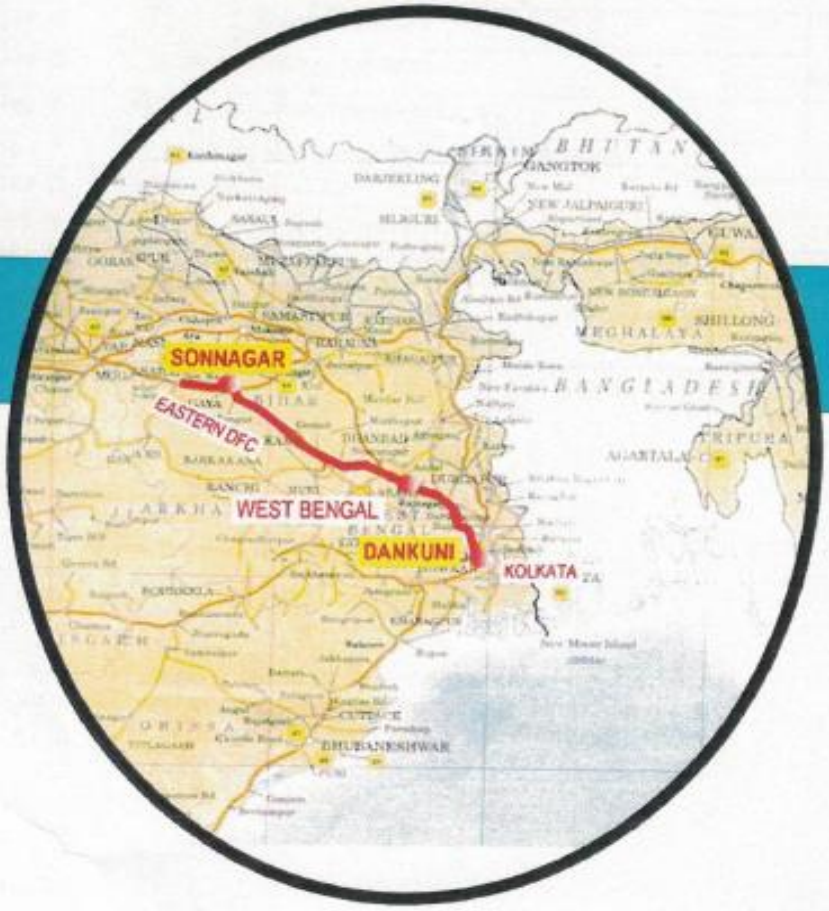
Dedicated Freight Corridor Corporation of India Limited (DFCCIL)

A Government of India (Ministry of Railways) Enterprise 5th Floor, Pragati Maidan Metro Station Building Complex, New Delhi – 110001

(VERSION 7.0)

MANUAL OF SPECIFICATION & STANDARDS

FOR DEDICATED FREIGHT CORRIDOR
BETWEEN DANKUNI - SONNAGAR (540 KMS)
THROUGH PPP MODE



(FEBRUARY 2015)

RITES
THE INFRASTRUCTURE PEOPLE

RITES LIMITED
RITES BUILDING, PLOT NO. 1, SECTOR 29,
GURGAON - 122001

Abbreviations

Abbreviation	Full Name
AAA	Authentication Authorization & Accounting
AAR	Association of American Railroad
AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current
ACL	Access Control List
ACTM	AC Traction Manual
AIS	Association for Information System
AIS	Air Insulated Switchgear
ALARP	As Low as Reasonably Practicable
ANSI	American National Standards Institute
AREMA	American Railway Engineering and Maintenance-of-way Association
ASCE	American Society of Civil Engineers
ASI	Archaeological Survey of India
ASM	Assistant Station Master
ASS	Auxiliary Sub-Station
AT	Auto Transformer
ATD	Auto Tensioning Device
ASTM	American Society for Testing and Materials
BEE	Bureau of Energy Efficiency
BGP	Border Gateway Protocol
BIS	Bureau of Indian Standards
BMS	Building Management Systems
BS	British Standards
BSC	Base Station Controller
BSS	Base station Sub System
BTS	Base Transceiver Station
CA	Concession Agreement

CAMEL	Customised Application for Mobile Enhance Logic
CB	Circuit Breaker
CEB/FIP	Comite Euro – Internationale du Beton(Euro-International Concrete Committee) – and Federation Internationale de la Pre-contrainte (International Federation of Pre–stressed Concrete)
CBIP	Central Board of Irrigation and Power
CEA	Central Electricity Authority
CEN	European Committee for Standardization
CENELEC	European Committee for Electro technical Standardization
CFM	Connectivity Fault Management
CIRIA	Construction Industry Research and Information Association
COD	Commercial Operation Date
CORE	Central Organization for Railway Electrification
CPCB	Central Pollution Control Board
CPWD	Central Public Works Department
CT	Current Transformer
CWR	Continuously Welded Rail
DAC	Digital Axle Counter
DB	Distribution Board
DBT	Dry Bulb Temperature
DC	Direct Current
DFC	Dedicated Freight Corridor
DFCCIL	Dedicated Freight Corridor Corporation of India Limited
DG	Diesel Generator
DHCP	Dynamic Host Configuration Protocol
DID	Direct Inward Dialing
DISCOM	Distribution Company
DLP	Digital Light Processing
DLT	Direct Line Telephone
DTMF	Dual Tone Multi Frequency
DVRS	Digital Voice Recording System

E&M	Electrical and Mechanical
ECBC	Energy Conservation Building Code
EDFC	Eastern Dedicated Freight Corridor
EFM	Ethernet in the First Mile
EHV	Extra High Voltage
EHT	Extra High Tension
EI	Electronic Interlocking
EIA	Environment Impact Assessment
EIG	Electrical Inspector of Government
EIRENE	European Integrated Railway Radio Enhanced Network
E-LAN	Ethernet Local Area Network
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EMP	Environmental Management Plan
EN	Euro Norm (European Standard)
EoS	Ethernet Over Synchronous Digital Hierarchy
EPABX	Electronic Private Automatic Branch Exchange
EPL	Ethernet Private Line
ETCS	European Train Control System
ETP	Electrolytic Tough Pitch
ETSI	European Telecommunication Standard Institute
EVPL	Ethernet Virtual Private Line
FAT	Factory Acceptance Tests
FC	Fixed Capacitor
FHWA	Federal Highway Administration (USA)
FOB	Foot Over Bridge
FP	Feeding Post
FRLS	Flame Retardant Low Smoke
FRS	Functional Requirement Specification

FTA	Fault Tree Analysis
GAD	General Arrangement Drawing
GCR	Group Call Register
GI	Galvanized Iron
GIS	Gas Insulated Switchgears
GoI	Government of India
GoS	Grade of Service
GPS	Global Positioning System
GRP	Glass Fibre Reinforced Plaster
GRIHA	Green Rating for Integrated Habitat Assessment
GSMR	Global System for Mobile Communications-Railway
G&SR	General & Subsidiary Rules
GSS	Grid Sub Station
GSSW	Galvanized Steel Standard Wire
GUI	Graphical User Interface
HAZOP	Hazard and Operability Study
HDPE	High Density Poly Ethylene
HLR	Home Location Register
HMI	Human Machine Interface
HSRP	Hot Standby Router Protocol
HT	High Tension
HV	High Voltage (as per Indian Electricity Rules)
HVAC	Heating Ventilation Air Conditioning
IABSE	International Association for Bridge and Structural Engineering
ICAO	International Civil Aviation Organization
IE	Independent Engineer
IEC	International Electro technical Commission
IED	Intelligent Electronic Device
IEEE	Institution of Electrical and Electronic Engineers
IGMP	Internet Group Management Protocol

IHA	Interface Hazard Analysis
IMD	Integrated Maintenance Depot
IMSD	Integrated Maintenance Sub-Depot
IP	Internet Protocol
IP	Ingress Protection
IPR	Intellectual Property Right
IPS	Integrated Power Supply
IR	Indian Railway
IRPWM	Indian Railway Permanent Way Manual
IRS	Indian Railway Standard
IRSEM	Indian Railway Signal Engineering Manual
IRTM	Indian Railway Telecom Manual
IRWM	Indian Railway Works Manual
IS	Indian Standard
IS-IS	Intermediate System – Intermediate System
ISO	International Organization for Standardization
TDD	Total Demand Distortion
ITU-T	International Telecommunications Union–Telecommunication Standardization Sector
JIS	Japanese Industrial Standards
KMPH	Kilometers per hour
KPI	Key Performance Indicator
LAN	Local Area Network
LC	Level Crossing
LDP	Label Distribution Protocol
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design (USA)
LEMP	Lightning Electro Magnetic Pulse
LHS	Limited Height Subway
LT	Low Tension

LV	Low Voltage (as per Indian Electricity Rules)
LWR	Long Welded Rail
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MD	Maximum Demand
MDB	Main Distribution Board
MMD	Maximum Moving Dimensions
MMI	Man-Machine Interface
MMIS	Maintenance Management Information System
MOR	Ministry of Railways
MOSRTH	Ministry of Shipping, Road Transport and Highways
MPLS	Multi Protocol Label Switching
MPPT	Maximum Power Point Tracking
MSDAC	Multi Section Digital Axle Counter
MTBF	Mean Time Between Failures
MTRC	Mobile Train Radio Communication
MTTR	Mean Time To Restore
NBC	National Building Code (of India)
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NMS	Network Management System
NSS	Network Sub System
NTP	Network Time Protocol
OAM	Operation Administration and Management
OAM&P	Operation Administration and Management Protocol
OCC	Operations Control Center
OCS	Overhead Catenary System
OEM	Original Equipment Manufacturer
OFAF	Oil Forced Air Forced
OFC	Optical Fiber Cable

OHE	Over Head Equipment
OHSAS	Occupational Health and Safety Advisory Services
O&M	Operation & Maintenance
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
OPC	Ordinary Portland Cement
OS&H	Occupational Safety & Health
O&SHA	Operating and Support Hazard Analysis
OSPF	Open Shortest Path First
PC	Personal Computer
PCC	Power Control Centre
PCI	Precast/Pre-stressed Concrete Institute
PCU	Power Conditioning Unit
PIJF	Polythene Insulated Jelly Filled
PIM	Protocol Independent Multicast
PLC	Programmable Logic Control
PPC	Portland Pozzolana Cement
PPE	Personal Protective Equipment
PPP	Public Private Partnership
PQMP	Project Quality Management Plan
PSI	Power Supply Installation
PT	Potential Transformer
PTFE	Poly Tetra Fluoro Ethylene
PTT ID	Push to Talk Identification
PV	Photo Voltaic
PVC	Poly Vinyl Chloride
Q	Design Discharge
Q_f	Design discharger for bridge foundations
QAP	Quality Assurance Program
QAS	Quality Assurance System

QoS	Quality of Service
RAM	Reliability, Availability and Maintainability
RAMS	Reliability, Availability, Maintainability and Safety
RCC	Reinforced Cement Concrete
RCC	Remote Control Centre
RDSO	Research Designs and Standards Organization
RF	Radio Frequency
RFO	Rail Fly Over
RFP	Request For Proposal
RFQ	Request For Qualification
ROB	Road Over Bridge
ROW	Right of Way
RSS	Receiving Sub Station
RSVP	Resource Reservation Protocol
RTU	Remote Terminal Unit
RUB	Road Under Bridge
SACFA	Standing Advisory Committee for Frequency Allocation
SAS	Substation Automation System
S&T	Signalling and Telecommunications
SAT	System Acceptance Tests
SC	Station Controller
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SEJ	Switch Expansion Joint
SER	Signalling Equipment Room
SF 6	Sulphur Hexa Flouride
SHE	Safety Health and Environment
SIL	Safety Integrity Level
SINAD	Signal plus Noise plus Distortion (ratio)
SIP	Signal and Interlocking Plan

SLD	Single Line Diagram
SMPS	Switch Mode Power Supply
SNS	Short Neutral Section
SOD	Schedule of Dimensions
SP	Sectioning and Paralleling Post
SPV	Solar Photo Voltaic
SRS	System Requirement Specification
SS	Sub Station
SSDAC	Single Section Digital Axle Counter
SSH	Secure Shell Protocol
SSOD	Standard Schedule of Dimensions
SSP	Sub Sectioning and Paralleling Post
STM	Standard Telecom Mode
SVC	Static VAR Compensator
TCR	Thyristor Controlled Reactor
TER	Telecommunication Equipment Room
TERI	The Energy and Resource Institute
THD	Total Harmonic Distortion
TIA	Telecommunications Industry Association
T-LDP	Targeted Label Distribution Protocol
TMS	Train Management System
TNS	Tetra Neutral Separate
TO	Train Operator
TPC	Traction Power Controller
TRANSCO	Transmission Company
TRC	Track Recording Car
TSC	Thyristor Switched Capacitor
TSS	Traction Sub-station
UIC	UnionInternationale des Chemins de Fer (International Union of Railways)

UPS	Uninterrupted Power Supply
UPQC	Unified Power Quality Correction
UPVC	Unplasticized Poly Vinyl Chloride
UTS	Ultimate Tensile Strength
VAC	Ventilation and Air Conditioning
VAR	Voltage Ampere Reactive
VHF	Very High Frequency
VLR	Visitor Location Register
VMS	Voice Mail System
VPN	Virtual Private Network
VRLA	Valve Regulated Lead Acid Battery
VRRP	Virtual Router Redundancy Protocol
VRS	Voice Recording System
VSWR	Voltage Standing Wave Ratio
WAN	Wide Area Network
WPC	Wireless Planning and Coordination
WRED	Weighted Random Early Detection
XLPE	Cross Linked Poly Ethylene

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Definitions

In this Manual of Specifications and Standards(the "Manual"), the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning herein after respectively assigned to them:

Term	Definition
ALARP	shall mean the principle that no risk can be accepted unless reduced to As Low As Reasonably Practicable;
Alignment	shall mean the horizontal and vertical profile of railway track;
As Built Drawing	Shall means those drawings produced by the Concessionaire and endorsed by it as true records of construction of the Permanent works and which have been agreed by the IE;
Auxiliary Equipment	shall mean auxiliary power supply equipment providing power for air conditioning, user facilities & station equipment;
Auxiliary Power Supply	shall mean supply for lighting and power sub-net work, required by all fixed low voltage electrical installations including electro mechanical installations at Stations;
Availability	shall mean the probability that an equipment or system can perform a required function under given conditions over a given time interval or similar measurement;
Bid documents	shall mean the documents in their entirety comprised in the bid submitted by the {selected bidder/Consortium} in response to the Request for Proposal in accordance with the provisions thereof;
Bi-direction	shall mean the operation of Trains in either direction over the same section of track subject to built in safety systems;
Bogie	shall mean a four wheeled truck used in pairs under the wagon. The Bogie has a central pivot on which the wagon is supported which allows it to guide the wagon into curved tracks;
Buffer Stop	shall mean the structure at the end of a track to prevent wagons from proceeding beyond the end of the railway line;
Building Management System	shall mean a computer-based control system installed in buildings that controls and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems;
Cant, or super elevation	shall mean the amount by which the outer rail is raised over the inner rail on horizontal curves;
Command	shall refer to the facility to perform or modify a function of the System;

"COD" or Commercial Operation Date	shall have the meaning ascribed to the term in the Concession Agreement;
Commissioner of Railway Safety	shall mean the Safety Commissioner appointed by the Government under Applicable Laws to observe all the necessary Tests and to certify that the Rail system is safe for entering into commercial Service;
Concession	shall have the meaning ascribed to the term in the Concession Agreement;
Concession Agreement	shall have the meaning ascribed to the term in the Concession Agreement;
Concession Period	shall have the meaning ascribed to the term in the Concession Agreement;
Console	MMI Device with video display, Keyboard and mouse for Traffic Controller and Assistant Station Master;
Construction Works	shall mean all works and things necessary to complete the Rail System in accordance with the requirements of the Concession Agreement and includes tracks, civil works, electrical, signalling systems and communication systems;
Conventional Track Circuit	All Kind of Track Circuits for the train detection consisting of electric/electronic circuit with rails and train wheels;
Cross over	shall refer to the means by which two juxtaposed tracks are connected;
Definitive Design	shall mean prepared and accepted part of drawings, documents, standards, and instructions, which give the abilities for supply, installation and testing. Giving Clearance by the IE/Employer as the case may be, to the definitive design is an obligatory condition for the commencement of construction work;
Degraded	shall refer to all states or conditions, other than "normal";
Delay	shall mean a delay caused due to the inability of a Train to move or due to reduction in the speed of such Train resulting from failures in the system;
Depot	shall mean the area designated for maintenance of sub-systems of the Rail System;
Design Headway	shall mean the minimum time interval between successive Trains operated at the permitted line speed, such that the speed of a following Train is not reduced by the Train ahead;

Design Life	The Design Life of the equipment and system is the period of time during which the item is expected to work within its specified parameters; in other words, the design expectancy of system;
Detection	shall refer to the ability to determine that a track section or block is occupied by a Train, or the ability to verify that a point or signal has operated correctly as part of interlocking;
DISCOM	shall mean a distribution company which is licensed to sell electric power;
"Document" or "Documentation"	shall have the meaning ascribed to the term in the Concession Agreement;
Downtime	shall refer to the time from when equipment, sub-system, or system becomes unavailable for use due to maintenance attention until the time it becomes available for use again;
E&M Equipment	shall mean all equipment and systems to be designed, manufactured, supplied, installed, tested and commissioned under the Concession Agreement for the operation of the Rail System and includes maintenance equipment, special tools, building and facilities;
Earthing or Grounding	shall mean the connection of equipment enclosures and non current carrying metal parts to earth to provide safety to personnel, public and to the equipment;
Emergency	shall mean a condition or situation that is likely to endanger the security of the individuals on or about the Rail System, including Users thereof, or which poses an immediate threat of material damage to any of the Project Assets;
Embedded E&M	shall refer to electrical and mechanical facilities, such as Earth mat, bonding, and the like, to be included within the structures;
Emergency Brake	shall mean the automatic brake system fitted to attain a restrictive braking distance/speed performance, which is applied continuously in emergency overriding any other control in operation;
Employer	shall mean Dedicated Freight Corridor Corporation of India Limited;
Fail Safe	shall mean a design feature which enables a system (or element of a system) to revert to the safe condition in case of its failure;

Failure	shall mean an event which causes loss of function or performance within any part of the rail system and requires a maintenance intervention to restore full functionality and performance;
General Rules	shall mean the rules for working of stations, Trains and methods of working;
Good for Construction Drawing	shall mean drawings derived directly from the Definitive Design and shall detail and illustrate in full the permanent and temporary works. These drawings are the one which concessionaire considers sufficient in detail for construction and are cleared by the IE/Employer, as the case may be, for construction;
Good Industry Practice	shall have the meaning ascribed to the term in the Concession Agreement;
Horizontal Curve	shall mean a track which is curved in plan;
Illuminance	shall mean the luminous flux incident on a surface divided by the area of the surface and is measured in lux where 1 lux=1 lumen/m^2;
Independent Engineer	Shall refer to Independent Engineer as defined in concession agreement;
Interlocking	shall refer to the system to prevent setting up of conflicting routes;
Key Performance Indicators	shall have the meaning ascribed to the term in the Concession Agreement;
Kinematic gauge	shall indicate the dimensions measured from the track center, beyond which no part of the vehicle in motion may protrude;
Lifting System	shall mean a system by which wagons are lifted from under their Bogies to an ergonomic working height, to facilitate Bogie disconnection, the wagon body being supported by body supports at specific locations points when the Bogies are removed;
Maintainability	shall mean the probability that a given maintenance action for a given equipment or system under given conditions of use, can be carried out in a stated time interval when the maintenance is performed under stated conditions using stated procedures and resources;
Maintenance	shall include visual inspection, adjustment, replacement or repair carried out on equipment, sub-systems or systems which results in the item undergoing attention being preserved within maintenance tolerances or returned to its design tolerances;

Maintenance Manual	shall refer to the manual prepared by the Concessionaire and approved by Employer for the regular and preventive maintenance of the Rail system in conformity with the maintenance requirements, safety requirements and Good Industry Practice;
Man Machine Interface (MMI)	shall mean the interface between the Controller and the control system;
Manual	shall mean this Manual of Specifications and Standards;
Maximum Safe Speed (MSS)	shall be the lowest of: (i) safe speed required to observe any Speed Restrictions in force, (ii) maximum permissible Train speed, and (iii) maximum speed set by the current operating mode and Train parameters;
Mimic	shall mean a graphical representation of the railway and its global operating status;
Operation Control Centre	shall mean the place for the operation and supervision of rail system;
Operating Headway	shall mean planned service intervals between all Trains. Operating headway should allow a defined margin over design headway;
Operating Manual	shall mean the rule book for operation of Trains;
Overlap	shall refer to the safe distance provided beyond a signal in case the Train fails to stop at the signal when it is showing a danger aspect;
OHE	The electrical conductors over the track together with their associated fittings, insulators and other attachments by means of which they are suspended and registered in position;
Parking Brake	shall mean a brake designed to hold a stationary train indefinitely with no air or electrical energy source available;
Permanent Way	shall mean railway track;
Points or Switch or Turn out	shall refer to the track mechanism operated to divert the Train where a single track splits to become two tracks and equipped with moving rails to change the route;
Preliminary Design	shall mean the submission of Concessionaire's Documents which comprise the initial stage of design phase;
Preliminary Drawings	shall mean the drawings prepared by the Concessionaire that are built on the reference Drawings and accompany the Concessionaire's Preliminary Design Submissions;

Project	shall mean the construction and maintenance of the Rail System in accordance with the provisions of the Concession Agreement, and includes all works, services and equipment relating to or in respect of the Scope of the Project;
Rail System	shall have the meaning ascribed to the term in the Concession Agreement;
Receiving Sub Station	shall mean the sub-station, which receives electric supply from Transco/Discom and supplies power network of TSS and ASS;
Rectifier	shall mean a converter to convert AC to DC;
Reference Drawings	Shall mean the drawings prepared by the Employer and included in the bidding document;
Regenerative Brake	shall mean the use of traction motors as generators when in braking mode to brake the Train by returning electrical energy to the conductor rails;
Reliability	shall mean the probability that an equipment or system can perform a required function under given conditions for a given time interval or given number of operations or similar measurement parameter;
Remote Control Centre	shall mean a nerve centre of traction system, from which full control over every switching operation on the entire electrified route is exercised. RCC is setup in OCC, to work in close liaison with the traffic control. The RCC includes the main control room, equipment room, Uninterrupted Power Supply (UPS) room, Remote Control Laboratory and Battery Room;
Restraining rail	shall mean the additional rail fixed inside the track and by the side of the inner rail at an appropriate distance;
Request For Proposal	shall have the meaning ascribed to the term in the Concession Agreement;
Request For Qualification	shall have the meaning ascribed to the term in the Concession Agreement;
Right of way	shall mean the constructive possession of the Site, together with all way leaves, easements, unrestricted access and other rights of way, howsoever described, necessary for construction, operation and maintenance of the Rail System in accordance with the Concession Agreement;
Route	shall mean a part of the line originating at a signal for which the points have been set and secured to enable the safe passage of a Train;

Safety Consultant	shall mean an experienced and qualified firm or organization appointed by the DFCCIL for carrying out safety audit of the Rail system in accordance with the Safety Requirements;
Safety Critical	shall mean a failure of the system, sub-system or equipment that will directly lead to a situation with the potential to cause harm, injury, damage to property, plant or equipment, damage to the environment, or economic loss;
Safety Health and Environmental Manual	shall mean the Employer's Manual containing the requirements and conditions regarding safety, Health and Environmental issues to be met during the execution of works by the concessionaire. This will be among the reference documents included in the bid document;
Sectional Speed	shall mean the optimum speed at which the Train should be driven;
Service brake	shall mean the brake used for routine stopping or slowing with variable and reversible control;
Service	shall mean the freight service available for the use;
Service Affecting Failure	shall mean a failure which causes a delay to Train Services;
Spares	shall mean components, assemblies or sub assemblies, which are used to replace items in operational use;
Specifications and Standards	shall have the meaning ascribed to the term in the Concession Agreement;
Station	shall mean a place in the Rail System where two or more routes are available (Junction stations) or where train stops for operating requirements of crossing / precedence to other trains (Crossing station);
Station Working Rules	shall mean the rules for working of Trains at the station;
Structure Gauge	shall indicate the dimensions of a structural cross section within which no outside object, such as signal masts, sign boards etc. may protrude;
Sub station	shall include the RSS, TSS and ASS where electric equipment are located that receives and converts or transforms the received electrical energy into usable electrical energy;
Substation Automation System	Shall mean a system installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre;

Sub system	Each System of a main system assigned a particular portion of overall function;
Tests	shall mean all the tests necessary to determine the completion of Rail System in accordance with the provisions of the Concession Agreement;
Track circuits	shall refer to the means by which the passage of Trains is detected and the information is used to control signals provided to control safe passage of Trains;
Track Gauge or Gauge	shall mean the distance between the inner faces of the head of rails of a railway track measured 14mm below top of rails;
Track Recording Car	Instrumented rail cars operated on the Rail System to have a continuous record of the track geometry under loaded conditions;
Traction System	shall mean the system which provides electric power for movement of Trains;
Track work	shall mean the Permanent Way system as defined in this Manual;
Train	shall mean a series of railway wagons that is hauled as a single unit by locomotive/s or by integral motors on the Rail System and includes a single wagon;
Train Number	shall mean alphanumeric number uniquely identifying a running train;
Train Operator (TO)	shall refer to the person in the cab in control of Train operation;
TRANSCO	shall mean a transmission company which is licensed to transport electric power;
Transition curve	shall mean a curve connecting sections of track laid to different radii;
Traction Sub-station	shall mean a sub-system of traction power supply which provides operational power supply to the Trains and receives return current via running rail;
Trouble Shooting Manual	shall refer to the manual giving step-by-step procedure to determine the cause for a given problem and then selecting the quickest way to solve that problem;
Vertical curve	shall mean a track which is curved in elevation;
Very High Voltage	shall be as defined in Indian Electricity Rules;
Vital	shall refer to any and all such equipment, devices and systems that are necessary for the safe operation of the Rail system;

Working Instructions	shall mean instructions approved and issued by the Employer for safe working of the system;
Works	shall refer to all labour, materials and equipment to be fitted into the stations and structures that are necessary to implement the Operation and Maintenance requirements;
Others	Any capitalized term used herein not specifically defined shall have the meaning ascribed to such term in the Concession Agreement;

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Chapter 1

GENERAL TECHNICAL REQUIREMENTS

1.1 General

1.1.1 This Manual is applicable for Planning, Design, Construction and Maintenance of Sonnagar-Gomoh-Dankuni section of Eastern Dedicated Freight Corridor (EDFC) through Public Private Partnership (PPP) mode. Operation of the rail traffic is not included in this Manual as train operations are not covered in the scope of concessionaire. The Rail System shall be designed, constructed, completed and maintained during the Concession Period by the Concessionaire with following broad objectives:-

i. To handle the user demand efficiently including the future traffic forecast;

ii. To provide adequate facilities for interchange of traffic with IR at Junction arrangements;

iii. To meet the performance requirements and the Key Performance indicators laid down in the Concession Agreement.

iv. To minimize intrusion and damage to environment;

1.1.2 **General Requirements**

a) The nominal DFC track gauge shall be 1676 mm measured at 14 mm below the top of the rail.

b) The Formation and Bridges shall conform to DFC Loading (32.5T Axle Load) of IR Bridge Rules. However, the track structure shall be suitable for 25T loading 2008 as per IR Bridge Rules.

c) Sonnagar-Gomoh-Dankuni section will have double line Track.

d) At Junction stations, yard layouts should suit the requirement of long haul (2x750 m) as planned in EDFC. Concessionaire may refer conceptual yard plans attached with Concession Agreement for further development. The work for IR yard / lines shall be as per IR / EDFC standard as per site conditions.

e) Crossing stations shall have minimum two loops (one UP & one DN) with 1500 m CSR (Provision of 750 m for present and additional 750 m for future shall be kept).Concessionaire may refer conceptual yard plans attached with Concession Agreement for further development.

f) Entire rolling stock shall be owned/operated and maintained by MOR/DFCCIL.

g) All operations shall also be under MOR/DFCCIL.

h) Role of Concessionaire shall be limited to constructing and maintaining fixed infrastructure.

i) Concessionaire may refer the Concession Agreement for detailed scope of project facilities to be provided.

j) Construction of ROB in lieu of level crossings within Sonnagar-Gomoh-Dankuni section is not included in the scope of concessionaire. However, FOB and RUB/LHS in lieu of level crossings will continue to be within the scope of concessionaire as per details mentioned in the concession agreement.

k) Traction System shall be 25 KV 50 Hz AC AT feeding system.

l) SCADA system shall be provided for remote monitoring and controlling the Traction Power Supply system from Remote Control Centre (RCC).

m) Signalling system for entire Sonnagar-Gomoh-Dankuni section will be automatic signaling with 2 Km nominal distances between signals.

n) Schedule of Dimensions for Broad Gauge shall conform to SOD for EDFC.

o) Line capacity of 20 hours / day should be made available by the Concessionaire.

p) System should meet the requirement of Traffic Projections including future traffic.

