The Permanent Works shall be sufficiently robust to restrict, to acceptable levels, their vulnerability to accidental or malicious damage.

G 7.2. G 7.2 All security measures shall be subject to the consent of the Employer's Representative.

G 7.3. G 7.3 Security against unauthorised access to the various parts of the Permanent Works shall be provided.

G 8. DURABILITY AND MAINTENANCE

G 8.1. The design shall ensure, by means of the appropriate choice of structural forms, details and materials, that the structure shall remain in a serviceable condition over its life, with due regard to its location and the environmental and climatic conditions prevailing. In particular, the following shall apply:

(a) Only materials and details having a proven record of durability in similar conditions shall be used.

(b) All bearings shall be replaceable without major disruption to traffic using the bridge or to rail, waterway or other operating traffic or to other activity scouring underneath the bridge. Appropriate jacking points shall be provided.

G 8.2. Access shall be provided for inspection and maintenance to all elements of the structure.

G 8.3. Maintenance requirements shall be minimised by appropriate detailing and the selection of suitable materials that will reduce weathering and staining as far as possible. Structures shall be detailed so as to shed surface water in such a way that ponding and streaking do not occur and details which encourage the accumulation of debris shall be avoided. Details shall be designed for ease of maintenance.

G 9. ROAD PAVEMENTS

Road pavements for reinstatement of roads excavated by the DDC shall be

designed to the same standard and form as the existing road, to the satisfaction of the Authority responsible for the road.

NOIDA METRO RAIL CORPORATION LIMITED

CONTRACT NO: NMRC/Projects/NGNEDDC/2025/415

Contract NGNEDDC: Detail Design Consultant (DDC) for Civil, Architectural and E&M works including Traction works for Elevated Sections of Extension Projects of Aqua Line from Noida Sec-51 to Knowledge Park-V, Noida Sec-142 to Botanical Garden & Depot Station to Boraki including augmentation of existing depot and RSS works (31.595 km).

VOLUME-5
STANDARD DOCUMENTS

PART IV - BUILDING SERVICES

NOIDA METRO RAIL CORPORATION LTD.
Block-III, 3rd Floor, Ganga Shopping Complex,
Sector-29, Noida -201301,
District Gautam Budh Nagar, Uttar Pradesh, India

CONTRACT No. NGNEDDC

INDEX

BUILDING SERVICES

H 1. GENERAL, CODES AND STANDARDS

H 1.1. Description of Works

H 1.1.1. The DDC shall provide designs and specifications for the mechanical and electrical works described in these criteria and on the drawings.

H 1.1.2. The emphasis is to explain the requirement of work, interfaces with other DDCs for achieving an efficient & safe system to the best international standards and practices. DDC shall follow acceptable standards & design procedures akin to the best systems where not explicitly mentioned.

H 1.1.3. The main items of the Works shall include but not be limited to:

(a) Power supply arrangements from 33 kV to 415V Auxiliary substation and associated incoming 33 kV feeders and LV Switch Board. (see also Clause H3.4.1)

(b) Power Distribution system at 415 V or below including LV switchboard, main distribution board, bus ducting, cabling, distribution and sub-distribution boards, feeder pillars etc.

(c) Electric Supplies to various plants & equipments provided under the scope of other DDC or contractor.

(d) DG set complete with automatic mains failure (AMF) panel & associated power distribution & change over panel.

(e) Station lighting parallel redundant online UPS to feed emergency loads and power supply extension with associated control change-over panel.

(f) Automatic Power factor correction at supply point and major loads with associated control, distribution boards and protection.

(g) Water pumping systems and potable water treatment & distribution system and drainage/sewage treatment & disposal system if required

(h) Power supply extension from Main Distribution Board for Normal, Essential & Emergency services backed by DG set supply through UPS, cabling, Bus-Trunking / ducting etc. for services i.e. Building Services including air conditioning, lighting (both indoor and outdoor) etc.

(i) Cable supports, ducts and draw pits for cables to be installed by others;

(j) Fixings on the structure for equipment to be installed by others;

(k) Earthing and lightning protection;

(l) Fire fighting systems including detection, alarm and suppression etc.

(m) Lifts & Escalators-Only provisioning of structural space and architectural finishes; Equipment shall be supplied by E&M group.

(n) DDC shall detail the complete requirement for the safe, efficient & cost effective solution furnishing study report covering the options available and suggested course of action with proper reasoning.

(o) Preparation of quality assurance, testing formats, manuals and misc other drawings.

(p) Furnishing of good for construction drawings for the contractor for all the above services excluding the shop drawings repetitive in nature.

H 1.2. Other Consultants and Contractors

H 1.2.1. The DDC shall make allowance for other concurrent electrical and mechanical works.

H 1.2.2. DDC shall Prepare Engineering design, Technical specifications, Special conditions of contract, Bills of quantities, layouts, erection / mounting details, interface with other DDC/contractors or arising out of concurrent works, typical arrangements / schemes and lay down testing and acceptance criterion and provide schedules and costs. The submittals shall be in the form of reports, drawings, calculation sheets and schedules both in hard copy and software. The DDC shall also furnish back up materials such as codes / standards and validated accredited software programs free of cost for the employers' representative use in understanding / evaluation of the submittals. The DDC shall furnish a list and format of submittals for each area of work for the consent of the employer's representative covering the requirements stated hereto.

H 1.2.3. The DDC shall prepare typical arrangements and schemes and lay-down testing and acceptance Criterion and provide schedules and costs.

H 1.3. Mechanical

CIBSE	Design Guides A, B and C
ASHRAE	Design Handbooks
CIBSE	Commissioning Codes A, C, R and W
CIBSE GN 3 :	1993 Legionellosis Montreal Protocol
	Subway Environmental Design Handbook USA Department of Transportation, Urban Transportation Administration
BSRIA	Design for Maintainability
BSRIA	Condition Based Maintenance for / Buildings TN1/95
BSRIA	Decisions in Maintenance TN14/92
COSHH	Regulations (UK)
HSE EH48	Guidance Notes
HVCA	Standard Specifications for Mechanical Services in Buildings Asbestos Regulations
	Health and Safety at Work Act
DHSS	The Control of Legionella - A Code of Practice
NFPA 10	Portable Extinguishers
NFPA 22	Water Tanks

NFPA 24	Private Service Fire Mains
NFPA 101	Life Safety Code
NFPA 130	Fixed Guideway Transit Systems
NFPA 204 M	Smoke and Heat Venting
NFPA 2001	Clear Agent Extinguishing Systems
IS 1172	Code of basic requirements for water supply, drainage and sanitation.
IS 1742	Code of Practice for Building Drainage.
IS 2064	Code of Practice for selection, installation and maintenance of sanitary appliances.
IS 2065	Code of Practice ifor water supply in buildings.
IS 2470	Code of Practice for installation of septic tanks.
IS 3114	Code of Practice for laying of Cast Iron Pipes.
IS 4111	Code of Practice for ancilliary structures in sewerage system.
IS 4127	Code of Practice for laying of glazed stoneware pipes.
IS 5329	Code of Practice for sanitary pipework above ground for buildings.
IS 7740	Code of Practice for construction and maintenance of Road Gullies.
IS 12251	Code of Practice for drainage of building basements
IS 12288	Code of Practice for use and laying of Ductile Iron Pipes.
BS 1387	Spec for screwed / socketed steel tube suitable for welding / BS21 pipe threads
BS3505	UPVC pipework and jointing
BS8301	Building Drainage
BS5572	Sanitary Pipework above ground
BS6700	Supplying Water for domestic uses within buildings
BS6742	Specifications for hand held spray guns and associated apparatus

H 1.4. Electrical

IEE	Regulations, 16th Edition
NFPA 70	National Electrical Code (NEC)
NFPA 101	Life Safety Code

NFPA 130	Fixed Guideway Transit Systems
NFPA 110	Emergency Standby Power Systems
NFPA 111	Stored Electrical Energy, Emergency and Standby Power Systems.
COSHH	Regulations (UK)
BSRIA	Design for Maintainability
BSRIA	Decisions in Maintenance TN 14/92
BS4066	Method of test on single vertical insulated wire or cable
BS4941	Specifications for motor starters for voltages up to and including 1000 V a.c. and 1200 V d.c. (now replaced by BSEN 60947)
BS5445 :	Part 5 - Heat sensitive detectors, point detectors containing a static element
BS5445 :	Part 7 - Spec for point type smoke detectors using scattered light transmitted light or ionisation
BS6651	Code of Practice for protection of structures against lightning
BS6425	Method for determination of amount of halogen acid gas evolved during combustion of polymeric material taken from cables

H 1.5. Codes and Regulations

H 1.5.1. Main Electrical Design

H 1.5.2. Equipment, materials and systems shall be designed, in accordance with the latest issue of the accepted codes and standards.

H 1.5.3. Electrical design shall be based on BS 7671 : 1992 "Requirements for Electrical Installations" or other internationally recognised equivalent standard approved by the NMRC examples of which are :

IE Rules & IE Act

National Building

Code

ANSI American National Standards Institute

ASME American Society of Mechanical

Engineers ASTM American Society for Testing

and Materials DIN Deutsche Industrie Normen

IEC International Electrotechnical Commission

JIS Japanese Industrial Standards

NEC National Electrical Code

NEMA National Electrical Manufacturers Association

NFPA National Fire Protection Association

VDE Verband Deutsche Elektrotechniker

H 1.6. Local Codes, Regulations and Standards

H 1.6.1. Unless otherwise stated, the electrical system design shall be governed by all applicable local codes, regulations and standards issued by the local agencies such as:

BIS Bureau of Indian Standards

IEEMA Indian Electrical and Electronic Manufacturer's Association.

H 1.6.2. The DDC shall specify the regulations laid down by local authorities i.e., Government or Municipal agencies including fire safety regulations, fire insurance regulations or other local codes and make provision so that the NMRC/ Noida-Greater Noida authorities obtains approvals from relevant authorities at appropriate stages of work. Such regulations are:

Indian Electricity Rules Indian

Electricity Act National Building

Code

Inspectorate of Lifts and

Escalators Central Pollution

Control Board

U.P. Police and Fire Brigade

Central Public Works Department

U.P. State Electricity Board

National Safety Council

H 1.7. Additional Codes, Standards, Specifications and Manuals

H 1.7.1. In addition to local requirements, electrical system designs shall comply with the codes of practice and standards specified in herein. Local codes, regulations and standards shall take precedence where their standards or requirements are more onerous than other national standards. All codes and standards shall be submitted in the English language.

H 1.7.2. The design of any one system shall be to a single code or specification. The parallel use of different codes for one particular item or component shall not be allowed.

H 1.7.3. The DDC shall prepare also a **check list** based on relevant standards for ensuring conformity and uniformity in evaluation. The check list should cater for design, manufacture, supply/storage, packing, erection/ installation , testing & commissioning and operation as applicable.

H 1.8. Safety and Escape

The design relating to fire safety and escape shall be in accordance with the requirements of NFPA 130 Standard for Fixed Guide-way Systems.

H 1.9. Standardisation

The DDC shall, in establishing his design, follow the principles provided below in the design and specification of all plant, equipment and components:

a) Similar plant and equipment shall be replaceable/interchangeable, modular in design, adaptable and extendable.

b) The technical specifications and design criterion shall be uniform. Uniform standards for clear spaces, working clearances, protection of equipment and physical dimensions of equipment and interfacing with other systems.

c) Type testing, routine testing and endurance test shall be required under similar conditions. Evaluation shall be conducted at all stages and performance compared with acceptance criterion. Testing values shall be commensurate with reference standards.

d) Test standards and standardised equipment shall be selected or built or framed carefully, bench marked, designated and explicitly marked.

e) A standard procedure shall be followed for identification of each category of equipment explicitly (suffixing or prefixing while marking and numbering for each category of equipment).

f) Similar principles of establishing footprints of plant and equipment shall be followed.

g) The operating system shall be uniform for all systems/ sub systems.

h) Standards for maintenance planning shall be uniformly categorised.

i) Uniform standards shall be designated for procurement, replacement stocking and availability.

j) Equipment and accessories shall be provided with uniform standard spare capacity, protection.

k) Piping, cabling etc., shall be suitably colour coded for identification and categorisation for each kind of use/type.

H 1.10. Manuals

H 1.10.1. The DDC shall require to include suitable manuals for all Contractor-supplied equipment and systems. These would typically include the following:

(i) ***System Manuals*** - a comprehensive description of all system principles at block diagram level giving details regarding power distribution and protection scheme.

(ii) ***User Manuals*** - broken down into as many sub-sections as may be necessary and providing sufficient information to enable non-technical staff to fully exploit the facilities of each system.

(iii) ***Workshop Manuals*** - installation and circuit descriptions, full schematics, circuits, wiring diagrams, mechanical construction drawings and itemised parts list to enable all maintenance rectification and setting-up to be carried out.

(iv) ***Software System Manuals*** - for each software package and each piece of equipment which incorporates programmable devices and for which bespoke software has been prepared specifically for this application. This shall also include furnishing of the software packages used for design of various components of work and validation of data. Source code listings with comprehensive comments shall be provided for all bespoke software together with configuration listings for all configured standard software packages.

(v) ***Equipment Room Manuals*** - all wiring diagrams and circuits, protection scheme, equipment layout, terminal and cable listing and including such external equipment as may be necessary for completeness.

(vi) ***Maintenance and Servicing Manuals*** - to specify requirements, procedures and servicing intervals for planned preventive/condition maintenance and in addition to convey sufficient information on equipment principles and practice to enable first line fault diagnosis and rectification by technician staff.

H 1.10.2. The User Manuals and the Maintenance and Servicing Manuals shall be prepared in both English and Hindi Languages. Other technical manuals shall be supplied in the English language only.

H 1.10.3. The Contractor shall submit all Manuals for review by the Employer's Representative prior to factory acceptance tests.

H 1.10.4. The Contractor shall provide 6 copies of all Manuals well in advance and explain so as to understand the manuals by the user prior to commissioning.

H 1.11. Acoustic Criteria

Noise emanating from the following equipment/service installations shall not exceed 55dB for the static machines and 70dB for rotating machinery at a distance of I metre minimum to match or exceed the relevant international standards:

- At UPS room, auxiliary substation and pumping installations- 55dB.
- Air conditioners
- Ceiling fan
- Exhaust fans
- Switch boards/Distribution/starter panels
- Motors
- DG sets
- UPS

H 1.12. Technical specifications

H 1.12.1. The DDC shall prepare technical, material & workman's specifications for manufacturer or supply & installation of all electrical works in style of Construction Standards Institute (CSI) of America's three part format.

- Part 1.General
- Part 2. Material products
- Part 3.Execution

H 1.12.2. Specifications shall be complete in itself & shall confirm as relevant to the subject, **but not limited to, such as g**eneral requirement, service condition, protection, interfacing, design norms and specifications for Equipment, components and material, Main Distribution Boards, other panels/boards, control panels, DG sets complete with AMF & load transfer panel, battery charger, UPS & Valve regulated Battery system, FRLS PVC cables, XLPE cables, Fire survival cables etc including accessories, cable trays etc.. lightning protection, Earthing & bonding system, Energy efficient Lighting luminaries including electronic chokes, accessories, lighting poles, automatic Power factor correction systems,air conditioning, Water pumping system

H 1.13. Computer simulation

H 1.13.1. The designs shall be substantiated through computerised simulation of calculations, Data verification and validation programs using standard simulation programs international accredited or indigenously developed, supported with quality verification and acceptability and shall provide input data, results and program description.

H 1.13.2. **Software** for electrical load analysis, electrical system analysis like load flow, voltage drop, short circuit analysis, protection, relay co-ordination, grounding, transient stability study, cable sizing, lighting design, water flow analysis & pump design, refrigeration load analysis etc. shall be provided by DDC free of charge.

H 1.14. Certification of Personnel & work

H 1.14.1. DDC shall stipulate conditions for certification of personnel to execute work & certification of work through qualified and certified license holders or have competency from National / Internationally recognised agency empowered to issue, to carry out similar work or authority.

H 1.14.2. DDC shall certify the design and get the designs insured from empowered authority.

H 1.15. Quality control of equipment, components and material

H 1.15.1. Pretender & post-tender standard program, checklist / questionnaire shall be framed by DDC to seek information from bidder/contractor to assess/ensure quality of all major equipment, components & material. Quality Assurance Programme shall ensure proper supply and use of raw materials, processes, service provision/verification/testing.

H 1.15.2. DDC shall design to provide and state the corrosion protection systemsused and the design lives of the systems.

H 1.16. Spares, special tools, test equipment & training

The DDC shall stipulate list of spares, special tools, test equipment & training with recommended stockholding considering lead-time & other condition including those required prior to commissioning.

H 1.17. Submission of drawings & details:

H 1.17.1. The DDC shall Provide section drawings through the station service routes to show the adequacy to accommodate services and layout drawings showing location of all major components including the co-ordination drawing indicating all services.

H 1.17.2. DDC shall prepare the all Electrical schematics, Control & interlocks diagrams, wiring diagrams, conduiting layouts, cabling layouts, General arrangement drawings for all kinds of Distribution boards incorporating Legends, abbreviations, revision numbers, material quantity sheets, BOQ item references, fixing and erection details etc. but not limited to.

H 1.17.3. The DDC shall specify detailed/schematic drawings to include Combined Services Drawings (CSD), Structural/Electrical Mechanical (SEM) Drawings, Structural drawings, Fabrication drawings, Schematic drawings, Interlock drawings, Erection drawings, Wiring drawings, As erected/finished drawings.

H 1.18. Submission of Documents

The review study report detailing the complete requirement, options available to fulfil and suggested course of action shall be submitted within a months time from date of award for Electrical work complete with details regarding following but not limited to:

a) Electrical load

b) Space requirement for all electrical utilities including switch room, pump rooms cable ducts/shafts etc.

c) Design criteria with reference of standards and clearances as applicable and as recommended.

d) Iso-lux profile for the areas to be illuminated

e) Air conditioning criteria with reference of standards and clearances as applicable and as recommended.

f) Water pumping with reference of standards and clearances as applicable and as recommended.

g) Fire detection and suppression criteria with reference of standards and clearances as applicable and as recommended.

h) Criteria for selection of equipment and accessories with reference of standards and clearances as applicable and as recommended.

i) Norms followed

The DDC shall also submit within 2 months the calculations for load, switch gear sizing, selection, short circuit, cable sizing voltage drop, bus bar sizing, selection bus duct etc but not limited to duly validated through accredited software as required by the employer. Employer reserve the right to ask details to any of the related subject or submittal as deemed fit

DDC shall furnish take-off sheets of all the equipment and accessories and items of proposed BOQ within 3 months

DDC shall provide simultaneously the schematics, single line diagrams, wiring diagrams, fixtures details, legends , abbreviations etc. as required

DDC shall submit the tender documents i.e. specifications, BOQ, Drawings etc. as required as per decided schedule.

DDC shall furnish the reviews as required by the employer to provide the best techno-cost effective provisions for services.

The DDC shall prepare the Good for construction drawings and shall co-ordinate at all stages of execution for the approval of the drawings etc. as required.

H 2. MECHANICAL WORKS

H 2.1. Introduction

This section contains a general description of the system concepts and major components; also sections covering definitions, requirements for interfaces with other contracts, general mechanical and electrical installation requirements, and testing requirements.

H 2.2. Definitions and Abbreviations

H 2.2.1. Definitions

Definitions used in these criteria are as follows:

Ancillary Rooms - the non-public areas or spaces of the stations which contain operating, maintenance or support equipment and functions.

Operations Control Centre - the operations centre that controls and co-ordinates the system-wide movement of passengers and trains and the point from which communication is maintained with supervisory and operating personnel.

Station Control Room – the local control room at the station for operational control of the station and to monitor station activities and functions relating to the movement of passengers and trains along with auxiliary and support systems.

Fireman's Control Panel - a vandal proof panel located within the unpaid/paid station concourse area comprising a mimic diagram of the station (all levels) showing fire compartmentation zones related to manual call points, fire/smoke alarms.

Noise criteria shall be based on the references in Clause F2..3.2 in conjunction with the local building control regulations.

H 2.2.2. Abbreviations

Abbreviations used in this specification include:

DB	- dry bulb
WB	- wet bulb
rpm	- revolution per minute
LPC	- Loss Prevention Council
ESPS	- Escalator Sprinkler Protection System
MJC	- Multiple Jet Control
FAP	- Fire Alarm Panel
SCADA	- Supervisory Control and Data
Acquisition OCC	- Operations Control Centre

SOR - Station Operations Room

FCP - Fireman's Control Panel

H 2.3. Environmental Control

H 2.3.1. The DDC shall be responsible for designing all equipment including pipe work, valves, brackets, fittings, sleeves and insulation to complete the installation.

H 2.3.2. The DDC shall be responsible for system sizing and shall submit calculations for approval. The DDC shall also confirm the general adequacy of the space requirements within voids or services ducts, openings, main routes etc.

H 2.4. Air-conditioning of Building / Rooms

H 2.4.1. DDC shall prepare technical specifications, location drawing, erection / mounting details including testing and acceptance criterion for air-conditioning systems at designated rooms to maintain temperature at 27□2□C& requisite air changes. DDC shall furnish economical design for centralised low capacity, or split type air conditioning system specifying the consideration and comparison criterion with software backed verification and design validation there off.

H 2.4.2. DDC shall stipulate the dimensional requirements for space and liaise with other system wide DDCs to fix the location and provide the co-ordination layout. The technical specification shall incorporate aspects like Heat load calculation for each utility rooms/ building, Rating of sub systems like Dehumidifier, temperature control, condenser, compressor, motors, power factor improvement, evaporator, blower motor, filters, Minimum guaranteed cooling requirement, Air delivery, fresh air intake requirement, Acoustic level, electrical power requirement etc.

H 2.5. Sanitation

H 2.5.1. General

This section covers the requirements of the soil, waste, ventilation, mains water and cold water services installed throughout the station. The DDC shall be responsible for assessing the water disposal requirements, pipe sizing and submit calculations to the Employer's Representative. The DDC shall also confirm the general adequacy of the space requirements within voids or services ducts, openings, main routes etc. Indian Standards are to be considered, but where special considerations may apply acceptable alternative specifications are quoted in the following sub-sections.

H 2.5.2. Water Services

2.5.2.1. Cold Water Storage Cisterns/Tanks

Requirement for drinking water for staff, toilet flushing, station cleaning and fire fighting make up water shall be included. Cold water storage cistern/tanks shall be installed at the highest possible location within each station area. The DDC shall be responsible for ensuring all aspects of the storage requirements have been met for both domestic cold water cisterns/tanks and for certain equipment demands in addition to personnel demands.

