SECTION – 8A

EMPLOYER'S REQUIREMENTS

GENERAL INFORMATION AND SCOPE OF WORK PART-2

SECTION 8A – PART 2 – EMPLOYER'S REQUIREMENT

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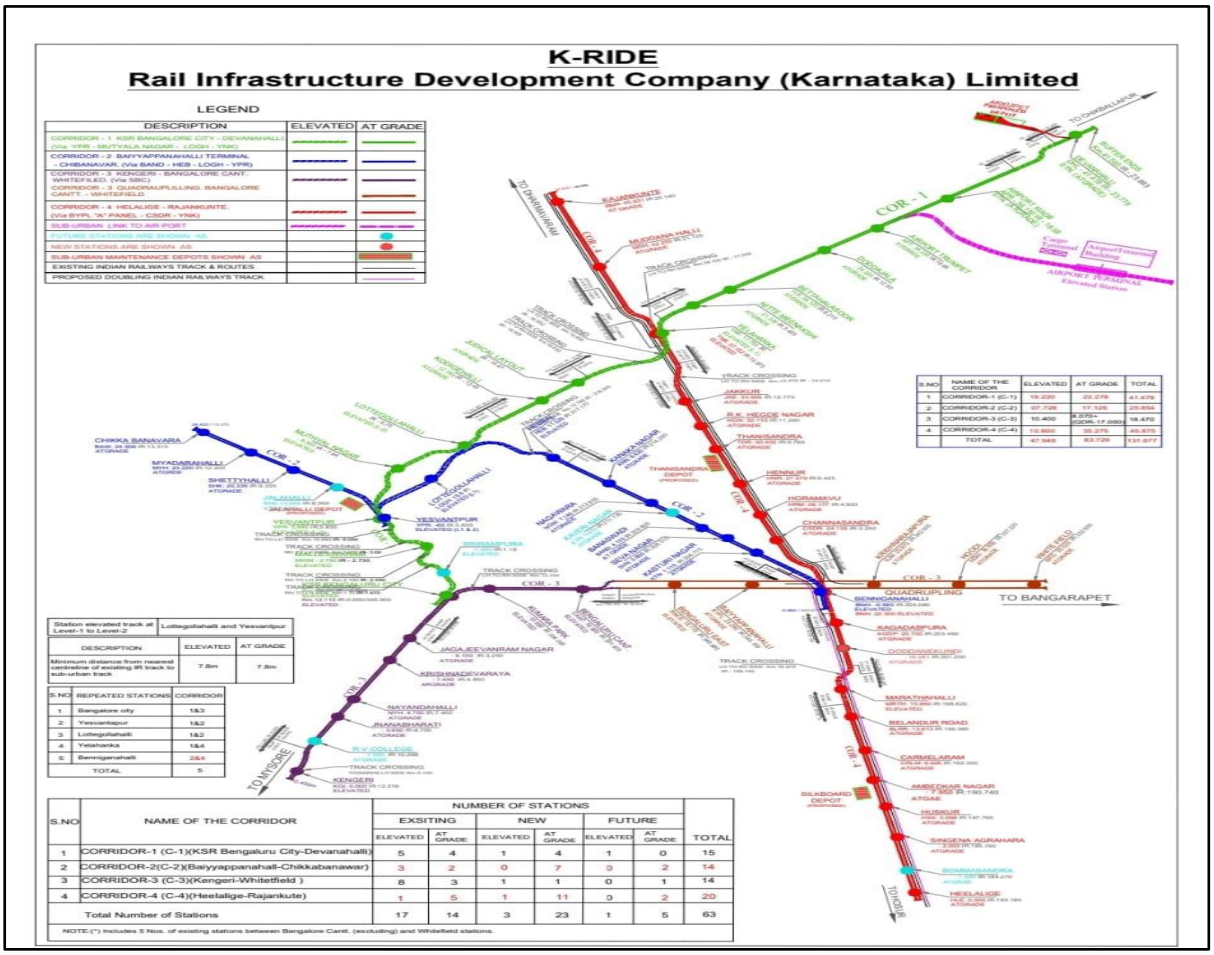
1 Project Brief

1.1 BSRP



a. The BSRP alignment consists of 4 lines with four passenger interchange stations, depot and assorted building developments.
b. The suburban rail system shall use 1676mm Broad Gauge Track.
c. The system shall have a design speed of 90 Kmph and maximum operational speed of 80 Kmph.
d. 25KV Traction Power will be provided by a OHE
e. The Following table provides the Scope of Stations

Sl. No.	Description	No. of Stations
1.	At-Grade Stations	08
2.	Elevated Stations	02
3.	Elevated Interchange Stations	02

f. This contract comprises "Design and Construction of all Civil structure, Structural steel including roof works, Entry/Exit structures, FOB including Design provision for Solar Panel installation in all structures.
g. Detailed Design and Engineering of all Mechanical, Electrical and Plumbing (MEP) works. Detailed Design and engineering of all Architectural Finishes and Façade works for Elevated and At-Grade BSRP Stations.

1.2 **General**

1.2.1 The works shall be deigned in accordance with the Employer's Requirements including CC (Section 6) and PCC (Section 7).

1.2.2 All designs shall be in accordance with the project Design Basis Reports (DBR's) and schedule of Dimensions (SOD) of BSRP.

1.2.3 A consistent set of Standards that specifically apply to the design of Civil, Structural, MEP and Architecture shall be adopted. If no local standard exists or if an applicable standard is not specified, then appropriate and compatible internationally recognized standards or codes of practice shall be proposed.

1.2.4 The hierarchy of standards is as follows:

a. Indian Standards and Specifications
b. Euro Norms (EN)
c. National European Standards
d. International Standards and Codes of Practice.

1.2.5 The Contractor shall ensure and demonstrate the design of the Works meet the future operation and maintenance (O&M) requirements. The design shall be based on a holistic whole-life approach that optimizes both capital and operating cost. Evidence of this approach shall be incorporated into the Contractor's submissions and particularly in the design documentation.

1.2.6 The contractor shall ensure and demonstrate the design of the works meets the O&M safety requirements, and evidence shall be incorporated into the contractor's submissions and O&M Manuals.

1.2.7 The design life shall be 100 years of all structures, and any replaceable items and planned life usage shall be confirmed in the O&M Manuals.

1.2.8 When an asset is required to be replaced, the replacement asset shall meet the minimum design life requirements of the asset it has replaced. Where part of an asset is not readily accessible for maintenance or replacement, it shall satisfy the design life requirements of the asset of which it forms a part.

1.2.9 The Contractor shall appoint a proof check consulting agency (the "Proof Consultant") after proposing to the Engineer / Employer a panel of 3 (three) names of qualified and experienced firms and Engineer / Employer will select 1 Proof Consultant from panel. The Parties agree that no firm or person having any conflict of interest shall be engaged hereunder.

1.2.10 All the designs & drawings shall be proof checked by the proof consultant before submissions.

1.3 **Durability**

1.3.1 Durability requirements shall be addressed throughout the design, construction, operation and maintenance of all assets and shall be reflected in the contractor's submissions and Operation & Maintenance (O&M) Manuals.

1.3.2 The Contractor's submissions and the O&M Manuals shall demonstrate how durability has been considered in the design, materials and construction to achieve the required design life of each asset. For each asset that comprises part of the works, the contractor's submissions shall:

a. Define the characteristics of the environment
b. Identify the potential mechanisms in that environment, determine the likely rate of deterioration;
c. Assess the material / equipment life;
d. Define the required material / equipment performance and assess the need for further protection;
e. If appropriate, develop procedures for replacement of material / equipment and asset sub-items at intervals consistent with the design life specified.
f. Determine inspection and monitoring requirements; and if appropriate, outline possible remedial measures.

1.3.3 In designing the works and selecting materials and equipment for durability, reliance shall not be placed solely on the recommendations of codes and standards, but due account shall be taken of the environment in which the structures, equipment and fixtures are situated and to the monitoring and maintenance works required to maximise the life of the structures, equipment and fixtures.

1.3.4 Particular attention shall be given to the deterioration of those materials and equipment and fixtures which cannot be easily accessed for maintenance or repair during the design life, such as reinforcement within the inaccessible faces of structures. In such a case, the design shall ensure that

the durability of the materials and equipment and fixtures can be achieved without maintenance.

1.3.5 The design shall consider the nature of the geological conditions at all work locations with regards to soluble sulphate, chloride and salt concentrations. This shall be taken into account for durability purposes when designing the underground structures.

1.3.6 **Concrete Structures**

a. The primary approach to designing concrete elements for durability shall be based on the need to achieve a high quality and relatively impermeable concrete, paying particular attention to structural detailing
b. The design shall consider the nature of the geological conditions at all work locations with regards to soluble sulphate, chloride and salt concentrations. This shall be taken into account for durability purposes when designing the underground structures (including foundations).
c. The presence of highly aggressive groundwater requires the design of resistant concrete mixes and increased cover to reinforcing steel, close control of flexural cracking and very careful detailing of gaskets, water bar and hydrophilic water stops to ensure water tight durable structures. Where particularly aggressive ground water conditions are found, a detailed assessment should be carried out to determine the need to install a full Cathodic protection system or if a corrosion monitoring system is needed, in order to achieve the design life of the structure.

1.3.7 Where the structure interfaces with or is in close proximity to other light rail, Indian Railway System or metro facilities, provisions to reduce and control stray current shall be adopted to mitigate associated corrosion problems as per the requirements of EN 50122-2; "protective provision against the effect of stray current caused by DC traction systems".

1.3.8 Where particularly aggressive ground water conditions are found, a detailed assessment should be carried out to determine the need to install a full Cathodic protection system or if a corrosion monitoring system is needed in order to achieve the design life of the structure.

1.4 **Alignment**

1.4.1 The horizontal and vertical alignments of the Station locations are given in Tender drawings ***(Section 11)*** and shall not be varied by the Contractor without prior approval of the Engineer/Employer. The horizontal and vertical alignments at the Stations location and Viaduct given in tender drawings are final and normally may not require any deviation/change. In case, any marginal deviation/change in the horizontal and vertical alignments, if requested by the Contractor to suit, the Contractor design in conformity with alignment criteria shall be approved by the Engineer / Employer.

1.4.2 The alignment shall be as shown in the tender drawings. The alignment has been developed by the Employer to meet operational and technical criteria. The Contractor is not required to evaluate the alignment for compliance with these criteria, but shall review it with respect to his own design and construction proposals and shall satisfy himself that there is no conflict with existing structures which are to be preserved.

1.4.3 The Contractor is permitted to propose minor deviations in alignment to suit his construction proposals, but he must demonstrate that any such deviations shall comply with good design practice and the alignment requirement of the Design Criteria. Such deviations shall require prior approval of the Employer subject to following conditions:-

a. There is no extra cost to the employer.
b. Changes proposed are essentially required to suit the contractor's specific design.
c. There is no change at the contract boundaries or if there is any, the same is agreed by the contractor of the adjoining section without any extra cost to the employer.

1.4.4 The location of all piers at all road junctions shall be approved by the relevant local Statutory Authority (IR, BBMP, BDA, NHAI, KPWD, BMRCL, UDD, IDD, BESCOM, KPTCL etc.)

1.5 **Design Software**

Any commercial or proprietary software can be used for analysis/design provided the same is validated with manual computations or other standard software in multiple scenarios. As a minimum, the Contractor shall provide certified copies of Softwares as defined in the Employer's requirements.

2 General Design Criteria

All Civil, Structural, MEP and Architectural works shall be designed in compliance with the Employer's requirements. The designs shall be in accordance with the design criteria and shall also comply with the Project Station Design Basis Reports (DBRs) and the Project Schedule of Dimensions (SOD) of BSRP and as per requirements of RDSO.

2.1 Codes and Standard

The Contractor shall provide a copy of all Standards and Codes used in their Design.

2.2 General

2.2.1 This section shall be applied for the design of temporary and permanent structures of all kinds related to the project, including all viaducts/bridges, stations and substructures such as piers and their foundations, abutments, culverts etc.

2.2.2 Deleted.

2.2.3 Station structures shall be designed in compliance with the Project Station Design Basis Report. The Station Design Basis Report (DBR) for the project is approved and the contractor shall follow the approved DBR.

2.2.4 Design shall be in accordance with the Project Schedule of Dimensions (SOD) of BSRP. The Schedule of Dimensions (SOD) is approved and the contractor shall follow the approved SOD of BSRP.

2.2.5 The design of elevated stations, At grade Stations, FOB, Bridges and their foundations shall include, but not be limited to, the following:

a. The selection of the structural system for station structures, the piers and foundations;
b. Aesthetics;
c. Clearances;
d. Evacuation and emergency access
e. Accidental impact from road traffic;
f. Construction methodology of all elevated construction, including Temporary Works and construction sequences
g. Ground / Structure interaction, including the effects of Temporary Works;
h. Dynamic, seismic loads and displacements;
i. Deflection and rotation of elevated structures;
j. Ground pressure (including swelling), shear force and bending distribution on structural members during construction and in the long-term;
k. Short and long-term ground and groundwater response;
l. Other changes in static loads such as excavation, surcharge, live loads, traffic loadings and others;
m. The variation in ground conditions along the alignment;
n. All dewatering and groundwater cut-off systems required to maintain dry and stable conditions within all excavations required for the Works;
o. The magnitude of ground and existing building structures settlements, movements, distortions and changes in loading conditions of existing building structures expected as a result of the Works and how these shall be mitigated;
p. The presence of existing building structures;
q. Maintenance of traffic flows along roads including access to adjoining properties and roads;
r. Control of heave, swell, piping and instability of the excavations related to the Works;
s. The effects of vibration so as to minimize disturbance to existing building structures;
t. Effects caused by creep and shrinkage of concrete and the resulting effects (including secondary effects). These effects shall be regarded as permanent loads;

2.2.6 **Clearance for Structure**

a. Horizontal and vertical clearances to road traffic shall be as per the relevant Indian Road Congress (IRC) specifications and GoI, GoK, IR and other local authority requirements.
b. Horizontal and vertical clearances to railway traffic shall comply with the Indian Railways SOD. Where a structure crosses existing railway track(s), the design shall be approved by the concerned Railway Authority, and the clearances shall comply with the Indian Railways SOD.

2.2.7 **Design Report**

a. The Contractor shall submit to the Engineer/Employer for approval a civil and structural design report which shall include:
   i) All relevant applicable codes, regulations and specifications;
   ii) Design assumptions;
   iii) Loads and load combinations as per the DBR;
   iv) Applicable safety factors;
   v) Deformation and tolerances;
   vi) The proposed structural and foundation system;
   vii) The proposed construction methodology;
   viii) Materials;

2.2.8 **Design**

The design for the submittal to the Engineer/Employer for approval for all At grade, elevated structures and stations, shall include but not be limited to the following:

a. A list of the applicable codes, regulations and specifications;
b. The detailed design assumptions regarding loads and load combinations, applicable safety factors and deformation tolerances;
c. The proposed structural and foundation system;
d. The methods used for the analysis of all relevant limit states;
e. Detailed results of the analytical calculations, sufficient to substantiate the selection of the geometrical sections, the amount of reinforcement and the type and amount of pre-stressing;
f. Detailed drawings for all structural members showing the steel reinforcement and pre-stressing (if applicable);
g. The proposed construction methodology and material types.

2.2.9 **Type of Stations**

All 12 Stations are with Cantilever / Portal type or specified otherwise. The Pier Cap / Pier Arm of Cantilever / Portal Type Stations shall be post Tensioned.

2.2.10 **Method Statements**

a. The Contractor's construction methodology for each element of the work shall be submitted to the Engineer for approval. These method statements shall detail the proposed construction method, sequence, materials, plant and operations involved in the construction and erection of the bridges and similar structures including all temporary structures required for the assembly and erection of the Permanent Works. These method statements shall include all required details to ensure the adequacy and safety of the proposed construction methods.
b. Special precautions shall be made for the safety of road traffic, the safety of railway train operations and assets wherever working close to railway lines, and to adjacent existing building structures that are affected by the Works and are within the range of potential settlement as predicted by the design.

2.2.11 **Temporary Works**

a. The Contractor shall comply with the requirements of all relevant Indian Standards and International Codes for the design of all Temporary Work installations. As a minimum for the design of Temporary Works, the Contractor shall comply with BS 5975: 2008.
b. Temporary Works, including At-grade and elevated deck launching systems, roof structure launching shall be designed in accordance with the same design standards and codes as the Permanent Works. The Temporary Works design may take into account the limited time they are expected to function. The calculations and drawings shall confirm where provision is made for limited duration, particularly where this may have a substantial influence on the stability of the Temporary Works.
   i) The Contractor shall provide a fully detailed Temporary Works submission for each and all types of construction methodology for all At-grade, Elevated station elements. This shall include;
   ii) Safety provisions to be taken to protect the public and other structures, including the crossing of rail track and roadways that may be affected by the Works.
   iii) The safe erection and dismantling of all Temporary Works, including Cranes, Launchers, Formwork and Falsework installations.

c. The design of Temporary Works shall take into account all the applied internal and external forces, including any imposed structural deformations.

2.2.12 **Foundation**

1.1 Foundation design shall comply with IRS Bridge Substructure and Foundations Code, the National Building Codes the IRS CBC Manual on the design and the construction of well and pile foundations.

1.2 The foundation design shall comply with IS:2911 and IRC: 45.

1.3 Foundations shall generally be piled, however open foundations can be proposed if the ground conditions and design permit.

1.4 The top of the foundation surface or pile cap shall be a minimum of 1.0 m below road or ground level.

2.2.13 **Reinforced Concrete and Pre-stressed Concrete**

Reinforced Concrete and Pre-stressed concrete shall conform to the IRS Concrete Bridge Code, IS:456 and IS:1343.

2.2.14 **Mechanical, Electrical and Plumbing (MEP)**

a. All MEP works shall be designed as per the Employer's Requirements.
b. The design of all MEP equipment and materials shall comply with relevant Indian Standards (IS) and International Standards as confirmed in Clause 2.5 and Appendix F of this section, or other internationally recognized standards consented to by the Engineer.
c. The design shall be fully integrated with compatible systems components including where these are provided and installed by other project Contractors.

2.3 **Architecture**

a. All Architectural Works shall be designed to the Employer's Requirements.
b. It is intended the station design shall have uniformity project wide in the construction, passenger circulation, and operations and maintenance procedures. Hence, the planning and design of all stations is to provide a consistency in the layout, appearance, structural soundness and identity with the prevailing Suburban/IR/Metro/ system.
c. Stations shall have specific requirements identified through an interactive design process in terms of the following: ridership forecasts, interchange requirements with other rail systems and public utility transport, spacing from station to station, alignment, utilities, roads and pedestrian requirements, interfaces with potential developments and environmental considerations.

2.4 **Civil & Structural Design Codes and Standards**

The IRS codes shall in principle be complied with at all times. Although the main clauses have been confirmed in this Section, other relevant clauses wherever applicable in the IRS codes shall also be complied with. If provisions are not available in the IRS codes then the order of preference shall be as follows, unless specifically mentioned otherwise by the Employer's requirements.

For Railway loading related issues:

a. UIC Codes
b. Euro Codes
c. Any Other Code which covers Railway Loading

Other Design and detailing related issues:

a. IRS
b. IS
c. IRC
d. Euro Codes
e. Other National Codes

A list of various design codes and standards to be used at various stages of works are confirmed below. These codes with latest revisions including all addendums, notifications and correction slips

only shall be complied with:

a. IRS Codes (latest version)
b. IRS Substructure & Foundation Code
c. IRS Bridge Rules
d. IRS Concrete Bridge Code
e. IRS Steel Bridge Code
f. IRS Fabrication Code (B1)
g. IRS Welded Bridge Code
h. IITK--RDSO Guidelines on Seismic Design of Railway Bridges.

In case of discrepancy among Standard Codes of Practice, the order of precedence will be IRS, IS, IRC, BS, DIN.

2.5 **MEP Design Codes and Standards**

The MEP System shall comply with relevant IS codes, NBC regulations, other codes and standards, and other requirements as applicable and those that are confirmed for information and reference below:

a. IET : Regulations, 16th Edition
b. NFPA 70: National Electrical Codes (NEC)
c. NFPA 110: Emergency Standby Power Systems
d. NFPA 111: Stored Electrical Energy, Emergency and Standby Power Systems
e. NFPA 130: Standard for Fixed Guideway Transit and Passenger Rail Systems

2.5.1 Local Codes, Regulations and Standards

Unless otherwise stated, the electrical and mechanical system shall be governed by all applicable local codes, code of practices, regulations and standards (all latest) as issued by the responsible Indian agencies, including but not limited to:

a. Indian Electricity Act
b. National Building Code
c. Public Works Department (Central/State/Municipal)
d. Regulations for Electrical crossings of Rail Track
e. Electricity Authority
f. Fire department
g. National Safety Council
h. Central Pollution Control Board
i. Chief Electrical Inspectorate
j. ISHRAE (Indian Society of Heating, Refrigerating and Air-conditioning Engineers)

The Contractor shall ensure compliance with the regulations laid down by local authorities i.e., Central, State and city Municipal Government, including the municipal Chief Electrical Inspector, and all other statutory agencies including fire safety regulations, fire insurance regulations or other local codes and obtain approvals from relevant authorities at appropriate stages of work as required.

2.6 **Architecture Design Codes and Standards**

The stations shall be designed in accordance with the requirements of the following codes and standards:

a. NFPA 130 (Latest Edition)
b. National Building Code (NBC)
c. NFPA101
d. The Persons with Disabilities Act; and Handbook on Barrier Free and Accessibility 2014 published by the CPWD (Central Public Works Department) India.
e. EN 81 Indian Standards for Elevators
f. EN115 for Escalators
g. Other applicable codes and standards

3 **Deleted**

4 Design Criteria for Station Structures (as per approved DBR)

4.1 Material

4.2 Cement

For plain and reinforced concrete structures cement shall be used as per clause 5.1 of IS:456 and in case of pre-stressed concrete structures as per clause 5.1 of IS:1343.

4.2.1 **Concrete**

As per Clause 6, 7, 8, 9 and 10 of IS:456 in case of Plain and Reinforced Concrete structures and Clause 6, 7, 8, 9 and 10 of IS:1343 for Pre-stressed concrete structures.

Short term modulus of elasticity (Ec) shall be taken as per Clause 6.2.3.1 of IS:456 for Plain and Reinforced Concrete structures and IS:1343 for Pre-stressed Concrete structures.

The modular ratio for concrete grades shall be taken as per Annex B of IS:456.

The Density of concrete shall be as per IS:456.

4.2.2 **Pre-stressing Steel for Tendons**

As per Clause 5.6.1 of IS : 1343:

a. Young's Modulus : As per prestressing steel used in accordance with Para 2,1,3 above.
b. Pre-stressing Units : As per clause 13 of IS:1343
c. Maximum Initial Pre-stress : As per clause 19.5.1 of IS:1343.
d. Density : Weight of strands shall be as per relevant clauses of IS codes as per material being used as indicated in para 2.1.3 above.
e. Sheathing : As per clause 12.2 of Is:1343

4.2.3 **Structural Steel :** Structural steel used shall be confirm to

a. The design shall comply with IS:800
b. Hollow steel sections as per IS;4923-1997
c. Steel for General Structural Purposes as per IS: 2062
d. Steel tubes for structural purpose shall be as per IS:1161

Note:

i. Grade of steel to be used shall be indicated and shall not be less than minimum grade as applicable, based on whether structure is taking moving loads or not and relevant code as indicated in note (ii) and (iii) below.
ii. Design of steel structure will be governed by IRS Steel Bridge Code in case structure is taking moving loads of BSRP / IR / Metro, otherwise will be governed by IS:800. In case of composite (steel-concrete) structures, it will be governed by IS:11384 & IS:3935.
iii. Fabrication shall be done in accordance with IRS B1 (Fabrication Code) in case structure is taking moving loads of BSRP/IR/Metro, otherwise shall be done as per IS: 800.

4.2.4 **Reinforcement**

a. As per clause 5.6 of IS:456 for Plain and Reinforced concrete structures and as per clause 5.6.2 of IS:1343 for Pre-stressed concrete structures.

Note:

For Seismic zone III, IV & V HYSD steel bars having minimum elongation of 14.5 percent and conforming to requirements of IS:1786 shall be used.

b. **Reinforcement Detailing**

All reinforcement shall be detailed in accordance with clause 12 and 26 of IS:456 for Plain and Reinforced concrete structures, as per clause 12.3 and 19.6.3 of IS:1343 for prestressed concrete structures. Ductile detailing of seismic resisting RC elements, shall comply with ductile requirements of IS:13920.

4.3 **Durability**

Durability of Concrete shall be as per clause 8.0 of IS:456 for Plain and Reinforced Concrete structures, as per clause 8.0 of IS:1343 for Prestressed Concrete structures and Section 15 of IS:800 for Steel Structures.

4.3.1 **Concrete Grades**

The minimum grade of concrete for all structural elements including piles shall be indicated in the design.

Minimum grade of concrete for binding layers and levelling courses shall be indicated.

4.3.2 **Cover to Reinforcement**

As per clause 26.4 of IS:456 for Plain and Reinforced Concrete Structures and clause 12.3.2 of IS:1343 for prestressed concrete structures. Cover to prestressing steel shall be in accordance with clause 12.1.6 of IS:1343.

4.3.3 **Fire Resistance Period**

All the structural elements in the station buildings shall be designed for a minimum fire resistance period of 2 hour. The minimum element thickness for this fire resistance shall be as per clause 21 of IS:456 for Concrete structures and as per Section 16 of IS:800 for Steel structures.

4.3.4 **Crack Width Check**

All structural concrete elements shall be designed to prevent excessive cracking due to flexure, early age thermal and shrinkage. Flexural crack width shall be checked in accordance with clause 35.3.2 and 43 of IS:456 for Plain and Reinforced Concrete Structures and clause 20.3.2 and 24.2 of IS:1343 for Prestressed Concrete structures.

4.3.5 **Design Life**

The design life shall be as per Clause 1.2.7.

4.4 **Clearances**

The following clearances are sole responsibility of contractor.

a. **Clearances for Road Traffic**: As per relevant Indian Road Congress (IRC) Specifications and Road Authority requirements
b. **Clearances for Railway Traffic**: Indian Railway Schedule of Dimensions (SOD) shall be applicable.
c. **Clearances for Metro Traffic**: The clearances to metro rail traffic shall comply with the Project Schedule of Dimensions (SOD).
d. **For Utility Service**: The clearances to utilities, drainage etc. shall be as mandated by the utility owner/department.
e. **For IR / BBMP / BDA / DULT / BMRCL, Local traffic police & Other Local Authorities Services**: The clearance pertaining to all local authorities shall be as mandated by the Owner / Department (including GAD & Detailed Designs).

4.5 **Design Loads**

For elementary loads refer to Clause 3.4.23 of this document.

4.5.1 **Dead Loads (DL)**

Dead load shall be based on the actual cross-section area and unit weights of materials and shall include the weight of the materials that are structural components of the Elevated Station and permanent in nature.

4.5.2 **Superimposed Dead Loads (SIDL)**

Superimposed dead loads include all the weights of materials and equipment on the structure that are not structural elements but are permanent at all levels.

Note:

i) The SIDL can be of two types: Fixed or non-variable, and variable. In case BSRP certifies

that a portion of SIDL is of fixed or non-variable type and is not likely to vary significantly during the life of the structure and a special Clause for ensuring the same is incorporated in the SOD/Maintenance manual, the load factors applicable for dead load may be considered for this component of SIDL.

ii) The minimum distributed and concentrated loads shall be in accordance to IS:875, wherever available for remaining BSRP/IR/Metro railway shall specify the loads.

4.5.3 **Imposed (Crowd Live) Load**

Imposed loads-on station buildings are those arising from occupancy and the values includes, normal use by persons, furniture and moveable objects, vehicles, rare events such as concentrations of people and furniture, or the moving or stacking of objects during times of re-organisation and refurbishment, shall be as per clause 19.3 of IS 456.

4.5.4 **Earthquake Loads**

Earthquake design shall follow the seismic requirements of IS:1893 (Part-I). The provision as per Design Basis Report for Stations of BSRP/IR system shall be followed where structures are taking moving loads of BSRP/IR.

Design Seismic Zone shall be as per Clause 3.4.11 of this document.

4.5.5 **Drift Limitation**

The storey drift in the building shall satisfy the drift limitation specified in Clause 7.11.1in IS:1893.

4.5.6 **Seismic Detailing**

a. For reinforced concrete structures as per IS:13920.
b. For other structures as per IS:4326.

4.5.7 **Wind Loads**

The Wind Load shall be calculated as per IS:875-Part 3.

4.5.8 **Collision, Impact Loads and Derailment Loads**

a. For road traffic as per IRC-6
b. For Railway as per IRS Bridge Rules

4.5.9 **Construction and Erection Loads**

The weight of all temporary and permanent materials together with all other forces and effects which can operate on any part of structure during erection shall be taken into account. Allowances shall be made in the permanent design for any locked in stresses caused by any member during erection.

4.5.10 **Temperature**

As per clause 19.5 of IS:456. Temperature gradient shall be considered as per Clause 215 of IRC-6, if applicable.

4.5.11 **Shrinkage**

The shrinkage strains shall be evaluated as per clause 6.2.4 of IS:456 for Plain and Reinforced Concrete Structures and clause 6.2.5 of IS:1343 for Prestressed concrete structures.

For structures supporting BSRP/IR loading the effects of creep as per Cl. 5.2.3 of IRS-CBC shall be considered

4.5.12 **Creep**

The creep strains shall be evaluated as per clause 6.2.5 of IS:456 for Plain and Reinforced Concrete Structure and clause 6.2.5 of IS:1343 for Prestressed concrete structures.

For structures supporting BSRP/IR loading the effects of creep as per Cl. 5.2.4 of IRS-CBC shall be considered.

4.5.13 **Earth and Water Pressure**

In the design of structures or parts of structures below ground level, such as retaining walls and underground pump room/water tank etc., the pressure exerted by the soil or water or both shall be duly accounted for.

When a portion or whole of the soil is below the free water surface, the lateral earth pressure shall be evaluated for weight of soil diminished by buoyancy and the full hydrostatic pressure (As per IS:875 Part 5).

All foundation slabs/footings subjected to water pressure shall be designed to resist a uniformly distributed uplift equal to the full hydrostatic pressure.

Checking of overturning of a foundation under the submerged condition shall be done considering the buoyant weight of foundation. If any of the structure supporting BSRP/IR loading is subjected to earth pressure, the loads and effects shall be calculated in accordance with Clause 5.7 of IRS Substructure Code.

4.5.14 **Surcharge Load**

In the design of structures or part of structures below ground level, such as retaining walls and underground pump room/water tank etc., the pressure exerted by surcharge from stationary or moving load shall be duly accounted for.

4.5.15 **Pre-stressing Force (PR)**

The pre-stressing force should be as per IS:1343.

4.5.16 **Long Welded Rail Force (LWR)**

LWR forces shall be as per BSRP Station DBR / BSRP Viaduct DBR.

4.5.17 **Settlement**

Maximum and differential settlement shall not exceed, as provided in Table 1 of IS:1904.

4.5.18 **Other Forces and Effects**

As per Clause 19.6 of IS:456.

4.6 **Design Load Combinations**

4.6.1 **Ultimate Load Combinations**

Each component of the structure shall be designed and checked for all possible combinations of applied loads and forces. They shall resist effect of the worst combination. The following shall be considered:

a. Load combinations and factors as per Table 18 of IS:456 for Plain and Reinforced Concrete Structures.
b. Load Combination and factors as per Table 7 of IS:1343 for prestressed concrete structures.
c. Load combination as per Section 3 and factors as per Section 5 of IS:800 for Steel structures.
d. Load combination as per clause 6.3 of IS:1893 (Part-I)
e. Load combination as per IRS, CBC and RDSO guidelines for Seismic design of Railway Bridges where BSRP live loads are applicable.

Note:

i) Load combinations for construction load cases shall be decided by Engineer/ Employer as per methodology of construction.
ii) Reference of IRC:6 be taken for collision case of collision of road vehicles are involved.

4.6.2 **Serviceability Load Combinations**

The following load combinations and load factors shall be used for design for serviceability limit state:

a. Load combinations and factors as per Table 18 of IS:456 for Plain and Reinforced Concrete Structures.
b. Load Combination and factors as per Table 7 of IS:1343 for prestressed concrete structures.
c. Load combination as per Section 3 and factors as per Section 5 of IS:800 for Steel structures.
d. Load combinations as per IRS, CBC where BSRP/IR Live Loads are applicable.

4.6.3 **Deflection Criteria**

The deflection limitations as per clause 23.2 of IS:456 for Plain and Reinforced Concrete Structures and clause 20.3.1 of IS:1343 for Prestressed concrete structures shall be followed.

4.6.4 **Lateral Sway**

The lateral sway at the top of the building due to wind loads shall not exceed H/500, where H is the height of the building.

4.6.5 **Fatigue Check**

Fatigue phenomenon shall be analysed only for those structural elements that are subjected to repetition of significant stress variation (under traffic load). Fatigue check for:

a. RCC and PSC structures – As per clause 13.4 of IRS CBC.
b. Steel Structures
   i) In case of BSRP/IR live loads, as per clause 3.6 of IRS Steel Bridge code shall govern. If λ* values are required to be used, the train closest to the actual train formation proposed to be run on the system shall be used. Otherwise, detailed counting of cycles shall be done.
   ii) For all other cases, the design shall comply with IS: 800 Section 13.

** Damage equivalence factors (As per IRS Steel Bridge Code)*

4.7 Foundations

4.7.1 Types of Foundation

a. Considering the nature of ground, type of proposed structures, expected loads on foundations, the following type of foundation are considered practical:
   i) Spread or Pad footings
   ii) Raft foundations
   iii) Piled foundations

b. No matter the type of foundation is adopted, the following performance criteria shall be satisfied:
   i) Foundation must not fail in shear
   ii) Foundation must not settle by more than the settlement permitted in IS:1904 Table-1

4.7.2 Design of Piles

IS: 2911 shall be followed for design of pile, load capacity etc.
IS:14593 shall be followed for board cast-in-situ pile found on rocks

Pile Settlement

i) Methods of estimating the settlement of deep foundations depend upon the type of deep foundation and the manner of transfer of loads from the structure to the soil. Theoretical estimation of settlement shall be done in accordance with IS:8009 (Part II) by integrating the vertical strain for the entire depth of soil and rock formation.
ii) The settlement of each pile and/or pile group should be determined and it should be demonstrated that such total and/or differential settlement can be tolerated by the structure.

4.7.3 Foundations in Soil

IS: 1904 shall be followed for design of foundation in soil. The safe bearing capacity for the shallow foundations shall be calculated in accordance with IS:6403.

Computation of Settlements of Foundations:

The Calculations for the settlement of foundations shall be done as per:
i) IS:8009 Part-1 for shallow foundations
ii) IS:8009 Part-2 for deep foundations

4.7.4 Design of Water Retaining Structure

It should be designed as per IS:3370.

4.7.5 Codes and Standards

a. The design of station buildings shall be carried out as per provisions of this Design Specification. Reference shall be made to following codes for any additional information.
b. Order of preference of codes shall be as follows:
   i) Indian Railway Standards- IRS.
   ii) Indian Roads Congress – IRC.
   iii) Bureau of Indian Standards – IS.
   iv) Euro Code.
   v) Other National Codes mentioned in the Viaduct design criteria shall be applicable.

5 System Technical Rooms Requirements

5.1 General

5.1.1 The following are generic requirements that are applicable to all systems technical rooms. The final

size of the rooms and their fit-out shall be fully interfaced and coordinated with the Project Partners. The Contractors design shall take cognizance of the following Employer's requirements.

5.1.2 **Electromagnetic Compatibility (EMC)**

The distances between the technical rooms shall be optimised to reduce cable length and subsequently to reduce electromagnetic interferences (EMI) and extensive and cost-intensive EMI protection measures. Other measures shall also be taken to reduce the EMI effect

5.1.3 **Load Bearing Capacity**

The weight and size of HVAC, MEP, Signalling &Telecommunication (S&T), AFC, PSD and Energy equipment including solar power, which have to be installed in technical rooms and on station roofs shall be taken in to account in the structural design. The Systems imposed loading on the structural design shall be coordinated with the Project Partners.

5.1.4 **Room Dimensions**

For approximate room sizing of the Systems Technical Rooms please refer to the Architectural Layout Plans in Section 11. The final room sizes shall be interfaced, coordinated and finalised with the Project Partners/System Wide Contractor's (SWC).

5.1.5 **Doors**

a. The door openings shall be of sufficient size that the equipment can be installed and easily moved through the doors, and this shall include racks including packing that shall also be required to be transported through the door openings. The use of double doors with clear passage is recommended where space permits. The final door opening sizes shall be interfaced and coordinated with the Project Partners.
b. The doors shall open in direction of escape, i.e. towards the access corridor.

5.1.6 **Openings for Transport and Construction**

a. Extra space for people and transporting equipment shall be provided.
b. To guarantee access to the technical rooms for heavy installations (in particular for HVAC, MEP, System rooms requirement and Energy equipment including solar power) adequate openings and removable panels shall be provided. The final opening sizes shall be interfaced and coordinated with the Project Partners.
c. If equipment installation requires the use of cranes or other hoisting devices (e.g. roof hooks) then provision shall be provided and interfaced and coordinated with the Project Partners

5.1.7 **Room Height**

The definition of the clear room height depends on the respective technical requirements, including; size of the technical equipment, raised or false floors (installation method of cables, type and number of cables, bending radii etc.) and suspended false ceilings. The final room heights shall be interfaced, coordinated and finalised with the Project Partners.

5.1.8 **Raised Access Flooring and False Flooring**

a. The technical rooms for Energy, S&T, AFC, GSM, PSD, SCR etc., shall be provided with anti-static high pressure laminated raised access floor. The raised access floor and false floor design shall be interfaced and coordinated with the Project Partners.
b. For S&T, AFC, GSM, PSD, SCR rooms a complete portable assembly of modular floor panels on an elevated support system to accommodate electrical and mechanical services shall be provided.
c. Raised floors shall be a stable structure that withstands the weight imposed by the installed equipment and racks.
d. The minimum height of the raised access floor shall be specific for each discipline and may depend on; the minimum bending radii of the installed cables, specific MEP requirements, etc.
e. The material of the floor cover shall fulfil vibration attenuation characteristics and be suitable for electrical rooms and comply with relevant codes and standards.
f. The raised access flooring shall have a fire resistance class that complies with relevant codes and standards.

5.1.9 **Suspended Ceiling**

A suspended ceiling for the technical equipment rooms shall be provided along with access panels and trap doors. The suspended ceiling design shall be interfaced, coordinated and finalized with the Project Partners.

5.1.10 **Electrical & Mechanical Requirements**

a. **HVAC**
The Air conditioning units shall be capable of operating within a wide range of ambient temperature conditions prevalent in Bengaluru as per the ISHRAE Handbook. The specific temperature and humidity HVAC requirements shall be interfaced and coordinated with the Project Partners.

b. **Lighting**
The Contractor shall make suitable provision for light fittings in the System technical rooms and shall be interfaced with the Project partners for their requirements.

c. **Earthing**
The Earthing system including clean earthing as required by Power supply, S&T, GSM, AFC, PSD and SCADA equipment etc. shall be interfaced, finalized, supplied and installed by the Contractor in co-ordination with Project Partners. There shall be provision for Main Earthing Terminals and Clean Earth in the Power Supply, TER, SER, S&T UPS, AFC, PSD and any other rooms required by the System Contractors.

d. **Low Voltage (LV) / Power Sockets**
All technical rooms shall be provided with Power sockets as per the ratings specified in technical requirements. The specific LV requirements shall be interfaced and coordinated with the Project Partners.

e. **Fire Detection, Alarm, Prevention, Fighting & Suppression**
The Contractor shall design and install a Fire Life Safety System including fire detection and alarm system. This shall include the monitoring and control through a Fire Alarm Panel and integrated with Building Automation System (BAS) at the Station Control Room (SCR), and at the OCC through SCADA as specified in technical specifications. The Fire system shall be interfaced with AFC Gates & PAS system.

5.1.11 **Telecommunications**
All technical rooms shall be provided with structured in-house cabling, for data and power, data and power points as per requirements shall be provided, a clock, radio coverage for operational train radio system & public & security radio systems, telephone phone sockets (VoIP), data connection (LAN/WAN), PA System etc. The specific telecommunication requirements shall be interfaced and coordinated with the Project Partners.

5.1.12 **Access Control**
The System technical rooms shall be provided with an access control system by S&T system. Only authorized staff will be allowed to access the System technical rooms. The specific access control requirements shall be interfaced and coordinated with the Project Partners keeping the provision for installing access system.

5.1.13 **Furniture**
In addition to the technical cubicles, cabinets, type-tested LV switchgear assemblies, all technical rooms (SCR, Ticketing room, EFO, Customer care rooms etc.) will be equipped with furniture (desks, chairs, table mounted bookshelves, lockable cabinets, etc.) for maintenance purposes. The specific furniture requirements shall be interfaced and coordinated with the Project Partners.

5.2 **Energy**

5.2.1 **General**
Energy shall comprise of the following main sub-disciplines:
a. Station Power Supply (SPS)

~~5.2.2~~ **Auxiliary (ASS)**
a. ASS room size, beam and column layout shall as far as possible be standardized allowing a standard open room layout. The specific furniture requirements shall be interfaced and coordinated with the Project Partners.
b. The ASS shall be located at Concourse/ Ground level ~~immediately beneath the tracks~~ in elevated stations. This is to reduce cable distance from traction equipment to the OHE Rail System and

to facilitate easy HV cable access from the track side cable routings.

c. The substations shall have access for the installation of equipment and for future renewal and replacement. The following dimensions are provided for reference, the specific dimension requirements shall be interfaced and coordinated with the Project Partners:

Description	Dimension (m)	Weight (kg)
	L x W x H	
33kV Switchgear Cell	3.6 x 1.2 x 2.6	2,500

d. ASS shall be equipped with lifting hooks placed in the ceilings, and located within the room as necessary to enable lifting and movement of heavy equipment. The minimum requirement for lifting hooks is 1 Tonne for the Auxiliary Transformer technical rooms. The specific lifting hook requirements shall be interfaced and coordinated with the Project Partners.

e. All ASS will require natural ventilation and this shall be provided by a suitable free area opening. Under normal ambient conditions cooling of the equipment can be by provided by natural cross flow ventilation via direct natural ventilation. The net area of the natural ventilation shall be designed by deducting the area of mesh and louvers etc.., The size of the opening shall comply with NFPA 70 NEC, in addition to the transformer equipment manufacturers specific requirements.

f. Windows will not normally be required in the ASS room as they will normally be unmanned, however national (NBC) and local codes for health and safety requirements shall be complied with.

g. ASS room access requirements:
   i) Every ASS will require a loading and unloading deck facility with a 3.5m width at the end of the station. One shutter shall be provided on the loading deck for each ASS room. The Rolling shutters shall not have mesh or grills that let rain into the room. The Rolling shutter clear height shall not be less than 3.6m.
   ii) Equipment room head clearance shall generally be not less than 3.6m.
   iii) The loading deck shall be accessible using a mobile crane from the street, and this provision is to also facilitate the initial installation delivery and future equipment replacement. A removable safety handrail shall be provided.
   iv) In stations where a loading deck is not possible then the rolling shutter may be replaced by a removable metallic hatch allowing delivery of equipment inside ASS
   v) Delivery routes for future replacement of equipment to and from the ASS including street access for the vehicles involved, shall be verified and clear distances confirmed to the Engineer.
   vi) One main door and one emergency door shall be provided for each ASS and these shall have access control and also be manually lockable. Emergency doors shall have a panic bar on the inside.
   vii) The main access door shall be a minimum of 2.5 m in height and shall have access control and also be manually lockable.
   viii) ASS access doors shall be fire rated in compliance with NBC and NFPA 130 (Latest edition) requirements.

h. ASS room height shall be generally 5m clear from finished floor to ceiling and a minimum 3.0 m beneath track girders.

i. Floors:
   i) ASS room finished flooring shall have a +/- 2 mm tolerance. Concrete floor finishes shall be granolithic sealed and hardened with an anti-static epoxy coat.
   ii) Floors must be suitable for the weight of the heaviest equipment. All flooring including the loading deck platform shall be able to accommodate the maximum weight. The specific weight requirements shall be interfaced and coordinated with the Project Partners.
   iii) The floor screed shall be a minimum of 50mm in depth to accommodate the embedding for equipment earth strips and for the embedded base frames of switchgear and

transformers.

iv) Connections for earth bonding shall be provided between reinforcement bars in the substation floor slab direct to a Main Earth Cable (MET) in the room. This should be carried out as a minimum at two places diagonally opposite to one another.

v) The floor near the loading deck shall be sealed and not permit rain water to enter into the substation.

vi) The transformers shall be dry type, and therefore no oil sumps or spillage requirements shall be required.

j. All ASS room walls and soffit shall be finished with anti-dust epoxy sealer and should be clean and dust free at handover.

k. Ceiling:

i) For erection of cable trays, fire pipes etc., it should be possible to post drill on slab. Where prestressed beams are extensively used drop rod fixing pockets shall be provided. Drilling is not allowed on prestressed beams.

ii) Ceilings shall be water tight and sealed sufficiently to exclude the ingress of rain water, station washing or water discharge from fire hoses and hydrants in the areas immediately above the ASS room.

l. The passage of water pipes and exposed drain pipes through ASS room shall be not be permitted. This is a precaution against equipment failure due to water leakage damage. NFPA 70 (National Electric Code) Clause 450 confirms routing water piping through transformer rooms is not permitted.

5.2.3 **Access for Maintenance**

a. All areas of the station shall be accessible for inspection and maintenance

b. Door and access panel sizes shall be of sufficient width and height for the installation and removal and replacement of equipment.

c. Room layouts shall make provision for withdrawal and circulation space around equipment where required.

d. For reliable and maintenance friendly access obstruction free, straight run spaces shall be provided for cable containment systems in compliance with applicable codes and standards.

e. A loading area/platform shall be provided at all stations to handle heavy equipment delivered by road craneage.

f. Access to the station roof for maintenance and cleaning of roof sheeting, solar panels, telecommunication equipment, etc. shall be provided in co-ordination and interface with Stakeholders.

g. Access to the Station roof and Entry/Exit roof for cleaning, re-painting, repair etc. be provided from platform top, track side under traffic block condition.

5.2.4 **Signaling**

a. The signaling system architecture will be supplier-specific, and the Contractor shall fully interface and coordinate this with the Project Partners.

The following general requirements shall be fulfilled:

i) One Signaling Equipment Room (SER) per station.

ii) Interlocking Signaling Equipment Rooms shall have a minimum area of 60m² and Non-Interlocking Signaling Equipment Rooms shall be combined with Telecom Equipment Room. The combined Room shall have a minimum area of 90 m^2. The room size estimation considers spare area of at least 50% for later extensions. The specific room size requirements shall be interfaced and coordinated with the Project Partners.

iii) Signaling rooms shall be located as close as possible to the main Telecom/IT room, UPS (S&T) room and PSD room.

iv) The height of the rooms shall be equal to or greater than 3.0m clear height above the raised floor. The specific room height requirements shall be interfaced and coordinated with the Project Partners.

v) The raised floor surface height shall be a minimum of 300mm high and sufficient for the cables bending radii. The specific raised floor height requirements shall be interfaced

and coordinated with the Project Partners.

vi) Signaling rooms shall be air-conditioned. The room temperature will be maximum 24 °C and the relative humidity shall be a maximum of 50%. The specific temperature and humidity room requirements shall be interfaced and coordinated with the Project Partners.

vii) The distances to other technical rooms (TER, Commercial TER, Energy, UPS/Battery room, PSD) shall be optimized to reduce cable length.

5.2.5 **Telecommunications and IT (TEL/IT)**

a. Telecom/IT equipment rooms and associated power rooms will be provided at each BSRP station as follows:

i) One Telecommunication Equipment Room (TER) with a room size of minimum 60m² to accommodate all telecom equipment. Non-Interlocking Signaling Equipment rooms shall be combined with Telecom Equipment Room. The combined room shall have a minimum area of 90m². The specific room size requirements shall be interfaced and coordinated with the Project Partners.

ii) One GSM/Commercial Telecom Equipment Room which will be operated and maintained by Third Parties (e.g. Public Mobile Providers, Suppliers of video advertisement etc.) with a room size of minimum 10m². The specific room size requirements shall be interfaced and coordinated with the Project Partners.

iii) The height of the rooms shall be equal to or greater than 3.0m clear height above the raised floor. The specific room height requirements shall be interfaced and coordinated with the Project Partners

iv) The raised floor surface height shall be a minimum of 300mm high, and sufficient for the cables bending radii. The specific raised floor height requirements shall be interfaced and coordinated with the Project Partners.

v) Telecom/IT rooms shall be air-conditioned. The room temperature will be maximum 24 °C and the relative humidity shall be a maximum of 50%. The specific temperature and humidity room requirements shall be interfaced and coordinated with the Project Partners.

vi) The distances to following technical rooms shall be minimized to reduce cable length; SER, UPS/Battery Room, Signaling Maintainer Room, AC / DC / SCADA Room, etc.

b. The components and systems shall be mounted on racks, typically 475mm standard industrial compartments which shall be accessible at both sides (back and front). In addition, wall mounted racks will be used. Accessibility to the equipment for maintenance must be provided.