1.1.3 The rail systems built by the concessionaire shall be able to run the trains at maximum speed of 100 kmph and to carry the traffic including future traffic.

1.1.4 The Rail System shall conform to the design requirements set out in this Manual which are the minimum prescribed. The Concessionaire shall be solely responsible for undertaking all the surveys, investigations, detailed designs, construction and maintenance in accordance with Good Industry Practice and shall have no claim against the Government for any loss, damage, risks, costs, liabilities or obligations arising out of or in relation to such surveys, investigations, designs, construction and maintenance.

1.1.5 The codes, standards and specifications applicable for design of the components of the Rail System and their maintenance are:

i. Indian Railway Codes;
ii. Indian Railway Manuals;
iii. Indian Railway Standard Specifications (IRS);
iv. Indian Railway / RDSO Guidelines;
v. G&SR of IR & DFCCIL;
vi. Indian Roads Congress (IRC);
vii. BIS Specifications;
viii. UIC Specifications;
ix. International standards : British Standards (BS); European Norms (EN); Association of American Railroads (AAR) standards; AREMA, German Standards (DN); Japanese Industrial Standards (JIS); International Electro Technical Commission Standards (IEC); International Organization for Standardization (ISO) etc.
x. Any other relevant standards.

In the event of conflict between standards and specifications prescribed in two or more of the aforesaid codes, the Concessionaire may rely on one of the aforesaid codes and on Good Industry Practice, provided however, that in the

event of any such conflict, the following codes shall have overriding priority in the order listed;

i. Specifications and Standards set out in this Manual;
ii. Indian Railway Codes;
iii. Indian Railway Manuals;
iv. Indian Railway Standards (IRS);
v. Indian Railway / RDSO Guidelines;
vi. BIS Specifications;
vii. UIC Codes; and
viii. International Codes and Standards.

1.1.6 List of codes, manuals, specifications and standards as mentioned in respective chapters of this Manual is indicative and not exhaustive. Latest codes, manuals, specifications and standards, corrected upto 28 days prior to date of submission of bid, shall be applicable.

1.1.7 The design of the Rail system shall also conform to:

i. Local bye-laws;
ii. All statutory requirements, guidelines and directives; and
iii. Local stipulations with regard to environment, fire safety, labour protection and welfare etc

1.1.8 All items of building works shall conform to the standards specified in the National Building Code (NBC), Energy Conservation Building Code (ECBC) and the relevant codes issued by BIS.

1.2 Alternative Standards and Specifications

The requirements listed in this Manual are the minimum. The Concessionaire may adopt alternative internationally recognized codes, standards and specifications if it can demonstrate to the IE/Employer that such alternative is superior or more pertinent to the Project than the standards specified in this Manual. Alternative standards will be applicable after approval of IE/Employer as prescribed in respective chapters of this Manual.

1.3 General Performance Requirements

From the point of view of system performance, the major requirements of rail system during construction and operation shall be:

i. Safe;
ii. Reliable;
iii. Efficient;
iv. Made of proven technologies and/or processes;
v. Easy to maintain with minimum efforts;
vi. Integrated to environment;
vii. Adapted to local climate;
viii. Inclusive of protective measures against storms and other local climate conditions;
ix. Comfortable;
x. Aesthetic; and
xi. Compliant to Applicable Law and statutory regulations.

Notwithstanding the generality of the foregoing, where specific standards or specifications are prescribed in relation to any of the foregoing, the Concessionaire shall comply, at the minimum with such standards and/or specifications.

1.4 Engineering System Design

1.4.1 The Concessionaire shall submit its engineering design for review and approval of the Independent Engineer.

1.4.2 The Concessionaire shall develop the Rail System based on the Specifications and Standards and in accordance with Good Industry Practice.

1.4.3 All systems and equipment to be used for the Rail System shall be designed taking into account the local climatic conditions.

1.4.4 The sub-systems and equipment proposed to be utilized by the Concessionaire shall be in revenue service with IR or other established railway systems and shall have established performance reliability as prescribed in respective chapters.

1.4.5 Adequate margin shall be built into the engineering to protect against high ambient temperatures, seasonal humidity, corrosive conditions, and the effects of lightning strikes, etc. prevailing at the site.

1.4.6 While designing the system, Concessionaire shall keep into consideration, following criteria:

i. Service proven design;
ii. High reliability;
iii. Fail safe design;
iv. Energy efficiency;
v. Minimum life cycle cost;
vi. Low maintenance cost;
vii. Adequate redundancy in system;
viii. Adherence to operational performance requirements;
ix. Compliance with relevant standards, Specifications and Statutory regulations;
x. Traceability of components;
xi. Fire and smoke protection;
xii. Environment friendly;
xiii. Use of open source (Non IPR) systems to the extent possible;
xiv. Design for mechanized delivery, construction, installation, maintenance and inspection; and

1.5 Quality Assurance

1.5.1 The Concessionaire shall develop and maintain a Project Quality Management Plan (PQMP) for design, installation and construction procedures and the interfaces between them. The quality plan shall also cover fully all quality assurance and quality management aspects of the operation and maintenance of the Rail System.

1.5.2 The Concessionaire shall set up adequately equipped field laboratories for testing of materials and finished products. It shall make necessary arrangements for such tests for which facilities at site laboratories are not available. Permanent records of all tests on materials and systems shall be maintained by the Concessionaire on specified format agreed by Independent Engineer.

1.5.3 The quality assurance program (QAP) and plan shall be implemented during the entire Concession Period, and shall conform to IS/ISO 9001:2008.

1.6 Safety Engineering

The Concessionaire shall prepare a system safety plan covering the engineering, fabrication, supply, construction, installation, test, commissioning and operation and maintenance of the Rail System in consultation with the Independent Engineer. The safety goals shall be in accordance with relevant applicable standards, local rules and regulations and stipulations of local fire authorities. The safety plan shall cover safety of life and safety of assets. The SHE Manual prepared by employer will be adhered to by the concessionaire while preparing his own safety plan.

1.7 Interface Management

The Concessionaire shall also act as an Interface manager for the whole Works during entire concession period and shall bear the overall responsibility for Interface management with other agencies. The Concessionaire shall prepare and submit an Interface Management Plan which shall include procedures and regulations to be developed and the mechanism by which interfacing will be implemented.

1.8 Definitions and Interpretation

1.8.1 All the obligations of the Concessionaire arising out of the provisions of this Manual shall be discharged in a manner that conforms to the provisions of the Concession Agreement.

1.8.2 The rules of interpretation as specified in the Concession Agreement shall apply mutatis mutandis to this Manual.

1.8.3 The definitions contained in the Concession Agreement shall apply to the provisions of this Manual unless the context otherwise requires. For terms or works not defined in this Manual or the Concession Agreement, the definitions contained in the applicable Specifications and Standards may be referred.

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CHAPTER 2

CIVIL ENGINEERING WORKS AND STRUCTURES

2.1 General

This chapter lays down standards for Civil Engineering works covering loading standards, Design, drawings, alignment (gradient and curves) and important schedule of dimensions, earth work, blanketing, formation drainage, ballast, railway bridges including Rail Fly Overs (RFOs), Road Under Bridges (RUBs), buildings and track i.e rails, sleepers, fastening, welding, special track layouts like points & crossings, switch expansion joints, glued joints, Level Crossings, system signages and fencing.

2.2 Loading Standards

Loading standards shall conform to "Rules specifying the loads for design of super-structure and sub-structure of bridges and for assessment of the strength of existing bridges" – IR Bridge Rules. The Formation and Bridges shall conform to DFC Loading (32.5T Axle Load) as detailed in Appendix XXV (in 4 sheets) of Bridge Rules. However, the track shall be suitable for 25T loading 2008 as per Appendix XXII (in 4 sheets) of IR Bridge Rules.

2.3 Design

2.3.1 General

Concessionaire shall fulfill the requirements for the preparation and submissions of the design of the works to cover the design phase as well as construction phase including those which are necessary for interface with various existing systems & agencies and those that are of general application. All technical solutions, schemes, structures, materials should be fully compatible with requirement of DFCCIL and should not be in conflict with the applicable rules/codes/manuals & standards as well as the legislation in India.

2.3.2 REQUIREMENTS DURING THE DESIGN PHASE

2.3.2.1 The principal requirements during design phase are the production of the documents by the concessionaire, which shall fully describe the works and include the preliminary design, definitive design and "Good for Construction Drawings".

2.3.2.2 The volume and contents of the documents shall be in accordance with the applicable regulations/legislation in India, existing codes, manuals and standards applicable on Indian Railways/DFCCIL, or suitable international norms.

2.3.2.3 The concessionaire shall obtain all necessary approvals and agreements for his designs on his account in accordance with the applicable legislation in India & current practices.

2.3.2.4 The preliminary design shall incorporate the design and reference drawings provided in the RFP by employer, and to be reviewed, verified and further developed by the concessionaire sufficiently to define the main structures including formation, bridges, buildings, track alignment & track components and building services etc. In addition, general construction, manufacture, installation, testing and commissioning methodologies and documentation needed to develop the definitive design shall be submitted.

2.3.2.5 The definitive design shall accord with and incorporate the concessionaire's proposals and shall be the design developed to the stage at which all elements of main structures including formation, bridges, buildings, track alignment & track components and building services etc are fully defined and specified. In particular definitive design shall be complete when:

i. All calculations and analyses are complete including verification;
ii. All main and other significant elements are defined;
iii. All tests, trials and selection of materials &equipments are complete; and
iv. The effects on the permanent works of the proposed methods of construction, installation, testing and commissioning and of the temporary works are assessed.

2.3.2.6 During the preparation of the definitive design, all surveys, investigations and testing necessary to complete the design of the permanent & temporary works shall be undertaken by the concessionaire.

2.3.3 REQUIREMENTS DURING THE CONSTRUCTION PHASE

The principal requirements relating to the concessionaire's documents during the construction phase are the production by the concessionaire of working drawings and documents, preparation of technical submissions, compilation of the final design and the production of the as-built drawings and final documentation.

2.4 Drawings

2.4.1 General

Various types of drawings are required for obtaining sanction/approval, carrying out execution and keeping record of the work executed. These are broadly defined as under:-

i. **Reference Drawings:** These are drawings prepared by the employer and included in the RFP.

ii. **Preliminary Drawings:** These are drawing prepared by Concessionaire on basis of reference Drawings and are part of Concessionaire's Preliminary Design Submissions.

iii. **Good for Construction Drawings:** These are based upon the Definitive Design and shall detail and illustrate in full the permanent and temporary works. These drawings are considered sufficient in detail for construction and are cleared by the Independent Engineer.

iv. **Working Drawings:** Preliminary Drawings and Good for Construction Drawings falls in this category.

v. **Site Drawings and Sketches:** These are the 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.

vi. **Shop Drawings:** These are special drawings prepared by the manufacturer/ fabricator of various items within the works to facilitate manufacture or fabrication.

vii. **As Built Drawings:** These are drawings prepared by the Concessionaire and endorsed by it as true record of the permanent works and have been agreed by the Independent Engineer.

2.4.2 **Scale of Drawings:** The drawings are to be prepared at a scale sufficient to accommodate all necessary details. Following scales are to be adopted for various drawings:-

S.N	Drawing	Horizontal Scale	Vertical Scale
1.	Index Map	1 : 1,00,000	-
2.	Index Plan and Section	1 : 50,000	1 : 1,000
3.	Detailed Plan and Section	1 : 5,000	1:500
4.	Plans of Station yards	1 : 1,000	-
5.	Plans of Junction Arrangement	1 : 1,000	-

2.4.3 **Size of Drawings**

The drawings are to be prepared at suitable size, sufficient to accommodate all necessary details. Paper and Drawing sizes shall be “A” series as specified in ISO 5457. Drawing sizes should conform to provisions of Engineering Code as well as IRWM.

2.4.4 **Title Block of Drawing**

Title Block should be of size 170 x 65 mm and should contain essential details.

2.4.5 **Details to be contained in drawing**

The details on drawings will be according to:-

General Details	Para 906 of Indian Railway Works Manual
Buildings and Structures	Para 906 of Indian Railway Works Manual
Bridges and rivers	Para 307 of Indian Railway Bridge Manual
Water supply and sewage	Para 906 of Indian Railway Works Manual

2.4.6 **Addition and Alteration to Drawings**

Addition and alteration to an existing drawing should be approved by the authority that has approved the original plan and all the addition and alterations are to be shown in red.

2.4.7 **CAD Drawings and Files**

2.4.7.1 The production of CAD files shall comply with the applicable legislations in India.

2.4.7.2 CAD file numbering should follow the system detailed by the Independent Engineer.

2.4.7.3 Automatic CAD dimensioning shall be used.

2.4.7.4 Any dimensional change must involve the necessary revision to the model space file.

2.4.7.5 All CAD elements shall be placed on the layers allocate for each different discipline. The layer naming convention shall be got approved by the Independent Engineer.

2.4.8 Maintenance of Drawings

The paper drawings shall be kept safely to avoid damage due to moisture, termite etc. Microfilming of such drawings may be done to have backup. Wherever, drawings are prepared in computer compatible media, adequate care shall be exercised in maintaining backup copies and installing security systems.

2.4.9 List of Specifications and documents

S.N	Document/ Specification No.	Document Title
1.	-	IR Engineering Code & IR Works Manual
3.	SP-46, 2003	Engineering Drawing Practice for School and Colleges
4.	IS : 962, 1989	Code of Practice for Architectural and Building Drawings
5.	IS : 1444, 1989 Reaffirmed 2011	Engineer's pattern Drawing Board
6.	IS : 7973, 1976 Reaffirmed 2011	Code of Practice for Architectural and Building Working Drawings
7.	IS : 10711, 2001	Technical Product documentation – Size and Layout of Drawing Sheets
8.	IS : 10968, 1984 Reaffirmed 2008	Drawing Practice for Simplified Presentation
9.	IS : 11664, 1986 Reaffirmed 2009	Folding of Drawing Prints
10.	IS : 11670, 1993 Reaffirmed 2009	Technical Drawings – Abbreviation and Symbols for use in Technical Drawings
11.	IS : 12160, 1987 Reaffirmed 2009	Technical Drawings – Fundamental Tolerance Principle
12.	IS : 12879, 1990 Reaffirmed 2009	Microfilming of Technical Drawings and Other Drawing Office Documents
13.	IS : 15093, 2002	Construction Drawings – Spaces for Drawing and Text, and Title Block of Drawing Sheet.

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2.5 Geometric design / Alignment

2.5.1 General

2.5.1.1 This section lays down the standards for design, construction, manufactureand documentation of the Permanent Way system as per specifications and kinematic envelope requirements so that the track structure provides safe and reliable guidance and support for the Trains allowed to operate on it.

2.5.1.2 The reference details of alignment as provided by the Employer in the RFP shall be reviewed and verified by the Concessionaire to satisfy himself that there is no conflict with regards to his own Design and Construction proposal as well as ongoing/sanctioned works of Railways. The Concessionaire 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 changes proposed are essentially required to suit to the Concessionaire's specific design and shall be accommodated within right of way as shown in the bidding documents. The deviations from the alignment indicated in the bid documents are to be approved by the Independent Engineer and Employer.

2.5.1.3 The geometric design of track work shall conform to the standards set out in this section as a minimum and provisions of SSOD of EDFC and IRPWM in general.

2.5.1.4 As far as possible uniformity of geometric design standards shall be maintained throughout the Rail System.

2.5.1.5 Geometric design shall include horizontal and vertical alignment. Horizontal curves are to be accompanied by cant and transition curves of suitable length. Vertical curves are to be provided at junction of grades having algebraic difference between grades being equal to or more than 0.4%.

2.5.2 Functional Requirements for Geometric Design

The Concessionaire shall, within the constraints imposed by the Rail System, maintainability as well as ROW shall adopt:

i. Large horizontal curve radii;

ii. Large vertical curve radii;

iii. Long transition curves; and

iv. Flat track gradients.

2.5.3 Horizontal Alignment

2.5.3.1 Horizontal curve in the DFC tracks shall be circular with transition curves at either end of such circular curve.

2.5.3.2 The horizontal curve radius is measured on the track centre line between the two rails. The DFC tracks will have concentric curves unless otherwise approved by the Independent Engineer.

2.5.3.3 Following spacing requirement between the tracks shall govern Horizontal alignment:-

S.N	Items	Dimensions
1.1	**Minimum Distance – Centre to Centre of Tracks**	
1.1.1	Between DFC Tracks	6000 mm
1.1.2	Between DFC Track and Existing IR Track	
	(i) Minimum Distance	6000 mm
	(ii) Recommended Distance	7925 mm
Note	(a) Spacing between the tracks will be suitably increased to provide the extra clearance on curves as per Annexure –I of SSOD for EDFC. (b) For spacing of tracks in tunnel, through and semi through girder bridges, items 1.9 of SSOD for EDFC may be followed. (c) OHE mast and signal post shall not preferably be provided in between tracks. However, under unavoidable circumstances, the clearances mentioned as above are to be increased by the width of such provisions/structures/foundations, as the case may be.	

2.5.3.4 Recommended Radius and degree of the curve shall be 700m and 2.5 degree respectively.

2.5.3.5 In general, the concessionaire shall provide the curves of recommended or flatter radius. In exceptional situations, where it is not feasible to provide the recommended radius, the concessionaire shall make all the efforts to provide the curves of radius 585 m(3 degree). Further, on entry to the existing IR operational system, the concessionaire shall make all the efforts to provide the curves of radius 438m (4 degree).

2.5.3.6 All curves including their transitions shall be designed for 100 Kmph. However, on curves sharper than 3 degree, the maximum speed of 100 kmph is not possible even with provision of maximum permissible cant and cant deficiency. At such critical locations, flattest possible curve shall be fitted so as to have the maximum possible speed potential under prevailing site conditions.

2.5.3.7 The maximum actual cant shall be limited to 165mm. However, from maintainability considerations, it is recommended to limit the actual cant by taking advantage of cant deficiency.

2.5.3.8 The maximum cant deficiency shall be 75mm and cant excess shall be 65mm.

2.5.3.9 All curves on mainlines shall be provided with transition curves to the straight which shall take the form of a cubic parabola with the equation as $y=x^3/6RL$.

2.5.3.10 Minimum length of the transition shall be the maximum length obtained from the following equation:

$L = 0.008 * C_a * V$

$L = 0.008 * C_d * V$

$L = 0.72 * C_a$

Where, C_a& C_d are the value of actual cant & cant deficiency respectively in mm and V is maximum permissible speed in kmph. The above requirement is based upon rate of change of cant and rate of change of cant deficiency as 35 mm/sec.

2.5.3.11 For design of transition length, value of C_a shall be calculated for speed of 100 kmph with $C_d = 0$, and V shall be taken as 100kmph, where it is not practical to use 100km/h, a reduced speed may be utilized with the approval of the Independent Engineer .

2.5.3.12 To accommodate transition curve, Shift (S) equal to $L^2/24R$ is to be provided, where L is the length of transition curve and R is radius of curve.

2.5.3.13 Horizontal curves and transitions length shall be avoided at turnout portion locations. There should be no change of super elevation between points 18 m outside toe of switch rail and nose of crossing respectively.

2.5.3.14 Minimum straight length between transitions of two reverse curves shall be 50 m. If it is not possible, the straight should be eliminated by extending the two transition curve lengths. In doing so, it should be ensured that the rate of change of cant and versine along the two transitions so extended is kept the same.

2.5.3.15 As far as possible, the turnouts should be avoided in the circular curves. Turnouts are not permitted in the transition curves.

2.5.4 Vertical Alignment

2.5.4.1 Concessionaire shall select sectional gradients for the alignment so as to enable smooth train operations taking into consideration the required optimum tractive effort, curvature and other obligatory parameters. For outside station yards, steepest gradient shall be 1 in 200 compensated. For station yards, gradients shall be as under:-

S.N	Items	Dimensions
1.	Maximum gradient in station yards unless special safety devices are adopted and/or special rules enforced to prevent accidents in accordance with approved special instructions.	
	(i) Desirable / Recommended Gradient	1 in 1200
	(ii) Minimum Gradient	1 in 600

Note :

(a) No station yard shall be constructed nor shall any siding join the DFC line on a steeper grade than 1 in 400, except where it is unavoidable and then only with the previous sanction of the Railway Board obtained through the Commissioner of Railway Safety when a safety arrangement is made sufficient to prevent accident. The power of condonation of gradient steeper than 1 in 1200 shall be as under:-

(i) Steeper than 1 in 1200 and upto 1 in 400 : Personal approval of Managing Director of DFCCIL after making efforts for providing grades as flat as possible.

(ii) Steeper than 1 in 400 and upto 1 in 260 : Commissioner Railway Safety.

(iii) Steeper than 1 in 260 : Railway Board through Chief Commissioner of Railway Safety

(b) The station yard will be as per definition provided in Chapter – II of SSOD for EDFC.

2.5.4.2 The gradient shall be compensated for curves @0.04% per degree of curve and the maximum gradient shall not be steeper than the ruling gradient of the section.

2.5.4.3 There should not be any change of gradient on turnout and within 30 m of any points and crossings.

2.5.4.4 Vertical curves to be provided when the algebraic difference between the grades is equal to or more than 4 mm per meter or 0.4%.

2.5.4.5 The Vertical curve shall have minimum radius of 4000 m.

2.5.4.6 Minimum length of vertical curve shall be 30 m.

2.5.4.7 Minimum distance between two vertical curves shall be 30 m.

2.5.5 Maintenance of alignment

The vertical profile as per tolerance for finished formation work is to be achieved. The alignment is to be maintained throughout the concession period. The curves are to be checked based upon versine measurement and based upon the cumulative frequency diagram, station to station variation as well as actual running condition of track, local attention / realignment of curves is to be carried out.

The rail posts at transition point, curve boards and other permanent markers and boards are to be maintained throughout the concession period.

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2.6 FORMATION

2.6.1 Definitions

(i) **Formation**: A general term which refers to the whole of blanket, prepared Sub-grade, embankments fill and sub-soil below the ballast

(ii) **Formation level**: The design level of the formation at the top of the blanket

(iii) **High Embankment**: Embankment having height more than 4.5 meters above toe of the bank on either side of the bank.

(iv) **Blanket**: A layer of select clean and well-graded granular material of Specified gradation and properties and designed thickness provided over the full width of the formation just below the ballast.

(v) **Prepared sub-grade**: A layer of soil of superior specification, which is provided below the Blanket

(vi) **Sub-grade**: The part of the formation which is below the prepared sub-grade and which may comprise of embankment fill or sub-soils

(vii) **Sub-soils**: Soils of natural ground below embankments or prepared sub-grade in cuts

2.6.2 Functional requirement of Formation

The formation is required to serve the following functions:-

- To provide support for a stable track structure, i.e.to check the sub soil and embankment deformation due to self weight and dynamic track loads.
- To provide desired line and level of track.
- To provide a smooth & regular surface on which ballast & track can be laid.