Actual storage capacity of domestic cold water cistern/tanks shall be calculated based on providing 45 litres per head of staff present within the largest shift and an adequate provision for public toilets. This storage allowance is for guidance purposes only. Staffing figures shall be provided during the design phase.

Due to the layout of fittings it may be considered that more than one domestic cold water storage cistern/tank shall be required, therefore it is the responsibility of the DDC to clearly identify his intention and provide details for consent.

Depending upon storage capacity required and accessibility of tank location, domestic cold water cisterns/tanks shall be of suitable type and capacity. No Glass Reinforced Plastic (GRP) tanks or plates shall be used.

2.5.2.2. Mains and Cold Water Pipe Installation

The mains water and cold water services shall be installed in a neat and workmanlike manner and shall, as far as practicable, follow the contours of walls and shall be graded to ensure satisfactory drainage.

All valves and drain cocks shall be located for ease of operation and maintenance. Valves located behind panels within toilet or other areas shall be clearly identified via appropriate marking on the external face of the panel.

The station shall be provided with a minimum of three drinking fountains. These shall not be connected to the piped supply. They shall be of the chilled, bottled type with power supply from the 220 V mains.

Where urinal cisterns are installed, they shall be complete with hydraulic flow control devices, installed within the supply pipework at an appropriate location prior to cistern.

Internal mains water and cold water down service pipes, pipe fittings, tubular fittings and pipe threads shall be to Indian Standards where these meet the operational standards.

2.5.2.3. Valves

All valves used on water services shall be in accordance with the requirements of the water authority. The DDC shall be responsible to see that the requirements of the water authority are complied with in full. All valves shall be non-dezincifiable.

Valves for use on mains water pipework shall be stopcocks to BS 1010.

Valves for use on cold water services for servicing purposes shall be isolation valves to BS6675.

Valves used on cold water services for isolation purposes shall be gate valves to BS 5154.

Drain valves for use on cold water services shall be screw down cock type to BS F2.79.

Ball valves shall be high pressure equilibrium pattern complying with BS 1212: Table 1, complete with arm and copper ball float complying with BS 1968: Class "B".

All single and double non-return valves shall be with screwed ends to comply with BS 2682.

H 2.5.3. Sewage System

2.5.3.1. Cast Iron pipes

Cast iron soil waste and ventilating pipes, fittings and accessories shall conform to BS 416, with approved coating providing fire and corrosion protection.

2.5.3.2. Soil Waste, Waste and Ventilating Pipes Installation

All pipe runs shall be arranged to present a neat appearance and where practicable be parallel both with one another and with the building structure. All vertical pipes shall be plumb.

Pipe work shall follow the lines of walls vertically and horizontally and shall be graded as necessary for draining and venting. The minimum clearance between a pipe and any adjacent finished building surface, fixing or pipe shall be 35 mm.

Pipe work runs shall in all cases be installed with a view to co-ordination with other services, whether provided by the DDC or not.

Careful consideration must be given to the low flow rates experienced within stations when designing suspended drainage schemes. Self cleansing velocities must be achieved, minimising potential blockages etc., therefore a normal minimum installation gradient of 1:60 should be achieved. Any flatter gradient than 1:60 must be proven by the DDC prior to receiving consent.

2.5.3.3. Traps

All traps to waste fittings listed below shall be manufactured from copper to BS F2.71: Table "X". All traps shall be two piece tubular construction with minimum of 75 mm deep water seal. The joint between the waste outlet and the trap shall be made with PTFE tape and rubber sealing washer. All exposed traps within public toilets and staff rooms shall have a chromium plated finish. All other exposed traps shall have natural copper or painted finish.

2.5.3.4. Sanitary Fittings

(a)	Wash Hand Basins	:	35 mm diameter two piece deep seal
(b)	Sinks	:	42 mm diameter two piece deep seal
(c)	Sanitary Disposal Units	:	54 mm waste to connect to (integral) 75 mm deep seal trap
(d)	Water Closets	:	100 mm soil pipe, trap incorporated within sanitary fitting

2.5.3.5. Sewage Pumping

2.5.3.5.1. Normally, the sewage disposal shall be by gravity flow. However, where this does not apply, then the requirements of this sub-section shall apply.

2.5.3.5.2. The pumps shall be centrifugal type suitable for handling raw sewage. The pumps shall comply with BS 4028, BS 5316 and BS 6835: Class II.

2.5.3.5.3. Discharge velocity shall be not less than 0.75 m/s nor greater than 1.8 m/s. The pumps shall have a stable head-flow characteristic and be suitable for prolonged running under site conditions. Hand holes shall be provided in the pump casings to facilitate clearance of obstructions. Pump bodies, covers, brackets, wear rings etc. shall be of close grained cast iron or nickel iron. Pump impellers shall be of close grained cast iron. Each pump shall be complete with all necessary fittings including isolating and non return valves.

2.5.3.5.4. A local control panel shall be provided. On/off pump control shall be from level in the tank. The pumps shall operate in duty/standby mode. Discharge shall be through a heavy grade galvanised pipe of a minimum bore of 100 mm rising to ground level. The diverter set shall be located in a pit of sufficient size to give a minimum of 1 m clearance around equipment for access. A sump pump shall be provided in a pit of minimum size 450 x 450 x 450 mm to cater for minor seepage from the diverter. The sump pump shall have an on/off "pear drop" control with facility for high level alarm transmission to the SCADA system. Discharge of all sewage shall be to a septic tank at ground level. Discharge shall be via a "goose neck" bend with invert above flood level to act as a safeguard against station flooding. Discharge pipe work shall be cast iron.

2.5.3.5.5. The septic tank shall be of the anaerobic filter type with scum box, separation chamber and filter chamber. The tank shall be below ground level and shall have convenient access from the public road. The septic tank shall conform to BS 6297: 1983 and the requirements of the Central Pollution Control Board of India.

H 2.5.4. Drainage

Preferably all drainage shall be by gravity flow, but where required the pumps shall be submersible units. The pumps shall be mounted on guide rails for ease of maintenance. Each pump shall have an isolating valve and non-return valve. A local control panel shall be provided. Pump start and stop shall be from high and low level in the sump. A lifting system shall be provided for each installation together with an access hatch. A high level alarm shall be fitted to relay back via the SCADA system to the Control Centre. Discharge pipework shall be in heavy duty galvanised steel. The water shall discharge to the local surface water drainage system via a "goose neck" bend with invert above flood level to prevent back flow.

H 2.6. Fire Protection

H 2.6.1. Scope of Works

2.6.1.1. This section covers the requirements of the Fire Protection System installed throughout the Contract.

2.6.1.2. The DDC shall be responsible for complete fire system functioning, interlocks, pipe sizing and submit calculations for approval`. The DDC shall also confirm the general adequacy of the space requirements within voids or services ducts, openings, main routes etc.

H 2.6.2. Hydrant and Hose Reels

At the Fire Valve Room an isolating valve shall be installed to control the hydrant main. The valve shall be both lockable and addressable.

Hydrants shall be mounted at end platform and centre of each platform level within equipment cabinets.

Hydrants shall be terminated with a landing valve such that the base of the valve is 300 mm from the finished floor level.

The hydrant main shall be run from the Fire Valve Room to the platform level with a spur(s) to the various hose reel positions. The hydrant main shall be run in its full extent in 150 mm pipe work. The DDC shall perform water pressure calculations to assess the pressure and flow at each hydrant landing valve. The location of every hydrant shall be clearly marked.

Hose reels shall be of non-kinking reinforced flexible tubing with an internal diameter of 25 mm. Hose reels should be 30 m in length and be manually operated.

Hose reels shall be typically connected to a 25-50 mm wheel operated isolating

valve.

Hose reels shall be fully recessed in purpose made cabinets or surface wall mounted standard pattern, according to design requirements.

One hose reel should be provided to cover every 800 m2 of floor space or part thereof in the ticket hall and concourse areas.

Hose reels should be sited in prominent and accessible positions at floor level, adjacent to exits or exit routes, in such a way that the nozzle of the hose can be taken into every room and within 6 m of each part of a room. The hose and nozzle should be capable of directing a jet of water into any recess area.

2.6.2.1. Hydrant and Hose Reel: Valves

These shall be to the requirements of BS 5041 : Part 1. The flanged inlet shall be suitable for sufficient flow of water for fire fighting purposes.

Valve outlet shall be 65 mm instantaneous.

Landing valves shall be gunmetal to BS 5041 : Part 2.

The first stop valve on the town mains supply shall be a double flanged cast iron wedge gate valve for waterworks purposes, to BS 5163, with open and shut indicator. Other main in-line stop valves to be gear operated butterfly valves to BS 5155 with rack and pinion gearbox with open and shut indication. Each valve to be secured open with strap and padlock.

Where non-return valves (NRV) are specified on a town mains supply they shall comply with BS 5152. A pressure gauge and test valve arrangement shall be fitted on the incoming supply side of each NRV and between the non-return valve and the stop valve.

2.6.2.2. Water Supply for Hose Reels

The DDC to ensure that, as a minimum, the water supply to hose reels should be such that when two reels in a building area are in use simultaneously, each shall provide a jet of approximately 6m in length and shall deliver not less than 30 l/min. For example, when a length of 30 m of the hose reel tubing (BS 5274) is in use with a

6.35 mm nozzle, a minimum static pressure of 1.25 bar shall be required at the entry.

The DDC shall perform water pressure tests for static pressure. Should the calculations reveal low pressure output at each hose reel, additional hose reel dual booster pumps shall be installed to provide the required pressures.

H 2.6.3. Portable Extinguishers

Three types of portable extinguishers shall be used :

- 4 kg CO_2 extinguisher (carbon dioxide) - HV and Switchrooms.
- 2 kg CO_2 extinguisher (carbon dioxide) - other electrical rooms.
- 9 litre foam extinguisher - water based.

Extinguishers shall be mounted securely on purpose made brackets. All extinguishers shall be manufactured to the requirements of BS 5423: 1987.

2.6.3.1. System Design Criteria: Portable Extinguishers

Both AFFF and CO2 and water based extinguishers must comply with the following requirements:

(a) BS 5423: 1980/87: Specification for Portable Fire Extinguishers.

(b) Must be type tested to a pressure of 200 bar, each cylinder type being tested. the manufacturer shall supply documentation of pressure testing and results.

Portable extinguishers shall be installed in groups to cover, for instance, multiple small office facilities.

CO2 extinguishers shall be installed in all electrical switchrooms, sub-stations, platform equipment cabinets, operations rooms and communications rooms.

H 2.6.4. Alarms, Indicators and Controls

Alarms are described in the Fire Detection and Alarms Section.

H 2.6.5. Power Supplies

Secured and standby supplies are described in the Power Supplies Section.

H 2.6.6. Extinguishing system for electrical/electronic areas/rooms

Various equipment rooms, control rooms where electronic, electrical equipments & electrical accessories need be provided ,CO2 based automatic fire extinguishing system shall be designed.

H 2.6.7. GENERAL REQUIREMENTS FOR MECHANICAL WORK

DDC shall design covering aspects like Vibration Isolation, Equipment Mounting, maintainability, removal and replacement, Equipment Identification like labeling designate equipment type, equipment function, flow direction and other such data as appropriate.

2.6.7.1. Electrical Requirements for Mechanical Systems

The DDC shall be responsible for assessing the requirement and the design, of control panels, motor starters, isolators, conduit and wiring between the motor starters and mechanical equipment. The control panels shall serve as the point of connection for the electrical system to be designed.

2.6.7.2. Motor Starters

AC power shall be distributed at a nominal 415/240 volts,3 phase/single phase, 4 wire, 50Hz. Dry type transformers shall be used when voltages other than distribution voltage are required. The starters shall be grouped starters with display panels. Starters for motors shall include individual unit control transformers. Direct-on-line motor starters shall be used for motors up to and including 3.75 kW at 415 volts, 3 phase. All motors over this limit shall be equipped with reduced voltage starters of the star delta or auto-transformer, two step, closed transition type.

2.6.7.3. Refrigerated water

DDC shall design for provision of cold & hot drinking fountains.

2.6.7.4. Lifts & escalators

Lifts and escalators shall be provided by E & M group. DDC shall design for space for lifts(for handicapped patrons & escalators required for connection between ground - concourse-platform. DDC shall include power requirement of equipment, machinery, associated equipments & other accessories if any and the lighting arrangement of the machine room. DDC shall liaise with SYS II DDC.

H 2.6.8. INTERFACES - MECHANICAL

The DDC shall ensure efficient interface and co-ordinate with other Contractors for interface regarding mechanical works for provision of fittings, opening, room sizes, installation sequences, working space etc.

2.6.8.1. SCADA System Interface with Mechanical Systems

Control and monitoring of mechanical equipment shall be carried out by SCADA system supplied under a separate contract. Status information and control commands will be transferred between the Control Centre and the SCADA outstations connected to the control panels of the mechanical equipment. During the preparation of detail design the Contractor shall liaise with the SCADA Contractor/DDC, Employer's Representative Noida-Greater Noida Fire Services and other Designated Contractors to determine all requirements for response in event of fire,

Transducers shall be designed to indicate equipment operational status (e.g. on/off, open/closed, forward/reverse, over- temperature, high level etc.). The system shall also indicate fault conditions, measured operational parameters necessary to determine whether the plant is functioning correctly (e.g.. motor current, flow rate, pressure, supply voltage etc.), control inputs to enable remote operation of the plant (e.g.. start/stop, forward/reverse etc.). Where control input is required the DDC shall ensure that the status of the item of plant is monitored directly. All SCADA control shall be passive.

The fire detection system shall include provisions for over-riding control of certain items of equipment to control or limit the spread of fire or smoke. To facilitate

connection work between sub-systems the DDC shall design terminal boxes and wiring to the control circuits of the appropriate units.

H 2.6.9. TESTING AND COMMISSIONING

2.6.9.1. The DDC shall stipulate all forms of test procedures applicable to the various equipment/ systems mentioned herein explicitly or as implied. DDC shall be responsible for furnishing testing & commissioning procedures including balancing of all mechanical work, Air and water system, Piping system water flows, Pumps, Fire protection equipment, Electrical distribution system, DG set, UPS, Sanitation plan, Monitoring equipment, including supervisory systems interface, sound attenuator noise suppression etc.

2.6.9.2. Testing shall be conducted by employing procedures that shall ensure compliance with all the requirements of this Specification covered above or elsewhere explicitly or implied. Any testing or approval by the Employers' representative of prototype shall in no way absolve the DDC of his responsibility under the terms of the contract for the satisfactory service of equipment/component/fitting supplied and erected on account of design.

H 3. ELECTRICAL WORKS

H 3.1. Introduction

This section contains a general description of the system concepts and major components; also sections covering definitions, requirements for interfaces with other contracts, general electrical installation and testing requirements, materials and workmanship criteria.

H 3.2. Definitions and Abbreviations

H 3.2.1. Definitions

(av) “voltage” means the difference of electric potential measured volt between any two conductors or between any part of either conductor and the earth as measured by a suitable voltmeter and is said to be ;

“Low” where the voltage does not exceed 250 volts under normal conditions subject, however, to the percentage variation allowed by the rules;

“Medium” where the voltage does not exceed 650 volts under normal conditions subject, however, to the percentage allowed by the rules;

“High" where the voltage does not exceed 33,000 volts under normal conditions subject , however, to the percentage variation allowed by the rules;

“extra high” where the voltage exceed 33,000 volts under normal conditions subject, however, to the percentage variation allowed by these rules.

H 3.2.2. Abbreviations

Abbreviations used in this specification

include :

HV	High voltage
MV	Medium voltage
LV	Low voltage
ac or AC	Alternating current
dc or DC	Direct current
kVA	Kilo volt-amps
kW	Kilowatts
V	Volts

A	Amps
mm	Millimetres
dB	Decibel (sound pressure level)
NC	Noise criterion
NFPA	National Fire Protection Association, USA
FAP	Fire alarm panel
BS	British Standard
EN	Euronorm Standard
ISO	International Standards Organisation
IES	Illumination Engineering Society, UK
SCADA	Supervisory Control and Data Acquisition
IS/BIS	Bureau of Indian Standards

H 3.3. Deleted

H 3.4. Electrical Equipment

H 3.4.1. General

a) The DDC shall design the station power supply based on supplies from the main LV switchboard to all distribution boards, consumer units and specialist services power supply isolating switches.

b) Electrical distribution and scope of work is as explained in para-H1.1.except the auxiliary substation and LV switch board which are in the scope of other DDC/contractor.

c) This also includes the electrical lighting installations at station access roads, pedestrian walk-in, scooter & cycle with parking, Bus taxi auto rickshaw, cycle rickshaw, station and site circulation area and other site utilities for rail corridor as detailed in appendix-G

d) Equipment, cables, Boards, panels shall be **numbered for type and serial number.** Each equipment number shall be preceded by a suitable letter designation. A list may be drawn & got approved to adopt in all references.

3.4.1.1. Rating, Sizes and Calculations

Power system analysis shall be provided to verify that all equipment chosen is rated for voltage, Continuous full load ampacity, fault duty to which it is exposed.

DDC shall be responsible for designing, system sizing and submit all calculations in support. DDC shall confirm the adequacy of requirement, overage, space for services, equipment and sizing there off and shall propose the best techno-cost effective solution, which will be approved by the employer.

Calculations shall be presented in software and as a minimum shall include equipment and component like Batteries, Diesel fuel tank, Generator, ACB / MCCB, panel/boards, switchboards, UPS, Capacitor bank, cables, illumination, Load Flow Analysis, load study calculation, Switching interlocks, power factor correction, protection co-ordination, relay co-ordination, short circuit calculation, voltage drop and regulation.

3.4.1.2. Earthing and Lightning Protection System: DDC shall examine the requirement and design for Earthing and Lightning Protection System in terms of relevant standards and safety norms earthing current/ resistance/ size, lightning protection, step/ touch voltages considering local soil characteristics shall be designed with validated design and calculations.

3.4.1.3. Cable Duct/Cable Trunking: Cable sizing, cable pulling tension calculation, cable tray sizing, conduit / tray fill calculation, man holes/draw box sizes etc. shall be designed by DDC suitably taking in to account the de-ratings involved if any.

3.4.1.4. Lighting System Calculations: DDC shall submit complete lighting design calculations for indoor lighting, out door lighting through validated accredited software including Iso-lux profile, geographical distribution, optimised figures etc

3.4.1.5. Panel Enclosures

All panel enclosures shall be of sturdy and robust construction to the best standards and practice to accommodate and firmly support all equipment. All holes in metal work shall be protected by substantial grommets or bushes.

3.4.1.6. Location and Space

Electrical power distribution equipment shall be located in dedicated electrical equipment rooms, battery rooms, and closets. Electrical rooms and closets shall have sufficient space to house all electrical .equipment, including future units, including working clearances.

3.4.1.7. Safety, Protection & Interlocks

The contractor shall equip all equipment plants with adequate safety, clearances, operational protection scheme conforming to relevant international standards and practices. The contractor shall also liaise with other designated contractors for finalising details of the cables, cable end

terminations, joint testing or commissioning procedures and list out requisite scheme of protection or interlocking. The scheme shall be agreed to by the Employers representative or the engineer.

The contractor shall also provision for all requisite equipment/accessories/displays etc for the safety of operator / general public coming in accidental or normal contact (touch potential) / equipment safety as per the statutory and technical provisions. The safety schemes shall ensure that any failure does not lead to an unsafe condition.

3.4.1.8. Control Supply

The control supply for the switchgear and other equipment in the station area shall be provided through UPS at 240 v,i1ph.,AC or the Building management system. The contractor shall liaise with the other designated contractors to make necessary provision in the equipment.

3.4.1.9. Design Considerations

All equipment **cables, wiring** shall be designed manufactured and installed so as to secure a service life as stipulated / best available/ recommended in relevant standard of the equipment/subsystem/accessories.

The **superiority of all equipment** will be judged by, compact size, energy efficiency, life cycle costs and performance parameters.

The **service life** of the equipment is the normal life expectancy of the equipment subject to its maintenance and preservations as per the recommended maintenance practice.

All the electrical boards/panels shall be dust, termite and rodent proof, modular, extendable, metal enclosed, rigid. free standing or wall mounting, construction with adequate steel sections

Switchboards, equipment and components shall be rated operation in ambient temperatures of 50□C and humidity up to 95%. In the design of switchboards an allowance of 15-20% spare capacity(/no) shall be provided for possible maintenance and additional 15-20% for future expansion and all main switchboards shall be user friendly, modular, extendable and aesthetic design, termite and vermin proof. Spare capacity of 30% shall be provided for all cables trays, trunking, wire-ways, (raceways), and brackets for future expansion.

H 3.4.2. Power Supply System for Stations

3.4.2.1. The 415V power supply for various services at the stations of rail corridor shall be derived from a single auxiliary substation (ASS) 33kV/415kV, generally located at the ground level/ concourse/ platform level or under the elevated viaduct at each location. The auxiliary substation shall receive 33 kV feed through loop-in loop- out arrangement and 415 V power shall be extended through a cast resin 33kV/.415 kV, (500/ 630/1000) kVA cast resin transformer and LV switch board comprising 415 V air circuit breakers in adequate number for feeding power to the

main distribution board (MDB) located at the station control centre adjacent to the Station Master's Office.

3.4.2.2. The equipment up to & including the main low voltage switch board forms the part of supply by the Contractor for SYS II. The building contractor shall liaise with the SYS-I and SYS-II contractors for ascertaining the space requirements and establishing the acceptability of power supply schemes. The power supply distribution shall be grouped to achieve minimum outgoing feeders while maintaining the flexibility of connection to DG set supply in case of power supply failure.

3.4.2.3. The Main distribution board (MDB) shall be designed to have sectionalised bus bars to feed the entire lighting/equipment load divided in two parts through normal supply and essential load through normal power backed with DG set supply. Accordingly the station load categorised based on supply backup is as under:

3.4.2.4. The services shall be designated as under:
Normal

Essential

Emergency

3.4.2.5. **Normal loads** like normal lighting (excluding emergency light outlets) of platform, station building, equipment rooms, Circulating area lighting, Seasonal loads like fans and air conditioners , **escalators** and water pumping installations such as station cleaning pump & sewage pumps if provided

3.4.2.6. Services designated as **essential** like, essential lights, **fire fighting pumps & lifts** being fed through separate bus shall be connected the DG set through microprocessor based intelligent AMF panel after the due wake up time. Essential services shall be maintained in the event of failure of supply. On restoration of transformer supply the DG set supply shall be disconnected through interlocks and essential load shall be fed by normal supply.