5.2.6 **Cables, Ducts and Pipes**

The routing, installation and mounting of cables, ducts and pipes have an influence on the architectural and structural design. The following basic requirements shall be considered during the architectural and structural design of the stations.

a. The installation of cables shall be such as to provide an orderly formation free of unnecessary bends and crossings, which will permit the removal of any cable without undue disturbance to adjacent cables.

b. Precautions shall be taken to ensure that cables are not installed in a manner, or under conditions likely to cause corrosive action or damage to cables or be detrimental to the performance of cables during operation.

c. Grounding, armouring and screening is to be provided to eliminate EMC issues.

d. Cable entry points shall be fireproofed and sealed for cables passing different fire compartments.

e. S&T cables, except optical fibre cables (OFC), shall be physically separated from energy power cables by the provision of separate cable routes or partitions. The separation shall be achieved according to relevant Indian and international standards and requirements.

f. S&T and energy cables shall be installed on heavy-duty cable trays and/or in concrete cable ducts.

g. At each station, shafts, ducts, pipes and heavy duty cable trays or raceways for the power and data cables shall be designed and provided starting at street level to the respective equipment rooms. The entry point from the street level (e.g. for interfaces to Third Parties) shall be guaranteed. At all station concourse levels, two separate raceways/trays for connecting EFO,

TOM, Gates etc. shall be provided for AFC systems along with junction boxes. The specific cable tray requirements shall be interfaced and coordinated with the Project Partners.

h. All pipes or ducts containing cables shall be effectively sealed where they enter substations, buildings, stations, and location kiosks, etc., to prevent the entry of water, dust and vermin.
i. Because of fire protection regulations within the structures only FRLSZH indoor cables shall be used with reduced fire propagation characteristics.
j. The cable routing design shall consider the deflection and bending radii. The mechanical parameters of the cabling shall be respected. In all cases the cable manufacturer's instructions (for bending and forming with and tensile forces) shall be followed. The specific cable requirements shall be interfaced and coordinated with the Project Partners.
k. The outdoor S&T/IT cables (trunk cables) shall be terminated in independent stand-alone frames, which will be located in the technical equipment rooms or separate cable rooms. The specific cable requirements shall be interfaced and coordinated with the Project Partners.
l. Telecom/IT trunk cables, i.e. copper cables and OFC cable shall be terminated in separate cable distribution frames for copper cable Main Distribution Frames (MDF), and for OFC cable Optical Distribution Frames (ODF) shall be used. The specific distribution frame requirements shall be interfaced and coordinated with the Project Partners.
m. System wide all cable termination and distribution frames and units as well as metallic cable shields shall be connected with the earthing system and meet the EMC requirements. The specific cable termination requirements shall be interfaced and coordinated with the Project Partners.
n. Wire and cable provision intended for use in control circuits and power circuits related to emergency devices shall be listed as being resistant to the spread of fire and shall have reduced smoke emissions. The specific cable requirements shall be interfaced and coordinated with the Project Partners.

6 Deleted

7 Deleted

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9 Geotechnical Specification

9.1 Geotechnical Investigations

9.1.1 The Contractor shall carry out Geotechnical Investigations (GI) in order to examine the geological, hydrogeological and geotechnical conditions and determine the design geotechnical parameters, as required as per Indian and international standards.

9.1.2 The Contractor shall submit to the Engineer for approval their GI programme including borehole locations in advance of undertaking any investigations along with method statement for Engineer's review and approval

9.1.3 The investigations shall be contained within the affected Works zone (construction influence zone). Any exception to these requirements shall obtain approval from the Engineer

9.1.4 The Contractor shall perform preliminary boreholes to estimate the Geotechnical capacity. The borehole depths shall be at least 5 m deeper than the estimated depth of the piles that are planned to be constructed

9.1.5 Notwithstanding that the entire geotechnical risk lies with the Contactor. The Contractor shall execute a minimum of one (1) borehole for every pile cap and other locations like entry/exit structures, UG sumps etc

9.1.6 The aforesaid principles shall not exclude the Contractor's obligation and sole responsibility to perform geotechnical investigations in addition to the quantities previously described. The Contractor's investigations shall evaluate the existing ground conditions, in relation to the design needs of all the temporary and permanent structures of the Works and the geotechnical risks that must be controlled both short term and long term

9.1.7 The Contractor shall be responsible for selecting and applying the methodology that covers comprehensively the geotechnical profile between physical boreholes. The methodology and

technology shall be submitted for a SONO (Statement of No Objection) from the Engineer

9.1.8 In the event that sampling/confirmatory boreholes need to be undertaken later than the GI time frame, at any area of the Works, these will be implemented in accordance with the requirements of this section. The results of these boreholes shall be evaluated by the Contractor in accordance with the relevant Employer's requirements

9.2 **Geotechnical Reports**

9.2.1 The Contractor shall submit for obtaining Engineer's NONO reports, in the following order:

a. Geotechnical Appraisal Report (GAR) including the Additional Geotechnical Investigations programme
b. Geotechnical Factual Report (GFR) including the results of the Geotechnical Investigations (GI)
c. Geotechnical Interpretive Report (GIR) for each pile cap.

9.3 **The Geotechnical Appraisal Report (GAR)**

9.3.1 The GAR shall contain two parts. In part 1 all the relevant information shall be included which exists prior to the GI, in order to plan the type, number and locations of the investigation works to be executed in the frame of the GI. In part 2 the programme of, and justification for, the GI shall be presented.

9.3.2 The area to be included in this study for data collection shall extend up to a distance of 10 m from the extremities of the footprint of the foundation works.

9.3.3 The GAR shall include a plan of the borehole locations and other data points against a mapping background. The alignment of the railway shall also be shown.

9.3.4 Part 1 of the GAR shall be prepared based on all the relevant information that exists and after on-site inspections. It shall include, as a minimum, the following:

a. Geomorphology (geological and topographical features) of the area
   i) General description of the Works within the wider area.
   ii) Reference to older and recent topographical maps, aerial photos etc., of the wider area.
   iii) Production of tables, maps and other data concerning the hydrographic network of the Works area and the classifications of uncovered, covered, backfilled as well as hydraulic works on the surface (e.g. embedded streams, channels, trenches).

b. Urban and Archaeological Conditions
   i) Short description of the urban conditions (coverage and building density, free spaces, buildings, infrastructure, main road arteries, etc.).
   ii) Short description of the archaeological finds based on information related to the Project. Presentation of maps with the locations of the archaeological finds.
   iii) Land-use data (maps, photos, aerial photos, etc.) with special reference to mines, quarries, backfills, etc.
   iv) History of previous land uses (maps, photos, etc.) with special reference to previous industrial uses, uses such as petrol stations, etc.
   v) Recording in tables and maps of the existing gas stations with their characteristics (location and distance from the Works, years of operation, number and location of pumps, dimensions and material of the fuel tanks, washing plants).
   vi) Recording in tables and maps of the main networks (sewage pipes, etc.) and underground structures.

c. Geological and Hydrogeological Conditions
   i) Short description of the geology of the wider area (stratigraphy, tectonics).
   ii) Presentation of older and current geological, geotechnical, seism tectonic, hydrogeological maps of the wider area of the Works.
   iii) Recording in tables and maps of any available geotechnical surveys conducted in the Works area for any other projects or purposes. Presentation of relevant data (borehole log, pictures, etc.).
   iv) Short description of the hydrogeological (ground water level and seasonal fluctuation, etc.) and hydrological conditions in the wider area.

v) Recording in Tables and maps data concerning the hydrographic network of the Works Area.

vi) Recording in Tables and maps, as well as photographic documentation of all shafts and water wells in the Works area with reference, as a minimum, to the location, the depth and their existing situation, the filling material, water level and any pumps with their capacity.

vii) Seismicity (the frequency of earthquakes) of the wider area.

9.3.5 In part 2 of the GAR, the Contractor shall declare that the Geotechnical Investigation (GI) proposed shall provide sufficient data enabling the design to be carried out in accordance with the Employer's Requirements. This shall include but not be limited to the following:

a. Codes and Standards of Investigations.
b. Work site Organization (for GI).
c. Works included in the GI.
d. Borehole programme.
e. In situ tests.
f. Laboratory tests.
g. Other investigations and tests.
h. Plan View with location of the proposed boreholes.
i. Organization chart of work group & CV's (for GI)
j. Equipment.
k. The programme of the GI shall be consistent with the Programme of the Works. It shall define any other surveys the Contractor proposes in the relevant area, and shall enable the Contractor to prepare the Reports described in the following paragraphs to achieve the Programme for the Works.

9.4 **Geotechnical Factual Report (GFR)**

9.4.1 The GFR shall include the presentation of the GI results. The GFR shall be prepared taking into account all relevant specifications.

9.4.2 The GFR shall include but not be limited to:

a. Specifications, related documents and drawings;
b. BSRP/IR Description of the geology of the area;
c. Information on works executed on site and worksite organization;
d. Borehole Data - Instruments – Sampling;
e. Description, brief and detailed results of in situ tests;
f. Ground water level measurements;
g. Description, tables, brief and detailed results of laboratory tests;
h. Specifications related to execution and presentation of soil mechanics and rock mechanics laboratory tests;
i. Layout of the borehole's location;
j. Borehole logs;
k. Photographs of the borehole cores.

9.5 **Geotechnical Interpretive Reports (GIR) for each Structure**

9.5.1 The GIR shall determine, based on the relevant GFRs the geotechnical sections of the ground indicating the required design geotechnical parameters for every part of the Works ('the Design Geotechnical Sections' or 'DGS').

9.5.2 These DGSs shall indicate the stratigraphy, the design values for various parameters (physical and engineering properties) of each layer, the ground water level, the foundation levels for the works and the adjacent structures, and any other information that is relevant for the Works.

9.5.3 Each GIR shall include but not be limited to the following:

a. Outline of the works in the subject section;
b. Abstract concerning the GAR findings in the area concerned;
c. Alignment of the section in question, in plan view and longitudinal profile;
d. Summary of the investigation works performed;

e. Description of the ground conditions;
f. Interpretation of the ground conditions as related to the design and construction of the Works;
g. Determination of the DGS;
h. Determination of geotechnical parameters for design work and construction;
i. Determination of the ground water level for the design work.

9.5.4 The report shall be accompanied by a geotechnical longitudinal profile along the axis of the Works section concerned and including respective transverse cross–sections, if necessary, for the design.

9.5.5 The types and the selected values of the design and geotechnical parameters shall include proposals about the design soil parameters, for the various depths under the surface of the ground, according to the geological formations and the proposed stratigraphy of the soil in the area where the works are to be performed. They shall take into consideration the type, extent and geometry of the underground and other structures, the construction methods and the requirements of the proposed analysis method, and any other relevant factors.

9.5.6 In the GIR, the design assumptions of the geotechnical conditions shall correspond to the actual:
a. Types of soil and their natural properties (specific weight, density, particle size, Atterberg limits, natural water content, and any other relevant properties).
b. Variation of soil properties.
c. Succession and layers of thickness, presence of discontinuities.
d. Ground water level and hydrogeological conditions, piezo metric pressures that shall be used in the temporary retaining systems and long-term conditions, permeability.
e. Loading rate and analysis method (total or active pressures).
f. Shear strength parameters in terms of total and active stresses.
g. Soil pressure coefficients (active, at-rest, passive) and any proposed modifications of the theoretical values.
h. Strength and compressibility parameters, including consolidation properties, compression module when loading and unloading, Poisson ratio, non-linear stress and deformation parameters (if applicable), dynamic shear module and any other relevant properties.
i. If anchoring is to be used, values of ultimate bond strength and working bond strength between anchor or anchoring and environmental medium (soil or rock).

9.5.7 To calculate the regime of the initial geostatic stress field (coefficient of earth pressure K), a typical range of its values shall be proposed to be used in a sensitivity analysis during the design, as well as design values for each section or sub-section or structure.

9.5.8 These values shall be based on:
a. Appropriate laboratory strength tests (e.g. triaxial tests and other relevant types of testing) as well as on in-situ tests (e.g. pressure meters and other relevant types of testing);
b. Well documented empirical correlations taken from relevant available sources according to the local conditions, including the soil type and loading history (e.g. pre-consolidation stress, over consolidation ratio, and other relevant factors).

9.5.9 A sensitivity analysis of the geotechnical parameter values shall be included as a part of the GIR.

9.5.10 The interpretation of the data obtained from the ground investigation (based on documented data from the field investigations and the laboratory test results) includes the definition and description of the materials encountered in all geotechnical formations.

9.5.11 All test results (in situ and lab) shall be checked by the Contractor to ensure compliance with the Employer's Requirements.

9.5.12 The classification of the materials of the Works area into geotechnical layers shall be made based on the evaluation of all geological and geotechnical data.

9.5.13 The selection of the classification of the soil materials of the Works area shall be submitted for approval from the Engineer.

10 Detailed Design for Mechanical, Electrical and Plumbing (MEP)

10.1 MEP Technical Specifications

10.1.1 General

This section contains a general description of the Technical Specifications for Station MEP comprising of Low Voltage Electrical Distribution System, Fire Detection and Alarm System, Air-

conditioning & Ventilation System, Fire Fighting and Suppression, Water Supply, Sanitary and Drainage Systems, Building Automation System (BAS), Rainwater Harvesting, Indian Green Building Council (IGBC) Certification and other services required for completion of the Work of the Stations.

The specific design requirements for System Technical Rooms shall be interfaced and coordinated with the Project Partners.

10.1.2 **Design Requirements**

The Contractor shall prepare the detailed design in accordance with the performance specifications and parameters confirmed in the Employer's requirements. The Contractor shall ensure compliance with the regulations laid down by all statutory authorities, including fire safety regulations or other local codes, and obtain approvals from the relevant authorities at appropriate stages of design and construction as required.

10.1.3 The E&M System requirements shall be compliant to Design Basis Report (E&M), MoHUA/GOI Guidelines/ report on Standardization / Indigenization of Electrical & Electromechanical Metro.

10.1.4 System (Electrical), relevant and recognized Indian/ International Standards as consented by the Engineer.

10.1.5 The Contractor shall furnish comparison of design criteria, specifications prevalent to other similar BSRP projects for approval of the Engineer as per requirement.

10.1.6 Detailed technical specifications for MEP Systems, as per prevailing practices of other BSRPs and relevant standards not limited to the following: IS, IEC, NBC, IE Rules, NFPA, ISHRAE, etc. shall be submitted by the Contractor for Engineer's approval.

10.2 **General**

10.2.1 This section contains the general description of the system concepts and major components for Electrical and Mechanical (E&M) Works, interface requirements with other contractors, manufacturing, general installation, design/ performance, and testing requirements. Detailed Specifications for the Items and Equipment to be used in E&M Works along with specific installation, design/performance and testing requirements are given in various sections of the Technical Specification.

10.2.2 The emphasis is to explain the requirements of work, interfaces with other contractors for achieving an efficient & safe working system commensurate to the best international standards and practices. The contractor shall follow acceptable standards akin to the best available in world Sub-urban Rail System where this is not specifically mentioned.

10.2.3 In this document the term "provide" shall mean "calculations, preparation of drawings for installations & maintenance, manufacture and factory testing or procurement, delivery, off-loading, installation, testing, commissioning, handover of completed works to K-RIDE.

10.2.4 K-RIDE staff training including supply of O&M manuals, As-built drawings, interface and co-ordination with other contractors arising out of concurrent works and warranties".

10.2.5 The design and supply of elements shall comply to International Specifications and Standards. Approved local standards shall also be complied wherever necessary.

10.2.6 Unless approved otherwise, all equipment and items shall be uniform throughout the Contract in order to minimise inventory of spares and the number of manufacturer interfaces. The tenderer shall constitute a competent qualified electrical team to execute the electrical Work in strict compliance to statutory rules and specifications, drawings and relevant standards.

10.2.7 Work under this contract shall be executed as given in this tender document and as required at site whether specifically shown or not. The Contractor shall carry out and complete the work under this contract in every respect in conformity with the contract documents, as per directions of and to the satisfaction of the Engineer.

10.2.8 The tenderer shall constitute a competent qualified electrical team to execute the electrical Work in strict compliance to statutory rules and specifications, drawings and relevant standards.

10.2.9 In case the work is planned to be executed through Electrical sub-Contractor, the tenderer shall assess the capabilities of the subcontractor and satisfy himself as regard to suitability, time schedule of work and quality standards of sub-contractor and furnish complete credentials viz. Willingness to quote, legal status, registration, owners /partnership, 1T return, sales tax registration, past experience, solvency certificate and other information asked in ITT regarding the proposed sub-

contractor/s which shall not be changed except in the cases where the change is approved by Engineer to control the quality and timely completion of work. The main bidder shall make available all the tender documents, specifications and drawings to the Sub-contractor prior to bidding to ensure quality, timely completion and understanding of work by Sub Contractors.

10.2.10 An undertaking from such sub-contractors for having received above information and related documents, having understood the Scope of Work and willing to execute the work shall be submitted at the time of submission of tender, however the employer reserves the right to reject /change the sub-contractor at any stage. Sub-contractor shall be deemed to be aware of the Site Conditions, contractual conditions, nature of work, and all the risks associated with the work. Sub-contractor shall at all times keep upon work site competent and experience person with communication and transport facility. Any instruction given to the representative shall be deemed as given to Contractor and Sub contractor.

10.2.11 No subletting by the sub-contractor shall be permitted except for specific items such as the distribution panels/board manufacture, DG set, UPS and high mast lighting subject to approval of Engineer/Employer.

10.3 **Scope of Work**

10.3.1 The works include the provision of all Building Services required in this contract, as specified below, for stations and also those which are not specifically excluded. The Services covered are those, which are necessary to permit the BSRP Corridor to perform its design functions in a safe and efficient manner, in compliance with the requirements of the Specifications and in accordance with modern BSRP/IR/ Metro Railway practice. Equipment and Systems provided shall be compliant with the Specifications.

10.3.2 The contractor has to install the following systems in the station:

a. Electrical Systems.
b. Hydraulic Systems.
c. Fire Detection and Protection System.
d. Building Management System.
e. Heat Ventilation and Air Conditioning Works.

10.3.3 Scope of works for Electrical, Hydraulics, Fire Protection and Detection System are detailed in Clauses 11.0, 12.0 and 13.0.

10.3.4 Approved Definitive Design Documents and Construction Reference Drawings prepared by Detailed Design Consultants of the Employer, approved by Engineer, shall be supplied progressively during Works. The Contractor must develop Working/Shop Drawings and documents from the above-mentioned drawings/ documents, submit to Engineer for reviewing and obtain written approval of Engineer and Employer prior to construction. (Refer Clause 20 for details).

10.3.5 The contractor shall make an allowance for fire sealing of all services penetrations and gaps and liaise and coordinate with other relevant sub-contractors to ensure suitable installation.

10.3.6 Scope of works shall also include

10.3.7 These civil works shall be executed as per latest KPWD/CPWD and contract specifications and additional specifications and latest IS & BIS codes.

10.3.8 Establishing contractor's site office with documentation, communication and transport facility, site safety requirements, storage, material security and maintenance of the area during implementation stage for the electrical work by the Electrical Contractor/Sub-contractor.

10.3.9 De-mobilisation, clearing of all temporary works and facilities after completion of job.

10.4 **Particulars to be Furnished along with Tender**

10.4.1 Tenderer and sub-contractors if any are expected to go through technical specifications, drawings and other details carefully and confirm full compliance to the same. Wherever technical specifications are not mentioned, contractor is required to follow latest national/ international standards to ensure highest quality of work.

10.4.2 In case the Tenderer finds himself unable to adhere to any of the specification/parameter, he should clearly indicate the reasons for the same in schedule of deviations with full particulars and reasons for the same and propose alternative standards as per the international practice.

10.5 **Intent of Specifications**

10.5.1 Technical specifications forming a part of this contract are intended to cover work referred above. It is not the intent to specify completely herein all aspects of design, constructional features of equipment and details of the work to be carried out, but nevertheless the intent of the specification is to ensure that the equipment and work shall conform in all respects to the relevant Bureau of Indian Standard Specifications, Codes of Practice, Indian Electricity Act, Indian Electricity Rules and other Statutory Regulations as may be applicable and to high standards of Engineering, design and workmanship. The equipment and work shall perform in continuous operation in a manner acceptable to the Employer/ Engineer who will interpret the meaning of the specifications and drawings and shall have the right to reject or accept any equipment or work which in their assessment is not complete to meet the requirements of this specification and/or applicable Codes and Standards.

10.5.2 The work shall conform to all provisions of the relevant Government Legislation, Regulations and Bye- laws of the Central/Local Authorities and of any State Electricity Boards/Companies to whose system the installation is proposed to be connected. The Contractor shall give all necessary notices required under the said Acts, Regulations and/or Bye – laws.

10.5.3 The contractor shall examine the installation specifications, drawings & schedule of quantities for feasibility & safety and may suggest or ask for change required if any to provide satisfactory & safe services of the equipment designated for the station.

10.6 **Specifications and Schedules**

10.6.1 The technical specifications and schedule of quantities shall be considered as part of this contract and any work or materials shown in schedule and not called for in the specifications or vice versa, shall be executed as if specifically called for in both. The drawings are for the guidance of the contractor. Exact locations, distances and levels will be governed by the site conditions.

10.6.2 Special conditions of contract shall be read in conjunction with the general conditions of the contract, technical specifications, schedule of quantities, drawings and any other document forming part of this contract. For any discrepancy between the general conditions and special conditions, provisions of special conditions shall prevail. For any discrepancy between technical specifications and schedule of quantities, the most stringent shall prevail (for the purpose of Clause 5.1 above, the omission is not considered discrepancy).

10.6.3 Wherever it is mentioned in the specifications that the Contractor shall perform certain work or Provide certain facilities, it is understood that the Contractor shall do so at his own cost.

10.6.4 Where the contract technical specifications stipulate requirements in addition to those contained in the applicable Indian Standard Codes and Specifications, these additional requirements shall also be satisfied.

10.6.5 The Contractor must get acquainted with the proposed site for the works and study specifications and conditions carefully before tendering. The work shall be executed as per programme approved by the Employer/Engineer. If part of site is not available for any reason or there is some unavoidable delay in supply of materials stipulated to be supplied by the Employer/Engineer, the programme of construction shall be modified accordingly.

10.6.6 Should the tenderer wish to depart from the provisions in these technical specifications, such Departure shall be listed in a separate schedule with full particulars and reasons for the same.

10.6.7 Contractor shall get the arranged material inspected/tested as required before use and shall not move/ dispose off the material so arranged without the written permission of authorized representative of Employer.

10.7 **Site Conditions**

10.7.1 Tenderers, if they so desire, can, before submitting the tender, inspect the site of the work after obtaining prior approval from Employer/Engineer in order to familiarize themselves of the conditions of work prevailing at site as also quantum of statutory levies (taxes, duties etc.) applicable. No extra claim on account of lack of such knowledge shall be entertained after award of contract.

10.7.2 All equipment and work covered by this contract shall be capable of operating continuously and delivering the rated output at ambient conditions prevailing at site.

10.8 **Statutory Approvals**

10.8.1 Obtaining all statutory and mandatory permissions/clearances/approvals required for temporary works/contractor's establishment, from the concerned authorities to commence works at site from local authorities including BWSSB, KPTCL, BBMP, Karnataka Fire & Emergency Services, Electrical Inspectorate, etc.

10.8.2 The Contractor shall submit the required applications, drawings, etc., to the concerned statutory authorities and obtain their approval, license, permission, clearance and/or sanction. All the workmen and supervisory staff shall be qualified and certified license holders or have competency from National or internationally recognized agency empowered to issue, to carry out similar work or authority.

10.8.3 The final completion certificate shall be obtained by the Contractor from all statutory authorities to enable the Engineer to commission the equipment's / installation for utilization. The Contractor shall bear all expenditure to be incurred for getting the installations approved and obtaining the statutory approvals. The work shall not be deemed to have been completed until all the approvals etc., have been obtained by the Contractor. Fees paid by the Contractor to the statutory authorities on the name of KRIDE shall be reimbursed by the Engineer on production of receipts. However, all other charges and liaisoning work expenses shall be borne by the Contractor. Obtaining statutory approvals by the Contractor shall form a part of the Contractor's scope of the contract work. The Contractor shall obtain all the required statutory approvals including but not restricted to the following.

a. **Electrical works.**
   Clearance from Statutory Authorities for energizing the system after completion of work as required.

b. **Fire Detection Alarm and Suppression System**
   Approval of fire detection alarm and suppression system layout from Local Fire Control Authorities prior to commencement of work and Clearance from Local Fire Control Authorities for energizing the systems after completion of work.

c. **DG Sets**
   Clearance from Electrical Inspector after completion of work for energisation of the system. Permission, on behalf of Employer, from Electric Supply Authorities to operate the DG sets. It may be noted that, the electrical installations are to be approved by the 'Electrical Inspector General' authorized by Govt. of Karnataka before energisation.

10.9 **Materials and Equipment**

10.9.1 Procurement of Material

The contractor shall include the supply of entire materials in accordance with these specifications, accompanying schedules and drawings for whole work necessary for a complete installation. Materials and components not explicitly stated in the specifications and/or bill of materials or noted on the drawing but which are necessary for satisfactory installation and operation of the system shall be deemed to have been included in the scope of work. Contractor/subcontractor shall order for the approved make of material only and shall progressively forward the copy of order placed and test certificates of the material to the Engineer

10.9.2 Make

All materials and equipment shall be new and of the approved make and design and as per schedule of quantities conforming to contract specifications. Employer reserve the right to choose an approved make of the material and all such rates are taken into consideration while quoting.

10.9.3 Samples

10.9.4 A list of items of materials and equipment together with samples, as required, shall be submitted to Engineer as per agreed schedule, for approval, before being used on work at least 15 days in advance. No change in samples and deviations from drawings of equipment shall be made without the written instructions of the Engineer. Approvals given by the Engineer to any samples or drawings submitted by the contractor shall not in any way exonerate the contractor from his liability to carry out the work in accordance with the terms of the contract and serving the purpose as per the standards.

10.9.5 Substitute Materials.

10.9.6 Any item, which is proposed as a substitution, shall be accompanied by all technical data giving sizes, technical specifications, technical literature, particulars of materials and the manufacturer's name. At the time of the submission of proposed substitution the Contractor shall state the credit, if any, due to the owner, in the event the substitution is approved. All changes and substitutions shall be requested in writing and approvals obtained in writing from the Engineer. However, decision of the Engineer is final and binding in this regard.

10.9.7 Manufacturer's Instructions

10.9.8 If manufacturers furnish specific instructions relating to the materials used in this contract covering points not specifically mentioned in this document, manufacturer's instructions shall be brought to the notice of Engineer for further instructions in the matter. Such instructions from the manufacturer shall be complied by the Contractor.

10.9.9 Interchangeability

10.9.10 All similar parts and/or equipment shall be interchangeable with one another.

10.9.11 Material Testing

10.9.12 The Engineer shall have full powers to require any material used in work to be tested by an independent agency at the Contractor's expense in order to prove its soundness and adequacy.

10.10 **Co-Ordination of Work at Site**

10.10.1 The work shall have to be carried out in co-ordination and co-operation with the Building Contractor and/or any other agencies at site and shall arrange to place the conduits/inserts etc. in the masonry and concrete as required, along with the progress of building works. Any hold up of the building or other works because of delay in placing the conduits/pipes/inserts etc. or otherwise shall be the responsibility of the Contractor and shall make him liable for damages as may be considered and levied by the Engineer.

11 Employer's Requirements

11.1 The Employer's Requirements establish the overall procedures to be followed by the Contractor for works under this Contract.

11.2 These Employer's Requirements are divided into three sections as follows:

a. General: These apply throughout the Contract. (Appendix III to General Specifications)
b. Design: These apply in respect of duties relating to the design of the Temporary and Permanent Works. (Appendix IV to General Specifications).
c. Manufacturing, Installation and Testing: These apply to the requirements relating to manufacturing, procurement, delivery and installation of plant and equipment, and the requirements for testing and commissioning. (Appendix V to General Specifications).

12 Scope of Electrical Work

12.1 The Electrical & mechanical works are to be provided as described in the scope of works which includes the Design, Preparation of Working or Shop Drawings, Manufacture, testing at manufacturer's works, Supply, Storage, Erection, Site testing and Commissioning of the works and other provisions as stipulated in GCC, SCC and other documents comprising of but not restricted to description given below:

a. Provision of (Power and Control) adequate size cables from LV Main switchboards in the Auxiliary Sub Stations (ASS) to the Sub main and other Distribution, Sub Distribution Boards, Motor Control Centers in the respective plant rooms and/or from the Switchboards/Distribution Boards to the equipment locations. This will include provision of feeder cables/bus trunking to the plant rooms or the UPS and DG set Rooms at the ground level as required. The cables shall be Medium Voltage, Copper Conductor, XLPE/PVC insulated, sheathed, Armoured cables of Fire Retardant-Low Smoke and Zero Halogen (FRLSZH) type, as specified and as required. Cables are to be laid in ground, cable trays, cable ladders, conduits or trunk/Race ways as required, including glanding and termination of the same with crimped sockets.
b. Provision of Main LV Switchboards, Sub Main Switchboards, Motor Control Centers, Normal Lighting/Socket and other Distribution boards, Power Panels, Automatic Harmonic Filter Panels, Emergency Lighting Panels etc. Distribution Board with Earth leakage Circuit Breakers, Miniature Circuit Breakers for power and light distribution including metering and earthing of the same. Metering and Indication System through digital meters as specified. These shall be

Medium Voltage, sheet steel clad floor/wall mounted with flush mounted switchgear including ACB, MCCB, RCBO, RCCB, MCB, ELCB's etc. with Copper bus-bars as per configurations detailed in the specifications/ drawings/ BOQ including metering, relays, earthing etc.

c. Provision of plug and sockets for power points and lighting in the station areas. Internal electrical installations including wiring in the GI Conduits with copper conductor, Fire Retardant-Low Smoke and Zero Halogen (FRLSZH) wires and including switches accessories etc. for lights, fans and socket outlets including earthing of all points.

d. Provisions of GI Conduits with accessories for the PA system, communication, Signaling Systems or any other systems etc. as required, including the drawing of fish wires for wiring by other agencies. Provision of Bus Trunking System/ race way for connection between various system requirements.

e. Medium voltage 1100-volt grade aluminium / copper conductor XLPE/PVC insulated and sheathed Armoured cables in ground and/or in cable trays including cable termination with crimped sockets and glands or cable jointing with cable jointing kits. External cabling for lighting, street lighting and landscape lighting, provision of poles, high mast lighting, earthing and including lighting fixtures with lamps and accessories complete as required.

f. Ascertain through liaison and interface, the adequacy of power supply feeding arrangements for Lifts/Escalators/Pumps/Generator/UPS and other plants/equipment to be provided by other Designated Contractors. Provision of supply feeders for the equipment and plants supplied by other Designated Contractors. Supply, erection, testing and commissioning of generator and UPS is also included in this part. Supply, erection and commissioning of pumps is included in Fire-fighting and PHE portion. The pumps shall be automatically controlled.

g. Control wiring from various equipment and accessories to extend the status of the supply position/ equipment position including the annunciation of critical states and control of the equipment from remote.

h. Provision of Earthing System comprising of Main Earth Bus in Auxiliary Substations, Clean Earth System and provision of Main Earth Terminals (MET). Co-ordination with Signaling and Telecom Contractor for arrangements within the Signal & Telecom rooms and other rooms requiring Clean Earth connection. Providing earth mat (If not provided by Civil Structure Works Contractor) and connecting the risers to MET at required locations in Ground, platform and concourse area is in the scope of work under this contract. Earthing of various system including construction of earth pits and earthing strips, complete including the lightning protection of station building.

i. Provision of normal and emergency lighting arrangement & automatic operation in all the station areas, parking areas, fore court, bridges connecting entry / exits and other plant rooms located at ground level. This includes external cabling and provision of lighting fixtures with lamps, ballasts, control gear etc. complete as required.

j. Provision of interlocks and protection schemes for the power distribution, to suit the desired operation, duly coordinated with high voltage side protections and protections of the individual equipment.

k. Provision of control and small power supplies to various station equipment/ panels.

l. Provision of Lightning Protection System for entire structures provided at the stations.

13 Scope of Hydraulic Work

13.1 Provision of pumping arrangement for the raw water supply, Coordination of Embedded Piping, water mains within the stations, station drinking water supply, Fire - fighting and Sprinkler System together with the Jockey pump, Hydrant pump & sprinkler system pump, drain pumps etc.

13.2 Provision of automatic control & monitoring of operation of pumps, incoming supply, liquid level controllers or the equivalent arrangement based on the liquid levels in the various tanks and as per the design requirements.

13.3 Provision of the feeding arrangement of various pumps from the main incoming supply provided in the pump room.

13.4 Provision of pipe line network with control valves and level monitors for providing automatic operation of pump room equipment's for domestic water supply and fire-fighting system.

13.5 Accessories required for complete functionality of all the equipment in the entire system must be provided.

14 Scope of Fire related Work

14.1 Provision of complete Fire Suppression System in the Stations and ancillary buildings/structures including hydrants, hose reels, sprinkler system, fire hose cabinets fire mains, portable extinguishers and pipe line network with control valves for sprinklers and hydrants.

14.2 Provision of complete Fire-Detection & Alarm system including monitoring and control through a fire alarm panel at Station Control Room and at OCC through SCADA Provision of suitable type of detectors, Break glass units/Manual call points, audio and visual display devices, gas-based flooding system for LT Panels etc. This system shall have an interface for monitoring through BMS.

15 Work excluded

15.1 The following works are to be designed, supplied, installed and commissioned by other contractors with whom the Contractor shall co-ordinate regarding all interface requirements during Construction and Integrated testing stages.

- Lifts and Escalators for stations
- Railway Electrification OHE, (25KV AC) HV power supplies and SCADA
- Auxiliary substations up to the provision of bus ducts from transformer to LV Main Switchboards
- Track work
- Rolling Stock
- Signaling, Telecommunications
- Automatic Fare Collection

16 Scope of Electrical Work

16.1 The Power Distribution System shall provide power to various electrical loads within the stations, Ancillary Buildings, parking areas and circulating areas along the permanent way except that for Rolling stock and traction power.

16.2 Switchboards / Distribution Boards / Motor Control Centres, Consumer units, and specialized services through power supply isolating switches and distribution boards to all consumer points for lighting, general purpose power, lifts, escalators, signalling and communication equipment, illuminated signages and maintenance equipment.

16.3 It shall be the Contractor's responsibility to interface and obtain all details from System Wide Contractors to determine power supplies and load details requirements.

16.4 **Incoming Supply:**

Electrical power will be received from the Power Utilities via 220 or 66 / 33kV Transformers at the Receiving Sub-Stations. Distribution for auxiliary services throughout the stations of BSRP will be at 33 kV with most equipment operating through 33 kV / 415V Transformers at 415 Volts or below. All electrical equipment from 33kV rating up to the LV main Switchboard connected to the 415V outlet of the 33 kV / 415V transformers (excluding the supply of LV Main Switchboards with Tie Bus) will be in the scope of Power Supply Contractor.

The interface between the Contractor and the System Wide Contractor for Power Supply shall be the LV switchboard connected to the 415 V outlets from the two nos. of transformers in Axillary sub-stations on each station.

16.5 **Power Supplies Classification**

Power supplies to the various systems and sub-systems are classified into two categories.

- "Emergency"
- "Normal"

All the interlock/interchange stations will have a Stand-by Diesel Generators that will auto-start on concurrent loss of supplies from the 33 kV / 415V transformers. The capacity of the stand-by generator shall be sufficient to power, equipment's defined as "Emergency" loads.

Services designated as "Emergency" shall be connected to battery backed UPS systems with a minimum capacity of 120 minutes. Changeover of supplies shall be automatic on loss of supply voltage from "Normal" power supply source. The UPS system shall prevent equipment's deemed as "Emergency" from any perturbations in supply on changeover or loss of supplies.

Services designated as "Normal" shall be provided with dual supplies from the respective 33kV / 415V transformers with automatic changeover system but will not be connected to UPS and DG. In the event of the loss of supply from one 33 kV / 415V transformers, loads need be automatically transferred to the other 33 kV / 415V transformers at Auxiliary Substation of that station. The Loads designated as "Normal" will remain off in case of power failure of both the transformers.

16.6 **Service Categories**

16.6.1 **Emergency Services:**

- Fire detection and alarm system
- Security systems
- Emergency illuminated signs, exits, etc.
- Emergency lighting at station
- Control circuits
- Air conditioning for equipment rooms, if required for continuous operation
- Any additional UPS or critical elements, identified in the station design.

16.6.2 Normal Services

- All other services provided under the Contract, not covered above.

17 Design Considerations for Hydraulics System

The Design Criterion used for Definitive Design and preparation of Construction Reference Drawings are highlighted in this clause for the guidance of the Contractor. The Contractor must use these considerations for preparation of Detailed Engineering Design and Working Drawings.

17.1 **Water Supply Arrangement**

17.1.1 Stations shall be provided with water supply system for drinking water and fire-fighting system.

17.1.2 Stations are designed to provide water supply from existing BWSSB (Bangalore Water Supply and Sewerage Board) distribution network and are routed via water meter to underground water storage tanks from where it shall be distributed via domestic/booster pump set, through pipes running inside the station to various locations of usage.

17.1.3 Water Supply System at the Station consist of tanks installed below the ground level in ancillary building for meeting the requirements of domestic utilities, drinking water, station cleaning and fire storage.

17.1.4 The tanks shall be provided with automatic level monitoring and control system with automatic operation of various pumps and control valves. Low water level status in the storage tank for fire and domestic shall be displayed at station control room.

17.1.5 The storage capacity of Fire Water Tank and Service Water (Domestic) Tank at the stations are designed as per NBC 2016.

17.1.6 The water distribution network from Underground tanks shall be provided with pipelines for Over Head Tank, drinking water outlets and fire hydrant system with routings provided to the required locations.

17.1.7 The mains shall be divided into sections by provision of valves so that water may be shut off for repairs. Wash out valves shall be provided for repairs. Air valves shall be provided where required.

17.1.8 Status of bursting of water from sprinklers shall be relayed to station control room & OCC through SCADA.

17.1.9 Testing of the system shall be as per NBC. The entire pipe line system shall be hydraulically tested to a pressure of 0.5 N/mm2 or twice the working pressure whichever is greater for a specified period of 48 Hours after a steady state is reached.

17.1.10 Provision shall be made for standby pumping arrangement for station domestic pumps, fire hydrant and sprinkler pumps together with the Jockey pumps.

18 Design Consideration for Fire Detection & Alarm System

The Design Criterion used for Definitive Design and preparation of Construction Reference Drawings

are highlighted in this clause for the guidance of the Contractor. The Contractor must use these considerations for preparation of Detailed Engineering Design and Working Drawings.

18.1 **Fire Detection**

18.1.1 The Fire Detection and Alarm System (FDA) shall consist of Fire Control Panels, Repeater Panels, Fire Detectors, Control/Monitoring Devices and Audio/Visual annunciation equipments. Fire Alarm Control Panel shall be provided at station control room and shall be enunciated at Central Control/BMS.

18.1.2 Approval of fire detection system layout from Local Fire Control Authorities prior to commencement of work. And Clearance from Local Fire Control Authorities for energizing the systems after completion of work.

18.1.3 NFPA 130 shall be used as the guiding standard for the Fire Detection and Alarm System. System shall be designed in an integrated manner in accordance with NFPA 72D, British Standards BS 5445 and BS 5839, EN 54, ISO 7240 - 1, as appropriate or other internationally recognized or local code of practice approved by the Engineer/Employer. The requirements of Bangalore Fire and Emergency Services shall be incorporated into the system. The panel will contain logic circuit indicators, controls, and alarm and signalling circuits associated with a number of Detector Heads and Call Points distributed in detection zones.

18.1.4 Manual Call Points will be of the break glass type or controlled reset type. MCP shall be located adjacent to all fire exits and station entries. MCPs shall be positioned at a height of 1.3 m at strategic points throughout the station such that they are clearly visible from front and sides as practicable. MCPs shall be located within the reach of 30 metres from any point in the Station.

18.1.5 Operation of any call point connected to the system shall cause the station FACP to enter the ALARM State within three seconds.

18.1.6 Automatic smoke and heat type fire detectors will be located in all areas. The audible alarms will be 150 mm and 200 mm self-interrupting type alarm bells.

18.2 **Fire Suppression System**

18.2.1 Provision shall be made for Hydrants / hose reels, sprinklers and extinguishers. Wet fire main system shall be provided to cover the Platforms and Concourse Level. Sprinkler systems shall be provided for store rooms, Parking areas and other enclosed spaces with combustible loading.

18.2.2 All piping shall be in accordance with NFPA – 13, 14 & 15, fully hydraulically designed. Automatic sprinkler system shall conform to NFPA-13. Automatic Sprinkler Protection shall be provided for station concessions, storage areas, trash rooms and other similar spaces Sprinklers shall be of the quartzoid bulb type with standard temperature ratings. In case of above normal temperature, high temperature sprinklers suitable for the temperature condition shall be provided. Sprinkler systems shall include shut-off valves and check valves. The flow switch shall be monitored by the fire detection system.

18.2.3 Minimum of two Nos. of UL listed combined fire hydrant & sprinkler's pumps, including one standby together with a pressurizing jockey pump for hydrant system shall be provided. Secondary power supply will be provided for all the pumps. Fire Pumps are required to deliver water at sufficient pressure to ensure a hydrant pressure as per NFPA 14 at the furthest hydrant with a flow of required LPM. The jockey pump shall be arranged to operate in the pressurizing / duty / standby mode to ensure that the wet mains are pressurized at all times. The pumps shall be automatically powered by the standby generator in the event of a mains failure at Interlock/Interchange stations and Diesel pumps are to be provided at all Non-Interlock/Interchange stations.

18.2.4 Hydrants shall be mounted at platform within equipment cabinets. Hydrants shall be terminated with a landing valve. Each hydrant shall be housed in a Hose cabinet of suitable size. Internal hydrants cabinets located in public areas shall fit the niche made for it to prevent unobstructed movement of the passengers.

18.2.5 The Hydrant main shall be run from the Plant 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 diameter pipe-work. The Contractor 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.

18.2.6 Hose reels shall be of non-kinking reinforced flexible tubing with an internal diameter as specified in

codes. Hose reels should be 45 m in length and be manually operated. Hose reels shall be typically connected to a suitable size Ball 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 45 m of floor space or part thereof in the ticket hall and concourse areas.

18.2.7 Hose reels should be located 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 and spray of water into any recess area.

18.2.8 Portable fire extinguishers shall be provided as per provisions of National Building Code of India and shall have consent of Bangalore Fire and Emergency Services authorities. CO2 extinguishers shall be installed in all electrical switch rooms, sub-stations, platform equipment cabinets, operations rooms and communications rooms ABC (dry chemical powder) Type Portable chemical and foam type extinguishers shall be provided in DG Rooms.

18.2.9 Inert Gas based suppression system to be provided in all LT Panels and shall meet the requirements of NFPA 2001 and Montreal Protocol. Gas based suppression system completely shall be integrated with Fire Alarm & Detection System.

19 Building Management System

19.1 Building Management System (BMS) to be provided by Designated Contractor for Electrical, Fire, Hydraulics related works. The equipment or a system comprising several components shall be controlled through suitable control regime to achieve desired operation normally automatically but with provision for manual intervention. The automatic operation shall conform to the operational, functional and overall system needs as specified.

19.2 BMS shall enable monitoring through a station control panel on operator's desk, located at the station control room comprising mimic display, for commands and warning-cum-alarm units.

19.3 Transmission of DATA between various equipments and the station Control Panel (including the provision of Local Sequential Controllers/PLC). However, the Contractor must liaise with the BMS contractor regarding cables and other connections required between the equipment and the PLC/Local Sequential Controllers through suitable cableways. Cables shall be of approved make and quality as described in the specification.

19.4 Power Distribution System display will include the status of incomer Air circuit breakers of Main LV Panel and the voltage conditions on the bus bars from both Transformers. Transmission of these status information/DATA shall be wired to the PLC panel mounted in ASS.

20 Interface

Contractor shall ensure interface and coordination with all designated contractors concerning Mechanical and Electrical works as indicated in Appendix XIII.

20.1 SCADA System Interface

20.1.1 Interfacing between the BMS and Electrical & Mechanical equipment will require co-ordination. Contractor shall liaise with the BMS system supplier to ensure the interfacing between each system to meet the requirements of its respective specifications.

20.1.2 The control of E&M equipment normally shall be local from the Station Control Room except where the operation is required on a system wide basis and simultaneous operation of equipment is warranted at more than one station or an emergency situation is required to be controlled from the OCC.

20.2 Hydraulics, Fire Detection and Suppression system Interface

20.2.1 **Design Principles**

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. These include but are not necessarily limited to air handling units, air conditioning units and fans serving a zone affected by fire or smoke conditions. To facilitate connection work between sub-systems the Contractor shall provide terminal boxes and wiring to the control circuits of the appropriate units. Terminal box shall be located in each plant room

adjacent to the motor control panels taking into account all requirements for segregation of equipment and wiring.

20.2.2 **Initial Basis for Design**

During the preparation of detailed Design / Working Drawings the Contractor shall liaise with the BMS Contractor, and other Designated Contractors to determine all requirements for response and then subsequently provide the necessary facilities.

Contractor shall provide Hydraulics, Fire Detection and Protection System as per scope of works above, which will be controlled & monitored by BMS System. Indicative list of BMS Alarms and Controls to be provided for Hydraulics, Fire Detection and Protection System is given as Appendix II to General Specifications. However, it may be noted that this list is not complete and may be modified / updated as the design of BMS System progresses. Contractor will be required to interface with the BMS contractor regarding incorporation of Control and monitoring requirements of Hydraulics and Fire Systems in the Building Management System.

20.2.3 **Power and Lighting Interface**

The following items for each station shall be monitored and abnormal conditions shall be alarmed:

- Main switchboard LV incoming circuit breaker status.
- Incoming power lines (2 Nos) healthy.
- UPS Status (I/O voltage, indication, and position of bypass switch & battery voltage).
- Operation and Status of DG set, battery voltage for starting.

Alarm in case DG set has not run during the last seven days. Indicative list of BMS Alarms and Controls to be provided for Electrical Systems is given as Appendix I to General Specifications. However, it may be noted that this list is not complete and may be modified / updated as the design of BMS System progresses. Contractor will be required to interface with the BMS contractor regarding incorporation of Control and monitoring requirements of Electrical Systems in the Building Management System.

20.2.4 **Deleted**

21 General Requirements for E&M Equipment

21.1 Codes, Regulations and Standards

Unless otherwise stated, applicable international / local codes, standards and regulations specified in the Technical Specifications, shall govern the electrical and Mechanical works. System shall comply with the following codes of practices, standards, specifications and manuals wherever specified.

NFPA 130: 2010 - Fixed Guideway Transit Systems:
The Guides of the Chartered Institution of Building Services Engineers (CIBSE).

Acceptable Internationally recognized standards for this Contract are;

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BS	British Standards
BIS	Bureau of Indian Standards
DIN	Deutsche Industrie Normen
IEC	International Electro Technical Commission
IEEMA	Indian Electrical and Electronics Manufacturers Association
JIS	Japanese Industrial Standards
NEC	National Electrical Code (NFPA 70)
NEC	National Electrical Code (Indian)
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association

VDE Verband Deutsche Elektrotechniker
BS 7671: 1992 "Requirements for Electrical Installations"

In case, Standards and Codes for any specific element are not defined explicitly in Technical Specifications, Contractor may use applicable Standards or Codes from the above list with the approval of Engineer.

21.2 Unless otherwise stated, the E&M System design and execution shall comply with all applicable local regulations issued by the agencies listed below:

Indian Electricity Rules
Indian Electricity Act
National Building Code
Chief Inspector (Electrical) Govt. of Karnataka
Central Pollution Control Board
Bangalore Fire and Emergency Services
Karnataka State Public Works Department
Central Public Works Department
Bangalore Electric Supply Company (BESCOM)
Chief Electrical Inspector General for KRIDE
Bangalore Civic Administration
Bruhat Bengaluru Mahanagar Palike (BBMP)
National Safety Council

Any additional requirements imposed by local agencies not listed above shall be incorporated into the designs. The contractor shall prepare a checklist based on relevant standards for ensuring conformity in design, manufacture, supply / storage, packing, erection / commissioning and operation as applicable. The contractor shall obtain approvals from relevant authorities at appropriate stages of work.

21.3 **Voltage Levels**

21.3.1 The voltage level for power equipment shall be 415V, 3-phase or 240V, 1-phase, as required.

21.3.2 Motors rated 0.37 kW and larger shall be rated 415V, 3-phase, 50Hz and motors rated smaller than 0.37 kW shall be operated at 240V, 1-phase, 50 Hz.

21.4 **Acoustic Criteria**

21.4.1 Noise emanating from mechanical services installations shall not exceed the following levels:

Area	Noise Levels
At station Concourse, Platform and Ancillary rooms	55 dBA.
At the surface, when measured at the nearest property line of a residence, commercial building or industrial building:	
Urban, residential	50 dBA
Urban, mixed	55 dBA.
Urban, non-residential	65 dBA.
Industrial	65 dBA.

21.4.2 Noise emanating from the following equipment / service installations shall not exceed 55 dB for the static machines and 70 dB for rotating machinery at a distance of 1 metre to match or exceed the relevant international standards:

- At UPS room, auxiliary substation and pumping installations
- Exhaust fans

- Switch boards / Distribution Boards / Starter Panels
- Motors
- DG Set

21.5 **Certification of Personnel & Work**

21.5.1 Contractor should possess valid Electrical Contractor License (Grade-A or Class-1) issued by State Licensing Board, Government of Karnataka.