2.6.3 Functional requirement of Blanket / Sub Ballast layer

Primary Function of the blanket is to reduce the traffic induced stresses on top of sub-grade to a tolerable limit. Secondary Function of the blanket layer includes:-

- Separation Function: Prevention of penetration of ballast into sub-grade and also prevention of upward migration of fine particles from sub-grade into ballast.
- Drainage Function: To intercept water coming from ballast away from sub-grade and at the same time, to permit drainage of water that is flowing upward from the sub-grade.
- Prevention of Mud Pumping: To prevent mud pumping by checking attrition of sub-grade particles by ballast.

2.6.4 Design of Formation

2.6.4.1 Concessionaire shall follow RDSO Report No. RDSO/2007/GE:0014, Nov' 2009 "Guidelines & specifications for design of formation for heavy axle load". At Page 35 of 75 and Page 36 of 75 of the aforesaid guidelines, minimum layer of 1.0 meter of embankment fill above HFL have been indicated. These provisions are not mandatory. For exceptional locations prone to flooding, the Independent Engineer may call for the stability analysis of banks.

2.6.4.2 Formation has to be provided with layers well designed to be safe against shear failure and accumulated/ plastic deformation under repetitive axle loads.

2.6.4.3 The maximum pressure on formation at bottom of ballast, typical values as good design practice, should not exceed 0.3 MN/m² or 3.0 kg/cm². For Indicative load distribution pressure bulb through the layers, due to wheel load, Fig. 4 of RDSO "Guidelines and specifications for design of formation of heavy axle load Nov' 2009 may be referred.

2.6.4.4 A uniform total thickness of formation layers of 1.75 m should be provided including blanket, prepared sub grade & top layer of embankment fill etc.

2.6.4.5 In case the difference between formation level and ground level is less than required thickness, the existing ground will have to be excavated to provide the formation layers of requisite thickness and specification as mentioned in the RDSO design. In case the existing ground soil at a particular level satisfies the specifications of the formation layers at that level, then the existing ground shall not be cut to provide total thickness.

2.6.4.6 Minimum height of embankment shall generally be 1.0 meter except at obligatory points like level crossings, junction yards, bridge approaches etc.

2.6.4.7 For banks higher than 4.5 m, suitable slope stability analysis shall be carried out to adjudge the slope stability. Following minimum factor of safety shall be ensured in design and construction of high embankment :-

- Bearing capacity: 2.0
- Lateral sliding: 1.5
- Foundation extrusion: 1.5
- Deep seated slip failure: 1.2 (short-term) and 1.4 (long-term)

Where the required factor of safety is not achieved suitable ground improvement shall be carried out.

2.6.4.8 In order to design & construction of stable formation for heavy axle load, EV2 should be determined in the field as per procedure given in German Code DIN: 18134 at ground. Undrained shear strength (Cu) of ground soil from Unconfined Compression (UCC) test or Vane Shear Test and Penetration Number (N- Value) from Standard Penetration Test should also be determined. Ground improvement will be required, if EV2 value is less than 20Mpa or sub soil strata having (Cu) < 25 KPa (mostly in Marshy area) or N- value <5.

2.6.4.9 Cross slope of 1:30 on the finished surface of prepared sub-grade/embankment fill/cut as well as on the finished surface of the formation (top of blanket) is to be provided.

2.6.4.10 Adequate drainage arrangement by way of side drains and catch water drains is to be provided. Stable slopes and adequate drainage arrangements in cutting areas should be provided as per details given in 'Guidelines for Cutting in Railway Formations - No. GE: G-2, August 2005.

2.6.4.11 Reinforced Earth Construction may be adopted at following locations:-

(a) On parallel sections, where the formation level of the proposed DFC track is at a higher elevation than the existing Indian Railway formation and the space available between the embankments is not sufficient.

(b) Locations where the embankment height is large and the right-of-way is not adequate.

(c) RUB/RFO

In this regard, RDSO's report No. GE-R-63, June' 2005 on 'Concept and Design of Reinforced Earth Structures', may be referred to. Reinforced earth walls are

to be designed as per BS 8006-1:2010 (Code of Practice for strengthened/Reinforced soils and other fills) / FHWA-NHI-1-024 (Geotechnical Engineering Circular no. 11- Design and construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes). Design life for reinforced soil walls shall be 120 years. The minimum embedment of the reinforced soil walls below ground level will be 1.0 m

2.6.4.12 Other provisions given in 'RDSO Guidelines For Earthwork in Railway Projects', GE:G-1, July 2003 also to be followed.

2.6.4.13 Following geometrical requirement to be fulfilled for design of formation:-

Minimum Formation Width of double line track in embankment	13500 mm
Minimum Formation Width of double line track in cutting	13500 mm
Minimum Formation Width of single line track in embankment	7600 mm
Minimum Formation Width of single line track in cutting	7500 mm
Side slope in Embankment	2H:1V*
Side Slope in cutting	1H:1V*
Cross slope of embankment fill / prepared subgrade / blanket layer	1:30

* To be verified by slope stability analysis.

2.6.4.14 On curves, additional Width of formation will have to be provided to cater for increase in extra ballast on outside of curves. Additional width of formation is also to be given to accommodate extra clearance required on curves as per SSOD of EDFC.

2.6.4.15 Wherever the height of bank is more than 6.0 m, berms of 1.5 m width shall be provided on either side at every 6.0 m from top of blanket layer.

2.6.5 Specifications for different formation layers

Soil classification, criteria for blanket layer, prepared sub grade, embankment fill and ground soil/sub soil shall be as per RDSO Report No. RDSO/2007/GE:0014, Nov' 2009 "Guidelines & specifications for design of formation for heavy axle load".

2.6.6 Ground Improvement of weak soils

Ground Improvement of weak soils can be carried out using following technique/s : -

- Removal and replacement (R&R) of weak soil,
- Stage constructions of the fill, preloading and surcharging,
- Installation sub drainage system,
- In-situ pile, Sand Gravel Compaction pile, Stone Columns,
- Vibro-floatation,
- Lime pile, Injection/ lime slurry pressure injection/ion exchange,
- Stir & Mixing,
- Sand mat, Geo-synthetics etc.

2.6.7 CONSTRUCTION

2.6.7.1 Any construction activity involving the existing embankment/formation/running track of the Indian Railways shall be carried out only with the prior specific authorization of the Independent Engineer. Protection measures are detailed in para 10.2.2 of this manual.

2.6.7.2 Before start of earthwork, unless otherwise directed by the Independent Engineer, the area to be cleared is that which is occupied by the completed works and stockpile sites, plus a clearance of 2m beyond the toe of embankments and top of cuts. The area within the specified limits shall be cleared and grubbed of all trees, shrubs, vegetation, stumps, stones, debris, trash, organic matter, any other objectionable materials or obstructions except those designated to remain as stated in the concession agreement or as directed by the Independent Engineer. Grubbing is to be carried out to a level as directed by Independent Engineer.

2.6.7.3 The concessionaire shall carry out true and proper setting out of the works and for the correctness of the position, alignment, levels and dimensions of all parts of the work, concessionaire shall establish a system of horizontal and vertical controls in relation to the reference bench marks and coordinates as specified by the Independent Engineer.

2.6.7.4 The concessionaire shall ensure that the safety and stability of all adjacent structures is ensured at all times and take suitable precautions against any soil erosion and water pollution.

2.6.7.5 Any portion of the ground or existing embankment slope steeper than 1V:4H shall be benched in accordance with standard procedures before filling is placed on it, unless otherwise directed by the Independent Engineer.

2.6.7.6 The movement of all construction vehicles and other traffic shall be distributed over the full width of the filling area, so as not to damage or overstress the construction. Damage by construction plant and other vehicular traffic shall be repaired by the concessionaire to the satisfaction of the Independent Engineer.

2.6.7.7 Successive layers shall not be placed until the layer under construction has been thoroughly compacted, tested and passed by the Independent Engineer.

2.6.7.8 Additional filling width of 500mm shall be placed on either side to ensure proper compaction of the fill at the edges, with the extra soil later cut and dressed to avoid any loose earth on the slopes.

2.6.7.9 In the absence of field compaction trials, the maximum compacted lift thickness shall be limited to 200mm. The Independent Engineer may allow higher lift thickness, provided the concessionaire satisfactorily demonstrates the efficacy of the compaction equipment and methodology through filed compaction trials. Filed compaction trials shall be in accordance with Annexure-IV of RDSO GE: G-1.

2.6.7.10 Moisture content of fill materials as placed shall be uniform throughout the lift and shall be within the limits specified in accordance with IS:2720:Part 8:1983 or approved Design and Drawings of formation.

2.6.7.11 Each lift of fill shall be compacted using appropriate equipment and standard procedures as agreed with the Independent Engineer, so that the specified relative compaction is achieved uniformly and throughout the full depth of the layer. For formation, the minimum relative compaction with respect to the maximum dry density shall be determined in accordance with IS: 2720: Part 8:1983 or as per approved design and drawings of formation.

2.6.7.12 For prepared sub-grade and blanket, the minimum relative compaction with respect to the maximum dry density will be determined in accordance with IS: 2720: Part 8:1983 and the required compaction shall be as per GE – 14 or as per the approved design and drawings of formation.

2.6.7.13 The top surface and side slopes of the formation shall be shaped dressed and finished to conform to the alignment, levels, cross-sections, dimension and cross slopes shown on the approved construction drawings and to the requirements and tolerances stated in this specification. Ballast bed shall be laid only after the top surface has been cleared by the Independent Engineer. The finished work will be as per following tolerances:-

- The top width of the formation (measured at the top of the blanket) and the bottom width of cutting shall not be less than the specified width.
- The finished level shall be within + 0mmand -25mm of the level shown on drawings.
- The deviation of the finished surface from a 3m straight edge laid on the surface parallel to the alignment shall not exceed 15mm.
- The deviation of the finished surface from a 3m straight edge laid on the surface perpendicular to the alignment shall not exceed 15mm.
- The cross-slope of the formation shall not deviate from the cross-slope shown of the drawings by more than 3mm per meter.
- Side slopes of fills and cuts shall not be steeper than the slopes shown on drawings
- The finished surface of the prepared sub-grade and blanket shall not have depressions or ridges which could hold water or prevent proper drainage

2.6.7.14 Methodology, construction and sequence of construction of side drains shall be carried out in accordance with Good Industry Practice. The level at any point on the surface of the lining shall be within ± 20mm of the design levels. When a 3m long straight edge is laid on the surface of the lining, parallel to the direction of flow, the surface shall not vary more than 10mm from edge of the straight edge.

2.6.7.15 While doing earthwork, concessionaire shall make provisions of RCC pipes of suitable diameter at level crossing gates and station yards for crossing of underground cables and wires.

2.6.8 QUALITY CONTROL AND QUALITY ASSURANCE

2.6.8.1 Quality assurance of formation is to be ensured at design stage itself by designing suitable thickness of various layers and checking the short term and long term slope stability. Soil used for construction of formation is to be suitable as per RDSO Report GE:0014. In order to ensure adequate compaction during construction, prior to obtaining clearance for further layers of earthwork/blanketing/track linking work, Quality Assurance Tests are required to be conducted on part completion stages of formation. Heavy Proctor test is required to be conducted to determine the Maximum Dry Density of soil as per IS: 2720 (part 8). In-situ density is measured in the field by Sand Replacement Method (IS: 2720 – part 28) or Core Cutter Method (IS: 2720 – part 29). Nuclear Gauge Method may also be used for the determination of field density & moisture content, subject to approval of Independent Engineer.

Frequency of tests for suitability of soil as well as for in-situ compaction will be done as per RDSO Report GE:0014.

2.6.8.2 A well-equipped Field Laboratory shall be set up at suitable locations and shall be manned adequately by trained official & staff capable of carrying out required investigation, soil testing and quality control at site. Field Lab shall be equipped to perform following minimum tests:-

i) To ensure that the quality of supplied soil and blanket material conforms to the accepted limits of gradation, classification, plasticity, etc.

ii) To evaluate method of compaction by conducting tests in connection with field trials.

iii) To exercise moisture and density control as the earthwork proceeds in layers rolled with the suitable equipment

2.6.9 Formation Drainage

2.6.9.1 Before work in or in the vicinity of Indian Railway yard is taken up, a drainage plan for protecting DFC as well as IR track shall be submitted by the concessionaire for No Objection of Independent Engineer. Such plans should be sufficiently detailed. The side drains shall be extended as necessary to lead the water clear of the Works to natural drainage courses, culverts or any other suitable outlets.

2.6.9.2 Where the alignment is parallel to the existing Indian Railway formation and the distance between the centre lines of the nearest DFC and IR tracks is equal to or more than 8.0 m, open drains shall be provided to ensure satisfactory drainage of the area between the DFC and Indian Railway's formation. These drains shall be designed and shall consist of suitable shape, material and dimensions to provide adequate flow capacity and permit easy maintenance. As per site requirements these shall be linked with cross drains at suitable intervals wherever required.

2.6.9.3 Where the distance between the centre lines of DFC and IR tracks is less than 8.0 m (a situation which may arise in existing IR yards) and provision of open drains is not feasible, alternative drainage arrangements in the form of suitably designed drains using good industry practices and technically sound systems such as perforated pipes etc. should be used with the approval of the Independent Engineer. It should be functional throughout the year and amenable to user-friendly maintenance.

2.6.9.4 For the portion in detours, generally no side drains would be required, if the formation is on an embankment. However, the conditions at the site may warrant the provision of the side drains at some locations. Such locations would be identified by the concessionaire.

2.6.9.5 When the formation is in cutting or where the bottom of the blanket is below the existing ground level, Pucca (concrete) side drains shall be provided at suitable distance for the proper drainage of the formation, the invert level of the drains shall be at least 300mm below the bottom of the blanket at the edge of formation. Such side drains shall generally be lined open drains of suitable shape and dimensions to provide adequate flow capacity, permit easy maintenance and shall have a uniform longitudinal gradient adequate to ensure a self-cleansing velocity. The lining shall be reinforced cement concrete of adequate thickness to prevent erosion and caving . Alternative Designs for this

item can also be suggested by the Concessionaire as per good industry practice and can be adopted after approval by Independent Engineer.

2.6.9.6 For deeper cuttings the provision of catch water drains would be required to tap the water flowing towards the cutting from the hill slope. Such locations would be identified by the Concessionaire and suitable profile of the catch water drains would be proposed by the Concessionaire and approved by the Independent Engineer.

2.6.10 LIST OF RELEVENT DOCUMENTS

S.N	Document	Description
1	IR Engineering Code	Engineering Code
2	RDSO Guidelines	Guidelines and specifications for design of formation of heavy axle load Nov 2009, G-0014
3	RDSO Guidelines	Guidelines For Earthwork in Railway Projects, GE:G-1, July 2003
4	RDSO Guidelines	Guidelines for Cutting in Railway Formations-No. GE: G-2, August 2005
5	RDSO Guidelines	Transition System on Approaches of Bridges report No. GE: R-50, August- 2005
6	RDSO Report	Concept and Design of Reinforced Earth Structures, No. GE-R-63, June 2005
7	IS: 460-1985 Part 1 Revision 3	Specification of test sieves. Wire cloth test sieves Wire cloth test sieves
8	IS: 460-1985 Part 2 Revision 3	Specification of test sieves. Perforated plate test sieve
9	IS: 460-1985 Part 3 Revision 3	Specification of test sieves. Part III Methods of examination of apertures of test sieves
10	IS: 1498, 1970	Classification & Identification of Soils for General Engineering Purposes. (Reaffirmed 2011)
11	IS: 1607-1977	Methods for test sieving
12	IS: 1888-1982	Method of Load test on soils
13	IS : 1892-1979	Code of Practice for site investigations for foundations
14	IS: 2131-1981 Revision 1	Method for standard penetration test for soils. (Reaffirmed 1987)
15	IS: 2132-1986 Revision 1	Code of practice for thin walled tube sampling of soils
16	IS: 2720 -1983 Part-1 (Revision 2)	Methods of test for soils. Preparation of dry soil samples for various tests.
17	IS: 2720-1973 Part-2 (Revision 2)	Methods of test for soils. Determination of water content
18	IS: 2720-1980 Part-3 Section 1	Methods of test for soils. Determination of specific gravity. Fined grained soils (Reaffirmed 1987)
19	IS: 2720-1980 Part-3 Section 2 (Revision 1)	Methods of test for soils. Determination of specific gravity. Section 2 Fine, Medium and coarse-grained soils. (Reaffirmed 1987)

20	IS: 2720-1985 Part-4 (Revision 2)	Methods of test for soils. Grain size analysis.
21	IS: 2720-1985 Part-5 (Revision 2)	Methods of test for soils. Determination of liquid and plastic limits
22	IS: 2720-1972 Part –6 (Revision 1)	Methods of test for soils. Determination of shrinkage factors
23	IS: 2720-1980 Part-7 (Revision 2)	Methods of test for soils. Determination of water content-dry density relation using light compaction.
24	IS: 2720-1983 Part-8 (Revision 1)	Methods of test for soils. Determination of water content-dry density relation using heavy compaction
25	IS: 2720-1992 Part-9	Methods of test for soils Determination of dry density –moisture content relation by constant weight of soil method. (Reaffirmed 1990)
26	IS: 2720-1991 Part-10 (Revision 2)	Methods of test for soils. Determination of unconfined compressive strength
27	IS: 2720-1993 Part-11	Methods of test for soils. Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure. (Reaffirmed 1990)
28	IS: 2720-1981 Part-12	Methods of test for soils. Determination of shear strength parameters of soil from consolidated undrained triaxial compression test with measurement of pore water pressure
29	IS: 2720-1986 Part-13 (Revision 2)	Methods of test for soils. Direct shear test
30	IS: 2720-1983 Part-14 (Revision 1)	Methods of test for soils. Determination of density index (Relative density) of cohesion less soils.
31	IS: 2720-1965 Part-15 Methods of test for soils.	Determination of consolidation properties.
32	IS: 2720-1987 Part-16 (Revision 2)	Methods of test for soils. Methods of test for soil. Laboratory determination of CBR.
33	IS: 2720-1986 Part-17	Methods of test for soils. Laboratory determination of permeability. (with amendment No. 1)
34	IS: 2720-1992 Part-18	Methods of test for soils. Determination of field moisture equivalent
35	IS: 2720-1992 Part-19	Methods of test for soils. Determination of centrifuge moisture equivalent
36	IS: 2720-1992 Part-20	Methods of test for soils. Determination of linear shrinkage. (with amendment No. 1)
37	IS: 2720-1977 Part-21 (Revision 1)	Methods of test for soils. Determination total soluble solids
38	IS: 2720-1972 Part-22 (Revision 1)	Methods of test for soils. Determination of organic matter

39	IS: 2720-1976 Part-23 (Revision 1)	Methods of test for soils. Determination of calcium carbonate
40	IS: 2720-1976 Part-24 (Revision 1)	Methods of test for soils. Determination of cation exchange capacity
41	IS: 2720-1982 Part-25 (Revision 1)	Methods of test for soils. Determination of silica sesquioxide ratio
42	IS: 2720-1987 Part-26 (Revision 1)	Methods of test for soils. Determination of pH value.
43	IS: 2720-1977 Part-27 (Revision 1)	Methods of test for soils. Determination of total soluble sulphate
44	IS: 2720-1974 Part-28 (Revision 1)	Methods of test for soils. Determination of dry density of soils in -place by the sand replacement method
45	IS: 2720-1975 Part-29 (Revision 1)	Methods of test for soils. Determination of dry density of soils in- place by the core cutter method
46	IS: 2720-1980 Part-30 (Revision 1)	Methods of test for soils. Laboratory vane shear test
47	IS: 2720-1990 Part-31	Methods of test for soils. Field determination of california bearing ratio
48	IS: 2720-1971 Part-33	Methods of test for soils. Determination of the density in- place by the ring and water replacement method
49	IS: 2720-1972 Part-34	Methods of test for soils. Determination of dry density of soil in- place by rubber balloon method
50	IS: 2720-1974 Part-35	Methods of test for soils. Measurement of negative pore water pressure
51	IS: 2720-1987 Part-36 (Revision 1)	Methods of test for soils. Laboratory determination of permeability of granular soils (constant head)
52	IS: 2720-1976 Part-37	Methods of test for soils. Part-37 Determination of sand equivalent value of soils and fine aggregates
53	IS: 2720-1976 Part-38	Methods of test for soils. Part-38 Compaction control test (Hilf method)
54	IS: 2720-1977 Part-39 Section 1	Methods of test for soils. Direct shear test for soils containing gravel. Section 1 Laboratory test
55	IS: 2720-1979 Part-39 Section 2	Methods of test for soils. Direct shear test for soils containing gravel. Section 2 in-situ shear test
56	IS: 2720-1977 Part-40	Methods of test for soils. Determination of free swell index of soils
57	IS: 2720-1977 Part-41	Methods of test for soils. Measurement of swelling pressure of soils
58	IS: 2810-1979 Revision 1	Glossary of terms relating to soil dynamics
59	IS: 4434-1978 Revision 1	Code of practice for in-situ vane shear test for soils
60	IS: 4616-1968	Specification for Sheep Foot roller (Reaffirmed 2008)

61	IS: 4968-1976 Part 1 Revision 1	Method of subsurface sounding for soils. Part I Dynamic method using 50mm cone without bentonite slurry
62	IS: 4968-1976 Part 2 Revision 1	Method of subsurface sounding for soils. Part II Dynamic method using cone and bentonite slurry
63	IS: 4968-1976 Part 3 Revision 1	Method of subsurface sounding for soils. Part III Static cone penetration test
64	IS: 5249-1992	Method of test for determination of in-situ dynamic properties of soils
65	IS: 5421-1981 Revision 1	Glossary of terms relating to test sieves and tests sieving
66	IS: 5500 Pt 1 &2 -2004	Specification for vibratory roller
67	IS: 5501-1969	Specification for pneumatic tyred roller
68	IS: 5502-1988	Specification for smooth-wheeled diesel road roller
69	IS: 6935 - 1973	Method of Determination of Water Level in a Bore Hole. (Reaffirmed 2008)
70	IS: 8763 - 1978	Guide for Undisturbed Sampling of Sands. (Reaffirmed 2011)
71	IS: 10074-1982	Specification for compaction mould assembly for light and heavy compaction test of soils
72	IS: 10077-1982	Specification for equipment for determination of shrinkage factors
73	IS: 10379-1982	Code of practice for field control of moisture and compaction of soils for embankment and sub-grade
74	IS: 10837-1984	Specification for moulds and accessories for determination of density index (relative density) of cohesionless soils
75	IS: 11196-1985	Specification for equipment for determination of liquid limit of soils-cone penetration method
76	IS: 11209-1985	Specification for mould assembly for determination of permeability of soils
77	IS: 11229-1985	Specification for shear box for testing of soils
78	DIN:18134- 2001	Determining Deformation & Strength Characteristics Of Soil By Plate Loading Test
79	UIC Code719R-1994	Earthwork and Track Bed Layers for Railway Lines
80	ORE report No. D - 117 RP 28	Optimum adoption of the conventional track to future traffic
81	BS 8006 Part1, 2010	Code of Practice for strengthened/Reinforced soils and other fills.
82	FHWA-NHI-10-024	Geotechnical Engineering Circular no. 11- Design and construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes.

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2.7 RAILWAY BRIDGES / RAIL FLYOVERS

2.7.1 Functional Requirement

Railway Bridges/Flyovers/RUBs should fulfill following functional requirements:-

- To provide the required line and level.
- Capable of carrying the LWR/CWR.
- To safely carry the combination of loads as per IR Bridge Rules and by keeping the deformation and differential settlement within the desired limit.
- To carry the design discharge effectively.
- To have adequate safety margin against high floods by way of sufficient clearance and free board.
- Easy to construct with minimum disruption to existing rail/road traffic.
- Easy to maintain with no or minimum maintenance efforts.
- Should be durable and serve satisfactorily for full minimum design life as described in the clause 15.1.3 of Concrete Bridge Code.
- All Important and Major bridges shall be capable of supporting masts of 2 x 25 KV OHE electrical systems.
- To provide suitable provision for earthing connections.
- To support and carry the electrical/signaling/telecommunication cables.

2.7.2 Classification of bridges

Important Bridges are those having a lineal waterway of 300m or a total waterway of 1000 Sqm or more and those classified as important by the Chief Engineer/Chief Bridge Engineer, depending on considerations such as depth of waterway, extent of river training works and maintenance problems.

Major Bridges are those which have either a total lineal waterway of 18m or more or which have a clear opening of 12m or more in any one span.

Minor Bridges are bridges other than important and major bridge

2.7.3 Design of Bridges

2.7.3.1 Relevant Design Codes

Railway Bridges including Rail Fly Overs (RFO) and Road Under Bridges (RUBs) are to be designed for 32.5 Tonne DFC Loading as detailed in Appendix XXV of Indian Railway Bridge Rules. The details of design of various types of bridges shall be controlled by the appropriate Codes of Practice as given below:

(a) **Steel Bridges** - Indian Railway Standard Code of Practice for the Design of Steel or Wrought Iron Bridges carrying Rail, Road or Pedestrian Traffic (Steel Bridge Code). Welding will be as per Indian Railway Standard Code of Practice for Metal ARC Welding in structural steel bridges carrying rail, rail- cum- road or pedestrian traffic.(Welded Bridge Code).

(b) **Concrete Bridges**- Indian Railway Standard Code of Practice for Plain, Reinforced and Pre-stressed Concrete for General Bridge Construction (Concrete Bridge Code).

(c) **Arch Bridges** - Indian Railway Standard Code of Practice for the Design and Construction of Masonry and Plain Cement Concrete Arch Bridges (Arch Bridge Code).

(d) **Sub-structures of bridges**- Indian Railway Standard Code of Practice for the design of Sub- structures of Bridges (Bridge Sub- Structure Code).

(e) **Sub-structures and super-structures of road bridges** - Standard Specification and Codes of Practice for Road Bridges and other codes as specified by the appropriate authorities.

2.7.3.2 Hydrological investigations

These are required to assess the flow channels, design discharge, High Flood Levels, afflux, scour depths etc for safe design of bridge and river training works. IRS Bridge Sub-Structures and Foundation Code may be referred to in this regard.

2.7.3.2.1 Discharge

The estimation of design discharge for waterway shall preferably be based, wherever possible, on procedures evolved from actual hydro meteorological observations of the same or similar catchments. All bridges shall be designed with adequate waterway for design discharge (Q).