3.4.2.7. Emergency Loads like emergency lighting of platform, station building, equipment rooms, & circulating area emergency light, control supply, CCTV,signage, station control room equipment supply, fire safety and security systems along with signaling, AFC and telecom shall receive normal supply extended from any of the healthy bus bars and DG set back up supply connected through UPS. For signaling, telecommunications and AFC systems, the Sys I contractor shall make provision for UPS of the requisite battery backup period

H 3.4.3. Switchgear

3.4.3.1. All assemblies of switchgear and control gear shall comply with EN 60 439-1 or approved equivalent.

3.4.3.2. The clearance in front of back and side of all assemblies of switchgear and control gear shall be not less than 1.2 metres. The switchgear should be considered with fully drawn out condition.

3.4.3.3. All **markings** shall be clear. The marking and arranging of switchgear, bus bars, connections and small wiring shall comply with an approved international standard. The identification marking on all terminals, cables and component parts shall correspond with those on the manufacturer's drawings.

3.4.3.4. **Terminal blocks** for low voltage wiring shall be of the rail mounted type moulded from high-grade non-hygroscopic melamine having all live parts fully shrouded. Terminals shall be assembled in banks and each terminal shall be complete with marking tags to fit into moulded tag slots.Terminals for final connections for indication, instrumentation and metering circuitry shall have test probe facilities and an integral disconnecting device to facilitate testing.

3.4.3.5. The switchgear assembly/sub assemblies or panels should be termite and rodent Free. The sub assemblies of similar equipment shall be modular, extendable and interchangeable duly painted.

H 3.4.4. Circuit Breakers and Switches

3.4.4.1. Circuit breakers shall comply with IEC 947-2 or approved equivalent and have the design uninterrupted current rating when enclosed and in its operating environment with a rated operational voltage as specified for the switchboard. The circuit breaker shall meet the fault conditions specified for the board.

3.4.4.2. Circuit breakers shall be of the metal clad withdrawal isolating removable type having provision for safe maintenance.

3.4.4.3. Low voltage air break switches shall comply with IEC 408 with an uninterrupted rated duty, and utilisation category AC 23.These shall be marked with disconnection and EMC conformity.

3.4.4.4. Each switch shall be provided with facilities for padlocking in the "OFF" position.

3.4.4.5. To prevent accidental contact with live parts, switches of the withdrawal chassis or insulating type shall have either fully shrouded fixed contacts or insulated cover plates.

3.4.4.6. Miniature circuit breakers shall be in accordance with IEC 898, or equivalent. The current rating and type of unit shall be appropriate to the application with nominal voltage to earth of 240 volts. The minimum category of duty for units of 50 amperes and below shall be 3kA (M3) and for all others 9kA (M9).

3.4.4.7. Circuit breakers shall be lockable in drawn in and drawn out positions. Circuit breakers shall be moveable in drawn out position or drawn in position when in open state.

H 3.4.5. Contactors

3.4.5.1. Contactors shall comply with IEC 158-1 and shall be of the break type having an uninterrupted rated duty, a utilisation category AC 3. Contactor operating coils shall be AC suitable for the phase to neutral voltage of the supply and shall be protected by means of a low current cartridge fuse.

H 3.4.6. Metering Equipment

3.4.6.1. Current transformers shall comply with an approved standard and shall be compatible with, and provide the necessary accuracy, over-current factors, characteristics, performance and VA rating for the satisfactory operation of the relevant protection devices, instruments and meters. Current transformers shall be capable of withstanding the maximum short time withstand current for the value and duration specified for the assembly within which it is mounted.

3.4.6.2. Test links shall be provided in the secondary connections of all current transformers to facilitate testing of instruments, meters and protection devices. These shall be so arranged as to ensure that the transformer secondary winding cannot be open circuited.

3.4.6.3. Voltmeters, ammeters, frequency indicators and power factor indicators shall be digital and comply with an internationally recognised standard. The wiring to voltmeters, and the potential coils of frequency indicators and power factor indicators shall be protected by separate fuses/MCBs.

3.4.6.4. All instruments and meters shall be completely segregated in instrument compartments.

H 3.4.7. Switchboards

3.4.7.1. Switchboards shall be metal clad comprising the assembly of switchgear, control gear and components indicated in the drawings and shall be floor standing of the multi-cubical type, Form4 construction, max. 2.6 m height with IP 54 degree of protection.

3.4.7.2. The switchboard shall have a rated short time withstand current of 50kA for 1 second and a fault withstand classification of Class 3 for a supply voltage of 415V a.c. between phases at 50Hz.

3.4.7.3. **Protection against shock** in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of all live parts.

3.4.7.4. **Cable terminations** shall be suitable for the size and type of cables used. H3.4.7.4 Where armoured multi-core and Mineral insulated copper sheathed (MICS)

cables terminate inside the switchboard enclosure, glanding plates or glanding brackets shall be provided for securing the cables to the switchboard. **Glanding plates**, glanding brackets and extension boxes shall be removable and shall be of adequate size for the particular cables to be terminated.

3.4.7.5. Separate current transformers shall be provided for each protection device and for instrumentation.

3.4.7.6. The main bus bar & secondary bus bar for incoming supply to individual MCCBs / MCBs shall be suitably designed as per code of practice for ease of accessibility & protection. The outgoing cables from the MCCBs / MCBs shall be terminated in terminal blocks.

3.4.7.7. All outgoing feeders shall be protected by Residual Current Devices (RCD's) as per Rule 61A of IE Rules.

3.4.7.8. All components, lifting lugs, earthing studs shall conform to respective Indian Standards or IEC specifications and shall be suitable for the particular requirements of rated current, voltage, service life, making and breaking capacity and short-circuit withstand strength. Co-ordination of component matching shall be observed.

3.4.7.9. Switch boards and panels shall be, but not limited to, such as

(i) Main distribution board

(ii) Lighting Distribution boards/panels

a) Station building supply including parking & circulating areas.

b) Platform lighting at stations.

c) Emergency lighting at station.

(iii) Pumping panels

a) Fire fighting pump.

b) Water supply pump.

c) Seepage pump panel.

(iv) Signal Telecom & AFC equipments

a) Equipment panel boards

(v) Low voltage power distribution boards

(vi) Escalator / Lift Supply

a) Escalator feeder

b) Lift feeder

(vii) Sub distribution boards
Lighting distribution and sub lighting distribution boards with multiple LED
/Neon type indication to diagnose the problem so that Station manager tells the maintenance problem details very precisely to the maintenance team.

(viii) Any other board/panel including control panels etc.

However list is not exhaustive and DDC shall update the same suitably.

3.4.7.10. Basically switchboards drawings of the switch board /distribution / sub distribution/ lighting distribution boards shall include but not limited to:

a) General arrangement and schematic together with the material schedule.

b) Overall or panel dimensions. ,annunciation, alarm control, protection scheme and calculations, Remote Control contacts.

c) Layout of the front of the switch board/ lighting panel including operating gear, indicating lamps etc.

d) Foundation drawing / mounting details in case of wall mounting.

Scheme of interlocking and protection & interface.

H 3.4.8. Main Distribution Board

3.4.8.1. DDC shall prepare technical specifications, location drawings, erection details for tendering including controls testing and acceptance criterion for provision of main distribution board (MDB). Mimic display panel if provided shall provide membrane touch controlled switching panel in the control center for electrical utility loads.

3.4.8.2. DDC shall specify the dimensional requirement for space and liaise with other system wide DDC to fix the utility loads and controls required to be incorporated with interlocking logic.

3.4.8.3. Control Mechanism

1. Control panel shall be designed to give full **feather touch control of switching** operation though membrane touch switching mechanism, contact system, arc extinguishing device and tripping unit.

2. The switching mechanism comprising of feather touch switching panel backed with operating circuit control shall operate the contact system for the purpose of power distribution. Switching mechanism through latched contacts shall operate **contact system.**

3. The **contact system** shall be designed to minimise the 'let thru' energises while handling normal currents. The contracts shall have 'self wiping' action, high resistance of erosion during interruption/operation and shall remain stable for normal service current.

3.4.8.4. Contactor- enclosure:

The contact and arc extinguishing system shall be enclosed in insulating case and cover made of high strength, flame retardant thermo-setting material providing inter phase insulation and protection against secondary fire hazards and safety to operating personnel. Extinguishing grid plates shall be designed between the gird plates and extinguisher. .Standard design features of wiring like tied/dressed coloured wires/cables, numbering ferrules crimped lugs etc. DIN rail mounting of components,

Terminal protection, Neutral links and other protections. The switching mechanism shall facilitate indication/annunciation for the status of the main contact duly displayed on mimic display panel (MDP). Specified indications shall be alarmed.

H 3.4.9. CAPACITOR BANK FOR IMPROVEMENT POWER FACTOR

3.4.9.1. The Capacitor Bank shall comply with IEC 60831 and other latest IEC specification beside other relevant international and Indian standards. The dedicated Capacitor Bank shall be installed in a separate cubicle at major loads in Equipment rooms, Pumping installation, Lifts & escalators Machine rooms & other loads more than 10KW.

3.4.9.2. The loads shall be normally of discrete cycle involving more switching operations, therefore the Capacitor bank associated with each major load shall be designed as per the switching and working requirements. The Capacitor Bank shall improve the power factor to 0.95. Capacitor bank shall get connected automatically when conditions prevail as per load to improve the power factor.

H 3.4.10. Distribution Boards

3.4.10.1. All main distribution boards, distribution and sub-distribution boards shall be surface mounted consisting of a sheet steel case enclosing banks of miniature circuit breakers and bases as indicated on the Drawings.

3.4.10.2. The case shall be soundly constructed of sheet steel of not less than 1.5 mm thickness with a hinged door hung by means of internally fixed hinges of substantial construction designed to avoid the door sagging when opened. When closed, the case is to be dust proof and entirely free from external protrusions.

3.4.10.3. Inside each case shall be fitted a table stating the circuit served under each number and the fuse rating. The table to be printed on durable material in such a manner as to be permanently legible. An engraved Traffolyte label, with black lettering on a white background, shall be fitted in the outside of each board, indicating the number of the board, the voltage, phase and service, the exact wording to be agreed with the Employer's Representative.

H 3.4.11. Uninterrupted Power Supply (UPS)

3.4.11.1. DDC shall design an **on-line parallel redundant Un-interrupted power supply (UPS)** system 415V, 3Phase, 50Hz, solid state type, suitable capacity complete with accessories / auxiliaries, rectifier, inverter, By-pass module, indicating instruments on the incoming / outgoing supply.

3.4.11.2. Both the UPS shall be designed to work in parallel if required. The UPS shall be suitable for continuous qualitative and reliable operation under the ambient conditions without any adverse effect on its performance. The UPS shall have a minimum degree of protection of min.IP 31 in accordance with BS 5420 or equivalent.

3.4.11.3. The UPS shall be with manual and solid state bypass switches and shall be complete with incoming mains isolator, input and output ammeters, voltmeters and frequency meters, power on indication and fault indication/diagnostic features. The distortion factor with linear load shall be specifically tested in addition to the load sharing of battery bank, component circuits and others. In case of any de-rating due to operating conditions, this must be specifically mentioned on the equipment.

3.4.11.4. The UPS shall be connected with ½ hr. back up valve regulated lead acid batteries twin battery sets. The UPS shall be designed to work at 50□C at0- 95%RH and built to comply with BS/IEC/ISO standards and shall be capable of sustaining overload.

3.4.11.5. Rectifier, inverter & chargers shall work in full cross redundancy. If charger of one module and inverter of other module fail together, the load continues to get clean UPS power through the working charger and inverter. The parallel redundant system shall have independent control circuit.

3.4.11.6. The UPS shall be provided with fault diagnostic system, LED display/annunciation, controls, status, alarm, status, metering, monitoring system & data logger and power monitoring software for operational status locally or with a Computer from remote with RS-232 & 485 compatibility.

3.4.11.7. UPS shall be compatible to take non-linear loads and capable to handle high crest load. UPS shall be provided with harmonics filter. The UPS Shall have input and output power factor correction features.

3.4.11.8. UPS shall be compatible to work on 2 sources of supply with reverse phase sequence protection.

3.4.11.9. The DDC shall design & specify for UPS the following parameters but not limited to as under: -

Output power, Input voltage, Input voltage variation, Input frequency, Output voltage AC, output voltage variation AC, Out put frequency variation, Ripple content with battery, Ripple content without battery, Impedance, Touch voltage, Phase sequence control, Reliability, Efficiency, Acoustic level, Cooling, Battery backup 30 minute on full load,

3.4.11.10. Overload duration/condition.

The Automatic change over switch shall be incorporated in UPS for selection of either source of supply. The voltage on both the incoming mains shall be continuously monitored through voltage sensing device with adjustable range, on all the three phases.

3.4.11.11. Protection

The UPS shall be suitable for taking unbalanced load and the UPS shall be provided with H class insulation.

3.4.11.12. annunciation

UPS system shall be designed with protection & annunciation system for monitoring Phase sequence, Overload and short circuit trip, Earth fault, Reverse power relay, Low battery voltage, Fault indication alarm through suitably designed hooter, self diagnostic annunciation system, controlled remotely/manually as per alarm and operation status available on auxiliary terminal board as extended to operation control center & station control center. The metering system shall be based on digital indication with status on auxiliary contacts. The monitoring system shall consist of comprehensive display system comprising of LED displays, touch membrane switches and 40/80-character LCD display and data logging storage for logging operational and failure events. Software controlled switching limits shall be in-built feature of the UPS. The control and metering panel shall provide for the following:

H 3.4.12. MAINTENANCE FREE VALVE REGULATED 220 V LEAD-ACID BATTERY

DDC shall design the maintenance free valve regulated lead acid battery system, its capacity, battery rack and other accessories including tests, performance parameters & technical requirements of individual components for the cells based on the technical requirements. The systems design shall cover aspects like rating and other particulars, Type, capacity of battery, watt hour efficiency of the battery, Construction,, electrolyte, battery stand ,marking, packing, maintenance instruments but not limited.

H 3.4.13. Diesel Generator Set

3.4.13.1. A DG set of suitable capacity shall provide the back up power to Emergency & Essential categories of loads as well as to the UPS. While working out capacity of DG set, provision shall be made for soft start of heavy loads such as fire fighting pumps for clipping the maximum demand during starting and running of such load.

3.4.13.2. The DG set shall also be located as close to the auxiliary sub station as possible. Starting of DG set shall be controlled through automatic mains failure panel (AMF). The supply from the DG set shall be received at LV switch board provided in ASS and DG set supply shall be extended to LV MDB through a bus coupler arrangement suitably interlocked to open whenever the income supply resumes after a failure.

3.4.13.3. The DG set shall be able to start automatically even in cold conditions to take full load within 10 seconds (wake up time) of failure of normal supply. The AMF panel shall be connected & provided with suitable interlocking arrangements to ensure automatic starting of the DG set on failure of supply from both the feeders and interlocking arrangement to avoid any incident of paralleling of normal power supply to DG set supply.

3.4.13.4. The equipment shall be designed, to the International Standards likeBS4999, BS5000, BS5514, IEC34, or equivalent, to the latest changes and tested as per these standards and designed for low specific fuel

consumption, low weight (KG) to KVA capacity ratio & less space (SQM) to KVA capacity ratio.

3.4.13.5. DDC 's design shall include following but not limited to diesel Engine, alternater, cooling system, filtration system, starting system, automatic idle run, battery charging system, exhaust silencer system, coupling arrangemen, mounting arrangement, lifting arrangement, auto start, foundation, Power factor correction, testing & commissioning.

3.4.13.6. Protection and annunciation system confirming to latest standards like BS/IEC or IS with soft control and touch resets shall be designed and provided comprising of Overload, short circuit trip, High temperature for cooling water trip, Alarm in case the DG set is not run for one week at a stretch, Earth fault, Reverse power relay, Low battery voltage, fault indication alarm through suitably designed hooter, Self diagnostic annunciation system

3.4.13.7. The engine will be provided with safety protection against low lubricating oil pressure, High engine-temperature, Fail to start, Safety control trip for the DG SET, Safety control trip for Engine over-speed. Each safety device shall include LED indication, annunciation, alarm and tripping arrangement. Alarm and operation status shall be available on auxiliary terminal board so as to enable to extend alarm and operation status to operation control center & station control center. The metering system shall be based on digital indication with status on auxiliary contacts. The control system and metering panel shall include all above parameters to be monitored.

H 3.4.14. CABLES AND ACCESSORIES

3.4.14.1. General

3.4.14.1.1. FRLS PVC and Cross linked polyethylene (XLPE) insulated single wire armoured and sheathed multi-core cables shall have copper conductors, for use at 415 volts or less, shall be 1100 volt grade, manufactured in accordance with an approved standard.

3.4.14.1.2. H3.4.14.1.2 All cables shall be firmly and adequately supported from cable supports for their entire length except where they run through the steel conduit or concrete encased PVC or polyethylene conduit or are buried direct in the ground.

3.4.14.1.3. H3.4.14.1.3 Cables shall be spaced according to Regulations, or to the manufacturer's recommendations, as appropriate for the cables to be supported, and the DDC shall take particular care to avoid sagging or stress on any cable.

3.4.14.1.4. H3.4.14.1.4 The DDC should clearly enumerate the method & means of supporting cables in different possible position and also white crossing roads / tracks / pavements.

3.4.14.1.5. H3.4.14.1.5 The cable sizes should be generally permit single cable for carrying full load current.

3.4.14.2. FRLS PVC Power Cables

PVC power cables shall be heavy duty, 1100 V grade, aluminium /copper conductor, PVC insulated, inner sheathed, suitably armoured and overall PVC sheathed with smoke retardant properties

3.4.14.3. XLPE Power Cables

XLPE power cables shall be heavy duty type, 1100 V grade with copper conductor. XLPE insulated, sheathed, armoured and with overall PVC sheath suitably compounded to meet FRLS properties. The core insulation shall be with cross-linked polyethylene unfilled insulation compound free from voids, of thickness as specified in IS:7098(Pt.I) or latest equivalent .The outer sheath shall meet FRLS properties mixed with chemicals for protection against rodent and termite attack.

3.4.14.4. Fire survival cable

Fire survival cables, an improved version, FRLS cables easy identifiably colured, shall be used at critical places/or for application where circuit integrity shall be required to be maintained even under fire condition for at least one hour. The cable shall meet the critical fire resistance test conditions as for IEC 331,The test sample of finished cable shall be subjected to flame test at 750□ C at rated voltage of the cable for a period of 3 hours..

3.4.14.5. Cable accessories

The terminating kits shall be suitable for termination of the cables on an indoor switchgear or equipment and shall be of proven design, established make and shall be tested as prescribed. The straight thro' jointing kits shall be suitable not only for conditions of high humidity, for underground buried installation with uncontrolled back-fill and possibility of flooding by water.

Necessary information such as manufacturer's name, type, size, voltage grade of cable, length of cable in meters, drum No., cable code, ISI certification mark, gross weight etc. shall be printed on flange of the drum. An arrow shall be printed on the drum indicating the direction of rotation of the drum.

3.4.14.6. Cable handling

Cables shall be spaced according to regulations, or to the manufacturer's recommendations, as appropriate for the cables to be supported and the DDC shall take particular care to avoid sagging or stress on any cable. The DDC should clearly enumerate the method and mean of supporting cables in different possible position and also white crossing roads / tracks/ pavements.

H 3.4.15. Cable Trunking

3.4.15.1. Under floor, skirting, wall trunking and high level ceiling trunking shall be in accordance with the highest standards, shall be of the steel type with steel covers and shall be hot dip galvanised or zinc plated finish.

3.4.15.2. The lengths of trunking, bends tee sections and offsets shall be coupled together by means of fish plates and the trunking manufacturer's cadmium plated steel set screws, nuts and shake proof washers.

3.4.15.3. At each joint in the trunking continuity shall be maintained by means of electrolytic copper links secured by brass nuts, locking washers and bolts.

H 3.4.16. Cable Tray

3.4.16.1. Cable tray shall be perforated full wrap around type not less than 1.5 mm thickness mild steel hot dip galvanised finish.

3.4.16.2. The cable tray shall be of sufficient width to take the cables without crowding and shall allow for future additions to the proportion of 25% of present requirements. Double stacking of cable shall not be allowed except where specifically agreed by the Engineer.

3.4.16.3. The cable tray shall be fixed to purpose made galvanised steel brackets that shall in turn be fixed to the structure. The brackets shall be hot dip galvanised. Acceptance test for each support fixture may be laid down to avoid any loosening or hanging of support structure. No supporting structure or bracket of fixing material should have sharp edge or abrasive effect on cable.

3.4.16.4. The fixing brackets shall rigidly support the cable tray and shall provide a clear space between the structure and/or obstructions and the back of the cable tray.

H 3.4.17. Conduit

3.4.17.1. PVC or Steel conduit and fittings shall comply with BS 4568 or approved equivalent specification and shall be screwed classification.

3.4.17.2. The class of protection against corrosion shall be as scheduled. Class 2 conduit and fittings shall have black enamelled finished and Class 4 shall be hot dipped galvanised.

3.4.17.3. Conduit boxes and covers shall have a minimum degree of protection as indicated in the table:

S.No.	Location	Against Corrosion	Enclosure	Surface/ Concealed
1	Outside buildings	Class 4	IP44	Surface
2	Plant rooms and service ducts	Class 4	IP41	Surface
3	Switch rooms	Class 4	IP41	Surface

4	Ceiling voids	Class 4	IP41	Surface
5	Below ground	Class 4	IP44	-
6	Store rooms	Class 2	IP41	Surface
7	All other locations	Class 2	IP41	Concealed

The minimum size of conduit shall be 20 mm.

3.4.17.4. To satisfy requirements for earth fault loop impedance, the layout of conduit, trunking and ducting and routing of cables shall ensure that the maximum circuit lengths allowable are not exceeded. DDC shall indicate maximum & typical values.

3.4.17.5. H3.4.17.5 Bending of conduit shall be done without the use of heat using a bending tool that complies with the British Standard appropriate to the conduit material.

Draw-in boxes shall be provided in conduit at the following maximum

intervals: Straight run 8 m

Run with one or two bends 6 m Run with three bends 4 m

Run with four bends 2.5 m

No conduit shall be under mechanical stress.

3.4.17.6. Where conduit is cast in-situ it shall be securely fixed before concrete is poured. As soon as shuttering is removed it shall be checked for freedom from blockage and continuity.

3.4.17.7. At expansion and settlement joints suitable provision shall be made in conduit, trunking and ducting to allow for movement of the structure. For trunking and ducting purpose-made expansion couplings shall be used.