21.5.2 All the workmen & supervisory staff shall be qualified and certified license holders or have competence certificate from nationally / internationally recognized agency empowered to issue certificate for carrying out similar work.

21.5.3 Methodology shall be designed to obtain certification of the work through check list and standards. The installations shall be checked by a Quality Assurance team having the representatives from Employers and Contractor's side.

21.5.4 Contractor shall be responsible for including all safety aspects in his protection schemes etc. correct installation, testing & commissioning.

21.5.5 Contractor shall obtain prior approval for energisation from the Competent Authority in accordance with statutory regulations in force. Contractor shall list out such statutory requirements and shall issue a certificate of compliance in above respect before energisation.

21.6 **Corrosion Protection**

The contractor shall design to provide and state the corrosion protection systems used and the design life of the systems. The contractor shall show that the civil works and the electrical works have an adequate co-coordinated protection system, against all types of corrosions.

21.7 **Vibration Isolation**

Equipment producing vibrations shall be isolated from the structure by spring or rubber-in-shear vibration isolators. All piping and ductwork connected to this equipment shall contain flexible connections.

21.8 **Equipment Mounting**

21.8.1 Equipment to be mounted on the floor shall be placed on reinforced concrete equipment pads. Minimum pad height shall be 100 mm. The Contractor shall co-ordinate as necessary.

21.8.2 Wherever pipe work passes through brick, block or concrete walls or floors, pipe sleeves are to be provided by the Contractor. Pipe sleeves are to be of the same material as the pipe work. Split sleeves shall not be permitted. The space between pipe work and sleeve shall be filled with an approved sealant. The sealant shall be of adequate fire rating to meet the fire rating of the wall or floor. Back plates comprising ring flanges shall be fitted over all pipes emerging through walls, floors or partitions and fixed back to the surface. Material and finish shall match the pipe work in the space. Pipe work must be dismantled if rings are omitted at installation stage.

21.8.3 In cases where units are ceiling suspended, the support system shall be adequately braced to ensure stability during unit start up, operation and shut down.

21.9 **Maintainability**

21.9.1 Items such as knock out panels, double doors, floor drains and access hatches shall be provided by the Civil Contractor. The Contractor shall co-ordinate with Civil Contractor as necessary.

21.9.2 Sufficient clear space shall be provided around equipment to facilitate equipment removal and replacement and to allow for ease in equipment servicing. Provisions shall be made for shaft; tube and filter pull space, access door swings and removal of miscellaneous components.

21.9.3 Control system schematic diagrams shall be displayed in the vicinity of all control panels.

21.9.4 Piping system schematic diagrams shall be displayed in each plant room.

21.10 **Equipment Identification**

21.10.1 Equipment, control devices, valves and piping systems shall be permanently labelled by the Contractor after installation. The labels shall conform to a system-wide method. This method shall identify individual equipment items and provide information regarding equipment type, equipment

function, flow direction and other such data as appropriate. Identification shall be keyed to the control and piping schematics.

21.10.2 Each part of electrical equipment shall be numbered according to the number of the circuit breaker feeding the piece of equipment. Terminal cabinets shall be numbered sequentially.

21.10.3 Each equipment number shall be preceded by a letter designation as follows:

Automatic Transfer switch	ATS
Control Panel	CP
Disconnect Switch	Z
Fare Collection Power Panel	F
Generator	G
Lighting Panel boards, 415/240V	L
Motor	M
Motor Control Centre	MCC
Motor Starter	MS
Power Panel boards	P
Supervisory Termination Cabinet	STC
Switchboards	A
Switchgear	SWGR
Terminal Cabinet	TC
Transformer	TX
Uninterrupted Power Supply	UPS

21.10.4 Switchboards, cables, equipment, components and all other electrical equipment shall be rated for operation in ambient temperatures of 45°C and humidity up to 75%. Suitable derating factor may be used in selection of equipment, if equipment is not designed for these conditions.

21.10.5 In the design of switchboards an allowance of 20 – 25 % spare space capacity shall be provided for possible future expansion and all Main Switchboards shall be user friendly, modular and aesthetic design, termite and vermin proof. Spare capacity of 30% shall be provided for all cable trays, trunking, wire ways, (raceways), and brackets, for future expansion.

21.10.6 Wherever any form of cable containment passes through a fire rated wall or floor, then suitable fire stopping to provide the same level of fire integrity as the wall or floor shall be provided, after the installation of all cables. The choice of fire stopping material shall allow for easy removal and adjustment of the space to allow cables to be removed or added during the lifetime of the buildings without affecting the overall performance of the fire stopping material when reinstated. The fire stopping material shall be compatible with the type of cables installed through the fire barrier and due allowance shall be made in the cable calculations for any required correction factors due to the type of material used.

21.10.7 All equipment, cables and wiring shall be manufactured and installed so as to secure a service life as shown below:

Main Switch Boards	30 Years
Transformers	30 Years
Sub-Main Switchboards	30 Years
Cables	30 Years
Luminaires	20 Years
Tray, Trunking and Supports	30 Years
Lightning Protection	30 Years
Sub-Assemblies and Components	30 Years
Other Equipment	Minimum 20 Years

22 Functional Requirements for Fire and Hydraulics Systems

22.1 Functional Requirements for Pumping Installations

22.1.1 Water pump installations have been designed for unmanned operation, controlled through liquid level controllers, capable of pumping the requisite amount of water to the utility or to the overhead tanks.

22.1.2 The pumping installation shall withstand the corrosive effects of normal water supply and serve for the anticipated life of the equipment. The discharge velocity for drain pumping shall not be less than 0.75 m/sec.

22.1.3 The pipeline size is such that the velocity head does not exceed the normal static head except for the fire pump, which is governed by separate criteria. The valve controls and regulating mechanisms shall be designed for automatic operation.

22.1.4 The pumps shall have 100% standby arrangement. The centrifugal pumps, if provided, shall be of self-priming type. The efficiency of the pump set shall not be less than 95% of the maximum theoretical efficiency possible for that type of pump.

22.2 Functional Requirements for Fire Protection System

22.2.1 Fire Protection has been provided in accordance with the NFPA 130 and other related NFPA, BS, NBC and EN Standards within the stations and service buildings and shall comply with the requirements of Bangalore Fire and Emergency Service Regulations.

23 Drawings & Other Documents

23.1 Working drawings and Particulars to be furnished by the Contractor before Commencement of Work the Contractors shall submit three sets of following drawings and technical particulars for approval of Engineer/Employer before commencement of work at site/fabrication at manufacturer's work. The mode of submission and procedure for incorporations of comments by Engineer on such drawings, resubmission and final approval shall be as finalised at site by the Engineer.

23.1.1 **Electrical Works**

1. Conduit layout for lights, fans, socket outlets and sub-mains showing size of conduit, number and size of wires in each run, location and size of accessories like junction boxes, ceiling boxes, fan hooks, draw boxes, switch boxes, bends, size and route of earth continuity conductor, mode of fixing fittings and fixtures etc.
2. GA and schematic drawings of MV Switchboards/Distribution boards prepared by the manufacturer showing name of the manufacturer, material and size of sheet steel/bus-bars/interconnections and makes and ratings of switchgear including details of protection, metering, indication, interlocks and foundation details etc.
3. Index and marking schedule for cabling, wiring and earthing including the identification tags, markers and painting of values.

23.1.2 **Fire Detection Works**

1. Layout drawings showing details of detectors, response indicator units, local and main control units, speakers, amplifiers and fire control room etc.
2. Conduit layout for all components of fire detection and PA systems.

3. Details of fire detection cable routing showing size, type, and number of cables and mode of installations.
4. GA and schematic diagram of main control panel, amplifier racks etc.
5. Approval of concerned authority as required of layout/working drawing prior to commencement of works.

23.1.3 **DG Sets**

1. Fully dimensioned layout and sectional drawings of DG sets and associated accessories in the plant room, based on actual dimensions.
2. GA and schematic drawings of AMF panel including manufacturing details, makes of Components, details of cabling and earthing etc.
3. Details of civil works including fully dimensioned drawings of foundations with sections for D.G sets, floor trenches for pipes and cables, cut-outs for exhaust pipes, fuel piping etc.
4. Fully dimensioned drawings of piping layouts with support details for exhaust, raw water cooling and fuel systems and all associated ancillary works.

23.1.4 **UPS**

Fully dimensional layout and other schematic, cabling, earthing, control and protection drawings including manufacturing, fixing, foundation and installation details etc.

23.1.5 **High Mast Lighting**

Fully dimensional layout and other schematic, cabling, earthing, control and protection drawings including manufacturing, fixing, foundation and installation details etc.

23.2 **Manuals, As Built Drawings and other Documents.**

23.2.1 **Manuals**

The contractor shall provide/produce 5 copies of manuals in bound terms as approved by the Employer for all Contractor-supplied equipment and systems. These would typically include the following:

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

b. **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.

c. **Workshop Manuals**
Installation and circuit descriptions, full schematics, circuits, wiring diagrams, mechanical construction drawings and itemized parts list to enable all maintenance rectification and setting-up to be carried out.

d. **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.

e. **Maintenance and Servicing Manuals**
To specify 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.

f. **Commissioning Test Procedure and Test Values**
Shall cover commissioning test procedures for all the equipment and the final test values of the equipment on load, without load, protective earthing and avoid surprised failures.

g. **Condition Monitoring Manuals**
Shall cover the condition monitoring procedures, yardsticks, equipment wise condition norms etc. to facilitate monitoring of equipment and avoid surprised failures.

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

23.2.3 Contractor shall submit all Manuals for review by the Engineer prior to factory acceptance tests and the Contractor provide 3 copies of all Manuals well in advance and explain so as to understand the manuals by the user prior to commissioning.

23.3 **Other Documents**

The Contractors shall supply three sets of hard copies of the following after completion of work: Work shall not be deemed complete till this requirement is satisfactorily complied with. Two reproducible copies of such drawings shall also be submitted separately.

23.3.1 Deleted.
23.3.2 Deleted
23.3.3 Deleted
23.3.4 Deleted
23.3.5 Deleted
23.3.6 Deleted

24 Safety Authority

24.1 The Contractor shall note that the Commissioner for Railway Safety (CRS), a Government of India Statutory Safety Authority, may inspect the Works from time to time for the purpose of determining whether the BSRP Corridor Project complies with the operational and infra structural safety stipulations in accordance with the Laws of India. The Contractor shall note that CRS approval is mandatory for commissioning the system. Notwithstanding other provisions of the Contract, the Contractor shall ensure that the Works comply with the requirements of CRS in terms of design and quality of construction and shall assist the representatives of CRS in carrying out their inspection duties and also comply with their instructions regarding rectifying any defects and making good any deficiencies.

25 Safety Regulations

25.1 The Contractors shall, at his own expense, arrange for safety provisions as per safety codes of Indian Standards Institution, Indian Electricity Act and such other Rules, Regulations and Laws as may be applicable, as indicated below, in respect of all labour, directly or indirectly employed in the work for performance of the Contractors' part of this agreement.

25.2 While the Indian Electricity Rules 1956, as amended up to date, are to be followed in their entirety, particular attention is drawn to the variation clauses indicated in Appendix 'C'. Any installation or portion of installation which does not comply with these rules should be rectified immediately.

25.3 It shall be ensured that the control switches and distribution boards are duly marked, the distribution diagrams of sub-stations are prominently displayed, and the sub-station premises, main switch rooms and D.B enclosure are kept clean. Particular care should be taken to prevent the sub-station being used as store for inflammable materials, broken furniture, waste materials etc.

25.4 No inflammable materials shall be stored in places other than the rooms specially constructed for this purpose in accordance with the provisions of Indian Explosives Act. If such storage is unavoidable, it should be allowed only for a short period and in addition, special precautions, such as cutting off the supply to such places at normal hours, storing materials away from wring and switch boards, giving electric supply for a temporary period with due permission of Engineer shall be taken.

25.5 Rubber or insulating mats should be provided in front of the main switch boards or any other control equipment of medium voltage and above.

25.6 Protective and safety equipment's such as portable fire extinguishers rubber gauntlets or gloves, earthing rods, line men's belt, portable artificial respiration apparatus etc. should be provided in easily identifiable locations. Where electric welding or such other nature of work is undertaken, goggles shall also be provided.

25.7 Necessary number of caution boards such as "Man on Line, don't switch on" should be readily available in easily identifiable locations.

25.8 Standard first aid boxes containing materials as prescribed by the St. John Ambulance Brigade or Indian Red Cross should be provided in easily identifiable locations and should be readily available.

25.9 Periodical examination of the first aid facilities and protective and safety equipments provided shall be undertaken and proper records shall be maintained for their adequacy and effectiveness.

25.10 Charts (one in English and one in regional language) displaying methods of giving artificial respiration to any recipient of electrical shock shall be prominently displayed at appropriate places.

25.11 A chart containing the names, addresses and telephone numbers of nearest authorized medical practitioners, hospitals, Fire Brigade and also of the officers in charge shall be displayed prominently along with the First Aid Box.

25.12 Steps to train supervisory and authorized persons of the Engineering staff in the First aid Practices, including various methods of artificial respiration with the help of local authorities such as Fire Brigade, St. John's Ambulance Brigade, Indian Red Cross or other recognized institutions equipped to impart such training shall be taken, as prompt rendering of artificial respiration can save life at time of electric shock.

25.13 All new recruits should be given such First Aid Training immediately after appointment.

25.14 All supervisory and authorized persons of the Engineering staff should be deputed for refresher course in First Aid Training periodically.

25.15 Electrical wiring and control switches should be periodically inspected and any defective wiring, broken parts of switches which will expose live parts, should be replaced immediately to make the installations safe.

25.16 No work shall be undertaken on live installations, or on installations which could be "energized" unless dedicated trained person is present to immediately isolate the electric supply in case of any accident and to render first aid, if necessary.

25.17 No work on live L.T. bus bar or pedestal switchboards should be handled by a person below the rank of a licensed Wireman and such a work should preferably be done in the presence of the Contractor's Engineer.

25.18 When working on or near live installations, suitably insulated tools should be used, and special care should be taken to see that those tools accidentally do not drop on live terminals causing shock or dead short.

25.19 The Electrical Switchgear and distributions boards should be clearly marked to indicate the area being controlled by them.

25.20 Before starting any work on the existing installation, it should be ensured that the electric supply to that portion in which the work is undertaken is preferably cut off. Precaution like displaying "Men at Work" cautions boards on the controlling switches, removing fuse carrier "from theses switches and these fuse carriers being kept with the person working on the installation, etc. should be taken against accidental energization. "Permit to Work" should, be obtained from the Engineer. No work on H.T. main should be undertaken unless it is made dead and discharged to earth with an earthing lead of appropriate size. The discharge operation shall be repeated several times and the installation connected to earth positively before any work is started.

25.21 Before energizing an installation after the work is completed, it should be ensured that all tools have been removed and accounted, no person is present inside any enclosure of the switch board etc. any earthing connection made for doing the work has been removed, "Permit to Work" is received back duly signed by the person to whom it was issued in token of having completed the work and the installation being ready for re-energizing and "Men at Work" caution boards removed.

25.22 In case of electrical accidents and shock, the electrical installation on which the accident occurred should be switched off immediately and the affected person should be immediately removed from the live installation by pulling him with the help of his coat, shirt, wooden rod, broom handle or with dry cloth or paper. He should be removed from the place of accident to a nearby safe place and artificial respiration continuously given as contained in BIS. Code and Standard prescribed by St. John Ambulance Brigade or Fire Brigade.

25.23 While artificial respiration on the affected person is started immediately, help of Fire Brigade and Medical Practitioner should be called for an artificial respiration should be continued uninterrupted until he recovers or medical help is availed.

25.24 These instructions should be explained in English & Kannada.

26 Cleaning, Final Paining and Marking

26.1 All exposed steel work not actually embedded shall be painted as instructed. The Contractor shall be required to clean all equipment under erection as well as the work area and site at regular intervals to the satisfaction of the Engineer. In case the cleaning is not up to the satisfaction of the Engineer the same shall be got done at the Contractor's cost by the Engineer.

26.2 **Stage of Debris at Site**

Debris and wastes like cable cut pieces, conduit pieces etc. shall be stored only in an identified and approved location at site and shall be periodically disposed, so that the site is maintained clean and tidy.

27 Workmanship

Good workmanship is an essential prerequisite to be complied for this work. Skilled workers under competent supervision shall carry out entire work in the most workmanlike manner by skilled workers under competent supervision.

28 Certification of Work

28.1 The methodology shall be framed mutually agreed to certify the work, through checklists, standards progressively. The installations shall be checked by a quality assurance team of the contractor and approved by the Engineer.

28.2 The Contractor shall enlist the equipment assemblies / sub-assemblies/ components accessories and other movable components on successful installation and commissioning of the equipment.

28.3 The prior approval for energisation from the competent authority shall be obtained as per the statutory regulations in force. The Contractor shall be responsible for all safety aspects included and approved.

29 Maintenance During Defects Liability Period

29.1 The Contractor shall maintain the entire work covered in this contract as free of cost and specified electrical work as mentioned in BOQ during the defect's liability period of 24 months.

29.2 Contractor shall establish an office for the purpose with communication facility so as to facilitate communication for reporting failures and liaison with maintenance staff manning at the station round the clock. Contractor shall ensure early restoration /rectification/replacement to the satisfaction of Employer/ Engineer. The Employer Engineer in case of the delay as deem fit shall be empowered to carry out the maintenance at the risk and cost of the Contractor.

30 Training & Demonstration for Operating and Maintenance Personnel

30.1 The Contractor shall provide training to Operation and Maintenance staff regarding Operation and Maintenance of all equipment and systems installed. All training materials required for the intended training should be supplied by the contractor.

30.2 Prior to final inspection or acceptance, instruct designated operating and maintenance personnel in the operation, Setting/adjustments and maintenance of all equipment and systems.

30.3 Explain to O&M personnel to their complete understanding, all procedures necessary to operate and maintain all equipment and systems on a continuous basis.

30.4 Review the contents of the O&M Manuals with O&M personnel with complete detail to explain all aspects of the Manual and the operation and maintenance of all equipment and systems.

The Contractor shall arrange to provide all equipment/ accessories as required for the work as per the approved list of the makes as specified in the Technical specifications unless the change is approved by the Engineer in case of non-availability or better substitute in writing as per Para 5.4 above.

Alarm and Controls for Electrical Systems

(This list is not exhaustive; the Contractor shall include more items as per the system requirement and also interface with BMS contractor to finalise the Input/output for BMS)

Plant Room or Local digital control (LDC)		Station Control Room		OCC / SCADA
Metering / Monitoring	**Operation**	**Status**	**Alarm**	**Remote Data**
1. DG set				
Incoming HT supply to ASS 1&2 transformers OFF	Bus couplers OFF, start DG set, load breaker ON	Starting the DG set	Warning, Supply failed	D (1) warning
Start command from control panel	Start DG set with load breaker OFF, load breaker ON		-	-
Start command from Local or remote			-	-
DG set running		ON (OFF)	-	-
Incoming HT supply to ASS transformers ON	DG set OFF,		-	-
	Bus couplers ON			
DG set failed to start or tripped			Alarm	D (1) Alarm
Hours of operation	Log at LDC	-	Not run for more than a week (Alarm)	D (1) warning
Starter battery voltage	If low Log at LDC		Warning, Maintenance required	D (1) warning
Lube oil level	If low Log at LDC			
Fuel oil level	If low Log at LDC			
Radiator water level	If low log at LDC			
Output voltage	Log at LDC	Within range, indicate on load	Alarm, if out of range	D (1) Out of range alarm
Output frequency	Log at LDC			
2. UPS				
Input voltage low		-	Supply failed	D (1) warning if supply fails for more than 5 minutes
Input frequency low		-	-	
Battery failed	Start second battery	ON (OFF)	Warning, Maintenance required	
Charger failed	Start second charger			
Inverter failed	Start second inverter			
Control module one failed	-			
Control module two failed	-			
Second battery failed	-			D (1) Alarm

Plant Room or Local digital control (LDC)		Station Control Room		OCC / SCADA
Metering / Monitoring	**Operation**	**Status**	**Alarm**	**Remote Data**
Second charger failed	-		Alarm, immediate attention to the UPS	
Second inverter failed	-	-		
Hours of operation	Log at LDC	-	-	-
Output bus voltage low		-	Alarm, manual fault attention	-
UPS failed			Alarm	D (1) Alarm

Alarms and Controls for Hydraulic and Fire Systems

(This list is not exhaustive; Contractor shall include more items as per the system requirement and also interface with BMS contractor to finalise the Input/output for BMS

Plant Room or Local digital control (LDC)		Station Control Room		OCC / SCADA
Metering / Monitoring	**Operation**	**Status**	**Alarm**	**Remote data**
1. Fire Fighting Pumps (Hydrant & Sprinkler System Pumps)				
Operation of fire hose	Start the pump		Warning	D (1) warning
Hydrant main/ Sprinkler main pressure fall (major)		Pump 1/2	Hydrant/ Sprinkler pressure fall (major)	
Pump running	-	ON (OFF)	-	-
Pump failure	Start standby		First pump fail warning	D (1) warning
Standby pump fail	-		Second pump fail Alarm	D (1) Alarm
Manual bypass local or remote	-	-	-	-
Pumping completed	Alternating pumps	-	-	-
Hours of operation	Log at LDC	-	Not run for more than a week (Alarm)	D (1) warning
Voltage	Log at LDC	-	No volt warning	
Current	Log at LDC	-	-	-
Energy (power factor)	Log at LDC	-	-	-
2. Jockey pumps for Fire Fighting System (one jockey pump for fire system)				
Operation of fire hose	Start the pump	-	-	-
Hydrant main/ Sprinkler main pressure fall (minor)		-	-	-
Manual bypass local or remote			-	-

Plant Room or Local digital control (LDC)		Station Control Room		OCC / SCADA
Metering / Monitoring	**Operation**	**Status**	**Alarm**	**Remote data**
Pump running	-	ON (OFF)	-	-
Pump failed	-		Alarm	D (1) warning
Hydrant pressure	Stop pump if adequate, Log at LDC	-	Warning if low pressure	-
Hours of operation	Log at LDC	-	Not run for more than a week (Alarm)	D (1) warning
Voltage	Log at LDC	-	No volt warning	-
Current	Log at LDC	-	-	-
Energy (power factor)	Log at LDC	-	-	-
3. Standby Pumps for Fire Fighting System (Hydrant & Sprinkler System)				
Pipe pressure fall (high)	Start the pump		Warning	Warning
Manual bypass local or remote		-	-	-
Pump starting	ON (OFF)	-	Warning	D (1) warning
Pump failure		Start standby	Main pump fail warning	
Standby pump fail	-		Both pump fail Alarm	D (1) Alarm
Hours of operation	Log at LDC	-	Not run for more than a week (Alarm)	D (1) warning
Voltage	Log at LDC	-	No volt Warning	-
Current	Log at LDC	-	-	-
Energy (power factor)	Log at LDC	-	-	-

Functions	Plant Room or Local digital control (LDC)		Station Control Room		OCC / SCADA
	Metering / Monitoring	**Operation**	**Status**	**Alarm**	**Remote data**
4. Fire Detection and Alarm System					
Detector Public areas	Alarm situation	Signal at FAP	-	WARNING	D (1) warning
Detector Electric installation	Alarm situation	Release gas agent	-	WARNING	D (1) warning
Detector non-hazardous area	Alarm situation	Signal at FAP	-	WARNING	-
FACP	System fault	Fault indication	ON	WARNING	D (1) warning
	External fault	Fault indication	ON	WARNING	D (1) warning
	Processor fault	Fault indication	ON	WARNING	D (1) warning

Functions	Plant Room or Local digital control (LDC)		Station Control Room		OCC / SCADA
	Metering / Monitoring	Operation	Status	Alarm	Remote data
	Device isolated / Device fault	Fault indication	ON	WARNING at fixed interval	D (1) warning
	Voltage	Log at LDC		No volt warning	-
	Maintenance Alarm	Device fault		WARNING	-
	Battery voltage	Log at LDC		WARNING	-
FACP	Detection in platform / concourse	1. Audible & visual alarm	ON	WARNING	D (1) warning
		2. Alert station staff			
		3. Alert line controller			
		4. Initiate operation of public address system			
		5. Initiate fire suppression system			
		6. Illumination of station entry sign			
		7. Initiate fire closure door			
		8. Initiate smoke extraction measures			
MCP	Operation of MCP	Signal at FAP	ON	WARNING	-
Sprinkler	Rise in temperature	Start pump	ON	WARNING	D (1) warning
Hydrant	Low Pressure in pipes	Start pump	ON	WARNING	

31 Manufacture, Installation and Testing

This Employer's Requirements establish the overall procedures to be followed by the Contractor for works under this contract relating to manufacture, procurement and delivery of plant and equipment and their installation, testing and commissioning.

31.1 Manufacturing

31.1.1 Management

Contractor shall establish procedures and controls that govern the procurement, integration, manufacture, testing, quality assurance and delivery of plant, equipment and spares to be supplied under the Contract. This shall include the administration and supply of spare parts and warranty in accordance with the Contract. Contractor's Manufacturing Management Plan shall be submitted to

the Engineer for his review within 45 days of the Date of Commencement.

31.1.2 **Procurement Management**

Contractor's management systems and procedures shall incorporate a procedure for materials procurement, sufficient to assure technical and quality controls consistent with those of this contract. Contractor's management system shall be auditable for materials sources, lot numbers, serialised equipment, etc.

31.1.3 **Manufacturing and Production Management**

Contractor's manufacturing and production management system shall encompass all points of receiving raw material and components, processing, fabrication, assembly, testing and all points of in-process inspections. Contractor shall submit manufacturing data as part of the Manufacturing Management Plan, which shall contain:

- A brief description of all inspection holds points and test points, and a correlation with the Programme Schedule;
- GAD, QAP and GTP shall be approved by Engineer prior to commencement of Manufacturing;
- A delivery schedule of each item of equipment to match installation plan;
- Manufacturer's Qualifications: The equipment manufacturer shall show at least ten years of continuous and current experience in the design, assembly and testing of similar equipment as being offered complying with the tender specifications.

31.2 **Testing**

A comprehensive testing programme shall be provided by the Contractor that shall include complete equipment, their subsystems, components and material to assure compliance with the Specifications. The purpose of the comprehensive testing programme shall be to:

- Substantiate performance characteristics;
- Ensure operational compatibility;
- Complete equipment verification and acceptance requirements; and
- Complete all reliability, maintainability and safety demonstration requirements.

31.3 **Quality Assurance and Controls**

Contractor's Management Systems shall emphasize quality assurance and controls. The programme shall be adequate to ensure an acceptable level of quality of the equipment supplied. The concept of total quality assurance shall be based on the principle that quality is a basic responsibility of the Contractor's organization, and shall be evidenced by:

- Firm procurement and job performance specifications;
- Firm procedures for transmission of information and data to their Subcontractors and ensuring their compliance;
- Adequate testing to ensure repetitive product conformity to design requirements; and
- total programme of surveillance and verification of physical performance and configuration accountability.

Adequate records shall be kept by the Contractor to provide evidence of quality and accountability. These records shall include results of inspections, tests, process controls, certification of processes and personnel, discrepant material, and other quality control requirements.

Inspecting and testing records shall, as a minimum indicate the nature of the observations made, and the number and types of deficiencies found and action proposed to correct deficiencies. Also, records for monitoring work performance and for inspecting and testing shall indicate action taken for the correction of deficiencies.

31.4 **Shipping**

Contractor's Manufacturing Management Plan shall provide for the proper inspection of equipment to ensure satisfactory completion of manufacturing and testing / check prior to shipment. All shipments shall be adequately prepared to preclude damage during shipment.

31.5 **Handling, Storage and Delivery**

Contractor's Manufacturing Management Plan shall provide for adequate work and inspection instructions for handling, shipping, storage, preserving, packing, marking, and shipping to protect the quality of the equipment and to prevent damage, loss, deterioration, degradation or substitution thereof.

Handling procedures shall include the use of special crates, boxes, containers, transportation vehicles, equipment and facilities for materials handling.

Means shall be provided for protection against deterioration or damage to equipment in storage.

31.6 **Installation**

31.6.1 **Installation Plan and Programme**

The Installation Plan shall show how the Contractor proposes to organise and carry out the Installation and complete the whole of the Works within the stipulated time. Contractor shall submit the Plan for the review by the Engineer at least 30 days prior to the start of Installation on Site.

Contractor shall attend weekly planning meetings with the Engineer to finalise the work detail, commencing 4 weeks prior to the start of Installation on Site.

31.6.2 **Method Statement**

The Method Statement shall be submitted to the Engineer for review at least 30 days prior to the installation activity commencing On-Site. This shall show in particular the loadings and modes of transport of the items of equipment and the routing used as they are taken to their final locations.

Prior to proceeding with installation, the Contractor shall submit for the Engineer's consent three copies of detailed drawings showing all installations including dimensions, supports, hardware, installation methods, and all other pertinent data.

The manufacturer's rigging or erection instructions shall be carefully followed. Contractor shall make certain that the installation of all supports, gaskets, hardware, etc., are accomplished with precision and ensure exercise of extreme care so as to assure safe, accurate and trouble-free installation. Installation shall be undertaken in the presence of the Manufacture's Field Service Representative.

Equipment that is improperly installed shall be removed, checked / tested and reinstalled. Any damage caused due to improper installation and removal shall be rectified before reinstalling at no extra cost.

Contractor shall submit the Installation Testing Plan (ITP) for major E & M items (e.g. Panels etc.) for approval by Engineer and installation and testing shall be carried out according to approved ITP.

31.6.3 **Contractor's Resident Staff**

Contractor shall ensure that a qualified representative of the manufacturer is available on-Site for the duration of the On-Site Works during normal working hours and installation period and on-call to arrive on Site within 60 minutes at all other times.

Manufacturer's Representative shall support the Contractor's Representative during the Installation and Testing phase of the Works.

Contractor's Representative shall have sufficient authority to progress the Contractor's work on Site. Contractor's Representative shall be competent and qualified to act on behalf of the Contractor, and provide upon request information that may include:

- Current progress of the Works;

- Planned work for the next 5 weeks;
- Audit and inspection reports;
- Health and safety information; and
- Documents and records pertaining to the Works.

31.6.4 **Drawings and Records**

a. General

Contractor shall provide 3 copies of all drawings in A3 size, bound into circuit books

- Contractor shall ensure that, at each equipment location, an as-built copy of the following Site documentation is provided.
- Power supply arrangement;
- Earthing & bonding arrangement; and
- Cable circuit information.

b. Cable Records

Contractor shall ensure that the as-built cabling infrastructure is fully documented and accurate at the time of substantial completion of the Section. The documentation shall include:

- Schematic of the cable routes;
- Location of cable joints;
- Cable types;
- Installed dates;
- Test data before and after installation; and
- Core plan indicating the circuit and function of each core.

Contractor shall be responsible for adding to all of the Combined Services Drawings the cable installation details and for the timely supply of these marked up drawings to the Engineer for overall co-ordination.

31.6.5 **Materials**

(1) Materials and goods for inclusion in the Permanent Works shall be new.
(2) Certificates of tests by manufacturer, which are to be submitted to the Engineer, shall be current and shall relate to the batch of material delivered to the Site. Certified true copies of certificates may be submitted if the original certificates could not be obtained from the manufacturer.
(3) Parts of materials, which are to be assembled on the Site, shall be marked to identify the different parts.
(4) Materials which are specified by means of trade or proprietary names may be substituted by materials from a different manufacturer which has received the consent of the Engineer provided that the materials are of the same or better quality and comply with the specified requirements.
(5) Samples of materials submitted to the Engineer for information or consent shall be kept on the Site and shall not be returned to the Contractor or used in the Permanent Works unless permitted by the Employer/Engineer. The samples shall be used as a means of comparison, which the Engineer shall use to determine the quality of the materials subsequently delivered. Materials delivered to the Site for use in the Permanent Works shall be of the same or better quality as the samples, which have received consent.

32 Testing and Commissioning

32.1 General

Contractor shall perform all forms of test procedures applicable to the system and shall conduct factory, site installation and acceptance tests.

The commissioning activity shall include a period of the Integrated System testing followed by a period of Trial Running and inspection by the CMRS and a period for staff training and familiarization.

32.1.1 **Test Programme and Procedures**

Unless agreed in writing by the Engineer, personnel engaged on testing shall be independent of those personnel, responsible for, installations of the same equipment.

All Test equipment shall carry an appropriate and valid calibration label. They shall be periodically checked for calibration accuracy.

All reports of Tests shall be signed by the Contractor.

Contractor shall present a comprehensive Testing and Commissioning Programmes within 3 months from the Date of Commencement of works.

All Test procedures shall be submitted at least 30 days prior to conducting any Test. Test procedures shall show the extent of testing covered by each submission, the method of testing, Acceptance Criteria, the relevant drawing (or modification) status, and the location.

Test Procedures shall be amended, as required, by the Contractor during the currency of the contract to reflect changes in system design or the identification of additional testing requirements.

The Employer, the Engineer and/or any of their staff shall have the facility to monitor all Tests and have access to all Test records.

All costs associated with Testing shall be borne by the Contractor, unless otherwise specified, including the services of any specialised personnel or independent assessors. Contractor shall also bear any expenses incurred due to re-testing caused by defects or failure of equipment to meet the requirements of the Contract in the first instance.

In the event of any tests being performed in countries other than India, the Contractor shall give sufficient notice to the Engineer for witnessing the tests. The cost of the Engineer's visit shall be borne by the Employer.

Contractor is reminded that, at some point, the traction system will be energized and that additional precautions for the safety of staff and co-ordination of activities after "power-on" shall be anticipated in his installation, testing and commissioning programmes.

32.1.2 **Sequence of Tests**

The sequence of tests shall be:

- Type tests;
- Factory acceptance tests (FAT) or works test;
- Installation tests;
- Partial acceptance tests (PAT);
- Functional tests;
- Integration tests;
- System acceptance tests (SAT);
- Integrated Tests;
- Tests on completion.

32.1.2.1 **Type Tests**

Unless agreed otherwise, type tests certificates from an accredited laboratory acceptable to Engineer should be provided for all equipment supplied under this contract. Should the Contract include any equipment not previously proven in service or of any modified design the Contractor shall undertake the thorough testing of the units at pre-production stage to the satisfaction of the Engineer. Contractor shall identify in his tender any equipment in this category or equipment that differs significantly from that already in service elsewhere.

Type tests including prototype shall be performed prior to full production and before Factory Acceptance Test (FAT).

Type testing shall be used to confirm that the proposed equipment is fit for purpose in the environmental conditions specified and meets the requirements of the Specifications.

32.1.2.2 **Factory Acceptance Tests (FAT)**

Works Tests shall include but not be limited to:

- Physical inspection
- Dimension check
- Electrical check
- Calibration
- Operational performance
- Full Load test
- Flash-over test
- Insulation test
- Any other test required as per relevant standards or codes

A Factory Test Plan shall be submitted for the Engineer's review within 3 months from the Date for Commencement of the Works.

All materials, components, sub-assemblies, unit assemblies (including software, cables and wiring) shall be subject to testing and certification. Notification of these Tests shall be submitted to the Engineer at least 30 days in advance of carrying out any such Test. Engineer will then determine which, items if any, may be accepted based on previous supply or experience.

Factory Acceptance Test (FAT) shall demonstrate that each sub-system and the System meet its functional specification.

No equipment or software shall be delivered to the Site until the Contractor has demonstrated to the satisfaction of the Engineer that the equipment or software conforms to the Specification by carrying out the FAT.

Where necessary, interfaces shall be represented by simulation.

Where processor-based equipment is to be used, the Works Tests shall also include, verification of software used in such application.

32.1.2.3 **Installation Tests**

32.1.2.3.1 **Prerequisites for Installation**

Prior to installation, Contractor shall ensure that equipment delivered to Site has not been damaged in transit and that their dimensional accuracy has not been impaired.

Designs for the Sections under test shall be completed and submitted to the Engineer for review prior to Installation

32.1.2.3.2 **Inspection**

The inspection shall verify that equipment has been installed as per the procedures and design that have been reviewed and consented by the Engineer and that equipment is correctly located and labelled.

The inspection shall verify that any false feed, temporary wiring and redundant items have been removed and that equipment is correctly protected against interference, damage and deterioration.

Contractor shall maintain inspection records to demonstrate that each item of equipment has been inspected and found to be satisfactory and attach to this record a detailed list of any discrepancies found and remedial work carried out.

As defects are rectified, these shall be recorded on the appropriate inspection record.

32.1.2.3.3 **Installation Tests**

Installation tests shall be carried out by the Contractor for each sub-system following Installation, but before Functional tests, to demonstrate that the installation has been carried out correctly and equipment is properly housed and fixed.

During and on completion of an installation, Contractor shall undertake testing of all cables, wiring and equipment, instrumentation and protection devices, in a progressive sequence and in accordance with the overall-testing programmes. These tests shall culminate in Functional Tests to verify the correct operation of all apparatus and, where appropriate, correct response to the respective control commands or monitored function.

32.1.2.4 **Partial Acceptance Tests (PAT)**

Installation work shall be completed and inspection records submitted to the Engineer for review before the commencement of each PAT.

The PAT Plan shall be submitted for the Engineer's review at least 30 days before the commencement of each PAT

32.1.2.5 **Functional Tests**

The functional tests of the PAT shall be carried out on installed equipment before System Acceptance Tests (SAT) to demonstrate that the Section of the Works operates correctly in accordance with the Specifications.

The functional tests shall sequence through all required operations to prove that the System performs in accordance with the Specifications and that the Local configuration data (for example, control tables) is correct.

Where necessary, input conditions shall be simulated.

The functional tests shall be specified and carried out by the Contractor's personnel independent of design and installation.

32.1.2.6 **Integration Tests**

Partial Acceptance Test (PAT) shall include integration tests to integrate the various sub-systems of the System and demonstrate correct operation of all internal and external interfaces.

Following satisfactory completion of these Tests, Contractor shall prepare the installation for formal demonstration in the presence of the Engineer.

32.1.2.7 **System Acceptance Tests (SAT)**

Contractor shall prepare and organise a comprehensive programme of Tests to demonstrate to the Engineer that all systems, sub-systems and apparatus defined under the Contract meet the specified performance requirements in all respects.

32.1.2.7.1 **Prerequisites for SAT**

The requirements that shall be satisfied before the commencement of the System Acceptance Tests (SAT) are:

- All documentation for the Safety Report shall be submitted to the Engineer for review.
- All PAT shall be completed and test records submitted to the Engineer for review.

- Facilities for the maintenance of the System shall be in place.

The SAT Plan shall be submitted to the Engineer for review at least 30 days before the commencement of the SAT

32.1.2.8 **Integrated System Tests**

a. Before the commencement of integrated tests, the contractor shall complete his own internal tests. The contractor shall submit list of specifications for integrated tests to the Engineer for accordance approval prior to commencement of the tests.
b. Contractor shall submit to the Engineer requirements and procedures, in respect of the Contractor's scope of work, for Integrated System Tests in conjunction with the Designated Contractors to demonstrate that the complete system provided under the Contract is fully operational and meets the specified performance criteria. The conducting of these Integrated System Tests, by the Contractor and the Designated Contractors, shall include a period of Test running.

32.1.3 **Batches, Samples and Specimens**

32.1.3.1 A batch of material is a specified quantity of the material that satisfies the specified conditions. If one of the specified conditions is that the material is to be delivered to the Site at the same time, then the material delivered to the Site over a period of a few days may be considered as part of the same batch if in the opinion of the Engineer there is sufficient proof that the other specified conditions applying to the batch apply to all of the material delivered over this period.

32.1.3.2 A sample is a specified quantity of material that is taken from a batch for testing and which consists of a specified amount, or a specified number of pieces or units, of the material.

32.1.3.3 A specimen is the portion of a sample that is to be tested.

32.1.3.4 Samples shall be of sufficient size and in accordance with relevant Standards to carry out all specified tests.

32.1.3.5 Samples taken on the Site shall be selected by, and taken in the presence of, the Engineer and shall be suitably marked for their identification. An identification marking system should be evolved at the start of works in consultation with the Engineer.

32.1.3.6 Samples shall be protected, handled and stored in such a manner that they are not damaged or contaminated and such that the properties of the sample do not change.

32.1.3.7 Samples shall be delivered by the Contractor, under the supervision of the Engineer, to the specified place of testing. Samples on which non-destructive tests have been carried out shall be collected from the place of testing after testing and delivered to the Site or other locations as instructed by the Engineer.

32.1.3.8 Samples that have been tested may be incorporated in the Works provided that:

- The sample complies with the specified requirements
- The sample is not damaged; and
- The sample is not required to be retained under any other provision of the Contract.

32.1.3.9 Additional samples shall be provided for testing if in the opinion of the Engineer/Employer.

- Material previously tested no longer complies with the specified requirements; or
- Material has been handled or stored in such a manner that it may not comply with the specified requirements.

Unless agreed otherwise, all Tests shall be carried out by the Contractor in the presence of the Engineer and/or his authorised representative.

Attendance on Tests, including that by the Employer, the Engineer and/or their authorised representative, and the Contractor, shall be as laid down in the Quality Assurance procedures.

32.1.4 **Testing**

32.1.4.1 Contractor shall be responsible for all on-site and off-site testing. All appropriate laboratory tests shall be carried out in the Contractor's laboratory at site, unless otherwise permitted or required by the Engineer. Where the laboratory is not appropriately equipped and/or staffed for some tests, or if

agreed to by the Engineer, tests may be carried out in other laboratories provided that:

(a) They are accredited for the relevant work to a standard acceptable to the Engineer; and

(b) Particulars of the proposed laboratory are submitted to the Engineer for his consent

32.1.4.2 In-situ tests shall be done in the presence of the Engineer.

32.1.4.3 Equipment, apparatus and materials for in-situ tests and laboratory compliance tests to be carried out shall be provided by the Contractor. The equipment and apparatus shall be maintained by the Contractor and shall be calibrated before the testing starts and at regular intervals as directed by the Engineer. The equipment, apparatus and materials for in-the situ tests shall be removed by the Contractor as soon as practicable after the testing is complete.

32.1.4.4 Contractor shall be entitled in all cases to attend the testing carried out in the Employer's or other laboratories, to inspect the calibration certificates of the testing machines and to undertake the testing on counterpart samples. Testing of such samples shall be undertaken in laboratories complying with Clause 2.4.3.1 above and particulars of the laboratory proposed should be submitted to the Engineer for consent prior to the testing.

32.1.4.5 Attendance during tests including that by the Engineer, the Contractor and the Designer shall be as laid down in the Quality Assurance procedures.

32.1.5 **Compliance of Batch**

32.1.5.1 The results of tests on samples or specimens shall be considered to represent the whole batch from which the sample was taken.

32.1.5.2 A batch shall be considered as complying with the specified requirements for a material if the results of specific tests for the specified equipment comply with the specified requirements of the equipment.

32.1.5.3 If additional tests are permitted or required by the Engineer but separate compliance criteria for the additional tests are not stated in the Contract, the Engineer shall determine if the batch complies with the specified requirements for the material on the basis of the results of all tests, including the additional tests, for every equipment.

32.1.6 **Records of Tests**

Records of Tests, carried out shall be kept by the Contractor and a report along with all Test results shall be submitted to the Engineer no later than 15 days after completion of the Test. In addition to any other requirements, the report shall contain the following details:

- Material or part of the Works tested;
- Location of the part of the Works;
- Place of testing;
- Date and time of tests;
- Technical personnel supervising or carrying out the tests;
- Equipment used and method of testing;
- Readings and measurements taken during the tests;
- Test results, including any calculations and graphs;
- Specified acceptance criteria;
- Other details stated in the Contract.

32.1.7 **Testing, Commissioning & Validation**

32.1.7.1 Testing, Commissioning and Validation Plan

The Contractor shall be required to submit the Testing and Commissioning Plan which shall include a schedule of tests with the identified standards to which the tests are to be carried out. The Contractor shall update the Plan as necessary. The Plan shall include the following:

a) A detailed description of the testing and commissioning philosophy and the testing & commissioning process including the demonstration of a successful interfaces with other systems.

b) Details of the testing & commissioning organization to be setup by the Contractor, including staff responsible for testing & commissioning activities.

c) Descriptions of methods and procedures for testing & commissioning, procedure for the setup of all test equipment with necessary supporting documentation.

d) Details of the testing & commissioning schedule, management and coordination requirements.
e) Details of how safety shall be addressed for all personnel and equipment during testing and commissioning.
f) Details of all testing & commissioning standards and guide lines that the Contractor shall follow.

The Contractor shall submit test specifications for all tests including integrated tests to the Engineer for acceptance prior to the commencement of the tests.

The Contractor shall perform testing and commissioning of all the fire protection system.

The Contractor shall provide all necessary facilities, labours, instruments, materials, inert gas, fuel and power to carry out such testing and commissioning to verify and validate that the installation meets the requirements.

32.1.7.2 **Hydrostatic Test**

All hydrostatic tests shall be conducted for a period of 48 at two (2) times the specified working pressure. The Contractor shall record all test figures together with schedules of pipe lengths and shall note that testing will be witnessed by the Engineer. A pressure drop of not more than 3% after 48 hours will be acceptable.

32.1.7.3 **Tests of Acoustic and Vibration**

a) Sound level readings and vibration tests shall be conducted in DG, fan and pump rooms during construction of the works and at any other time as desired by the Engineer.
b) Sound level readings shall be taken with correctly calibrated octaveb and sound level meter at designated spaces as desired by the Engineer.

32.1.7.4 **Electrical Test**

The following tests shall be carried out to the satisfaction of Engineer:

1) Verification of polarity
   To ensure that all fuses and single pole control devices are connected to the live conductor only.
2) Insulation resistance tests
   Insulation resistance tests shall be carried out at 240V single phase and at 415V three phase circuits for:
   i) Line to line
   ii) Line to earth
   iii) Neutral to Earth
   iv) Line to Neutral
3) Earth Continuity Test
4) The test shall be carried out by means of a line-earth loop test or neutral earth-loop test in accordance with IEE regulations.
5) Battery capacity of the FDA system shall be tested by tripping the AC supply (normal and emergency) and by setting the entire system under alarm condition. Time period for which the battery can support the system shall be recorded.

32.1.7.5 **Test at Manufacturer's Factory and On Site**

The tests at Manufacturer's factory shall include all tests in accordance with the relevant standards and any tests called for by the Engineer to ensure that the Plant being supplied meets the requirements of the Specification. For material / equipment not covered by any standard or specifically mentioned in this Specification, the tests shall be done as agreed by the Employer/Engineer.

The Contractor shall supply and install all materials, supplies, labour and equipment/instrument required for testing at site. The Contractor shall make preliminary tests and prove the Works as satisfactory. The Contractor shall notify the Engineer well in advance to be present for final testing of all materials / equipment. The Contractor shall replace defective Works with new Works for defects identified/disclosed by tests or, if required by the Engineer. The Contractor shall conduct tests in stages if so directed by the Engineer to facilitate work of others.

For all pipe work, all necessary testing junctions and bends shall be supplied & installed and sealed off or removed as directed by the Engineer.

32.1.7.6 Site Tests during Construction

a. The pressure tests shall be carried out on site in convenient sections during the construction of the Works.
b. Before the tests are carried out, the Contractor shall remove connected equipment and components which are liable to be damaged under test, and shall provide and fix all necessary gauges, blanking flanges etc.

32.1.7.7 Preliminary Commissioning Checks

a. The Contractor shall ensure that all equipment are thoroughly cleaned, lubricated and checked for serviceability immediately before setting to Works. The Contractor shall pay particular attention to the removal of building debris from the pipe work systems.
b. The Contractor shall pay special attention to the need to thoroughly flush out all pipe work systems to ensure that all foreign matters are removed.
c. The Contractor shall inspect and check all automatic controls and safety devices for serviceability before the working fluid or electricity is applied to the system.

32.1.7.8 Commissioning

When the various installations have been completed and the preliminary commissioning checks carried out, the Contractor shall set to work, regulate and calibrate all systems in the entire installation. Special attention shall be paid to the following items.

a. That all valves, switches and controls etc. are regulated and capable of proper operation and in the case of isolation valves that they are capable of tight shut off.
b. That all instruments are correctly calibrated and read accuracy.
c. That all services are tested in accordance with the details in the relevant clauses of the Contract specifications and relevant standards.
d. Pumps, pressure reducing sets, etc. shall be operated to ensure that all control systems are functioning correctly and are properly set, sequenced or interlocked.

32.1.7.9 Performance Tests

a. After the Works have been completed, the Contractor shall be required to carry out or assist in carrying out the performance tests.
b. Performance tests for all installations shall be carried out to demonstrate that they function in accordance with the intent of the Contract Specification.
c. Should the performance tests prove that the equipment do not comply with the requirements of the Contract Specification, the Contractor shall be responsible for the rectification, modification or replacement of the equipment and/or system as required by the Engineer.

32.1.7.10 Final Acceptance Tests

a. Following commissioning of the entire installation, the Contractor shall carry out final acceptance tests in accordance with a programme to be submitted to the Engineer for Notice of Clearance.
b. Should the results of the acceptance tests show that plant, systems and/or equipment fail to perform to the efficiencies or other performance figures as given in the Contract Specification, the Contractor shall adjust, modify and if necessary replace the equipment without any additional cost implications to the Employer in order that the required performance be obtained.
c. Where acceptance tests are required by the relevant authorities having jurisdiction, these tests shall be carried out by the Contractor, the proposal for which shall be submitted to the Engineer for Notice of Clearance.