Design Discharge for Foundations(Q_f) shall be computed by increasing the design discharge (Q), by the percentage indicated below :

Catchment Area	**% Increase**
Catchment less than 500 Sq.km	30%
Catchment more than 500 Sq.km and upto 5,000 Sq.km.	30% to 20% (decreasing with increase in area)
Catchment more than 5,000 Sq.km. and upto 25,000 Sq.km.	20% to 10% (decreasing with increase in area)
Catchment more than 25,000 Sq.km	Less than 10% (at the discretion of the Independent Engineer).

2.7.3.2.2 Flood recurrence interval

Important and Major Bridges: Once in 100 years
Minor Bridges: Once in 50 years

2.7.3.2.3 Scour Depth

In the case of natural channels flowing in alluvial beds where the width of waterway provided is not less than Lacey's regime width, the normal depth or Scour (D) below the foundation design discharge (Qf) level may be estimated from Lacey's formula as indicated below

$$D = 0.473 (Q_f / f)^{1/3}$$

where D is depth in m, Q_f is in cumecs and 'f' is Lacey's silt factor for representative sample of bed material obtained from scour zone.

Where due to constriction of waterway, the width is less than Lacey's regime width for Q_f or where it is narrow and deep as in the case of incised rivers and has sandy bed, the normal depth of scour may be estimated by the following formula:

$$D = 1.338 (Q_f^2 / f)^{1/3}$$

Where Q_f is the discharge intensity in cubic metre per second per metre width and f is silt factor.

To obtain maximum depth of scour for design of foundations, protection works and training works, the calculated scour shall be increased as indicated below:-

Nature of the river	**Depth of scour**
In a straight reach	1.25D
At the moderate bend conditions e.g. along apron of guide bund	1.5D
At a severe bend	1.75D
At a right angle bend or at nose of piers	2.0D
In severe swirls e.g. against mole head of a guide bund.	2.5 to 2.75D

2.7.3.2.4 Afflux (h)

For streams with non-erodible beds, the afflux may be worked out by Molesworth formula given below:-

$$\mathbf{h = [V^2 /17.88 + 0.01524] \times [(A/a)^2 - 1]}$$

Where,
h = Afflux in m
V = Velocity in un-obstructed stream in m per second
A = Un-obstructed sectional area of the river in square metres
a = Sectional area of the river at obstruction in square metres

2.7.3.3 Clearance

The minimum clearance for bridges excluding arch bridges, siphons, pipe culverts and box culverts from the water level of design discharge (Q) including afflux shall be in accordance with Table below :

Discharge in cumecs	**Vertical clearance (mm)**
0–30	600
31–300	600-1200 (Pro-rata)
301–3000	1500
Above 3000	1800

When rebuilding bridges on existing lines or building new bridges on these or new lines, with the personal approval of Competent Authority, clearance can be relaxed to the limits shown below**:**

Discharge in cumecs	Vertical clearance (mm)
Less than 3	300
3 – 30	300 - 400 Prorata
31 – 300	400 - 1200 Pro rata

In the case of arch bridges, minimum clearance measured to the crown of the intrados of the arch shall be as under:

Span of arch	Clearance (mm)
Less than 4 m	Rise or 1200mm whichever is more
4.0m to 7.0 m	2/3 rise or 1500mm which-ever is more
7.1m to 20.0m	2/3 rise or 1800mm which-ever is more
Above 20.0m	2/3 rise

Siphons, pipes and box culverts are designed as pressure conduits therefore no clearances are considered necessary for these structures.

2.7.3.4 Free Board (F)

The free-board from the water level of the design discharge (Q) to the formation level of the Railway embankment or the top of guide bund shall not be less than 1m. In cases where heavy wave action is expected, the free-board shall be increased suitably. In special circumstances, where the free- board can be safely reduced and where adoption of the prescribed values would result in heavy expenditure and/or serious difficulties in construction, the free-board may be relaxed at the discretion of the Competent Authority as indicated below :-

Discharge in cumecs	Vertical clearance (mm)
Less than 3	600
3 – 30	750
More than 30	No relaxation

2.7.3.5 Various Loads to be considered in design

The bridge loading for the DFC shall be 32.50T axle load with corresponding locomotives and wagons as per IRS Bridge Rules. Where a bridge is to be constructed for IR tracks, the applicable loading shall be as per the requirements of IR. In addition, the weight of services to the tune of 300 kg/RM shall be considered. For the purpose of computing stresses, following loads as applicable, shall be taken into account. The details of loads are to be as per Bridge Rules.

(a) Dead load
(b) Live load
(c) Dynamic effects
(d) Forces due to curvature or eccentricity of track
(e) Temperature effect
(f) Frictional resistance of expansion bearings
(g) Longitudinal force
(h) Racking force
(i) Forces on parapets
(j) Wind pressure effect

(k) Forces and effects due to earthquake
(l) Erection forces and effects
(m) Derailment loads
(n) Load due to Plasser Quick Relay System (PQRS)

Longitudinal forces shall include tractive effort, braking forces, forces due to resistance to movement of bearings and forces due to combination of LWR/CWR over bridges. All bridges shall be capable of carrying through LWR/CWR. Forces due to continuation of LWR/CWR shall be as per provisions of UIC 774-3R Oct' 2001 edition with latest modification (if any)read along with the amendment slip No. 45 dated 27/9/2013 issued by Indian Railways.

The criteria for seismic analysis shall be carried out as per IITK-RDSO Guidelines on Seismic Design of Railway Bridges, Nov 2010, with latest seismic maps.

For design of foundations, in addition to above loads, following loads as per Sub-Structure Code are to be considered:-

- Earth pressure including earth pressure due to surcharge on abutments and other earth retaining structures like wing wall, return walls.
- Forces due to water current on any part of the bridge substructure which may be submerged in running water.
- Buoyancy effects may be considered for foundations due to HFL / LWL as per critical combinations.
- Any other load as per Bridge Rules/substructure Code.

2.7.3.6 Combination of Loads

Combination of loads will be as per relevant code i.e. IRS Sub-Structures and Foundation Code/ IRS Steel Bridge Code / IRS Concrete Bridge Code, Bridge Rules etc.

2.7.3.7 Conditions for Stability of foundations:

This shall be adjudged as per sub-structure code.

2.7.3.8 Selection of Span and their arrangement

Concessionaire shall verify and validate the General Arrangement Drawings (GADs) provided by the employer in the RFP along with other reference drawings. Concessionaire shall have the liberty to choose any other type of structure and structural system, except drop in spans with halved joint (articulation) and trestle type frames for sub-structure.

The proposed bridges constructed for the DFC tracks shall be sized as a minimum to match the existing bridges on the IR tracks on the parallel section to ensure the least obstruction to the flow of water. In parallel sections, if the existing opening sizes of bridges are different in adjacent UP & DN IR tracks, then in such cases, the minimum recommended opening size / linear water way for the DFC tracks shall be the maximum of the existing opening sizes.

Minimum size of RCC Box with or without fill shall be 1.2 x 1.2 m and no pipe culverts are permissible.

All Box Culverts and Slab Top Bridges shall be continuous to cover the requirement for all the tracks passing over the bridge with details as under:-

a) **Bridges without surcharge**: The barrel length of the bridge shall be equal to the top width of the formation on the approaches.

b) **Bridges with surcharge**: The bridge shall have an adequate barrel length to accommodate duct-ways of 900mm each on both sides beyond the length required to accommodate the formation.

c) **Concrete Girder Bridges – Deck Type Bridges** : The deck for each track shall be separate. Minimum width of deck between inside to inside of the ballast retainers will be 5.15m for straight track & for curves having a radius of 875m or more and 5.45m for curves having a radius of less than 875m. The space between the ballast retainers of UP and DN track shall be covered with precast reinforced slabs. A walkway/ duct-way with a width of 900mm shall be provided for both tracks separately. 900mm width required for the walkway/ duct-way will be additional to 5.15m / 5.45m. The walkway is to be protected with railing of 1.2 m height. All bridges shall have trolley and man refuges as per EDFC standards.

d) **Concrete Girder Bridges – Through and Semi- Through Bridges** : The deck for each track shall be separate. Minimum width of deck between inside to inside of the ballast retainers will be 5.15m for straight track & for curves having a radius of 875m or more and 5.45m for curves having a radius of less than 875m. A walkway/ duct-way with a width of 900mm shall be provided for both tracks separately. 900mm width required for the walkway/ duct-way will be additional to 5.15m / 5.45m. The walkway is to be protected with railing of 1.2 m height. All bridges shall have trolley and man refuges as per EDFC standards.

e) **Steel Girder Bridges – Non Ballasted type**: The deck for each track shall be separate. The dimension shall be as per SOD of EDFC. A steel chequered plate (minimum 6mm thick) in between two rails separately for UP and DN tracks to permit the inspecting officials to walk between the two rails, shall be provided. A walkway / duct-way with a width of 900mm shall be provided for both tracks separately. For steel truss bridges, such walkways/ duct- ways can be a cantilever outside. The walkway is to be protected with railing of 1.2 m height. All bridges shall have trolley and man refuges as per EDFC standards.

f) **Steel Girder Bridges –Ballasted type**: The deck for each track shall be separate. Minimum width of deck between inside to inside of the ballast retainer will be 5.15m for straight track & for curves having a radius of 875m or more and 5.45m for curves having a radius of less than 875m. A walkway / duct-way with a width of 900mm shall be provided for both tracks separately. 900mm width required for the walkway/ duct-way will be additional to 5.15m/ 5.45m. For steel truss bridges, such walkways/ duct- ways can be a cantilever outside. The walkway is to be protected with railing of 1.2 m height. All bridges shall have trolley and man refuges as per EDFC standards.

2.7.3.9 Clearance for FOB/ROB/RUB/LHS

Clearance for FOB/ROB will be as per SSOD for EDFC. For RUB, clearance will be as per IRC specification. For Limited Height Subway(LHS), minimum clearance as agreed by Railway and State Authorities will be provided.

2.7.4 Positional Tolerance for bridge foundations

Positional tolerances for various types of bridge foundations i.e. open foundation, pile foundation, well foundation shall be provided as per relevant IRS/BIS specifications.

2.7.5 For Concrete bridges, provisions of IRS Concrete Bridge Code will be applicable.

2.7.6 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required workability, durability and required characteristic strength. The procedure given in IS:10262 may be followed for mix design. Ready mixed concrete may be used as per provisions of IRS Concrete Bridge Code, IS:4926 (Specifications for Ready Mixed Concrete) and IS:9103.

2.7.7 Superstructure for bridges

Various types of superstructure – Steel (Solid web and open web), RCC (Slab type, T type), PSC (Slab, I-Girder, Box) and composite (Steel and concrete) may be chosen. Post tensioned precast segmental box girder construction is not permitted for this work.

2.7.7.1 Steel Superstructure

For steel superstructures, spacing and depth of girders will be as per provisions of IRS Steel Bridge Code. For road bridges and special cases of railway bridges the limits mentioned in the IRS Steel Bridge Code may be exceeded with the approval of Independent Engineer.

2.7.7.1.1 Minimum Sections

Minimum sections of steel components shall be provided as per IRS Steel Bridge Code.

2.7.7.1.2 Camber

Camber is to be provided as per provision of IRS Steel Bridge Code.

2.7.7.1.3 On non-ballasted Steel Bridges, Steel channel/H-Beam sleepers will be provided on steel superstructure.

2.7.7.2 Concrete Superstructure

Concrete wearing course of same grade as of deck slab with minimum thickness of 40 mm and cross slope of 1 in 40 shall be used on the deck of all the ballasted bridges. For pre-stressed girders, no external strands shall be allowed for permanent pre-stress. The provision for imparting 15% design pre-stress at a future date shall be made in the pre-stressed girders and suitable anchorages, bulkheads, diaphragm etc. shall be constructed for this purpose.

2.7.7.2.1 Span/Depth ratios

Span-to-depth ratio should as far as possible be restricted as indicated below:

Reinforced concrete member	-	10
Pre-stressed concrete member	-	14
Composite members	-	16

For Box girders, these ratios shall be further subject to stipulations with regard to internal dimensions required for inspection and future pre-stressing. For road bridges and special cases of rail bridges, these limits may be exceeded with the approval of Independent Engineer.

2.7.7.2.2 Design surface crack width

For the serviceability limit state of cracking, design surface crack width of reinforced concrete and pre-stressed concrete structures shall not exceed values given in IRS Concrete Bridge Code. The applicable exposure condition shall be as per prevailing site conditions and for this purpose definitions of exposure conditions as per Concrete Bridge Code shall be followed.

2.7.7.2.3 Temperature effects

Temperature effects shall be taken into account in accordance with the requirements of IRS Concrete bridge Code, where applicable.

2.7.7.2.4 Minimum thickness of members

Desirable minimum thickness of any concrete member shall be as required by IRS Concrete Bridge Code.

2.7.8 Abutments/Wing Walls/Reinforced Soil walls

All bridge abutment to be designed to carry the applicable combination of loads. Bridge abutments are to be designed with appropriated drainage system which should be adequate to drain off the expected run off without dripping along the bridge structure. Pier/Abutment cap shall have sufficient plan area so as to accommodate the inspection/access ladders & OHE mast pedestals.

To protect the adjoining slope of earthwork, wing wall/ return wall is to be provided. The wing walls are to be designed for long term deformations considering creep strains. Maximum deflection after such consideration shall be confined to L/250, where L is height of the wall.

Reinforced soil walls/slopes and other earth retaining structures may be used in RUBs as well as RFOs, but shall not be designed as an alternative to the abutments or the wing walls. Relevant specifications of Reinforced Soil Walls shall be as per para 2.6.4.11 of this manual.

2.7.9 Approach Slabs& Backfill arrangement

Back fill arrangement behind abutments shall be as per relevant RDSO guidelines. Behind Abutments and Wing walls backfill material shall be provided as per RDSO report GE-R- 50.

Transition on the approaches to the bridge from the embankment leading to the bridge shall provide a smooth passage for rail vehicles by a gradual change in the Track Modulus support stiffness with no settlement.

2.7.10 Bearings

Bearings shall be designed in accordance with the requirements of UIC 772/BS:5400/BSEN:1337/IRC:83. Concessionaire shall submit manufacturer's warranty for all types of bearings as a part of design submission. These shall

be accepted after conforming to relevant codes/manuals. Bearing of the bridges should be procured through RDSO approved source or other International reputed firm to be approved by Engineer.

2.7.11 Stray Current Corrosion Control

The continuous electrical path shall be provided by ensuring full and reliable electrical connection throughout the structure. The electrically continuous path shall be provided through the steel reinforcement, either by continuous welding of structural reinforcement or by the provision of additional welded mesh reinforcement. The continuity of current between 30 m isolated spans shall be ensured by copper connectors.

The Concessionaire shall demonstrate during construction that the electrical continuity between all metallic structures has been achieved.

2.7.12 Sampling, Strength Tests and Acceptance Criteria

Frequency of sampling & Sampling Procedure, Test Specimen, Test Strength of Sample, Standard Deviation, Acceptance Criteria and Quantity of Concrete Represented by Strength Test Results will be as per clause 8.7 of IRS Concrete Bridge Code.

2.7.13 Load Test of Structures or Parts of Structures

This will be governed by the provisions of IRS Concrete Bridge Code. For acceptance of piles, vertical and lateral load, testing of piles as required will be carried out as per procedure laid down in IS : 2911 (Pt-IV)- Code of Practice for Design and Construction of Pile Foundation -Load test on piles.

2.7.14 RUB/LHS/FOB

RUBs/ROBs/LHS/FOB including approach roads, connections, drainage facilities and road diversions etc. shall be provided as per scope of the work provided in the Concession Agreement.

Relevant provisions of Railway Board letter no. 97/CE-I/BRO/158(Policy) Pt.II, Dtd. 31.07.2009 for “Safety measures to be observed during execution of RUB works” and of Railway Board letter no. 2006/CE-I/AC-1(pt.), Dtd 27.10.2009 for “Safety precautions and measures of RUB works” are to be followed.

For locations having restriction of headway, limited height subway with vertical clearance, as agreed between Railway and Road Authorities, will be provided.

2.7.15 Codes and Standards : Following codes shall be applicable:

A: <u>Indian Railway documents</u>

Indian Railway Engineering Code

IRS Bridge Rules

IRS Bridge Sub-Structures and Foundation Code

IRS Steel Bridge Code

IRS Concrete Bridge Code

IRS Arch Bridge Code

IRS Code for Metal Arc Welding

IRS Code of practice for electric welding of mild steel structures

IRS Fabrication and Erection of Steel Girder Bridges & Locomotive Turn Tables

IRS Erection and Riveting of Bridge Girders

Indian Railway Bridge Manual

Indian Railway Manual on the design and Construction of well and pile Foundations-1985

B: IS Codes

IS: 75-1973 Linseed oil, raw and refined (Reaffirmed 2010)

IS: 77-1976 Linseed oil, boiled for paints (Reaffirmed 2009)

IS: 104-1979 Ready mixed paint, brushing, zinc chrome, priming (Reaffirmed 2009)

IS: 269-1989 Specs for Ordinary Portland cement 33 Grade Re-affirmed 2008

IS: 280-2006 Mild steel wire for general engineering purposes

IS: 383-1970 Specs for course and fine aggregate from natural sources of concrete

IS: 432-1982 Specs for Mild Steel & medium tensile steel bars (Part 1)
IS: 455-1989 Specifications for Portland Slag Cement

IS: 456-2000 Code of Practice for Plain and Reinforced Concrete – based essentially on CP-110

IS: 487-1997 Brush, paint and varnish

IS: 516-1959 Method of test for strength of concrete (Reaffirmed 2008).

IS: 800-2007 Code of Practice for General construction in steel

IS: 814-2004 Covered electrodes for manual metal arc welding

IS: 816-1969 Metal arc welding for general construction in mild steel (Reaffirmed 2008).

IS: 817-1966 Training and testing of metal arc welders (Reaffirmed 2011).

IS: 819-1957 Resistance spot welding for light assemblies in mild steel (Reaffirmed 2008)

IS: 875-1987	Code of Practice for Design Loads Parts 1,2,3,4 & 5 (other than Earthquake) for Buildings and structures (Reaffirmed 2008)
IS: 1080-1985	Code and Construction of shallow foundations in soils (Other than Raft, Ring & Shell) (Reaffirmed 2011)
IS 1148-2009	Specification for rivet bars for structural purposes
IS: 1343-1980	Code of Practice for Pre-stressed Concrete
IS: 1489-1991	Specifications for Portland Pozzolana Cement (Part 1) (Fly ash based)
IS: 1786-2008	Specs for High Strength Deformed steel bars and wires for concrete Reinforcement
IS: 1791-1985	Batch type concrete mixers Part 1) (Reaffirmed 2009)
IS: 1852-1985	Rolling and cutting tolerances for hot rolled steel products (Reaffirmed 2008)
1875-1992	Specification for carbon steel billets, blooms, slabs and bars for forgings
IS : 1888-1982	Method of Load Test on Soils (Reaffirmed 2011)
IS: 1892-1979	Subsurface investigations for foundations (Reaffirmed 2011)
IS: 1893-1984	Criteria for Earthquake Resistant Design of structures (Reaffirmed 2008)
IS: 1904-1986	Design and Construction of Foundation in soils: General Requirements
IS: 1905-1987	Code of Practice for Structural Use of Un-reinforced Masonry
IS 2004: 1991	Carbon steel forgings for general engineering purposes
IS 2062: 2011	Steel for general structural purposes – specification
IS 2074: 1992	Ready mixed paint, air-drying, red oxide-zinc chrome, priming – specification
IS 2090: 1983	Specification for High tensile steel bars used in pre-stressed concrete (Reaffirmed 2009)
IS: 2339-1963	Aluminum paints for general purposes, in dual container (Reaffirmed 2009)
IS 2386: 1963	Methods of test for aggregates for concrete (Reaffirmed 2011)
(Part 1)	particle size and shape

(Part 2)	Estimation of deleterious materials and organic impurities
(Part 3)	Specific gravity, density, voids, absorption and building
(Part 4)	Mechanical properties
(Part 5)	Soundness
(Part 6)	Measuring mortar making properties of fine aggregates
(Part 7)	Alkali – aggregate reactivity
(Part 8)	Petrographic examination
IS 2430: 1986	Methods of sampling of aggregate for concrete (Reaffirmed 2009)
IS: 2502-1963	Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement (Reaffirmed 2008)
IS 2751: 1979	Code of Practice for welding of mild-steel plain and deformed bars used for reinforced concrete construction (Reaffirmed 2008)
IS: 2911-2010	Code of Practice for Design & Constr. Of Pile Foundations Part 1Sec 1 &2) Concrete Piles
IS: 2911-1985	Code of Practice for Design & Constr. Of Pile Foundations Part 4 Load test on Piles (Reaffirmed 2010)
IS: 2950-1981	Design and Construction of Raft Foundations (Reaffirmed 2008)
IS: 3085-1965	Method of test for permeability of cement mortar and concrete (Reaffirmed 2011)
IS: 3502-2009	Steel Chequered plates
IS: 3764-1992	Safety code for excavation work (Reaffirmed 2011)
IS : 3812-2003 Pt 1	Fly ash for use as Pozzolana in Cement, Cement Mortar and Concrete
IS : 3812-2003 Pt-2	Fly ash for use as Admixture in Cement Mortar and Concrete
IS 4081-1986	Safety code for blasting and related drilling operations (Reaffirmed 2010)
IS 4082: 1996	Recommendations on stacking and storage of construction materials and components at site (Reaffirmed 2008)
IS 4138: 1977	Safety code for working in compressed air (Reaffirmed 2011)

IS4326-1993	Code of Practice for Earthquake Resistant Design and Construction of Buildings (Reaffirmed 2008)
IS 4464-1985	Code of Practice for Presentation of Drilling Information and Core Description in Foundation Investigation (Reaffirmed 2009)
IS 4736: 1986	Specification for Hot-dip zinc coatings on mild steel tubes (Reaffirmed 2010)
IS 4826: 1979	Specification for Hot-dipped galvanized coatings on round steel wires (Reaffirmed 2010)
IS: 4923-1997	Hollow Steel section for structural use specification (Reaffirmed 2009)
IS 4925: 2004	Concrete batching and mixing plant – specification
IS 4926: 2003	Ready mixed concrete – Code of Practice
IS 4968: 1976	Method for sub surface sounding for soils Pt 1 to 3 (Reaffirmed 2011)
IS 5313-1980	Guide for Core Drilling Observations (Reaffirmed 2009)
IS 5525: 1969	Recommendations for detailing of reinforcement in reinforced concrete works (Reaffirmed 2008)
IS 5529:1985	Code of practice for in-situ permeability tests : Pt 1 Test in overburden (Reaffirmed 2009)
IS 5529:2006	Code of practice for in-situ permeability tests : Pt 2 Test in bed rock (Reaffirmed 2011)
IS: 5624-1993	Foundation bolts (Reaffirmed 2008)
IS 5640: 1970	Method of test for determining aggregate impact value of soft coarse aggregate (Reaffirmed 2011)
IS: 5666-1970	Etch (Pretreatment) primer (Reaffirmed 2009)
IS 5816: 1999	Method of test for splitting tensile strength of concrete (Reaffirmed 2008)
IS 5889: 1994	Vibratory plate compactor (Reaffirmed 2009)
IS 5892: 2004	Concrete transit mixers (Reaffirmed 2009)
IS 6003: 2010	Specification for indented wire for pre-stressed concrete
IS 6006: 1983	Specification for uncoated stress relieved strands for pre-stressed concrete

IS 6403: 1981	Code of practice for determination of bearing capacity of shallow foundations (Reaffirmed 2011)
IS: 6586-1989	Metal spraying for protection of iron steel (Reaffirmed 2010)
IS: 6925-1973	Methods of test for determination of water soluble chlorides in concrete admixtures (Reaffirmed 2008)
IS 7205: 1974	Safety code for erection of structural steel work (Reaffirmed 2010)
IS: 7215-1974	Tolerances for fabrication of steel structures (Reaffirmed 2010)
IS 7293: 1974	Safety code for working with construction machinery (Reaffirmed 2011)
IS 7320: 1974	Specification for Concrete slump test apparatus (Reaffirmed 2008)
IS 7861:1975	Code of practice for extreme weather concreting : Pt 1, Recommended Practice for hot weather concreting (Reaffirmed 2011)
IS 7861:1981	Code of practice for extreme weather concreting : Pt 2, Recommended Practice for cold weather concreting (Reaffirmed 2011)
IS 7969: 1975	Safety code for handling and storage of building materials
IS 8009	Calculation of settlement of foundations
Part 1 1976	Shallow Foundations Subjected to Symmetrical Static Vertical Loads (Reaffirmed 2008)
Part 2 1980	Deep Foundations Subjected to Symmetrical Static Vertical Loading (Reaffirmed 2010)
IS 8041:1990	Specification for Rapid – hardening Portland cement (Reaffirmed 2009)
IS: 8112-1989	Specification for 43 Grade Ordinary Portland cement (Reaffirmed 2009)
IS 8142: 1976	Method of test for determining setting time of concrete by penetration resistance (Reaffirmed 2011)
IS 9013: 1978	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens (Reaffirmed 2008)
IS 9103: 1999	Admixtures for concrete (Reaffirmed 2008)

IS 9284: 1979	Method of test for abrasion resistance of concrete (Reaffirmed 2011)
IS 9417: 1989	Recommendations for welding cold worked bars for reinforced concrete construction (Reaffirmed 2008)
IS 9556:1980	Code of practice for design and construction of diaphragm walls (Reaffirmed 2008)
IS 9595: 1996	Recommendations for metal arc welding of carbon and carbon manganese steels (Reaffirmed 2007)
IS 10262: 2009	Recommended guidelines for concrete mix design
IS: 12070-1987	Code of Practice for Design and Construction of Shallow Foundations on Rocks (Reaffirmed 2010)
IS 12269 1987	53 grade ordinary Portland cement (Reaffirmed 2008)
IS: 13920-1993	Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces (Reaffirmed 2008)
IS: 14268-1995	Uncoated Stress Relived Low relaxation Seven-ply Strands for Pre-stressed Concrete (Reaffirmed 2008)
IS: 14593-1998	Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks-Guidelines (Reaffirmed 2008)
IS 15388: 2003	Specifications for Silica Fume (Reaffirmed 2007)
SP	SP 6, 7, 16, 21, 23, 24, 34, 36

C: List of IRC Codes / Standards / Acts for Road/Bridge Works

IRC: 3 -1983	Dimensions and weight of Road Design vehicles. (First Revision)
IRC: 5 -1998	Standard Specification & Code of Practice for Road Bridges, Section I – General Features of Design (7th Revision)
IRC: 6 -2010	Standard Specifications & Code of Practice for Road Bridges, Section II – Loads and Stresses (Fourth Revision)
IRC: 15 -2011	Specifications & Code of Practice for Construction of Concrete Roads (Third Revision)
IRC: 16 -2008	Specification for Priming of Base Course with Bituminous Primers (First Revision)
IRC: 18 -2000	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Third Revision)

IRC: 20 -1966 Recommended Practice for Bituminous Penetration Macadam (Full Grout)

IRC: 21 -2000 Standard Specifications and Code of Practice for Road Bridges. Section-III Cement Concrete (Plain and reinforced) (Third revision)

IRC: 22 -2008 Standard Specifications and Code of Practice for Road Bridges. Section-VI Composite Construction (First Revision).