3.4.17.8. Temporary plugs shall be fitted to open ends of conduit and ducting to prevent ingress of water and solid material.

H 3.5. Sub-main Distribution

H 3.5.1. General

3.5.1.1. The DDC shall design and make provision for 415 Volt distribution systems with associated protection switch gears and LV connections to the LV Switch board in auxiliary substation, to main distribution board and further to other distribution and sub-distribution boards.

3.5.1.2. The DDC shall design the equipment including cabling, metering, power factor correction and connections to control cables, etc.

H 3.5.2. Technical Requirements

The switch boards shall be designed to incorporate the following principles:

a) Normal power shall be available from the two 33kV/415V transformer supplies on the basis of one as the main supply and then other as a live standby supply at LT panel in auxiliary substation.

b) There shall be voltage sensing with automatic changeover switches by phase failure detection.

c) Correct phase sequence (rotation) shall be determined for both transformer supplies before connection is made to the LT panel switchboard and after any supply reconnection that may occur within the contract period.

d) The LT panel shall provide outgoing power to main distribution board provided in the station control room.

e) Metering shall include:

f) Mains incoming power V, A, and PF and Energy Meter for each in-comer on the main distribution board.

g) Incoming power V, A and Energy Meter for each in-comer on the distribution board to identify energy consumption for the purpose of energy conservation.

h) Automatic power factor correction shall be provided through capacitor banks located in the plant room and connected to the main distribution board via an adequately rated circuit breaker.

i) Correction shall be in two or three steps with PF= 0.95 lagging or better. The system shall ensure that a leading PF does not occur.

H 3.6. Power Supplies

H 3.6.1. General

3.6.1.1. DDC shall design for power to be supplied from the main LV switchboard to all distribution positions including distribution boards, consumer units and specialist services power supply isolating switches.

3.6.1.2. The principle of dual power supplies shall extend to the last distribution board feeding the final power supply cable.

3.6.1.3. Power shall be provided to all services such as communications and SCADA systems, lighting and general power distribution boards, consumer units, and all items of power equipment supplied under system wide contracts such as escalators, lifts and CCTV camera points.

H 3.6.2. Technical Requirements

3.6.2.1. The DDC shall include for cables between the sub-main LV switchboards and the main LV switchboard, to distribution boards, to consumer units and to local plant isolators. The cables shall be adequately rated for normal and fault withstand current in accordance with the highest protection device settings.

3.6.2.2. The distribution system shall safely and adequately provide outgoing power to all LV power consuming positions.

3.6.2.3. Full allowance shall be made for liaison with other equipment suppliers requiring electric power.

3.6.2.4. Allowance shall be made for the provision of 25% spare capacity in switchboards, cables and wire-ways.

H 3.6.3. Distribution System Design

The following feeders shall be provided from the man distribution board located at the station control room.

a) Emergency lighting

b) Signal, Telecom and AFC feeder

c) Station building & platform lighting supply

d) Watering Pump feeder

e) Pump feeder for emergency fire fighting /sprinkler pumps

f) Lifts

g) Escalators

h) Circulating area lighting

i) Seasonal loads

The power distribution for each of the above feeder breakers is

set out as

H 3.6.4. Emergency lighting

Separate emergency lighting feeder shall run from central bus connected to DG set backed supply and shall supply through UPS to emergency lighting loads of platforms, concourse, DG set room, signage and station control supply t to station control centre and various panels.

H 3.6.5. Signal, Telecom & AFC feeder

3.6.5.1. This feeder feeds the emergency load of signal, telecom, AFC system and related equipments. One panel is envisaged in the designated equipment room housing any of the above equipment. Incoming power supply through two separately located cables from the MDB shall be received in this panel. The outgoing to each equipment or equipment rooms or accessory/ancillary shall be drawn through an individual switch housed in the above said panel. . For the Air- conditioning load of these plant/equipment rooms powers, a separate Air- conditioning feeders is envisaged from the above panel.

3.6.5.2. The backup UPS shall be connected to the designated equipment along with the power supply feeder to the panel.

3.6.5.3. It will be the responsibility of SYS I contractor for taking power supply from this panel to all the work areas and equipment related to his supply or provisioning.

The building contractor shall provision for cable trays / trunking or means to carry these cables. The building contractor shall be required to liase with SYS I contractor for ascertaining the panel design, provisioning of feeders, other design matter, location and mounting / erection details.

3.6.5.4. The cables from auxiliary sub stations to MDB shall be normal, non-fire survival cable as the UPS is proposed to be located alongside each of the equipment in the respective equipment rooms. However, it is also a fact that DG set supply is available at the main bus of MDB through ACB provided in LV switch board. This power needs to be carried uninterruptedly to the respective equipment.

3.6.5.5. Station building & platform lighting supply

The entire load of the station shall be divided into two and shall be connected to different bus bars of MDB and each platform and concourse shall be provided a lighting distribution board to feed platform light load in two normal light circuit and one emergency light circuit further distributing loads in different phases through sub distribution boards so as to minimise the impact of failure on feeder or bus. Similarly the lighting load of station building shall be subdivided for lighting, power sockets equipments supply etc. to avail similar benefit. The second normal lighting circuit shall be charged through essential feeder in case of prolonged power failure.

H 3.6.6. Watering Pump feeder

Watering pump panel shall also receive supply from both/single the bus bars so as to ensure availability of power supply for pumps

H 3.6.7. Pump feeder for emergency fire fighting /sprinkler pumps

The fire fighting pumps, station cleaning, sewage pumps(if any) shall be connected to DG set backed supply.

H 3.6.8. Lifts

The lift load shall be connected to normal supply but one of the lift on demand can be connected to UPS supply to evacuate trapped handicapped person in case of fore at the station.

H 3.6.9. Escalators

Escalators shall be divided and connected to normal supply through two different feeders to minimise the impact of supply/feeder failure and services shall not be available in case normal power is not available.

H 3.6.10. Circulating area light

Circulating area lighting shall be divided in two parts and connected to normal supply through two different feeders to minimise the impact of supply/feeder failure and services shall not be available in case normal power is not available.

Parking area for cycle/ auto rickshaws, cycles /motor cycles & car & bus parking areas shall be illuminated through normal power extended.

H 3.6.11. Seasonal load

Seasonal load like Air Conditioners and fans required in summer shall be separate from normal load and shall be subdivided in two parts with above view with control at station control centre to switch off when not needed.

H 3.7. Earthing and Bonding

H 3.7.1. General

3.7.1.1. Earthing and bonding shall be designed by the DDC in accordance with BS 7671: 1992 or approved equivalent in order to protect persons and equipment from the effects of an electrical fault anywhere in the system.

3.7.1.2. Earthing shall be designed to allow safety equipment to operate properly and to maintain touch voltages below 50V in the event of a short circuit in any part of the system. The extent and adequacy of the system must be established and suitable testing method laid down for ascertaining and then accepting the system as a sound and adequate one.

3.7.1.3. All the criterion shall be incorporated by DDC strictly in conformity with this Specification, relevant rules, Regulations and Codes of Practice including the following:

i) Indian Electricity Rules 1956 as amended up to date.

ii) Indian Standard Code of Practice for Earthing IS:3043-1987.

iii) Regulations laid down by the Chief Electrical Inspector.

iv) Regulations of the Electricity Supply Authority concerned.

v) Regulations for crossing of Railway tracks- 1987.

vi) Indian Standard Code of Practice for electrical wiring installation: IS:732-1989

3.7.1.4. Earthing shall be designed to ensure the following:

a) Compliance with regulations

b) Safety of passengers and staff from the possibility of high potential to structural earth potentials

c) Correct operation of breakers and tripping devices and maintaining loop impedance to a accepted value

d) Equi-potential bonds to ensure touch voltages (between conducting components accessible to persons) during a fault condition do not exceed 50V.

3.7.1.5. The DDC shall design an earth bar in each of the substations to meet the requirements of the System wide Contractors. The DDC shall liaise and co- ordinate closely with the System wide Contractors to select the most suitable locations around the station to locate the earth electrodes. An independent earthing system shall be provided for computer equipment, signaling and telecommunication equipment.

H 3.7.2. Technical Requirements

3.7.2.1. Main Earth

The main earth shall be derived from a main earthing bar in the plant room which in turn shall be connected to a local earthing network of low impedance (less than one ohm unless otherwise authorised by the Employer's Representative).

3.7.2.2. Main Equipotential Bonding

Incoming services to the stations in metal pipe or armoured cable shall be fitted with isolating joints as close as possible to the point of entry. On the station side of the joints, the pipe/armour shall be bonded to the main station earth bar with earthing cables or tapes. On the incoming side the pipe/armour may, with agreement between the NMRC/Noida-Greater Noida authorities and the utility be connected via a diode and switch to the stray current mitigation bus.

3.7.2.3. Supplementary Bonding

3.7.2.3.1. All sinks, wastes, and all metallic plumbing connections to sanitary equipment shall be bonded to earth by means of 6mm earth cable.

3.7.2.3.2. All ceiling space equipment shall be bonded in agreed positions and the final bond taken to the local sub-distribution board earth.

3.7.2.3.3. Layout of earthing electrodes should be such as to have distinction between equipment, neutral and lighting earth electrodes in addition to permit access for future testing / maintenance or replacement.

3.7.2.3.4. The earthing bus design should also provide visual distinction between equipment and neutral earthing.

H 3.8. Lightning Protection

H 3.8.1. General

3.8.1.1. Due to the high annual incidence of thunderstorms, and the concentration of people at stations, lightning protection shall be designed for all buildings and structures.

3.8.1.2. The lightning protection system for the surface structures of the station shall include air tapes and down conductors and earth rod/mat system. Bonding to metal features such as steel chimneys and fan grilles shall also be included.

H 3.8.2. Technical Requirements

3.8.2.1. Lightning protection shall be designed to a high standard in accordance with local regulations (or a recognised approved standard such as BS 6651: "Protection of Structures Against Lightning").

3.8.2.2. Concrete structures shall employ roof tapes (air tapes) while steel structures may use the structural steelwork frame as a collector and as a down conductor system. Vertical finials over 400mm shall not be required.

3.8.2.3. The DDC shall pay particular concern regarding penetration of the roof fabric for connecting of roof tapes to structural steelwork and for the bonding of steelwork at the joints to ensure a low resistance earth path.

3.8.2.4. The down conductors or the connecting wires of lighting electrodes to lighting earth

electrodes to lightening earth should be at least 1.5m away from any power / control /

telecom cable.

3.8.2.5. The DDC shall provide concrete earth inspection pits complete with concrete covers.

3.8.2.6. The lightning conductor and earthing system shall be designed to conduct lightning discharges without damage or injury to personnel, structures or the conductor system.

3.8.2.7. The earthing system shall consist of copper or stainless steel earth mats, or a network of specially drawn copper-clad steel rods bonded together, to give the necessary low impedance for an effective system.

3.8.2.8. Test facilities shall exist for disconnecting down conductors at earthing points to allow testing of the individual earthing points.

3.8.2.9. Where aluminium tapes are employed great care shall be exercised in protecting the system components from electrolytic corrosion due to dissimilar metals being in contact with each other. Special bi-metallic connectors shall be employed at junctions of copper and aluminium conductors. Copper air and down conductor tapes shall be PVC sheathed.

H 3.9. Lighting

H 3.9.1. General

3.9.1.1. General lighting shall be provided in all areas of the station. The DDC shall make suitable provision for light fittings, cable runs, and associated accessories.

3.9.1.2. The deliverable shall include detailed design in tabular form, drawings and isometric charts generated by suitable software packages. The minimum, maximum level of lighting and other suitable parameters shall be mentioned. This shall include behaviour of luminaires, lighting levels for different service life. The optimisation shall be based on life cycle costing basis.

3.9.1.3. Each lighting panel shall consist of two separate and distinct sections or two separate panels for normal and emergency lighting. The normal lighting section shall feed the 80- 85% by two lighting circuits in

accordance with the scheme of lighting indicated in the Specification. The emergency lighting section shall feed the15-20%lighting circuit covering the emergency lights, which are provided with electronic ballast capable of working on 230 V AC. These lights are also distributed on all the three phases for their normal operation.

H 3.9.2. Technical Requirements

3.9.2.1. Lighting within the stations shall be to a high standard. Lighting requirements at stations are described in Appendix E

3.9.2.2. The type and quality of fittings and their luminous intensity shall relate to the space being illuminated. Light level shall be uniformly distributed throughout the station and shall be designed such that glare, dark recesses and areas of poor lighting levels are avoided.

3.9.2.3. At station entrances passengers enter passages from sunlit streets and graduation of lighting levels shall be provided.

3.9.2.4. Escalators and stairways shall be well illuminated and sub-divided to provide at least minimum prescribed emergency levels of illumination in case of no normal power supply as detailed in the power supply scheme.

3.9.2.5. Concourse and ticket hall areas require a reduced level of lighting except at ticket machines, automatic fare collection (AFC) gates and tops and bottoms of escalators and stairs.

3.9.2.6. The lighting intensity at platform level shall be compatible with that of train vehicle, reducing in intensity at platform ends, particularly the leading end, thus reducing glare to the driver on entering the station. Lighting shall provide a continuous run adjacent to platform such that the threshold of the platform edge is well illuminated.

3.9.2.7. Glare shall be avoided while design of the lighting by the correct choice of location, number fitting type, luminance and shielding of luminaries.

3.9.2.8. Luminaries in control rooms shall be positioned so that no reflected glare from dials or monitor screens interferes with the operator's vision.

3.9.2.9. Lighting switches shall be rated for 20 amperes, and shall have white moulded plastic operating rocker bars. The switches shall be mounted on adjustable steel grids, enclosed in pressed steel boxes finished electrolytic zinc plate.

3.9.2.10. Station lighting in public areas, e.g. platforms, concourse, etc. shall be arranged in banks and switched remotely by means of contactors with self diagnostic identification to indicate failure in the sub-circuit.

3.9.2.11. Surface mounted switches shall have standard surface type plates in all locations except plant rooms where stove enamelled aluminium finished plates shall be provided. An earthing terminal shall be provided in each switch box and on the grid.

3.9.2.12. Splash proof lighting switches shall be rated at 5 amperes and housed in galvanised cast iron or impact resistant moulded plastic enclosures providing the minimum degree of protection compatible with IP 44.

H 3.9.3. Time switches.

3.9.3.1. Spring reserve 24 hour dial time switches shall be suitable for operation on a 220 volt 50Hz ac supply and shall be driven by a self-starting synchronous motor with a spring reserve mechanism which shall enable the clock to continue to function for a period of at least 30 hours after interruption of the supply. Separate motor and switch terminals shall be provided. Switch contacts shall be rated at 20 amperes.

3.9.3.2. The time switch shall be fitted with a 24 hour dial complete with one set of ON and OFF levers. A selective day omitting device shall also be provided. The time switch shall be provided with an "ON-OFF" by-pass switch to completely over-ride pre-set switching functions.

3.9.3.3. Spring reserve - solar dial time switches shall be suitable for operation on a 240 volt 50Hz ac supply and shall be driven by a self-starting motor with a spring reserve mechanism which shall enable the clock to continue to function for a period of at least 30 hours after interruption of the supply.

3.9.3.4. Separate motor and switch terminals shall be provided. Switch contacts shall be rated at 20 amperes.

3.9.3.5. The time switch shall be fitted with a 24 hour dial complete with one set of ON and OFF levers. A selective day omitting device shall also be provided. The time switch shall be provided with an "ON-OFF" by-pass switch to completely over-ride pre-set switching functions.

3.9.3.6. For safety reasons, where lighting switches occur in different phases they must be separated by a distance of not less than 2.0 m unless phase barrier type switches are used. This type of switch is only to be used when shown on the drawing or on the specific instruction of the Engineer.

H 3.10. Emergency Lighting

H 3.10.1. General

3.10.1.1. An emergency and escape lighting system shall be provided in accordance with the requirements of the NMRC/Noida-Greater Noida authorities, the fire department and internationally accepted practice.

3.10.1.2. The design shall for emergency lighting covers the detailed design, of a working system. Emergency lighting shall be provided in all public areas

3.10.1.3. Technical Requirements

Lighting within the stations shall be to a high standard. Lighting requirements at stations are described as Under:

Level of Illumination adopted for Rail Corridor Stations

Sr.	Activity area	Illumination	
		Normal	Emergency
		(Lx)	(Lx)
	Passenger area		
1	Circulating area	30 - 50	5-8
2	Entrance hall	200	5-30
3	Mezzanine	200	5-30
4	Concourse	250	5-37.5
5	Booking counters	300	5-45
	Ticketing machines	(Localized)	
	Time table		
6	Passenger staircase / subw a	100 - 150	5-22.5
	from Ground to Mezzanine		
7	Escalators	250	5-37.5
8	Platforms (General)	200	5-30
	Platforms (Edge)	250	5-37.5
	Operation areas		
1	Control room	500	75
2	Equipment rooms	300	5-45
	and other operation area	or 200	5-30
3	Store room	150	5-22.5
	Battery room		
	Cable distribution room		
	Void area		
1	Void area	5 lux min.	5
Service Illumination *will be working condition Level*			
Above illumination levels are indicative,DDC shall not be limited to above.			

H 3.11. General Power

H 3.11.1. General

3.11.1.1. H3.11.1.1 Low voltage ring main circuits of 240 volts single phase shall provide a small power supply throughout the station.

3.11.1.2. Switched sockets shall be of robust materials and positioned in the following areas :

3.11.1.3. Platform Concourse spaced at a distance of 15m along the back walls of column supports, at a height of 350mm above finished floor level. These units shall be backed by earth leakage protection devices, 30mA rated.

3.11.1.4. All other areas spaced to the design requirements with type and height to suit the application.

3.11.1.5. Heavy duty single phase, and three phase 30A/32A power outlets shall be provided for workshops and maintenance areas on ring or radial circuits.

H 3.12. SCADA Interfacing

H 3.12.1. General

3.12.1.1. Monitoring of all electrical equipment shall be carried out by the SCADA system supplied under the another Contract. Status information shall be transferred between the Control Centre and the SCADA outstations connected to the electrical equipment. Interfacing between the electrical system components and the SCADA system shall require detailed co-ordination between the respective DDCs. The DDC shall liase with the

contractor for the EST Works to ensure the interfacing between the mutual systems meets their joint and individual specification requirements.

3.12.1.2. All electrical equipment shall be provided with monitoring facilities for connection to the SCADA system. Transducers shall be provided to indicate equipment operational status (e.g. on/off, forward/reverse, over-temperature, power demand, etc.), and fault conditions.

3.12.1.3. Lighting and LV power shall be controlled locally or at the Main Distribution Board, and not via the SCADA control system. All SCADA interfaces shall be passive with sufficient auxiliary controls shall be made available for measurement of metering parameters.

3.12.1.4. Transducers for measured operational parameters (or "analogue signals") shall provide an output of 4-20mA output over the full operating range of the input variable. Particular attention shall be paid to correct scaling of the transducers to ensure that the full output range corresponds to the maximum expected operating range of the measured variable. For instance, 4-10 mA shall correspond to a supply voltage range of, say, nominal +/-25%, not 0 to 100%.

3.12.1.5. The equipment to be monitored is listed below. The DDC shall compile and submit for consent a list of the proposed monitoring and control signals for each item of plant, copied to the EST contractor.

(a) Fire Detection and Alarm Interface

The following items for each station shall be monitored and abnormal conditions shall be alarmed :

- Main station fire panel healthy.
- Fire alarm condition.
- Zone of reported fire.
- Non synchronising clock.

(b) Power and Lighting Interface

The following items for each station shall be monitored and abnormal conditions shall be alarmed:

a) LV Main Distribution Board incoming circuit breaker status.

b) LV Main Distribution Board outgoing circuit breaker status.

c) Protection relay operation.

d) Incoming power lines (2 No) healthy.

e) Dual supplies healthy; all areas.

f) Emergency lighting fault status.

g) UPS Status (I/O voltage, indication and position of bypass switch).

h) Power distribution circuit faults one for each group of loadings at the local level.

i) Services Annunciation Panel for lifts, fire fighting panel supply, control centre supply, escalator supply, pumps supply, DG Set status.

j) Water level annunciation.

k) Equipment status annunciation.

H 3.13. Water Supply System

A suitable water supply system shall be provided at each station for meeting the passenger, staff & operational requirement of water i.e. as drinking, flushing, fire fighting & station premises washing etc. comprising of **under ground static tank** suitably chambered to receive water in fire fighting tank to overflow to raw water tank and get collected after treatment in treated water chamber/tank. The water for daily drinking, toilet flushing & station cleaning water shall be stored in overhead tank.

H 3.13.1. Water Pumping System

3.13.1.1. A water pumping system comprising of 2/3 automatically controlled bore well pumps shall be designed to supply water to under ground static tank.

3.13.1.2. H3.13.1.2 Submersible type bore well pumps of staggered capacity working for 4-5 hours a day at head of 40-50 meter head shall be installed to pump required water.

3.13.1.3. 2/3 suitable booster pumps automatically controlled through self-priming & level actuated switches, shall be designed for secondary pumping installation to pump treated water to overhead tank.

3.13.1.4. 2/3 suitable booster pumps automatically controlled through self-priming & level actuated switches, shall be provided for secondary pumping installation to pump raw water through water treatment system to treated water tank. The water treatment system shall be complete with al accessories and back wash pumping system if required, suitably designed to meet daily requirement

3.13.1.5. Pump sets for fire fighting and jockey pumps etc., with requisite stand-by units shall be located in a pump room provided at ground/concourse level including that for sprinkler system if provided for.

3.13.1.6. Standby pumps, identical to the installed one, shall be installed with automatic control to work alternatively to ensure reliability of water supply.

3.13.1.7. The operation of all pumps shall be controlled automatically through level actuated limit switches and status monitoring with remote controlled facility for the pumping installations shall be provide at station managers room with requisite facility for alarm for any in-operative pump for 7 days.

3.13.1.8. Status of operations, ON/OFF, Fault alarm, water level of tanks shall be provided for all pumps with Station manager for monitoring.

3.13.1.9. Station washing system with gravity water shall be provided at all the stations of Rail corridor. However wherever necessary, an automatically operated water hydrants shall be provided for station washing by suitable

twin controlled Ejecto- pumps, pressure tank, pressure switch and air volume control systems. DDC shall furnish the optimal design.

3.13.1.10. Fire fighting pumps:-Pumps shall be provided for fire fighting system at each station as stipulated in national building code with suitable & reliable design to arrange water at required pressure, velocity with stand by pump driven with alternate source like DG set.