32.1.7.11 Integrated Testing and Commissioning (ITC)

a. Before the commencement of integrated tests, the Contractor shall complete his own local tests. The Contractor shall submit test specifications for integrated tests to the Engineer for Notice of Clearance, prior to the commencement of the tests.
b. The Contractor shall coordinate with the civil works and System Working Contractors in preparing an integrated system test plan to test all the points/installations. All testing tools and manpower required for the tests, which will be witnessed by the Employer/Engineer shall be provided by the respective Contractors. The integrated system test plan shall at least include:
    1. The scope of the integrated testing,

2. The objective of the tests and the associated design and operating criteria to be proved / demonstrated,
3. The pass / fail criteria of the test,
4. The inter-dependency and interaction with all systems supplied and those supplied by other interfacing contractors and their integrated testing programme,
5. The systems / equipment required to be completed by other interfacing Contractors for each test,
6. A schematic diagram of the integrated tests in the sequence they are to be carried out,
7. A narrative explaining the integrated testing process and methodology, with cross-reference to the schematic diagram,
8. The write-up format explaining the test basic,
9. Estimated duration of the contractor's involvement in each test.

c. The contractor shall generate or emulate data signals for the points/ installations being tested. Emulation shall be used only if real time signal generation is not possible or impracticable.

d. On completion of tests or test cases, both interfacing contractors shall endorse the test records for submission to the Employer. Where a failure is recorded in any test cases, the interfacing contractors shall reschedule another test regardless if where the fault or defect lies.

e. The contractor shall be responsible for taking the lead in conducting the ITC of Fire Alarm system, clean gas system, pre-testing the activation and re-setting the associated Fire Alarm devises and panels of the clean gas room.

f. Fire Alarm tests:
   1. Active Voice communication system
   2. AMS
   3. AFC gates
   4. M&E SCADA
   5. ECS/HVAC
   6. Fire Roller Doors if any
   7. Lifts & Escalators
   8. Door Access Control systems & Security systems
   9. Power supply & Traction
   10. Signaling, Telecommunication & PSD

g. Clean gas test including VESDA system

The Objective of the clean gas test are to verify and validate the correct sequences and operations of the clean gas test system within a clean gas protected room in the event of fire alarm within protected area.

32.1.7.12 Integrated Factory Acceptance Test (IFAT)

The contractor shall undertake an Integrated Factory Acceptance Test which will be held in the manufacturer's factory. Such IFAT shall be done in the presence of the Employer.

A 100% input/output check simulated data may be used subject to the approval by the Employer. The contractor shall be responsible for planning, programming, coordinating, preparing, managing and executing the IFAT.

This IFAT will be the final proving of the interface design prior to on site interface tests and commissioning. The contractor is required to coordinate and agree on the schedule of IFAT ad provide input in the preparation of IFAT plan & procedures.

The contractor shall provide the Testing, Commissioning & Validation certificate after the successful installation, Testing & commissioning, Validation of the systems in accordance with the applicable standards and the contract documents.

32.2 **Maintenance**

Contractor shall provide a maintenance support plan that shall include such items as:

- Operating and Maintenance Instructions which describe the procedures for operating and maintaining each item, unit / equipment and which will include all technical data for its operation, routine inspection/survey, routine maintenance, periodic overhaul, test running & procedures for removal.
- Replacement of components and test running.
- Parts catalogue along with Pricelist and Recommended List of Spares for One Year's operation and for 10 Years of Operation after Defects, Liability Period
- List of Special Tools, Material Handling Equipment, Jigs and Fixtures required for dismantling & assembling and test/diagnostic equipment for Performance Monitoring/Maintenance
- List of M&P, T&P, Testing Instruments, Material Handling Equipment, Jigs & Fixtures etc. required for Maintenance to be submitted
- Periodic running of equipment and machines, which would otherwise deteriorate because of non-operation for more than a week
- Manpower plan required for maintenance

On commencement of Revenue Services, the Contractor shall deliver to the Employer, copies of all such manufacturing drawings, schedules and software for all components, as well as all such as Built Drawings, as shall have been amended or updated.

32.2.1 During the defect liability period the contractor shall maintain all the assets on the lines of a Comprehensive Maintenance Contract which will include replacement / Rectification of Defective Equipment/Component. Contractor Is Also Required to Carry Out All the Preventive Maintenance Schedules, Specified by The Manufacturers. The Consumables Required for Undertaking Preventive Maintenance Schedules Shall Be Supplied by The Contractor. The Contractor Shall Be Responsible for Preventive as Well As Corrective Maintenance. The Infrastructure Including T&Ps, M&P, Testing Instruments, Material Handling Equipment, Jigs & Fixtures and Ladder Etc. Are to Be Arranged By The Contractor For Maintenance During Defect Liability Period. Contractor Shall Furnish A List Of M&Ps, T&Ps, Testing Instruments, Material Handling Equipment, Jigs & Fixtures, Exchange Spares, Rotational Spares, And Components And Consumables Along With Quantities To Be Kept In Premises During Defects Liability Period.

32.2.2 Contractor Shall Establish an Office For The Purpose With Communication Facility so as to facilitate communication for reporting failures and liaison with KRIDE maintenance staff manning BSRP round the clock. The supervisor in-charge of contractor should be provided with mobile communication facility to ensure his presence at the site within 2 hours of reporting. Contractor shall ensure restoration / rectification/replacement within 4 hrs. for attending to Defects / Failures of Minor Nature and 8 hrs. for attending Defects / Failures of Major Nature to the satisfaction of Employer / Engineer. The Engineer in case of the delay as deem fit shall be empowered to carry out the maintenance at the risk and cost of the Contractor. The Contractor shall carryout Corrective Maintenance at any time during 24 hrs. X 365 days based on the occurrence of failures / breakdowns.

32.2.3 Deleted.

32.2.4 **Routine Maintenance**

32.2.4.1 Submit a Schedule for routine maintenance which shall include the Manufacturer's recommendations and / or common engineering practice (for all plant and equipment). Any comment / instruction given by the engineer - in - charge vis - a - vis the maintenance schedule shall not absolve the contractor of his obligation to properly and fully maintain all the systems at all times.

32.2.4.2 Plant and equipment history card shall be maintained by the contractor which shall give full details of equipment and frequency of checks and overhaul.

32.2.4.3 Submit weekly status report to the engineer - in – charge.

32.2.5 **Repairs**

All equipment that requires repairing shall be immediately serviced and repaired. All replacement parts and labour shall be supplied promptly.

32.2.6 **Manpower**

32.2.6.1 Adequate number of manpower shall be provided including relief personnel for satisfactory maintenance.

32.2.6.2 Duty allocation and roster control shall be the contractor's responsibility but shall be subject to the approval of the engineer - in – charge.

32.2.6.3 The contractor shall furnish the bio-data of all the personnel whom he proposes to deploy for the maintenance work for the approval of the engineer - in - charge. The contractor shall deploy only those personnel who are approved by the engineer - in - charge. Such approval shall not absolve the contractor of his obligations of proper conduct and performance of his personnel.

32.2.6.4 The engineer - in - charge shall have the right, without assigning any reason whatsoever, to ask the contractor to remove from the site any person, regardless of his having been approved earlier by the engineer - in - charge and replace with another suitable person approved by the engineer - in – charge.

32.2.7 **Shut Down**

32.2.7.1 No routine shut downs shall be permitted.

32.2.7.2 Contractor shall carry out preventive maintenance during non-operational hours with prior permission of the engineer - in - charge. Corrective maintenance to be carried out as and when failures/ defects occur any time during 24 hrs. X 365 days.

32.3 **Manuals and Test Certificates**

32.3.1 **Manuals**

Contractor shall produce manuals for all equipment and systems supplied. These shall include, but may not necessarily be limited to, the following:

- System manuals - a comprehensive description of all system principles at block diagram level.
- Operating/user manuals - broken into as many sub-sections as may be necessary and providing sufficient information to enable non-technical staff to exploit fully the facilities of each system.
- 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.
- 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. Source code listings with comprehensive comments shall be provided for all bespoke software together with configuration listings for all configured standard software packages.
- Equipment Room Manuals - all wiring diagrams and circuits, equipment layout, terminal and cable listing and including such external equipment as may be necessary for completeness.
- Maintenance and Servicing Manuals - to specify requirements, procedures and servicing intervals for planned preventative maintenance and in addition to convey sufficient information on equipment principles and practice to enable first line fault diagnosis and rectification by technician staff.

Operational / user manuals and a summary (suitable for use at technician level) of the maintenance and servicing manuals shall be prepared both in English and Kannada languages. Other technical manuals shall be supplied in the English language only.
Contractor shall submit all manuals for review by the engineer prior to factory acceptance tests.
Contractor shall provide 4 controlled copies of all manuals for the use of the engineer.
Contractor shall maintain all manuals in an up-to-date condition throughout the contract period.

32.3.2 **Deleted**

33 Deleted

34 Design and Construction Interfaces

34.1 **Interfaces**

34.1.1 The Contractor shall interface the detailed design, installation and commissioning of works with that of other contractors, principally the other Designated Contracts as defined in the General Conditions of Contract. The Contractor shall keep the Engineer fully informed in respect of such interfaces, such information being given to the Engineer in a manner and form and at such intervals as stated in the Contract or as required by the Engineer.

34.2 **Interfacing Parties:**

i) **Contractor for Elevated Viaduct and At- Grade (Civil Works)**
This contract provides the complete design and construction of the Elevated and At-Grade section of Corridor-2, BSRP.

ii) **Architectural Finishes & MEP works**

iii) **DDC for Power Supply & Traction**
Detail design Consultancy Contract for Power Supply Receiving, Distribution System, OHE Traction Electrification and SCADA System.

iv) **CC for traction power contractor**
This contract provides for Supply, Erection Testing and Commissioning of OHE traction power, traction & auxiliary substation equipment, AC and DC switchgear, transformers and rectifiers, auxiliary power equipment and power cables and power SCADA system.

v) **E&M Contractor**
This contractor will provide LV supply for entire E&M load through 33 kV/ 440 v Auxiliary Transformer via LT bus duct/Cable terminated to E&M's Main Distribution Board (MDB) in ASS room.

vi) **Elevators**
This Contractor will design, manufacture, install and commission all lifts in the stations.

vii) **Escalators**
This Contractor will design, manufacture, install and commission all escalators in the stations.

viii) **S&T for signaling works**
This contract provides for signaling and automatic control systems including equipment in Station Control rooms, Station Equipment Rooms, telecom Equipment Room, S&T UPS Rooms, Signal maintenance Rooms in Interlocked stations with points and crossings and OCC, Train mounted control equipment, independent telephone exchanges including automatic switching centers and exchanges, main trunk cables, direct telephone lines, communication equipment, emergency telephones, closed circuit television, radio communication, Passenger Announcement, passenger Information Display system, co-axial cable arrangement and all non-power SCADA system. Line side signals in the platforms of interlocked stations, track mounted beacons and Emergency stop plungers in platforms also form part of the contract.

ix) **TEL for telecommunication works**
This Contract provides for independent telephone networks including automatic switching centers and exchanges, main trunk cables, direct telephone lines, communication equipment, emergency telephones, closed circuit television, radio communication and all non-power SCADA system.

x) **AFC for automatic fare collection works**
The contractor shall interface with designated contractors (e.g. Building service / Civil contractor / Electrical contractor /signaling train control and communication contractor), Agencies (government or private), UPS contractor, consultants and other sub / local contractors etc. to ensure smooth execution of works.

xi) **DDC for Signages**
This Contract provides for design, manufacture, supply, installation, Testing and

commissioning of all Signages at Stations.

xii) **RS for Rolling Stock**
This Contract provides for Design, Manufacture, Supply, Testing & Commissioning of Rolling Stock.

34.3 **Interface Responsibilities**

34.3.1 The responsibility for specification and provision of the requirements for the works, which interface with Designated Contractor's equipment, are tabulated below.

34.4 This Appendix describes the interface requirements between the Contractor and other Designated Contractors which includes Architectural finishes, MEP Works, DDC's, POWER SUPPLY & TRACTION, ELEVATOTRS, ESCALATOR, S&T, TELECOMMUNICATIONS, AFC, PSD, RS, and DDC/DM contractors.

34.5 This shall be read in conjunction with the relevant clauses of the Employer's Requirements and Outline Specifications. The Contractor shall be responsible for ensuring that all requirements of the specifications pertaining to interfaces of system are properly satisfied.

34.6 This outlines the interfacing requirements during the execution of the Works. However, the requirements herein specified are by no means exhaustive and it remains the Contractor's responsibility to develop, update and execute jointly an Interface Management Plan after the commencement of the Works and throughout the execution of the Works to ensure that.

a. All interface issues between Station Contractor and the Designated Contractors are satisfactorily identified and resolved.
b. All the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points.

34.7 Where details of the design are required to enable the Designated Contractor to implement interface works, the Contractor shall provide the Designated Contractors 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 to design and / or construct the required interface works.

34.8 The Contractor will provide all information in developing the Interface Management Plan. The IMP will be prepared in conjunction with the Designated Contractors 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.

34.9 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.

34.10 The IMP shall be submitted by the Contractor to the Engineer, in a preliminary form, within sixty (60) days of the date of Commencement of Work. Thereafter, the IMP shall be updated by the Contractor at regular intervals of not exceeding twenty-eight (28) days, agreed with Designated Contractors and submitted to the Engineer. Should it appear to the Engineer that the progress of the Works, Works Programme or the Three Month Rolling Programme does not conform to the IMP, the Contractor shall be required to revise all such programmes and plans such that they do reflect the progress of the Works, are mutually consistent and conform to other provisions of the Contract.

34.11 The Contractor shall review the details of interface works and notify the Engineer of any amendments to the summary table required in the process of his works. Unless such requests are reviewed without objection by the Engineer, the Contractor shall design and construct the works in accordance with the provisions outlined.

35.1 Scope of Work of Interface Management Plan (IMP)

- The information and scope of works to be provided by the E&M Contractor shall include but are not limited to those outlined in the attached summary table. This table only defines those tasks at the interface point and is not a complete itemization of the Scope of Work.
- The Contractor shall identify all access and attendance required for completion of works in accordance with the contract requirements to enable the Designated Contractors to complete those activities defined under the summary table attached to this interface specification in a timely manner. Such access and attendance shall include the provision of lighting for the station works and safety provisions such as safe access and egress to all parts of the works required to complete the survey and marking out works for a limited number of Designated Contractor's staff.
- Where Contractor works are identified as failing to meet the requirements of the contract and which will impact the Designated Contractor's works, the Contractor shall submit the proposed remedial measures to the Engineer for review and shall copy the same to the Designated Contractors.

35.2 **Scope of Work of Interface with Civil Works**

- MEP works and architectural works of a station are to be executed by a separate Civil Contractors. The Contractor shall ensure efficient interface and Coordination with both the Contractor concerning Electrical Works, Fire Fighting, Hydraulics, etc on site.
  1. Such coordination responsibility of the contractor shall include the following:
     - i) To obtain from the other Contractor information reasonably required enabling the Contractor to meet the construction target dates.
     - ii) The Contractor will be the coordinating entity and play the major role in the interface with MEP Contractor and will also be responsible for any delay on the schedule.
     - iii) The Contractor will make sure that he provides the updated valid documents, for the reference of the other Contractor in time, where the Contractor requires the other Contractor to execute his work as per the requirement of the Station Contractor. These documents will be the reference documents for the Interface Management being carried out by the Contractor.
     - iv) Where the execution of the other Contractor depends upon the Site Management or information to be given by the Contractor, the Contractor shall provide correct and accurate information in time so as to enable them to meet their respective programs.
     - v) It is to be ensured that all provisions for access and delivery of plant is Co-ordinated with and reflected in the Contractors Delivery Route Drawings.
     - vi) The Contractor must ensure that the production of Working Drawings for Services to be provided in the base slab, other slabs and structures (such as provision of conduiting, cable routing, fixture mounting, DB mounting, lightning, piping, firefighting system and other works included in the tender) is carried out in time and approval obtained from the Engineer. A Copy of Drawings along with schedule for execution of such works must be handed over to other Contractor in time, to enable him to plan his activities. Further, Contractor shall ensure that information required by other Contractor for any concreting / other works where electrical work is involved is made available him in time.
     - vii) The Contractor shall conduct regular meetings with the designated Contractor as necessary to clarify particular aspects of the interfacing requirements of the works. He will also attend regular Co-ordination meetings convened by the Engineer for interface.
     - viii) The Contractor, shall in carrying out his co-ordination responsibilities, raise in good time and provide sufficient information for the Engineer to decide on any disagreement with other Contractor. If the Contractor despite having taken all reasonable efforts cannot resolve such disagreement, then the decision of the Engineer shall be final.

ix) The Contractor shall ensure the presence of his qualified and experienced Engineer (Chief Co-ordinator) during civil construction of station to enable proper interface with other Contractor so as to ensure smooth completion of works.

x) Access will be provided to the MEP & Architectural Contractor staff for carrying out their works and bringing materials and Equipment at the site. However, the security of material and Equipment brought at the site, by the Designated Contractor is station Contractor's responsibility.

35.2.1 **Other Services to meet the requirements of this Technical Specifications**

35.2.1.1 IGBC Certification

a. The Contractor shall implement and obtain IGBC certification for the Station Buildings. The Contractor shall provide all the electrical and mechanical systems of the Station earmarked for IGBC certification and they shall attain a Platinum Rating.

b. The Contractor shall adhere with the policy, rules, norms, requirements and methods of the Confederation of Indian Industry's (CII) Indian Green Building Council (IGBC) Green Mass Rapid Transit System (MRTS) Rating Abridged Reference Guide for individual use.

c. Benefits of Green Transit Facilities
   i) Integration with other modes of public transport.
   ii) Enhanced Station accessibility.
   iii) Maximise resource efficiency.
   iv) Increased environmental awareness among commuters.
   v) Enhanced commuting experience.
   vi) Reduced energy and water usage.
   vii) Reduced maintenance and operation costs.
   viii) Reduced construction waste during the building process.
   ix) Reduced liability.
   x) Increased employee performance, satisfaction, and retention.

d. In order for the project to earn IGBC Certification, it must meet certain criteria and goals within the following categories:
   i) Planning
      - Site Environment management to minimize impacts on construction.
      - Basic facilities for construction workforce, i.e. personal protective equipment, protected temporary staircase and facilities, drinking water facility.
      - Integration with other modes of transport
      - Intermodal Commuter transport
      - Promote use of alternative fuel vehicles
      - Universal access
      - Heat island mitigation
      - Green education / creating "Green" awareness for commuters

   ii) Water Efficiency
      - Water efficient flow and flush fixtures
      - reduce potable water usage
      - Rain Water harvesting

   iii) Energy Efficiency
      - improve energy performance and indoor air quality
      - Reduced energy and reduced life cycle costs
      - Accounts to 20-30% of total energy demand

   iv) Material Conservation
      - Segregation of waste
      - Construction waste management
      - Recycled content
      - Regional sourcing
      - Use locally sourced, sustainable products

v) Indoor Environment and Comfort
- Green Design encourage more fresh air.
- Use low volatile organic compound
- Pollutant source control

e. Certification Rating.
- The Station certification rating shall be platinum.

35.2.2 **Rain Water Harvesting**

The rain water harvesting of the runoff water within the Station areas shall be planned as per the policy, rules, norms, requirements and methods of the State and the Central Government and IGBC Certification requirements.

36 Architecture Design Criteria

Introduction:

1.1 This section sets out the design criteria to be adopted in the planning and designing of Bangalore Suburban Rail Project, to ensure consistency in layout, form, operations, maintenance, and system-wide identity. It is also intended that there shall be consistency in construction, passenger circulation, operation, and maintenance procedures throughout the system.

1.2 The BSRP project is divided into four corridors with a total of 65 (58 + 5 quadrupling +2 cut & cover) stations.

Corridor-1, KSR Bengaluru City to Devanahalli Station, is a 41.2 Kms corridor. It consists of fifteen stations, out of which seven are elevated and eight (7 present and 1 future) are at-grade stations.

Corridor- 1A, Airport link is 5.9 Kms long corridor, it consists of 2 cut and cover stations from airport trumpet station to airport terminal.

Corridor-2, Baiyyappanahalli to Chikkabanavara Station, is 25.85kms in total length. It consists of 12 stations, out of which six are elevated stations and six are at-grade stations.

Corridor-3, Kengeri to Whitefield Station, is 35.52kms in total length. It consists of fourteen stations, out of which four (with a section of five quadrupling stations) are elevated stations and five (4 present & 1 future) are at-grade stations.

Corridor-4, Heelalige to Rajanakunte Station, is a 46 Kms long corridor. It consists of twenty stations, out of which three are elevated and seventeen (16 present & 1future) are at-grade stations.

36.1 Station Planning Philosophy

1.3 A brief narrative for corridor 2, has been presented below for a better understanding, as this document covers the station design criteria of only corridor-2 stations.

Table 2: Corridor 2 Stations

Sl. No.	Name of the Station	Typology
1	Benniganahalli	Interchange Elevated Station
2	Kasturi Nagar	At-Grade Station
3	Sevanagar	At-Grade Station
4	Banaswadi	At-Grade Station
5	Nagawara	At-Grade Station (On raised formation)
6	Kanaka Nagar	At-Grade Station (On raised formation)

Sl. No.	Name of the Station	Typology
7	Hebbal	At-Grade Station
8	Mathikere	Elevated Station
9	Yeshwantpur	Interchange Elevated Station
10	Shettyhalli	At-Grade Station
11	Medarahalli	At-Grade Station
12	Chikkabanavara	Elevated Station

1.4 Stations will vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, interchange requirements with other modes, station spacing, alignment, utilities, road and pedestrian requirements, interfaces with developments and environmental considerations.

1.5 Unless stated otherwise in this document, the whole of the architectural works shall be constructed to comply with relevant laws and regulations of the Indian Government and Karnataka state government as well as complying with the requirements of the Bangalore public utility authorities, fire regulations and such additional requirements as may be stated in the documents.

1.6 The Design requirement relating to the station passenger capacity shall be based on the best information on passenger numbers and flow patterns available at the time of design. Unless otherwise stated in the contract document the design requirements relating to fire safety and escape shall be generally in accordance with Annex J, Fire and Life Safety Requirements for Metro Stations, NBC 2016.

1.7 Station shall be designed with 205-meter platform length for at grade stations and elevated stations to cater for 9 car trains. The length of the concourse shall be designed at 205 for at grade station and elevated stations.

36.2 Station Planning (SAP) Guidelines

1. The stations in corridor 2 are located adjacent to the Indian Railway (IR) tracks. Only one station, Mathikere, is located within the road, away from the IR tracks. Where the stations are located off-road adjacent to IR tracks, the overall station width shall be governed by site conditions.
2. For the on-road station. the overall width of station structure shall be limited to be within the road width including footpaths.
3. Clearance of 7.8m (min) shall be maintained from the IR tracks to the BSRP tracks. Minimum 5.3m distance shall be maintained from the IR track to any adjacent structure. The clearance required from the IR track to bottom of any structure (e.g., skywalks or FOB connections) is 6.3m (min). A road clearance shall be 5.50m (min) shall be maintained below the on-road elevated stations.
4. The layout of the stations is influenced by the track geometry, operational requirements, predicted passenger flows, electrical & mechanical requirements. The station can be divided into public & non-public areas (areas where access is restricted). The public areas can be further subdivided into paid and unpaid areas.
5. Stations shall be designed either with a centre platform or with side platforms configurations. Any chosen configuration shall consider the constraints and objectives outlined above.
6. The platform level at each station is determined by the alignment
7. The concourse area will contain the Automatic Fare Collection system and is divided into paid and unpaid areas. The 'unpaid areas' are where passengers gain access to the suburban system, obtain travel information and purchase tickets. Once the passengers have passed the security check and AFC gates, they enter the 'paid area' through which access to the platforms is available.
8. The arrangement of the concourse area is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it shall be planned in such a way that maximum surveillance can be achieved by station staff over security,

automatic fare collection gates, lifts, stairs, and escalators.

9. Ticketing and AFC gates shall be positioned to minimise cross flows of passengers and provide adequate circulation space. Also, the location of AFC gates may be planned in such a way that they are not exposed to direct sunlight.
10. Station entrances are located with reference to passenger catchment points and physical site constraints within the right of way allocated to KRIDE. Entrance locations and sizes are severely constrained by the need to be able to provide enough space for a minimum width of stair and pedestrian footpath space alongside.
11. Stations will be covered by an overlapping roofing system, open at sides, covering the platform or concourse depending upon elevated or at grade station. The extent & length of the roof may vary from station to station. The Contractors designer to present various roof design & facade options to KRIDE for confirmation and approval. The roof & facade should protect the station concourse/platform from any wind driven rain and ensure sufficient natural lighting and ventilation.
12. The roof shall also be designed for installation of the solar panels. Necessary structural arrangement for installation, maintenance of the solar panels is to be provided in the roof design.
13. Adequate space for services and cable trays shall be considered
    - Generally, the services shall not be covered except at a few places for aesthetic reasons.
    - Ducts and shafts shall be considered on a modular basis for ease of installation and maintenance of cabling and DB's.
    - Lighting design shall be designed meeting the functional as well as aesthetics requirements.
    - Station design shall incorporate the design guidelines listed by Indian Railways to the extent possible. Refer attachment E for the Indian Railway check list.

36.3 Design Features for General Station Security

36.3.1 The Station design should be such as to promote real and perceived security for the Users.

36.3.2 The following features shall be incorporated in Station design to maximize the safety and security of the BSRP system and its users:

- Station shall be provided with Baggage scanners, DFMDs and X-ray machines for security and scrutiny purposes to the passengers entering the stations.
- Stations shall be open, spacious, and well-lit to maximize the visibility of people, platform, other building/structure areas, and parking areas.
- Hiding areas shall be minimized.
- Access points to the parking area shall be minimized.
- Adequate lighting shall be provided, minimizing shadows, and avoiding dark areas.
- Transparent material for doors of elevators shall be provided.
- Planning shall provide for open lines of sight to as much area as possible.
- All passenger routes of travel shall be clearly defined, and shall be direct, well-lit and with good visibility.

36.3.3 To facilitate addressing emergency conditions from both traditional static and non-traditional dynamic threats to the stations, provisions shall be made to permit mobilization of emergency response.

36.4 Site Access and Circulation

36.4.1 Circulation patterns for traffic within Station sites and on approaching streets shall be site-specific, and shall consider.

- Integration of Stations with the existing urban fabric, merge with the surroundings, respect for local traditions, and minimize visual intrusion into the urban landscape.
- Separation of traffic modes to allow convenient, safe, and rapid access to and from BSRP facilities; and
- Passenger design loads for the Rail System.

36.5 The Stations shall be designed in a manner that enables Users to arrive at and depart from the Stations via the following modes:

- Pedestrian walk-in.

- Two-wheeler and cycle with parking facilities; and car with parking facilities wherever feasible.
- bus; and
- Taxi, auto-rickshaw, cycle-rickshaw, and car drop-off.

36.5.1 Site circulation and Station circulation shall be separated vertically, in most cases, with the Station above the site circulation.

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

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

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

36.5.5 Sightlines at merges or intersections shall be left clear.

36.6 Entrances

36.6.1 Station entrances provide the link between the station concourse and the surrounding streets. These could also cater for intermodal interchange which may include transfer to adjacent metro station/ IR platforms, bus transfer, taxi and motorcycle transfer and park and ride facilities subject to availability of space.

36.6.2 The width of entrances shall consider predicted passenger flows and available space. Entrances to stations shall have adequate capacity to satisfy predicted passenger flows and emergency evacuation requirements.

36.6.3 Entrances at Street Level shall be easily identifiable.

36.6.4 Where entrances contain escalators, protection against localised flooding shall be provided.

36.6.5 Each entrance may contain a security gate (also used for crowd control purposes in the event of an emergency or severe congestion). Other measures to enable station closure and security shall be incorporated at staircase entrances.

36.7 Entrances within or associated with adjacent developments may be provided for normal passenger handling and emergency escape. Street-level entrances shall be within the right of way limits.

36.8 Passenger Movement at Stations

36.8.1 To transfer passengers efficiently between street level and train and vice versa, station planning must be based on principles of pedestrian flow and arranged to minimise unnecessary walking distances and cross flows between incoming and outgoing passengers. Tactile guiding path shall be provided at all instances for the differently abled passengers.

36.8.2 The detailed passenger flow forecast figures to be used for station design are provided in Attachment A. These figures provide peak-hour flows for each direction of travel.

36.8.3 Stations shall be designed for following design year and headway: - the Year 2041 with an operating headway as per DPR.

36.8.4 A typical flow pattern for a passenger using the system will be as follows. Upon arrival at one of the entrances, a passenger will precede to the concourse unpaid area where he can consult travel information and buy a ticket. The passenger then enters the paid area through AFC gate and proceeds to the platform and boards the train to his destination.

36.8.5 The path from platform to entrance will be in reverse. When a passenger's ticket is invalid for the journey, it will have to be exchanged for a valid ticket and an excess fare paid at the customer care /EFO office before leaving the paid area.

36.8.6 The station's design shall accommodate peak minute passenger flow forecasts for normal operation as well as meeting-related requirements for emergency evacuation.

36.8.7 Each station shall be individually assessed, and a view taken to ensure ultimate passenger handling capacity is available. Passenger handling facilities (stairs, escalators, and AFC gates) required to process the peak traffic from street to platform and vice versa.

36.8.8 During design peak minute flow conditions, the level of service for passenger flow in stairways, passageways, corridors, queuing area near AFC gates, ticket offices, staircases and escalators, and passenger interchange areas shall be kept such that average passenger area occupancy is not less than 0.5 sq. metre per passenger.

36.8.9 The same facilities must also enable evacuation of the station under emergency conditions, to a point

of safety as per ANNEX J- NBC 2016. On the control line, AFC will open automatically. In addition, a service gate will be provided to give free way to the unpaid area. The same facilities must also enable evacuation of the station under emergency conditions, to a point of safety as per ANNEX J- NBC 2016. On the control line, AFC will open automatically. In addition, a service gate will be provided to give free way to the unpaid area.

36.8.10 Tactile paths may be installed at the vicinity of pedestrian crosswalks, the platforms, and both the top and bottom of stairs, ramps and in front of escalators and elevators/lifts. And the like to ensure safety. They may also be used to indicate an approaching potential hazard or a change in direction of the walk way. Tactile blocks/tiles may be used in combination with attention indicators in order to indicate the walking route where no actual tactual information is available to get from one place to another. Also, for outdoor floors such as footpaths, courtyards, multimodal locations etc. As per provision in ''The Persons with Disabilities Act" and "Harmonized Guidelines and space standards for Barrier-free Built Environment for Persons with Disability and Elderly Persons", February 2016 and "Handbook on Barrier-Free and Accessibility 2014'published by the CPWD (Central Public Works Department) India.

36.9 Passenger handling

36.9.1 It is essential that the system is designed to maximize its attractiveness to potential passengers and the following criteria shall be observed:

- a minimum distance of travel to and from the platform.
- sufficient capacity for passenger movements.
- convenience, including good signage related to circulation and orientation
- Safety and security, including a high level of protection against accidents

36.9.2 The design will consider the following:

- optimized operating costs are incurred consistent with maintaining efficiency and the safety of passengers and staff.
- the flexibility of operation including the ability to adapt to different traffic conditions, changes in fare collection methods and provide for the continuity of operation during any extended maintenance or repair period, etc.
- provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
- Provision of passenger information, advertising, and commercial concessions.
- Provision of tactile paths in approved materials, colours and finishing for guiding the users along an intended safe path for people with visual impairments along the entire circulation path of approved make as per provision in ''The Persons with Disabilities Act" and "Harmonized Guidelines and space standards for Barrier-free Built Environment for Persons with Disability and Elderly Persons", February 2016 and "Handbook on Barrier-Free and Accessibility 2014'published by the CPWD (Central Public Works Department) India.

36.10 Platform Design Standards

36.10.1 Platform length must allow safe access to all doors of Trains including door to the driver's cab and shall accommodate the longest Train plus allowance for inaccurate stopping.

36.10.2 Platform width shall be calculated as per ANNEX J- NBC 2016 for a minimum level of comfort E (Fruin level of service) during an emergency scenario.

36.10.3 Platforms built approximately to the height of the Coach floor and designed to give free visual access along its length shall be provided, subject to meeting requirements of SOD of BSRP.

36.10.4 The platform width shall be designed to accommodate PSDs in the later stage. Handrail shall be provided all around the platform except for the trackside.

36.10.5 Platform floor shall have durable, non-slip and visually pleasing finish using heavy-duty homogeneous tiles/granite flooring & tactile tiles wherever needed as per provision in "The Persons with Disabilities Act" and "Harmonized Guidelines and space standards for Barrier-free Built Environment for Persons with Disability and Elderly Persons", February 2016 and "Handbook on Barrier-Free and Accessibility 2014'published by the CPWD (Central Public Works Department) India.

36.10.6 The roof shall be provided over the platform length, which shall vary station by station.

36.10.7 Roof options sufficiently detailed shall be prepared according to the requirements, for the employer's approval for further detail.

36.10.8 Platforms shall have a clear headroom of at least 3000 mm to structures and platform signs to a width of at least 2400 mm from the platform edge over their entire length. Suspended signs, fittings, and fixtures shall have a minimum clearance of 2.4 m above the finished floor".

36.10.9 Platforms shall be laid to a fall at 1:100 away from the platform edge. The platform shall also follow the slope according to the track slope.

36.10.10 Markings on the platform to assist and control the flow of passengers boarding and alighting the trains shall be provided.

36.10.11 An under-platform refuge shall be provided below the cantilevered portion of the platform for the full length of the platform. The minimum horizontal width from the side of a train to any obstruction shall be 600 mm and the full height from the track slab to the underside of the platform shall be available.

36.10.12 Space for fire hydrants, fire hose reels, communications equipment, Emergency trip system, trackside advertising panels, and commercial communications facilities, shall be provided as required.

36.10.13 Passenger access points shall be arranged to encourage the distribution and collection of passengers evenly along the whole of the platform length.

36.10.14 The platform should have clearances as per Schedule of Dimensions given by KRIDE.

36.10.15 Platform Width Calculation (for an emergency scenario)

a. The minimum platform width shall be checked for against the following criteria for a delayed service scenario;

i) An average of 0.2 square metres per passenger is acceptable under delayed service conditions.

Required Platform Width= POL X 0.2 + (Area of Stairs, Escalators & lifts along with the associated queuing areas)/ Platform length
POL = Platform Occupant Load (POL will be calculated as per Clause J.4.1 of ANNEX J- NBC 2016edition)

Platform Length= 205 meter

36.10.16 Geographically earmarked/demarcated spaces shall be allocated for aesthetic installation of lighting and system cable containment.

36.11 Concourse Design Standards

36.11.1 The size of the concourse would be based on the traffic figures, ROW availability, type of station and other system requirements. In congested areas, with high traffic station, if additional space is required for passenger handling arrangement, entrance locations and space requirements for offices, electrical and mechanical plant, then additional land may have to be procured.

36.11.2 The layout of the typical station concourse is mainly determined by the upper landing of the access to the station and symmetrical arrangement as far as possible of the stairs and escalators to the platform.

36.11.3 General standards are:

- Where more than one concourse area is planned then the unpaid areas are connected where possible to allow station staff access to both areas
- Public facilities in the concourse should be located clear of the main passenger flow routes

36.11.4 The station concourse shall provide adequate space for passenger circulation, security checks, and direct flow lines between ticketing and AFC gates.

36.11.5 Means of securing and closing the station at concourse and street-level shall be provided. Crowd control measures will be provided at entrances.

36.11.6 In all public areas, a minimum ceiling height of 3000 mm shall be adopted with a minimum height of 2500 mm to the underside of local obstructions such as signage, PIDS. Electrical and Mechanical installations and service routes shall be contained above the ceiling height, and allowances for these services shall be considered.

36.11.7 A floor finishes zone 150 mm deep shall be provided to contain all necessary floor cable raceway for the provision supply communications of ticket machines and ticket gates associated with the Automatic Fare Collection system. The trunking shall not disrupt the finished floor surface. Tactile tiles wherever needed as per provision in "The Persons with Disabilities Act" and "Harmonized Guidelines and space standards for Barrier-free Built Environment for Persons with Disability and Elderly Persons", February 2016 and "Handbook on Barrier-Free and Accessibility 2014'published by the CPWD (Central Public Works Department) India to be given.

36.11.8 The structural clearance in the concourse shall depend on the relationship between concourse and platform. The minimum vertical clearance to structural members shall be 3000mm. The minimum clear height of 3000mm should be adopted with a minimum height of 2500 to the underside of local obstructions such as signage. Electrical and Mechanical installations and service routes shall be contained above the minimum 3000 mm clear height, and allowances for these services shall be considered.

36.11.9 Due consideration shall be given to the acoustic environment of all public areas with reference to the design and performance of the public address system.

36.12 Corridor & Ramp Design Standards

36.12.1 The width of corridors or passageways in public areas shall be determined by capacity requirements subject to the minimum dimensions given below:

i) Minimum for unidirectional movement - 1800 mm
ii) Minimum for bi-directional movement - 2000 mm
iii) Minimum for Staff only movement - 1200 mm

36.12.2 Ramps shall only be used for small changes in level or use by wheelchairs and the following gradients shall apply:

i) Preferred maximum gradient - 1:20
ii) Absolute maximum gradient - 1:12

- Ramps shall be of a minimum width of 1200mm for unidirectional movement and 1500mm for bi-directional movement. Rest platforms should be considered for long ramps (exceeding 9m) provided for wheelchair users. Rest platforms should also provide a level area of 1800mm long at intervals as per provisions of "The Persons with Disabilities Act" and "Harmonized Guidelines and space standards for Barrier-free Built Environment for Persons with Disability and Elderly Persons", February 2016 and "Handbook on Barrier-Free and Accessibility 2014'published by the CPWD (Central Public Works Department) India.

36.13 Provision of Escalators, Stairs and Elevators

36.13.1 The positioning of escalators, elevators and stairs shall be integrated with User flows throughout the station. They shall be positioned to encourage left-hand circulation and minimize conflicting User movement.

36.13.2 The provision to install escalators shall be made in station layout. Even though an escalator may not be installed in the first instance, allowance both spatially and structurally shall be made. Provision shall also be made in the electrical supply.

36.13.3 The numbers of escalators and sizes of the staircases shall be determined by checking the capacity against the peak one-minute passenger flow rate for both normal and emergency evacuation conditions according to ANNEX J- NBC 2016.

36.14 Escalator Design Standards

36.14.1 Escalators shall be provided at all Stations to assist vertical User traffic flow between street level, concourse and platforms to meet the requirement of the Key Performance Indicators.

36.14.2 Capacity and travel speed of escalators shall be computed as per NBC 2016

i) Capacity - 120 persons

36.14.3 Escalators running in the direction of escape shall be considered as working and the ones running the direction opposite to that of escape shall be reversed to move in the direction of egress during an Emergency for Station evacuation. All escalators shall be of a standard pattern, two lanes wide,

having a minimum width of 1000 mm with a width at the hip height of 1200 mm.

36.14.4 Escalators shall be reversible, monitoring and control of the operation being through the system of BMS.

36.14.5 Escalators shall be located along the normal and direct path of User circulation and be easily identified by users.

36.14.6 Escalators shall be so designed that routine operation and maintenance can be performed with minimum disruption to Station functioning.

36.14.7 A drainage outlet or sump shall be provided in the ground to concourse escalator pits for the removal of water.

36.14.8 To prevent escalator pits from flooding, minimum 450mm high landing shall be provided for each escalator from street to concourse level.

36.15 Stair Design Standards

36.15.1 Staircases in public areas shall comply with the following criteria.

36.15.2 All steps in a flight of stairs should have the same dimensions.

a. The clear width of stair shall be measured from finished surfaces of the inside faces of the balustrades or staircase walls with the only projection into this width being handrails.
b. Intermediate landings shall be min length of 2000mm or width of the staircase whichever lesser.
c. Staircases shall have no open risers.
d. Step noses shall be rounded, and colour contrasted.

36.15.3 All stairs shall be provided with handrails on both sides.

a. Where the width exceeds 2400mm a central handrail shall be installed. A central handrail may also be considered elsewhere where crowd control and passenger flows dictate. The handrail shall extend a minimum of 600mm beyond the bottom riser and 300mm beyond the top riser
b. Minimum vertical clear distance from nosing to any obstruction or to any ceiling or structural bulkhead shall be 2.7 m.
c. Top of handrails shall be minimum 900mm measured vertically from the pitch line.

36.15.4 Parameters for calculating staircases in case of emergency are based on ANNEX J- NBC 2016 editions.

36.16 Elevators Design Standards

36.16.1 The preliminary purpose of the lifts is to provide barrier-free access to all levels and shall be provided at all stations unless otherwise noted herein.

36.16.2 Elevators with a carrying capacity of not less than 13 Persons and designed to accommodate wheelchairs shall be provided. They shall be suitable for service as public service/goods elevators and shall be rated for a minimum of180 movements/ hour.

36.16.3 The elevators shall comply fully with "The Persons with Disabilities Act"; "Guidelines and space standards for Barrier-free Built Environment for Disabled and Elderly Persons"; "Handbook on Barrier-Free and Accessibility 2014' published by the CPWD (Central Public Works Department) India; EN and Indian Standards.

36.16.4 During a fire situation, the use of elevators shall be prohibited.

36.16.5 Elevators shall be electric traction type and machine-room less arrangement with the traction drive motor and controls mounted within the hoist way of the Elevator at the top landing.

36.16.6 The size of the lift shaft will be consistent throughout the corridor.

36.16.7 Elevators with single access shall include a laminated framed safety mirror in the rear panel of at least half of the elevator height, for ease of reversing of wheelchairs from the elevators.

36.16.8 Operating panel buttons shall have the operation of the button superimposed on it in Braille. A suitable ventilation opening or duct to open-air shall be provided at the top of each elevator shaft.

36.16.9 The ventilation openings shall have a minimum free area as per relevant standard.

36.17 Provision for Fare Collection

36.17.1 Fare collection in the concourse areas of stations will consist of automatic gates together with provisions for the sale of stored value tickets and the collection of excess fares.

36.17.2 Automatic gates shall be exit only, entry only and reversible types.

36.17.3 The following design criteria shall be adopted for the requirements of ticket gates:

a. All passengers will use AFC gates on entering and leaving the system.
b. Gates shall have a minimum 550mm clear opening. One specific AFC gate will have a 900mm clear opening for physically challenged passengers at every control line. This will also serve as ticket gate for those carrying large bulky items (luggage etc.).
c. Each gate shall cater for a minimum of 30 passengers per minute.
d. One gate being out of service shall be considered in the design.
e. The minimum number of entry/exit gate array shall be 2 gates.

36.17.4 As future layouts are expected to differ from the initial operating layout, the provision shall be made for power and control cable connections in the initial design.

36.17.5 The ultimate width of the barrier gate line required in the concourse will depend on the requirements for peak traffic flow and emergency escape.

36.17.6 Queuing.

36.17.7 Space shall be provided for queuing at all circulation and passenger service elements. The queuing area provides space for passengers to queue at various circulation elements, service areas and decision points without disrupting the movement of other passenger flow routes.

36.17.8 Queuing spaces shall be placed end to end; and shall not overlap. They shall be considered as part of the general space requirements for any given area, as indicated below:

36.17.9 Level of service in queuing areas shall be kept such that minimum passenger occupancy area provided is 0.5 sq.metre per passenger during normal peak flow conditions. At platform level queuing area provided for escalators & staircases shall be adequate to provide the above mentioned level of service to alighting passengers from trains running at designed headway during peak hours.

Table 1: Queuing Spaces

Location	Queuing spaces
Add-Value Machines, from face	2400mm
Card Readers, from face	2400mm
Customer Service Centre, from counter edge	2400mm
Escalators, from working points	8000mm
Fare Adjustment Office, from counter edge	2400mm
Lifts, from the threshold	2400mm
Stairs, from working points	4000mm
Ticket Gates and Smart Card Gates, scanners from face	6000mm
Ticket Sales Windows, from counter edge	2400mm
Ticket Vending Machines, from face	2400mm

36.18 Emergency Egress

36.18.1 Station design should allow safe evacuation of occupants in an Emergency.

36.18.2 For fire detection, suppression, egress/fire evacuation measures, the Station design shall meet the requirements for Stations as provided in ANNEX J- NBC 2016.

36.18.3 For calculation of occupant load, projected ridership figures or maximum Train load capacities as per future plan, whichever is more shall be used. Boarding and alighting loads at the time of evacuation should be based on peak usage with service disruption period, to the scheduled Train service in the busiest direction only.

36.18.4 Each Station shall have a minimum of two main access/egress points remotely located from one another. There shall be sufficient exit to evacuate the Station occupant load from the Station platform within the time period prescribed as per ANNEX J- NBC 2016 standard.

36.19 Passenger Flow Assessment / Modeling

The Contractor's Designer must provide Station Sizing Reports. The reports must confirm that the stations are adequately sized for all projected ridership figures of 2041 as provided in attachment A.

The calculation will be provided as specified below:

- Numerical Calculations
- Passenger simulation modelling undertaken using an industry standard modelling software such as Bentley Legion, PTV Viswalk/Vissim or similar that has been accepted by KRIDE & General Consultants.

Prior to commencing the works listed above the Contractor's Designer is to present station sizing basis of design proposals to KRIDE & General Consultant for review and acceptance. These basis of design proposals must include recommend standards to be achieved in the station with regards to passenger safety and comfort including but not limed to:

1. Level of Service in normal and delayed service (numerical and Fruin)
2. Vertical Circulation Capacities
3. Allocation for queuing

The passenger simulation models to be provided in the Station Sizing Report must cover the entire passenger journey, including arrival from the vicinity of the stations, finding train information, buying tickets for the appropriate trains, passing through security, getting to the platforms and boarding the trains and the reverse journey for exiting passengers. At stations that provide interchange between different services the passenger simulation model must also analysis the boarding, alighting and interchange movements associated with these services.

36.20 Fire Protection

36.20.1 The design of a station shall include the following:

- fire prevention measures
- fire control measures
- fire detection systems
- means of escape
- access for firemen
- means of fire Suppression and fighting

36.20.2 All aspects of fire prevention and control will be subject to the approval of the authority having jurisdiction.

36.20.3 Fire Prevention

- Fire prevention measures shall be designed and implemented to minimise the risk of outbreak of fire by appropriate choice, location and installation of materials and equipment.
  a. In station planning terms, potential sources of fire shall be reduced by;
  b. the use of non-combustible or smoke retardant materials where possible
  c. provision of layouts which permit ease of maintenance for equipment and cleaning of the station
  d. provision of special storage spaces for combustible materials such as paint and oil
  e. prohibition of gas-based cooking facilities in the staff areas.
  f. prohibition of smoking
  g. provision of cigarette and litter bins.
  h. general good housekeeping.
  i. staff training and procedures.

36.20.4 Fire Control

- Control of the spread of fire and smoke shall be achieved by compartmentation of fire risk areas, smoke extraction and smoke containment.
- Compartmentation is aimed at limiting the extent of the fire. A compartment consists of a portion of the station or other structure, which is separated from adjoining portions by walls, floors and/or doors. Any opening shall be capable of being sealed in the event of a fire, e.g. duct openings sealed with fire dampers. Fire resistance periods (FRPS) shall be selected for spaces according to their degree of fire load and the degree of protection required for life safety, security of the system and the preservation of adjoining areas.
- Openings, including ducts and passages between BSRP property and any adjoining structure which allows free access into the BSRP property, shall be protected by fire doors, fire shutters,

fire dampers, etc., as appropriate.

36.20.5 Means of Escape from Non-Public Area

- Non-public areas of stations are accessible only to Staff and usually only in small numbers. These areas shall be compartmented and fully covered by the fire detection and alarm system.
- Escape from all non-public areas shall be possible to a point of safety.

36.20.6 Fire Resistance Construction

The main structural elements shall be designed to have a Fire Resistance Period (FRP) not less than that specified below:

Table 2: Fire Resistance Periods: Structural Elements

Structural Elements	Surface and overhead structures, without development above (In hours)
Roof Structure	0*
Stations	2
Substations	2 or as per ANNEX J- NBC 2016
Cable tunnels	2
Ancillary Buildings	2
Staircases	2

* Where it can be shown that the structural elements supporting the roof can survive the design fire without undue risk of collapse

36.20.7 Compartmentation of Station Area

- Station Control Room glazing shall be protected by two hour FRP automatic fire shutters.
- All offices and plant rooms shall be separated from the public circulation spaces by two hour FRP separation. Each plant room shall be a separate compartment.
- In-plant rooms roller shutters may be used, in addition to fire-rated personnel pass doors. Such shutters shall normally be closed and shall be fire rated to the same FRP as the wall in which they are contained. The Fire Resistance Periods to be used for sub-compartmentation shall be not less than specified below. Offices and staff areas shall be separated from the public spaces, but shall not be subject to sub-compartmentation

36.20.8 Fire Resistant Period for Sub-Compartmentation

- In the accompanying Table

Note

1. The FRP requirements in the Table are for general application only. Individual FRP requirements considered on a case by case basis.

Table 3: Fire Resistance periods: Sub-Compartmentation

Compartments	Surface and overhead structures, without development above (In hours)
ASS	2 as per ANNEX J- NBC 2016
Electrical Equipment Rooms (excluding transformer rooms)	2
Signaling Equipment Rooms	2
Control Rooms (including Computer rooms)	2
Telecommunication Rooms	2
Protected Staircases	2
Store Rooms	1

Compartments	Surface and overhead structures, without development above (In hours)
Refuse Rooms	1
Station Facilities, Offices, and other Rooms in Staff Areas	1
Pump Rooms	2
Standby Diesel generator Rooms	2
All other Areas	1

36.21 Passenger Amenities

- Several amenities shall be provided for the use of passengers within the station such as sitting benches, drinking water dispensers and toilets etc. The facilities shall be away from the main passenger flows.