IRC: 32 -1969 Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads

IRC: 38 -1988 Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision)

IRC: 40 -2002 Standard Specifications and Code of Practice for Road Bridges, Section IV - Brick, Stone and Block Masonry (Second Revision)

IRC: 54 -1974 Vertical Clearances at Underpasses for Vehicular Traffic

IRC: 56 -2011 Recommended Practice for Treatment of Embankment Slopes for Erosion Control

IRC: 57 -2006 Recommended Practice for Sealing of Joints in Concrete Pavements

IRC: 67 -2012 Code of Practice for Road Signs (First Revision)

IRC: 69 -1977 Space Standards for Roads in Urban Areas

IRC: 73 -1980 Geometric Design Standards for Rural (Non-Urban) Highways

IRC: 75 -1979 Guidelines for the Design of High Embankments

IRC: 78 -2000 Standard Specifications and Code of Practice for Road Bridges. Section-VII Foundations &Sub-structure (Second Revision)

IRC: 83 -1999 Standard Specifications and Code of Practice for Road Bridges. Section-IX Bearings, Part-I: Metallic Bearings

IRC: 83 -1987 Standard Specifications and Code of Practice for Road Bridges, Section-IX Bearings, Part-II : Electrometric Bearings

IRC: 83 -2002 Standard Specifications and Code of Practice for Road Bridges, Section-IX Bearings, Part-III : POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS

IRC: 84 -1983 Code of Practice for Curing of Cement Concrete Pavement

IRC: 86 -1983 Geometric Design Standards for Urban Roads in Plains

IRC: 98 -2011 Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Area (First Revision)

IRC: 101 -1988 Guidelines for design of continuously reinforced concrete pavement with elastic joints

IRC: 102 -1988 Traffic studies for planning bypasses around towns.

IRC: 103 -2012 Guidelines for Pedestrian Facilities

IRC: SP: 33 Guidelines on Supplemental Measures for Design, Detailing & Durability of Important Bridge Structures

IRC: SP: 35 Inspection and Maintenance of Bridge

IRC: SP: 42 Guidelines on Road Drainage

IRC: SP: 44 Highway Safety Code

IRC: SP: 47 Guidelines on Quality System for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete)

IRC: SP: 50 Guidelines on Urban Drainage

IRC: SP: 51 Guidelines for Load Testing of Bridges

IRC: SP: 59 Guidelines for Use of Geotextiles in Road Pavements and Associated Works

IRC:SP-67 Guidelines for use of external pre-stressing in bridge structures

D: MOSRT&H Documents

MOSRT&H Standard Plans for 3.0 m Span Reinforced Cement Concrete Solid Slab Superstructure with and without Footpaths for Highways, 1991

MOSRT&H Standard Plans for Highways Bridges R.C.C. T-Beam & Slab Superstructure - Span from 10 m to 24 m with 12 m width, 1991

MOSRT&H Standard Plans for Highway Bridges PSC Girder and RC Slab Composite Superstructure for 30 m Span with and without Footpaths, 35 m Span with Footpaths and 40 m Span without Footpaths, 1991

MOSRT&H Standard Drawings for Road Bridges -R.C.C. Solid Slab Superstructure (15* & 30* SKEW Span 4.0 m to 10.0 m (with and without Footpaths), 1992

MOSRT&H Standard Drawing for Road Bridges R.C.C. Solid Slab Superstructure (22.5* SKEW) R.E. Span 4M to 10M (with and without Footpath), 1996

MOSRT&H Addendum to Ministry's Technical Circulars and Directives on National Highways and Centrally Sponsored Road & Bridge Projects (Jan. 93 to Dec. 94), 1996

Standard Plan for Highway Bridges –Pre-stressed Concrete Beam & RCC Slab Type Superstructure - Volume –II MOSRT&H Addendum to Technical Circulars & Directives on National Highways & Centrally Sponsored Road & Bridge Works Projects (Jan. 1995 to Dec. 1997)

MOSRT&H Standard Plans for Single, Double and Triple Cell Box Culverts with and without Earth Cushion Manual for Safety in Road Design MORT&H Manual for Construction and Supervision of Bituminous Works, 2001

E: Foreign Codes and specifications

AASHTO		Guide specifications for Design and Construction of segmental concrete Bridges
Structural Engineering Documents No.6 of IABSE, 2002		Structural Bearings and Expansion Joints for Bridges
BS 410	2000	Specification for test sieves
BS 812	1999	Testing aggregates
BS 1154	2003	Specification for natural rubber compounds
BS 5400	Pt 1-10	Steel concrete and composite bridges
BS 5400	Part 9.1, 1983	Steel Concrete and Composite Bridge Bearings. Code of Practice for Design of Bridge Bearings
BS 5400	Part 9.2, 1983	Steel Concrete and Composite Bridge Bearings. Specification of materials, manufacture and installation of Bridge Bearings
BS 5930	1999	Code of Practice for Site Investigations
BS 8006	Part1, 2010	Code of Practice for strengthened/Reinforced soils and other fills
BS 8110	Part 1, 1997	Structural use of Concrete : Code of practice for design and construction
BS EN 1337	Part 2: 2004	Structural bearing sliding element
BS EN 1337	Part 3: 2005	Structural bearing : Elastomeric bearing
BS EN 1337	Part 4: 2004	Structural bearing : Roller bearings
BS EN 1337	Part 5: 2005	Structural bearing : POT bearing
BS EN 1337	Part 6: 2004	Structural bearing : Rocker bearings

BS EN 1337	Part 7: 2004	Structural bearing : Spherical and Cylindrical PTHE bearings
UIC-772R:		Bearings of rail bridges
FHWA-NHI-10-024		Geotechnical Engineering Circular no. 11- Design and construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes

Other Publications

(i) CEB – FIP Model Code;
(ii) Indian Standard Hand Book on Steel Sections (Part I);
(iii) PCI STD-112-84 – Standard Prestressed Concrete Piles;
(iv) CIRIA C660 – 2007 – Early Age Thermal Crack Control in Concrete; and
(v) UIC-774-3R-Track/Bridge Interaction-Recommendations for circulations.
(vi) IITK-RDSO Guidelines on Seismic Design of Railway Bridges, Nov 2010

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2.8 TRACK

Track structure selected for the Project shall:

(i) Ensure highest levels of safety, reliability, and comfort;

(ii) Be of proven design

(iii) Require minimum maintenance and;

(iv) Be long lasting.

2.8.1 Track Requirements

2.8.1.1 Track Design

Track layout and track component shall be based on the provisions contained in Indian Railways Permanent Way Manual, Track Manual & relevant IRS specifications with latest amendments/corrections up to the base date. Wherever, design features deviates from above provisions, these are to be fully justified by the concessionaire, based upon acceptable international practice and are to be agreed by the Independent Engineer.

Concessionaire shall use track components which are approved by RDSO. Wherever concessionaire intends to use other than RDSO approved components, approval of RDSO shall be obtained for the same.

2.8.1.2 Design Documentation

Apart from the general requirements, the Concessionaire shall submit the following documentation to the Independent Engineer, for review and approval:

(i) Description of Permanent Way, its functional requirements, technical requirements and how these requirements are proposed to be met. This shall be supported by drawings of layouts and components:

(ii) Geometry of rail and track including tolerances for their installation;

(iii) Tolerances of track before and immediately after maintenance;

(iv) Rail lubrication system, if proposed;

(v) Rail flaw detection proposals;

(vi) Full details of all welding processes including Test plan before welding, quality assurance plan, and quality procedures to ensure controlled cooling;

(vii) Track side signs to indicate reference data for the alignment, curve radius, super elevation, transition curves, vertical curves etc.

(viii) Test plan before commissioning

(ix) Plan for preventive rail grinding irregularities in the railhead and gauge face to ensure smooth running and decreased noise production; and

(x) Packing of track by On Track Machines.

(xi) Maintenance Manual, covering visual and machine based inspection of track, Scheme of deployment of machines and manpower for inspection and maintenance, Schedule of inspections, renewal of assets including criteria for renewal. Key Performance Indices as included in Concession Agreement shall be adhered to.

2.8.1.3 Maximum Speed

The track shall be designed to carry 25 T loading 2008 at speed of 100 kmph.

2.8.1.4 Track Gauge

Track shall be laid down to Broad gauge of 1676 mm, the track gauge being the distance between the inner sides of the head of rails measured 14 mm below top of rails.

2.8.2 Track Structure

Concessionaire shall follow track component suitable for 25 T axle load. Indian Railways has developed drawings for 25.0 ton axle load for various track components, which are under trial. Concessionaire may refer these drawings and if the Concessionaire is satisfied that it meets the Employer's requirement, he may use the same. Some of IR Drawings are for 1673 track gauge which differs from DFC Track Gauge and will need suitable modifications. List of RDSO Drawings is indicated below :

1	Pre-stressed Concrete Sleeper for 25 tone Axle Load for BG	RDSO / T - 7008
2	Rail seat Assembly on concrete sleeper with 60 kg UIC rails	RDSO / T- 7009
3	ERC MK V	RDSO / T- 5919
4	10 mm thick composite GRSP	RDSO /T – 7010
5	Fish plates and Fish bolts for UIC 60 rail	RDSO /T- 5916
6	Weldable CMS crossing	RDSO /T - 6412
7	Switch Expansion Joints (SEJs)	RDSO / T-6902 RDSO /T - 6922
8	Fish plates and Fish bolts for UIC 60 rail	RDSO /T- 5916
9	Prestressed concrete sleeper for SEJ for long welded rails, BG 1676mm, 60kg (UIC)	RT- 8224 SEJ
10	PSC sleeper for BG (1676 mm), 60kg (UIC) running rail & 60kg(UIC) guard rail on Bridge approaches	RT - 8229 Bridge Approach
11	PSC guard rail sleeper for 60 kg running rail & 60 kg (UIC) guard rail for BG (1676 mm)	RT- 8228 Ballasted Bridge Deck
12	PSC sleeper for level crossing with 60 kg (UIC) running rail, 52 kg check rail for 25 tonne axle load BG (1676 mm)	RT - 8225 Level Crossing
13	Rail seat assembly for level crossing on PSC sleeper with 52 kg check rail for BG (1676 mm) 60 kg (UIC)	RT- 8226 Level Crossing
14	CI Bracket for 52kg check rail to be used on PSC sleeper BG (1676mm) 60 kg (UIC)	RT- 8227 Level Crossing
15	Glass filled Nylon- 66 insulating liner for use with ERC mk-V on concrete sleeper (RT – 7008) suitable to 60kg UIC rail for 1676mm gauge	RT- 8222 & RT-8223 Rail Seat
16	Metal Liners	RDSO/T-8254 to RDSO/T-8256

2.8.2.1 RAILS

All the rails to be laid in the track structure shall be Flat Bottom Rails as per specifications: IRS T-12-2009. Only new rail will be used for permanent work. The broad requirements are as under:

a) Rail Steel Grade: 880

b) Rail Section Profile: As per Appendix-II of IRS T-12-2009 for UIC 60

c) Class of Rail: A

d) Rail Ends: Undrilled

e) Color Code: As per Appendix IV of IRS T12-2009

f) The manufacturer of the rails shall operate an independently approved and audited Quality Assurance System (QAS), conforming to the requirements of ISO 9000 or equivalent.

g) The standard length of rails shall be 13.0 meters or more.

h) Rails of not more than 2m shorter than the standard length to be supplied in pairs may be accepted up to 10% the total quantity of rails required in the contract.

i) The rails must be free from all detrimental defects having an unfavorable effect on the behavior of the rails in service, such defects include, among others, surface defects & internal defects like cracks of all kinds, flaws, piping, or lack of metal, hot or cold marks, seams, scabs, protrusions etc,.

j) The Concessionaire is free to purchase rails from any domestic or international supplier.

k) The manufacturing process of rails shall be offered to the inspecting agency at the beginning & at intervals. Independent Engineer shall be entitled to observe, by day or night, the method of manufacture and to be present at all tests relating to all batches of casting used for the PPP project.

l) A method statement, describing in detail the precautions that will be taken during handling and transport of rails, will be prepared by the concessionaire and submitted for the approval by Independent Engineer. The guidelines issued vide RDSO drawing no. RDSO/T-6219 will be strictly followed.

m) Third party, selected by Employer, at his discretion may inspect the rails on arrival at site against any bruising, rubbing nicks and any other damage, reject them and order for their removal from site, if found damaged.

n) Use of rails with holes shall not be allowed unless specifically permitted by the Independent Engineer for specific locations. If required in exceptional cases, the holes shall be suitably hardened for its fatigue improvement by carrying out well established cold rail-hole expansion technology. The equipment and methodology for the same shall be agreed by the Independent Engineer prior to making holes in the rails.

o) Drilling of holes required for earthing and bonding will be done by the Concessionaire at appropriate locations after approval of Independent Engineer.

2.8.2.2 CONTINUOUS WELDED RAIL TRACK

a) Rail panels, after laying in track, shall be welded to make Continuously Welded Rail (CWR) track for as much length as possible, for which the Concessionaire shall prepare the CWR plans for the approval of the Independent Engineer. In addition to bridges, CWR shall be continued through the turnouts. The temperature range for the fastening of CWR rail to the sleepers without the distressing operation shall be as per the provisions of LWR manual.

b) CWR tracks lengths installed outside this temperature range shall be distressed before the laying and final setting of Switch Expansion Joints (SEJ) at the end of breathing length.

c) De-stressing of the LWR/CWR shall be carried out as required by the provisions of the LWR Manual.

d) Rails after distressing shall be checked by a non-destructive rail stress measuring equipment to verify the correctness of the distressing temperature. Concessionaire shall arrange such testing equipment in adequate numbers on its own, which shall also be made available to the Independent Engineer for this purpose.

e) The Concessionaire shall submit detailed process of neutralization of stresses in the rails during construction ensuring that the rails in track remain distressed in the prescribed temperature range and shall form part of CWR plans submitted by the Concessionaire.

2.8.2.3 Welding of Rails

a) The rail panels, used for CWR track shall be of length not less than 260m. All rails joints shall be welded in construction depot or manufacturing unit using Flash Butt welding process.

b) The rail panel of length 260m or more shall be welded together in-situ to make LWR/CWR panels as per the approved plans using mobile flash butt welding plant. In special locations where the use of mobile flash butt welding plant is not practicable latest RDSO approved Alumino Thermic (AT) weld process may be used, with prior permission of the Independent Engineer. The detailed process of rails welding shall be submitted along with acceptance test & acceptance criteria by the Concessionaire for approval by the Independent Engineer. The design concepts & performance criteria for flash butt welding of rail joints are given in detail in Indian Railway Manual for Flash Butt Welding of Rails.

2.8.2.4 TURNOUTS AND DERAILMENT SWITCHES

a) Turnouts and derailing switches shall be used with following parameters:

i.	Gauge	1676mm
ii.	Crossing Angle (on main lines and loop lines)	1 in 12
iii.	Rail Profile	UIC 60
iv.	Speed potential on the main lines	100 kmph
v.	Axle Load	25 tone
vi.	Designed Annual Traffic	> 50 GMT
vii.	Type of Web	Thick web
viii.	Tangential entry and the switch entry angle	≤ 0^0-20'-00''

b) The Concessionaire shall also carry out detailed design including design of interlocking arrangements, manufacturing and assembling of the turnout and derailing switches suitable for above requirements.

c) LWR/CWR shall be carried through the turnout assembly.

d) The left hand and right hand turnouts shall be designed with common concrete bearers (PSC fan-shaped layout) and shall have provision of anti-creep fastenings and other relevant fastenings and fixtures

e) Installation and maintenance of turnouts will be compatible to signaling systems The turn-outs shall meet with all the provisions set out in Para 12.40 of chapter XII of Indian Railways Signal Engineering Manual.

f) Prior to the mass procurement of turnout, at least one turnout shall be completely pre-assembled for inspection and clearance by the Independent Engineer.

g) All turnouts shall be pre-assembled at a workshop. After these are cleared by the Independent Engineer, these shall be dismantled and carried to site in special vehicles for assembling using cranes.

h) For manufacturing stock, lead, intermediate sections and closure rails, 90 UTS (UIC 60 kg/m) section with IRS: T-12-2009 specifications of rail shall be used.

i) For switch rails, thick web section manufactured out of asymmetrical rail section shall be used. Both switch & stock rails shall be of special grade steel (minimum 1080 grade as per IRS: T-12-2009) and have hardened heads for better life.

j) The rails, for the turnouts, shall have no drilled holes. Drilling of holes will be required for connecting the interlocking arrangements and will be done by the Concessionaire at appropriate locations. Concessionaire shall provide necessary interfacing arrangements in this regard.

k) Turnouts shall not be manufactured from any larger sections of rails and all rails so used shall be defect free rails.

l) Each thick web device shall consist of 2 stock rails, one left hand and one right hand and two switch rails, one left hand and one right hand, complete set of PSC sleepers along with all fittings e.g. slide chairs, base plates/special base plates, brackets, rail pads, insulating bushes, washers, all stretcher bars, various blocks, bolts and nuts, any special fitting like spring setting device etc..

m) The switch rail shall be one piece without any weld or joint within the switch rail length.

n) The end of the asymmetrical switch rail shall be forged to UIC 60 rail profile and shall be suitable for welding or for installation of insulated glued joint.

o) The switch shall provide suitable flange way clearance, between the stock rails and switch rail at the end of the head in open position as per SSOD for EDFC.

p) In the cleared position, the switch rail shall house properly against the stock rail and shall bear evenly against all the distance blocks and slide base plates.

q) Spring setting device (concessionaire may refer IR drawing number RDSO: T-6216, which is under trial) / double pull arrangement is recommended to secure the housing of tongue rail with stock rail.

r) The turn-out system shall be designed to prevent the switch lifting

s) Switches made from asymmetrical thick web rails shall be machined carefully to achieve the profile at different locations. Such machining is required to be done by CNC millings machine to achieve correct profile and good quality.

t) The manufacturer shall be responsible to make provisions in switches (stock rail and switch rail) for all the required connections for point machine, clamp lock and any other provisions necessary for connecting the signaling equipment duly interfacing with signaling systems.

u) The fitting for intermediate rails shall be suitably designed to ensure full compatibility and effective fixation of the rails with PSC sleepers with the desired toe loads as that of the elastic fastening in the main line.

v) All crossing on the DFC track shall be 1 in 12 weldable Cast Manganese Steel (CMS) (manufactured from Austenitic Manganese steel as defined in IRS: T-20-2000) crossing for the turnouts. In this regard, Concessionaire may refer Indian Railways drawing no: RDSO/T-6412.

w) All CMS crossings shall be welded with intermediate piece and other end of the intermediate piece shall have welded leg extension of 60 Kg UIC 880 grade rails. This shall have to undergo test regime to be proposed by concessionaire and approved by Independent Engineer.

x) Check rails in all turnouts shall have the facility for the adjustment of check rail clearances up to 10mm over and above the initial designed clearance.

y) Each check rail end shall be properly flared by machining.

z) Fastenings for the turnouts shall be elastic type and compatible with the main line rail to sleeper fastening system.

aa) The design of the fastening for the turnouts shall be suitable for 25 tonne axle load and 60 Kg UIC section of rails laid in PSC sleepers confirming to Indian Railway Standards or UIC Code or other International Code of Practice.

2.8.2.5 PRESTRESSED CONCRETE SLEEPERS

A) General Requirement and Parameters

Mono-block pre-stressed precast concrete sleepers shall be used on all DFC tracks for main lines, loop lines, sidings shall conform to specifications as per IRS T-39. PSC Sleeper will conform to following general requirements and parameters.

a)	Gauge (measured at 14 mm from the top of the rail)		1676 mm
b)	Maximum speed of trains		100km/h
c)	Traffic Density		>50 GMT per year
d)	Maximum Axle Load		25.0 tones
e)	Electrical resistance	(to suit 2 x 25KV AC)	As per design code

f) Ballast cushion below bottom of sleeper is to be a minimum of 350mm on main lines and 250mm in other lines in the yard lines. Slope of ballast profile below the sleeper shall be taken as H: V = 1.5:1

g) Design life 40 years

B) Design parameters for the PSC sleepers

The important design parameters to be considered for the PSC sleepers shall be:

a) Design load and ballast reaction are to be as set out in the applicable RDSO standards for PSC sleepers.

b)	Ballast pressure	6 kg/cm²
c)	Load distribution factor	0.55
d)	Dynamic augment for speed and rail wheel	2.5
e)	Centre binding co-efficient	0.4
f)	Factor of safety for resisting bending moment	2
g)	Load factor at rail seat bottom for bending moment	3
h)	Cracking load of Centre Top	65 KN
i)	Cracking load for centre bottom	60 KN
j)	Cracking load for rail seat	270 KN
k)	Failure load at rail seat	490 KN
l)	Initial pre stress force	up to 75% of breaking load
m)	Losses in pre stress	30% of initial pre stress or as per actual
m)	Minimum Compressive strength (f_c)	60 N/mm²

o) Minimum Compressive strength prior to the transfer of the pre-stress load is to be 40 N/ mm²

p) Minimum bending stresses

a)	Compressive	0.4 f_c
b)	Tensile	0.04 f_c
c)	Modulus of rupture	5.0 N/ mm²

q) Cement shall conform to IRS: T-40 or any other similar or equivalent International Standards.

r) HTS in the form of plain wires or strands shall conform to IS: 1785 – Part-I and IS: 6006 respectively or equivalent International Standards.

C) Design Qualification Tests

The Design of all types of PSC sleepers and elastic fastenings with rail will be agreed by the Independent Engineer before manufacturing process is initiated by the Concessionaire. Design for the concrete sleepers and fastenings shall be subjected to qualification tests, as listed below, which require that 40 pre-production sleeper from 3 separate concrete pours be tested

The Independent Engineer shall select 8 separate complete sleepers plus 3 sleepers which shall be cut in half to produce 3 sleeper blocks equipped with rail fastening system identical to that on the concrete sleepers furnished for testing.

Minimum Design Qualification Tests

Test Type	Track Sleeper	Turnout Sleeper
Rail Seat Vertical Load Test	X	X
Centre Moment Test	X	--
Rail Seat Repeated Load Test	X	X*
Fastener Insert Test	X	X*
Fastener Uplift Test	X	X*
Fastener Repeated Test	X	X*
Lateral Load Restraint Test	X	X*
Longitudinal Restraint Test	X	X*
Bond Development or Tendon Anchorage Ultimate Load Test	X	X
Rail Pad Test	X	X*

X = Test required

X* = Test not required if the fastening system provided is identical to the fastening system for concrete track sleepers, and the test on the track concrete sleeper has been successful.

Pre-stressed concrete sleeper for special locations like bridge approaches, derailing, switches, SEJ, level crossings etc shall also have to follow a similar process. The “design qualification test” results shall from part of Design process of sleepers.

D) Manufacture of PSC Sleepers

The Concessionaire shall submit for the Independent Engineer's agreement, his proposed method of manufacturing of pre-stressed concrete sleepers which shall cover the following in addition to the technical specification for manufacturing and supply of plain line PSC sleeper and technical specification for manufacturing and supply of turnout PSC sleeper:

a) Manufacturing method
b) Moulds
c) Production machines
d) Moulding/de-moulding
e) Mould cleaning
f) Pin and spacer bar assembly/removal
g) Wire hauling/placement
h) Tensioning equipment
i) Concrete placing/ vibrating
j) Control of minimum strength at transfer
k) Curing
l) De-tensioning and wire cutting
m) Loading handling, storage and transportation

The proposed method of manufacturing must have been used for manufacturing mono-black PSC sleepers which have already been laid in tracks and have given satisfactory performance in similar environmental conditions.

E) Manufacturing Tolerances

Item	Tolerances
Length	+/- 3mm
Maximum top width of the sleeper	+1 mm & - 0.5 mm
Maximum width of the base of the sleeper	+/- 3 mm
Height at centre of rail seat	+4.5 mm & -3 mm
Track Gauge	+/- 1 mm
Rail Cant	1 in 19.75/1 in 20
Rail Seat plane	+/- 0.8 mm
Differential tilt of rail seats	Shall not exceed 1.5 mm
Convex or concave camber in any direction on rail seat	Shall not exceed 0.8 mm

F) Inspection and Quality Control

The quality control test regime shall be submitted by concessionaire and will be approved by Independent Engineer as part of initial design approval. Concessionaire may follow stage tests and quality control checks as described in IRS:T-39-1985 (4th revision –August 2011).

2.8.2.6 RAIL TO SLEEPER ELASTIC FASTENING SYSTEM

Track laid on PSC sleepers, shall be equipped with self tensioning elastic fastening system, having the following components:

a) Elastic fastening clip compatible with the rail/sleeper assembly having a nominal toe load on the rail of 1045kg.

b) Cast in insert as to suit the elastic fastening.

c) An under rail pad compatible with toe load, sleeper and rail profile.

d) Insulated liner to suit the clip and fastening system. In this regard, Concessionaire may refer IR drawing no. RDSO/RT-8222/8223.

e) Concessionaire shall furnish relevant analysis and simulation data to the Independent Engineer to substantiate that all fastening shall have a minimum service life of 07 years after laying in track except rubber pad which shall have a minimum service life of 05 years.