3.13.1.11. The following pumps may be required but not limited to. DDC shall design the water pumping system as per international standards and practices.

-set of Bore well pumps, where required

-set of booster pumps to pump from sump/under ground tank to elevated tank

-Fire fighting pump with jockey for hose reel system

-Fire fighting pump with jockey for sprinkler system if provided

-Seepage /sewage disposal pumps if provided

H 3.13.2. Technical requirement

3.13.2.1. An energy efficient, cost effective system shall be designed taking into consideration the yield, head, discharge, installation depth, bore/delivery dia , Piping length and reliability with guarantee to work consistently at **same efficiency**

3.13.2.2. **Pump** shall be robust, corrosion free, low power to weight ratio, compact, noise free and vibration less in operations .

3.13.2.3. A **pump house**, to control primary pumping locations of bore well, shall be provided at station level near the load center. Another pump house shall be provided at ground level to house centrifugal pumps, booster pumps, fire fighting pumps & other pumps and control. Pump house shall be equipped with lifting arrangements suitable to each kind of pump housed.

3.13.2.4. Separate & individual **control panels** shall be provided with status regarding working & electric supply with indications of voltage, current, energy meter, power factor meter along with protection.

3.13.2.5. Adequate **space** shall be kept near the pumping installation for obstruction free supervision and easy removal in case of failure, dismantling /assembly, repair, unit spares, storage & tool room.

3.13.2.6. The pumps NPSH shall always be lower than the atmospheric NPSH to avoid cavitation due to vapourisation.

3.13.2.7. The motor shall be over rated over BHP of the pump or in line with internationally accepted norms..

H 3.13.3. Design considerations

a) Water demand aspects like peak hour water requirement, No. of Hrs. of pumping, Realistic water demand

b) Hydrological aspects like Ground water occurrence, Different type of rock formation, Water bearing properties, Static water level, draw down water level, Draw down level, recuperation time(yield),Average depth of water table in well during peak time, Frictional losses in pipe line, fittings, valves, Quality of water, Type of starter, protection and monitoring devices

As per NFPA recommendations, a fire fighting system shall be designed by DDC with water supply requirement of Q lpm continuously for no.of hours for n no. of hose reel workings/ Sprinkler system.

While submitting design parameters DDC Shall specify discharge, Static head, Dynamic head, Speed of liquid, Specific weight of liquid assumed, Efficiency of coupling, Efficiency of transmission, Motor efficiency, Pump efficiency, Designed Pump capacity, Spare motor capacity adopted, Available range of capacities, Selected capacity, Formulae used for discharge frictional head & pump capacity, Operational interlocks

H 3.13.4. Piping System

A colour scheme, material scheme and sizes, their control and metering system shall be stipulated by DDC. The piping material &sizes shall be specified for each service for low friction loss & anti corrosive. DDC shall stipulate the Piping control scheme for various water lines/circuits through timer switches to avoid wastage.

H 3.13.5. Pump operation scheme

3.13.5.1. Primary pumping operation system

DDC shall design complete pump operation scheme and interlocks for satisfactory automatically operated pump including requisite electrical & mechanical protection as recommended in various standards, NFPA or IEC.The Status of water level in the tank and that of the pumps for operation or standby shall be reported to Station Control Room. The normal operation of pump shall be automatically controlled by liquid level controller at different levels and remote control operation by Station Control Room.

3.13.5.2. Secondary pumping operation system

Suitable water pump operational scheme shall be designed by DDC for pump operation control for pumping water from ground static tank level to overhead tank.

3.13.5.3. Pumping operation & controls for fire fighting Pumps

The pump operation scheme shall be designed as per the NFPA's recommendation/ Noida-Greater Noida authorities fire service requirements.

3.13.5.4. Automatic level controller:

Mechanically activated switch, suitably designed to directly control pumps shall be provided .

- The float type switch non-sensitive to turbulence /rotation.
- The float should be of non- corrosive material.
- The calibration should be precise and simple.

The level actuated switch should have multifunctional, multi-level, ready adjustable design to provide complete status of the water level and control circuit for automatic pump operation.

H 3.13.6. SCADA monitoring

Provision of extra contacts should be available for relaying operating status of the equipment such as pumps to the Station Manager. All the fault alarms, status to be relayed to the panel at Station Manager ‘s room through a RS 485/232 network. In case of pumping applications the level of water in the ground tank, toilet and station sump should be displayed to the panel at Station Manager ‘s room. The water level of mid section sump should also be relayed to the OCC.

H 3.13.7. Switching control procedures:

A designated person shall keep informed of operating conditions affecting the safe & reliable operation of the system and shall maintain a suitable record showing operating changes.

H 3.14. Fire Detection and Alarms

H 3.14.1. General

The fire detection and alarm system, wired in zones (to be agreed with the Employer’s Representative), using break glass units and automatic smoke/heat detectors shall be provided in accordance with NFPA 72D, British Standards BS5445 and BS5839, EN 54, or ISO 7240-1, as appropriate, or other Internationally recognised or local code of practice approved by the Engineer.

H 3.14.2. Technical Requirements

3.14.2.1. The fire alarm control system shall comprise a fully automatic station fire alarm panel, specialist mimic display panel, specialist interfaces for the purpose of plant and equipment control and further electronic interfaces to detection systems in machine rooms and remote locations.

3.14.2.2. The main station **fire alarm panel** (FAP) shall be located in the station operations room (SOR) and repeater panel(s) located as necessary to guide staff in evacuating passengers and for the fire brigade to accurately assess the source of the fire and the physical routes for combating it.

3.14.2.3. The station fire alarm system panel shall be equipped with monitoring/relay points to relay status and alarm messages to the SCADA

system. The DDC shall provide relay points for the following but not limited to:

1. FAP healthy signal.
2. Fire alarm condition.
3. Fire zone of such alarm condition.
4. Fire condition link to public address automatic messaging.
5. Non-synchronising clock.

3.14.2.4. These relay signals shall be connected to the station communications equipment under the EST Contract.

3.14.2.5. The station fire alarm panel (FAP) shall provide alarm and fault monitoring to analogue addressable detection loops.

3.14.2.6. The station FAP shall provide continuous status information distinguishing between system faults and operation of call points/detectors together with identifications of the zone involved.

3.14.2.7. **Automatic detection** of a fire shall be by:

- point type;
- rate of heat rise (with fixed temperature element); and
- twin ionisation chamber smoke detectors.

3.14.2.8. Automatic fire detectors shall be analogue addressable type using the latest algorithm principles for accurate indication of normal condition, detector condition, pre-alarm and alarm indications.

3.14.2.9. The operation of an automatic detection device shall be indicated on the appropriate section of the fire alarm indicator panel.

3.14.2.10. **Manual reporting** of a fire shall be by break glass contacts strategically positioned in the means of escape routes and this shall also be indicated on the appropriate section of the fire alarm indicator panel.

3.14.2.11. The station FAP shall utilise current pulse transmission techniques for two way transmission of data and command signals between the fire alarm processor and the field devices. The processor shall be capable of polling all field devices on a loop within three seconds.

3.14.2.12. The response to alarms from various combinations of the detectors, flow switches or manual call points shall, via the dedicated microprocessor, initiate performance of such other functions as may be required. Such functions shall be:

a) Alert station staff.

b) Alert line controller.

c) Initiate operation of fire suppression equipment.

d) Initiate operation of automatic public address system message.

e) Release smoke stop doors held open.

f) Allow any emergency exit fastenings to open on transmission of the evacuation signal.

g) Initiate illumination of the station no entry signs, on transmission of the evacuation signal (via the SOR and Telecommunications).

h) Initiate closure of fire shutters.

3.14.2.13. All detector and bell circuits shall be continuously monitored and a fault on either shall be indicated on the main fire alarm panel in the appropriate zone section.

3.14.2.14. Where automatic fire detectors are required in ducts in which there is continuous air movement up to 25m/s, they shall comprise a perforated outlet tube across the inside of the duct at 90° to the air flow and leading out to the expansion chamber containing an ion-chamber detector. An extension tube shall return air to the duct for continuous sampling.

3.14.2.15. The station FAP shall control detection to all designated areas of coverage including remote equipment locations.

3.14.2.16. The detection system via the station FAP shall interface with the station pre- action sprinkler system and escalator sprinkler system as provided.

3.14.2.17. Generally the DDC shall provide **zoning** such that a logical sequence is followed which is easily transferable to either or both of a computer based building information management system or a mimic display panel.

3.14.2.18. The station fire alarm panel shall be fully analogue addressable. The station FAP shall be capable of full "stand alone" operation.

3.14.2.19. Each loop shall support a combination of analogue sensors and output devices, these being ionisation smoke detectors, optical smoke detectors, rate of rise heat detectors, fixed temperature or analogue temperature detectors, addressable interfaces for input from call points and external equipment, or addressable volt- free outputs to other systems. Other detector types may be fitted according to specific local requirements. Each cable loop shall be of any length up to a maximum acceptable length of 1.2 kilometres for the connection of input and output devices.

3.14.2.20. **Actuation of call points**, smoke or heat detectors shall be identified by panel indications giving the loop number and device address of the device as well as the fire zone. A text message shall simultaneously be displayed to identify the location. A facility shall be provided for the entry of data by authorised personnel on site.

3.14.2.21. The station FAP shall incorporate orange indicators covering system fault, device fault, external fault, processor fault and device isolated.

3.14.2.22. H3.14.2.22The station FAP shall be self checking, and shall identify contamination of any device or malfunction of any part of the system in such a way that fire alarms are not confused with fault indications. The

loss of failure of any device or sounder shall be identified and presented as a fault within 60 seconds.

3.14.2.23. A facility shall be provided to isolate any loop mounted single device or group of devices on a temporary basis, this shall cause the illumination of a warning indicator on the panel which shall remain illuminated until all loop devices are again operating normally.

3.14.2.24. The station FAP shall interface with the Station Centralised Clock System, provided by the EST DDC to ensure uniform time throughout the System.

3.14.2.25. **Repeater panels** shall be fitted where required to enable a member of staff to operate the fire panel remotely from a position regularly used as either remote rendezvous point or station control point. Controls shall be provided on repeater panels to perform basic panel functions at the remote location. Controls shall include the silencing of alarms, acknowledgement of alarms, display of alarms received and panel reset to normal status. The reset function only shall be protected by key access.

3.14.2.26. Presentation of information, legends and controls shall be similar to that of the station FAP.

3.14.2.27. Repeater panels shall possess an internal buzzer that shall operate in all cases of fire and fault, and the ability to operate monitored alarm sounders. The buzzer shall be capable of being accepted remotely.

3.14.2.28. The repeater panel shall incorporate integral batteries that shall be capable of full panel function for a period of 24 hours in "monitoring" mode. In the event of an alarm condition at the end of the 24 hour period the batteries shall be capable of full panel, mimic and sounder functions for a further 30 minutes.

3.14.2.29. **Manual call points (MCP)** shall be provided in designated areas to allow the manual initiation of a fire alarm. An MCP shall be located adjacent to all fire exits, and other MCPs shall be located so that one is within 30 metres of any point in the Station.

3.14.2.30. MCPs shall be positioned at a height of 1.3m at strategic points throughout the station such that they are clearly visible from front and sides as practicable. The operation of any call point connected to the system shall cause the station FAP to enter the ALARM state within three seconds.

3.14.2.31. MCPs shall be manufactured in bright red compliant material, measuring appx. 85 x 85mm with 50mm overall depth. Operation shall be via a plastic membrane (non breakable) with wording on method of operation in white lettering. The MCP cover shall be etched in black lettering in Hindi and English "FIRE", the lettering measuring 10mm high.

3.14.2.32. Where MCP are mounted externally, in outside weather or where intrinsically safe operation is required, an MCP rated to IP 66 shall be utilised.

3.14.2.33. Care shall be taken in designing for areas identified as requiring intrinsically safe fire detectors, these items shall be connected to the addressable loop via the appropriate addressable module units.

3.14.2.34. Each sprinkler system fire hydrant and hose reel shall be fitted with a flow sensing switch. This switch shall be of the automatic type with baffle and clamp sized according to the pipe-work to which it is fitted.

3.14.2.35. The pneumatic time delay fitted to the switch shall be set to 20 seconds to avoid actuation by pressure surges.

NOIDA METRO RAIL CORPORATION LIMITED

CONTRACT NO: NMRC/Projects/NGNEDDC/2025/415

Contract NGNEDDC: Detail Design Consultant (DDC) for Civil, Architectural and E&M works including Traction works for Elevated Sections of Extension Projects of Aqua Line from Noida Sec-51 to Knowledge Park-V, Noida Sec-142 to Botanical Garden & Depot Station to Boraki including augmentation of existing depot and RSS works (31.595 km).

VOLUME-5
STANDARD DOCUMENTS

PART V - INTERFACE SCHEME MANAGEMENT

NOIDA METRO RAIL CORPORATION LTD.
Block-III, 3rd Floor, Ganga Shopping Complex,
Sector-29, Noida -201301,
District Gautam Budh Nagar, Uttar Pradesh, India

INTERFACE SCHEME MANAGEMENT

DESIGN INTERFACES

1. INTERFACES

1.1. The Contract NGNDD01 DDC (Project Leader/ E&M Consultant/ VAC Consultant/ Traction Consultant) shall interface the design of the Works with that of other Designers (excluding Structure Design), principally the Designers for the Designated Contracts as defined in this document. The Project Leader shall keep the Employer's Representative fully informed in respect of such interfaces, such information being given to the Employer's Representative in a manner and form and at such intervals as stated in the Contract or as required by the Employer's Representative.

1.2. Designated Contractors in interface with the NGNDD01 Contract are:

A. Design and Built Civil Contract

Civil Structures

This contract provides for Noida-Greater Noida corridor. The Contractor shall provide design information to DDC to enable the DDC to carry out the SES analysis for the Metro Corridor.

B. Contract for

Signalling and Communications -

This contract provides for signalling and automatic train control systems including equipments in the station control rooms and the Operation Control Centre (OCC) such as train mounted control equipment, relay room equipment, independent telephone networks including automatic switching centres and exchanges, main trunk cables, direct telephone lines, communication equipment, emergency telephones, closed circuit television, radio communication and all non-power SCADA system.

C. Contract for

Railway Electrification and Power Supply –

This contract provides for Flexible Overhead 25 kV. ac traction power system, receiving traction & auxiliary substation equipment, AC switchgear, transformers and rectifiers, auxiliary power equipment and power cables and power SCADA system.

D. Contract for

Track work -

This contract provides for, manufacture and installation of points and crossings and plain line throughout the Metro Corridor Project including the Depot track work. It includes the provision of the second stage concrete track bed.

E. Contract for

Automatic Fare Collection

This contract provides for the revenue control system at stations, including automatic ticket vending machines, barriers, manual control and checking equipment and electronic linkages to station control rooms and the Central Control room.

F. Contract for

Track and Turnouts

This contract provides for detailed design of ballast less track and turnouts in the Metro & Rail Corridor projects.

G. Contract for

Rolling Stock

This contract provides for air-conditioned rolling stock in rakes of up to 6 coaches.

H. Contract for

Lift & Escalator Contract

This Contract will design, manufacture, install and commission all lifts and escalators in the stations.

I. Contract for

Signage and Graphics Contract

This Contract will provide for supply, installation and commissioning of signage and graphics.

J. Contract for Electrical and Mechanical (E&M) Systems works

2. INTERFACE RESPONSIBILITIES

2.1. The responsibility for specification and provision of the requirements for the works, which interface with Designated Contractor's equipment, are tabulated below.

2.2. This Part of tender document describes the interface requirements between DDC and other Designated Contractors/ Designers/ Consultants.

2.3. This Part of tender document 2D shall be read in conjunction with the relevant clauses of the Employer's Requirements and Outline Specifications. The Project Leader shall be responsible for ensuring that all requirements of the specifications pertaining to interfaces are properly satisfied.

2.4. Notw ithstanding the requirements described elsewhere in the Contract regarding document precedence the provisions contained in the Drawings and elsewhere in the Employer's Requirements shall prevail over the provisions contained in this Part of tender document.

2.5. This Part of tender document 2D outlines the interfacing requirements during the design and execution of the Works. However the requirements herein specified are by no means exhaustive and it remains the DDC's responsibility to develop, update and execute jointly an Interface Management Plan (IMP) after the commencement of the Works and throughout the execution of the Works to ensure that:

a) All interface issues between DDC and the Designated Contractors/ Designers/ Consultants are satisfactorily identified and resolved; and

b) All the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points.

2.6. Where the details of the DDC's design are required to enable the Designated Contractors/ Designers/ Consultants to implement interface works, the DDC shall provide the Designated Contractors/ Designers/ Consultants with the necessary information including, but not limited to, those described in the summary table appended to this requirement. The level of information provided shall be in sufficient detail to enable the Designated Contractors/ Designers/ Consultants to design and / or construct the required interface works.

2.7. The DDC shall take a lead in developing the Interface Management Plan. The IMP will be prepared in conjunction with the Designated Contractors/ Designers/ Consultants to cover all aspects of the implementation of the interface works required. The IMP will define the interface works necessary to complete all the works in this contract and is not limited to those listed in the summary table attached.

The IMP shall be fully conforming with the Works Programme and shall, in respect of the DDC and each of the Designated Contractors, show and be in logical agreement with Key Dates and Works Areas Handover Dates. The IMP shall indicate dates for the commencement and completion of each principal activity on the Site by each contractor, and delivery and installation of principal items of equipment.

Interfaces between Design & Built (Civil) Contractors/ Designers and DDC

Item No.	Subject	DDC responsibilities	Design & Built (Civil) Contractors/ Designers'	Remarks
1.	Elevated Stations/ Ancillary buildings	• Preliminary layout and cross-sections of the station box. • Details of all the openings/ cutouts in the Diaphragm Walls. • Details of all the cutouts for all the services in the station box and other structural members. • Provisions for specific arrangements in the structural design to meet systems/design requirement. • Final layout and detailed cross-sections of the station area Including ancillary building and service galleries incorporating final dimensions of the structural members in consultation with the Designated Contractor. • Coordinated Details of Station-Ramp interfaces to be incorporated into Structural Design/ Construction. • Final Sizes of all the Structural members like Columns, Beams and Structural Slabs to be worked out. .	• To co-ordinate and carry out the responsibilities as per Closing of cut-outs Civil contractor to close/optimize all cut-outs as cleared by system wide contractor wherever the gap for closing is more than 200mm in stations. Civil contractor will carryout fire proofing sealing of all cut outs opening of more than 200mm size gap at stations with concrete/block workcontract.	System Wide Contractor to give clearance to civil for optimization/closing of cutouts after installation of services. In stations, Fire sealing openings of 200 mm and below gap, shall be done by the respective system contractors whose service is passing through the cut out.

2.	At-Grade Ramp and Elevated Viaduct (For Designated E&M and VAC Consultant)	● Design details to be worked out in co-ordination with Designated Contractor's design requirements. ● Requirement for Provisions of all services in the Ramps and Elevated Viaducts to be given to the Civil Contractor as per the Detailed Project Programme. ● CSD to be provided to the Civil Contractor for Construction ● Reference and necessary Interfacing work.	● To co-ordinate and carry out the responsibilities as per contract.	●

Interfaces between E&M Contractors and DDC.

Item No.	Subject	DDC responsibilities	Design & Built (Civil) Contractors/ Designers' Responsibilities	Remarks for system wide contractor.
1	Elevated Stations.	● Details of all the cutouts for all the services in the station box, Diaphragm walls and other structural members. ● Details of all the Ducts, Shafts and Utility/ Service galleries. ● Provisions for specific arrangements in the structural design to meet systems/design requirement. ● Final layout of all the Operational rooms with details of cutouts. ● Coordinated Details of Station-Ramp/ Station Viaduct Services interfaces to be worked out in consultation with the Civil Contractor. ● Design details to be worked out in co-ordination with Designated Contractor's design requirements.	● Designated Contractor shall review the Systems design as per the Detailed Project Programme an indicate modifications etc required in the civil work if necessary. ● Provide details of all cutouts/ shafts/ ducts/ etc as per the actual equipment layouts. ● All borewell pumps, drainage pump, all pipings, fittings, accessories etc. ● Drainage channels at track as per approved drainage plan. ● HDPE pipes for cables as required by E&M contractor for external lighting	● Poles/structures of lighting, support structures for cable trays/lightening arrester. ● Hydraulic & plumbing pumps (except bore well pumps) as well as their starter panel shall be provided by E&M. ● External bus duct/cable tray support to be provided by E&M contractor. ● The E&M contractor needs to provide all foundation details/drawing, ● Civil to provide details of submersible and borewell pump rating and quantity

			poles at road crossing, footpath area etc. ● Coordinate with the Designated DDC and Civil Contractor for Design and Construction Interfacing.	of all pumps to E&M contractor for providing required breaker feeder & cabling up to Civil Starter panel. ● Hook details, cutout details etc to NMRC well in advance, so that the same are incorporated in the approved GFC prior execution of civil works. ● Cable bracket for HT, LT, OFC and control cable etc. at via-duct will be provided by civil contractor and DDC shall provide the drawing.
2	At-Grade Ramp and Elevated Viaduct (For Designated E&M and VAC Consultant)	• Services Provision to be kept inside Ramps/Elevated Viaducts in confirmation with the Designated Contractor's design requirements • GFC to be provided to the designated systems contractor for provision of services on the ramps and elevated viaducts. • CSD to be provided to the Designated Contractors for Construction Reference and necessary Interfacing.	• Coordinate with the Designated DDC, Civil Contractor and Other Designated Contractors for Design and Construction Interfacing.	

Interfaces between Contract for Railway Electrification and Power Supply and NGNEDDC.