36.22 Advertising

36.22.1 Potential sites for advertising within a station shall be located so as not to conflict with the principal requirement of the provision of signage to direct passengers, especially in an emergency.

36.22.2 There are various advertising media that can be used both within and outside the station. Provision shall be made for cast in conduit and fixings for advertising media at identified sites whether or not the media is installed at the opening of the KRIDE system. Particular attention shall be made to ensure maintenance access to these zones.

36.22.3 Advertisement installations may be installed in public areas and at Station site areas including at inter-modal transfer facilities.

36.22.4 Advertisement installations shall not adversely impact BSRP operations, station circulation pathways or create a safety hazard and shall be compatible with Station design including signage and art installations.

36.22.5 Commercial third-party advertising or news messages shall not be combined with messages to Users on BSRP services.

36.22.6 The installations shall be of standard sizes with fire-resistant/ non-combustible materials.

36.23 Commercial Areas with the Stations

Areas for commercial use could be located on the concourse level at stations in the unpaid zone.

36.24 Signages

36.24.1 Signage's shall be user-friendly and shall provide information essential to Users, engendering a sense of reassurance, security and orientation when entering, exiting or transferring. It shall Guide Users to various Station areas, provide information of the Station and its services and provide information on Train services.

36.24.2 Essential public information signage's shall be of retro-reflective high-intensity prismatic boards or equivalent.

36.24.3 User information shall cover the following as the minimum:

- Static signage's such as Station name, destination of services, platform number, the position of doors of Coaches, wayfinding signs, direction, entry, and exit.
- variable Signages such as real-time travel information to customers.
- maps and long-term changeable information on scheduled services
- information on the use or operation of a place or system
- intermodal connections
- emergency exits; and
- Rules of conduct to Users.

36.24.4 Major information to Users such as platform number, direction, entry, exit etc shall be in letters of size not less than 300mm. For other information, size and colour code shall be decided in the detail design stage. Preferably the back Lit signages shall use the LED Lights.

36.24.5 All signages shall have alternate pictorial signages of the same size as the letters.

36.24.6 The technical fabrication details for the fixed hardware system shall be in accordance with security requirements.

36.24.7 The following principles shall be followed for placement of signages:

- User information displays should be so located that Users seeking information have ready access without obstructing the free flow of Users.
- signs shall be placed at decision points, and perpendicular to the line of sight; and
- Signages shall be placed on the left side of passages including stairs, lifts and escalators.

36.25 Seating

Seats shall be provided at regular intervals for people with ambulatory disabilities. Seats will be located at every 30m interval. The height of the seats shall be at 450mm – 480mm.

36.26 Bins

36.26.1 Refuse bins shall be located throughout the station and approaches for disposal of small items of rubbish. The size of the bins shall be restricted to minimise the fire risk.

36.26.2 Bins as well as "no smoking zone" signages shall be located adjacent to the litter bins at the station entrances at street level.

36.27 Station Staff Accommodation & Mechanical Rooms

- A list of rooms with their minimum required sizes is provided in Attachment C.
- Expansion joints through the Mechanical rooms are not permitted.
- All station equipment rooms, and operation rooms will be equipped with Access control.

The schedule is included to

- Indicate the minimum requirements which shall be included but which is not limited to the spaces indicated.
- Illustrate typical content, which shall be reassessed according to specific station requirements.

36.28 Civil requirements for SS Substation Room

- ASS room size, beam and column layout should be as far as possible standardized allowing homogenization of room layout, which limits design costs.
- The ideal location of the ASS substation is on the ground level and outside the station box. It will be located at any of the entry structures. This is to increase retail space in the station box.
- Substation must have access for installation of equipment and future renewal and replacements.
- ASS Substations shall be equipped with a flat landing in front of the rolling shutters and a ramp leading to the landing. This shall be provided for the easy transfer of the equipment into the ASS room.
- All Auxiliary Substations require natural ventilation of suitable free area opening. Under normal ambient conditions cooling of equipment can be by natural crossflow ventilation. Substation shall, therefore, be provided with ventilation directly to the outside air. The net area of the natural ventilation shall mean after deducting area taken up by mesh and louvres etc. Natural Air Circulation. The size of the opening can be determined according to the guidance given in NFPA 70 NEC or by reference to transformer equipment manufacturers.
- Windows are normally not required in ASS room as such rooms are normally unmanned. Requirements of local code and health and safety to be observed, National Building Code prescribes 20% of floor area as window requirement. Classification under NBC shall be clarified if being applicable.

36.29 ASS Room Access Requirements

- Every Auxiliary Substation requires loading/unloading dock facility and opening/roller shutter door c/w winding handle of 3500mm clear height and 4000mm width beyond the structural beams. Roller shutter at loading docks shall not have mesh or grills that let rain into the room.
- Equipment room head clearance at any point shall not be less than 3600mm.
- The loading dock has to be accessible from the street. This is to facilitate initial installation

delivery plus future renewals. Removable safety handrail shall be provided.

- In some of the stations, a loading deck would not be easily accessible. In such stations, the loading deck and rolling shutter are replaced by a removable metallic hatch allowing delivery of equipment inside ASS.
- The delivery route to and from the substation for future replacement of equipment including street access for the vehicles involved shall be verified and be clear.
- One main door and one emergency door shall be provided for each substation room with locking arrangements. The emergency door shall have a crash bar on the inside.
- Main access door shall be a minimum of 2500mm height; main access doors shall be lockable from the outside.
- Substation access doors will be fire-rated according to the NBC classification.
- Room Height: The substation room height shall be 5 m clear from the finished floor to ceiling and 3.6 m beneath any beams or pier arms.

36.29.1 **Floors**

- Substation room finished flooring shall be +/- 2 mm tolerance due to withdrawable.
- Floor finish shall be floated and be of anti-dusting finish.
- Floors must be suitable for the weight of heaviest traction equipment; the heaviest item is the rectifier transformer. All flooring including the loading dock platform shall be able to accommodate the weight.
- The floor screed shall be a minimum of 50 mm depth to accommodate the embedding for earth strips for equipment and the embedded base frames of switchgear and transformer
- Connections for earth bonding shall be provided between steel rebar in substation floor slab direct to a MET in the room. This should be carried out as a minimum at two places diagonally opposite to one another.
- The floor near the loading dock shall not allow rainwater to flow into the substation.

36.29.2 **Walls**

All substation walls shall be whitewashed and be clean at the handover of the room.

36.29.3 **Ceiling**

- All substation ceilings shall be whitewashed and be clean at the handover of the rooms.
- It should be possible to post drill ceilings for the erection of cable trays. Where prestressed beams are extensively used consideration to drop rod fixing pockets may be given.
- Ceilings should be watertight and not permit egress of rainwater, station washing, or water discharged from fire hoses/hydrants in the areas immediately above the substation.
- Other Utility pipes: The passage of water pipes and exposed drainpipes shall be avoided from passing through substations. This is a precaution against equipment failure due to water leakage damage. Under NFPA 70 NEC article 450, routing water piping through transformer rooms is not permitted.

36.30 Access for Maintenance

36.30.1 All areas of the station shall be accessible for inspection and maintenance.

36.30.2 Door and access panel sizes shall be of sufficient width and height for the installation/removal of the equipment within the room.

36.30.3 Room layouts shall make provision for withdrawal space and circulation space around equipment where appropriate.

36.30.4 Loading area/platform shall be provided at all stations to handle heavy equipment's using road cranes.

36.30.5 Door and access panel sizes shall be of sufficient width and height for the installation/removal of the equipment within the room.

36.30.6 Obstruction Free, straight run spaces shall be considered for Cable containment system as per the applicable codes and standards for reliability and maintenance-friendly access.

36.31 Acoustics

36.31.1 Due consideration shall be given to the acoustic environment of all public areas with particular reference to the design and performance of the public address system. The acoustic design of stations must provide a good aural environment, in which people can communicate clearly and easily, and the build-up of excessive noise is suppressed. Public Address announcements must be easily heard and understood. A comfortable acoustic environment must also be provided for the employees in the non-public areas, such as in office and administration areas. The detailed design consultant must provide documentation that the final station designs achieve these goals. Selection of appropriate finishes providing effective sound absorption can control the level of the reverberation and provide a comfortable acoustic environment.

36.32 Materials and Station Finishes

The materials selected and finishes adopted for doors, walls and ceilings should provide comfort and safety, improve the aesthetics, and be durable, operable and maintainable with minimum resources. The materials chosen should be durable, resistant, vandal resistant, environment friendly and pleasing.

36.32.1 Basic Requirements

a. Safety

i) Fire Resistance and Smoke Generation
Use materials with minimum burning rates, smoke generation, and toxicity characteristics for Station finishes, consistent with requirements of Fire/Life Safety requirements

ii) Attachment
Eliminate hazard from dislodgment due to temperature change, vibration, wind, seismic forces, ageing, or other causes, by using proper attachments of adequate bond strength.

iii) Skid-resistant (for walking surfaces)
Use floor materials with skid-resistant qualities. Entrances, stairways, platform edge strips, and areas around equipment should have flooring having high skid-resistant properties.

iv) The following static coefficients of friction shall be provided as a minimum Coefficient of Friction
- Public area horizontal surfaces-0.6;
- non-public area horizontal surfaces, interior-0.5;
- non-public area horizontal surfaces, exterior-0.6;
- stairs, ramps, sloping sidewalks-0.8; and
- The area around equipments-0.6.

v) Contrast
Platform edge strips shall be of visually contrasting material

b. Durability
Use materials with wear resistance, strength, and weathering qualities consistent with their initial and replacement costs, and their location in the Station. The materials must maintain good appearance throughout their useful life. Materials shall be colour fast.

c. Ease of Maintenance

i) Cleaning
Use materials which do not soil or stain easily, which have surfaces that are easy to clean in a single operation, and on which minor soiling is not apparent. Materials shall be cleanable with standard equipment and cleansing agents

ii) Repair or Replacement
Use materials which, if damaged, are easily repaired or replaced without undue interference with the operation of the System. Spare materials shall be available with O & M wing for tile and other unit materials. (Say a quantity of approximately two per cent of the total used.)

Clutter/obstruction-free space for cable trays and equipment as per codes & standards

d. Resistance to Vandalism
   i) Materials and features that do not encourage vandalism and are difficult to deface damage or remove shall be provided. All surfaces exposed to the public are to be finished in such a manner that the results of casual vandalism can be readily removed with normal maintenance techniques.
e. Aesthetic Qualities
   i) Create a feeling of warmth, attractiveness, quality, and civic pride in the facility.

36.32.2 **General Criteria**

Certain general criteria for finish materials are indicated below to achieve the goals outlined above as well as those, which would result in a high level of illumination, good cleanliness levels, and the appearance of high cleanliness.

a. Surface
   i) Applied materials shall be hard, dense, non-porous, non-staining, acid and alkali resistant, of long life and low maintenance. Surfaces within reach of the public up to 3 m above the floor level may be finished with applied materials.
b. Colour
   i) Colours shall aid maintaining high illumination levels, with sufficient contrasts and accents to provide visual interest and warmth and to conceal minor soiling.
c. Texture
   i) Smooth surfaces should be preferred over rough ones for ease in cleaning and being less prone to catch settling dust. Rough surfaces are desirable where a skid-resistant feature is important and are acceptable where surfaces are difficult to reach.
d. Unit Size
   i) The unit should be large enough to reduce the number of joints yet small enough to conceal minor soiling and scratches and to facilitate replacement if damaged. Monolithic materials may be used if they have inherent soil hiding characteristics that can be easily repaired without the repair being noticeable.
e. Joints
   i) Joints should be small, flush, limited in number and using the best possible materials. Horizontal joints should not be raked but should be flush or tooled concave. Monolithic materials should have adequate control joints and expansion joints at the proper spacing in order to prevent surface cracking.
f. Cost
   i) Materials shall be selected for long life, low maintenance, easy to replace and overall aesthetic and functional qualities.
g. Availability
   i) Materials selected should be readily available. Domestic products shall be selected unless the product is not available within the country
h. Proprietary Materials
   i) Proprietary items shall only be used where it is established that no other materials would meet the particular design requirements.
i. Installation Standards
   i) Materials shall be detailed and specified to be installed in accordance with industry standards and manufacturer's printed directions.
j. Flammability
   i) Interior finishes including doors/ windows shall meet requirements of the code and the fire/life safety requirement.
   ii) Finishes for all protected exit ways shall be Class A as defined by NFPA101. Platforms, mezzanines, corridors, stairways and vestibules shall be considered exit ways.
   iii) Finishes for all protected exit ways shall be Class A as defined by NFPA101. Platforms, mezzanines, corridors, stairways, and vestibules shall be considered exit ways.
   iv) Finishes in all other areas shall be Class B as defined by NFPA 101, and combustible adhesives and sealants may be used when they meet the requirements.

36.32.3 An indicative selection of finishes is included in Attachment D for reference purposes only.

36.33 Standards and Codes

36.33.1 The stations shall be designed in accordance with the requirements of the following codes and standards:

- ANNEX J- NBC 2016Edition
- NFPA 130, 2017
- NFPA101
- The Persons with Disabilities Act; and Handbook on Barrier-Free and Accessibility 2014 published by the CPWD (Central Public Works Department) India.
- EN 81 Indian Standards for Elevators
- EN115 for Escalators.

ATTACHMENT A: Boarding-Alighting Figures

Boarding-Alighting Figures for the year 2025

Stations	Direction 1		Direction 2	
	Board	Alight	Board	Alight
Benniganahalli	13,180	0	0	12,779
Kasturi Nagar	4,673	8,488	8,230	5,170
Sevanagar	10,834	4,728	5,379	11,554
Banaswadi	6,192	4,558	4,916	6,928
Nagawara	14,221	20,375	20,356	12,613
Kanaka Nagar	5,218	9,572	8,368	5,354
Hebbal	4,786	6,508	6,356	4,928
Mathikere	6,885	7,248	7,130	10,791
Yeshwantpur	20,672	11,167	15,331	22,738
Shettihalli	8,904	22,002	25,607	8,416
Medarahalli	2,425	14,189	12,147	2,324
Chikkabanavara	0	14,163	16,579	0

Table 4: Boarding- Alighting Figures for the year 2031

Stations	Direction 1		Direction 2	
	Board	Alight	Board	Alight
Benniganahalli	17,953	0	0	17,714
Kasturi Nagar	5,640	10,044	10,026	5,887
Sevanagar	12,750	6,121	6,939	14,931
Banaswadi	7,336	5,330	6,686	7,656
Nagawara	18,361	25,226	24,813	16,607
Kanaka Nagar	6,325	11,829	10,506	6,401
Hebbal	5,128	8,413	8,206	5,422
Mathikere	7,697	9,528	9,276	11,952
Yeshwantpur	27,212	12,871	17,288	30,087
Shettihalli	12,891	28,786	33,745	13,156
Medarahalli	2,611	19,971	17,237	2,524
Chikkabanavara	0	18,222	22,466	0

Table 5: Boarding- Alighting Figures for the Year 2041

Stations	Daily 2041		Peak 2041	
	Board	Alight	Board	Alight
Benniganahalli	23,487	0	0	23,102
Kasturi Nagar	6,452	11.407	11,646	6,609
Sevanagar	14,880	7,461	8,689	15,279
Banaswadi	8,159	6,202	7,660	9,281
Nagawara	25,902	28,147	28,624	23,868
Kanaka Nagar	8,177	15,050	13,818	8,268
Hebbal	5,961	11,275	11,409	6,424
Mathikere	10,000	14,073	13,180	13,579
Yeshwantpur	34,371	16,296	18,037	36,345
Shettihalli	16,691	35,050	37,587	18,598
Medarahalli	3,146	27,610	23,920	3,070
Chikkabanavara	0	26,359	34,774	0

ATTACHMENT B: Minimum Station Accommodation

Sl. No.	Room Name	Area (Sq. M)	HVAC requirement
1	ASS	210	
2	Excess Fare Office (EFO)/ Ticket Office Room (TOM)	30	AC required
3	Ticketing	Along with EFO	AC required
4	TER + SER (Non-Interlocking Station)	70	AC required
	TER (interlocking station)	60	AC required
5	UPS & Battery	35	AC required
	SER (interlocking station)	60	AC required
9	Staff Room	25	
10	Station Control Room + Audit & Cash + Store	35	AC required
11	Stn. Manager's Room	20	
15	Security Room	12	
16	Signal Maintenance Room	20	
19	First Aid Room	12	
20	Cleaner Room	10	
21	Refuge Room	7	
22	Gents Toilet	Minimum 2 Western WC and 1 Indian WC, 3 urinals & 3 washbasins	
23	Ladies Toilet	Minimum 2 Western WC and 1 Indian WC, 3 washbasins	

Sl. No.	Room Name	Area (Sq. M)	HVAC requirement
24	Disabled Toilet	As per the Indian disability code	
25	DG set	70	
26	Pump room	80	
27	Underground water tank for Fire fighting	As per NBC 2016	
28	Permanent way store (terminal station)	15	
29	Crew Controller (terminal station)	15	
30	Train operator restroom (terminal station)	12.5 for Men and 12.5 for Women	
31	Solar battery room	40	

Notes

1.1 The actual number of TOM, TVM and AFC gates will be as per Automatic Fare collection contract.
1.2 Clear Height in equipment room between false floor to false ceiling should be 3m.
1.3 Minimum Clear Height in ASS should be 3.6 meter.

ATTACHMENT C: Schedule of Indicative Finishes - Envelope (facade

Element	Description
Roof - Station, FOB and Entrances	Standing Seam roofing system of Galvalume / Zincalume / Galvanized sheeting with 4 Multiwall Polycarbonate for Skylights
Roof - Ancillary Buildings	Flat roof with double layer waterproofing and gravel
Façade	Indicative Facade finishes to be checked on the BOQs
Facade (exposed concrete)	Epoxy textured finish (anti-dust, anti-graffiti)
Glazing	Extruded aluminium powder coated profiles with laminated security glass (single or double), ironmongery of stainless steel.
Balustrades and Railings - FOH	Stainless and/or laminated security glass/ 900 mm parapet with cladding & SS guard rail on top
Balustrades and Railings - BOH	MS railing with synthetic enamel paint

ATTACHMENT D: Schedule of Interior Finishes

S. No	Area	Floor	Skirting	Walls (Internal)	Ceiling
	Concourse Level (C)				
C1	Excess Fare Office (EFO)/ Ticket Office (TOM)	450 mm Raised Vinyl Floor tile 600X600mm, Anti-dust sealer on the concrete slab*	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
C2	TER (Interlocking Station)	450 mm Raised floor with Vinyl Floor tile 600X 600mm, Anti-dust sealer on the concrete slab	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD/ Non-perforated metal panel ceiling*

S. No	Area	Floor	Skirting	Walls (Internal)	Ceiling
C3	SER (Interlocking Station)	450 mm Raised floor with Vinyl Floor tile 600X 600mm, Anti-dust sealer on the concrete slab	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD/ Non-perforated metal panel ceiling*
C4	UPS/Battery	Acid-resistant flooring	Acid Resistance Tiles	Plaster with OBD	R.C.C. slab + Plaster + OBD/ Non-perforated metal panel ceiling*
C5	SER + TER (non-interlocking station)	450 mm Raised floor with Vinyl Floor tile 600X 600mm, Anti-dust sealer on the concrete slab	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD/ Non-perforated metal panel ceiling*
C6	Stn. Master's Room	Vitrified Tile	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
C7	SCR	450 mm Raised floor with Vinyl Floor tile 600X 600mm, Anti-dust sealer on the concrete slab	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
C8	Concourse Public Areas	Honed granite flooring with Tactile strip as per design 14.5mm thk Yellow Coloured Directional Vitrified Tactile*		Lacquered Glass Cladding + SS Railings	Perforated metal ceiling between C beams/ Unpainted surface
C9	Security Room	Vitrified Tile	-	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
	Platform Level (P)				
P1	Platform	Honed granite flooring with Tactile strip as per design 14.5mm thk Yellow Coloured Directional Vitrified Tactile*	-	Granite Cladding up to 1200mm + Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
P2	Cleaner Room	Vitrified Tile	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
P3	Refuse Room	Anti-Skid Vitrified Tiles (600 x 600)	-	Plaster + Glazed vitrified Tiles up to 2100 height + OBD	R.C.C. slab + Plaster + OBD
P4	Male Toilet	Anti-Skid Vitrified Tiles (600 x 600)	-	Plaster + Glazed Vitrified Tiles up to	R.C.C. slab + Plaster + OBD

S. No	Area	Floor	Skirting	Walls (Internal)	Ceiling
				2100 height + OBD	
P5	Female Toilet	Anti-Skid Vitrified Tiles (600 x 600)	-	Plaster + Glazed Vitrified Tiles up to 2100 height + OBD	R.C.C. slab + Plaster + OBD
P6	Handicapped Toilet	Anti-Skid Vitrified Tiles (600 x 600)*	-	Plaster + Glazed Vitrified Tiles up to 2100 height + OBD	R.C.C. slab + Plaster + OBD
P7	Staff Room	Vitrified Tile	Vitrified Tile (100mm high)	Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
P8	Lactation Room	Anti-Skid Vitrified Tiles (600 x 600)	-	Plaster + Glazed Vitrified Tiles up to 2100 height + OBD	R.C.C. slab + Plaster + OBD
P9	First Aid Room	Anti-Skid Vitrified Tiles (600 x 600)	-	Plaster + Glazed Vitrified Tiles up to 2100 height + OBD	R.C.C. slab + Plaster + OBD
	Street Level (S)				
S1	DG set	52mm thk Hardonite Flooring	18mm thk Cement Plaster	Plaster with Anti Dust	R.C.C. slab + Plaster + OBD
S2	Pump room	52mm thk Hardonite Flooring	18mm thk Cement Plaster	Plaster with Anti Dust	R.C.C. slab + Plaster + OBD
S3	ASS	52mm thk Hardonite Flooring	18mm thk Cement Plaster	Plaster with Anti Dust	R.C.C. slab + Plaster + OBD
S4	Entrance Lobby	Honed granite flooring with Tactile strip as per design*	150mm high polished granite cladding	Granite Cladding up to 1200mm + Plaster with Putty + Acrylic emulsion	R.C.C. slab + Plaster + OBD
S5	Ramp to Lift Lobby	20mm thick Honed Granite, 150mm wide strips, anti skid installation	N/A	N/A	N/A
	STAIRCASES (ST)	**TREAD**	**RISER**	**LANDING**	
ST1	Concourse to Platform level	30mm thk Honed Granite*	18mm thk Polished Granite	30mm thk Honed Granite	

S. No	Area	Floor	Skirting	Walls (Internal)	Ceiling
ST2	Street to Concourse level	30mm thk Honed Granite*	18mm thk Polished Granite	30mm thk Honed Granite	

*Tactile path shall be provided at all levels for guiding the users along an intended safe path at pedestrian crosswalks, the platforms, and both the top and bottom of stairs, ramps and in front of escalators and elevators/lifts

Note:

- Minimum size of the Flooring unit should be 1200mm by 600mm and 30mm thick for all public area
- Wherever required within SCR, Staff Room, TOM, etc. granite counter top (30mm thick) with suitable support system shall be provided
- Soffit of all concrete exposed slabs shall be painted with epoxy finish as per approved texture and colour 60 mm thick granite for PSD area in Platform edge
- Roof sheeting above Platform Level & Entry/Exit structures shall allow for atleast10-15% transparency for natural light

Attachment D – Exterior finishes

Particular	Finishes
Exterior	Powder coated Aluminium Louvers and Fixed Glass pannels from 1800mm to beam soffit
	Remaining area above painted with texture paint with grooves to break the monotony
	Plazas - kerb stone & interlocking paver blocks
Stairs (BoH) / Ancillary Building / Emergency Egress Staircases	25mm thick polished kota on treads and landing with 20mm thick Kota Stone Skirting (150mm high)
	20mm thick polished kota on risers
	MS enamel painted handrails
Exterior columns	10mm thick vitrified tile cladding upto 2400mm height from plaza level
	Remaining area above finished with epoxy finish as per approved texture and colour
Soffit of concrete exposed slabs	Soffit of all concrete exposed slabs finished with epoxy finish as per approved texture and colour
Lift Lobby / Ramp	30mm thick honed granite on floor of lobby
	30mm thick honed granite, 150mm wide strips, anti skid installation for ramp
	SS Floor Mounted Balustrade with top and intermediate bar / rail and horizontal SS tie rods running between balusters
	SS Wall Mounted Grab bar (if applicable)

Attachment E - Load considerations

For all stations the minimum distributed and concentrated loads shall as a minimum be used.

If higher loads are required by the Project Partners or to suit the Contractors MEP and Architecture design, then

they shall be coordinated and interface and accommodated at no extra cost

Description	Superimposed Dead Loads		Imposed Loads	
	Finishes (kN/m2)	Ceilings & Services (kN/m2)	UDL (kN/m2)	Concentrated (kN)
Public Areas	5	1	5	5
Non-Public Areas - (offices, toilets, non equipment rooms)	5	1	5	5
Heavy Equipment Rooms	5	1	25	40
Light Equipment Rooms	5	1	10	20
Stairs & Landings	5	1	5	5

Appendix A - BIM MANUAL

INDEX

General

1 Purpose

1.1.1 This Building Information Modelling - Standards, Methods and Procedures (SMPs) describes the use of Building Information Modelling (BIM) for the work under the Contract.

1.1.2 This SMP's shall be used as a reference for the Contractor to develop specific Work Package SMPs that shall detail the specific CAD/GIS/BIM software and Electronic Content Management System (ECM) software used within the Work Package to control the specific BIM and CAD process. The outputs from this ECM system will be drawings as PDF's that will be input to the Contractors EDMS system for distribution.

1.1.3 SMPs establish the methodology for managing the production, distribution and quality of the design information generated by CAD, GIS and BIM systems, using a disciplined process for collaboration and a specified file and model naming policy.

2 Scope

1.2.1 This BIM SMP outlines the roles and responsibilities that are necessary for a successful collaborative Building Information Modelling approach.

1.2.2 The Common Data Environment (CDE) is mandated for the structure and the controlled sharing of the building information with known provenance and status in a multi-disciplinary environment.

1.2.3 The Contractor's SMPs are required to control the production and coordination of the design information within each Works Package.

3 Introduction

1.3.1 BSRP Projects are implementing BIM for the delivery of the projects to return significant time, cost and quality improvement in the way that the program will be delivered, constructed and ultimately operated.

1.3.2 The gradual development of BIM, with the support of new digital technologies, aim to improve the quality of planning, construction and operation of BSRP Rail system. BIM can be successfully implemented if effective forms of collaboration are also adopted.

1.3.3 Collaborative project execution is a central factor for success. Openness, transparency and a goal and solution-oriented approach must become the core value of all activities in the infrastructure area.

1.3.4 The BIM Manual should be implemented for all the project phases.

4 Standards, Norms and Guidelines

This manual makes use of the following technical standards

- ISO/DIS 19650-1.2 Organization of information about construction works -- Information management using building information modelling -- Part 1: Concepts and principles.
- ISO/DIS 19650-2.2 Organization of information about construction works -- Information management using building information modelling -- Part 2: Delivery phase of the assets.
- PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling.
- PAS 1192-3:2014 Specification for information management for the operational phase of assets using building information modelling.
- PAS 1192-4:2014 Collaborative production of information.
- PAS 1192-5:2015 Specification for security-minded building information modelling, digital built environments and smart asset management.

5 Terminology

Terms	Description
2D	Two-dimensional representation of an object, typically plans, sections, elevation and details.

Terms	Description
3D	A model with objects having three-dimensional properties. Model may have varying levels of detail and development depending on the project phase.
Asset Information Model	File based federated BIM Model, set of BIM extraction (drawings, data drops) and project related documentation (reports and forms) developed during the Operation and maintenance stages.
Attribute	Data field populated with pieces of information attached to each BIM object to provide different type of information like physical/geometrical characteristics, classification codes, locations, relationships or data related to the BIM use cases. It may be called as Parameters.
Authoring Tools	BIM Software developed by different providers that enable the creation and modification of BIM Models.
Aggregated Model	A compilation of multiple models into a single manageable model. For example, an Aggregate Model may include a building model plus a site model, or several Mono-Discipline Models aggregated into a single Multi-Discipline Model. Aggregation - as a term - applies to both Integrated Models and Federated Models
BIM Execution Plan	BIM Execution Plan developed by the contractor to address the Employer's Information Requirement (EIR).
BIM Model	3D Model containing information and attribute data
Clash Rendition	Rendition of the native format model file to be used specifically for spatial coordination processes to achieve clash avoidance or to be used for clash detection.
Common Data Environment	Single source of information for any given project used to collect and manage all relevant approved project documents for multi-disciplinary teams in a managed process
Data Exchange	BIM Deliverables
Data Drop	Extraction of the data information store in the BIM Models. This data is extracted to Spreadsheets of databases.
Federated Model	A BIM Model which links (not merge) several individual discipline Models together. It does not merge the properties of individual models into single database.
Gate review	Design review carried out by Engineers to confirm the design outputs
Information Exchange	Structure collection of information at one stage of a project in a defined format
IFC	Data model neutral and open specification that is used by BIM programs and that contains a model of a building or facility including spatial elements, materials, shapes and information.
Level of Definition	It includes Level of Geometry and Level of Information
Master Information Delivery Plan	Post-contract award deliverable which includes a plan listing all the information deliverables of a project including models, drawings, specification and other kind of deliverables. It identifies when project information is to be prepared, by whom and define the Level of definitions and the procedure. It will be created by collating Task Information Delivery Plan (TIDP) of all discipline of a project
Milestone	Scheduled event marking the due date of accomplishment of a specified task of objective.
Project Implementation Plan	Post-contract award deliverables which assess the capability, competence and experience of the potential contractor bidding for the project along with quality documentation.
Project Information Model	File based federated BIM (model), set of BIM extraction (Drawings, data drop) and project related documentation (report and forms) developed during the design and construction stages.
Task Information Delivery Plan	Post-Contract award deliverable, which includes a plan listing all the information deliverable of a specific discipline of a project including model, drawings, specification, and other kind of deliverables.

Terms	Description
Virtual Design Review	Team review the digital engineering design model
Work Breakdown Structure	Multilevel framework that organizes and graphically displays elements representing work to be accomplished in logical relationships. Each descending level represents an increasingly detailed definition of a project component. Project components may be products or services. It is the structure and code that integrates and relates all project work (technical, schedule, and cost) and is used throughout the life cycle of a project to identify and track specific work scopes.
Zone	Set of spaces (locations) sharing a specific Attributes, such as activity, access, management or condition

6 Abbreviation

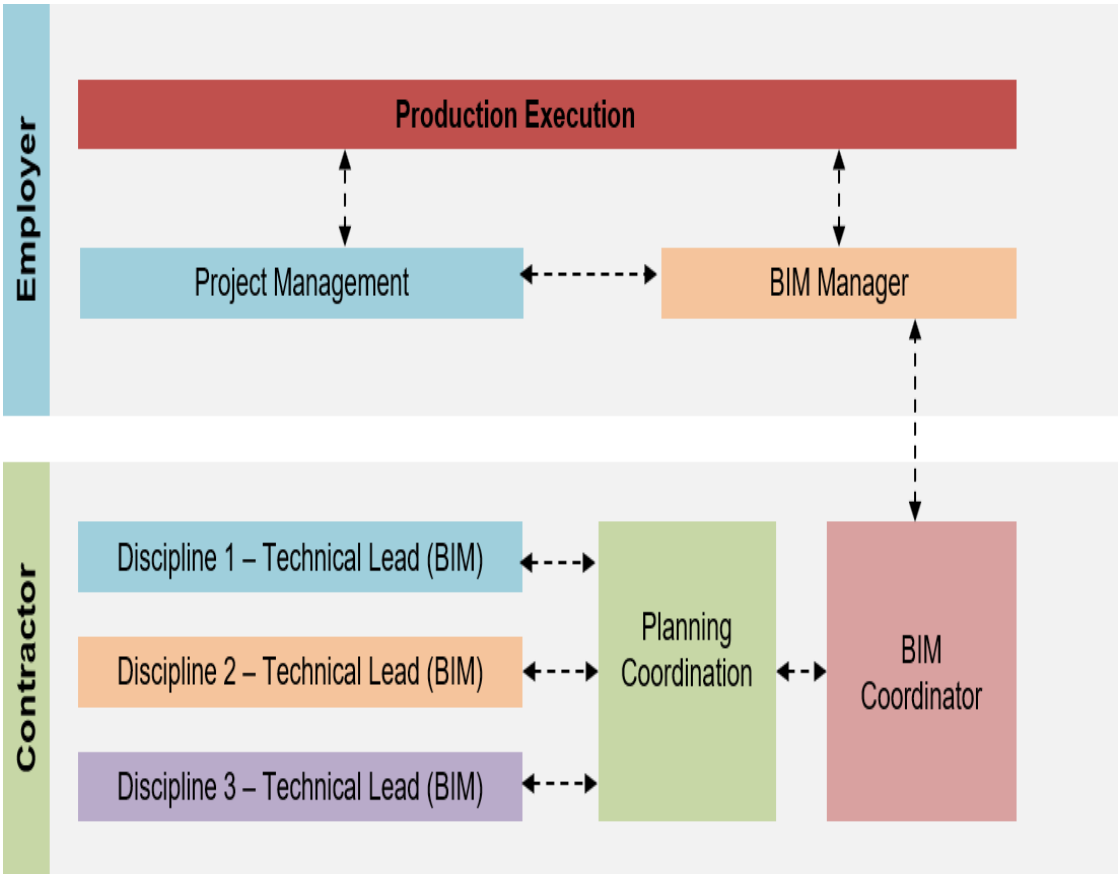
Abbreviation	Meaning
AIM	Asset information Model
AIR	Asset information Requirement
BEP	BIM Execution Plan
BIM	Building Information Modelling
BOQ	Bill of Quantities
CDE	Common Data Environment
COBie	Construction Operation Building Information exchange
EIR	Employer Information Requirement
GIS	Geographical Information System
IFC	Industry Foundation Class
LOD	Level of Definition
LoG	Level of Geometry
LoI	Level of Information
MEP	Mechanical Electrical Plumbing
MIDP	Master Information Delivery Plan
PIM	Project Information Model
PIP	Project Implementation Plan
QAQC	Quality Assurance & Quality Control
QC	Quality Control
TIDP	Task information Delivery Plan
VDR	Virtual Design Review
WBS	Work Break-down Structure

7 BIM Management

1.7.1 Employer / Engineer Team

The Employer BIM Management team has the following roles to monitor / review the BIM process for the whole project till handover. This may either be directly with the Employer or through the Engineer.

BIM Manager – Primary contact for the various BIM Coordinators within a project
BIM Coordinator– Secondary contact for the various BIM related query (on-site)



Interface between Contractor and Employer/ Engineer

Role	Description	Tasks / responsibilities
BIM Manager	The BIM Manager leads the implementation of BIM throughout the project in compliance with Employer and leads the project as BIM Integrated team. The BIM Manager is the primary point of contact for any BIM related issues within the BIM project	Define the BIM strategy and requirements for the project, identifying and maintaining the BIM goals and priorities Review and approve the BIM Execution plan and the MIDP Lead the BIM teams, tracking and monitoring their performance Report to Employer management on any issues surrounding BIM Implementation. Ensure the project proves the tools, process and support to engage the information in a Structured, coordinated and accurate way. Hosting the BIM team Meeting. Coordinate efforts within the BIM Teams in accordance to project needs. Facilitate the adoption of collaborative ways of working
BIM Coordinator	Equivalent role to the BIM Manager but focused on local delivery aspects	Similar task of the BIM Manager but in close discussion with local implementation bodies.
Technical lead - BIM	Key person for all BIM Technical related issues within the BIM Project (for each discipline)	Ensure that Design/ Construction / Operation uses BIM. Ensure the quality and the BIM standards within the discipline. Performs a BIM Model quality verification. Participate in the BIM related meetings with local contractor / specialists. Organizes and leads the BIM kick-off meeting with the BIM Coordinator for his/ her discipline. Ensure that the 3D models are clash free Support the contractor in BIM related issues.

1.7.2 Contractor's Team

Role	Description	Tasks / responsibilities
BIM Manager	The BIM Manager leads the implementation of BIM throughout the project from the Contractor side	Leads the BIM Implementation during the project from contractor side. Produce and updates the BIM Execution Plan in collaboration with the BIM Coordinator. Produces MIDP by collating the TIDP at the start of the project. (BIM perspective). Assure the BIM deliverable. Act as a contact for any BIM related issues. Leads the Virtual Design / Construction review
BIM Coordinator	Equivalent role to the BIM Manager but focused on local delivery aspects	Similar task of the BIM Manager but in close discussion with local implementation bodies.
Technical lead – BIM (Discipline)	Technical lead – BIM (Discipline) is responsible for the interdisciplinary coordination of the BIM Model per package	Reports to the BIM Coordinator. Produce the BIM Execution plan in coordination with the BIM Coordinator / BIM Manager. Ensure that the BIM process and procedures per discipline are compliant with the project goals. Ensure that discipline models can be used to properly deliver the requested BIM uses. Support and advises on the adoption of BIM processes within the discipline. Define and updates best practice and procedure per discipline. Configure and develop Clash Detection analysis on a regular basis. Leads regular coordination meeting and track the process. Responsible for the integration and the geolocation of the models per package. Support interface Coordinator and Design Coordinators. Support the BIM Coordinator on discipline specific issues (i.e. Clash detection analysis or the Gate Review meeting). Define the TIDP (per discipline) at the start of the project (deliverable)
BIM Engineer	BIM Engineer reports to Technical Lead – BIM (BIM perspective) and to the BIM Coordinator	Develop the BIM Models and constituent parts. Developing the content for the 3D model. Generate the 2D drawings from the 3D model. Following the standards and incorporating in the 3D/2D . Owns their model information. Generate the project output, such as drawings, the quantity (if necessary) the data drops, the visualization work and any other BIM output. Internal quality check (Self check) related to the design

8 BIM User Cases

BIM information (both graphical and non-graphical data) is initially created during the Design phases of the project. This information will be consumed later by functions based on the data that can be input into their work process. The use cases are summarized in the list below against each function. All the BIM use cases to be applied in each project shall be defined in the BIM Execution Plan.

The following table shows the mandatory (M) and optional (O) use cases.

Mandatory (M) Optional (O)	Design Authoring (Collaboration)	Engineering Analysis	2D Drawing	Interference Management (Clash Checks)	Interactive Design Review	Structural detailing	Quality Control	As-Built documentation	Operation & Maintenance Information (Attributes)
Concept Design	M	O	M	O	M	O	O	-	-
Preliminary Design	M	M	M	M	M	M	M	-	-
Detailed Design	M	M	M	M	M	M	M	-	O
Design for Approvals	M	M	M	M	-	M	O	-	-
Construction	M	O	M	M	M	M	M	-	-
As-Built	M	-	M	-	-	M	M	M	O

- **Design Authoring (Collaboration)**
  A BIM model of the principal elements of Civil works including Track work inside the Depots covering Architectural, Structural and MEP works shall be created in accordance with the Master Information Development Plan using discipline-based software which each designer's controls and where the required information from other teams is referenced from the Contractor CDE and the Employer CDE using Open BIM formats.

  The contractor shall deploy their own CDE where their WIP (Work In Progress) design will be carried out. A Contractor CDE with a "Client Shared" area is necessary to make possible Gate Reviews for the Employer's Approval.

- **Engineering Analysis**
  The BIM Model produced from the core BIM authoring tools may be linked to / exported to analysis software for Structural, Mechanical, Electrical and other design analysis.

- **2D Drawings**
  2D General Arrangement drawings, coordination drawings, location drawings and schedule of elements objects components and materials for all works that is modelled shall be generated from the 3D BIM Model as sheet sets (data drop) that are contained in the BIM Project model for that discipline. Typical details, assembly and component details and shop drawings may be created separately from the BIM Model depending on the Level of Definition of a stage.

- **Interference Management (Clash Detection)**
  Design Collaboration between disciplines shall be supported by running clash detection in both the authoring and reviewing software to identify spatial interference between modelled elements. A Clash register will be maintained for review and action during design review (the Clash Detection Report is a deliverable). Lead Engineers shall not be permitted to approve an element unless it is confirmed as being clash free against all related model for that work.

- **BIM Quality Control and Assurance**
  Quality Control and Assurance of the BIM Data (3D and information) will be done through the process of design, collaboration, checking review and audit. These processes measure how well the BIM objects fulfil their purposes and follow the processes defined to achieve those purpose

  - Coordination of the BIM Data through Design / Construction Review, Clash check etc.,
  - Checking the deliverable created from the BIM Model prior to Employer's approval'
  - Specific Checks of the BIM Model content by any Subcontractor prior to approval (Shop Drawings generation for instance),
  - Audits by the Contractor BIM Management Team

- **As-Built documentation**
  The BIM Model shall be revised as work packages are completed to record the As-Built status of the works and if necessary, to adapt the positioning / shape / type of the objects to the built condition

  The Contractor during the Design Stage shall develop a model that can be used / updated as a base for the As-Built models. The As-Built model documentation will also be stored and used during the Operation Stage that takes place after BIM commission (Hand-over). LOD shall be as defined in Clause 4.9.

- **Operations & Maintenance Information**
  The BIM model will be used to both visualize and report the status of construction testing and the collaboration of work packages ready for Hand-over to the Client for Operation and Maintenance

9 BIM Execution Plan (BEP)

A "**BIM Execution Plan" (BEP)** is a plan prepared by the Contractor to explain how the information modelling aspects of a project will be carried out. The plan is prepared as a direct response to the Employer's Information Requirements and Technical Specifications and shall detail the project deliverables stipulated by the contract and the information exchange requirements detailed in the BIM Manual.

This plan is prepared at the beginning of the project but must be updated later for each project stage. The Contractor shall provide the BIM Execution Plan in order to explain in detail how they intend to carry along all the BIM Objectives in this project.

The BIM Execution Plan includes Specific Annexes for the different disciplines and authoring tools describing how all the procedures shall be implemented.

The contents of the BEP shall consist of everything requested in the EIR and also the following information:

- **Management:**
  - Roles, responsibilities and authorities
  - Master Information Delivery Plan (MIDP)
- **Planning and documentation:**
  - Capability of the Contractor / Sub-contractor
  - BIM Use Cases
  - Agreed project processes for collaboration and information modelling
  - Agreed matrix of responsibilities across the Supply Chain
  - Task Information Delivery Plan (TIDP to be collated in the MIDP)

- **The standard method and procedure:**
  - File Naming Convention to be followed as per the BIM Manual Naming Convention, any change will need to be approved by the Employer.
  - Geo-location & Coordinates system.
  - Levels of definition (LOD).
  - Specific Annexes from the different disciplines and authoring tools (one per authoring tool), describing:
    - Modelling standards (including model's size and length recommendations)
    - Workflows
    - Agreed construction tolerances for all disciplines
    - Drawing sheet templates
    - Contractor CAD manual (Adaptation of the CAD Standard to its authoring tool)
- **The IT solutions**
  - Software versions
  - Exchange formats
  - Security & Extranet Access

The BEP shall include the MIDP.

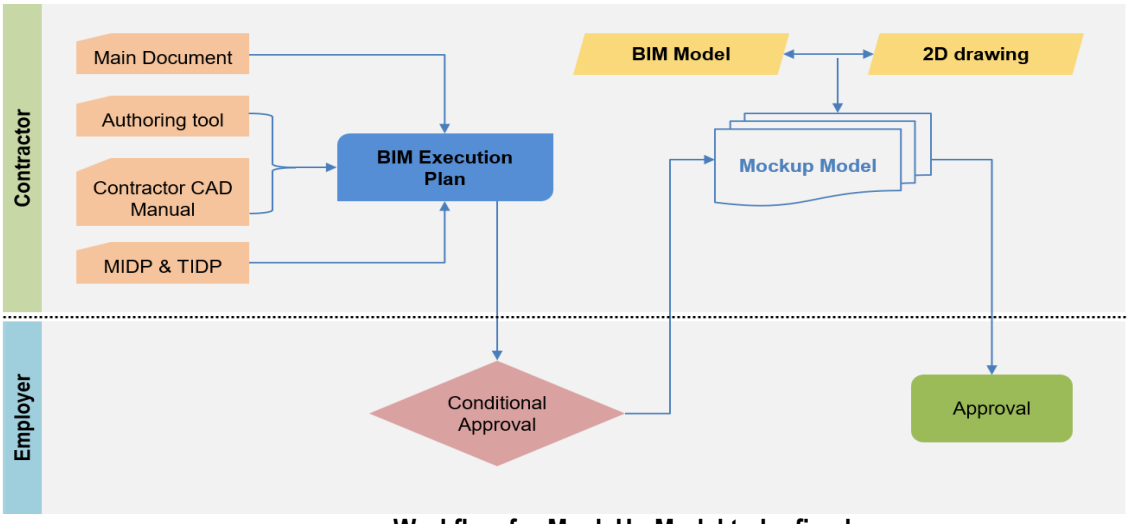
The BIM Execution Plan is comprised of the main document (describing the overall information of the BEP) and a list of annexes including the TIDP, the MIDP and the different BIM Authoring tools – specific procedures and workflows.

The Contractor shall provide 4 Nos. of Authoring tool licenses for the Engineer to review the deliverables throughout the entire project phases.

- **BIM Authoring tool**
  The Contractor shall provide at least one annex by BIM Authoring tool and there could be more if the contractor considers it necessary; for instance, due to the existence of various disciplines developing the project with the same BIM Authoring tool.

  This annex should include a small mock up model geo-located correctly. It shall be an aggregate model containing at least two BIM models from various disciplines and shall be submitted in the delivery format defined in BEP (Preferably IFC). The content of the model should have a simple 3D model to identify the proper project geo-location (Northing, Easting & Elevation).

  The Engineer will review the model by linking the model to the other discipline and to export IFC with minimal loss of information.



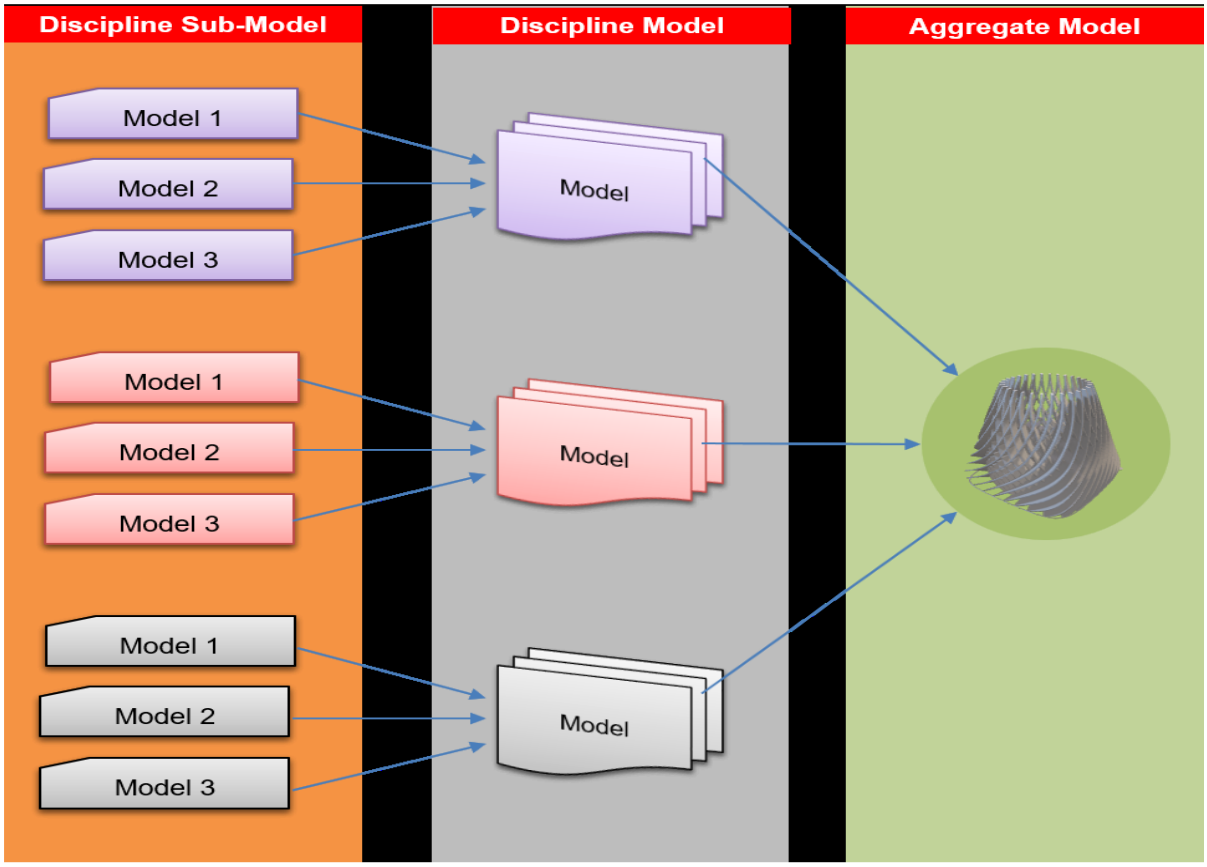
Workflow for Mock Up Model to be fixed

10 Main Deliverables

The BIM strategy is a file-based information delivery, where the featuring files can be consumed independently but also used, viewed and referenced together, by means of the federation of the files according to the Work Breakdown Structure (WBS) and the way the Contractor structures the delivery.