The components set out above should be compatible with each other and provide an effective fastening system so as to ensure effective sleeper to rail resistance is more than sleeper to ballast resistance with adequate factor of safety.

The fastening assembly shall be subjected to ‘Design Qualification Tests” along with the PSC sleepers for which the acceptance values derived on the basis of the design shall be submitted along with design details.

2.8.2.7 INSULATED GLUED JOINTS

All Insulated Glued Joints (IGJs) shall be factory manufactured to be compatible with the IRS T-12-2009, UIC 60 rail of 880 grade. The Glued Insulated Rail Joints shall comply with the requirements of RDSO’s Manual for Glued Insulated Rail Joints of 1998 with latest amendments up to the base date. Concessionaire shall submit, complete design details along with acceptances tests to the Independent Engineer for prior approval before procuring the same.

2.8.2.8 SWITCH EXPANSION JOINTS

a) Switch Expansion Joints (SEJs) shall be manufactured from rail compatible with the rail proposed for the CWR.

b) Concessionaire may refer IR drawing RDSO RT-6902 for 60 kg (80mm gap), RT-6922 for 60kg (65mm gap).

c) Concessionaire shall submit, complete design details along with acceptances tests for prior approval by Independent Engineer before procuring the same.

d) SEJs shall be manufactured and supplied with all corresponding PSC sleepers, fitting, fastening and fixtures as required for easy installation into track.

2.8.2.9 BALLAST

a) All ballast shall be procured from the quarries approved by the Independent Engineer.

b) All ballast shall be machine crushed and comply with the specifications set out in IRS GE 1 June 2004. Frequency for quality tests shall be proposed by the concessionaire as part of technical proposal for approval by Independent Engineer

c) Minimum ballast cushion and ballast profile below the bottom of sleeper on main lines and on other lines in the yard shall be 350 mm and 250 mm respectively.

2.8.2.10 FISH PLATES AND FISH BOLTS

Fish plates and fish bolts for UIC 60 rail shall be of the 6 bolt type. Inthis regard, Concessionaire may refer IR Drawing No-T-5916 &relevant technical specification IRS:T-1 of 1996.

2.8.2.11 Friction Buffer Stops

Properly designed Friction type Buffer Stops will be provided in the station yards at the end of over run lines and at buffer ends provided at the station. These friction buffer stops for over run line will be designed for a train load of 6500 tons, coasting at a speed of 10 Kmph. At other locations, the design of friction buffer stops will be site dependent and shall take into account the maximum vehicle mass, probable impact speed and available stopping distance at the location etc. Design of the friction type buffer stops shall be of the type that is being adopted by heavy haul railways operating under similar conditions as on DFC.

2.8.2.12 PERMANENT MARKERS

Upon completion of the track installation following permanent markers shall be provided as per IRPWM and prior approval by the Independent Engineer of their information, plates/boards, colour scheme and fixation arrangement:

a) Kilometer markers;
b) Change of gradient markers;
c) Curve reference markers;
d) LWR/CWR references markers;
e) SEJ markers including its references markers;
f) Fouling point markers;
g) Turnout markers;
h) Land Boundary markers;
i) Level crossing markers and 'W' Boards for level crossings;
j) Bridges boards/signage's;
k) Fog signal locations; and

l) All markers required to be painted on rails for curves, turnouts and SEJs etc. shall be paint marked by the concessionaire as per IRPWM.

2.8.2.13 Track Tolerances for ballasted track (Installation tolerances)

The dimensional tolerances at the time of installation shall comply with the following:

Measurements in Floating condition: The track Parameters will be measured in floating condition (unloaded condition) of track. All the parameters, so measured, must comply with the following tolerances:-

1. **Maximum Variation from designed Alignment**
   a. Vertical: ± 10 mm
   b. Horizontal: ± 10 mm

2. **Track Geometry Parameters**

2.1 Gauge (with reference to 1676 mm – to be checked every 10 sleepers at 14 mm below head of rail)

a. Maximum variation over the prescribed track gauge: +3/0 mm
b. Maximum variation in track gauge from sleeper to sleeper: 1 mm per sleeper.
c. Average track gauge over 100 m length: + 1.8 mm to 0 mm.

2.2 Misalignment: ± 5 mm on 20 m chord base

2.3 Unevenness : + 2 mm to -1 mm on 10 m chord base

2.4 Versines on Horizontal curves and Transitions
(to be measured on 20 m chord)
a. Maximum deviation of versine on a 20 m chord: ± 5 mm

2.5 Cant / Cross levels (to be measured every 3 m)
a. Straight and curved track: ± 3 mm
b. Sleeper to sleeper variation of cant /cross level : ± 1 mm

2.6 Twist (to be measured every 3 m)
a. On Straight or circular curved track: ± 1 mm/m
b. On transitioned curves: ± 0.5 mm /m over designed value.

3. **Fishplate Joints**
   a. Squareness of fish plated joints across the track: ± 10 mm

4. **Turnouts** (max variation from the designed position)
   a. Stock Rail joint in the longitudinal section: ± 15 mm
   b. Nose of Crossing in a cross over: ± 10 mm
   c. Flange way clearance at the end of switch planing: +5 mm to – 0.0 mm
   d. Switch Toe Opening: +1 mm to – 0.0 mm
   e. Switch Toe squareness: 5 mm
   f. Deviation of measured versine over the design value for the switches, intermediate track and curved crossings (measured over a 6 m overlapping chord): ± 3 mm
   g. Sleeper spacing: ± 10 mm
   h. Sleeper out of square: ± 5 mm

5. **Switch Expansion Joints** (max variation from the designed position)
   a. Gap at the opening of SEJs: ± 2 mm
   b. Out of squareness of switch rails of SEJs: ± 2 mm
   c. Gauge at SEJs: ± 1 mm

Note: No individual component shall exceed the track tolerance limits as above.

2.8.3 Mechanized Maintenance: The Concessionaire shall make provision for mechanized maintenance of the track infrastructure using latest technology prevalent globally. This includes mechanized Ultra Sonic Flaw Detection by means of self driven / Manually pushed probing equipment, Mechanized recording of track parameters, mechanized ON-Track and OFF -Track tamping equipment, mechanized ballast profiling, regulating & screening equipment, mechanized equipment for handling and transportation of track spares etc. The Concessionaire shall ensure availability of essential spares & Tools for the quick maintenance of track system.

2.8.4 Mechanized laying of track

The Concessionaire shall plan and work out the methodology of track construction in various stages as per the requirements in consultation and approval of Independent Engineer taking into account the contractors' coordination and integration responsibilities with the inter-facing contractors.

The track construction shall be done by using mechanical track laying method. For this purpose, Flash Butt Welding of free rails will be carried out in Flash Butt Welding Plants under controlled conditions to form rail panels of length 260 m or more. Track laying at site will be carried out by deploying track laying train, tamping machines, dynamic track stabilizers, shoulder ballast compactors etc.

2.8.5 List of documents

A : IR Manuals

S.N	Description
1	Indian Railway Permanent Way Manual
2	Manual for Glued Insulated Rail Joints, 1998
3	Manual for Flash Butt Welding of Rails, 2012
4	Manual for fusion welding of rails by the Alumino- Thermic Process, Revised, 2012
5	Manual of instructions on Long Welded Rails, 1996
6	Manual for Ultrasonic Testing of Rails & Welds, Revised 2012
7	Manual for reconditioning of Medium Manganese (MM) Steel/ Points and Crossings, Switch Expansion Joints (SEJ's) and Manganese Steel Crossing (CMS) 1996
8	Track Manual Volume-I 1994
9	Track Manual Volume-II 1989
10	Track Machine Manual
11	Small Track Machine Manual, July 2005

B: IR Specifications

S.N	Description	Specification No.
1	Fabricated Switches and crossings, welded/heat treated crossings and switch expansion joints (SEJ)	IRS. T-10-2000
2	Flat bottom railway rails	IRS. T-12-2009
3	Fangs, bolts and nuts	IRS. T-13-66
4	Inspection trolleys, material trolleys or lorries and duplicated lorries	IRS. T-15-67
5	Rail/plate screws	IRS. T-16-81
6	Fusion welding of rails by Alumino-thermic process	IRS. T-19-1994
7	Track bolts and nuts	IRS. T-23-67
8	Rail Anchors	IRS. T-24-65
9	Non-infringing track jacks of 5 tonnes capacity	IRS. T-27-72
10	High tensile fish bolts and nuts.	IRS. T-28-73
11	Cast Manganese Steel Crossings	IRS. T-29-2000
12	Elastic Rail Clip	IRS. T-31-1992
13	Grooved Rubber Sole Plates 4.5 mm thick	IRS. T-37-1982
14	Pre-tensioned Pre-stressed Concrete Sleeper for Broad gauge and meter gauge	IRS. T-39-85
15	Special grade cement for use in concrete sleepers	IRS. T-40-1985
16	Single Coil Spring Washer	IRS. T-42-1988
17	Glass Filled Nylon-66 insulating liner	IRS. T-44-1995
18	Pre-tensioned Pre-stressed Concrete Sleeper for turnout for Broad Gauge and meter gauge.	IRS. T-45-1996
19	Spheroidal Graphite Cast Iron inserts	IRS. T-46-1996
20	Grooved rubber sole plates 6.0 mm thick	IRS. T-47-2006
21	Grooved rubber sole plates 10 mm thick	Provisional-1989
22	ERC-J Clip	Provisional Revised -1994
23	Rail joints welded with mobile gas pressure Welding equipment	Provisional-1995
24	Polyethylene dowel	Provisional-1997
25	Track Based Lubricators (Electronic & Hydraulic type)	Provisional-2003
26	Ultrasonic testing of rails/welds using vehicular systems.	Provisional-2009
27	Metal Liner	Provisional-2010
28	Retro-Reflective Engineering Indicators using High intensity grade sheeting (encapsulated lens type)	Provisional-2011
29	Fishplates	(Provisional) IRS T1 – 2012
30	Ultrasonic testing of rails/welds	Provisional-2012

31	Technical specification for Improved SEJ.	Provisional-2008
32	6.2 mm thick composite Grooved Rubber sole plates for placing beneath rails.	Provisional-2006*
33	10 mm thick composite Grooved Rubber sole plates for placing beneath rails.	Provisional-2007

C: RDSO Drawings: Track Design Directorate RDSO document no. TD-M-4.2.4-1 "Master List of Drawings by Track Design Directorate"

D: Foreign Codes and Specifications

1	American railway engineering and maintenance-of-way association.
2	European sleeper standard EN 13 230:2010, CEN/TC 256.
3	UIC 713 R, Design of Mono Block Concrete Sleepers.
4	AS 1085.14-2003, Australian Standard, Railway track material.
5	EN 1992-1-1:2004, Euro code 2, Design of concrete structures – Part 1-1: General rules and rules for buildings, 2004
6	ORE D71/RP9, Stresses in the rails, the ballast and in the formation resulting from traffic loads – Stresses in concrete sleepers, October 1969
7	Railway Board letter No. 2009/Proj/MAS/9/2 dated 21.05.10
8	DD ENV 13481-6
9	EN 13481-5:2002 Railway applications – track – Performance requirements for fastening system – part 5: Fastening systems for slab track.
10	EN-13146-1:1998 Railway application-Track-Test methods for fastening system-Part 1. Determination of longitudinal rail restraint
11	EN-13146-2:1998 Railway application-Track-Test methods for fastening systems-Part 2. Determination of torsional resistance.
12	EN-13146-3:1998 Railway application-Track-Test methods for fastening. Determination of attenuation of impact loads.
13	EN-13146-4:1998 Railway application-track-Test methods for fastening. Effect of repeated loading.
14	EN-13146-5:1998 Railway application-Track-Test methods for fastening. Determination of electrical resistance.
15	EN-13146-6:1998 Railway application-Track-Test methods for fastening. Effect of severe environmental conditions.
16	EN-13146-7:1998 Railway application-Track-Test methods for fastening. Determination of clamping force.

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2.9 Buildings

2.9.1 General

(i) The scope of buildings and structures i.e. location, numbers and other details shall be provided in the concession document.

(ii) The architecture and profile of all buildings shall conform to the local aesthetics, cultural ethos, local architecture and environment, where ever applicable.

(iii) Building shall be designed for seismic forces as per applicable seismic zone.

(iv) Location and Layout of buildings shall be decided to avail natural ventilation, natural lighting and to minimize the energy requirement of heating/cooling.

(v) Plinth level of building shall be carefully fixed based upon the level of land and general drainage features. The plinth level of station buildings for Junction and crossing stations and Gate Lodges shall be at least 300mm above the rail level. The plinth level of residential quarters, service buildings like lMDs, lMSDs, and other buildings shall be 900mm above the natural ground level or 600mm above HFL (High Flood Level) whichever is higher. The ceiling height of station buildings and service buildings shall be approximately 4.2 m above floor level.

(vi) Anti termite treatment shall be done at the construction stage.

(vii) Rain Water Harvesting shall be adopted as far as possible. Local by laws in this regard shall be followed.

(viii) Energy Conservation Building Code 2007 shall be followed to increase the Energy efficiency of buildings.

(ix) All buildings, required to be constructed under this contract, shall comply with the applicable Indian building standards and codes.

(x) Concessionaire shall submit all building plans for prior agreement of Independent Engineer. Concessionaire may follow indicative drawings for buildings as given in Concession Agreement. In case, Concessionaire adopts alternate drawings, plinth area shall not be less than as given in the indicative drawings.

(xi) The design shall be capable of allowing the construction to be carried out in the minimum time possible and to the required quality standards.

(xii) The building shall be durable and serve satisfactorily for full service and designed life.

(xiii) The building shall be designed to withstand relevant weather conditions of exposure as per the Indian building codes.

(xiv) Buildings shall be detailed for ductility requirements as per the codal provisions.

(xv) All buildings shall be capable of maintenance with minimum effort.

(xvi) All building area including roof spaces and basements if provided shall be easily accessible for inspection.

(xvii) At each location water supplies shall be derived from the local water utility wherever possible. If local water utility supplies are not available

then deep tube wells shall be provided to meet the water supply requirements.

(xviii) Air conditioning and other facilities shall be provided as mentioned in Chapter 8 of this Manual.

(xix) Illumination of buildings and installations shall be as per standards laid in this manual.

(xx) Energy efficient fittings shall be provided.

(xxi) Building structure and roof shall be able to accommodate equipment for solar power.

2.9.2 List of Documents

A: List of Codes and Standards

National Building Code;
Bureau of Indian Standards (BIS);
Energy Conservation Building Code (ECBC);

B: Detailed list of BIS Documents

SL	B.I.S. No	Subject
1.	16	Shellac : Part I – Hand Made Shellac
2.	16	Shellac : Part II – Machine Made Shellac
3.	63	Whiting for paints and putty
4.	73	Specification For Paving Bitumen
5.	75	Linseed Oil Raw and Refined
6.	77	Linseed Oil Boiled For Paints
7.	104	Specification for Ready Mixed Paint, Brushing, Zinc Chrome, Priming
8.	109	Ready Mixed Paint, brushing priming plaster to IS: Colour No. 361 light stone and 631 light grey.
9.	133	Enamel, Interior (a) Under Coating (b) Finishing
10.	137	Ready Mixed Paint, Brushing, Matt or Egg Shell Flat, Finishing Interior to Indian Standard colour
11.	158	Ready Mixed Paint, Brushing, Bituminous Black, Lead Free, Acid, Alkali and Heat Resisting
12.	198	Varnish gold size
13.	204	Specification for tower bolts (Part II) non-ferrous metals
14.	204	Specification for tower bolts (Part I) ferrous metal
15.	205	Specification for non-ferrous metal butt hinges
16.	206	Specification for Tee and strap hinges
17.	207	Gate and shutter hooks and eyes
18.	208	Specification for door handles
19.	210	Grey Iron Castings
20.	217	Specification for Cut Back Bitumen
21.	218	Specification for Creosote and Anthracene Oil for Use as Wood Preservatives
22.	277	Specification for Galvanised Steel Sheets

23.	281	Specification for mild steel door bolts for use with padlocks
24.	287	Recommendations for maximum permissible moisture content of timber used for different purposes
25.	290	Coal Tar Black Paint
26.	303	Specification for plywood for general purposes
27.	337	Varnish, Finishing Interior
28.	341	Black Japan, Types 'A', 'B' & 'C'
29.	347	Varnish, Shellac for General Purpose
30.	348	French Polish
31.	364	Specification for fanlight catch
32.	383	Specification for coarse and fine aggregate from natural source for concrete
33.	404	Lead Pipes Part 1: For other than chemical purposes
34.	419	Putty for use on Window frames
35.	427	Distemper, Dry Colour as Required
36.	428	Distemper, Oil Emulsion, Colour as Required
37.	432	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part I mild steel and medium tensile steel bars
38.	432	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part II Hard drawn steel wire
39.	451	Technical supply condition for wood screws
40.	452	Specification for door springs rat-tail type
41.	453	Specification for double-acting spring hinges
42.	455	Specification for Portland slag cement
43.	456	Code of Practice for Plain/Reinforced Concrete.
44.	458	Specification For Precast Concrete Pipes (With and Without Reinforcement
45.	459	Corrugated and Semi Corrugated Asbestos Cement Sheets
46.	460	(Part -I) Specification for test sieves : wire cloth test sieves
47.	516	Method of test for strength of concrete
48.	524	Varnish, Finishing, Exterior, Synthetic Air Drying
49.	525	Specification for Varnish, finishing exterior and general purposes
50.	554	Dimensions for pipe threads with pressure tight joints on the threads
51.	650	Specification for standard sand for testing of cement
52.	651	Specification for salt glazed stoneware pipes and fittings
53.	653	Specification for linoleum sheets and tiles
54.	654	Clay Roofing tiles – Mangalore Pattern
55.	661	Code of practice for thermal insulation of cold storages
56.	702	Specification for industrial bitumen
57.	710	Specification for Marine Plywood
58.	712	Specification for building lime
59.	723	Specification for steel countersunk head wire nails

60.	729	Specification for drawer locks, cupboard locks and box locks
61.	733	Specification for wrought Aluminum and Aluminum Alloys, Bars, Rods and Sections (For General Engineering Purposes)
62.	737	Specification for wrought Aluminum and Aluminum alloy sheet and strip for general engineering purposes
63.	771	Glazed Fire-Clay Sanitary appliances : Part 1 : General requisites
64.	771	Glazed fire-Clay Sanitary appliances : Part 2 Specific requirements of Kitchen and laboratory sinks
65.	771	Glazed fire Clay Sanitary appliances : Part 3/Sec.I Specific requirements of urinals: Slab Urinals
66.	771	Glazed fire Clay Sanitary Appliances – Part 3.Sec.II Specific requirements of urinals: Small Urinals
67.	772	General requirements for enameled cast iron sanitary appliances
68.	774	Flushing cisterns for water closets and urinals (other than plastic cistern)
69.	778	Specification for copper alloy gate, and check valves for water works purposes
70.	779	Specification for water meters (domestic type)
71.	781	Specification for cast copper alloy screw down bib taps and stop valves for water services
72.	782	Specification for caulking lead
73.	800	Code of practice for use of structural steel in steel construction
74.	806	Code of practice for use of steel tubes in building construction
75.	808	Dimensions for hot rolled steel beam, column, channel and angle sections
76.	809	Specification for rubber flooring materials for general purposes
77.	812	Glossary of terms relating to welding and cutting of metals
78.	813	Scheme of symbols for welding
79.	814	Part 1 Covered Electrodes for Metal Arc Welding of structural steel for welding other than sheets
80.	814	Part 2 For welding sheets
81.	816	Code of Practice for use of Metal arc Welding
82.	817	Code of practice for training and testing of metal arc welders
83.	818	Code of practice for safety and health requirements in electric and gas welding and cutting operations
84.	822	Code of Procedure for Inspection of welds
85.	848	Specification for synthetic resin adhesives for plywood (phenolic and amino plastic
86.	851	Specification for synthetic resin adhesives for construction work (non-structural) in wood
87.	875	Code of practice for design Loads (other than Earthquake) for Building and Structures. Part-1 Dead Load-Unit weights of Building Materials & stored
88.	909	Specification for underground fire hydrant; sluice valve type

89.	958	Temporary corrosion prevention grease, soft film, cold application
90.	962	Code of Practice for Architectural and Building drawings
91.	1003	Specification for timber panelled and glazed shutters (Part 1) Door shutters
92.	1003	Specification for timber panelled and glazed shutters (Part II) Window and ventilator shutters
93.	1030	Carbon Steel Castings for General Engineering purposes
94.	1038	Steel doors, windows and ventilators
95.	1077	Common burnt clay building bricks
96.	1081	Code of practice for fixing and glazing of metal (steel and aluminum) doors, windows and ventilators
97.	1121	Methods of test for determination of properties and strengths of natural building stones (Part – 1 Compressive strength).
98.	1122	Methods of test for determination of specific gravity of natural building stones
99.	1123	Methods of identification of natural building stones
100.	1124	Methods of test for determination of water absorption, apparent specific gravity and porosity of natural building stones
101.	1125	Methods of test for determination of weathering of natural building stones
102.	1126	Methods of test for determination of durability of natural building stones
103.	1127	Natural Building Stones
104.	1128	Lime stones (slab & tiles)
105.	1129	Recommendations for dressing of natural building stones.
106.	1130	Specification for marble (blocks, slabs and tiles)
107.	1141	Specification for code of practice for seasoning of timber
108.	1148	Hot rolled steel rivet bars
109.	1161	Steel tubes for structural purposes
110.	1172	Code of basic requirement for water supply, drainage and sanitation
111.	1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates
112.	1195	Bitumen Mastic for Flooring
113.	1197	Code of practice for laying rubber floors
114.	1198	Code of practice for laying fixing and maintenance of linoleum floor
115.	1199	Method of sampling and analysis of Concrete
116.	1202	Determination of Specific Gravity
117.	1237	Specification for cement concrete flooring tiles
118.	1239	Specification for mild steel tubes tubular and other wrought steel fittings Part II mild street tubular and other wrought steel pipe fittings
119.	1239	Specification for mild steel tubes tubular and other wrought steel fittings, Part I mild steel tubes
120.	1254	Corrugated aluminum sheet – Specification
121.	1278	Filler rods and wires for gas welding

122.	1285	Specification for wrought Aluminum and Aluminum Alloy, Extruded Round Tube and Hollow sections (For General Engineering Purposes)
123.	1322	Specification for bitumen felt for water proofing and damp proofing
124.	1328	Specification for veneered decorative plywood
125.	1341	Specification for steel butt hinges
126.	1343	Code of Practice for Pre-stressed concrete
127.	1344	Specification for calcined clay Pozzolana
128.	1346	Code of Practice for Water Proofing of roofs with Bitumen Felts
129.	1395	Low and medium alloy Steel covered electrodes for manual Metal Arc Welding
130.	1443	Code of practice for laying and finishing of cement concrete flooring tiles
131.	1464	Clay ridge and Ceiling tiles
132.	1489	Part 1: Portland Pozzolana Cement: Part 1: Fly-ash based
133.	1489	Part 2: Portland Pozzolana Cement: Part 2: Calcined Clay based
134.	1536	Specification for centrifugally cast (spun) iron pressure pipes for water gas and sewage
135.	1537	Specification for vertically cast iron pressure pipes for water, gas and sewage
136.	1538	Specification for cast iron fittings for pressure pipes for water, gas and sewage,
137.	1542	Specification for sand for plaster
138.	1566	Specification for hard-drawn steel wire fabric for Concrete reinforcement
139.	1580	Bituminous Compounds for Water Proofing and caulking purposes
140.	1592	Specification for Asbestos cement pressure pipes
141.	1597	Code of practice for construction of ruble stone masonry: Part 1 : Rubble Stone masonry
142.	1597	Code of practice for construction of Ashlar stone masonry : Part 2 : Ashlar masonry
143.	1599	Method for bend test for steel products other than sheet, strip, wire and tube (2nd Revision) (Superseding IS : 1692-1974, IS : 3260-1960, IS : 4598-1968)
144.	1608	Method for tensile testing of steel products
145.	1609	Code of Practice for laying damp-proofing treatment using Bitumen felt
146.	1626	Specifications for Asbestos Cement Building Pipes and Pipe Fittings, gutters and Gutter Fittings and Roofing Fittings: Part –I; Pipe and Pipe Fittings
147.	1626	Specifications for Asbestos Cement Building Pipes and Pipe Fittings, gutters and Gutter Fittings and Roofing Fittings: Part –II; Gutter and Gutter Fittings
148.	1626	Specifications for Asbestos Cement Building Pipes and Pipe Fittings, Gutters and Gutter Fittings and Roofing Fittings: Part –III; Roofing Accessories
149.	1635	Code of Practice for field slaking of lime
150.	1658	Specification for Fibre hard boards