Item No.	Subject	DDC responsibilities	Design & Built (Civil) Contractors/ Designers' Responsibilities	Remarks for Design & Built (Civil) Contractors/ Designers'.
1	Traction Substation structures, earth mats and supplementary earth pits,	**Design:** • Design details to be worked out in co-ordination with Designated Contractor	**Design:** • Confirm basic room sizes and building layout with reference to tender drawings	**(i)** Since Over Head Equipment are installed on the outer parapets of viaduct, access to OHE from stations through

	material handling cranes and gantries, access roads, fencing, ventilation, outdoor & Indoor lighting, other building services like fire detection, drinking water, drainage and toilet facility etc. & Receiving substation access roads,fencing/boundary walls, gates etc. Note: For the outdoor receiving substation portion, the earth mat shall be provided by SYS2.	design requirements.	and the capacity of lifting equipments Vertical and Traveling hoists). • Furnish equipment sizes and weights. • Furnish equipment foundation/ mounting details • Confirm room finishes. • Furnish earth mat and supplementary earth pits & earth risers constructional requirements. • Furnish requirement of cable trenches, cable routing and cable support provisions. • Furnish ventilation and lighting requirements. • Confirm fire safety provisions. • Review the design from NGNEDD.	the parapet is required. Railing on both sides of viaduct (UP and Down) is required for the safety of the staff attending OHE at designated locations like Anchor mast, Anticreep mast, Switching Posts etc. Civil Contractor to interface with OHE contractor for locations with monkey ladder as per requirement of Traction contractor at designated locations within SOD. (ii) In case of Box girders, the man-holes may be provided with heavy duty covers and proper locking arrangement so that viaduct cannot be accessed by miscreants (through these holes) (iii) ASS should be avoided under the expansion joints of viaduct. (iv) Trees at both side of viaduct may be removed in such a manner that no tree branch comes within 10 m from the viaduct. Long trees such as Eucalyptus may not be allowed up to 50m distance from the via-duct as per advice and confirmation of NMRC (v) The earthing terminal of the railing should be provided. Sectioning of
2	Cable gallery structure from TSS to station structure including pathway, internal lighting and ventilation, fire detection, fire separation and cable mounting support.	**Design:** • Design details to be worked out in interface with Designated Contractor's design requirements.	**Design:** • Furnish & Confirm cable gallery size and route alignment. • Furnish ventilation and lighting requirements. • Confirm fire safety and fire separation provisions. • Furnish cabling mounting.	

				railing to be done as per earthing requirement, and drawings. (vi) Drop Arms provided under the RCC Roof of the Elevated stations to be provided with earthing terminal. (vii) Proper earthing arrangement in the RCC Roof is required for the safety of the occupants. (viii) Earthing scheme and drawing for such installation is to be developed in consultation with Electrical System Contractor. (viii) The width of the parapet should accommodate the mast base plates properly, as at several locations. Adequate width of parapet to be ensured by the civil contractor as per approved drawings approved by NMRC (ix) OHE Holding down bolt threads at parapets should be greased and properly covered by civil contractor so that damage to threads can be avoided during shifting/transportation. (x) A loading deck of minimum size 3.0 m x 5.0 m for loading and unloading of equipment outside the ASS room to be considered which may change as per the requirements at site and system contractors' requirements.

3	Oil drainage from main intake transformer oil sump.	**Design:** Design details to be worked out in-co-ordination with Designated Contractor's design requirements.	**Design:** • Confirm oil drainage requirement.	
4	Auxiliary substation, Track cabin and OCS disconnection switch room structures in the stations including the surface finishes, ventilation, lighting, fire detection and doors/louvers and local power supply and the Earthing arrangement.	**Design:** Design details to be workedout in-co-ordination with Designated Contractor's design requirements.	**Design:** • Confirm basic room sizes and layout. • Furnish equipment sizes and weights. • Furnish equipment foundation/ mounting details • Confirm room finishes. • Furnish Earthing system and earth risers' constructional requirement. • Furnish requirements of cable routing and cable support provisions. • Furnish ventilation and lighting requirements • Confirm fire safety provisions. • Review the design from NGNEDD.	
5	Provision for passage/crossing of various cables in the stations along the walls, central columns, under the platform coping etc. Including all fire separation requirements.	**Design:** Design details to be worked out in-co-ordination with Designated Contractor's design requirements.	**Design:** • Confirm the requirement of passages for cable crossings and alignment of cables in station areas. • Confirm bending radii of different types of cables and appropriate design of cable runs. • Review the design from NGNEDD.	
6 (i) (ii)	Access from track (from open well wagon) for auxiliary transformer and switchgear equipment installation and future replacement. Provision of	**Design:** • Design of hatch, gantry beams, traveling hoists to meet the material movement.	**Design:** • Confirm the dimensions and weight of various equipment,which are likely to, transported by rail wagons.	

	adequate capacity gantry for material handling.			
7	Deleted			
8	Deleted			
9	Electrolytic corrosion prevention.	**Purpose:** Implementation of the system for protection of reinforcements,prevention of corrosion of metallic pipes and structures. **Design:** Design details to be workedout in-co-ordination with Designated Contractor's design requirements.	**Design:** • Confirm the detailed requirements for stray dc current control. • Review the design from NGNEDD.	
10	Deleted			
11	OCS warning and different types of Indicator Boards in the tunnels, stations and depot.	**Design:** Design details to be workedout in-co-ordination with Designated Contractor's design requirements.	**Design:** • Confirm the location of OCS warning and Indicator Boards. • Furnish the relevant drawings. • Review the fixing arrangement design from NGNEDD.	
12	Deleted			
13	Platform Insulation at stations.	**Design:** Design details to be worked out in-co-ordination with Designated Contractor's design requirements.	**Design:** Confirm the requirement and material specification for safety of passenger/ safe touch potential limit.	

Interface Specification of Lifts & Escalators Contract

Item No.	Subject	DDC responsibilities	Design & Built (Civil) Contractors/ Designers' Responsibilities	Remarks
1	**Lifts**	**Design:** • Establish lift	**Design:** • Provide NGNEDD with	To supply shaft and pit dimension data,

		locations and requirement. • Suggest machine room locations. • Consider m aintenance access requirements. • Suggest lift and escalator monitoring panel location.	detailed requirement for standard cab size machine room and structural provision and electric load. • Design cab communication system. • Inform the size of access necessary likely along the passage for moving the lift for installation. • Co-ordinate fire safety requirement with firefighting systems. • Furnish requirement for lifting beams. • Furnish design for monitoring and control panel.	details of cutouts recess, lifting beams, drainage provision, detailed load calculations, hooks provision etc.
	Escalators	**Design:** • Identify e scalator locations and sizes of escalators. • Define mounting and structural provisions for escalator assemblies, also electrical power, Control Interfaces and system shall be developed. • Co-ordinate access and delivery space provisions	**Design:** • Co-ordinate details of mounting provisions, power supply, electric load and control requirements. • Define requirements and provide design details to DDC for escalator sprinkler protection system. • Furnish the sizes for escalator machine rooms.	To supply shaft and pit dimension data, end and intermediate support details, earthing requirement equipment loads, cutout * recess details, lifting hook locations etc. for incorporation in GFC of civil works.

Interface specification of Track Work Contract

Item No	Subject	DDC responsibilities	SYS responsibilities

2	Provision of access from ground level to track level at each station for transportation of track material	Design: • Design details to be worked out in interface with Designated Contractor's design requirements.	**Design:** • Confirm location and size of access for transportation of track material.
3	Details of track drainage	• Design of drainage system of metro corridor except the drains required within track. • Furnish details of levels of drainage system to Designated Contractor's to connect the drains required to be constructed within track.	**Design:** • Design and construction of Drains required within track based on details of levels of drainage system provided by NGNEDD01.

Interface Specifications of Automatic Fare Collection Contract

Item No.	Subject	DDC responsibilities	SYS responsibilities
1	**Ticket Booth** related **works:** Construction of ticket booth with false ceiling and windows with glass panes, Indoor and outdoor lighting, Air-conditionig, Power points at Counters Supply through UPS, Communication line for ticketing Machines, Phones, Earthing Facility for ticketing machines, Fare and Route display. Construction of trenches for laying of Power and Communication lines	• **Design:** • Design of booth – number of windows and its location; • Design details to be worked out in interface with Designated Contractor's design requirements.	**Design:** • Confirm basic booth sizes and layout; • Furnish equipment sizes and • Weights; • Furnish equipment mounting details; • Confirm room finishes; • Furnish equirements of cable trenches, cable routing and cable support provisions on walls and floor; • Furnish lighting requirements; • Confirm fire safety provisions; • Review the design

			from NGNEDD.
2	**Passenger Operated Machines** POM	**Design:** • Design details to be worked out in interface with Designated Contractor's design requirements.	**Design:** Furnish requirement of cable trenches, cable routing and cable support provisions.
3	**Automatic Gates related works:** • Construction of bases for mounting of Gates, • Construction of trenches for laying of Power and Communication lines, • Lighting arrangement, • Supply through UPS, • Communication line for gates, • Earthing facility for Gates • Phone.	**Design:** • Design details to be worked out in interface with Designated Contractor 's design requirements. • Location and number of gates to be decided in consultation with Designated Contractor's contractor.	**Design:** • Confirm basic gate sizes and booth layout • Furnish equipment sizes and weights • Furnish equipment mounting details • Confirm finishes • Furnish requirement of cable trenches, cable routing and cable support provisions • Review the design from NGNEDD.
4	**Supervisor Room** related works: Construction,indoor and outdoor lighting, Air-conditioning, Power points for Station computer, Supply through UPS, Communication line for Station Computer, Earthing Facility for computer, Phones.	**Design:** • Design details to be worked out in interface with Designated Contractor's design requirements.	**Design:** • Confirm basic booth size and layout • Furnish equipment size and weight • Furnish equipment mounting details • Confirm room finishes • Furnish requirement of cable trenches, cable routing and cable support provisions • Furnish lighting requirements • Confirm fire Safety provisions • Review the design from NGNEDD.

5	**Ticket stock and Audit** Room related works: Construction, Lighting arrangement Power point for one computer, Supply through UPS, communication line for computer, Earthing facility for computer, Vaults	**Design:** • Design details to be worked out in interface with Designated Contractor 's design requirements.	**Design:** • Confirm basic size and layout • Confirm room finishes • Furnish requirement of cable trenches, cable routing and cable support provisions • Furnish lighting requirements • Confirm fire safety provisions • Review the design from NGNEDD.

Interface Specifications of Signalling and Communications Contract

Item No	Subject	DDC responsibilities	SYS responsibilities
1	Signalling & Telecommunication equipment rooms, UPS, and Station control rooms at stations	**Design:** • Develop location, room layout with dimensions of Signalling & Telecommunication equipment room, UPS and station control room in relation to the entire station and facilities layout; • Develop routing of Cable ducts / conduits / hangers / trays within and between Signalling, Telecom equipment, UPS and station control rooms. • Furnish details of architectural finishes and building materials of the entire station; • Design details to be worked out in interface with Designated Contractor's design requirements;	**Design:** • Confirm basic room sizes; • Furnish equipment dimensions, weights and colors. • Furnish equipment foundation/ mounting details; • Confirm room finishes; Furnish cabling requirements including destinations, sizes, quantities and cable loadings of Cable ducts / conduits / hangers / trays within and between Signalling, Telecom equipment, UPS and station control rooms. • Furnish requirements of

			cable bores on walls/ floor penetrations, complete with pipe, sleeves for routing of all types of cables • Furnish requirements of EMC and fire separation for cabling • Furnish air-conditioning/ventilation, lighting and power socket requirements; • Confirm fire safety provisions; • Review the design from NGNEDD.
2	Cabling infrastructure for Signalling & Telecommunication	**Design:** • Furnish sectional details of /guideways including structure gauge, architectural finishes and building materials**;** • Furnish details of architectural finishes and building materials of the entire station; • Develop routing of Cable ducts / conduits / hangers / trays for Signalling & Telecommunication cables throughout the station and each guideways. Design details to be worked out in interface with Designated Contractor's design requirements.	**Design: Trackside:** • Furnish dimensions, weight minimum bending radius supporting and mounting details of Fibre Optic Cable, Cu- cable, Outdoor / indoor Sigg. & Telephone Cable, Leaky coaxial cable, along each guideways; **At Stations:** • Furnish dimensions, weight minimum bending radius supporting and mounting details of Optic Fibre Cables,Cu – cables, Leaky Coaxial Cables, radio antenna feeder cables and cables for Sigg. &

			Telephones, CCTV, Public Address system, Master clock system, PIDS and UPS power supply/ earth distribution • Furnish destination of each cable • Confirm size and location of Cable ducts/ conduits/ hangers / trays for routing Signalling & Telecommunication cables throughout the station including Receiving and Traction Substation and Auxiliary Substations. The cabling shall include, bur not be limited to Optic Fibre Cables, Cu-cables, Leaky Coaxial Cables, radio antenna feeder cables and cables for Sigg. & Telephones, CCTV, Public Address system, Master clock system, PIDS and UPS power supply / earth distribution • Confirm size of cross track cable ducts; • Furnish requirements of EMC and fire separation for cabling • Review the design from Project Leader.
3	Track side Signalling & Train Control Equipments.	**Design**: • Provision of space & fixing arrangements for	**Design**: • Furnish the exact sizes,

		lineside equipments like signal units, AFTC units, junction boxes, etc. Design details to be worked out in interface with Designated Contractor's design requirements.	weight and fixing arrangements of the line side equipments like signal units, AFTC units, junction boxes, etc. • Review the design from Project Leader.
4	Clocks, Public Address System, CCTV cameras, CCTV monitors, Passenger Information Display Boards, telephones and Radio access units and associated MMIs at stations	**Design** • Furnish details of architectural finishes, acoustic treatment and building materials of the entire station; • Develop locations of CCTV cameras for coverage for station surveillance and platform monitoring using a maximum of 24 cameras at each station • Furnish level of lighting (Lux) both normal and emergency in various areas of CCTV coverage • Design details to be worked out in interface with Designated Contractor's design requirements;	**Design:** • Furnish weight, dimensions, colours and mounting details of clocks, telephones, Public address loudspeakers, ambientnoise sensors, Passenger Information Display Boards, all types of CCTV cameras including housing and associated pan/ tilt / zoom units, CCTV monitors on each platform and in station Control Room; • Furnish quantities, position and sizes of space cut-outs to the ceiling/ wall finishes for mounting clocks, telephones, Public address loudspeakers, ambient noise sensors, Passenger Information Display Boards, all types of CCTV cameras including housing and associated pan/ tilt / zoom units,

			CCTV monitors on each platform and in station Control Room; • Confirm standard of acoustic treatment of areas of coverage by PAS throughout the station • Confirm level of emergency lighting • Review the design from NGNEDD.
5	Power supply source (AC single phase / 3 phase)	**Design**: • Furnish details of normal and standby power supply for the Train control & Signalling and & Telecommunication installations; Design details of normal and emergency supply to be worked out in interface with Designated Contractor's design requirements.	**Design**: • Furnish details of complete load for Telecommunication and Train control & Signaling installation; • Review the design from NGNEDD.
6	Train Radio Antenna system	**Design:** • Design details to be worked out in interface with Designated Contractor's design requirements.	**Design:** • Furnish the locations, dimensions & load for Antenna mounting Tower Structure for Train Radio Base Station (s).
7	Station Control Room	**Design:** • Design details to be worked out in interface with Designated Contractor's design requirements;	**Design:** • Furnish weight, dimensions, colours and mounting details of work stations/control panels/ Radio access unit for all Signalling & Telecommunication system and telephones.
8	Provision of Earthing	**Design:** • Design details to be	**Design:** • Furnish

	(1) At station in Signalling & Telecom equipment rooms, Station Control room, UPS/Battery room.	worked out in interface with Designated Contractor's design requirements;	requirements for clean earth and main earth • Review the design from NGNEDD.

Interface between Rolling Stock Contract and NGNEDD Contracts

These shall include the following but not limited to:

Item No	Subject	NGNEDD	RS
1	Kinematic Envelope	DDC shall incorporate in his design.	Designated Contractor shall provide the DDC with the Kinematic Envelope.
3	Location of air-conditioners of Cars	DDC shall incorporate in his design as regard to location of Track way exhaust duct.	Designated Contractor shall indicate location of the car air-conditioners vis-à-vis the train.
4	Heat release rate from air-conditioners	DDC shall incorporate in his design.	Designated Contractor shall provide data of heat release rate from the air-conditioners.
5	Heat release rate from brake system	DDC shall incorporate in his design.	Designated Contractor shall provide data of heat release rate from the brake system.
6	Train fire and heat release load	DDC shall incorporate in his design.	Designated Contractor shall indicate the fire load of the train
7	Train Configuration and specification	DDC shall incorporate in his design.	Designated Contractor shall provide this information as SES input data.
8	Station ambient details	DDC shall provide to RS	Designated Contractor shall take account of this data in his design.
10	Heat release rate from traction and Auxiliary equipments and their location	DDC to use data in ECS design	Designated Contractor to furnish data

Earthing & lightning protection to be provided by the DDC to meet the Interface Requirements of Signal & Train Control and Telecom System.

1.0 Objectives

Earthing points shall be designed by the DDC and shall be provided by the civil contractor for all the indoor Signalling & Train Control and Telecommunication installations to achieve the following objectives:

1. To provide safety for the operating & maintenance personnel against electric shock on account of any potential (voltage) appearing on exposed equipment or conductive surfaces with respect to earth due to electromagnetic or due to electrostatic induction.
2. To ensure safe & reliable operation of the equipment by limiting or eliminating the induced voltages in the Signalling & Train Control and Telecommunication equipments.
3. To protect equipment against build up of unduly high voltages, which can cause dielectric (Insulation) breakdown or damage to the equipment or their parts?
4. To serve as a common voltage reference point.

2.0 Policy:

1. The Earthing system shall meet or exceed the requirements of IEEE 1100, NFPA 780 and IEC 1024 or relevant international standards.
2. Earthing shall be designed by DDC to accomplish the following minimum requirements but not limited to:
   a) Protection of personnel and equipment from electrical hazards, including lightning.
   b) Reduction in potential to system neutrals.
   c) Reduction or elimination of the effects of electrostatic and electromagnetic interference arising from within the DMRTS on account of traction voltages, traction return current, rolling stock characteristics and other extraneous sources in the vicinity of Designated Contractor's installations
   d) Provision of a proper Earthing method for all equipment enclosures, cabinets, drawers, assemblies and sub-assemblies.
   e) Provision of a clean zero-volt reference point where required.
3. The Earthing system shall be so designed by DDC so as to give earth resistance within the stipulated limits (as given below) at all locations and under all climatic conditions.
4. Any electrical joints in the Earthing system shall be protected from moisture ingress by using proper wrapping, sealing with waterproof tape, or such other approved measures.
5. For the purpose of measurement of earth resistance, a small interconnecting copper strip of appropriate cross-section shall be provided in the ring earth in a small accessible chamber so that the ring earth can be broken from the loop for testing.
6. The Earthing methods design and details be submitted to the Employers'Representative for review.

2.1. Stations area (Indoor Equipments):

2.1.1. Clean Earth System:

"Clean Earth system means earth network for the use of particular systems which are not to be subjected to electrical interference from other systems."

There shall be two separate & independent "Clean- Earths", one each for Signalling equipments & Telecom equipments (separate from system earth i.e. main electrical earth bus for other utilities). These earths shall cater for the Signalling & Train Control and Telecom Equipments to be provided inside the equipment rooms at the Station/Control centre. These earths shall be brought inside the equipment rooms using insulated copper conductors & connected to the "Clean-earth terminals" using isolating link. It shall provide full earth, fault protection facilities. A local "Clean- earth" bus shall be set up in side the equipment rooms by running a copper strip. The route chosen for the insulated clean earth conductor shall minimise inductive interference from power-supply cables and the main earth network.

These "Clean-Earths" shall be designed so as to give not more than ***0.5 Ohm*** resistance in dry condition. The earths shall make use of copper electrodes of appropriate size. The Earthing electrodes for these equipment earths shall be kept at least 20 m away from the "Main-Earth" provided for electrical systems & utilities.

2.1.2. **Main Earth:**

Apart from these two separate clean earths, one earth point shall also be provided from the "Main-Earth" bus in each of the Signalling & Telecomequipment rooms, Station Control room (SCR) and UPS/Battery room at the station and Control center. This shall be used as the chassis earth. The value of this earth should not be more than ***1.0 Ohm*** at any location and under any climatic condition.

NGNEDD: DDC shall design and the Civil contractor shall provide the Earthing pits for clean earths & main earth and shall connect them up to the Earthing terminals inside the rooms as above.

Other Designated Contractor: Designated contractor shall set up Earthing ring bus inside the rooms.

Structural Eathing: DDC shall design and the civil contractor shall provide structural Earthing (Via-duct, peer, civil structure etc.)

3.0 Out Door Installations:

The following out door installations are required to be earthed:

i) Metallic sheath & armouring of all main cables at regular intervals.

ii) Location Boxes.

iii) Signal posts and screens.

iv) AFTC tuning units.

v) Any other installation as may be necessary to cover complete scope of works under Other Designated Contractor

4.0 Guidelines for Transient Protection & Lightning protection:

4.1. General:

a) Despite the provision of Earthing as specified above, failures of Solid State Electronic equipments do occasionally occur on account of finite earth resistance, particularly high voltage transients and also due to lightning.

b) Typically, transient & lightning are temporary, and are usually short duration, surge voltages of limited energy. Electronic equipment with high input impedance is inherently more susceptible to transients.

4.1.1. Lightning Protection:

While the Station/Control center above ground structures shall be provided with lightning protection arrangements by DDC the protection against lightning surges traveling through conductors into equipment's side shall be done by the Designated Contractor using appropriate devices in accordance with Designated Contractor's contract document.

Earthing and protective measures in preceding para are given only as indicative guidelines. The Designated Contractors shall interface with each other to ensure the correct & safe working of equipments / sub-system

NOIDA METRO RAIL CORPORATION LIMITED

CONTRACT NO: NMRC/Projects/NGNEDDC/2025/415

Contract NGNEDDC: Detail Design Consultant (DDC) for Civil, Architectural and E&M works including Traction works for Elevated Sections of Extension Projects of Aqua Line from Noida Sec-51 to Knowledge Park-V, Noida Sec-142 to Botanical Garden & Depot Station to Boraki including augmentation of existing depot and RSS works (31.595 km).

VOLUME-5
STANDARD DOCUMENTS

PART VI - DESIGN CRITERIA (DEPOTS, YARDS AND WORKSHOPS)

NOIDA METRO RAIL CORPORATION LTD.
Block-III, 3rd Floor, Ganga Shopping Complex,
Sector-29, Noida -201301,
District Gautam Budh Nagar, Uttar Pradesh, India

CONTRACT NO: NGNEDDC

INDEX

PART-I

Design Criteria (General)

Depots, Yards and Workshops

1.0 General

This section presents design criteria of a general nature applying to the areas of the system intended for the stabling, servicing, repair and overhaul of transit vehicles. They also contain other functions as herein defined. For terminology, these areas are collectively termed depots regardless of their specific functions. Because of the unique characteristics of any depot facilities the design criteria can only encompass the broadest of requirements and may not address all the design criteria can only encompassed the broadcast of requirements and may not address all design challenges that arise in the course of developing the total system design. The designer is encouraged to view these requirements as standards, which express the overall intent of the NMRC to achieve an efficient operation of the storage and maintenance of the system and to adopt this general intent to the specific design under consideration. However, any clear variation from these criteria must be identified and brought to the attention for appropriate direction before the design proceeds.