The Federation of models attempts, as much as possible and depending on the CDE environments deployed by the Employer and the Contractor, to build one model but using multiple source files (federated model for instance) controlled by the Employer's CDE.

If the files are federated models, this single model is called Aggregated Model. An Aggregated model can also be generated by adding several Aggregated models.



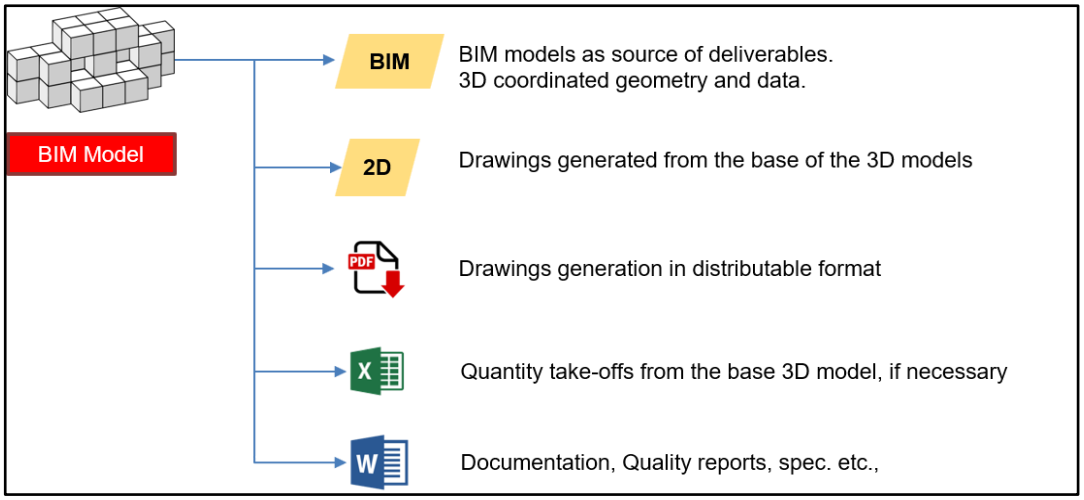
Aggregated Model

a. 3D BIM Models

The 3D BIM Models are the core deliverables in the Project Information Model Phase (Design and Construction Stages). These models become the source any information provided in the different stages, up to the point of taking precedence in the event of discrepancies and inconsistencies between models and drawings

The Master Information Delivery Plan (MIDP) shall include the estimated list of BIM models. It will not be necessary to develop in depth the breakdown of models for each discipline/ package, but the list must include at least one model per present discipline per package/ segment and submission.

The Level of Definition, LoG (Geometry) + LoI (Information), shall be shown for each deliverable.



3D BIM Model and Data Drops

b. **2D Drawings**
2D Drawings are the preferred source of information for the transmission of information among the different stakeholders.

The MIDP will include the forecast of drawings needed for every submittal. 2D drawings shall be generated from the base of the 3D models.

c. **BIM Data drops and extraction**
The BIM Data drops are the Quantity Take-off Spreadsheet (if necessary) and the information from the BIM Model (at later stage)

d. **Master information Delivery Plan (MIDP)**
The Master Information Delivery Plan (MIDP) is a main Post-Contract award deliverable, which includes a plan listing all the information deliverables of a project including models, drawings, specifications, equipment and other kind of BIM deliverables.

It shall identify when project information is to be prepared, by whom, and defines the Levels of Definition and the procedures.

The MIDP incorporates all relevant Task Team Information Delivery Plans (TIDP), which list all the information deliverables of a discipline of a project, and an updated / detailed Responsibility Matrix. The MIDP is an independent deliverable, while the TIDPs commonly are included within the BEP. The TIDP could be also included within the MIDP documentation.

11 Level of Definition

Level of Definition is used to determine both the level of geometry detail (LOD), and level of associated information (LOI) for any given model element at project work stage. Defining LOD and LOI informs the Contractor of the degree of information reliability when using the model (LOD = LoG + LoI).

a. Level of Geometric detail (LoG)
The Level of Geometric detail (LoG) is the description of the quality of the graphical content of a container at a particular point during project delivery. It relates to how much detail is included within the model space, system of element.

Level of Geometric detail (LoG)	Definitions
LoG 200	The Model Element is graphically represented within the Model as a generic system, space, object, or assembly with approximate quantities, size, shape, location, and orientation. The Model must be accurate enough to ensure that the design complies with the defined restrictions (clearances for administrative, legal, environmental, adjacent roads, railways, space for utilities/ electro-mechanical systems verification or transversal discipline coordination) prior to detailing. As such, the LoG 200 is defined to reach the requirements of the Master Design, by focusing on the outer geometry and allowance of the objects. The elements may be recognizable as the components they represent or as volumes for space allocation and reservation. This LoG can be used to verify regulatory requirements if those are allowance-related (clearances).
LoG 300	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Objects modelled can be measured directly from the model and those non-modelled can be calculated considering measures extracted from related objects This LoG can be used to verify any regulatory requirements unless those are related to specific brand/model/materials etc.,
LoG 400	The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. This LoG incorporates coordinated specialist sub-contract design models and reaches the highest level of definition geometrically speaking. It is important to mention that when LoG 400 is a requirement of the Design Phase, brand/model may not be stated; therefore, during the Construction Phase that Design LoG 400 would need to implement the finally chosen brand/model to the Construction LoG 400.
LoG 500	As per LoG 300 but with sufficient verification as to demonstrate the accuracy of the model as a constructed at Hand-over. It is focused on the graphical information needed to support the model and the LoI for the Operation & Maintenance stage. It is important to mention that this LoG does not necessarily need to reach the highest detail of the LoG 400.

b. Level of Information (LoI)

The Level of Geometric detail (LoI) is the description of the quality of the non-graphical content of a container at any point during project delivery. It relates to the information that is included within the Models elements and that is contained in the elements Attributes.

Concept Plan	Preliminary Design	Detailed Engineering Design	Construction Drawings	As Built	Operation (Future)
Stage Definition (PAS 1192:2)	Stage 2 Concept / Stage 3 Definition	Stage 3 - Definition / Stage 4 – Design	Stage 4 – Design / Stage 5 – Building and commission	Stage 6 Handover	Stage 6 – Handover / Stage 7 – Operation
Level of Definition	LOD 200	LOD 300	LOD 400	LOD 500	LOD 500

12 Common Data Environment (CDE)

A Common Data Environment (CDE) is a single source of information for any given project or asset, used to collect, manage and disseminate all relevant approved project documents and data for multi-disciplinary teams in a managed process.

The CDE is core to Building Information Modelling [BIM] and information management processes and shall act as a means of providing a collaborative environment for sharing work in a consistent, managed and lean way for all project stakeholders.

The CDE shall support container-based collaboration where information management processes are applied to all information content (model files, drawings, documents and objects etc.).

The project's CDE shall have the functionality to deliver secure, managed access to information based on a stakeholder's role in the project and the status of the information being accessed.

No information exchanges shall be permitted out of the Employer CDE environment including e-mails. This promotes a collaborative environment where all stakeholders can integrate and share appropriate content.

- **Naming Conventions within CDE**
  The Project CDE shall be based on at least the following naming codification:
  - Project Name / Location
  - Line
  - Originator Name
  - Volume System / Zone
  - File Type
  - Discipline Code
  - Floor Level
  - Number
  - Revision No.

- **Project Name / Location**
  This will consist of a distinct common project identifier to Detailed Technical Design (three characters)

- **Line**
  Line name according to the Detailed Technical Design

- **Originator Name**
  Each Contractor shall be allocated a unique code.

- **Discipline Code**
  Each Discipline shall have the following code

Code	Description
ARC	Architecture
CTV	Closed Circuit Television
COM	Communications
CIV	Civil
ETP	Electrical Traction Power
ELV	Extra Low Voltage
ELE	Electrical Emergency Voltage
FRD	Fire Detection
FRS	Fire Suppression
MHV	Mechanical HVAC
MLF	Mechanical Lifts
MES	Mechanical Escalators
MTR	Mechanical Travellators
PUA	Public Address
PUH	Public Health
SNG	Signage
STR	Structural
SIG	Signals
TRK	Track
UTL	Utilities
GEO	Geotechnical
TUN	Tunnelling

- **File Type**
  The File type shall be used from the below table:

Code	Description
DRG	2D Drawing
MD2	2D Model
MD3	3D Model
MDR	Model Rendition File, e.g. PDF, Navisworks, i-model
AMF	Animation file (of a model)
VSF	Visualization File (of a model)
RPT	Report
SKE	Sketch
DAT	Data Sheet
STA	Standard

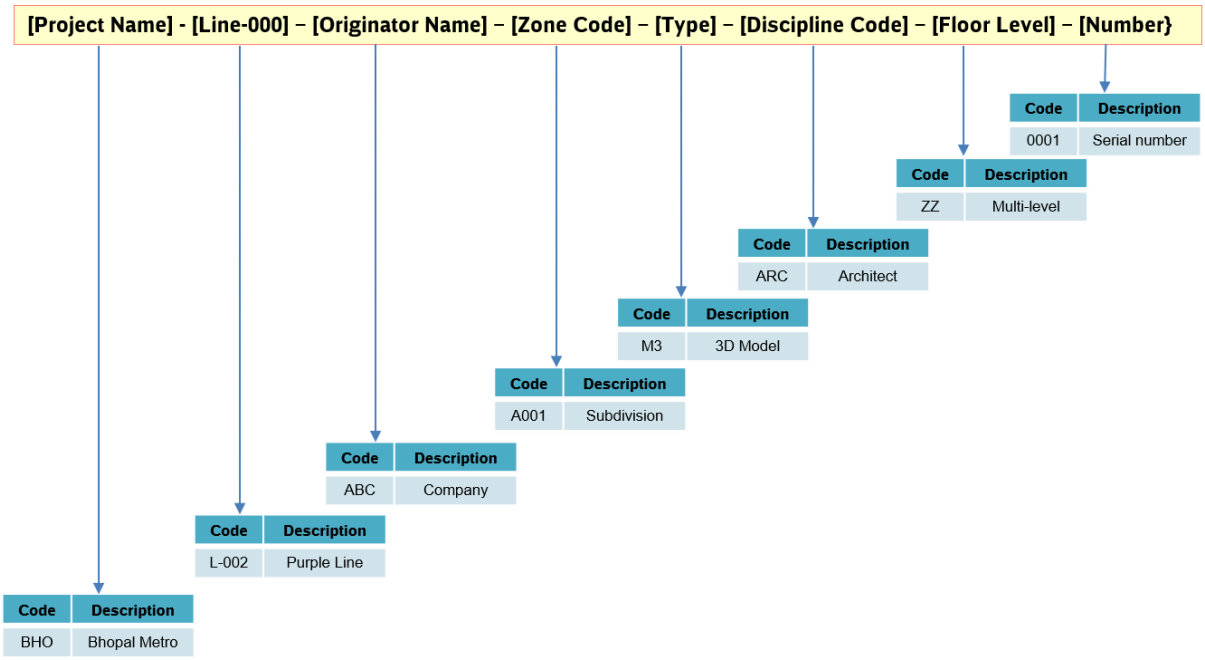
- **Floor Type**
  The Floor type code shall be used from the below table:

Code	Level	Description
ZZ	Multiple level	Where the file applies to multiple levels, for example a cross sectional drawing
XX	No level	For files that are not relevant to the levels, for example specifications or meeting minutes
GF	Ground floor	
0	Base level	For linear assets (for example roads) or where GF isn't applicable
1	Level one	The first level primary level above ground level
M1	Mezzanine one	Mezzanine level above level one
M2	Mezzanine two	Mezzanine level above level two
B1	Basement one	The first level below ground level
B2	Basement two	The second level below ground level

- **Number**
  This will consist of four numeric digits used sequentially to when a container is one of a series not distinguished by other of the fields.

- **Revision No.**
  The Revision number of the document (three characters) only within the CDE

  The Contractor CDE Shall follow the Revision-Version concept and depending on the CDE used it could be one or two attributes. (Detailed in CDE Revision & Version Attribute).



1.12.1 Common Data Environment (CDE) Container Attributes

Containers within the Employer CDE shall have the following attributes defined:

- Suitability / Issue Purpose
- Revision
- Classification

1.12.2 Common Data Environment (CDE) Revision & Version Attributes

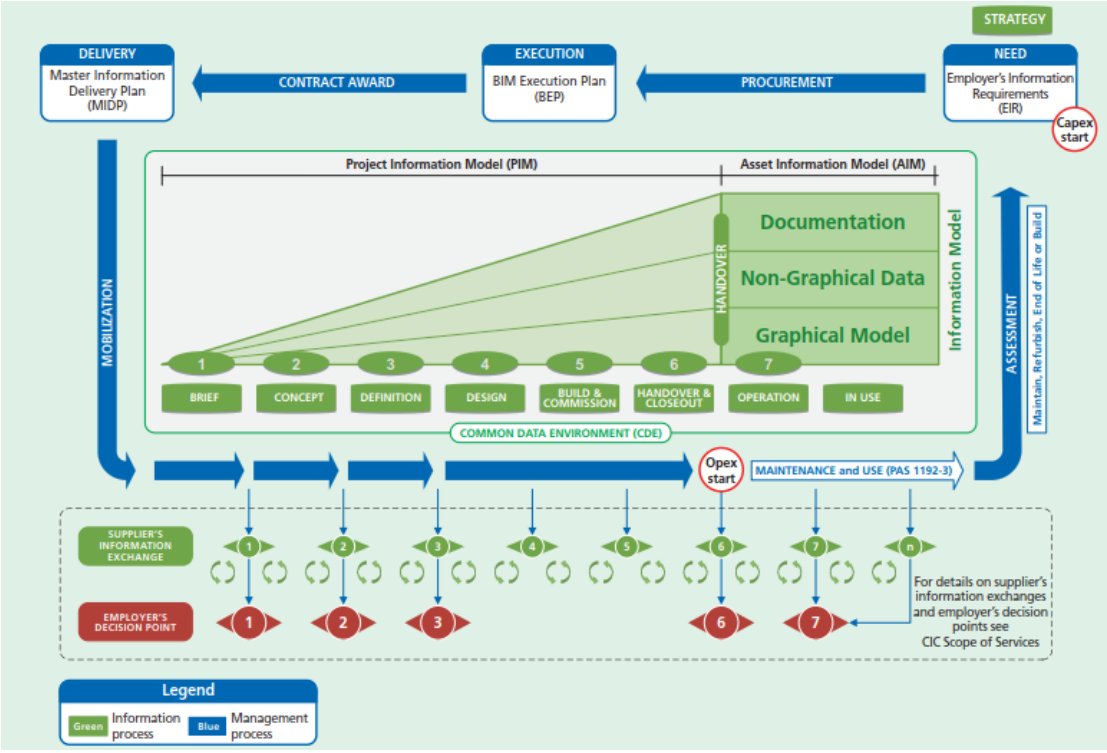
Each container within the Employer Common Data environment shall have an attribute indicating the container Revision on the other hand container within the Contractor shall have an additional Version number, added to the Revision on for their internal approval / validation tracking. This contractor "Revision" will be the Revision-Version number.

Contractor CDE shall define the attribute for the Revision-Version
[Revision]. [Version] = 0001.03

Employer CDE shall define the attribute for the Revision-Version
[Revision] = 0001

Revision-Version numbers shall be used only in the Contractor CDE, and within the Employer CDE only Revision numbers shall remain. (Version number shall be removed when submitting to the Employer CDE.

1.12.3 Common Data Environment (CDE) and the Information Life Cycle



Extracted from PAS 1192-2-2013 – Figure 2

1.12.4 Process and the Common Data Environments

Work-in-Progress (WIP):

Used to hold unapproved information. [Contractor CDE]

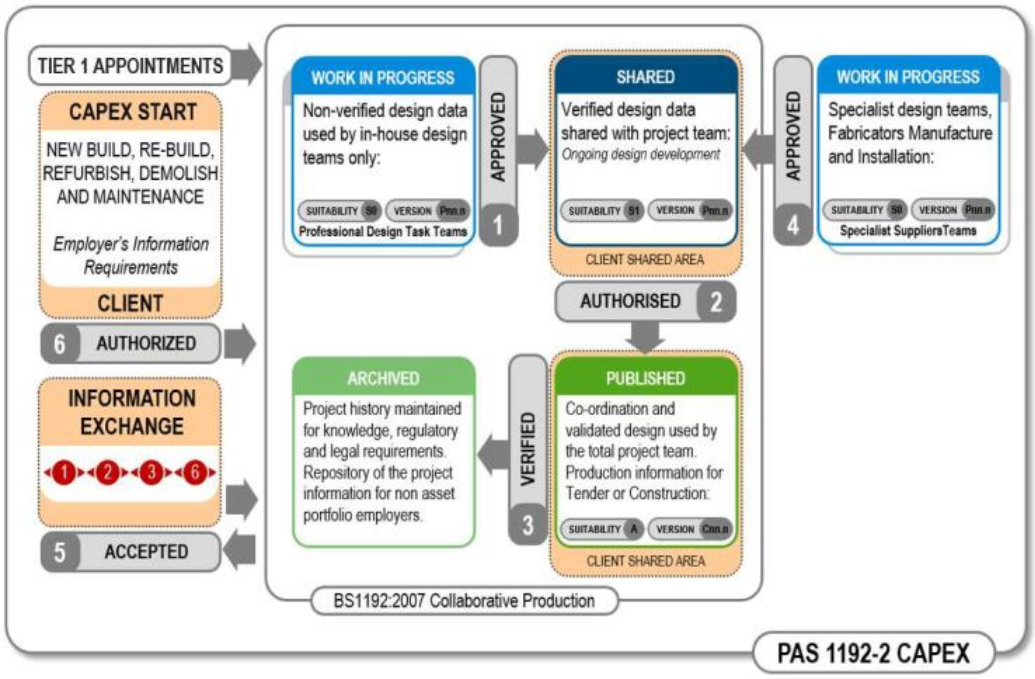
Shared:
Used to hold information which has been approved for sharing with other organizations/ teams to use as a reference in design/construction development.

[Contractor CDE]
Client Shared:
Used to hold completed information, placed for Client (Employer) authorization by means of Gate Reviews. [Contractor CDE] (Employer will need to be granted with Read privileges in the Client Shared area within the Contractor CDE).

GC Shared:
Used to release the information from the Contractor CDE to the Employer CDE, for sharing with Engineers or the local implementing bodies. [Client CDE]

Published:
Used to hold published (Approved by the Employer for a final stage) information for use by the entire project team. (both design/construction team and project team).

Archived:
Used to store all progress as each project milestone is met. In practice, the Archive area holds a record of all versions of the Published data, providing a tracking and trail in the dispute event. [Employer CDE].



CDE Model Principal phases according to the PAS 1192-2

Appendix B - CAD Manual

1 General

1.1 Purpose

1.1.1 The purpose of this Manual is for effective use of Computer Aided Design (CAD) for Suburban Rail Project (BSRP) in KRIDE. The Contractor shall use this manual as a template to produce a project CAD manual specific to the hardware and software selected.

1.2 Scope

1.2.1 These standards apply to all work prepared by the Contractor (Originators) for the design and construction for the Employer. No deviation from these standards shall be permitted without the written consent of the Employer or their authorised representative.

1.3 Definitions

1.3.1 The following terms are specific to this procedure

a. ABWF — Architectural builder's works and finishes
b. Alignment Drawings — Drawings that show the horizontal or vertical railway alignment which shall be used for the design and construction of the Works
c. Approve — Data originators shall approve their work through the workflow prescribed in the common data environment before sharing it with other disciplines
d. As Built Drawings — Drawings produced at the conclusion of construction to upgrade the design drawings to incorporate all design changes made during construction in order to reflect the as built facility in the final drawings
e. As Built Models — Models produced from 'approved for construction' data that accurately reflects the as built asset
f. Computer Aided Design (CAD) System — The computer hardware and software used to create CAD drawing files and to produce hard copy plots of those files
g. Construction Drawings — The drawings prepared by Contractors to supplement Design Drawings to specify additional details and procedures for construction of the Works including:
    i) Shop Drawings
    ii) Fabrication Drawings
    iii) Erection Drawings
    iv) Working Drawings
    v) Temporary Works Drawings
    vi) Field Design Change Drawings
    vii) Construction Details
h. Design Model — A design model with entities having two/three-dimensional properties which are coordinated to the agreed geospatial reference system.
i. Design Package — A distinct portion of the Works whose design is performed as a contiguous, integrated package of work.
j. Drawing Status — Metadata for all drawings and models that shall not form any part of the file name but shall be critical for the provenance of any the printed drawing. It shall designate the purpose of issue for that drawing. It is linked into the workflows declared in the common data environment and is critical knowing to what purpose the drawing can be put.
k. General Arrangement (GA) Drawing — General arrangement drawing which shows the location of major features and facilities.
l. Geographical Information System (GIS) — The computer hardware and software system used to store and analyse graphically referenced (spatial) data and its associated non-graphical attribute data that is stored in a relational database.
m. Originator — Any person or organisation with responsibility for producing drawings for the Project. Originators include members of the Contractors for design and or constructing the works.
n. Right to Access — The land corridor acquired or to be acquired for the construction and operation of the Project. The land for permanent road and river diversions and the land for certain emergency access.

o. Stations — The station architecture, ABWF, mechanical ventilation and air- conditioning, elevators and escalators, plumbing and drainage, fire services, civil works, ancillary structures, ancillary electrical and mechanical work, drainage, landscaping and all associated works.
p. Standard Drawings — Any Contractor's drawing which depict the dimensional requirements and clearances of certain features of the Works, and components, sub-assemblies or systems to be incorporated into the Works.
q. Survey Drawings — Drawings which show the primary survey monuments and relevant survey information which shall be used for the design and construction of the Works.

2 Procedure

2.1 Methodology

2.1.1 Drawings must be clear, accurate and concise and contain no ambiguities, which could lead to confusion or wrong interpretation. To help achieve this aim, numbers of drawings must be kept to an absolute minimum and organised into sets that read logically, similar to a set of reference books i.e. volumes, chapters and pages. Avoidance of duplication is essential to ensure the drawings maintain their integrity as the iterative design process progresses and amendments are made. To this end, efficient minimum detailing and above all elimination of double detailing shall be the method adopted. Grouping common elements into detail sheets and extensive use of cross referencing to those details and avoiding duplication, shall be exercised in order to minimise both the amount of drawings produced and the risk of error and/or ambiguity.

2.2 Drawing Standards Requirements

2.2.1 Purpose of drawings and general philosophy.

2.2.1.1 The mandated BIM approach involves the construction of a 3D model and the extraction of coordinated multi- disciplinary 2D plans, sections and elevations. These extractions shall be used as the basis for the production of 2D documentation and drawings. They shall serve the purposes of design and construction and provide record data that can be taken into operations and maintenance of the as built railway.

a. During the design and construction phase, the drawings and models convey the intent of the Originator to:
   i) Project Team, Employer and other consultants:
   ii) Statutory authorities and other involved parties;
   iii) Contractor

2.2.1.2 To guarantee success, the information shown on the drawings and models must be clear, accurate, legible and above all, unambiguous.

a. At the appropriate time the design drawings and models shall be revised by the Contractor to show the as built status. After Taking over the Works, the CAD files, models and drawings shall become part of the Construction Contract Records and shall be used by the Employer for management and maintenance of the operating railway.

2.2.1.3 Drawings and CAD files mentioned in the Tender documents to be supplied by the Employer or Engineer.

2.2.1.4 The Employer may, at its discretion, supply base data in CAD format, as well as any files relevant to this standard. This data shall be for information only and is to be verified by the Contractor.

2.2.2 CAD files produced by Originators (Contractor or their representative)

2.2.2.1 The Drawings produced by Originators shall be classified into the groups listed below.

2.2.2.2 With the exception of Sketches, which may be hand drawn, all drawings shall be prepared totally on a CAD system in accordance with this Manual.

a. **Sketches**
   i) A sketch generally contains graphic and/or textual information to illustrate a point e.g
   ii) Sketches included with site instructions to clarify the installation method
   iii) Sketches used to establish design concepts, etc

b. **Cover Drawings**
   Are located at the front of the drawing set and include title sheet, general notes, symbols, material indications and the abbreviations used throughout the drawing set.

c. **General Arrangements**
Show the general layout and dimensions of civil, structural, architectural and MEP Works. They also include site plans and site surveys.

d. **Plans and Profiles**
Show the plan and profile views for all civil, structural and architectural works as well as the railway track alignment and geotechnical bore hole information among others.

e. **Diagrams and Schematics**
Used to show electrical circuits, plumbing and drainage isometrics, piping arrangements and so on.

f. **Detail Drawings**
These drawings shall give additional detailed information on specific components of the design, generally at larger scales. They include all the details for civil, structural and electrical and mechanical works. The architectural drawings of building cores, toilets, stairs, elevators, escalators, etc. shall be shown on these drawings.

g. **Assembly / Component / Parts Drawings**
Assembly and component or parts drawings include three dimensional or exploded view drawings, assembly drawings with cut-away sections, and drawings of individual parts and components.

h. **Schedules / Tables**
These drawings include all drawings or portions of drawings which contain information in schedule or table format, such as reinforcement bar bending schedules, materials schedules, door schedules, fuse analysis drawings, contact analysis drawings, etc.

i. **Standard Drawings**
Standard drawings include those used to illustrate drawing standards, material indications, and standard line types, as contained in the Appendices to this Manual.

j. **Reinforcement Detail Drawings (RC Details)**
These drawings are used to indicate the position of steel reinforcement bars within structural concrete members and are usually read in conjunction with barbending schedules.

k. **Alignment and Track work Drawings**
Show specific details of the railway track alignment and track construction.

l. **Method Statement Drawings**
Are used to describe details and information on the method and / or sequence of construction or installation and may therefore contain a substantial amount of textual data.

m. **Three Dimensional (3D) Models**
The mandated BIM approach involves the construction of 3D single discipline model sand the extraction of coordinated multi - disciplinary 2D plans, sections and elevations. These extractions shall be used as the basis for the production of 2D documentation and drawings. They shall serve the purposes of design and construction and provide record data that can be taken in too preparations and maintenance of the As Built drawings and model. Selected views shall be setup from the 3Dmodel and rendered with material maps and lighting to present a photo - realistic image of the design by the contractor when required.

2.2.3 Application of Standards

2.2.3.1 Conformance with the requirements and intent of this Manual is mandatory. If a situation occurs which is not covered by this Manual, Originators shall request clarification from the Engineer.

2.2.4 Units and Language

2.2.4.1 All text descriptions shall be in English language

2.2.4.2 Units of measurement shall be Metric and shall follow the System International (S.I.) units of measurement convention. All linear dimensions shall be in millimetres (mm).
e.g. 7.500 indicates seven points five metres

2.2.4.3 All surveyed levels and chainages shall be shown in meters and decimals of a meter to three decimal places.
e.g. 7.500 indicates even point five meters

If the dimension is less than one meter, a 0 shall be placed in front of the decimal point
e.g. 0.500 indicates point five of a metre

2.2.4.4 The following units of measurement shall be adopted for the specific drawing types noted:
a. Civil and Utilities Drawings.

Generally, use meters and decimals of a metre. Layout dimensions and details shall be in millimetres

2.2.4.5 Structural, Architectural, Mechanical and Electrical Drawings:

a. Linear dimensions shall use millimetres. Elevations shall be expressed in meters and decimals of a meter.
b. Slopes and gradients shall be expressed in percentage - e.g. 5 %
c. Coordinates shall be expressed as whole numbers to three decimal places - e.g. 1,646.134.
d. The unit symbols for dimensions i.e. "m" for meters and "mm" for millimetres are not required. Decimal numbers shall generally indicate meters and whole numbers shall indicate millimetres.
e. Where unit symbols are used, a space shall be left between the number and any unit symbol to ensure clarity. The position of the decimal point shall be the same as a full stop – e.g. 24.000 m.
f. Surveyed levels should be indicated with a '+' or '- 'and shown in meters to three decimal places – e.g. + 12.000.
g. Chainages shall be written in kilometres and meters with + separating the two numbers. The meter portion of a chainage shall be written to three decimal places.

e.g. 0 + 345.100
41 + 155.750
202 + 630.000

h. All non-linear measurements such as areas and volumes shall be followed by the unit symbol.
e.g. Square meter m2
Cubic meterm3

2.3 CAD System Standards

2.3.1 The Contractor shall ensure that a single platform CAD system shall be used throughout the work package. It shall be capable of modelling object data in 3D and attaching attribute data to it. It shall be capable of generating reports directly from the object model, including clash detection.

2.3.2 Where separate work packages interface the contractors shall identify what model data and information is to be shared for co-ordination and ensure that all digital data exchange is compatible and has no fidelity loss.

2.3.3 At the designated data drop stages the Contractor shall deliver all CAD, GIS and BIM data as described in the Master Document Index (MDI) in native file format together with verified Industry Foundation Class (IFC) for all object attributes declared.

2.3.4 Seed/Template file set up

2.3.4.1 The use of a single co-ordinate space for the Works is critical. The seed/template file resolution shall be compatible with the survey grid set up for the entire scope of works.

2.3.4.2 It shall use real world co-ordinates for Eastings Northings and datum

2.3.4.3 All BIM Model data shall be produced at full size (1:1), coincidentally and using the same co-ordinate systems to allow all files to be referenced without modification.

2.3.4.4 The coordinate/grid systems shall be agreed at the outset of a project.

2.4 Drawing File Organization

2.4.1 The current status of each drawing shall be clearly defined by the use of a single letter code as follows:

a. Detailed Design Stage 1 {DS1};
b. Detailed Design Stage 2 {DS2};
c. As-built Drawings.

The submissions shall include the following as per Employer's Design Management

P - Preliminary Design Drawing
D - Definitive Design Drawing
C - Construction Reference Drawing
W - Working Drawing
B - As-Built Drawing
M - As Manufactured Drawing
E - Employer's Drawing

2.4.2 Types of drawings

a. 'Design drawings' mean all drawings except shop drawings and as-built drawings
b. 'Working drawings' are design drawings of sufficient detail to fully describe the Works and adequate to use for construction or installation
c. 'Site drawings and sketches' are drawings, often in sketch form, prepared on site to describe modifications of the Working drawings where site conditions warrant changes that do not invalidate the design
d. 'Shop drawings' are special drawings prepared by the manufacturer or fabricator of various items within the Works to facilitate manufacture or fabrication
e. 'As-built drawings' show the Works exactly as constructed or installed. They are usually prepared by amending the working drawings to take into account changes necessitated by site conditions and described in Site drawings. These drawings shall be completed on a regular basis as the works progress and shall not be left until completion of the entire works

2.4.3 The extent of these data drops shall be declared by the Contractor in the master document index which shall form part of the Contractor's procedures.

2.4.4 At each of the data drop stages the delivered CAD drawings shall have the original plot composition files containing all extractions.

2.4.5 All delivered CAD drawings shall have a simplified standalone 2D vector plot composition file.

2.4.6 All delivered CAD drawings shall have a corresponding PDF.

2.4.7 All delivered CAD drawings shall have their provenance shown on the plot i.e. the references, extractions, model revision used to generate the plot.

2.4.8 Master Document Index (MDI) (Drawing and Model Register)

2.4.9 All CAD models and drawings shall be compiled in a Master Document Index (spreadsheet) by the Design Coordination Manager prior to commencement of work.

2.4.10 It shall list out all Models and drawings that are contracted for delivery at each of the data drops stages. i.e. Preliminary, Final, and As Built. All Models and drawings required for submission shall be identified on the MDI by the Design Coordination Manager.

2.4.11 The MDI spreadsheet shall include the following information:

a. File identifier
b. Title
c. Sheet size
d. Scale(s)
e. Programmed delivery date.

2.4.12 The CAD MDI shall be used as the basis of and be maintained by means of the drawing register and the document submittal register

2.4.13 File naming convention.

2.4.14 All files created for the Works shall be identified quickly, accurately and without ambiguity. Ownership, location, type of file and a unique number are all of paramount importance when identifying the content of a file.

2.4.15 The Contractor shall maintain a register that shall allocate file naming code on the basis set out below. When a new code is required the contractor shall propose the new code based on the constraints listed and submit it to the Engineer.

Field1: City Identifier (3char max)

Code	Description
BSRP	Bengaluru Suburban Rail Project

Field2: Corridor/Contract Identifier (3 char max)

C-Corridor	Description
C2	Corridor-2 Stations

Field 3:Originator (3char)

Each contractor shall be allocated a unique code by the Employer.These codes shall be managed by the Contractor.

Code	Description
ABC	ABC company

Field4:Discipline (Role) (3char)

Code	Description
ARC	Architecture
CTV	Closed Circuit Television
COM	Communications
CIV	Civil
ETP	Electrical Traction Power
ELV	Electrical high Voltage
ELL	Electrical Low Voltage
ELE	Electrical Emergency Voltage
FRD	Fire Detection
FRS	Fire Suppression
GEO	Geology
MHV	Mechanical HVAC
MLF	Mechanical Lifts
MES	Mechanical Escalators
MTR	Mechanical Travellators
PUA	Public Address
PUH	Public Health
SNG	Signage
STR	Structural
SIG	Signals
TRK	Track
UTL	Utilities
CIV	Civil Infrastructure
GEO	Geotechnical
TUN	Tunnelling

Field5:File Type(3char)

Code	Description
DRG	2D Drawing
MD2	2D Model
MD3	3D Model

MDR	Model Rendition File, e.g. PDF, Navis works, imodel AMF Animation file (of a model)
VSF	Visualisation File (of a model)
RPT	Report
SKE	Sketch
DAT	Data Sheet
STA	Standard
Field6:	Zone (3 char)

The 'zone' identifier isused to split the project into manageable sub divisions; all members of the Contractors design team must agree zones at the start of a project and publish to the Contractor's procedures. Individual design team members may require alternative zones for their individual needs. Zones are not drawing are as, and do not relate to the amount of the project shown on any given drawing. They are the responsibility of each Contractors' discipline leads.

There as on for splitting the project into zones is to enable multiple users to work on the project, as well as limiting the size of model files to prevent reduced performance of software or communication.

Code	Description
TBD	to be designated by the Contractor and issued to the Engineer for entry into the register

Field 7:Level (2 char)

The 'Level' code is a two-character alpha numeric code that represents the level or storey of a building. Within the civil engineering package, the 'level' code may indicate different construction levels. It shall also be applied to grade separated structures where the level on an interchange may be above or below the 'highway level'. In shafts, sewers and galleries we invariably encounter levels and so the notation shall hold. On specialized infrastructure aspect of the build other notations may be necessary and these shall be discussed with between the Contractor and the Engineer agreed and entered in the document control register. Some examples are shown below:

Code	Description
ZZ	Multiple Levels
02	Second Floor
01	First Floor
MX	Mezzanine Floor X
L1	Lower Ground Level 1
L2	Lower Ground Level 2
F1	FoundationLevel 1

Field 8: Sequence Number(4 char)

Code	Description
1234	Sequence Number
2345	
3456	

Drawing Status Codes (2 char)
These shall not form any part of the file name but shall be critical for the provenance of the printed drawing.

Drawing status or suitability codes shall designate the purpose of issue for that drawing. It is linked into the work flows designated in the common data environment an discritical in knowing to what purpose the drawing can be put.

Code Description
S0 WIP Initial status

Common data environment 'Shared' section
S1 Fit for coordination (Shared area of the CDE)
S2 Fit for information
S3 Fit for internal review and comment
S4 Fit for construction approval

Commondata environment 'Document' section
P Preliminary Design Drawing
D Definitive Design Drawing
C Construction Reference Drawing
W Working Drawing
B As-Built Drawing
M As Manufactured Drawing
E Employer is Drawing
D1 Fit for costing
D2 Fit for tender
D3 Fit for Contractor design
D4 Fit for manufacture procurement
A Fit for construction
B Fit for construction (with minor comment)
AB As-built.

2.4.16 Revisions
The 'revision' is an attribute defined in the title block of a model or drawing sheet template, shall also be defined and tracked in the ECM. It shall also be tracked by the Contractors when the CAD model and or drawing is saved as a PDF document and up loaded to the Contractor's EDMS system. The revision shows the iterative nature of the information as it progresses to completeness. The revision and status are required to track the progression of a file or document to its completion and authorisation. The revision and status code shall be part of the attributed metadata, not part of the file name.

WIP Status S0 before released to 'shared' R1.1
R1.2 R2.1 R2.2
Before authorised for construction
Status R1-RnR1
R2R3
Authorised for construction Status
AC1
C2C3
File extensions/ File formats

2.4.17 The file extension is used by the computer's operating system to denote the application that controls or is used to open a file.

2.4.18 These file extensions shall not be altered from the defaults provided by the CAD software. e.g. (DGN, RVT, DWG etc.).

2.4.19 Only use letters A-Z, numbers 0-9 for all fields of file naming

2.4.20 A single period character '.' should be used to separate the file name from the extension. This character should not be used anywhere else in the file name.

2.4.21 All fields should be separated by a hyphen character '-' to distinguish between the fields and aid comprehension. Do not use spaces.

2.4.22 An 'x' should be used if the contents of a file do not refer a single specific Type or Level and it is decided that the fields should still be used to maintain identical file name lengths.

2.4.23 The following software latest and update version compatible for use with Intel-Windows based computers shall be used, unless otherwise stated, for the various electronic submissions required.

Document Type	Electronic Document Format
Text Documents	MS Word,
Spread Sheets	MS Excel,
Data Base Files	MS Access,
Presentation Files	MS PowerPoint,
Programmes Ver2.0a	Primavera for Windows, Suretrack
CAD Graphics	Corel Draw / AutoCAD/Revit
Photographic	Adobe Photoshop,
Desktop Publishing	Page Maker
CADD Drawings	AutoCAD/Revit/DGN

2.4.24 Media for Electronic File Submission.

2.4.25 One copy shall be submitted unless otherwise stated in CD-ROM.

2.4.26 Internet File Formats/Standards

2.4.27 The following guidelines shall be followed when the Contractor uses the Internet browser as the communication media to share information with the Employer.

2.4.28 All the data formats or standards must be supported by Microsoft Internet Explorer version 3 or above running on Windows NT and Windows 98.

2.4.29 The following lists the file types and the corresponding data formats to be used on Internet. The Contractor shall comply with them unless prior consent is obtained from the Employer's Requirement for a different Data format:

File Type	Data Format
Photo Image	Joint Photographic Experts Group (JPEG)
Image other than Photo	GIF or JPEG
Computer Aid Design files (CAD)	Computer Graphics Metafile (CGM)
Video	Window video (.avi)
Sound	Wave file (.wav)

2.4.30 Typical CAD Files

- Typical CAD File Number for BSRP; BSRP-C2S-ABC-ARC-DRG-XXX-LG-2345
- Typical Drawing number; BSRP-C2-ABC-ARC-DRG-XXX-03-2345.S1.P2
- Typical CAD Model Number; BSRP-C2S-ABC-CIV-MD2-XXX-XX-6789

2.4.31 Families, Block Libraries, Blocks, & Block Names

2.4.32 All Construction Industry symbols produced as CAD Cells shall typically conform to British Standard BS1192 - part 3.

2.4.33 All Blocks created shall be Primitive (i.e. NOT Complex) and shall be placed Absolute (i.e. NOT Relative).

2.4.34 The Contractor's specific block libraries shall be transmitted to Engineer together with an associated block library list containing the filename (max. 6 characters) and block description. The Contractor shall ensure that the library is regularly updated and circulated to all other users, together with the associated library listing.

2.4.35 All Blocks of a common type, symbols or details should initially be created within a CAD "Model Space File" specifically utilised for that purpose. These files will be made available on request by Employer's Representative.

2.4.36 All Blocks created will typically be 2D unless 3D is specifically requested. In both instances they shall have an origin at a logical point located within the extents of each Block's masked area or volume.

2.5 Coordinates and orientation of drawings

2.5.1 Coordinates

2.5.2 Location or Plan information in "Model Space" files shall coincide with the correct location and orientation on the Project grid for each specific contract.

2.5.3 Location plans shall have at least three setting out points shown on each CAD "Model Space" file. Each setting out point shall be indicated by a simple cross-hair together with related Eastings and Northings co-ordinates. The Civil Contractor(s) will establish the three setting out co-ordinates for their respective works, which will then be used by all other contractors including the Contractor.

2.5.4 This relationship is required for co-ordination of design data and for the spatial database/GIS to be developed for the facilities management and maintenance of the operating railway.

2.5.5 All 3D models shall be created on the project grid @ 1:1 scale using real world coordinates. All extracted geometry shall be placed in a 2D model in its coincident position on the project grid. When the 2D model is placed into a drawing it shall be subject to relocation and scaling.

2.5.6 All model data shall be defined by map coordinates.

2.5.7 To maintain the correct relationship between the station and the railway alignment, station plans (layouts, detailed plans, GAs, etc.) shall be controlled by four Setting Out Points (SOP). per platform.

2.5.8 The central SOP shall be the intersection between the chainage at the centre of platform and the centre line of the platform. The two outer SOPs shall be points on a grid line at either end of the platform.

2.6 Geographic Information Data (Spatial Compliance)

2.6.1 Exterior data.

2.6.2 All CAD drawings that primarily relate to exterior systems shall be submitted as per National Datum with two points of geodetic control for spatial reference. Features in drawing files that are stored in drawing units shall be translated to real world locations. The geodetic control chosen must correspond to existing features in GIS. The new structures and features must be geographically registered to the geodetic control. It is a requirement that the control used be referenced and shown in the plan drawing. If the point of control is located within the project limits it should be symbolically indicated and annotated in the drawing file. If the nearest control is located well outside of the project area then it should be tied to one of the other geodetic control points used, and a reference tie annotated and indicated in the design file. Any land survey information, such as basis of bearings and or any assumptions must be submitted and annotated on the drawing file.

2.6.3 Interior data

2.6.4 All CAD drawings that primarily relate to interior systems shall be submitted using project drawing units. However, for each drawing set, the locations of at least two points of geodetic control must be shown on an overall plan, and the coordinate values for those points provided for reference. If the nearest control is located well outside of the project area then it should be tied to one of the other geodetic points used and a reference tie annotated and indicated in the design file. Any land survey information such as basis of bearings and or any assumptions must be submitted and annotated on the drawing file.

2.6.5 Mapping data.

2.6.6 All proposed data to be mapped to existing Topographic data.

2.7 Drawing numbers

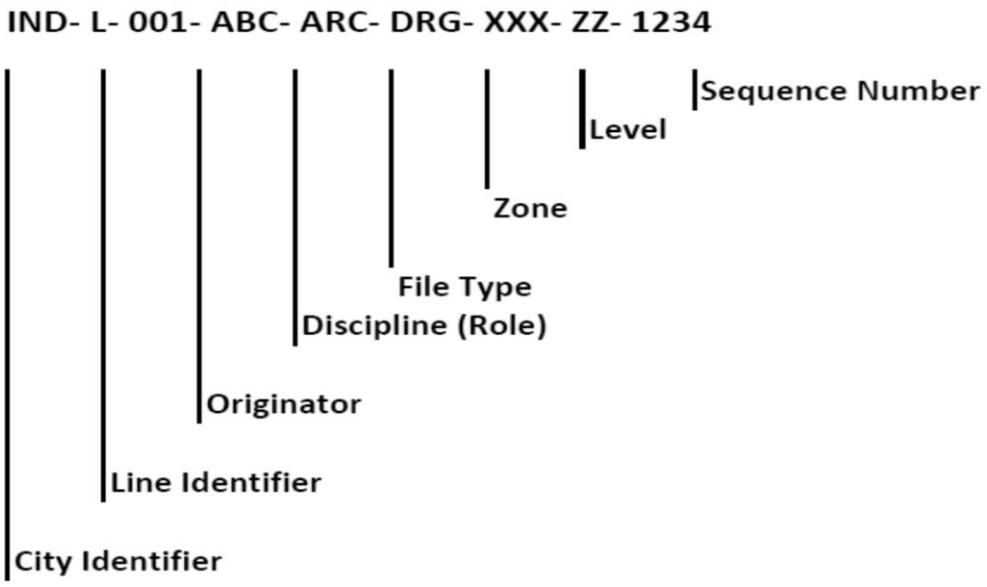
2.7.1 General

2.7.2 All drawings shall be numbered in accordance with the guidelines set at below:

2.7.3 This Drawing Number System is designed to provide the flexibility to the numbering of drawings required for a large-scale project of this type. It is co- ordinated with the general document numbering system of the project. The drawing number is split into eight fields to allow the establishment of logical groupings or series, based on different criteria as shown in the following example. These drawing number fields provide the flexibility to insert new drawings into a logical location in the drawing set if

and as required. In addition, it allows a great deal to be known about the drawing content directly from the Drawing Number.

Example Drawing Number:



2.7.4 Drawing Register Stability.

2.7.5 It is essential to the project management effort that once a drawing number has been established and submitted to the Engineer, the drawing numbers shall not be altered in any way. New drawings may be added however and superseded drawings may be removed from the Master Document Index, subject to agreement by the Engineer. Superseded drawing numbers shall not under any circumstances, be re-used for new drawings. Superseded Drawings should have their status changed to 'No Longer in Use'``.

2.8 Drawing sizes, scales, arrangement and layout

2.8.1 Required sizes

2.8.2 All drawings sheets shall conform to the International Organisation for Standardisation (ISO) - A series sizes. Standard ISO - A series sizes (in mm) are:

- A1 –594x 841
- A3 –297x 420
- A4 –210x 297

2.8.3 The maximum standard for full size drawings for the Project shall be A1. Therefore, all CAD files shall be prepared for plotting at A1 size. The standard for reduced copies is A3 (i.e. 25% of full size).

2.8.4 In special cases, such as Alignment drawings, the Engineer may accept the use of elongated drawings; however, the vertical side of the drawing shall match either A1 or A3.

2.8.5 Each set of drawings shall use only one drawing size.

2.9 Drawing Scales

2.9.1 CAD Model files shall be prepared at full scale (1:1). Hard copy scale shall be established at the time of plotting or creation of the plot file.

Hard copy scales shall be selected from the tables below for civil works and building design.	Scale (1: xxxxx)									
Drawing Type	**2000**	**1000**	**500**	**200**	**100**	**50**	**20**	**10**	**5**	**1**
Site Surveys			▯	▯	▯	▯				
Site Location/ Key Plan			▯	▯	▯	▯				
Location Plans	▯	▯	▯							
Disposal Area Plans		▯	▯							
Construction Plans / Layouts				▯	▯	▯	▯			
Surface Drainage Plans			▯			▯				
Tunnel and Building Drainage Plans				▯						
General Arrangements			▯	▯	▯	▯				
Plan / Profile for Alignment, Soil Borings, and Drainage										
(H)		▯								
(V)				▯						
Plan / Profile for Structures										
(H)			▯							
(V)					▯					
Plan / Profile for Utilities										
(H)			▯							
(V)						▯				
Other Plan / Profile										
(H)			▯							
(V)					▯					
Reinforcing Details					▯	▯	▯	▯		
Steel work Details					▯	▯	▯	▯	▯	
Other Details							▯	▯	▯	▯

Schedule of Preferred Drawing Scales–Civil Work

	Scale (1: xxxx)									
Drawing Type	**2000**	**1000**	**500**	**200**	**100**	**50**	**20**	**10**	**5**	**1**
Structural										
Framing Plans & GA's		▯	▯	▯	▯	▯				
Sections and Details					▯	▯	▯	▯	▯	▯
(Architectural Builder's works and finishes (ABWF)										
Master Plan	▯	▯								
Site Plans	▯	▯	▯							

	Scale (1: xxxx)									
Floor Plans & GA's		▯	▯	▯	▯	▯	▯			
Reflected Ceiling Plans				▯	▯					
Elevations				▯	▯	▯				
Sections				▯	▯	▯	▯			
Elevators, Escalators, Stairsand Core					▯	▯	▯			
Bath rooms and Kitchens						▯	▯			
Details							▯	▯	▯	▯
Mechanical, Electrical and Plumbing (MEP)										
Plans & GA's		▯	▯	▯	▯	▯				
Details					▯	▯	▯	▯		

2.9.2 The general scale used on each drawing shall be noted in the title block. The number of scales used on any one drawing shall be kept to a minimum.

2.9.3 On a drawing where multiple scales are used, the scale box of the title block shall read 'AS NOTED' and each scale used shall be identified under the title of each detail of the drawing, drawn at a different scale.

2.9.4 The scales selected shall be large enough to permit easy and clear interpretation of the information and ensure clarity of prints on the original as well as reduced copies (i.e. A3 versions of A1 drawings).

2.9.5 Originators shall submit for review by the Engineer on minimum scales to be used for Plans, Layouts and General Arrangement drawings.

2.9.6 When a drawing is not drawn to any particular scale the initials NTS (Not to Scale) shall be placed in the title block in the space provided for the drawing scale.

2.9.7 Graphic scales shall be used on all drawings except not to scale drawings. Graphic scales shall be placed under each title within the drawing if multiple different scales are being used. In addition, a bar scale 100mm long shall be located in the bottom left corner of the drawing outside the drawing border to indicate the degree of alteration on reduced or enlarged copies. The bar scale shall bear the words 100mm on Original.

2.9.8 Title Blocks

2.9.9 Drawing title blocks shall be positioned at the bottom of drawings in accordance with Fig 1 overleaf.

2.9.10 Drawing titles shall be concise and informative, clearly indicating the content of the drawing. All Drawing Titles shall be in UK English.