151.	1659	Specification for block boards
152.	1703	Copper alloy float valves (horizontal plunger type) for water supply fittings
153.	1726	Specification for cast iron manhole covers and frames
154.	1727	Methods of Test for Pozzolanic materials
155.	1729	Specification for sand cast iron spigot and socket soil waste and ventilating pipes, fittings and accessories
156.	1730	Steel plates, sheets, strips and flats for structural and general Engineering purposes - Dimensions
157.	1734	(Pt.1 to 20) Methods of test for plywood
158.	1742	Code of practice for Building drainage
159.	1786	Specification for high strength deformed steel and wires for concrete reinforcement
160.	1791	Specification for batch type concrete mixers
161.	1795	Pillar taps for water supply purposes
162.	1805	Glossary of terms relating to stones, quarrying and dressing.
163.	1823	Specification for floor door stopper
164.	1837	Specification for fanlight pivots
165.	1852	Rolling and cutting tolerances for hot rolled steel products
166.	1868	Specification for anodic coating on aluminum and its alloy
167.	1875	Carbon Steel Billets, blooms, slabs, bars for forgings
168.	1904	Code of practice for Design and construction of foundations in Soils -
169.	1948	Specification for Aluminum Doors, Windows and Ventilators
170.	1949	Specification for aluminum windows for industrial buildings
171.	2004	Carbon Steel Forgings for General Engineering purposes
172.	2062	Steel for general structural purposes (4th Revision) (Supersedes IS : 226 – 1975)
173.	2064	Code of practice on selection, installation and maintenance of sanitary appliances.
174.	2065	Code of Practice for Water Supply in buildings
175.	2074	Ready mix paint , Air drying, Red oxide- Zinc chrome priming
176.	2095	Specification for gypsum plaster boards
177.	2096	Specification for asbestos cement flat sheets
178.	2114	Code of practice for laying in-situ terrazzo floor finish
179.	2115	Code of Practice for Flat Roof Finish: Mud Phuska
180.	2116	Specification for sand for masonry mortar
181.	2185	Concrete masonry units: Part I: Hollow and solid concrete blocks.
182.	2191	Specification for Wooden Flush Door Shutters (Part 1)(Cellular & Hollow Core Type) (Plywood Panels)
183.	2202	Specification for wooden flush door shutters(Part 1) (Solid core type) plywood face panels
184.	2202	Specification for wooden flush door shutters (PART II) 1Solid core type) Particle Board & Hard Board Face Panels
185.	2209	Specification for mortice Locks (Vertical type)
186.	2212	Code of practice for brick work
187.	2250	Code of Practice for preparation and use of masonry Mortar
188.	2267	Polystyrene moulding materials
189.	2309	Protection of Buildings and allied Structures Against Lightning -Code of Practice

190.	2326	Automatic flushing cisterns for urinals
191.	2339	Aluminum paint for General purposes in dual container
192.	2380	Method of test for wood particle boards from other lingno cellulosic material (Parts 1 to 23)
193.	2386	Method of test for aggregate for concrete work (a) Part I Particle size and shape
194.	2386	(b) Part II Estimation of deleterious materials and organic impurities
195.	2386	(c) Part III Specific gravity, density, voids and absorption and bulking
196.	2386	(d) Part IV Mechanical properties
197.	2438	Specification for Power Driven Mobile Roller Pan Mixer
198.	2470	Code of practice for installation of septic tank Part 1 Design criteria and construction, Part 2 Secondary Treatment and Disposal of Septic Tank effluent.
199.	2502	Code of practice for bending and fixing of bars for concrete reinforcement.
200.	2505	General requirement for concrete vibrators immersion type
201.	2506	General requirement for screed board concrete vibrators
202.	2541	Code of Practice for preparation and use of Lime Concrete
203.	2547	Gypsum building plaster: (Part 1) Excluding premixed, light weight plaster
204.	2547	Gypsum building plaster: (Part 2) premixed, light weight plaster
205.	2548	Plastic seats and covers for water – closets: Part I Thermoset seats and covers
206.	2548	Plastic seats and covers for water – closets: Part II Thermo Plastic seats and covers
207.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt.II Specific requirements of wash-down water-closets
208.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt.III Specific requirements of squatting pans
209.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt.IV Specific requirements of wash basins
210.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt.VI Specific requirements of urinals, Sec. 1 Bowl type
211.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt.VI Specific requirements of urinals, Sec.2 half stall urinals
212.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt.VI Specific requirements of urinals, Sec.3 squatting plates
213.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt,VI Specific requirements of urinals, Sec.4 partition slabs
214.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt.I General requirements,
215.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt. XIV Specific requirements of integrated squatting pans

216.	2556	Specification for vitreous sanitary appliances (vitreous China) Pt. XV Specific requirements of universal water closet
217.	2571	Code of practice for laying in-situ cement concrete flooring
218.	2572	Code of Practice for construction of hollow concrete block masonry.
219.	2633	Methods of Testing Uniformity of Coating on Zinc Coating Articles
220.	2644	High Tensile Steel Casings
221.	2645	Specification for integral cement water proofing compounds
222.	2673	Dimension of extruded round tube and the tolerances
223.	2681	Specification for non-ferrous metal sliding door bolts (aldrops) for use with pad locks
224.	2685	Code of Practice for Selection, Installation and maintenance of sluice valves.
225.	2690	Pt.1 Burnt clay flat Terracing Tiles – Machine made
226.	2690	Pt.2 Burnt Clay flat Terracing Tiles – Hand made
227.	2692	Specification for ferrules for water services
228.	2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
229.	2835	Flat transparent sheet glass
230.	2932	Enamel, synthetic, Exterior (a) Undercoating, (b) Finishing
231.	2933	Enamel, Exterior (a) Undercoating (b) Finishing
232.	2963	Copper alloy waste fittings for wash basins and sinks
233.	3006	Chemically resistant glazed stoneware pipes and fittings
234.	3007	Code of Practice For Laying of Asbestos Cement Sheets Part-I: Corrugated Sheets Part-II Semi Corrugated Sheets
235.	3016	Code of practice for fire precautions in welding and cutting operations 1982
236.	3036	Laying Lime Concrete for Water Proofed Roof Finish
237.	3037	Bitumen Mastic for use in Water Proofing of Roofs
238.	3067	Code of Practice for General Design Details and preparatory work for Damp Proofing and Water Proofing of building
239.	3068	Specifications for broken brick (burnt clay) coarse aggregates for use in lime concrete.
240.	3087	Specification for wood particle boards (Medium density) for general purposes)
241.	3092	Rubber Draining and tapping knife
242.	3093	Jungle Cutting
243.	3097	Specification for veneered Particle Boards
244.	3144	Mineral Wool Thermal Insulation Materials Methods of Test
245.	3316	Structural Granite
246.	3346	Method of the Determination of Thermal Conductivity of Thermal insulation Materials (two slab guarded hot plate method)
247.	3348	Specification for Fibre Insulation Boards
248.	3384	Specification for Bitumen primer for use in Water proofing and Damp proofing
249.	3389	Urea-formaldehyde moulding materials
250.	3400	Pts 1 to 22 Method of tests for vulcanized rubbers

251.	3461	Specification for PVC asbestos floor files
252.	3462	Specification for un-backed flexible PVC flooring
253.	3495	Method of test for clay building bricks (Part 1 to 4 in one volume)
254.	3502	Chequered plates
255.	3536	Specification for ready mixed paint brushing wood primer
256.	3537	Specification for ready mixed paint finishing Interior for General purposes to specified Indian Standard column
257.	3564	Specification for door closers (hydraulically regulated)
258.	3585	Specification for ready mixed paint Aluminum, brushing priming, water resistant for wood work.
259.	3613	Acceptance Tests for wire flux combinations for submerged arc welding of structural steel
260.	3618	Phosphate treatment of iron and steel for protection against corrosion
261.	3620	Laterite stone block for masonry
262.	3622	Specification for sand stone (Slab and Tiles)
263.	3640	Hexagon fit bolts
264.	3670	Code of practice for construction of timber floors
265.	3696	Safety code of Scaffolders - Part 1 - Scaffolds 1987
266.	3757	High tensile friction grip bolts
267.	3764	Code of Safety for excavation work
268.	3812	Fly Ash for use as Pozzolana and admixture
269.	3818	Piano Hinges
270.	3828	Specification for Ventilator chains
271.	3847	Specification for mortice night latches
272.	3908	Aluminum equal leg angles
273.	3909	Aluminum unequal leg angles
274.	3950	Specifications for surface boxes for sluice valves
275.	3965	Dimensions of bar, rods and sections and their tolerances
276.	3989	Specification for centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings, and accessories
277.	4014	Code of practice for steel tubular scaffolding; Part 2 Safety regulations for scaffolding
278.	4020	Pts. 1 to Pts.16 Method of Tests for Door Shutters
279.	4029	Specifications for Timber, door, window & Ventilator frames
280.	4031	(Part I) to (Part XIII) Method of Physical test for hydraulic cement
281.	4032	Method of chemical analysis of Hydraulic Cement
282.	4081	Safety code for blasting and related drilling operations
283.	4082	Recommendation on stacking and storage of construction materials at site
284.	4098	Specification for Lime Pozzolana mixture
285.	4101	Code of practice for external facings and veneers: Part 2: Cement concrete facing Reaffirmed 1990
286.	4101	Code of practice for external facings and veneers: Part1: Stone facing
287.	4111	Code of practice for ancillary structure in sewage system Part 1 manholes Part 2 flushing tanks
288.	4127	Code of practice for laying of glazed stone ware pipes
289.	4130	Safety Code for Demolition of buildings

290.	4138	Safety Code for Working in Compressed Air
291.	4351	Specification for steel door frame
292.	4365	Code of practice for application of Bitumen Mastic for water proofing of roofs
293.	4454	(Part 1) Steel wires for cold formed springs. Patented and cold drawn steel wires unalloyed
294.	4637	Alloy & tool steel forgings for general industrial use
295.	4671	Expanded Polystyrene for Thermal Insulation Purposes
296.	4736	Hot – dip zinc coatings on mild steel tubes
297.	4835	Specification for polyvinyl acetate dispersion based adhesives for wood
298.	4845	Definitions and terminology relating to Hydraulic Cement
299.	4912	Safety requirements for floor and wall openings, railings and toe boards
300.	4925	Batch Plants Specification for concrete batching and mixing plant.
301.	4948	Specification for welded steel wire fabric for general use
302.	4970	Key for identification of commercial Timbers
303.	4984	Specification for high density polyethylene pipes for potable water supplies, sewage and industrial effluents
304.	4985	Specification for Unplasticized PVC pipes for potable water supplies
305.	4992	Specification for door handles for mortice lock (vertical type)
306.	5121	Safety code for Piling and other deep foundations
307.	5187	Specification for flush bolts
308.	5312	Specification for swing check type Reflux (Non- return) valves for Water works purposes.
309.	5318	Code of practice for laying of flexible PVC steel and tile flooring
310.	5329	Code of Practice for sanitary pipe works above ground for buildings.
311.	5410	Cement Paint
312.	5411	Plastic Emulsion Paint: Part 1: For Interior Use
313.	5454	Methods of sampling of clay building bricks.
314.	5456	Specification for cast Iron steps for manholes
315.	5523	Method of testing anodic coating on aluminum and its alloys
316.	5624	Foundation bolts
317.	5688	Method of Test of Preformed Block Type and Pipe Covering Type Thermal Insulations
318.	5766	Code of practice for laying of burnt clay brick flooring
319.	5871	Bitumen mastic for Tanking and Damp Proofing
320.	5913	Method of test for asbestos cement products
321.	5916	Safety code for constructions involving the use of hot bituminous materials
322.	5930	Specification for mortice latch (vertical type)
323.	6198	Ledged, Braced and Battened Shutter
324.	6248	Metal rolling shutters and rolling grills
325.	6278	Code of Practice for White Washing and Colour Washing
326.	6313	Code of Practice for anti-termite measures in Building: (Part II) Pre-constructional Chemical treatment measures

327.	6313	Code of practice for Anti-termite measures in buildings Part 1-constructional measures Part 2-Preconstructional chemical treatment measures
328.	6313	1987Code of practice for Anti-termite measures in buildings part 3-- treatment for existing buildings
329.	6315	Double action hydraulic floor spring for aluminum doors
330.	6318	Specification for plastic window stays and fasteners
331.	6411	Specification for gel-coated-glass fibre reinforced polyester resin bath tub
332.	6419	Welding rods and bare electrodes for gas shielded arc welding of structural steel
333.	6452	Specification for High Alumina Cement for Structural Use
334.	6477	Dimension of extruded hollow section and tolerances
335.	6494	Code of practice for water proofing of underground water reservoirs and swimming pools
336.	6523	Specification for pre-cast reinforced concrete door, window frames.
337.	6530	Code of Practice for Laying of Asbestos Cement Pressure pipes
338.	6560	Molybdenum and chromium – molybdenum low alloy steel welding rods and bare electrodes for gas shielded arc welding
339.	6598	Cellular Concrete for Thermal Insulation
340.	6607	Specification for rebated mortice lock (vertical type)
341.	6909	Specification for Super-sulphated Cement
342.	6922	Criteria for safety and design of structures subject to underground blasts 1973
343.	6932	(Part 1 to 10) Method of test for building lime
344.	7193	Glass Fibre base Coal tar pitch and Bitumen felts
345.	7196	Specification for hold fast
346.	7198	Code of Practice for Damp Proofing using Bitumen Mastic
347.	7205	Safety code for Erection of structural steel work
348.	7215	Tolerances for fabrication of steel structures
349.	7231	Plastic flushing cisterns (Valves siphonic type) for water closet and urinals.
350.	7280	Bare wire electrodes for gas shielded arc welding of structural steel
351.	7290	Use of Polyethylene film for water proofing of roofs
352.	7293	Safety code for working with construction machinery
353.	7452	Specifications for hot rolled steel sections for doors, windows and ventilators
354.	7509	Thermal Insulating Cement
355.	7634	Code of Practice for Plastic pipes iron for potable water supply
356.	7740	Code of practice for construction and maintenance of road gullies.
357.	7861	Code of practice for extreme weather concreting (Part I) recommended practice for hot weather concreting
358.	7861	(Part II) Cold weather concreting
359.	7969	Safety code for Handling and storage of building materials
360.	8041	Rapid Hardening Portland Cement
361.	8042	White Portland Cement

362.	8043	Hydrophobic Portland Cement
363.	8112	Specification for 43 grade ordinary Portland cement
364.	8183	Bonded Mineral Wool
365.	8756	Specification for mortice ball catches for use in wooden almirah
366.	8794	Specification for cast iron detachable joints for use with asbestos cement pressure pipes
367.	8989	Safety code for Erection of concrete framed structures
368.	9012	Recommended Practice for Shotcreting
369.	9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens
370.	9103	Admixtures for concrete
371.	9295	Metal arc welding of Carbon and Carbon manganese Steels -recommendations
372.	9375	Specification for pre cast reinforced concrete plant guards.
373.	9417	Recommendations for welding cold worked bars for reinforced concrete construction
374.	9556	Code of Practice for Design and Construction of Diaphragm Walls 1980
375.	9743	Thermal Insulation Finishing Cements
376.	9759	Guidelines for Dewatering during construction
377.	9762	Specification for polyethylene floats (spherical) for float Valves
378.	9763	Specification for Plastic Bib Tap and Stop Valves (Pressing Spindles) for cold water service
379.	9918	Code of Practice for in-situ water proofing and damp proofing treatment with glass fibre tissue reinforced bitumen
380.	10262	Recommended guidelines for concrete mix design.
381.	10772	Quick setting Lime Pozzolana mixture
382.	11134	Code of practice for Setting out of Buildings
383.	11652	Woven HDPE sacks for packing cement
384.	11817	Classification of joints in buildings for accommodation of dimensional deviations during construction
385.	11972	Code of practice for safety precautions to be taken when entering a sewage system.
386.	12183	Code of Practice for plumbing multi storied building. Part-1 Water supply
387.	12269	Specification for 53 grade ordinary Portland cement
388.	12288	Code of Practice for use and laying of ductile iron pipes
389.	12330	Specification for sulphate resisting Portland cement
390.	12406	Specification for medium density fibre boards for general purposes
391.	12440	Pre cast concrete stone masonry blocks.
392.	12592	Specification for precast man hole covers and frames
393.	12701	Rotational Moulded Polyethylene water storage tank – Specification
394.	12806	Indian Timbers for Door and Window Shutters and Frames
395.	12817	Stainless Steel Butt Hinges
396.	12823	Pre-laminated Particle Board
397.	12894	Fly ash-lime bricks.
398.	13182	Water Proofing and Damp Proofing of wet areas in Building – Recommendation

399.	13311	Indian Standard for non-destructive testing of concrete Method of test for ultrasonic pulse velocity. (Part I)
400.	13311	Indian Standard for non-destructive testing of concrete Method of testing for rebound hammer. (Part II)
401.	13415	Code of safety for protective barriers in and around buildings
402.	13416	Recommendations for preventive measures against hazards at workplaces: Part 2 Fall prevention
403.	13416	Preventive measures against Hazards at work places - Part 1 -falling material Hazard prevention
404.	13416	Preventive measures against Hazards at work places - recommendations - Part-III - disposal of debris (MULBA).
405.	13417	Preventive measures against Hazards at work places - recommendations - Part-IV - Timber structure
406.	13418	Preventive measures against Hazards at work places - recommendations - Part-V - fire protection.
407.	13430	Code of practice for safety during additional construction and alteration to existing buildings
408.	13592	Specifications for UPVC pipes for soil and waste discharge systems inside buildings including ventilation and rainwater system
409.	13607	Ready Mixed Paint, Finishing, General purposes, synthetic
410.	13630	Ceramic Tiles – Methods of Test (Pts 1 to 15)
411.	13712	Ceramic Tiles – Definitions, Classifications, characteristics and marking (under revision)
412.	13983	Stainless steel sinks for domestic purposes-specifications.
413.	15450	Polyethylene/Aluminum/Polyethylene composite pressure pipes for hot and cold water supplies
414.	14587	Pre-laminated Fibre Board
415.	14616	Laminated Veneer Lumber
416.	14687	False Work for Concrete Structures - Guidelines
417.	14846	Sluice Valve for water works purposes (50 to 1200 mm size)
418.	14856	Glass Fibre Reinforced Plaster (GRP) Panel Type Door Shutters for internal use
419.	15380	Moulded raised High Density (HDF) Panel Doors
420.	15622	Pressed Ceramic Tiles

C: Other Codes and Standards

ASTM Standards in Building Codes;
International Standards Organization (ISO);
American Society of Civil Engineers (ASCE);
American National Standards Institute (ANSI);
British Standards (BS); and
American Architectural Manufacturers Association (AAMA);

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2.10 Level Crossings

2.10.1 All level crossings shall comply with the provisions of chapter IX of IRPWM in all respects which includes - track structure, type and width of road, fencing, clearances, rumble strips, gradient, drainage etc., except gate lodges and equipment for level crossing. The level crossing shall be connected to adjacent approach roads after suitable profiling of surface.

2.10.2 Ballasted track structure will be continued through the level crossing. The level crossing will have a track friendly maintenance free road surface. The track/road infrastructure at level crossings will have PSC sleepers with concrete panels/Blocks which can be easily removed either manually or with the help of small road cranes, to enable continuous working of track maintenance machine through the level crossing. The system should be suitably designed so that it can be easily removed during mechanized maintenance and re-fixed after mechanized maintenance. With the prior approval of Independent Engineer, Concessionaire may use rubberized panels for road surface at level crossings with suitable systems for maintaining check rail clearances.

2.10.3 The plan including methodology of work on IR level crossings shall be approved by the Independent Engineer before commencement of works at site.

2.11 FENCING AND PLATFORM DESIGN CRITERIA

2.11.1 All stations shall have the provision of a rail level platform with concrete surface of size 50.0 meters length and 4.0 meters width at a location approved by the Independent Engineer .

2.11.2 Wherever DFC alignment is passing through/ adjacent to Indian Railway stations, DFC tracks shall have a provision of a permanent continuous un-scalable but see-through fencing on both sides. Such fencing shall cover the entire length between outer most points on both sides of the existing IR stations or to cover the length of 24 coach train, whichever is more. A similar fencing will also be required to be provided at locations wherever the alignment is passing close to habitations. The identification of such locations will be done by the Independent Engineer .

2.11.3 Fencing can be designed as RCC/ Pre-cast or Metal grill of suitable strength.

2.11.4 All fencing and Platform construction shall comply with the applicable Indian building standards and codes.

2.11.5 The design shall be capable of allowing the construction to be carried out in the minimum time possible and to the required quality standards.

2.11.6 While working at vulnerable locations from safety and security point of view like in close proximity of the running track of Indian Railways, the Concessionaire shall construct temporary fencing.

2.11.7 Concessionaire shall submit plans of all types of fencing and platforms to the Independent Engineer for prior agreement.

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CHAPTER 3

SIGNALLING AND TRAIN CONTROL SYSTEM

3.1 General

3.1.1 This section lays down the standards for the signaling and train control system to be designed, constructed, commissioned and maintained by Concessionaire and operated by DFCCIL.

3.2 DESIGN CRITERIA AND STANDARD

3.2.1 Basic Design Philosophy and Requirements

3.2.1.1 Proven Design

a The Signalling and Train Control System including all sub-systems and equipment shall be of proven design. The system/sub-system, equipment, hardware and software proposed by the Concessionaire shall have been in use and have established their satisfactory performance over a period of at least two years on the worldwide railway/metro systems during last five years from the base date.

b Where similar equipment or sub-systems of a different rating are already proven in service, then the design shall be based on such equipment. In case these stipulations are not fulfilled, the Concessionaire shall furnish sufficient information to prove the basic soundness and reliability of the offered Sub-system.

3.2.1.2 The design philosophy should meet the following criteria:

a Application of state-of-the-art Technology
b Service proven design
c The minimum design life of mainline electronic equipment and the associated wayside equipment is 20 years and 30 years respectively
d Minimum life cycle cost
e Ease of maintainability
f Use of interchangeable, modular components
g Extensive and prominent labelling of parts, cables and wires
h Use of unique serial numbers for traceability of components
i High reliability
j Energy efficiency
k System safety
l Adequate redundancy and factor of safety
m Environment friendly
n Adherence to technical specifications.
o Open Architecture for integration with other Systems
p Ease of expansion and integration.
q Protection against theft/pilferage.

3.2.1.3 Adequate margin shall be built into the design particularly to take care of the environmental considerations prevailing at the location of the project.

3.2.1.4 All Signalling and Train Control system designs of hardware and software shall be prepared by experienced Signalling engineers. All Signalling system installation, testing and commissioning shall be executed by well trained and qualified engineers under the leadership of an experienced Signalling Engineer.

3.2.2 DESIGN PRINCIPLE

Signalling system shall be designed as per the requirement of DFCC General Rules and Indian railway Signal Engineering Manual (DFCC General Rules are under approval of Railway Board). SOD of EDFC shall be followed.

3.2.3 DESIGN CRITERIA

3.2.3.1 Track Vacancy Detection System at stations shall consist of Digital Axle Counters, with automatic resetting without line verification (in case of a failure) by using alternate detection techniques.

3.2.3.2 Track Vacancy Detection System in Block sections shall consist of Digital Axle Counters with Supervisory track section.

3.2.3.3 All Level Crossing gates shall be provided with Electric Lifting Barriers and interlocked. Wherever Level Crossing gate serves both DFCCIL and IR tracks together, the work will be suitably coordinated with IR.

3.2.3.4 Automatic Block Signalling shall be provided with nominal signal spacing of two Kms.

3.2.3.5 One modified semi automatic stop signal as per gazette notification GSR 705 (E) dated 21st September 2011 shall be provided so as to run the trains during foggy weather.

3.2.3.6 Electronic Interlocking shall be provided for station and Automatic Section.

3.2.3.7 Train management system for section shall be installed at OCC of EDCC at Allahabad. OFC Connectivity from section to OCC shall be made available by DFCCIL. The Concessionaire shall construct new OCC building adjacent to the existing/ proposed OCC building at Allahabad. The Concessionaire shall provide all necessary Civil, Electrical and S&T infrastructure.

3.2.3.8 LED type line side signals shall be provided on independent post or gantry as per the requirement of SOD of EDFC.

3.2.3.9 Absolute Block Signalling shall be used for connecting Nominated stations of DFC with corresponding stations of IR.

3.2.3.10 Power supply for S&T equipment shall be derived from UP & DN AT.

3.2.3.11 Integrated Power Supply (IPS) or Uninterrupted Power Supply (UPS) shall be used for powering signalling circuits. Power Supply System shall have the capacity to power all the signalling system for a minimum of 4 hrs. with maximum depth of discharge of battery as 70%.

3.2.3.12 All the points shall be worked with point machines. Non- trailable point machine in conjunction with external mechanical lock (clamp lock) shall be used.

3.2.3.13 Signalling System shall be designed, manufactured, installed and validated to CENELEC Standard EN 50125, EN 50126, EN 50128 and EN 50129 or equivalent SIL standard. The Concessionaire shall submit a certificate from accredited Independent Safety Assessor (ISA) to this effect.

3.3 RELIABILITY REQUIREMENTS

3.3.1 If failure of any sub-system is likely to adversely affect the train operation, the reliability shall be enhanced by providing redundancy in the equipment.

3.3.2 Duplicated system shall change uninterrupted when one system fails. If duplicated system has changing time, concessionaire shall show that its system shall not obstruct the train operation.

3.3.3 Track side equipment for track vacancy detection system shall be provided with independent concrete foundations clear of SOD of EDFC and shall be housed inside the location boxes or any other housing arrangement and properly secured against theft. In no case these shall be simply buried in the ground or ballast.

3.3.4 Trackside equipments, Location boxes, Impedance Bonds, Absorbing Bonds, Auto Location Huts etc. shall be designed and fixed with anti-theft measures.

3.3.5 Cables shall normally be stored, transported and laid as per the provisions of chapter-XV and Chapter XXII of IRSEM. Electrical cables (LT, HT) shall not be laid in the same trench as signalling and telecom cables. Minimum separation between OHE components and signal and telecom cables shall be as specified in IRSEM and Telecom manual. Where ever electrical cables (LT, HT) cross signal and telecom cables suitable protection measures to protect signal and telecom cables shall be taken. Signalling and telecom cables shall be laid in separate trench or suitable separation shall be provided between the two if laid in the same trench, in line with the requirement of IRSEM and Telecom Manual. Signalling power cable shall be suitably separated from other signalling cables in line with IRSEM. Independent Engineer's approval shall be obtained for the same.

3.3.6 All cables shall be laid with in DFCC boundary; on the side opposite to IR track (excluding OFC cables for path diversity) and as far away from the track as possible. If it is necessary to lay cable outside the DFCC boundary, permission shall be obtained in advance from the concerned authority. If it is necessary to lay cable on the side towards IR track, cable route of exiting IR cables shall be ascertained before starting the digging and protection of existing IR cable shall be ensured. Concessionaire shall be solely responsible for consequences of damage to IR cable.

3.4 MAINTENANCE REQUIREMENTS

3.4.1 Fundamentally, the system shall be designed based on the maintenance free concept.

3.4.2 The Concessionaire shall provide built-in diagnostics and remote monitoring functions for each equipment and module of the systems such that the performance can be demonstrated.