1.1. General Climatic Conditions

- The recorded highest and lowest temperature in past 10 years is 48.1 degree Celsius and 2.4 degree Celsius respectively.
- Summer season is from April to June and the winter season is from November to March.
- Wind pressure is 150 kg/m_2 for Noida-Greater Noida areas.
- Rainy season is from June to August sometimes extending to middle September.

1.2. Seismic Zone

Noida-Greater Noida falls in seismic zone IV as at present. If there is any change subsequently during the pendency of the work the design shall have to be revised accordingly. Earthquake of maximum magnitude 7 on modified Mercalli scale has been experiences in the past

1.3. Not Used

2.0 Codes and Standards

- The design and the construction of the depot shall comply with the codes of practice and standards current at the time of submission of tender documents. Regulations made and requirements issued by the Indian Government and by relevant utility companies shall be followed and specified.

- Alternative or additional codes, Standards and specifications proposed by the DDC shall be internationally recognized shall be equivalent to or better than Indian Standards issued by the Bureau of Indian Standards subject to being, in the opinion of the Employer's Representative, suitable for incorporation into the specification.

3.0 Deleted

4.0 Depot Layout

The buildings and other structures and the track in the depot have been arranged to accommodate the intended functions within the available land area in the most efficient manner. The functions for the depot, as defined in Table 1, can be summarized as:

- Stabling of EMU vehicles awaiting revenue service, inspection, repair or overhaul.
- Internal and external cleaning. Maintenance and Inspection of EMU vehicles.
- Provision for Emergency Response equipment.
- Repairs and overhaul of EMUs.

4.1. Deleted

4.1.1. Deleted

4.1.2. Deleted

4.1.3. Public Road Access

Movement of pedestrians and vehicles in and out of the depot shall be controlled through the use of a minimum number of entrances. Appropriate security measures such as gates and checkpoints shall be incorporated to permit adequate vehicular inspections both leaving and entering the depot. Pedestrian paths shall be provided to separate foot and vehicular traffic to the maximum extent possible. Clearly identifiable entrances shall be provided and shall be situated to allow adequate surveillance of incoming traffic. Separate entrances shall be provided, where appropriate for non-maintenance or operations related traffic such as trainees, goods delivery and visitors. Adequate turning radium shall be provided for large vehicles carrying EMU bodies / rails for entrance into the workshop area/P. way material stacking area for delivery of vehicles.

4.1.4. Internal Traffic Pattern

The internal traffic patterns must also be designed considering rail borne vehicles, road vehicles such as automobiles, trucks, and other rubber typed equipment and foot traffic of personnel moving about the depots. In general, the layout of all tracks, roads and footpaths shall be arranged to separate the traffic and avoid, as far as possible, intersecting paths that expose either persons or

equipment to hazards due to collisions. Level crossings of tracks and roads shall be kept to a minimum. All level crossings shall be protected by height gauge and should not path through the points and crossings.

5.0 Deleted

6.0 Deleted

7.0 Deleted

8.0 Not used

9.0 Deleted

9.1. Stores:

- Storage of consumable, capital spares and spares parts for maintenance of Rolling Stock.
- Storage of tools, consumable, capital spares and spares parts for maintenance of Metro Corridor assets such as P-way, Signalling & Telecommunication, etc. The main storage area will be located close to the workshop area. The DCOS Stores will provide facilities, to account for all NMRC Metro Corridor maintenance and operation requirements for material and supplies, spare parts and overhauled components waiting to be put back in service. Design of these facilities will fully account for security and climatic considerations, included shall be the provision of all racking, shelving, bins and material handling equipment.

9.2. Water supply, Sewerage, Drainage:

9.2.1. Water supply, sewerage system:

- Bore wells are planned for water supply for the depot including washing of rakes, drinking water for the staff, firefighting purpose, etc.
- Adequate water storage for minimum 12 hours is needed.
- Adequate standby arrangement for Bore-well failure or pump failure to be incorporated in the system design.
- Sewerage can be disposed off by soak pits.
- Overhead storage tank of adequate capacity and height.
- Planning & design of sewerage & drainage disposal as per requirement of facility planned by NMRC in future.

9.2.2. NOT USED

9.2.3. Waste Water Treatment:

- Waste water of the workshop after cleaning of trains, bogies, bearings,

traction motors, filters etc. shall be treated by a waste water treatment plant so as to limit the effluents to the general standards for discharge of environmental pollutions as specified in The environment (Protection) to check up from relevant books Rules, 1986 Schedule-IV, notified vide G.S.R. 422 (E) dated 19/05/1993.

- Similar treatment is required for the wastewater released after washing of the cars by detergents or acids before the same may be discharged.

9.3. Deleted

9.4. Staff facilities:

Staff facilities such as canteen, toilet, changing room, cycle / scooter / cark parking etc. shall be planned.

Employee welfare areas shall consist of rest rooms, locker areas, showers, first aid room, and lunch facilities. The facilities shall be sized for the number of persons employed in the workshop as well as in the inspection shed in shifts. Separate facilities will be provided for both sexes where appropriate.

9.5. Security:

Entry to depot by road and rail by suitable security arrangements with a suitable height of boundary wall all around the depot to be provided.

10.0 Civil Work

10.1. Foundations

For heavier structures like depot, workshop, staff quarters, RCC Deck slab over stabling lines (for a future load of 6 storey building over deck slab / or number of storey as intimated by NMRC) etc. particularly those with crane loading, and above stabling lines, pile foundations shall be such that no cracks or settlement is notified.

10.2. Super – Structure

Super structure shall be of Reinforced concrete cement framed structure or steel column, supplemented by brick work in shed structures and of brickwork in other buildings and ancillary works.

10.3. Roofing

Shed structures such as Main Workshop, Inspection bays, stabling lines, ETU workshop etc. shall have steel truss roof/Pre-Engineered Structures with steel cladding. The office & other structures and staff quarters shall have normal flat Reinforced concrete roofing.

10.4. RCC Deck Slab over Stabling lines

Deleted.

10.5. Flooring

Heavy-duty flooring (Cement, concrete reinforced with short steel bars or iron casting) is prescribed in heavy repair and lifting bays for EMUs. Other buildings such as sub-station shall also be provided with heavy-duty floorings. The flooring should be suitable for withstanding jacks of 15-tonne capacity used for lifting of EMUs. Generally plinth level should be 460 mm (minimum) above the natural ground level or centre of road whichever is higher. In acid storeroom, acid and alkali resistant tiled floor is envisaged. In rest of the buildings cement concrete floorings are prescribed.

10.6. Steel Work

Workshop doors shall be of collapsible steel shutters. Gantry girders for overhead cranes shall be of built-up steel sections. Doors and windows in all the other structures shall be of steel, with glazed shutters shall be provided.

10.7. Wood Work

Door shutter in offices and other buildings shall be of flush panel and glazed type.

10.8. Paved Area

A 20 m space on either side of depot and workshop shall be paved with cement concrete of given mix to reduce dust nuisance.

10.9. Miscellaneous work

Utility diversion works if any, boundary wall, earth work & site development/landscaping work etc.

11.0 Design Life

The design life of the Permanent Works shall be:

a.	for civil engineering structures	100 years
b.	for building structures	50 years
c.	for Plant and equipment	30 years
d.	for road pavements	20 years

TABLE 1

Major Facilities in NMRC Depot cum Workshop

S.no	Description	Facilities	
1	Stabling Lines	13x2=	26 Rakes
2	Stabling Lines (covered)	6x2=	12 Rakes
3	Inspection Bays (for 3 lines)	3	
4	Workshop Bay	1	
5	Workshop Bay (Future)	1	
6	Auto coach washing plant	1	
7	ETU double storey building	1	
8	Heavy internal cleaning building	1	
9	Emergency building	1	
10	Pit wheel lathe	1	
11	Test track (650 m.)	1	
12	Shunting Neck (CSL 165 m.)	2	
13	ETP/STP	1	
14	P-Way material section (open storage) & cover store	1	
15	Tower wagon shed	1	
16	Engineering Siding (CSL 140 m.)	1	
17	Radio tower	1	
18	D.C.C & S&T	1	
19	U.G Tank	1	
20	O.H Tank	1	
21	R.S.S.	1	
22	Canteen	1	
23	Sub station	2	
24	Feeding post	1	
25	CWM office	1	
26	Time & Security office	1	
27	DCO store Cum Inflammable & Dangerous item	1	
28	Offices & Repair section building		
29	Contractor's staff Cleaner room		

TABLE 2

MAJOR CHARACTERISTICS OF VEHICLES

S.No.	ITEM	RAIL CORRIDOR
1	Supply voltage system	25 KV flexible OHE on surface
2	Type of OHE	Flexible (and or rigid centenary)
3	Current collection	By Pantograph
4	Min. Height of Contact wire from Rail Level	4570 mm
5	Train Control System	CBTCS
6	Train Control Mode	i. Automatic Mode (Normally) ii. Manual Mode (infrequently)
7	Tare Weight of Motor Car	40 tonnes
8	Tare Weight of Driving Trailer Cars & Trailer Cars	25 tonnes
9	Max. speed	90 Km/h
10	Length Over Body	21340 mm/ 21640mm
11	Max Width Over Body	2900 mm
12	Overall Car Height from top of Rail Roof center	3690 mm
13	Height of Floor from Rail Level	1130 mm
14	Wheel Diameter (New)	860 mm
15	Wheel Diameter (Fully Worn)	780 mm

PART-II

TRACK LAYOUT CRITERIA

Depots, Yards and workshops

1.0 GENERAL

The purpose of this section is to define the general approach and specific requirements for the track layout. In addition, track configuration is defined for co-ordination with other design disciplines.

2.0 DEFINITIONS

Ballast: Crushed hard rock material placed below and around the sleepers on ballasted track. Bottom ballast is that ballast placed below the sleeper. Top ballast is that ballast placed around and between the sleepers.

Ballasted Track: Track elements comprising of running rails, rail-fastening assemblies, base plates, concrete sleepers, ballast and sub-ballast. Also, track consisting of rails attached to concrete sleepers that are supported by ballast on a concrete slab or on a layer of sub-ballast that is resting on a track bed of compacted sub-trade, may incur at-grade, on a raised or retained embankment, in an open or retained cut, on a deck bridge. .

Ballastless Track: Track elements comprising of running rails, rail-fastening assemblies, rail pads, sleeper blocks/RCC, resilient pads, embedded in concrete, on slab, on earth or directly fixed steel column.

Bonded Joint: A rail joint that use high-strength adhesives in addition to bolts to join two rail lengths together. The joint may be insulated or non-insulated.

Cant: The designed vertical distance that the that the outside rail of a curve is set above the inner rail on a curve (also called super-elevation).

Cross level: The vertical relationship of the top of one running rail to that of the opposite running rail at any point in the track.

Crossover: Two turnouts connecting one track to another. Crossovers may be facing or trailing.

Direct Fixation Track: Track constructed of rail and direct fixation fasters attached to a concrete plinth of slab. May occur on viaductsand on at-grade concrete track slabs.

Direct Fixation Fastener (DFF): A resilient device for securing running rail to a concrete track bed in direct Fixation track.

Double Crossover: Two- single crossovers in close proximity enabling moves in either direction.

Electrical Isolation: The electrical resistance required between the running rail and the ground to prevent harmful levels of stray current from the DC traction power circuit.

Friction Buffer: An energy-dissipating device consisting of a steel frame, a cushioned head to engage the vehicle-end and friction shoes attached to the railhead.

Scissors (Diamond) Crossover: A double crossover where the two crossovers are superimposed.

Shop or Pit Track: Special track where the rails are embedded in the concrete floor of a shop or supported on columns in a service or inspection pit.

Sub-ballast: An aggregate material that is placed and compacted between the ballast and sub-grade to prevent migration of ballast in to the sub-grade and to prevent the migration of sub-grade into the track ballast.

Turnout: Switching-and-crossing mechanism that allows rolling stock to divert from one track to another. Turnouts may be facing (diverting from the line in the direction of normal running) or trailing converging to the line in the direction of normal running).

3.0 RAILWAY ALIGNMENTS

3.1. Criteria

3.1.1. General Criteria

S.No.	Criteria	Dimension
1.	Gauge (14 mm below top of rail crown)	1435 mm
2.	Maximum Train speed	80 km/h
3.	Operational speed in Depot	25 Km/h
4.	Maximum axle load loaded Condition AW4	16 tonnes
5.	Maximum axle load empty Condition AW (Depot)	10 tonnes
6.	Maximum gradient running track Maximum Depot connecting track	4% compensated 4% compensated
7	Minimum vertical curve radius Minimum horizontal curve radius	1500m 120m Running track) 100m (Depot track)
8	Electric Power collection – SC-BP Corridor	Overhead catenary – AC 25 KV

3.1.2. Track Standard

S.No.	Criteria	Broad gauge
1.	Maximum Cant	110 mm
2.	Maximum Cant deficiency	80 mm

3.2. Horizontal Alignment

3.2.1. Transition Curves

In general for all running and depot lines transition curves shall be provided where possible between a circular curve and adjoining straight, between the different radii of a compound curve and at the adjoining ends of circular curves forming reverse curves. Transition curves are not required in sidings.

Transition curves will not normally be required between different radii of a compound curve where the change of radius of curvature does not exceed 15% of the smaller radius and provided that the cant deficiency and/or cant excess criteria are not exceeded for either curve.

Transition curves shall be in the form of cubic parabolas or clothoid spirals for which the equations are:

a) **Cubic Parabolas**

i. $$y = \frac{d^3}{6RL}$$

ii. $$A = \frac{d^2}{2RL}$$

iii. $$S = \frac{L^2}{24R}$$

b) Clothoid spiral

$$S = \frac{L^2}{24R} - \frac{L^4}{2688R^3}$$

Where L = length of transition

R = radius of circular curve

S = shift

y = offset from tangent

d = distance along transition

A = deviation angle of transition

3.2.2. Cant Gradient

The cant gradient (nor cant deficiency) shall be subject to the following limits:

Absolute maximum = 1 : 440

Preferred maximum = 1 : 720

The rate of change of cant or cant deficiency shall be limited to:

Absolute maximum = 40 mm/sec.

Desirable maximum = 25 mm/sec.

3.2.3. Compound Curves

Where a compound curve is employed with a change of radius greater than 15% of the smaller radius, or where the cant deficiency or cant excess criteria necessitates a change in cant between the circular curves suitable transition curve shall be interposed between the two parts of the curve may be omitted. In this case, the required change of cant shall take place over the calculated length of the transition, or 15 m which ever is the greater, and in the same location as if the transition had been provided.

When the actual shift of any calculated transition curve would be less than 10 mm the actual transition curve may be omitted. In this case, the required change of cant shall take place over the calculated length of the transition, or 15 m which ever is greater, and in the same location as if the transition had been provided.

3.2.4. Reverse Curve

Where a a reverse curve is employed, a minimum straight length of 30m shall be kept between two transitions of reverse curves. Where this length is not possible and the straight is less than 50m between the reverse curves, the same should be eliminated by suitably extending the transition length. In doing so it should be ensured that the rate of change of cant and versine along two transitions so extended is kept the same.

3.3. Vertical Alignment

3.3.1. General

Vertical curve shall be provided whenever the change of grade exceeds 0.4%. Vertical curves shall wherever possible be positioned such that coincidence with horizontal transitions is avoided.

Vertical curves shall, for each location, be selected on the basis of the largest practicable vertical curve radius subject to:

Minimum desirable radius 1500 m

3.3.2. Length of Vertical Curve

The length of constant grade between consecutive vertical curves shall be as follows:

Desirable minimum 50 m

Absolute minimum 20 m

3.4. Gradients

The limits of gradients shall be:

- The desirable maximum gradient shall be 0.1% on stabling tracks and the absolute maximum gradient shall be 0.25% for all other tracks expect in workshop inspection shed where level track should be laid.

3.5. Points and Crossings

Whenever possible points and crossing work shall not coincide with vertically or horizontally curved track.

Where it is not possible to avoid coincidence with vertical curves the switches and rails shall not be laid on vertical curves.

Points and crossing work shall not coincide with horizontal transitions

No part of the switches, switch operating gear or crossing nose shall be over a structural movement joint.

3.6. Types of Tracks

There will be four types of tracks in depots:

- Ballast less track in washable aprons, automatic coach washing plant, workshops etc.
- Ballast less track elevated above an open depressed floor area for raising the cars 1.1m above the sunken floor level.
- Blasted track in rest of the depot such as stabling lines, test track etc.
- Blasted track on level crossings.

3.7. Derailment Protection

Trap points must be provided for isolation of main line & trial track from other depot lines to restrain vehicles from colliding with other vehicles.

Trap points must be provided for isolation of main line & trial track from other depot lines to restrain vehicles from colliding with other vehicles.

Part-III

Building Services (Electrical and Mechanical)

1.0 GENERAL

- This section presents outline design requirements for electrical and mechanical works such as:
- Distribution system including main LV panel, switchboard panel, bus ducting, cabling, distribution and sub-distribution boards, feeder pillars etc.
- Standby power supply system including diesel generating set, associated control, changeover, automatic mains failure panel.
- Building Services including air conditioning, lighting (both indoor and outdoor), water pumping, storage and distribution system, and sanitation;
- Cable supports, ducts and drawpits for cables to be installed by others;
- Earthing and lightning protection;
- Fire fighting system;
- Access Control System
- The DDC shall assist NMRC to get the necessary clearances from the local fire safety authority for the preliminary approval of the Depot design as per Fire safety norms.

These requirements only give the system requirements in the broader sense and may not address all design challenges that may arise in the course of developing the total system design. The designer is encouraged to view these requirements as standards, which express overall intent of NMRC to adopt this general intent to the specific design under consideration. However any clear variation from these criteria must be identified & brought to the attention for appropriate direction before the design proceeds.

2.0 ABBREVIATIONS

Abbreviations used in this specification include:

HV: High Voltage

MV: Medium Voltage

LV: Low Voltage

AC or ac: Alternating Current

DC or dc: Direct Current

DCOS: Divisional Controller of Stores

KVA: Kilo volt-amps

KW: Kilowatts

V: Volts

A: Amps

Mm: Millimeters

Db: Decibel (sound pressure level)

NC: Noise creation

NFPA: National Fire Protection Association, USA

FAP: Fire alarm panel

BS: British Standards

ISO: International Standards Organisation

IES: Illumination Engineering Society

SCADA: Supervisory Control and Data Acquisition

IS/BIS: Bureau of Indian Standards

AMF: Auto Main Failure

LT: Low Tension

3.0 CODE AND REGULATIONS

Main Electrical Design:

Equipment, materials and systems shall be designed, in accordance with the latest issue of codes and standards.

Electrical design shall be based on BS 7671:1992 “Requirements for Electrical Installations” or other internationally recognized equivalent standard approved by NMRC examples of which are:

IE Rules & IE Act

National Building Code

ANSI American National Standards Institute

ASME American Society for Testing and Materials

ASTM American Society for Testing and Materials.

DIN Deutsche Industrie Normen (German Industrial Standards)

IEC International Electrotechnical Commission

JIS Japanese Industrial Standards

NEC International Electrical Manufacturers Association (USA)

NEMA National Electrical Manufacturers Association (USA)

NEPA National Fire Protection Association (USA)

VDE Verband Von Deutsche Standards (German standards association)

Mechanical design shall be based on the following codes:

IS 1172 Code of basic requirements for water supply, drainage and sanitation.

IS 1742 Code of Practice for Building Drainage.

IS 2064 Code of Practice for selection, installation and maintenance of sanitary appliances

IS 2065 Code of Practice of water supply in buildings.

IS 2470 Code of Practice for installation of septic tanks.

IS 3114 Code of Practice for laying of Cast iron pipes.

IS 4111 Code of Practice for ancillary structures in sewage system.

IS 4127 Code of Practice for laying of glazed stoneware pipes.

IS 5329 Code of Practice for sanitary pipe work above ground for buildings.

IS 7740 Code of Practice for construction and maintenance of Road Gullies.

IS 12251 Code of Practice for drainage of building basements.

IS 12288 Code of Practice for use and laying of ductile iron pipes.

3.1. Local Codes, Regulations and Standards

Unless otherwise stated, the electrical system design shall be governed by all applicable local codes, regulations and standards issued by the local agencies such as:

BIS Bureau of Indian Standards

IEEMA Indian Electrical & Electronic Manufacturers Association

The DDC shall specify the regulations laid down by the local authorities i.e., Government of Municipal agencies including fire safety regulations, fire insurance regulations or other local codes and make provision so that NMRC obtains

approvals from relevant authorities at appropriate stages of work. Such regulations are:

Indian Electricity Rules

Indian Electricity Act

National Building Code

Inspectorate of Lifts and Escalators

Central Pollution Control Board

U.P. Police & Fire Brigade

Central Public Works Department

U.P. Vidut Board

National Safety Council

Building Bye Laws – U.P. Govt.

3.2. Additional Codes, Standards, Specifications and Manuals

In addition to the local requirements, electrical system designs shall comply with the codes of practice and standards specified herein. Local codes regulations and standards shall take precedence where their standards or requirements are more onerous than other national standards. All codes and standards shall be submitted in English language. The design of any one system shall be to a single code or specification. The parallel use of different codes for one particular item or component will not be allowed.

A checklist based on relevant standards for ensuring conformity shall be prepared. The checklist should cater for design, manufacture, supply/storage, packing, erection/commissioning and operation as applicable.

4.0 Standardisation

In establishing his design, the principles provided below shall be followed in the design and specification all plant, equipment and components.

- Similar plant and equipment shall be replaceable/interchangeable, modular in design, adaptable and extendable.
- The technical specifications and design criterion shall be uniform. Uniform standards for clear spaces, working clearances, protection of equipment and physical dimensions of equipment and interfacing with other systems shall be followed.
- Type testing, routine testing and endurance test shall be required under similar conditions.

- A standard procedure shall be followed for identification of each category of equipment explicitly (suffixing or prefixing while marking and numbering for each category of equipment).
- Equipment and accessories shall be provided with uniform standard space capacity, protection.
- Piping, cabling etc shall be suitably colour coded for identification and categorization for each kind of use/type.

5.0 DESIGN CRITERIA MECHANICAL WORKS

This section covers the requirements of the water supply, storm water drainage, sewerage system air-conditioning, lifts, water coolers and fire fighting systems in the deports.

5.1. Water Supply and Sanitation

The DDC shall be responsible for assessing the water/drainage requirement, pipe sizing, effluent treatment procedure, fire-fighting requirements and submit calculations to the Employer's Representative.