2.9.11 Copyright note

2.9.12 The following note shall appear on Contractor's border frames and consequently of Contractor's drawings:

"This drawing and any information or descriptive matter set out hereon is property of K-RIDE and is confidential and subject to copyright. It must not be disclosed, loaned, copied or used for manufacturing, tendering or for any other purpose without written permission of K-RIDE"

2.9.13 General Drawing Layout

a. Key Plans
   i) All plans showing an enlarged part of an overall project shall includea Key Location Plan in the top right- hand corner of the drawing sheet, with the location of that sheet clearly indicated.
   ii) All plans shall include a North direction, which shall be correctly orientated in accordance with the specific drawing view.

b. Match Lines
   i) Where the continuation of detail spans to an adjacent drawing sheet, a Match line shall be placed at the break point and no detail shall be shown on a drawing outside of the match line. Match Line in sertion shall be as follows.

c. For Civil Works:
   i) Each match line shall be drawn perpendicular or radial to the railway alignment preferably at an even chainage mark.
   ii) Match lines shall be labelled and numbered and the continuation drawing reference shall be added as follows:

d. For Buildings
   i) Each match line shall be drawn perpendicular or radial to the established building grid.
   ii) Match lines shall be labelled as follows : MATCH LINE.
   iii) The matching drawing reference shall be added adjacent to or under the match line label

2.9.14 Sections and Elevations

2.9.15 Sections through plans shall be taken looking:
a. To the left, and
b. Upwards

2.9.16 Sections through track alignment, viaducts and stations shall generally be taken looking:
a. In the direction of increasing chainage (e.g. up-station).

2.9.17 Sections through elevations shall be taken looking:
a. To the left, and
b. Downwards.

2.9.18 Sections shall be labelled and tagged with the appropriate drawing cross reference where required. Drawing cross reference shall not include the revision code because of its changing nature.

2.9.19 Cranked sections shall be avoided as far as possible. Section lines shall not be stepped more than once. Sections shall not be viewed or drawn at unnatural angles.

2.9.20 Section and Detail Marks:

2.9.21 Section and Detail marks shall be used; the section/detail identifier mark shall be located in the upper half of the circle.

2.9.22 Cross References in Section and Detail Marks.
a. All sections and details shall be correctly cross referenced in both directions i.e. Cross reference to the drawing where the section / detail is actually drawn shall be located in the lower half of the section/ detail marks circle. In the detailed section / detail title, all the drawing numbers where the section / detail is identified shall be listed out side the circle, below the line and to the right. If the drawn section / detailis located on the same drawing, a dash may replace the drawing number inside the circle to indicate the location on the same drawing.
b. Designation
   i) Sections shall be identified by upper, case alpha character marks. Wherever practical, sections shall be listed consecutively, from left to right and from top to bottom on the drawing on which they are drawn (i.e.Section A, Section B, Section C, etc.). To avoid potential conflict with numerical values, the alpha characters I, O and Q shall not be used as section marks.
   ii) Details shall be identified by numerals. Wherever practical these shall run in sequence from left to right and from top to bottom on the drawing.
c. Similar Sections and Details
   i) To help minimise detailing,a required section or detail that is similar to one already drawn may be nominated as similar to the existing section / detail. The word similar may also be expanded to explain how it is similar, such as (similar, but opposite hand) or (similar, except as noted). In designating a similar section / detail, anew unique section / detail mark shall be used. Use of the word same shall be avoided.
d. Composite Drawings
   i) Where a composite drawing (one containing both layouts and or sections and details) is used, all plans, elevations and sections shall be clearly identified by their titles.

2.9.23 General Notes

2.9.24 General notes (notes applying generally throughout the drawing set) shall be consolidated into a General Notes sheet located at the front of the drawing set before the first detail drawing. All drawings that make reference to the General Notes shall have a cross reference stated clearly as the first note in the notes column as follows:

For General Notes refer Drawing No. XXXX
Notes shall not be used to change Contract requirements or Works Specifications.

2.10 CAD Layer/Level/Attribute Naming

2.10.1 This layer/level format shall be mandatory across the project. The Contractor shall submit to the Engineer for review any non-standard layer names before implementation.

2.10.2 The layer naming standard shall be applied to all 2D and 3D CAD models that shall be shared among the design teams.

2.10.3 The following convention based upon BS 1192 (AEC Uniclass) shall be adopted to define layer/level name. All layer/level names shall be derived from this standard.

2.10.4 Note that there are hyphen '-' delimiters between the first three mandatory fields, and an underscore '_' delimiter is used between the mandatory and the alias.

Role	Classification	Presentation	Description
Example	G332	M	Doors
Layer Name	A- G332	M	Door

The Role shall be taken from a list of standard disciple Role codes recommended in BS1192. Listed below:

a. Architect
b. Building Surveyor
c. Civil Engineer
d. Drainage, Highways Engineer
e. Electrical Engineer
f. Facilities Manager
g. Geographical and Land Surveyor
h. Heating and Ventilation Designer
i. Interior Designer
j. Client
k. Landscape Architect
l. Mechanical Engineer
m. Public Health Engineer
n. Quantity Surveyor
o. Structural Engineer
p. Town and Country Planner
q. Contractor
r. Subcontractor
s. Specialist Designer
t. General (non-disciplinary)

2.11 The Presentation Code

2.11.1 A layer should be consistent in its individual presentational convention.

2.11.2 Graphical and textual content should be distinguished by using layers to ensure information can still be re-used for a variety of presentational purposes.

2.11.3 The Presentation code shall indicate how the element is displayed and is taken from the list below:

Code	Description
D	Dimensioning
H	Hatching and shading
M	Model related elements
P	Plot/page related elements
T	Text

2.11.4 Note that the M code can be extended to define specific requirements of MD2 to mean 2D and MD3 to mean 3D graphic files.

2.12 The Description:

2.12.1 The description shall be appended to the layer name to assist layer identification.

2.12.2 Following an underscore delimiter character '_', the 'description' or 'alias' directly correlates to the 'Uniclass classification'. The 'description' should not be treated as a user- definable field, but must be agreed and used consistently by the Contractor and shall be declared in the Contractor's procedures. The Contractor shall coordinate description aliases to ensure they are consistent across the Works Package.

Role	Classification	Presentation	Description
Example	CH 222	M	Tunnel Formation
Layer Name	CH 222	M	Tunnel Formation

Note:The as-Built CAD data shall be used to update the Indian GIS system and that identifying CAD layers by this system shall assist in the final transfer of relevant CAD layers to the GIS system

2.13 Line work

2.13.1 General

2.13.2 Line work shall be consistent to maximise the clarity and readability of drawings. Proper line work includes using the correct line type as well as the correct line thickness to convey the desired information. Both line types and line thickness may vary depending on the drawing scale and the size of the drawing.

2.13.3 Line Styles

2.13.4 Elaborate line styles including those which incorporate text and/or special graphic attributes shall not be permitted. Line types of this nature shall not translate to other systems. Similarly, user defined and multi-line types shall not be allowed. All lines shall have a distinct beginning and end point. Dashed lines shall be actual patterned lines and not multiple line segments, i.e. they must have a distinct beginning and end point and not end points for each dash.

2.13.5 Plot legibility.

2.13.6 All line work shall be clearly legible on plots of reduced scale drawings. The Contractor's CAD system plot settings shall be configured to accommodate A1 plots legibility when printed at A3.

2.13.7 Line Thickness

2.13.8 Lines of varying thickness shall be used to facilitate the reading of a drawing by providing suitable contrast. The actual thickness of lines used depends on the purpose of the drawing, its size, scale and the method of reproduction..

2.13.9 In general line weights shall be chosen which prioritise elements in the drawingi.e. priority elements have thicker line weights. For example, on reinforcement detail drawings where reinforcement is the subject of the drawing, the reinforcement shall be in a thicker line weight to emphasise it as the key item.

2.13.10 The number of different line thicknesses allowed on each drawing shall be as shown in Table. Once line weight usage has been determined these shall be used in a consistent manner for the same type of drawing.

2.13.11 Primary elements cut by a section such as concrete walls, slabs and beams, shall be highlighted by a thicker line weight than those of the plans and elevations.

Colour	Code No	Line Thickness
Red	10	0.18
White	7	0.25
Yellow	2	0.35
Brown	34	0.50

Colour	Code No	Line Thickness
Blue	130	0.70
Orange	30	1.00
Green	3	1.40
Grey	253	2.00

Table of Plotted Line Weights

2.14 Text

2.14.1 General

2.14.2 The rules listed below shall be followed when adding text to drawings to ensure uniformity and clarity. No exceptions to these rules shall be made.

2.14.3 The font is:

a. TrueType Arial font
b. All text shall be highly legible so that information can be communicated with the minimal possibility of error in reading. Text must remain legible when drawings are reduced to A3 size and no text shall be less than 1mm in height on a reduced copy.
c. All text shall be neat, regularly spaced, upright, upper case and of uniform appearance. The mixing of text styles is not permitted. Sloping, italic and elaborate fonts are not permitted in English language text font.
d. Terms and abbreviations not defined in Annex 1 shall not be permitted. New terms and abbreviations shall be submitted to the Engineer for review before use on any drawing.
e. Minimum clear space between lines shall be equivalent to one time the text height.
f. All text shall be left justified. Align, fit and centre justification is not permitted due to poor translation.
g. The plotted text heights (full size A1) shall use corresponding line weights as shown in the following table

Plotted Text Height (mm)	Plotted Text Width (mm)	Plotted Line Weight (mm)	Used for
2.50	1.90	0.25	General Text, Dimenions Standard Lettering Notes
3.50	2.60	0.35	
5.00	3.80	0.50	Normal Tiles, Drawing Numbers Match Line Numbers
7.00	5.30	0.70	Major Tiles, Sections

2.14.4 Text shall be consistent, both in size and placement. Text sizes for specific applications, such as notes or titles, shall not vary within the same drawing or set of drawings.

2.14.5 For clarity, text shall not be placed directly on top of lines or symbols where possible. All text shall be orientated to facilitate reading horizontally from left to right and vertically from the bottom to top when viewed from the right-hand edge of the drawing. Vertical text shall not be carried more than 10 degrees counter clockwise past vertical as shown in the Figure 1 below:

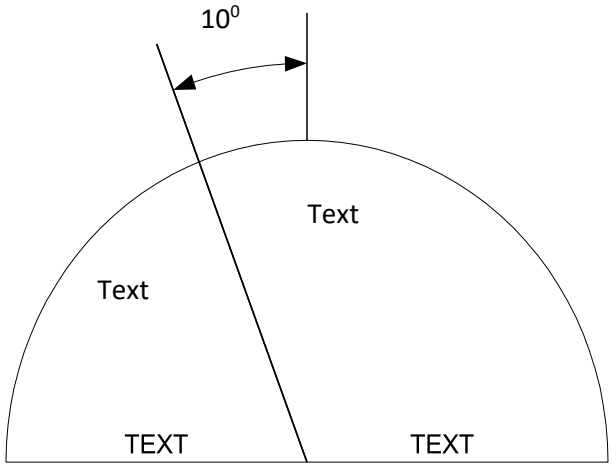


Figure1 Angular dimensioning

2.14.6 On maps, lettering shall be parallel to streets, rivers, lines, etc. so that it reads horizontally from left to right and vertically from the bottom to top when viewed from the right-hand side of the drawing.

2.15 Abbreviations

2.15.1 Abbreviations shall be controlled by an agreed ontology listed in the attached Annex 1. If this ontology is to be amended then it shall be submitted to the Engineer for review before usage and before including it in the Contractor's procedures document.

2.15.2 Rules for use of abbreviations:

a. use upper- case lettering, without full stops,
b. do not use spaces within an abbreviation, and
c. use the same abbreviations for singular or plural.

2.15.3 Abbreviations shall be mnemonic as far as possible and shall be defined in Annex 1.

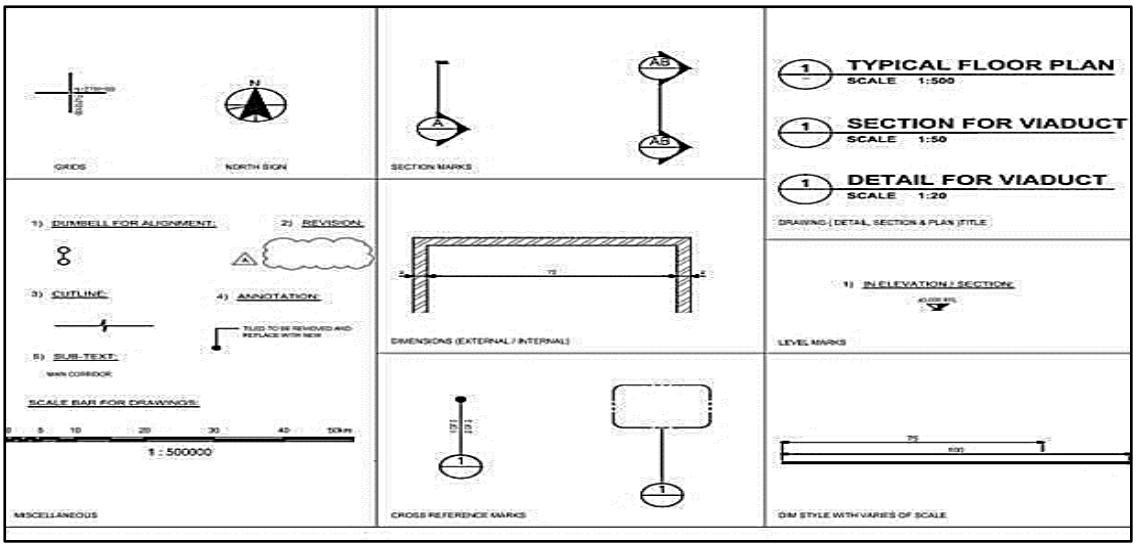
2.15.4 If required the Contractor shall submit a proposal to establish additional abbreviations to the Engineer for review.

2.16 Dimensioning

2.16.1 All dimensions shall be generated as associative dimensions and never added as text. Dimension text shall not be modified and automatic or associative dimensions shall never be broken into their constituent parts.

2.16.2 The rules listed below shall be followed when adding dimensions to drawings to ensure uniformity and clarity of drawings.

a. Dimensions shall be placed on the drawing so they can be read from the bottom or right-hand side of the drawing. If it is essential to dimension on an angle, dimension text shall be placed in accordance with Figure 1 Angular Dimensioning above;
b. Dimension text shall be placed centred and above the dimension line, and shall be clear of other lines so that it is legible;
c. Dimension lines shall not be broken, except where it is absolutely necessary to cross other dimension lines;
d. Dimension leader lines shall begin close to the object or point the dimension refers to, and may be broken when crossing other dimension lines if this adds to the clarity of the drawing;
e. Dimensions may end in arrowheads or circles, depending on the type of drawing that is being produced. Solid arrowheads shall enclose an angle not greater than 30o;
f. Refer to the following figure for dimensioning style details:



2.17 Material hatching and shading;

2.17.1 Material hatching shall be used to indicate features of the sections cut through building elements such as walls, floor slabs, and sections through component parts or assemblies. For clarity the area cut in section need not be filled in its entirety with the hatch pattern. It is acceptable to show patches of the material hatch pattern sufficient to clearly show the intent of the hatching (e.g. material type, fire rating etc.).

2.17.2 Application

2.17.3 Drawing Originators shall exercise caution regarding the use of hatch and shading patterns, as they can cause considerable problems for file translation. Originators are advised to test the hatch and shading patterns supported by their respective CAD systems, for compatibility with the CAD file deliverable requirements, prior to adopting them for use.

2.17.4 Reducing (dropping / exploding) complex elements and hatch patterns to primitive elements can assist the translation process but this has an impact on file size often causing the file to grow substantially.

2.18 Symbols

2.18.1 The Contractor's Discipline leads shall control the use of symbols on their drawings through the application of the mandated engineering standards for that discipline.

2.18.2 All proposals for additional symbols shall be submitted in CAD format in accordance with the requirements of this manual.

2.19 Reference files

2.19.1 XREfs

a. Use of Reference files

i) The ability to cross reference multi- discipline 3D model storeal world coordinates of a known provenance shall be at the centre of the design and systems assurance coordination process through out the design and build of the project. Effective use of reference files ensures that data integrity and accuracy across multiple disciplines and users is maintained. The advantage show ever do not come without considerable effort and Originators are encouraged to exercise care and diligence when sharing Reference files / XRefs across different works packages and disciplines within the project, particularly with respect to maintaining accurate version control. The use of the BIM modelling process, in particular the Common Data Environment as described in BS1192 shall ensure that only approved data is released and available to be referenced.

ii) In order that the full potential of a collaborative BIM environment is realised a disciplined and structured approach to the common data environment is essential.

b. Referencing Image (Raster) Files

i) Image files shall becom pressed before referencing into a CAD file to ensure file size remains manageable and the CAD file remains plottable.

2.19.2 Managing CAD Reference File Data and Deliverables

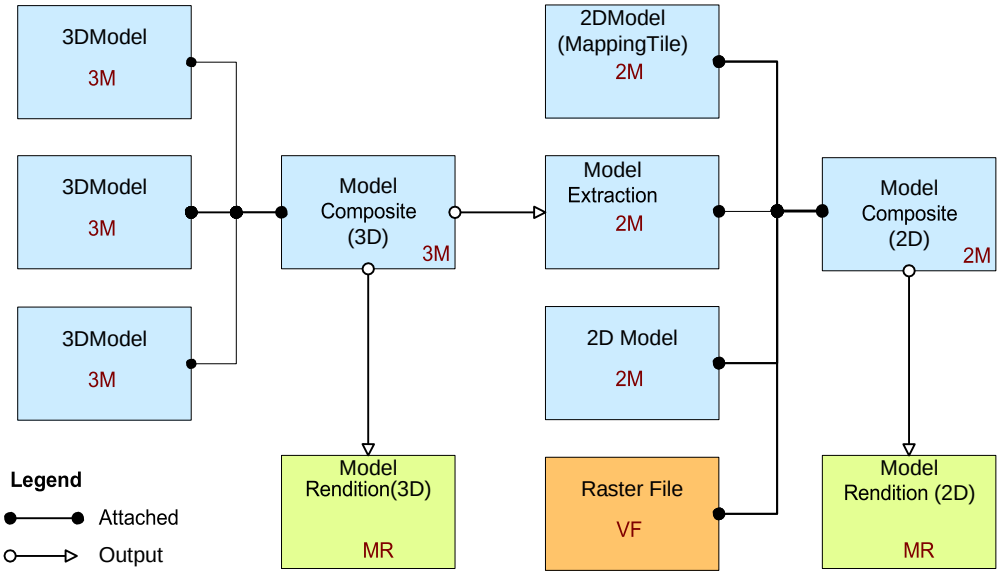
2.19.3 The soft copy deliverable shall consist of both the native CAD file and a PDF file of the same, in accordance with the approved Master Document Index.

2.19.4 When preparing deliverable CAD data sets all reference file data associated with a drawing and or model shall be contained within the same directory folder as the master drawing, sub-directories are not permitted in digitally issued documents unless agreed in advance by the Engineer.

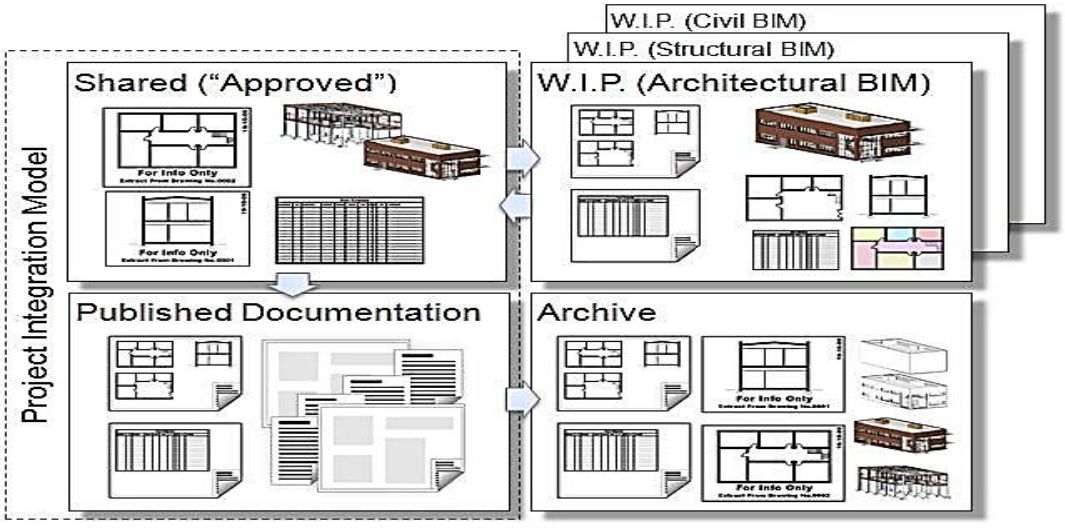
2.19.5 CAD plot file data shall remain in its compound structure, i.e. not merged or bound. All CAD drawing data submissions shall be accompanied by a rendition of the plot file in (PDF).

2.19.6 Care shall be taken to ensure reference file level symbology, boundary clips, scale and rotation is maintained in the final rendition file (PDF).

2.19.7 The figure below shows the principle of reference file attachment within the CDE.



CAD Drawing File Composition



2.20 The BIM Process

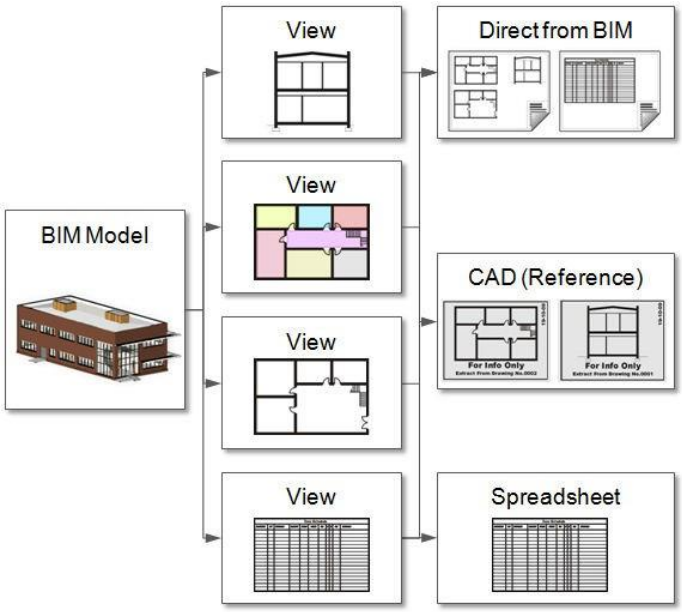
2.20.1 Individual discipline 3D model data shall be produced in discipline specific work in progress areas of the Contractor's Engineering Content Management System that shall ensure that only authorised users can access and edit that data. Once the data has been checked through the workflow it moves into the shared area of the CDE. This is where the other disciplines can access the data for referencing and co-ordination. Therefore, they shall only reference 'approved' data from the shared area.

2.20.2 Primary coordination occurs in the discipline WIP areas and at the agreed time the Design Coordination Manager shall coordinate all discipline data from the shared area. The multi-discipline 3D CAD model that now resides in the shared area shall have spatial clashes detected and resolved at this stage. When clashes are detected the data is passes back to the discipline WIP area for resolution and further coordination. This iterative cycle continues and is controlled by the ECM system until the Design Co-ordination Manager is satisfied that the design is fully coordinated with all discipline data. At this stage 2D extractions are taken from the combined model and referenced into drawing sheets for drawing creation and annotation. Other 2D data shall be referenced into the drawing file (i.e. raster data) at this stage.

2.20.3 Access to the Contractor's ECM system shall be provided to the Engineer with sufficient privileges and functionality to interact with the models and drawings as specified in the contract.

2.20.4 The Contractor shall retain all compound document relationships, structure and configuration so as reproduce the original plot at any time from the source data from within the ECM system.

2.20.5 Once to 2D Model composite file (plot file) is complete it shall be saved off into the ECM and a rendition of the file (PDF produce) this moves into the published area of the ECM, and at this stage can enter the Project Document Control System (EDMS) for circulation. Superseded issues are archived in the ECM.



2.21 Document cross reference

2.21.1 Supplementary drawings, specifications and other documents to be read in conjunction with any drawing shall be fully cross-referenced. Cross references shall generally be listed on the drawing in the column notes.

2.21.2 Where general references are required on a drawing (i.e. reference to other drawings detailing the same structure, associated drawings and location plans) they shall be located on the right-hand side of the drawing sheet below the notes. This position shall be maintained on all drawings where possible.

2.21.3 References, which are specific to a part of a drawing, shall appear next to that particular part.

2.21.4 The notes shall include, where relevant.

a. Reference to Works Specifications
b. Reference to other drawings that need to be read in conjunction with the drawing
c. Reference to associated bending schedules finishes schedules, etc.
d. Reference to any methods statements or procedures
e. Tolerances

2.22 Drawing Issue

2.22.1 Drawing issue requirements

a. **D**rawing Transmittal
   i) The Contractor shall issue drawing sets (PDFs) via the EDMS to the Engineer.
   ii) The Contractor shall have the capability to produce any hard copy print / plot of any issued drawing, and of any model and or drawing regardless of work flow state. Where physical transmittals are required the transmittal shall state the reason for issue and a 'respond by date' where required. The transaction capture of the Contractors EDM system shall provide a concise and continuous record of drawing Revision, Status and Issue.
b. Drawing Status
   The Drawing Status highlights the drawing's purpose of issue e.g. whether it has been issued as Preliminary (For Information), Issued for Tender, Construction or is an As Built drawing. It is mapped into the status code mandated for the project. Any drawing issued without a status code shall not be valid.

2.22.2 Signatures on drawings

2.22.3 The approval process of models and drawings in the CDE is mandated. There shall be a full audit trail available to the Engineer at any time on any issued document. If there is a further requirement for all approved hardcopy drawings issued to the Employer to bear hand written signatures, then both the Originators' Responsible Engineer/Architect and the Originators' Project Manager.

2.22.4 Originators shall complete the boxes of the Drawing Title Block and the Drawing Revision column in CAD files and hardcopy as follows:

a. CAD File:
   Shall contain the name or initials of all persons in CAD text
b. Hardcopy
   The original hardcopy plot of the CAD file, used to produce the deliverable drawing sets, shall have the hand-written signature of the person superimposed over the CAD generated initial.

Title Block	CAD File	Hard Copy
Drawn	CAD Initials	CAD Initials
Designed	CAD Initials	CAD Initials
Responsible Engineer/ Architect (Checked)	CAD Initials	CAD Initials+ Signature
Project Manager	CAD Initials	CAD Initials+ Signature
Revision Box		
By	CAD Initials	CAD Initials+ Signature
Responsible Engineer	CAD Initials	CAD Initials+ Signature

Initial and Signature Requirements

2.22.5 The Contractor shall submit to the Engineer a list of persons within their organization who are authorized to check drawings (Responsible Engineer/Architect). This list shall be cross reference with the general roles and responsibilities of those who are authorized to sign as Project Manager. The list shall contain the typed name and initials of each authorized person together with specimen signatures as follows:

Name	Initials	Signature
J.B. Bharghav	JBB	

2.22.6 In circumstances where the authorized person is not present in, the Contractor may nominate a person to sign on the authorized person's behalf. Under such circumstances the Contractor shall notify the Engineer and provide the names, initials and specimen signature of the nominated person.

2.22.7 The Contractor shall also provide the Engineer with the Quality Assurance Procedure for informing the nominated person from the Contractor of the right to sign the drawing on behalf of the authorized person.

2.22.8 Drawing delivery sets.

2.22.9 To streamline drawing management and reference, submission drawings shall be organized into logical sets based on subject content. The sets shall be bound into volumes prior to delivery to the Engineer and shall include the following:

a. A Cover Sheet for each bound volume
The Cover Sheet shall contain a description of the project, submission stage, design package and on of work (as appropriate) that the drawings in aparticular volume refer to. The Originator's name and logo may be included on this sheet.

b. Index Sheet(s) for all bound volumes
Index Sheets shall contain a list of all the drawings and include the Drawing Number, Drawing Title and CAD file name. The Index sheet shall be generated from the Master document index that is managed and maintained by the contractor. The Index sheets shall contain a complete list including any deleted or superseded drawings as well as the drawing numbers in a series which have been allocated but not used at the time of submission. The words DELETED, SUPERSEDED or NOT USED shall be placed in the drawing title column adjacent to the drawing number referred to as appropriate. This data shall be generated from the Master Document Index (MDI)

c. General Notes Sheet

d. Symbol Sheet(s) and Abbreviations Sheet
All other Drawing Sheets shall be arranged in sequence in accordance with the drawing number system

2.22.10 Drawing creation

2.22.11 Multi-discipline data coordination

a. Originators of single discipline model's layouts and schematics shall use all other relevant discipline model's layouts and schematics to co-ordinate their work from within the CDE. As a function of the CDE the single discipline engineers can only reference other discipline data that has been approved. It is critical to the success of the BIM approach that the maturity and granularity of the single discipline models match that of the other discipline models.

b. As an example, it is expected that the MEP design shall start at a later date than the civil works. The Contractor is responsible for ensuring that the level of detail in any model is appropriate for that stage in the project. The appropriate version of the model shall be agreed and accepted before any data is published out of the shared area of the CDE.

c. A note shall be placed in the notes area within the title block stating the following:
This drawing contains the following model files: An example listing:

- BSRP-C2S-ABC-ARC-MD2-XXX-XX-2345.S3.P2
- C2S-ABC-STR-MD2-XXX-XX-4567.S2.P2
- C2S-ABC-CIV-MD2-XXX-XX-3456.S2.P2
- C2S-ABC-CIV-MD2-XXX-XX-1221.S3.P2
- C2S-ABC-CIV-MD2-XXX-XX-3317.S2.P2

These references shall include Status and Revision codes

2.23 CAD File deliverable requirements

2.23.1 CAD Format and file management

2.23.2 The Contractor shall designate a single CAD/BIM application platform across the entire work package. The ECM system shall control access to the application and serve as a central repository for all Work package Project CAD drawing and BIM model files and control versions, access and workflow within the ECM. This configuration is the Common Data Environment (CDE).

2.23.3 At the designated data drops i.e. Preliminary, design stage 1, Final, design stage 2, and As Built record. It is envisaged that CAD data transfer at these designate data drops shall be electronic and direct. i.e. database to database.

2.23.4 When requested the Contractor shall submit their drawings in both hard and softcopy versions.

2.23.5 Softcopy deliverables of two-dimensional (2D) CAD drawings shall comprise the CAD plot composition files and all associated references and configurations together with the 2D renditions PDFs. Softcopy deliverables of three dimensional (3D) objects such as CAD models, digital terrain models (DTM), alignment and survey files, shall be 3D CAD files and 3D PDFs.

2.23.6 Where attribute object data is included in the submission it shall be transmitted in its native file format together with a verified IFC.

2.23.7 The Contractor shall be responsible for the verification of the IFC and the fidelity of the output.

2.23.8 Hard Copy Drawings

2.23.9 Staged hardcopy deliverable requirements in terms of the number of copies, media type and drawing size, shall be as defined in the Works Contract.

2.23.10 However, the minimum hardcopy submission shall comprise one A1 full size and three (3) A3 reduced size plot for each drawing contained in the submission.

2.23.11 CAD Data Sets

a. Softcopy

i) Each submitted CAD data set shall be treated as an official document and all submissions shall conform to the requirements of this Manual.

ii) CAD data sets shall be delivered in a form at that is directly readable and compatible with the Project CAD system and operating system as previously described.

iii) Before submission, all media shall be scanned for viruses and verified to be virusfree. Electronic media shall be dispatched in a clearly labelled package together with the supporting documentation.

b. Delivery Media

It is envisaged that CAD data transfer at these designate data drops shall be electronic. This may be backed up by bulk file issue on CD- ROM or DVD, depending on the size of the files to be issued.

c. Other Requirements

i) All submissions of CAD digital data sets shall meet the following conditions

ii) All delivered CAD files issued via digital media shall reside in the root directory. The use of sub directories is not permitted except to separate categories of files by discipline, contract number or other logical category, included in the submission.

2.23.12 CAD file house keeping

2.23.13 When opened, the delivered CAD files shall be fitted to its content extents.

2.23.14 All environment parameters shall have standard settings as defined in the Contractor's procedures and contain any necessary configuration files.

2.23.15 The use of shared or nested cells or blocks is not permitted.

2.23.16 Before delivery the Contractor shall process all CAD files through an automated QA checking routine to ensure work package conformity.

2.23.17 Evidence of the success of this process must accompany any CAD file submission to the Employer. The Employer shall not accept any CAD data that has not been verified compliant with this standard.

2.23.18 CAD File Translation

2.23.19 CAD file translations between application platforms are not permitted. The Contractor shall ensure that there is a single software application platform across the work package that provides for all BIM process and engineering complexity as set out in this Manual.

2.23.20 Seed/Base/Template File Settings

2.23.21 The Contractor shall establish a single Base CAD file which sets the primary parameters across the work package. It shall control the survey grid and any other settings such as Global Origin, Working Units, base units of measurement, drawing accuracy, file resolution, read out accuracy text settings etc. It shall be used to generate any new file for the project.

2.23.22 Plotting

2.23.23 All plots shall indicate in the drawing margin area, the date and time at which they were produced. Date and time stamp recording shall be automated in the plotting software to ensure it is recorded on all plots and appear in the drawing border space near the title block

2.23.24 Plotting Scale

2.23.25 All CAD models shall be created at full scale (1:1). The required scale for hard copy out-put shall be established at the time of plotting. The requirements for text placement and block or cell insertion shall take into consideration the desired final plotted output.

2.24 Updates policy

2.24.1 **Intent**

2.24.2 It is intended that this document be functional and useful for all types of BIM Modelling, CAD and GIS drawings to be produced for the projects, regardless of discipline.

2.24.3 The constraints set out in this manual shall therefore be reviewed and updated periodically and shall take into consideration all changes deemed necessary. The Contractor shall advise the Engineer of any errors or omissions they discover when implementing these standards. Additionally, all participants are invited to suggest any additions or modifications they feel would improve the Manual.

2.24.4 **Update procedure**

a. Proposal for Amendment by Users
If the Contractor discovers omissions or errors, or wishes to make suggestions for addition or improvement, the details of the proposal shall be submitted to the Engineer for consideration

b. Interim Amendments
Amendments deemed necessary shall be compiled into Interim Amendments (IA). The IA's of the manual shall be distributed in accordance with the document control and records management procedure as an interim measure and to expedite the release of the amended information subsequent to full update and re-posting of the revised SMP

c. Revised Issue
At appropriate times the BIM SMP and appendices shall be updated to incorporate all IA amendments. Following the update, a new Revised Version of the SMP shall be appropriately distributed. The Contractor shall amend his Work package SMPs to comply.

d. Project Sponsor
Direct any suggestions for improvement of the BIM SMP to the Employer.

Appendix C - Terms and Abbreviations:

1 General Abbreviations sections
2 Electrical Mechanical Services
3 Electrical Services
4 Environmental Control System
5 Fire Services
6 Plumbing and Drainage Services
7 Rolling Stock
8 Control & Communications
9 Automatic Fare Collection
10 Building Design / Civil Works
11 Permanent Way Civil

Electrical & Mechanical Services AND Electrical Services

Ø	Diameter
Δ T	Temperature Differential
A	Ampere
ABC	Automatic Brightness Control
AC	Alternating Current
ACB	Air Circuit Breaker
ACP	Access Control Panel
ACU	Automatic Calling Unit
ADC	Analog Digital Converter
ADJ	Adjustable
AF	Audio Frequency
AFFL	Above Finished Floor Level
AGC	Automatic Gain Control
AH	Amperes Hour
AI	All Insulated
AL	Aluminium
ALC	Automatic Light Control
AM	Amplitude Modulation
AMPL	Amplifier
ANI	Automatic Number Identification
ANN	Annunciator
ANT	Antenna
APC	Automatic Phase Control
APM	Automated People Mover
APPROX	Approximate
ARQ	Automatic Request for Repetition
AS	Ammeter Switch
AT	Automatic
ATS	Automatic Transfer Switch
AUTO	Automatic
CFS	Combined Fuse Switch
CL	Centreline
CM	Centimetre
COAX	Coaxial
CONN	Connector, Connection
CONS	Console
CPI	Call Progress Identificator
CPT	Control Power Transformer
CPU	Central Processor Unit

AUX	Auxiliary
AVC	Automatic Volume Control
B/B	Busbar
BAR	Baggage Handling Arrivals
BAT	Battery
BAT CHG	Battery Charger
BBC	Bus Bar Chamber
BC	Bayonet Cap
BCD	Binary Coded Decimal
BD	Board
BDL	Baggage Handling Distribution Line
BES	Baggage Handling Early Storage
BGM	Background Music
BIL	Basic Insulation Level
BLDG	Building
BLK	Block
BMS	Building Management System Cables
BOG	Baggage Handling Out of Gauge
BS	British Standard
BTR	Baggage Handling Transfer
CA	Cable
CAB	Cabinet
CAM	Camera
CAP	Capacitor/ Capacitance
CB	Circuit Breaker
CB	Common Battery
CC	Central Control Centre
CCTV	Closed Circuit Television
CDA	Command and Data Acquisition
CE	Coupling Equipment
DF	Distribution Frame
DGT	Directorate General of Telecom
DSB	Double Side Band
DSE	Date Switching Exchange
DSU	Disc Storage Unit
DTE	Data Terminal Equipment
DP	Double Pole
ECD	Error Control Device
ELEC	Electrical

CR	Control Relay
CRQ	Call Request
CS	Control Switch
CT	Current Transformer
CTL	Control
CU	Copper
D/A	Digital to Analog Converter
DAC	Digital - Analog Convertor
DBmV	A dB Referred to One Millivolt
DBES	Sub-main Distribution Board for Essential Power
DBLG	Sub-main Distribution Board for Lighting
DBNE	Sub-main Distribution Board for Non-essential Power
DC	Direct Current
DCV	Document Conveyor Vehicle
DD	Digital Display
DDC	Data Distribution Controller
DDD	Direct Distance Dialling
DDIE	Direct Digital Interface Equipment
DDT	Data Display Terminal
DEPT	Department
FGU	Fixed Ground Power Generating Unit
FIB	Fibre Optic Cables
FID	Flight Information Display
FIT	Failure in Time
FLEX	Flexible
FM	Frequency Modulation
FO	Fibre Optic
FOP	Fuel Oil Pump
F/S	Fuse Switch
FSK	Frequency Shift Keying
FT	Feature Telephone
FU	Fused Unit
FU	Fuse
GB	Ground Bus
GEN	Generator
GI	Galvanised Iron
GND	Ground
H	Hour

ELV	Extra Low Voltage
E&M	Electrical & Mechanical
EM	Emergency Cables
EMC	Electromagnetic Interface
EMS	Environmental Management Subsystem
EQ	Equalizer
EQPT	Equipment
ESC	Escalator
ESS	Essential
ET	Emergency Telephone
EWS	Emergency Warning and Intercom System
EX	Exchange
EXT	Exterior
F, F1, F2	Frequency
FA	Fire Alarm
FAS	Fire Alarm System
FAX	Fax Machine
FAX	Facsimile
FB	Fuse Block
FCU	Fan Coil Unit
FEC	Forward Error Connection
HZ	Hertz
I	Intensity
I/F	Interface
I/O	Input/ Output
IC	Integrated Circuit
ID	Identification
IDMT	Inverse Definite Minimum Time
IDN	Integrated Digital Network
IEE	Institution of Electrical Engineers
IFM	Intelligent Field Module
IMP	Impedance
INC	Incoming
INST	Instantaneous
INTLK	Interlock
IP	Index of Protection
ISDN	Integrated Service Digital Network
IT	Isolating Transformer

HD	Hand Dryer
HDB	High Density Bipolar Code
HDX	Half Duplex
HLT	Hot Line Telephone
HP	Horse Power
HPF	High Power Factor
HRS	Hours
HSR	High Speed Railway
HV	High Voltage
HVB	High Voltage Switchboard
HVC	High Voltage Cables
LB	Local Battery
LBE	Laboratory Equipment
LCC	Lighting Control Cubicle
LCD	Liquid Crystal Display
LED	Lighting Emitting Diode
LFT	Lift
LMCP	Local Motor Control Panel
LSOH	Low Smoke Halogen Free
LTG	Lighting
LV	Low Voltage
LVC	Low Voltage Cables
M	Motor
MA	Milli Ampere
MAINT	Maintenance
MAN	Manual
MAN OP	Manually Operated
MAX	Maximum
MBPS	Megabits/Second
MC	Master Clock
MCB	Miniature Circuit Breaker
MCP	Master Control Panel
MCCB	Moulded Case Circuit Breaker
MCT	Measurement Current Transformer
MDF	Main Distribution Frame
MECH	Mechanical
MED	Medium
MEZZ	Mezzanine
MH	Man Hole
MHZ	Megahertz
MNE	Maintenance Equipment

JB	Junction Box
JKP	Jacking Pump
KB	Keyboard
Kg/M	Kilogram
KHZ	Kilohertz
Km	Kilometre
kV	Kilovolt
kVA	Kilovolt-Ampere
KVAH	Kilovolt Ampere Hour
kvar	Kilovolt-Ampere Reactive
KWH	Kilowatt
L&P	Lighting and Power Cables
LA	Lightning Arrester
MIC	Microphone
Min	Minute
MISC	Miscellaneous
M/L	Mid-Level
MML	Man-Machine Language
MON	Monitor
MRS	Maintenance Radio Station
MTD	Mounted
MTG	Mounting
MTR	Motor
MTS	Manual Transfer Switch
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
MUX	Multiplexer
mv	Millivolt
MV	Medium Voltage
MV	Microvolt
MVA	Meavolt Ampere
MWW	Moving Walkway
No	Number
O&M	Operating and Maintenance
O/C	Overcurrent
OCB	Oil Circuit Breaker
OD	Outside Diameter
OF	Optical Fibre
O/L	Overload
OLS	Oil Level Sensor
P	Pole

PAC	Public Address Cables
PB	Push Button
PCC	Public Carrier Cables
PCM	Pulse Code Modulation
PCT	Protection Current Transformer
PF	Power Factor
PFM	Power Factor Meter
PH	Phase
PM	Phase Modulation
PNL	Panel
POS	Positive
PR	Pair
PRI	Primary
PRL	Parallel
PS	Power Supply
PSD	Platform Screen Doors
PSK	Phase Shift Keying
PT	Potential Transformer
PTI	Passenger Train Information
PUBT	Public Telephone
PVC	Polyvinyl Chloride
PWR	Power
R	Relay
RC	Remote Control
RCD	Residual Current Device
RCT	Remote Computer Terminal
REF	Refrigerator
REF	Reference
REG	Regulator
REM	Remote
SPN	Single Pole & Neutral
SPSN	Single Pole & Switching Neutral
SQ	Square Sub Switchboard
SS	Substation
SSB	Single Side Band
STA	Station
SUPV	Supervisory
SW	Switch
SWA	Steel Wire Armoured
SWBD	Switchboard

PA	Public Address
PABX	Private Automatic Branch Exchange
REQD	Required
REV	Revision, Reversing, Reverse
RF	Radio Frequency
RM	Room
RM	Refrigeration Machine
RMC	Railway Maintenance Circuit
ROC	Railway Operation Circuit
rpm	Revolution Per Minute
RT	Radio Telephone
RTD	Resistance Temperature Detector
RX	Receiver
S	Second
SB	Stand By
SC	Signalling & Communication
SCP	Security Control Panel
SDB	Sub distribution Board
SEC	Security Cables (CCTV & Access Control)
SEL CAL	Selective Calling
SEM	Smoke Exhaust Motor
SEQ	Sequence
SFU	Switch Fuse Unit
SGN	Signage
SIP	Sub-Indicator Panel
SM	Surface Mounted
S/N	Signal to Noise Ratio
SO	Socket Outlet
S/O	Socket Outlet
SP	Spare, Single Pole
SPC	Stored Program Control
SPKR	Speaker
TS	Time Switch
TV	Television
TWS	Wayside Telephone
TX	Transformer
TX	Transmitter
TYP	Typical
UCP	Unit Control Panel
U/F	Under Floor

SYM	Symbol
SYMM	Symmetrical
SYNC	Synchronize
TB	Terminal Board
TBX	Terminal Box
TD	Time Distribution
TDB	Tenancy Distribution Board
TEL	Telephone
TELECOM	Telecommunications
TEMP	Temperature
TEN	Tenancy Cables
TERM	Terminal
TIDS	Train information Display System
TM	Television Monitor
TMH	Telecommunications Handbook
TMS	Main Station
TMSR	Main Station Radio
TP	Triple Pole
TPN	Triple Pole & Neutral
W	Watt
W/O	Without
XLPE	Cross Linked Polyethylene
XRY	X-ray Machine
1/C	Single Core

UHF	Ultra-High Frequency
UG	Underground
UPS	Uninterruptible Power Supply
UT	Universal Telephone
UV	Under Voltage
V	Volt
VA	Volt - Ampere
VAC	Volt Alternating Current
VCB	Vacuum Circuit Breaker
VD	Video
VDC	Video Display Controller
VDCt	Volts Direct Current
VDT	Video Display Terminal
VDU	Video Display Unit
VD3	Type 3 Cables
VD5	Type 5 Cables
VF	Voice Frequency
VHF	Very High Frequency
VSWR	Voltage Standing Wave Raito
W	Wait
4P	Four Pole
4/C	Four Core
3/C	Three Core
2/C	Two Core

Environmental Control Systems

AAV	Automatic Air Vent
A/C	Air Conditioning
ACC	Air Cooled Chiller
ACC	Air Cooled Condensing Unit
ACH	Air Cooled Water Chiller
ACF	Air Curtain Fan
ACO	Air Cooler
ACU	Air Conditioning Unit
AD	Access Door
AF	Air Filter
AFF	Above Finish Floor
AFR	Auto-Roll Filter
AHU	Air Handling Unit

BV	Butterfly Valve
BWS	Backwash Strainer
CA	Compressed Air
CAP	Capacity
CAC	Computer Room Air Conditioning Unit
CAV	Constant Air Volume
CHWR	Chilled Water Return Pipe
CI	Cast Iron
CL	Centre Line
CMH	Cubic Meter Per Hour
CMM	Cubic Meter Per Minute
CMS	Cubic Meter Per Second
CO SENSOR	Carbon Monoxide Sensor

AID	Automatic Incident Detection Loop
AIR	Air Receiver
AIRC	Air Compressor
AMS	Air Measuring Station
AP	Access Panel
ARF	Automatic Roll Filter
ASD	Aspirating Smoke Detector
ASD	Automatic Smoke Damper
AV	Air Vent
BD	Board
BDD	Back Draft Damper
BEF	Battery Exhaust Fan
BHP	Brake Horse Power
BOD	Bottom of Duct
BOP	Bottom of Pipe
BOT	Bottom
BV	By-Pass Valve
DDG	Double Deflection Grille
DFC	DX Type Fan Coil Unit
DIA	Diameter
DISCH	Discharge
DL	Door Louver
DN	Down
DP	Disposable Panel Filter
DPS	Differential Pressure Switch
DWG	Drawing
DX	Direct Expansion
E/P	Electric Pneumatic Panel
EA	Exhaust Air
EAD	Exhaust Air Duct
EAF	Exhaust Air Fan
EAG	Exhaust Air Grille
EAL	Exhaust Air Louver
EAR	Exhaust Air Register
EC	Evaporative Cooler
ECL	Electro-Chlorinator
ECU	Evaporative Cooler Unit
EDH	Electric Duct Heater
EFF	Efficiency
EG	Exhaust Air Grille

COMP	Compressor
CON	Condensing Unit
CP	Control Panel
CT	Cooling Tower
CV	Control Valve
C/W	Complete With
CW	Cold Water
CWC	Cold Water Coil
CWF	Condenser Water Flow Pipe
CWR	Condenser Water Return
CWP	Condenser Water Pump
dB	Decibel
DB	Dry Bulb
DBF	Disposable Bag Filter
DBT	Dry-Bulb Temperature
DCM	Digital Control Module
DDC	Direct Digital Control
ESR	Electricity Supply Room
ESS	Essential Supply Source
ET	Expansion Tank
ETD	Electro-Thermal Fusible Link Fire Damper
ETD	Electro Thermal Link Damper
ETL	Electro-Thermal Link
EVP	Evaporating Unit
EX	Existing
EXA	Exhaust Air
EXF	Exhaust Fan
EXT	External
EVS	Exhaust Vent Shaft
FA	Fresh Air
FAD	Fresh Air Duct
FAF	Fresh Air Fan
FAG	Fresh Air Grille
FAI	Fresh Air Intake
FAL	Fresh Air Louvre
F/A	From Above
F/B	From Below
FCC	Fan Coil Unit (concealed ceiling type)
FCE	Fan Coil Unit (exposed ceiling type)
FCF	Free Cooling Fan

EH	Exhaust Hood
EJ	Expansion Joint
EL	Elevation
EMF	Emergency Fan
ENT	Entering
ER	Exhaust Roof Ventilator
ERV	Exhaust Roof Ventilator
FPM	Feet Per Minute
FS	Flow Switch
FW	Flushing Water
GA	Gauge
GL	Ground Level
GVA	Gate Valve
HC	Heating Coil
HE	Heat Exchanger
HFD	Heavy Duty Motorized Control Damper (Fire Rated Type)
H/L	High Level
HT	Height
HTR	Heater Element
HUM	Humidifier
HVAC	Heating Ventilation & Air Conditioning
HW	Hot Water
IAF	Impulse Air Fan
ID	Inside Diameter
INF	Intake Fan
IVS	Intake Vent Shaft
JAF	Jet Air Fan
KE	Kitchen Exhaust
KG	Kilogram
KPA	Kilopascal
KW	Kilowatt
LEAV	Leaving
LFD	Light Duty Motorized Control Damper (Fire Rated Type)
L/L	Low Level
LPM	Litre Per Minute
LPS	Litre per second
LTS	Lower Track Slab
NO	Normally Open
NRD	Non-Return Damper
NTS	Not to Scale