5.1.1. Water Services

Water Storage Tanks

RCC water storage tanks shall be installed at the height of 20 metres or adequate height at a possible location within each depot.

Requirement of water shall include:

1) Coach Washing
2) Depot/Workshop/Machinery requirement
3) Personal use
4) Gardening
5) Road watering
6) Fire Fighting (make up water)

5.1.2. Mains and Water Pipe Installation

The mains water and water services shall be installed as a grid iron system and shall be graded to ensure satisfactory drainage.

Pressure head of water in pipes shall not be more than 70 m. For up to double storey buildings the pressure head may be 50m.

Minimum size of C1 mains shall be 100 mm for one sided mains fed & 80mm for

both sided mains fed. Any branch feeder or main distribution shall not be less than 50mm. Wherever a pipe has to pass through floor or wall, it shall pass through a sleeve.

No service pipe shall be directly connected to distribution pipes to avoid contamination due to backflow from flush cistem etc.

Velocity of flow shall be 0.75 m/s to 3 m/s (preferably 1.5 m/s). In no case it shall be less than 0.6 m/s.

Internal mains water pipes shall be installed in heavy grade galvanized steel. Pipe fittings shall be compatible metal fittings to Indian Standards.

Valves

All valves used on water services shall be in accordance with the requirements of the water authority. All valves shall be non-dezincifiable.

All valves and drain cocks shall be located for ease of maintenance. Valves located behind panels within toilet or other areas shall be clearly identified via appropriate marking on the external face of the panel.

5.2. Sewage System

Pipes

Cast iron soil waste and ventilating pipes, fittings and accessories shall conform to BS 416, with approved coating providing fire and corrosion protection.

Pipe of minimum dia of 250 mm shall be used.

Soil Waste, Waste and Ventilating Pipes Installation

All pipe runs shall be arranged to present a neat appearance and where practicable be parallel both with one another and with the building structure. All vertical pipes shall be in plumb The minimum clearance between a pipe and any adjacent finished building surface, fixing or pipe shall be 35 mm.

Pipe-work runs shall in all cases be installed with a view to co-ordinate with other services, whether provided by the DDC or not.

Careful consideration must be given to the low flow rates when designing suspended drainage schemes. Self-cleansing velocities must be achieved, minimizing potential blockages etc., therefore a normal minimum installation gradient of 1:60 should be achieved. Any flatter gradient than 1:60 must be proven by the DDC prior to receiving consent.

Septic Tank:

Minimum width & depth of septic tank shall be 750 mm & 1000 mm respectively. Length of septic tank shall be 3 to 4 times that of the width. Minimum liquid

capacity of a tank shall be 1.14 cum.

Manholes.

Side of a manhole shall not be lessthan90 cm and it shall not be less than 1 m deep. Manholes shall be kept 45 to 100m apart.

Soakpits.

Soakpits shall be kept at least 30 m away from any residential/office building.

5.3. Storm Water Drainage

The drainage disposal shall be gravity flow. In case the same is not possible and needs mechanical disposal then suitable pumping system shall be designed (e.g. sunken floor inspection area, waste water treatment plant etc.)

Basis for storm water drainage system design shall be the rainfall of 80mm/hr – 25 years to 30min. Storm water drains shall be laid at a gradient not flatter than 1 in 400 to achieve a self cleaning velocity of 1m/s.

To avoid the chocking of drains during lean period, they should have trapezoidal section except those crossing under the track, which shall be rectangular cross-section.

6.0 VENTILATION & AIR-CONDITIONING

6.1. General

The ventilation and air-conditioning systems are to be based on the current “hard Book” series by the American Society of Heating Refrigeration and Air-conditioning Engineers and also National Building Code, India and relevant IS code.

6.2. Ventilation

The design of ventilation system shall be based on the latest National Building Code (INDIA) & I.S 3103 – 1975 or ASHRE guidelines.

If the air changes cannot be achieved by the natural ventilation then mechanical ventilation shall be provided.

The ventilation in the workshop and Inspection Bay shall be provided through Industrial type Air – circulators mounted on the steel structural column.

In the repairs & overhauling sections, offices, control rooms, plant room etc. the ceiling fan shall be provided.

In addition, exhaust fans of suitable capacity shall be provided in the plant rooms, control rooms, etc. where heat dissipation takes place, the air changes shall be

based on actual heat gain of the equipment. Exhaust fan shall also be provided in the bathrooms, toilets, cloakroom & kitchen.

The paint shop and places where harmful dust, fumes, vapors, gases etc. are released in the working area, special care has to be taken and adequate exhaust system provided.

6.3. Air Conditioning

The following room shall be air-conditioned

- Officers' chamber
- Computer room
- Conference room
- S&T relay room & telecom exchange room

The air-conditioning unit shall be air-cooled unitary or ductible split type or package type air conditional depending upon the size of the space to be air-conditioned, in accordance with relevant Indian standards.

Out Door / Indoor Design Conditions

Summer	Dry Bulb 43^{o} C	Wet Bulb 28^{o} C
Monsoon	Dry Bulb 35^{o} C	Wet Bulb 29^{o} C
Winter	Dry Bulb 7^{o} C	Wet Bulb 5^{o} C
Inside		
Summer	24 + 1^{o}C	50 + 15% RH
Winter	20 + 1^{o}C	50 + 15% RH

7.0 WATER COOLERS

150 litre storage capacity water coolers along with stabilizers & control units in inspection shed, workshops, canteen & other places shall be provided at strategic location depending upon the occupancy of the building.

8.0 FIRE PROTECTION, DETECTION, ALARM AND FIRE FIGHTING SYSTEM

Adequate Fire Protection, early detection, alarm and fire fighting equipment are essential for car depot and workshop including service and ancillary buildings. The design of car depot and workshop shall include provision for following:

- Fire Prevention Measures

- Fire detection system
- Fire control measures
- Access for fire engine and firemen to various locations in depot
- Means of fire fighting

1) Fire Prevention Measures

Fire prevention measures will be designed and implemented to minimize the risk of out-break of fire by appropriate location of machinery and plant, material and equipment storage.

2) Fire Detection System

The following types of smoke/fire detector shall be provided in depot and service and ancillary buildings where necessary

- Ionization Smoke Detector
- Optical Smoke Detector
- Heat Detector

3) Fire Fighting Equipment

The choice of fire – fighting equipment and its installation details shall be governed as per NFPA or as per relevant Indian Standard

4) The fire fighting as proposed for depot, services and ancillary buildings shall be as per the requirement and rules of the Local Fire Safety Authority.

Table-1

S.No.	DESCRIPTION OF BUILDING AND LOCATION	TYPE OF DETECTION	TYPE OF FIRE FIGHTINGN EQUIPMENT
1.	Stabling shed	NIL	i) fire hydrants with stand pipe and hose system. (Manually Actuated) ii) CO_2 portable/trolle mounted fire extinguishers
2	Inspection Bays	NIL	Portable CO2 fire extinguishers. Portable/ trolley mounted fire extinguishers
3	Work shop area	NIL	Portable and trolley mounted CO_2 fire extinguishers.
4	Substation	Smoke detection, Alarm system	i) Portable and trolley mounted CO_2 fire extinguishers
5	DCOS Store	Early smoke detection and alarm system	i)Sprinkler system for DCOS store
6	Repair section and offices Including WM office	Early smoke detection and alarm system	i)Water hydrant and FHR ii) Portable fire extinguisher CO_2 and dry chemical Powder fire Extinguisher
7	ETU	NIL	Manually actuated CO_2 fire Extinguishers and dry chemical Powder fire Extinguisher
8	Depot Control Centre and back up control centre	Early smoke detection and alarm system	Portable CO_2 and dry chemical powder fire Extinguisher
9	Other Service and ancillary buildings	NIL	Local fire fighting with manually activated CO_2 fire extinguishers at strategic locatio

Note: **External fire hydrant at strategic location around service and ancillary building shall be provided.**

9.0 DESIGN CRITERIA ELECTRICAL WORKS

9.1. POWER SUPPLIES

An auxiliary sub station along with HV switch gear & step-down transformer etc. is being entrusted for design to another system-wide contractor. The sub station will be fed through a 33 KV feeder by loop-in-loop out arrangement.

The capacity of the substation shall be adequate to support the electrical loads of all the installation inside the GREATER NOIDA Depot except the traction power. The DDC shall make the assessment and calculation of he electrical loading. The LV switchgear panel and requirement of the low voltage feeders based on his proposed design of the depot shall be designed by DDC

The system will be rated 415+-6%, 3 phase 4 wire 50 c/s. The LV cable will be connected from the main LV switchboard and from AMF cum load panel to individual load center. The power distribution on board for lighting & small power will be located at the convenient places in the respective buildings. Additional sub-main power distribution board shall be provided at strategic location to overcome excessive voltage drop in the final circuit. The power supply distribution for the small distributed load shall be grouped to achieve minimum outgoing feeders.

9.2. STANDBY POWER SUPPLY

The standby power supply through D.G. set with AMF panel at 415V 3-phase 4 wire system, 50Hz shall be provided. The capacity of the DG set shall be adequate to supply all essential loads without over loading of the DG set. The complete stand by generator installation and operation will comply with National Fire Protection Code requirement. The generator flue The generator will be equipped with fuel storage, which will have sufficient capacity to support the generator for 12-hour operation.

The maximum generator for 12 hour operation.

The AMF panel with incoming and outgoing feeders shall be capable of starting DG set in the event of main power supply failure; single phasing or low voltage going below specified limit. Any variation of ± 10% of voltage, which also includes single phasing and power failure should be taken as unhealthy conditions.

The generator will support depots emergency load, which includes:

- Workshop and Inspection Bay Lighting
- Pumping installation
- High mast lighting
- Tower wagon shed

- Canteen
- Jib cranes
- DCOS & other stores officer chambers
- CWM office
- Pit Jacks
- Electrical Sub-Station
- Depot control center with all signaling load (without a/c)
- Officer & supervisor's chamber in workshop building.
- Complete Inspection Bay
- Covered Stabling Shed
- Computer section
- PPIO
- Fire Engine Shed
- Telecom Exchange
- Air conditioning of critical rooms.

9.3. SWITCH BOARD DISTRIBUTION BOARD FEEDER PILLARS

LV switchboard distribution board for indoor application shall be of protection class I.P.54 and that for outdoor application they shall be of I.P. 65 class.

The clearance in front of all assemblies of switchgear and control gear shall be not less than 1.2m the maximum height of the switch board shall be 2.2m. The switchboard shall be of modular design and extendable on both sides, preferably there should be separate chambers for the cables/bus-bars which are duly portioned with easy access for inspection and maintenance. Adequate protection from access to any live part inside to be ensured.

Switchgear should be designed to have adequate clearance as per the relevant standard rules for various components installed there.

The LV circuit breaker, air brake switches & miniature circuit breakers shall comply with IEC 157, IEC 408 & IEC 898 respectively.

Allowance shall be made for the provision of 25% spare capacity in switchboard cables and wire ways.

Metering Equipment

Current transformers shall be capable of withstanding the maximum short time withstand current for the value and duration specified for the assembly within which it is mounted. Test links shall be provided in the secondary connections of all current transformers to facilitate testing of instruments, meters and protection devices. These shall be so arranged as to ensure that the transformer secondary winding cannot be open circuited.

Voltmeters, ammeters, frequency indicators and power factor indicators shall comply with an internationally recognized standard.

The wiring to voltmeters and the potential coils of frequency indicators and power factor indicators shall be protected by separate fuses.

9.4. POWER FACTOR CORRECTION PANEL

Power Factor Correction Panel shall be provided and connected to the main LV panel in the substation. The automatic power factor correction panel shall be suitable for operation on 415 V, 3-phse, 4-wire, system with neutral directly earthed. The system will consist of modular rakes accommodating capacitor sub-units, switching contractor and protecting MCCB.

The PF correction panel shall have relay/Microprocessor based controllers with PF setting range from 0.5 lag to 0.5 lead. The panel shall be provided with digital PF meter, auto-manual operation facility & LED indication for various functions.

The PF correction capacitor banks shall be of suitable capacity and shall be metalised, polypropylene, self healing type, self protected by two in rush current limiting coil for switching surges and discharge resistors to reduce residual voltage less than 50 volts in one minute. The capacitors will conform to IS 2834-1986.

9.5. CABLES

The cable for use at 415 V shall be cross polyethylene (XLPE) insulated single wire armoured. Al/Cu conductor and 1100V grade cable in accordance with an approved international standard.

The cable shall be laid as per code of practice for cable laying, I.S-1255-1983. IE rules, 1956 & Indian Railways regulations for electrical crossings of railway tracts 1987.

As far as possible the alignment of cable should be decided taking into consideration the present and future requirements of other services like water supply, sewage, and telecom. The corrosive soil and water logging areas should be avoided.

Cables of different voltages i.e. HT cables, LT cables and control cables shall be laid in different trenches. Wherever power cables and telecom cables cross each other they will cross at right angle to avoid interference.

Wherever the cables are to be laid under the track they shall be laid in RCC/C1 pipes not less than1000 mm depth measured from the botto0m of the sleeper. The pipe should extend 3000mm from the center of the track on both sides.

The cable shall be laid directly in ground where it is passing open country and along the road. Open cable duct with suitable removable covers shall be provided in substations, switch room, plant rooms, DG set room; workshop and inspection's shed.

Cable route markers should be provided along the route of cable laid in the soil.

9.6. EARTHING AND BONDING

9.6.1. General

Earthing and bonding is to be designed by the Contractor in accordance with BS 7671:1992 or approved equivalent in order to protect persons and equipment from the effects of an electrical fault anywhere in the system.

The earthing system shall ensure that touch and step voltage does not exceed the safe limit.

The system should give protection both in normal and in case of fault. Earth fault leakage protection should be achieved through equipotential bonding.

The earthing shall consist of copper or stainless steel earth mats, or a network of specially drawn copper-clad steel rods bonded together, to give the necessary low impedance for an effective system. The whole of the earth resistance should have a combined resistance to earth not exceeding 1 Ohms.

Test facilities shall exist for disconnecting down conductors at earthing points to allow testing of the individual earthing points. Where aluminium tapes are employed great care shall be exercised in protecting the system components from electrolytic corrosion due to dissimilar metals being in contact with each other. Special Bi-metallic connectors shall be employed at junctions of copper and aluminium conductors. Copper air and down conductor tapes shall be PVC sheathed.

9.6.2. System Earthing

The neutral of 3 phases 4 wire system shall be earthed at sub stations by not less than 2 separate and distinct connections with each having its independent earth electrode. The electrode will be interconnected to achieve system earth resistance such that when any earth fault occurs for which system earthing has been designed to give protection, the protection gear will operate the circuit breaker, thus isolating the faulty mains or defective plant.

9.6.3. Equipment Earthing

All medium and high voltage equipment shall be earthed by two separate and

distinct connections with earth; each having its own electrode. The equipment earthing shall ensure freedom from dangerous electric shock to persons in that area and provide current carrying capacity both in magnitude and duration in case of ground fault.

The metal frame of all LT switchgear shall be connected to earth by means of two separate earth conductors.

Besides, provision of earth stations all cubicles and panels, sub panels, main distribution boards, sub distribution boards, light fixtures and fans shall be connected to earth by means of earth continuity conductor (through armour of cable and separate earthing conductors run along cable or separately from earth bus).

9.7. LIGHTNING PROTECTION

Lightning protection shall be designed to a high standard in accordance with local regulations (or a recognized approved standard such as BS 6651: “Protection of Structures against Lighting”).

Concrete structures shall employ roof tapes (air tapes) while steel structures may use the structural steelwork frame as a collector and as a down conductor system. The lightning conductor and earthing system shall be designed to conduct lightning discharges without damage or injury to personnel, structures or the conductor system.

9.8. LIGHTING

9.8.1. General

General lighting shall be provided in all areas of the Depot Extension part. Lighting system

Requirements associated with electrical system and equipment shall comply with the relevant latest versions of the following standards.

BS 8206	Lighting for Buildings
BS-EN60598	Road Lighting

The type and quality of fittings and their luminous shall relate to the space being illuminated and will take in to account the effect of architectural space concept and colors scheme. Light level shall be uniformly distributed throughout the relevant area and shall be designed such that flare, dark recesses and areas of poor lighting levels are avoided.

9.8.2. Inspection Pit Lighting

Inspection pit lighting shall be provided in all the inspection pits at suitable

spacing to give adequate illumination for inspection of the under gear of the rolling stock.

9.8.3. Outdoor Lighting

Outdoor yard lighting shall be provided by using high mast of 30m height at suitable locations to avoid glare and long shadows. Floodlights can also be provided on the workshop and Inspection shed structures. Lighting levels shall be of 16-30 lux. The lux level on points and crossings will be maintained at 30 lux.

The high mast shall be designed in a manner so that it is capable of withstanding the forces exerted on it by wind speed specified in the S 875 with an adequate load factor. The mast shall comprise of 3 section with minimum length of 10m each mast section shall have only longitudinal welds & not have any circumferential welded points. Steel to I S 226/BS4360 shall be used for the construction of the mast. The lantern carriage shall be of mild steel in the form of a ring split on the one diameter enabling it to be assembled or removed from the shaft after erection. Each mast shall be provided with double drum winch. Power winch shall be driven by 3 phase 415V reversible A/C motor & it shall have remote control unit for operation to provide safety to operational personal.
The street lighting for security patrolling shall be provided by using HPSV street light luminaries. Where necessary street light luminaries shall be provided on the building structures also.

Tentative outdoor lighting arrangement is shown in depot lay out drawing no. RC/Depot cum Workshop layout/001 sheet no. 1 of 2.
The outdoor light shall be controlled with the help of 24 hr dial time switches and light sensitive switches. The switches shall be provided with “on-off” by-pass switches to completely override preset switching functions.
The illumination level in various indoor and outdoor areas shall be as given below:

S.No.	AREA	ILLUMINATION LEVEL	
		GENERAL	LOCALISED
1.	Workshop Bays	300	-

2.	Inspection Bays	300	-
3.	Repair & Overhauling Sections	300	500
4.	Offices & Conference Room, PPIO, Computer room, Classroom	300	500
5.	Sub stations, Switch Room, Plant & equipment control area, Pump house, Compressor room, DG set room	150	-
6.	Clock room, Bath room, toilets, locker room	100	-
7.	Store ward	100	-
8.	Paint Shop	300	-
9.	Covered Stabling Lines	100	-
10.	Covered Stabling Lines & Relief train SDI	16	-
11.	Canteen (Kitchens) (Dining Hall)	150 200	-
12.	Heavy Washing Line	50	150
13.	Stair Case	100	-
14.	General security Lights	15	-
15.	Points & Crossings	30	-

9.9. INTERNAL WIRING

The wiring in the workshop, inspection shed and associated buildings shall be in recessed conduit wiring system with rigid steel conduits. The conduit shall comply with 3S 4568 or approved equivalent and shall be of screwed classification. The minimum size of the conduit shall be 30 mm Dia. The conduit shall not be of gauge less than 16 SWG for conduit up to 32 mm dia and not less than 14 SWG above 32 mm dia.

The concept of Point Wiring Circuits and Group Wiring shall be followed depending upon the requirement, type of Point Wiring Circuits and Group Wiring shall be followed depe3nding upon the requirement, type of installation and

electrical load.

I. Point Wiring

For Point Wiring of light, fans and plug socket, the length of conduit from Distribution/Sub. Distribution Board upto farthest fitting shall constitute point. The Point Wiring shall be sub-divided into short point, long point and extra point depending upon the length of conduit upto 2, 5, 8.5 & 12m respectively

II. Group Circuit

The Group Wiring circuit shall be subdivided into short-way, medium-way, long-way and extra-long-way depending upon the length of Conduit from distribution/sub distribution board of 30, 60, 100 & 150m.

9.10. 24 V HAND LAMP

Deleted.

9.11. PORTABLE MACHINE SOCKETS

The 15 A single-phase socket for transportable M/c shall be ironclad switch-cum-plug unit. They shall be provided at a distance of 20 m in the workshop bays, inspection bays and repair & overhauling section. Three phase power outlets for welding machine shall be provided at a distance of about 40m in the inspection & workshop bays.

9.12. PUMPS

9.12.1. General

To meet the requirement of the water supply a submersible pumps of adequate capacity shall be provided with 100% standby. One pump shall be able to pump the total requirement of the water in 12 hours. The pump shall be of submersible type conforming to I.S 8034-1976. All accessories to the pump will conform to respective Indian standard. The motor fitted with submersible cable of suitable type. The motor shall conform to I.S. 9283-1979 & I.S. 325-1987, latter as far as it can be applied to submersible motor. The motor rating shall be 10% higher than the maximum BHP required by the pump. The motor should not be overloaded throughout the working range of pump even when voltage is as low as 350V.

9.12.2. Control Panel

The control panel shall be complete with auto start/stop control gear and level guards. Up to 7.5 HP the starter shall be air break AC/3 category, heavy duty, DOL, starter with over load/under voltage protection release. Above 7.5HP the starter shall be air break AC/3 category, heavy-duty auto transformer starter.

10.0 ACCESS CONTROL

The Access control system will be required to control entry and exist of personnel from the following areas:

- External Areas of the Building
- All Public areas inside the workshop
- Monitor intrusion at various strategic locations.

The system shall utilize Proximity Cards which will be issued to both staff and visitors, to monitor flow of the people. All doors to and from public areas shall be equipped with readers and automatic electric magnetic locks. The system shall, depending on the coded information on the Proximity cards, allow the persons access to certain parts of the building.

The system shall have facility to generate attendance statement of staff regularly employed in a building.

The system shall have a provision of interconnection to Fire System and shall automatically open in condition of Power Failure of the Access control system or in case of fire detection.

The system shall consist of Daisy wheel chain connected Door controllers, Door Position detectors and card readers with keypads to press access code or finger print reading in addition to the Access cards. The entire system shall be console operated

S. No.	DESCRIPTION OF BUILDING LOCATION	TYPE OF ACCESS CONTROL
1.	Stabling shed	NIL
2.	Inspection Bays	Access Control for Attendance only
3	Work shop area	Access Control for Attendance only
4	Substation	Access Control
5	DCOS Store	Access Control with Integration to Attendance as well as double confirmation with Finger Print reading or in Access code
6	Repair section and offices including WM office	Access Control with integration to Attendance
7	ETU	Access Control with integration to Attendance

8	Depot Control Centre and back up control centre	Access Control with integration to Attendance as well as double confirmation with Finger Print reading or an Access code.
10	Other Service and ancillary	Access Control with integration to Attendance