FCU	Fan Coil Unit
FD	Fire Damper
FLD	Fusible Link Damper (Fire Rated)
FF	Fan
FFL	Finished Floor Level
FM	Flow Metre
F/O	Floor Opening
L/S	Litre Per Second
M	Metre
M2	Metre Squared
mm	Millimetre
MAF	Make-up Air Fan
MAX	Maximum
M3/S	Metre Cubed Per Second
M/C	Main Contractor
MCC	Motor Control Centre
MCD	Motorized Control Damper
MCP	Motor Control Panel
MCS	Main Control System
MD	Motorized Damper
MFD	Motorized Fire Damper
MIN	Minimum
MIS	Modified Initial System
M/L	Mid-level
MODR	Motor Operated Damper
MOV	Motor Operated Valve
MP	Impulse Fan
MPS	Meter Per Second
MSD	Motorized Smoke Damper
MSFD	Motorized Smoke and Fire Damper
MSS	Mechanical Services Switchboard
MST	Measuring Station
MVD	Motorized Vent Shaft Damper
MWP	Make-up Water Pump
N/C	Normally Closed
N/O	Normally Open
NIC	Not in Contract
RE	Refer To
REF	Reference
REG	Relief Grille

OA	Outside Air
OBD	Opposite Blade Damper
OD	Outside Diameter
OTE	Over Track Exhaust
OTEL	Over Track Exhaust Louvres
O/F	Overflow
Pa	Pascal (N/M2)
PAD	Primary Air Duct
PAU	Packaged Air Handling Unit
PCP	Primary Chilled Water Pump
PCU	Packaged Condenser Unit
PD	Pressure Drop
PEN	Penstock
PEU	Evaporating Unit
PG	Pressure Gauge
PHX	Plate Heat Exchanger
POD	Pneumatic Operated Damper
PS	Pressure Switch
PSI	Pound Per Square Inch
RA	Return Air
RAD	Return Air Duct
RAF	Return Air Fan
RAG	Return Air Grille
RAR	Return Air Register
RAL	Return Air Louver
RAP	Return Air Perforated Plate
RC	Reinforced Concrete
SEL	Smoke Exhaust Louvres
SG	Supply Air Grille
S/F	Switch Fuse
SIL	Silencer
SLD	Supply Linear Diffuser
SMC	Smoke Curtain
SNo	Silencer with Equipment Numbering
SPF	Stair Pressurisation Fan
SPR	Sprinkler
SPS	Stair Pressurisation Sensor
SR	Supply Air Register
ST	Stop Tap
SUP	Sump Pump

REU	Roof Extraction Unit
RG	Return Air Grille
RHC	Reheat Coil
RIF	Roof Intake Fan
RI/O	Remote Input/Output Processing Unit
RL	Rail Level
RPM	Revolutions Per Minute
RR	Return Air Register
RSF	Remote Sensor (Flow)
RSH	Remote Sensor (Humidity)
RSL	Remote Sensor (Level)
RST	Remote Sensor (Temperature)
RT	Refrigeration Ton
RXF	Roof Extract Fan
SA	Supply Air
SAD	Supply Air Duct
SAG	Supply Air Grille
SAF	Supply Air Fan
SAR	Supply Air Register
SAT	Sound Attenuator
SCD	Supply Ceiling Diffuser
SCHW	Secondary Chilled Water Pump
SCP	Security Control Panel
SD	Smoke Damper
SED	Smoke Extraction Duct
SEF	Smoke Extraction Fan
SEG	Smoke Extraction Grille
TREF	Trackway Exhaust Fan
TSF	Trackway Supply Fan
TVF	Tunnel Vent Fan
TX	Transformer
TYP	Typical
UBS	Under Beam Soffit
U/B	Under-Beam
U/S	Under-Slab
URS	Under Roof Soffit
VCD	Manual Volume Control Damper
VD	Volume Damper
VI	Visibility Sensor
VS	Velocity Sensor

SV	Solenoid Valve
SVS	Supply Vent Shaft
SWP	Sea Water Pump
T/A	To Above
T/B	To Below
TAD	Transfer Air Duct
TAF	Transfer Air Fan
TAG	Transfer Air Grille
TBS	Travelling Bank Screen
TEF	Toilet Exhaust Fan
T/H	Turn at High Level
T/L	Turn at Low Level
T/P	Terminated at Plenum
TOD	Top of Duct
TOP	Top of Pipe
TP	Triple Poles
TPN	Triple Poles and Neutral

WAC	Window Type Air Conditioner
WB	Wet Bulb
WCC	Water Cooled Chiller
WCT	Water Chemical Treatment
WF	Wall Mounted Fan
WP	Weather Proof
WPF	Washable Panel Filter
WPL	Weather Proof Louver
WT	Water Tank

Fire Services

ADB	Automatic Drop Barrier
BG	Break Glass
BGU	Break Glass Unit
DJPP	Drencher Jockey Pump
DRCP	Drencher Pump Control Panel
DRI	Drencher Inlet
DRP	Drencher Pipe
DRPP	Drencher Duty & Standby Pump
FALM	Fire Alarm
FD	Fire Damper
FDB	Fixed Drop Barrier
FFP	Fixed Fighting Pump
FGCP	FM200 System Control Panel
FHCP	Fire Hydrant Pump Control Panel
FHJP	Fire Hydrant Jockey Pump
FHP	Fire Hydrant Pipe
FHPP	Fire Hydrant Duty & Standby Pump
FIR	Fire Alarm System Cables
FREP	Fire Fighting Pump
FSI	Fire Services Inlet
FSP	Fire Service Pipe

SD	Smoke Damper
SFD	Smoke & Fire Damper
SFE	Safety Equipment
SFP	Sub-Fire Alarm Panel
SHCP	Street Hydrant Pump Control Panel
SHJP	Street Hydrant Jockey Pump
SHPP	Street Hydrant Duty & Standby Pump
SJPP	Sprinkler Jockey Pump
SPCP	Sprinkler Pump Control Panel
SPP	Sprinkler Pump
SPRI	Sprinkler Inlet
SPRP	Sprinkler Pipe
W/	With
WJPP	Water Spray Jockey Pump
WSCP	Water Spray Pump Control Panel
WSI	Water Spray Inlet
WSPP	Water Spray Duty & Standby Pump

FSS	Fire Services Switchboard
HWL	High Water Level
JP	Jockey Pump
LWL	Low Water Level
MFP	Master Fire Alarm Panel
M/L	Mid-Level
OF	Overflow
PSCP	Pre-actions Recycle Sprinkler Control Panel
SB	Sand Bucket

Plumbing and Drainage Services

BL	Bottom Level
BP	Booster Pump
BSN	Basin
BT	Boundary Trap
BWU	Boiling Water Unit
CI	Cast Iron
CKV	Check Valve
CLSP	Cleansing Water Pipe
CS	Carbon Steel
C/W	Complete With
DG	Disconnector Gully
DHW	Domestic Hot Water
DI	Ductile Iron
DP	Down Pipe
DTL	Disconnection Trap Invert Level
DW	Dish Washer
FLSP	Flushing Water Pipe
FRP	Fresh Water Pipe
FWP	Flushing Water Pump
GFRP	Glass Fibre Reinforced Polyester
GI	Galvanized Iron
GIASP	Galvanised Iron Anti-Siphonage Pipe
GIFWP	Galvanised Iron Fresh Water Pipe
GIT	Grease Interceptor Trap
GLW	Glass Washer
GR	Gas Regulator
GSP	Galvanised Steel Pipe
GTV	Gate Valve

HS	Hydraulic Services Water Pump
HSS	Hydraulic Services Switchboard
HWL	High Water Level
HWU	Hot Water Unit
HWHT	Hot Water Heater
HWPP	Hot Water Pump
KIT	Kitchen
IL	Invert Level
LWL	Low Water Level
MH	Man Hole
O/F	Over Flow
ORG	Overflow Relief Gully
PE	Polyethylene Pipe
PTBP	Potable Water Pipe
PTV	Parity Valve
PWP	Potable Water Pump
RMU	Ring Main Unit
SDU	Sanitary Disposal Units
SK	Sink
SP	Sump Pump
UR	Urinal
V	Vent
W/	With
WC	Water Closet
WM	Water Meter
WTPP	Waste Sump Pump

GV	Greasy Vent
GW	Greasy Waste

Rolling Stock

ACB	Auxiliary Control MCB
ACSB	Air Conditioning Supply MCB
AIC	Auxiliary Supply Inverter Contactor
AMR	Auto Mode Relay
ARR	Auxiliary Run Relay
ASB	Alternator Supply MCB
ASC	Alternator Supply (Isolating) Contactor
ATB	Automatic Train MCB
ATC	Automatic Train Control
ATDR	Auto Trip Delay Relay
ATO	Automatic Train Operation
ATP	Automatic Train Protection
BAU	Brake Analogue Unit
BCB	Battery Control MCB
BCC	Battery Charging Contactor
BCG	Brake Cylinder Governor
BIC	Brake Isolating Cock
BLCS	Brake Loop Cutout Switch
BMC	Blower Motor Contactor
BSB	Brake Supply MCB
BSRB	Brake Supply Relay MCB
CCB	Compressor Control MCB
CCS	Control Cutout Switch
CDCR	Cab Door Closed Relay
CH	Controller Handle
CHB	Charging MCB
CLCB	Cab Light Control MCB
CMR	Coded Manual Relay
COR	Cab Occupied Relay
CSB	Compressor Synchronizing
IEG	Inverter Equipment Governor
IES	Inverter Electronic Switch
ILB	Indications MCB
LACB	A' Phase Lighting Control MCB
LBCB	B' Phase Lighting Control MCB
LC	Line Contactor

DCB1	C' Car Control Positive MCB
DCB2	C' Car Motor Alternator Control MCB
DCH	Door Control Handle
DIC	Door Isolating Cock
DIL	Door Indication Light
DLCS	Door Loop Cutout Switch
DLR	Door Light Relay
DPR	Door Proving Relay
DR	Door Relay
DSCB	Door Supply Control MCB
DSD	Driver's Safety Device
EBR	Emergency Brake Relay
EBV	Emergency Brake Valve
ECC	Emergency Charging Contactor
EDI	Emergency Door Interlock
EG	Equipment Governor
ELCB	Emergency Lighting Control MCB
EP	Electro-pneumatic
ES	Emergency Switch
ESB	Emergency Stop Push
ESC	Emergency Supply Contactor
FCS	Filter Capacitor Switch
FLCB	Flashing Light Control MCB
FPIC	Footpump Isolating Cock
GC	Ground Contactor
GCES	GTO Chopper Electronic Switch
HMS	Hostler Master Switch
HOR	Hostling Overspeed Relay
ICS	Inverter Cutout Switch
ICCB	Inverter Control Circuit Breaker
PIC	Pantograph Isolating Cock
PWM	Pulse Width Modulation
RB	Radio Equipment MCB
RFL	Rear Flashing Switch
RMR	Restricted Manual Relay
ROR	Restricted Overspeed Relay

LCB	Local Control MCB
LCCB	C' Phase Lighting Control MCB
LCSC	Local Control Supply Contactor
LDR	Local Door Relay
LMRG	Low Main Reservoir Governor
LPRC	Local Parallel Relay Contactor
LSRC	Local Series Relay Contactor
LVR	Low Voltage Rectifier
LVT	Low Voltage Transformer
LWFR	Local Weak Field Relay
MA	Motor Alternator
MACS	Motor Alternator Cutout Switch
MCC	Main Compressor Contactor
MCG	Main Compressor Governor
MFB	Micro-Processor Fan MCB
MLB	Marker Light Control MCB
MRR	Mode Repeater Relay
MS	Mode Selector
NVRR	No Volt Repeater Relay
OLR	Overload Relay
PAB	Public Address
PCM	Pneumatic Camshaft Mechanism
PEP	Passenger Emergency Plunger
PEIC	Pantograph Equipment Isolating Cock
SC	Series Contactor
SCC	Shunting Control (Hostler) Cubicle
SCOS	Safety Cutout Switch
SDR	Shut Down Relay
SES	Sealed Emergency Switch
SHR	Start Hold Relay
SIR	Safety Interlock Relay
SPB	Start Push Button
TIR	Traction Interlock
TLB	Train Line MCB
TLSC	Train Line Supply Contactor
ZVR	Zero Velocity Relay

Control & Communications
Automatic Fare Collection

A0	Anal/Dispenser
AFC	Automatic Fare Collection
AMP	Amplifier
ANT	Antenna
AOM	Auto Off Manual
ATS	Automatic Ticket System
AVE	Audio/Visual Equipment
AXF	Transformer (Power)
BAE	Bus AFC Equipment
BD	Board
BLK	Block
CAM	CCTV Camera
CCTV	Closed Circuit Television
DB	Distribution Board
DDP	Depot Data Processor
DGP	Data Gathering Panel
DL	Door Latch
DM	Door Monitor
DTR	Data Terminal
ECM	Encapsulator (CEU)
EFM	Excess Fare Machine
ENM	Encoding Machine
ENMBK	Encoding Machine, Backup
ENT	Entry Gate
ES	Encoder/Sorter
EST	End Stanchion

CCU	Cash Collection Unit
CHE	CCTV Head End
CHM	Change Machine
CLK	Clock
CMS	Central Monitor System
CMT	Central Monitor Terminal
CNW	Computer Network
COC	Coin Counter
COM	General Communications Cables
COR	Code Reader
CPU	Central Processing Unit
CR	Card Reader
CR1	Cash Register 2510
CR2	Cash Register 252
CRT	Cathode Ray Tube
CSC	Contactless Smart Card
CVC	Customer Service Centre
IND	Indicator
ING	Entry Gate (CGA)
IRG	Reversible Gate (CGA)
IXG	Exit Gate (CGA)
JB	Junction Box
KDU	Keyboard Display Unit
LA100	Printer LA100
LA120	Printer LA120
LA210	Printer LA210
LA34	Printer LA34
LA38	Printer LA38
LC	Line Conditioner
LX800	Epson Printer LX800
MC	Magazine Cart
M-G	Motor - Generator
MBR	Mobile Radio
MCOR	Motorised Code Reader
MCP	Master Control Panel
MDP	Main Distribution Frame
MIC	Microphone
MIX	Mixer Panel
MOD	Modem
MP	Mimic Panel

EXI	Exit Gate
FA	Fire Alarm
FCP	Fire Control Panel
FIP	Fire Indicator Panel
FSO	Fused Spur Outlet
FSV	File Server
FTP	Fibre Termination Panel
FWS	Free Wheel Switch
FX100	Printer Model FX100
GEN	Generator
GMP	Gate Monitor Panel
HD	Hard Disk, CEU
IAD	Anal/dispenser (CGA)
IC	Intercommunicator
ICR	Cash Register RS12
IDF	Intermediate Distribution Frame
II	Intelligent, Interface
PDP53	PDP 11/53
PDU	Power Distribution Unit
PGR	Pager
PHM	Photo Max
PLC	Programmable Logical Control
PNL	Panel
PTT	Press to Talk
PXS	Proximity Sensor
RG	Reversible Gate
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SAS	Station Accounting System
SBD	Switchboard
SCP	Security Control Panel
SCT	Station Cash Trolley
SEC	Security Cables (CCTV & Access Control)
SEM	Smoke Exhaust Motor
SIP	Sub Indicator Panel
SPK	Speaker
SSB	Sub Switchboard
SW	Switch
SVT	Store Value Ticket Issue Machine
TCK	Ticket Checker

MSB	Main Switchboard
MTR	Motor
NG	Entry Gate
PB	Push Button
PC	Person Computer
PCOR	Portable Code Reader
PDP23	PDP 11/23

TCM	Ticket Counting Machine
TCM	Ticket Checker Monitor Panel
TCVT	Trolley Cash Vault Transporter
TEL	Telephone
TEM	Ticket Encoding Machine
TEMBK	TCK Encode MC Backup
TESTR	Workshop Tester

Civil Site Plans/Surveys

BH	Bore Hole
BS	Boundary Stone
CIP	Construction in Progress
CL	Cover Level
COL	Column
CONC	Concrete
CS	Concrete Stand
CUL	Culvert
DW	Drainage Works
E	Electrical Pole
EB	Electric Box
FB	Footbridge
FP	Footpath
IC	Inspection cover
IL	Invert Level
L	Lamp Post
MH	Manhole
WT	Water Tank Concrete Reinforcing Bars Building Plans/Sections/Elevations
&	And
@	At
#	Number
1F	First Floor
2F	Second Floor
A. B.	Anchor Bolt
AASHTO	American Association of State Highway and Transportation
ABUT	Abutment
ACOUS	Acoustical
AC	Asphalt Concrete
AC	Air Conditioning

A/C	Air Conditioning
ACI	American Concrete Institute
ACC	Access
A/D	Air Duct
AFA	Automatic Fire Alarm
AFFL	Above Finished Floor Level
A/G	At Ground
AG	Above Ground
AGG	Aggregate
AISC	American Institute of Steel Construction
AHU	Air Handling Unit
ALT	Alternate
ALUM	Aluminium
ANG	Angle
ANCR	Anchor
A/P	Access Panel
APPVD	Approved
APPROX	Approximately
APS	Additional Principal Station
ARCH	Architectural
ASPH	Asphalt
ASTM	American Society for Testing and Materials
AT	Ash Tray
AUTO	Automatic
AVG	Average
AWS	American Welding Society
AZ	Azimuth
B	Bench
B	BARD

B2	Second Basement
BC	Beginning of Simple Circular Curve
BCF	Bromo-Chloro- Fluoro
BET	Between
BIT	Bitumen
BK	Brick
BKWK	Brickwork
BLDG	Building
BLKG	Blocking
BLWK	Blockwork
BM	Beam
BM	Bench Mark
BMS	Building Management System
BOT	Bottom
BOX	Box Culvert
BR	Brass
BRG	Bearing
BRK	Brick
BS	British Standard
BSMT	Basement
BVC	Beginning of Vertical Curve
BW	Both Ways
C&C	Cut and Cover
C&S	Civil and Structural
CAB	Cabinet
CB	Catch Basin
C. C.	Column Centre
C/C	Centre to Centre
CC	Point of Curve to Curve (Compound Point)
CCTV	Closed Circuit TV
CRG	Corrugated
CSD	Combined Services Drawings
CSK	Countersink/Countersunk
C/S	Cement Sand
CS	Point of Curve to Spiral
CT	Point of Curve to Tangent
CW	Cold Water
CW	Curtain Wall
D	Depth

B1	First Basement
C/D	Cable Duct
CE	Civil Engineering
CEM	Cement
CF	Point of Contra-Flexure
CG	Clear Glass
CGS	Centre of Gravity of Prestressing Tendons
CH	Chainage
CiPC	Cast in Place Concrete
CI	Cast Iron
CIP	Cast Iron Pipe
CJ	Control Joint
CKD	Checked
CL	Centre Line
CL	Cover Level
CL	Clearance
CLL	Clearance Line
CLG	Ceiling
CLR	Clear
cm	Centimetre
CMU	Concrete Masonry Unit
CO2	Carbon Dioxide
COL	Column
CONC	Concrete
CONST	Construction
CONST JT	Construction Joint
CONT	Continuous
CONTRJT	Contraction Joint
CORR	Corridor
CP	Chrome Plated
CP	Convergence Plug
EC	End of Simple Circular Curve
ECS	Environmental Control System
ED	Electrical Duct
EF	Each Face
EGL	Existing Ground Level
EJ	Expansion Joint
EL	Elevation (Height)
ELEC	Electrical

D	Disabled
DBL	Double
DET	Detail
DF	Drinking Fountain
DG	Double Glazed
DGL	Designed Ground Level
DIA	Diameter
DIM	Dimension
DL	Dead Load
DN	Down
DO	Door Opening
DP	Drain Pipe
DR	Door
DWG	Drawing
DWGS	Drawings
DWL	Dowel
E	Escalator
E	East
E&M	Electrical and Mechanical
EA	Exhaust Air
EA	Each
F	Fixed
FA	Fire Alarm
FAI	Fresh Air Inlet
F/A	From Above
FB	Fire Blanket
F/B	From Below
Fc	Allowable Compressive Strength of Concrete
FCP	Fire Control Panel
FD	Floor Drain
FDN	Foundation
FE	Fire Extinguisher
FF	Far Face
FFL	Finished Floor Level
FGL	Finished Ground Level
FH	Fire Hydrant
FHR	Fire Hose Reel
FIG	Figure
FIN	Finish Level
FHC	Fire Hydrant Cabinet

ELEV	Elevation (View)
EMB.PL	Embedded Plate
EMER	Emergency
ENT	Entrance
EOP	End of Platform
EP	Earth Pressure Cell
EQ	Equal
EQ	Equivalent
ES	Each Side
ESCA	Escalator
ETP	Existing Top of Pavement
EVC	End of Vertical Curve
EW	Each Way
EX	Existing
EXC	Excavate
EXEC	Executive
EXH	Exhaust
EXT	External
EXT	Exterior
EXTN	Extension
EXP	Expansion
F	Female
GALV	Galvanized
GD BRG	Guided Expansion Bearing
GEN	General
GI	Galvanised Iron
GL	Glass
GL	Ground Level
GMS	Galvanized Mild Steel
GRC	Glass fibre Reinforced Concrete
GRD	Ground
GT	Gully Trap
GYP	Gypsum
H	High
H.S.B	High Strength Bolt
H.T.S	High Tensile Strand
H.T.W	High Tensile Wire
HB	Hinged Bollard
HC	Heel of Crossing
HD	Heavy Duty

FL	Floor Level
FL	Floor Elevation
FLUOR	Fluorescent
FLR	Floor
FRP	Fire Resistant Period
FS	Fire Service
FSI	Fire Service Inlet
FTG	Footing
FURN	Furnishings
G	Gully
G	Ground
HW	High Windows
HW	Hot Water
HW	Water Depth
HWD	Hardwood
HWSC	Hardwood Solid Core
HYP	Hydraulic Piezometer
ID	Inside Diameter
IE	Invert Elevation
IF	Inside Face
IL	Invert Level
INC	Including
INFO	Information
INSUL	Insulation
INT	Internal
INV	Invert
IP	Intersection Point
IPI	In Place Inclinometer
IRJ	Insulate Rail Joint
ISD	IndividualServices Drawings
JAN	Janitor
JT	Joint
Kpa	Kilopascal
L	Length
L	Litre
LAM	Laminate
LAV	Lavatory
LB	Litter Bin
LCC	Length of Circular Curve
LCX	Leaky Coaxial Cable
LEV	Level

HDWR	Hardware
HIP	Horizontal Intersection Point
HL	Horizontal Line
HLF	Hair Line Finish
HORI	Horizontal
HP	High Point
HR	Hose Reel
HR	Hour
HRS	Hours
HT	Height
HTR	Heater
HVAC	Heating, Ventilation, air-conditioning
LL	Live Load
LoC	Load Cell
LONG	Longitudinal
LP	Low Point
LP	Light Panel
LR	Local Road
LS	Length of Spiral
LT	Left
L/U	Loading/Unloading
LVR	Louvre
LV	Low Voltage
LVC	Length of Vertical Curve
M	Male
M	Metre
M2	Square Metre
M3	Cubic Metre
MAC	Macadam
MAX	Maximum
MD	Mechanical Duct
MDF	Main Distribution Frame
MECH	Mechanical
MEZZ	Mezzanine
MF	Mirror Finish
MFR	Manufacturer
MH	Man Hole
MIN	Minimum
MISC	Miscellaneous
ML	Match Line
mm	Millimetre

LH	Left Hand
MS	Mild Steel
MS	Mechanic Shaft
MTL	Metal
MVC	Middle of Vertical Curve
N	North or Newton
NF	Near Face
NGD BRG	Non-Guided Expansion Bearing
NIC	Not in Contract
No	Number
NOM	Nominal
NOS	Numbers
NTS	Not to Scale
OA	Outdoor Air
OC	On Centre
OD	Outside Diameter
OF	Out Side Face
O/H	Overhead
OL	Outlet Level
OPNG	Opening
OPP	Opposite
OW	Observation Well
P	Potable
PA	Public Address
PABX	Private Auto Branch Extension
PB	Panic Bolt
PC	Prestressed Concrete
PCC	Precast Concrete
PCE	Plain Concrete
P. C. O.	Pile Cut Off
PD	Principal Datum
RCP	Repeater Control Panel
RCW	Reinforced Concrete Wall
RD	Road
RD	Roof Drain
RECT	Rectangular
REF	Reference
REINF	Reinforced
REQ	Required
RET	Return

MO	Material Opening
PED BRG	Pedestrian Bridge
PED U/P	Pedestrian Underpass
PERP	Perpendicular
PF	Platform
PG	Pressure Gauge
PIDS	Passenger Information Display System
PI	Point of Intersection
PT	Point
PTN	Partition
PL	Passenger Lift
PLAT	Platform
PLC	Permanent Lining Concrete
PLYWD	Plywood
PREP	Preparation
PS	Principal Station
PSC	Prestressed Concrete
PSI	Pounds Per Square Inch
PTF	Poly-tetrafluoroethylene
PROJ	Projection
PVC	Polyvinyl- Chloride
PVI	Point of Vertical Intersection
QT	Quarry Tile
R	Radius
RTA	Roads and Transport Authority
R	Riser (Stairs)
RAD	Radius
RAL	Rail Level
RB	Removable Ballard
RB	Rock Bolt
RC	Reinforced Concrete
SECT	Section
SEM	Structural, Electrical and Mechanical Drawings
SERV	Service
SFL	Structural Floor Level
SG	Surrounding Ground
SHC	Shotcrete
SHT	Sheet
SIM	Similar
SM	Square Metre

REJ	Rail Expansion Joint
REV	Revision
RF	Roof
RG	Reinforcing Bar Strain Gauge
RHS	Rectangular Hollow Section
RL	Reference Line
RM	Room
ROW	Right-of-Way
RR	Roller
RSJ	Rolled Steel Joist
RT	Right
RW	Retaining Wall
RWDP	Rain Water Down Pipe
RWO	Rain Water Outlet
RWP	Rain Water Pipe
S	Scale; Slope South
S&G	Signage and Graphics
SC	Self-Closing
SC	Point of Spiral to Curve
SCH	Schedule
SCR	Screwed
STOR	Storage
STR	Straight
STR	Stairs
STRUC	Structural
STT	Strain Transducer
SUSP	Suspended
SVP	Soil Vent Pipe
SW	Switch
SWD	Soft Wood
SYMM	Symmetrical
SYS	System
T	Tread
T	Top
T&B	Top and Bottom
T/A	To Above
T/B	To Below
TC	Point of Tangent to Curve
TEL	Telephone
TEMP	Temporary
THK	Thick

SM	Settlement Maker
SOP	Setting Out Point
SL	Sump Level
SL	Smoke Lobby
SP	Spiral
SPEC	Specification
SPK	Speaker
SQ	Square
SR	Settlement Rod
SRC	StructureReinforced Concrete
SRC	Steel Reinforced Concrete
SRJ	Stock Rail Joint
SS	Stainless Steel
SS	Point of Spiral to Spiral
ST	Street
ST	Stair
ST	Silt Trap
STA	Station
STD	Standard
STIR	Stirrup
STL	Steel
TYP	Typical
UB	Universal Beam
UC	Universal Column
UCI	Uniform Construction Index
UD	Under Drain
UFA	Usable Floor Area
U/G	Underground
UNO	Unless Noted Otherwise
UP	Up (Stairs)
UPS	Uninterrupted Power Supply
UPVC	Unplasticised PVC
UR	Urinal
US	Unapparent Section
U/S	Underside
UT	Utilities
UTIL	Utility
VAR	Variable
VB	Vapour Barrier
VEH BRG	Vehicular Bridge
VEH U/P	Vehicular Underpass

TI	Tiltmeter
TOC	Top of Concrete
TOG	Top of Grout
TOPO	Topography
TS	Point of Tangent to Spiral
TT	Point of Tangent to Tangent
T/W	Top of Wall
TV	Television
TVM	Ticket Vending Machine
TX	Transformer

VENT	Ventilation
VER	Vertical
VG	Vibrating Wire Strain Gauge
VOL	Volume
VP	Vent Pipe
VR	Vibrating Rod
VS	Vent Stack
W	Width; Water; West
W	Wide

Appendix –E:Civil & Structural Codes

IRC CODES (WITH LATEST VERSIONS)	
IRC: 5	Standard Specification & Code of Practice for Road Bridges – General Features of Designs
IRC: 6	Standard Specification & Code of Practice for Road Bridges – Loads and Stresses
IRC: 22	Standard Specification & Code of Practice for Road Bridges, Section VI – Composite Construction of Road Bridges
IRC: 24	Standard Specification & Code of Practice for Road Bridges, Section V – Steel Road Bridges
IRC: 112	Code of Practice for Concrete Bridges
IRC: 78	Standard Specification & Code of Practice for Road Bridges-Section Foundations and Sub-structure
IRC: 83(I)	Standard Specification & Code of Practice for Road Bridges, Part I Metallic Bearings
IRC: 83(II)	Standard Specification & Code of Practice for Road Bridges, Part II Elastomeric Bearings
IRC: 83(III)	Standard Specification & Code of Practice for Road Bridges, Part III Pot, Pot-cum-PTEF, Pin and Metallic Guide Bearings
MoRTH	Specifications for Road and Bridge Works

IS CODES (with latest versions)	
IS: 269	Specifications for Ordinary and Low Heat Portland cement
IS: 383	Specifications for coarse and fine aggregate from natural sources for Concrete
IS: 432	Specifications for Mild steel & medium tensile steel–bars (Part 1)
IS: 456	Plain and Reinforced Concrete – Code of Practice
IS: 800	Code of Practice for General construction in Steel
IS: 875	Code of Practice for Design Loads Parts 1,2,3,4 & 5 (Other than Earthquake) for Building and structures
IS: 1080	Design and Construction of shallow foundations in soils (Other than Raft, Ring & Shell)

IS: 1343	Code of Practice for Pre-stressed Concrete – based essentially on CP-110
IS: 1364	Hexagon Head Bolts, screws & nuts of product grades A & B Part-1 (Part 1 Hexagon Head Bolts (size range M1:6 to M64)
IS: 13920	Ductile Detailing of Reinforced concrete structures subjected to Seismic structures code of practice
IS: 1489	Specifications for Portland Pozzolana Cement (Fly ash based)
IS: 1786	High Strength Deformed steel bars and wires for concrete reinforcement
IS: 1893	Criteria for Earthquake Resistant Design of structures
IS: 1904	Design and Construction of Foundation in soils General Requirements
IS: 2062	Specifications for Weldable structure steel
IS: 2502	Codes of Practice Bending and Fixing of Bars for Concrete Reinforcement
IS: 2911 (Part-1)	Code of Practice for Design and Construction of Pile Foundations Part-1 Concrete Piles Section 2 Bored Cast-in-situ Piles (with amendments)
IS: 2911	Code of Practice for Design & Construction of Pile Foundation Part 4 Load test on piles
IS: 2950	Design and Construction of Raft Foundations
IS: 3935	Code of Practice for Composite Construction
IS: 4326	Code of Practice for Earthquake Resistant Design and construction of Buildings
IS: 4923	Hollow steel sections for structural use – specification
IS: 8009	Calculation of settlement of shallow foundations
IS: 9103	Concrete Admixtures - Specifications
IS: 11384	Code of Practice for Composite Construction in Structural Steel and Concrete
IS: 12070	Code of Practice for Design and Construction of Shallow Foundations on Rocks
IS: 14268	Uncoated stress Relieved Low relaxation Seven-ply Strands for pre-Stressed Concrete
IS: 14593	Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks

EURO CODES (with latest versions)	
EN 1990	Euro code: Basis of Structural Design
EN 1991	Euro code 1: Actions on structures
EN 1992	Euro code 2: Design of concrete structures
EN 1993	Euro code 3: Design of steel structures
EN 1994	Euro code 4: Design of composite steel and concrete structures
EN 1995	Euro code 5: Design of timber structures
EN 1996	Euro code 6: Design of masonry structures
EN 1997	Euro code 7: Geotechnical design
EN 1998	Euro code 8: Design of structures for earthquake resistance
EN 1999	Euro code 9: Design of aluminium structures

OTHERS (with latest versions)	
UIC-774-3R	Track Bridge Interaction
UIC-772-2R	Code for the use of Rubber Bearings for Rail Bridges
CEB-FIP	Model Code 1990 for concrete structures FIP Recommendations for the Acceptance of Post tensioning Systems
NFPA	Relevant Codes
	Technical Papers

Appendix – F: MEP Codes
Main Panels & Switch boards

Standard / Code No	Title
IS 13947: Part 1 - 1993	Specification for Low-voltage Switchgear and Control gear - Part 1: General Rules
IS 13947: Part 2 - 1993	Specification for Low-voltage Switchgear and Control gear - Part 2: Circuit Breakers
IS 13947: Part 3 - 1993	Specification for Low-voltage Switchgear and Control gear - Part 3: Switches, Dis-connectors, Switch Dis-connectors and Fuse Combination Units
IS 13947: Part 4 - Sec 1 - 1993	Specification for Low-Voltage Switchgear and Control gear - Part 4: Contractors and Motor-Starters - Section 1: Electromechanical Contactors and Motor Starters
IS 13947: Part 5 - Sec 1 - 2004	Low-Voltage Switchgear and Control gear - Specification - Part 5: Control Circuit Devices and Switching Elements - Section 1: Electromechanical Control Circuit Devices
IS 13947: Part 5 - Sec 2 - 2004	Low-Voltage Switchgear and Control gear - Specification - Part 5: Control Circuit Devices and Switching Elements - Section 2: Proximity Switches
IS: 3231 - 1986	Specification for Electrical Relays for Power System Protection
IS: 11353 - 1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS: 10118 (Parts 1 to 4) 1982	Code of practice for selection, installation and maintenance of switchgear
IS: 3043 – 1987	Code of Practice for earthing
IEEE Standard 80-2000	IEEE Guide for Safety in AC Substation Grounding
IS: 732 – 1989	Code of Practice for Electrical Wiring Installations
IS: 5578 – 1984	Guide for marking of insulated conductors
IS: 5216 Part I & II 1982	Recommendation on Safety Procedures and Practices in Electrical Work
SP: 30: 1985	National Electrical code
IS: 1646 – 1997	Code of practice for fire safety of buildings (general): Electrical installation
IS: 2075 – 2000	Ready Mixed Paint, Stoving, Red Oxide Zinc Chrome, Priming – Specification

IS: 1248 (All Parts) 2003	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories Specification
IS: 3618 – 1966	Specification for Phosphate Treatment of Iron and Steel for Protection Against Corrosion
IS: 6005 – 1998	Code of practice for phosphating of iron and steel
IS: 5 - 2004	Colours for Ready Mixed Paints and Enamels
IEC 61439-1	Specification for Low-Voltage Switchgear and Control-gear Assemblies - Part 1 &2: Requirements for Type-Tested Assemblies.
IEC 61439-2	Specification for Low-voltage Switchgear and Control gear Assemblies - Part 2: Particular Requirements for Bus bar Trunking Systems (Bus-way)
IS: 8828 – 1996	Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations.
IEC-61643, 62305, 60364	Lightning & Surge Protection
IEC-60947.7-14	Low Voltage Switchgear and Control-gear Terminal Blocks for copper conductors.
IEC 61641 V2	Internal arc test – Version V2

Final Distribution Boards/Lighting Distribution Boards

Standard / Code No	Title
IS: 8828 – 1996	Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations
IS 8623: Part 1 - 1993	Specification for Low-Voltage Switchgear and Control gear Assemblies - Part 1: Requirements for Type-Tested and Partially Type-Tested Assemblies
IS 8623: Part 2 - 1993	Specification for Low-voltage Switchgear and Control gear Assemblies - Part 2: Particular Requirements for Bus bar Trunking Systems (Bus way)
IEC-60947: Part 1 - 1993	Specification for Low-voltage Switchgear and Control gear - Part 1: General Rules
IEC-60947: Part 2 - 1993	Specification for Low-voltage Switchgear and Control gear - Part 2: Circuit Breakers
IEC-60947: Part 3 - 1993	Specification for Low-voltage Switchgear and Control gear - Part 3: Switches, Disconnections, Switch Disconnections and Fuse Combination Units
IEC-60947: Part 4 - Sec 1 - 1993	Specification for Low-Voltage Switchgear and Control gear - Part 4: Contractors and Motor-Starters - Section 1: Electromechanical Contactors and Motor Starters
IEC-60947: Part 5: Sec 1: 2004	Low-Voltage Switchgear and Control gear - Specification - Part 5: Control Circuit Devices and Switching Elements - Section 1: Electromechanical Control Circuit Devices
IEC-60947: Part 5: Sec 2: 2004	Low-Voltage Switchgear and Control gear - Specification - Part 5: Control Circuit Devices and Switching Elements - Section 2: Proximity Switches

SP: 30: 2011	National Electrical code
IEC 61439,60439-1	Low-voltage switchgear and control gear assemblies for Type-tested and partially type-tested assemblies
IEC 60439-2	Low-voltage switchgear and control gear assemblies- Particular requirement for busbar trunking system (Bus bay)
IEC-60947: Part 1: 1993	Specification for Low-voltage Switchgear and Control gear - Part 1: General Rules
IS: 13947	Specification for Low-voltage Switchgear and Control gear
IS: 10118 – 1982	Code of Practice for Selection, Installation and Maintenance of Switchgear and Control gear
IS: 2675 - 1983	Enclosed distribution fuse boards and cut-outs for voltages not exceeding 1000 V AC and 1200 V DC
IS: 5578 – 1984	Guide for marking of insulated conductors
IS: 11353 – 1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
IS: 9926 – 1981	Fuse wires used in rewire able type electric fuses up to 650 volts Lightning and Surge Arrestors.
IEC-61643, 62306, 60364	

Conduit and Wiring

Standard / Code No	Title
IS: 1554 Part-1 - 1988 (Amendment no. 1 of 1994)	PVC insulated (heavy duty) electric cables: Part 1 For working voltages up to and including 1100 V
IS: 694 - 2010	PVC Insulated unsheathed and sheathed cables/cords with rigid and flexible conductor for rated voltage for working voltages up to and including 450/750 Volts – specification
IS 9537: Part 1 - 1980	Conduits for electrical installations: Part 1 General requirements
IS 9537: Part 2 - 1981	Conduits for electrical installations: Part 2 Rigid steel conduits
IS 9537: Part 3 - 1983	Conduits for electrical installations: Part 3 Rigid plain conduits of insulating materials
IS 9537: Part 4 - 1983	Specification for Conduits for Electrical Installations - Part 4: Pliable Self-recovering Conduits of Insulating Materials
IS 9537: Part 5 - 2000	Conduits for Electrical Installations - Part 5: Pliable Conduits of Insulating Material
IS 9537: Part 6 - 2000	Conduits for Electrical Installations - Specification - Part 6: Pliable Conduits of Metal or Composite Materials
IS 9537: Part 8 - 2003	Conduits for Electrical Installations - Specification - Part 8: Rigid Non-Thread able Conduits of Aluminium Alloy
IS 3837 - 1976	Accessories for rigid steel conduits for electrical wiring
IS 3480 - 1966	Flexible steel conduits for electrical wiring
IS 3854 - 1997	Switches for domestic and similar purposes

IS 1644 - 1988	Code of practice for fire safety of buildings (general): Exit requirements and personal hazard
IS 1646 - 1997	Code of practice for fire safety of buildings (general): Electrical installations
IS 732 - 1989	Code of practice for electrical wiring installations
IS1387-1993	General requirements for the supply of metallurgical materials
IS800-1984	Code of practice for general construction in steel
IS5-2004	Colours for Ready Mixed Paints and Enamels
IS2551-1982	Danger notice plates
IS5578-1984	Guide for marking of insulated conductor
IS2675-1983	Enclosed distribution fuse boards and cut-outs for voltages not exceeding 1000 V AC and 1200 V DC
IS2667-1988	Fittings for rigid steel conduits for electrical wiring
IS1255- 1983	Code of practice for installation and maintenance of power cables up to and including 33 kV rating
IS3961	Recommended current ratings for cables
	Indian Electricity Act 2003 and IE Rules 1956 as amended from time to time
	Regulations for the electrical equipment in buildings issued by the Tariff Advisory Committee of the Insurance Association of India
IS 7098	Current Ratings for Cable - XLPE insulated Heavy duty cables

Indoor and Outdoor Lighting, Fans and Plug Sockets

Standard / Code No	Title
IS - 3646 (All 3 parts)	Code of practice for interior Illumination
IS - 1913.	Electric light fittings General and safety requirements
IS - 1777	Industrial lighting fittings with metal reflectors
IS - 5077	Decorative lighting outposts
IS - 1947	Flood Lights / Metal Halide lamps
IS – 2149	Luminaries for street lighting
LM-79	Performing measurement of LEDs
IS - 1258	Bayonet lamp holders
IS - 3323	Bi-pin lamp holders for tubular fluorescent lamps
IS - 1534	Ballasts for use in fluorescent light fittings
IS - 2215	Starters for fluorescent lamp
IS - 6616	Ballast for HP MV lamps
IS – 2215	Capacitors for use in fluorescent, High pressure mercury vapour & sodium vapour lamps circuits
IS - 2418 (Part I)	Tubular Fluorescent lamps/Compact Fluorescent Lamps (CFL)
IS - 2183	High pressure mercury vapour lamps
IS - 9974 (Part -I)	High pressure sodium vapour lamps

IS: 374	Ceiling Fans
IS: 2312	Exhaust Fan

Generators

Type	Standard / Code No	Title
Diesel Engines	BS: 5514	Reciprocating internal combustion engines – Performance
	BS 4552	Fuel filters, strainers and sedimentary for compression-ignition engines
	IS: 10000	Method of tests for internal combustion engines
	IS: 1460 – 2005	Automotive Diesel Fuels – Specification
	IS 3169: 1991	Internal Combustion Engines – Two Stage, One Litre, Diesel Fuel Filters
	IS 3351: 1991	Internal Combustion engines – Diesel fuel filters Methods of Tests
Alternator	BS: 2613	The Electrical Performance of Rotating Electrical Machinery
	IS: 13364 Part-II 1992	Specification for ac generators driven by reciprocating internal combustion engine: Part 2 – Rated above 20 KVA and up to 1250 KVA
	BS: 5000	Specification for rotating electrical machines of particular types or for particular applications
	BS: 4999	General requirements for rotating electrical machines
	IS: 4722 – 2001	Rotating Electrical Machines – Specification
	IS 6362: 1995	Designation of Methods of Cooling of Rotating Electrical Machines
Sound Insulation	IS: 8183 – 1993	Bonded mineral wool

Earthing System

Standard / Code No	Title
IS:3043 - 1987	Code of Practice for earthing
IEEE 80: 2000	Guide for Safety in AC Substation Grounding

Fire Protection System

The station design shall comply with NFPA 130-Latest edition (Standard for Fixed Guide way Transit and Passenger Rail system). In addition to that, the following specifications, IS standards and codes of practice shall be applicable for design of this Fire Protection System.

All equipment, supply, erection, testing and Commissioning shall comply with the latest requirements of relevant Indian standards and codes of practice. The Tariff advisory committee's regulation (fire insurance), electrical inspectorate and Indian Electricity rules and other Codes and Publications shall be applicable.

TAC	Tariff Advisory Committee fire protection manual
NFPA	Standards for Fire Protection System

Standards for Fire Protection System

Standard / Code No	Title
IS: 884	Specification for first aid hose reel for firefighting.
IS: 901	Specification for couplings, double male and double female, instantaneous pattern for firefighting.
IS: 902	Suction hose couplings of firefighting purposes.
IS: 903	Specification for fire hose delivery couplings, branch pipe, nozzles and nozzle spanner.
IS: 904	Specification for 2-way and 3-way suction collecting heads for firefighting purposes.
IS: 907	Specification for suction strainers, cylindrical type for firefighting purposes.
IS: 908	Specification for fire hydrant stand post type.
IS: 909	Specification for underground fire hydrant sluice valve type.
IS: 910	Specification for portable chemical foam fire extinguisher.
IS: 1648	Code of practice for fire safety of building (general): Firefighting equipment and its maintenance.
IS: 2171	Specification for portable fire extinguishers dry powder (cartridge type)
IS: 2878	Specification for fire extinguishers, carbon dioxide type (portable and trolley mounted).
IS: 3844	Code of practice for installation and maintenance of internal fire hydrants and hose reel on premises.
IS: 8423	Specification for controlled percolation type hose for firefighting.
IS: 11460	Code of practice for fire safety of libraries and archives buildings.
IS: 1309	External hydrant systems – Provision and maintenance – Code of practice.
IS: 15683	Specification for Portable fire extinguishers.

Fire Detection and Alarm System

Title	Standard
Fire detection and fire alarm systems for buildings Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises.	NFPA 72 / BS 5839 -1:2013 / IS - 2189: 2008 / NBC 2005
Specification for heat sensitive fire detectors for use in automatic fire alarm system.	BS EN 54-7/ IS 2175: 1988

Specification for smoke detectors for use in automatic electrical Fire alarm system	BS EN 54-7/ IS 11360: 1985
Code of practice of Electrical Wiring Installations (system voltage not exceeding 660 V)	IS 732: 1989

HVAC System

Standard / Code No	Title
IS 7896	Data for Outside design conditions for air conditioning for summer months.
IS 5111	Testing of refrigerant compressors.
IS 659	Safety code for air conditioning
IS 660	Safety code for Mechanical refrigeration.
IS 3016	Code of practice for Fire precautions in welding and cutting operations.
IS 818	Code of practice for safety and health requirements in Electrical, Gas welding and Cutting operations.
IS 5216	Code for safety procedure and practice in electrical works.

Building Automation System

Standard / Code No	Title
IEC 445	Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system
IEC 571-1	General requirements and tests for electronic equipment's
IEC 571-3	Components, programmable electronic equipment's and electronic system reliability
IEC 870-5-4	Definition and coding of application information elements- Transmission protocols
IEC 1082-1	Preparation of document (Signals, Diagrams)
ISO/IEC 4873	Information technology ISO 8-bit code for information interchange-Structure and rules for implementation
IEC 60848	Preparation of function charts for control systems
IEC 61175	Designations for signals and connections
IEC 61346 (All parts)	Industrial system installation, equipment's and industrial products-Structuring principles and reference designations
IEC 61850-Part 2	Glossary
IEC 61850-Part 3	General requirements
IEC 61850- Part 4	Communication networks and systems in substations- System and Project management
IEC 61850- Part6	Substation automation system configuration description language
IEC 61850-7-1	Basic communication structure for substation and feeder equipment- Principles and models
IEC 61850-10	Conformance testing
BS 4737: Part 2	Specification for installed systems for deliberate operation

BS4737: Section 4.1	Code of practice for planning and installation
BS 4737: Section 4.2	Code of practice for maintenance and records
BS EN 14908-1:2005	Open data communication in building automation, controls and building management, building network protocol, protocol stack.
BS EN 50090-2-1	Home and building electronic systems-System overview, Architecture
BS EN 50090-2-2	Home and building electronic systems-System overview, General technical requirements
BS ISO/IEC 6592	Information technology. Guidelines for the documentation of computer-based application systems
BS 5839-1:2002 68 Pages	Code of practice for system design, installation, commissioning and maintenance for fire detection and alarm systems for buildings
BS EN 54-2 30 Pages	Specification for control and indicating equipment
BS 6266 38 Pages	Code of practice for fire protection for electronic data processing installations
BS EN ISO 9000-3	Development, supply, installation and maintenance of computer software
IS: 1765	Direct current potentiometers
IS: 3043	Code of practice for Earthing
IS: 4007 Part1	Terminals for electronic equipment- General requirements
IS: 5051 Part 1	Relays for electronic and telecommunication equipment- General requirements
IEEE 802 series	Local area network
ISO 3511	Process measurement control functions and instrumentation-Symbolic Representation-Part 1 Basic requirements
IEC-60947-1	Low voltage switchgear and control gear part 7.1
IEC-61643,62305, 60364	Lightning and Surge Protection.

PHE Services

IS: 2556(Part-I to III)	Vitreous Chinaware
IS: 1703	Ball Valve
IS: 2548	Toilet Seat Cover
IS: 775	Cistern Brackets
IS: 1726	San Cast Iron Pipes and Fittings
IS: 3989	Spun Cast Iron Pipes and Fittings
IS: 1239, IS: 3589	GI Pipes
IS: 4736	Galvanizing for GI Pipes
IS: 554	Pipe Threads
IS: 1879	Milleable Iron Fittings
IS: 780	Cast Iron Sluice Valves
IS: 778	Full Way Valves
IS: 2692	Brass Ferrule
IS: 651	Stone Ware Gully Trap

IS: 458	RCC Pipes
IS: 1536	Cast Iron Class LA Pipes
IS: 1538	Cast Spun Iron Fittings
IS: 782	Pig Leg
IS: 4691	Induction Motors
IS: 1200	Code for Measurement
IS: 4984	UPVC Pipes and Fittings
IS: 782	Specifications for Caulking Lead
IS: 783	Code of Practice for Laying of Concrete
IS: 15450	Composite Pipe & Fittings
BS 2871,BS 864	Copper Pipes and Fittings
ASTM	CPVC,PVC Pipes Fittings
IS: 10500	Drinking Water