3.4.3 On line monitoring system for all the signaling equipment; either as part of TMS or separately; shall be provided for real time monitoring and maintenance. The

system shall be capable of locating the failure points, subsystem/ module and shall keep a record of the operations.

3.4.4 Each location box and other such stand alone track side box shall be provided with it's independent light to attend to failures during night time.

3.5 ELECTROMAGNETIC COMPATIBILITY (EMC) REQUIREMENTS

3.5.1 The EMC management plan shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified by the relevant international standards and Indian Railway RE practices or better. The plan shall specify measures to increase immunity of the signaling system. The plan shall take in to account 25 KV AC AT feeding system on DFC and 25 KV AC traction on nearby IR lines.

3.5.2 The plan shall specify basic protective measures proposed for all electrical and electronic subsystems and components and specific measures to be adopted for the selected subsystems and components.

3.5.3 The plan shall analyze EMI/ EMC impacts on the design of the Train control and signalling system including train-borne equipment, if any, and trackside equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding, bonding, shielding, filtering and cabling arrangements.

3.5.4 The Concessionaire shall ensure that the signaling system meets the EMC requirements as per IEC 62236 and IR practices or better.

3.6 ENVIRONMENTAL CONDITIONS

3.6.1 All equipment shall be protected from damage or degradation in performance due to shock or vibration as experienced in railway environment.

3.6.2 All signaling equipment shall be designed for operation continuously in temperatures of -5° C to $+55^0$ C.

3.6.3 Signaling equipment rooms at OCC and stations shall be provided with room air-conditioning.

3.6.4 If required, Signaling equipment rooms at all other places shall also be provided with air-conditioning in 1 + 1 configuration for signaling equipment.

3.6.5 Signal power supply rooms shall be provided with suitable means for air circulation (1 + 1 configuration).

3.6.6 Status of temperature of all signaling buildings and functioning of the temperature – regulator equipment and air conditioning equipment shall be centrally monitored.

3.7 EQUIPMENT SPECIFICATIONS AND SOURCES OF SUPPLY

3.7.1 Signalling equipment shall be procured as per relevant IRS/RDSO specifications from RDSO's "Approved list of firms for manufacture and supply".

3.7.2 If any equipment appearing in RDSO approved list is proposed to be imported then the same shall be got approved from RDSO/DFCCIL as per their cross approval procedure.

3.7.3 If any equipment other than covered in item (4.7.1) and (4.7.2) above is proposed to be supplied, then the same must be proven being in regular use and having established it's satisfactory performance over a period of at least 2 years during last five years on the world wide railway/ metro system .

3.8 Some of the important specifications are as under:-

SN	Standard	Description
1	RDSO/SPN/144	Safety and reliability requirement of electronic Signaling equipment.
2	IRS: S-36	Relay Interlocking systems.
3	IRS: S- 23	Electrical Signalling and Interlocking Equipment
4	RDSO/SPN/192/2005	Electronic Interlocking
5	RDSO/SPN/165/2012	Integrated Power Supply
6	RDSO/SPN/153/2011 Rev.4.1	LED signal lighting unit
7	IRS : S-6	Tubular Steel Signal Poles
8	IRS : S-26/64	Colour light signal – Multi unit type
9	IRS:S-24 /2002(Amd.1)	Electric Point Machines
10	IRS:S-63 /2007(Amd.3)	Signalling Cables
11	IRS:S- 93 /96(A)	Secondary Cell – Maintenance Free
12	RDSO/SPN/177/2003 Ver-1 with Amd.-2 or RDSO/SPN/177/2012 Ver-3	Single Section Digital Axle counter
13	RDSO/SPN/176/2005 ver.-2 & firm's Specification.	Multi Section Digital Axle counter
14	RDSO/SPN/208/2012	Electric Lifting Barrier
15	IRS: TC 30 /2005 ver.-1,Amd.4	Jelly filled telecom quad cable
16	IRS: TC 55/2006 Rev-1,Amd.2	24 fiber armoured optical fiber cable
17	IEC 62278	Railway Applications- Specifications and demonstration of Reliability, Availability, Maintainability & Safety.
18	IEC 62279	Railway Applications-Communications, Signalling and processing systems-Software for Railway Control and Protection Systems.
19	IEC 62425	Railway Applications-Communications, Signalling and processing systems- Safety Related Electronics Systems for Signalling.
20	IEC 62427	Railway Applications- Compatibility between Rolling Stock and Train Detection Systems
21	IEC 62280-1	Railway Applications-Communications, Signalling and processing systems - Safety related communication in closed transmission systems.

22	IEC 62280-2	Railway Applications- Communications, Signalling and processing systems - Safety related communication in open transmission systems.
23	IEC 62236	Railway Applications – Electromagnetic compatibility (EMC)
24	IEC 60571	Electronic Equipment Used on Rail Vehicles
25	IEC 61373	Railway Applications – Rolling stock equipment Shock and vibration tests
26	IEC 62305	Protection against Lightning
27	IEC 61992	Railway applications – Surge arresters and low-voltage limiters for specific use in DC systems
28	IEC 60364	Electrical Installations for Buildings
29	IEC 62505	Railway applications – Fixed installations – Particular requirements for AC switchgear

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CHAPTER 4

TRACTION POWER SYSTEM

4.1 General

4.1.1 This section lays down the standards for design and performance and general features of the Traction Power System to be designed, constructed, tested, commissioned and maintained by the Concessionaire for the Rail System.

4.1.2 Traction sub stations and utility grid sub stations location is already finalized. The Employer shall construct transmission network up to DFCCIL traction sub-station and carry out associated bay modification/augmentation works at GSS through TRANSCO/DISCOM/Power Supply Authorities including arranging power supply for the TSS.

4.1.3 The Concessionaire shall supply and commission the SCADA System equipment for the control and monitoring of each high voltage electrical power supply system switching and protection equipment including auxiliary power supply system.

4.1.4 The electric power load to be connected shall comply with the TRANSCO/DISCOM/Power Supply Authorities regulations for electrical loads.

4.1.5 The system shall be so designed as to provide sufficient reserve whereby failure of any one of electrical equipment does not lead to disruption of supply.

4.1.6 25 kV, 50 Hz AC AT Feeding system shall be installed throughout the route except siding and loop lines, where 1 x 25 KV direct system shall be applicable. The system shall be designed to meet traffic and other functional requirements as given in respective chapters of this Manual.

4.1.7 The traction system should be sufficient to operate the trains at designed speeds over the operating routes, negotiating all gradients and curves without any train regulation.

4.1.8 The capabilities, ratings and number of equipment proposed to be connected as determined by the Concessionaire, shall be demonstrated to the Independent Engineer by simulation study and proper engineering for the services envisaged considering the possibility of equipment failures/ malfunctioning. The short circuit levels (of state power utilities) and load flow studies on the system during normal and abnormal working and failure conditions shall be determined and coordinated for his design of the Traction Substation equipment/ Power distribution arrangements.

4.1.9 The traction system should not generate, or risk dangerous interactions with any other system. The touch and step potential value shall be within limits prescribed in table 4 of EN: 50122. The fault clearing time shall be taken as 300 milli sec.

4.1.10 The system shall be designed considering 12kA fault level on 25 kV side.

4.1.11 Egress/ Fire evacuation measures shall be as per relevant BIS codes. The Fire fighting system is to be designed in accordance with IS 3218, National Building Code-2005, Local codes and relevant Indian/ International standards.

4.1.12 The Concessionaire shall maintain the traction substations and other electrical assets (excluding transmission line between GSS & TSS) of DFCCIL.

4.2 Codes, Standards and Specifications applicable for design of the component of the 25 kV AC AT Feeding System

The works shall be carried out in accordance with the following governing specifications and other statutory rules as per the priority given below:

a) Safety Regulations-2010 issued by Central Electricity Authority with latest amendments
b) Indian Electricity Act – 2003 with latest amendments
c) Regulations laid down by Chief Electrical Inspector to the Govt.
d) Rules and Regulations prescribed by local authorities as applicable
e) Relevant Indian standards,
f) Standard Schedule of Dimensions (SSOD) for EDFC - 2013 and the Indian Railways Schedule of Dimensions (2004) for the works concerning Indian Railways and connecting tracks,
g) EN-50122-1 Railway Application, fixed installation – electrical safety, earthing and return circuits & EN 50119
h) Design Manual for Electric Traction (Indian Railways)
i) Indian Railways AC Traction Manual
j) Electrical Safety Code and National Building Code
k) IEC Standards, British Standards and other national / international standards, provided always that these meet or exceed the requirements of the standards mentioned above.
l) List of standards & specifications is attached as **Annexure-A**

4.3 Environmental Conditions

The system is expected to be used in varying atmospheric and climate conditions. The environmental factors are expected to vary in the range as tabulated below:

S.N	Parameters	Range
1.	Ambient air temperature	-2.5º C to +50º C
2.	Maximum temperature of metallic object under sun	70ºC
3.	Maximum relative humidity	100%
4.	Annual rainfall (Most of the rainfall may be expected in the monsoon seasons)	Dry Arid regions and also heavy monsoon affected regions with rainfall ranging from 1750 to 6250 mm
5.	Maximum number of thunder storm days per annum	45
6.	Maximum number of dust storm days per annum	35
7.	Number of rainy days per annum	120

S.N	Parameters	Range
8.	Basic wind pressure	150 kgf/m^2, as per wind map based on BIS - 875. For long bridges (more than 150 m) and within 100 m from their abutments on either side and on banks, where the height of catenary above surrounding mean retarding surface is more than 30 meters, the specified 25% reduction in wind pressure shall not be reckoned for purposes of design.
9.	Creepage distance for Extreme pollution condition. Polluted Conditions (Normal & Light)	31mm/KV 20 mm/kV
10	Average Ambient temperature	35ºC
11	Solar radiation	1 kW/m2

4.4 25 kV AC AT Feeding Traction system:

4.4.1 **Heavy freight trains (with trailing l**oad up to 12000 tonnes) on DFC will be handled by electric locos, of 12000 HP at the head of the train. The overhead equipment (OHE) shall however be designed, developed and tested for 120 kmph speed with study / simulation of the multiple pantographs interaction. However the freight corridor design speed is 100kmph.

4.4.2 The system shall be designed for two single trains of 6000T hauled by 12000hp locomotive & one twin train (2x6000T) hauled with 2x12000hp locomotive at 12 minutes interval. In one direction 70% trains shall be empty N-Box. Wagons. 50% train will start & stop at every 30 km be considered for simulation.

4.4.3 Power supply Installation: General arrangement of power supply:

4.4.3.1 The capacity, rating, number and location of equipment as basic requirement of the design development shall be demonstrated by proper design calculations and traction simulation study. This shall be got approved from the Independent Engineer before proceeding to work out the detailed system design.

4.4.3.2 The concessionaire shall deemed to include necessary equipment of higher capacities and higher rating for the systems and sub systems necessary for the complete, safe, reliable, operable and maintainable traction power supply system with minimum voltage drop in feeder circuit, large spacing of traction sub-station & less telecommunication interference. Adequate redundancy should be built in for critical equipment.

4.4.3.3 TSS/SP/SSP location has been fixed by DFCCIL, however there shall be flexibility in finalization of neutral section based on the outcome of simulation study.

4.4.3.4 Power supply shall be received at the Traction Sub-Station (TSS) from state power Utilities through 220/132/110/66kV double circuit transmission line. The power supply shall be stepped down at each TSS as follows:

(i) 54 kV AC single phase converted to 2x27 kV by the TSS AT, which shall be distributed between feeder/catenary-contact/earth.Auto transformers shall also be installed at about every 10-20 km along the track.

(ii) 240V AC single phase for auxiliary supply.

4.4.3.5 The detailed calculations of exact equipment rating & system design parameters like location of neutral section, fault current & voltage drop shall be furnished as part of design report based on the data provided in this document. In this connection, detailed calculation & study for EMI/EMC, induced voltages & return current shall also have to be furnished. The study shall take into account the installation of surge arresters at appropriate locations.

4.4.3.6 **Auxiliary power Supply:** Following auxiliary power supplies shall be made available:

i) 110V DC from a battery bank. For substation battery bank should have minimum backup of 10 hrs.

ii) 240V AC, 50 Hz, Single phase from 25/0.240 kV auxiliary transformer feed from Traction supply.

4.4.4 Power supply Installation: Feeding & sectioning arrangement at TSS/SP/SSP:

4.4.4.1 Suitable feeding arrangement at TSS /SP/SSP shall be designed taking in to account ease of maintenance of equipment, power block implementations with minimum interruptions, feed extension requirements and derivation of full advantages of redundancy of equipment & circuit to provide uninterrupted traction power supply. Automatic fault locator working on principle of AT neutral current sensing or line reactance shall be provided at TSS, SP, SSP & AT.

4.4.4.2 **Sectioning:** Sectioning shall be provided to permit quick isolation of OHE in small sections through remote controlled switching using interrupters which can be monitored & operated through SCADA from OCC.

4.5 Power Supply System equipment

4.5.1 Traction Transformers:

TSS shall have provision for two transformers. The traction transformers shall be provided with motorized off circuit tap changer. The TSS shall be designed such that both traction transformers can be in service and coupled to be same bus bar, while load is transferred from one transformer to other. Each transformer shall be designed to comply with IEC – 60076.

4.5.1.1 Salient Features of Traction Transformers

Parameter	Rating
Power Rating	60/84/100 MVA (Minimum) However, the exact rating of transformer shall be fixed by the Concessionaire along with detailed calculations and reasoning or based on simulation study.
Cooling	ONAN/ONAF/OFAF
Rated secondary voltage	54kV

Rated secondary current	556 / 778/926 (for dual secondary winding)
Phase difference between main and teaser windings	90^{o}
Rated Primary voltage Un	220/132kV
Highest system voltage Um	245/145kV
Percentage Impedance at 60 MVA	11-13%
Non-cumulative overload capacity after the transformer has reached steady temperature on continuous operation at rated power	150% rated load for 15 Min 200% rated load for 5 min
Protection system of the traction transformer.	As per IEC-60076

4.5.2 Auto Transformer

Auto transformer shall be used as per particulars given below:

	TSS	**SP & SSP**
Rating	8 MVA (min)	8 MVA (min)
Short Circuit capacity	35 times	25 times

The auto transformer shall conform to IEC-60076.

4.5.3 Auxiliary & Instrument Transformer

The auxiliary transformer shall have losses as per specified criteria of BEE for 5-star rating wherever applicable. Instrument transformer such as Potential Transformer (PT) & Current Transformer (CT) & auxiliary transformer shall be so designed that they are maintenance free.

i) Auxiliary transformer shall have provision of spark gap as per latest RDSO instruction.
ii) Auxiliary transformers installed for S&T installations shall be monitored with energy meter/suitable RTU for status of supply through SCADA.

4.5.4 HV & LV switch gear:

25kV circuit breaker shall be vacuum type only. The circuit breakers proposed shall have minimum maintenance requirements with maximum availability. For higher voltages, SF-6 / vacuum circuit breakers shall be used. These shall comply with relevant RDSO specifications.

4.5.5 Protection & Control:

4.5.5.1 The OHE impedance data used for the purpose of relay setting and prospective fault current calculation shall be supported by simulation, supporting calculation, experimental trials or past experience results.

The Concessionaire shall submit detailed fault calculation, relay settings & fault co-ordinate curves showing proper protection, discrimination between upstream & downstream equipment.

4.5.5.2 The exact fault levels on HV side shall be obtained from the utilities.

4.5.5.3 All the relays employed for the protection of the system shall be numerical type & shall conform to 60255-IEC or RDSO specification, wherever applicable. The relay shall have communication capabilities as per IEC 61850 & 60870-5-103. Optical LAN communication between different relays & Intelligent Electronic Devices (IED) of substation should be adopted.

4.5.5.4 The Concessionaire shall design the protection system for power supply to ensure:

i) Adequate co-ordination with power supply authorities.
ii) Satisfaction of power supply authorities.
iii) Adequate discrimination between load & fault conditions.

4.5.5.5 Insulation co-ordination shall follow IEC 60850, IS/2165, EN 50124 & EN 50152 as applicable.

4.5.6 **Reactive Compensation & Energy Management Systems:**

4.5.6.1 The tariff imposed by different utilities varies widely in terms of Energy charges, Maximum Demand (MD), penalties & incentives on power factor & other power quality aspects. Provision shall be made for UPQC (Unified Power Quality Correction) to take care of tariff penalties on account of variation beyond prescribed limit in various parameters like PF, harmonics & Unbalance etc. Assuming power factor of 0.85 for the train journey, power factor correction shall be improved to 0.95 using 50% static & 50% variable or 100% variable capacitors.

4.5.6.2 Technical standards for connectivity to the grid regulations-2007, dated 21-02-2007 or latest issued by CEA (Central Electricity authority) such as Total Harmonic Distortion (THD) / Total Demand Distortion (TDD) limits at Power Control Centre (PCC) shall be considered while designing the system.

4.5.6.3 Integration of IEC 62056 open standard communication protocol compliant electronic energy meters to be considered at TSS for, analysis of energy related data at central Location.

4.5.7 **SCADA System**

4.5.7.1 The SCADA system shall monitor the entire traction power system and auxiliary power system and automatically reboot the equipment in the event of failure or maintenance activities, so as not to affect safety or normal operation of the services.

4.5.7.2 The software shall be compatible for working on IEC 60870-5-104 communication protocol & shall support multiple channels for communication to all RTU's.

4.5.7.3 The functions provided by the SCADA shall include:

a) Data Acquisition and processing from the Remote Terminal Unit (RTU)
b) Alarm processing
c) Provision of MMI for operator monitoring and control, and
d) Individual control, sequence of control and time schedule control.
e) Remote MMI.

4.5.7.4 The SCADA shall provide monitoring and both manual and automatic control of the power equipment, including:

a) Equipment status and switching, including traction transformer off load tap changer.
b) Reconfiguration of the power supply system and
c) Metering

4.5.7.5 The RCC equipment shall comprise of workstation, FEP's MIMIC panels and Digital Light Processing (DLP) unit or other systems, displaying the entire Traction Power System and Auxiliary Power System. Two servers (one hot standby) shall acquire real time equipment status from Remote Terminal Units (RTU), process the operation commands and perform the SCADA operations.

4.5.7.6 Any change of state of an input shall be reported at the RCC within 3 seconds of the occurrences.

4.5.7.7 The SCADA system shall record any events caused by faults, malfunctions, warnings or alarm information generated automatically by the selected equipment.

a) A central recording system shall be provided to record the followings events, including but not limited to:

i) Events designated as alarms
ii) Faults
iii) Control actions, and
iv) System generated messages e.g. equipment malfunction etc.

b) Events shall be given an order of priority to allow them to be classified, sorted and filtered. Subject to the requirements of the operation plan, events shall be classified as:

i) Emergency – This type of fault shall require instant attention in order to minimize interruption of the normal operation of the train services or the risk of injury to people. Overriding feature shall be incorporated in software for this purpose.

ii) Urgent - This type of fault shall require reasonably prompt, though not instant attention in order to minimize interruption of the normal operation of the train services and

iii) Non urgent - This type of fault shall be dealt with after urgent events.& shall not directly result in any degradation of the normal operation of the train services.

4.5.7.8 The design of the earthing system shall conform to EN 50122-1, EN 50522, IS: 3043:1987 The system shall have fail safe features.

4.5.8 Substation equipment

An RTU shall be provided at each TSS to communicate with the central SCADA servers. The RTU shall interface with the field equipment to be monitored or controlled .The RTU shall support a Local Interface Unit (LIU) for use by maintenance engineers & shall allow local operation.

For the event of loss of the OCC, a fall back arrangement shall be provided to enable the supervision of the entire Electric Power System. The backup SCADA shall have two central servers, two FEP & two MMI's at the least.

4.6 Over Head Equipment (OHE):

4.6.1 **Over Head Structure/ Mast:** Rolled/Fabricated Hot Dipped Galvanized OHE structure shall be provided as per RDSO specification no. ETI/OHE/13. Minimum coating of zinc for steel structures and small steel parts shall be 610 gm/sqm. For marine and chemically polluted areas, identified as a result of pollution mapping by the concessionaire and approved by the Engineer/Employer, the coating shall be 1000 gm/ sqm.

4.6.2 **Catenary Wire:** Catenary wire shall be minimum 120 sqmm Copper Alloy conforming to DIN 48201-T1 & T2, EN-50119, DIN 43138 or any other equivalent International standard. The maximum temperature withstanding capacity shall be validated through simulation study. In sidings & loop lines size of catenary wire shall be 65 sqmm conforming to RDSO specification. No. ETI/OHE/50 (6/97)

4.6.3 **Contact wire:** Contact wire shall be minimum 150 sqmm manufactured out of continuous cast rods by any processing conforming to EN-50149. The maximum temperature withstanding capacity shall be validated through simulation study continuously without affecting mechanical properties as per EN 50119. In sidings & loop lines, size of contact wire shall be minimum 107 sqmm conforming to RDSO specification. No. ETI/OHE/76 (6/97).

4.6.4 **25 kV Feeder**: 25 kV feeders shall be of AAAC material having minimum withstanding temperature of 80°C as per EN 50119.

4.6.5 **Aerial Earth Conductor**; ACSR material having minimum withstanding temperature of 80°C.

4.6.6 **Buried Earth Conductor**: Buried earth conductor's material (as and if required) shall have minimum withstanding temperature of 80°C.

4.6.7 **Flexible Jumpers and Feeders**

Flexible jumper wire shall be fabricated from soft annealed high conductivity copper with stranded conductors. The size of the jumpers shall be decided based on train simulation study & temperature rise shall be within limits in extended feed condition. The jumper shall conform to DIN 43138.

4.6.8 **Dropper**

Each current carrying dropper shall conform to DIN 43138. & size shall be based on train simulation study.

4.6.9 **Cantilever assemblies**

The Modular cantilever assembly (MCS) shall be of proven design & meet cross acceptance criteria listed in para 4.13.6. The components of cantilever shall be corrosion resistant. The number of component shall be bare minimum & easy interchangeability of the component on the same cantilever shall be ensured, so as to have ease in maintenance & faster restoration. For better interchangeability, ease in construction & smooth inventory control the design of mast side fitting as well as OHE side fittings of both stay & bracket insulators of the cantilever shall be same. The design shall conform to EN 50119. Cantilever made of fibre shall not be used. Concessionaire to develop functional specification for the product for approval of Independent Engineer.

4.7 Over Head equipment (OHE) Design

4.7.1 OHE shall be designed for a minimum train test speed of 130 kmph, The normal train operation shall however be at 100 kmph. Detailed design calculations along with dropper schedule and associated software shall be submitted.

4.7.2 The tension in the contact & catenary conductors of the flexible overhead equipment shall be regulated at all temperatures by auto-tensioning devices of

proven design. The auto tensioning device shall be conforming to RDSO specifications. The use of gas ATD shall be restricted to viaducts and tunnels.

4.7.3 The OHE at crossover & turnout shall be designed in such a way that there is no possibility of pantograph entanglement at these two most critical points/locations. GPS mapping of all traction assets like mast, portals, SP, SSP, TSS, overlaps to be carried out & data submitted in hard & soft copy.

4.7.4 Design of OHE at transition locations shall be compatible with the feeder routes of the existing conventional 25kV A.C. overhead traction system having maximum permissible gradient of 3mm per meter for mainline and 10 mm per meter for sidings. Relative gradient of contact wire in two adjacent spans shall not be more than 1.5 mm/meter on main line and 5mm per meter on loop lines and sidings. Gradient of contact wire may be designed to ensure smooth current collection. For this purpose, contact wire & pantograph interaction study using simulation software shall be submitted.

4.7.5 Due to rising level of pollution, the high voltage lines shall be designed with creepage level as defined in clause 5.3. Porcelain insulators as per RDSO Spec No.TI/SPC/OHE/INS/0070 shall be provided at all locations except at polluted zones, where polymer insulators as per RDSO Spec. No. TI/SPC/ (OHE)/INCOM/0070(04/07) shall be used.

4.7.6 Height of contact wire shall be so decided that the requisite clearances are within SSOD of EDFC.

4.7.7 Minimum E&M clearances have to be adopted as per EN 50119, ACTM and SSOD for EDFC for 25 KV AT feeding systems.

4.8 Neutral section &section insulator:

Selection of particular design of neutral section to be adopted in the system shall be proposed for approval by Independent Engineer. Light weight neutral sections having self arc extinguishing feature may be considered.

4.9 Reliability, Availability and Maintainability

4.9.1 **General**

The Concessionaire shall design the Rail System with a high degree of reliability and availability in order to provide a dependable service. The RAMS shall conform to EN 50126.

4.9.2 **Reliability**

A fault study shall be prepared for the Various Systems, identifying the System failure modes which contribute to reliability and quantitative estimates prepared of the likelihood of failure. The system and the components shall comply with EN 50126.

4.9.3 **Dynamic Validation**

a. Dynamic validation shall be undertaken to ensure compliance with the specified current collection criteria of all relevant parts of the project including track work and catenary interfaces.

b. If the technology for measuring by force is not available, then the criteria for measurement shall be loss of contact with measurable arcs lasting longer than 10ms (maximum 25ms) shall not occur more than once in 100m.

c. The system dynamic performance shall comply with the requirements as per EN: 50119.

4.9.4 **Availability Requirement**

The overhead contact system design, arrangement and component design shall be chosen to ensure that the DFC shall have high service availability. The SCADA system at the OCC shall be designed to a reliability level of minimum N-1 communication between the OCC & the outstations in the field.

4.9.5 **Maintainability Requirement**

The Concessionaire shall state the maintainability requirements, and demonstrate that System maintainability is sufficient to support the claimed System reliability and availability performance. The Concessionaire shall demonstrate that maintenance errors have been considered and as far as practicable, the risk of maintenance induced faults has been mitigated by the appropriate design.

4.10 Electromagnetic Compatibility (EMC) Requirements

4.10.1 **General**

4.10.1.1 The EMC Control Plan shall include measures to reduce conducted, induced and radiated emissions, especially the levels of harmonic, to acceptable values as specified by the relevant International Standards.

4.10.1.2 The Concessionaire shall identify all EMC tests to be undertaken in the EMC Control Plan and where ever appropriate in the integration testing plan. The test plan shall make clear the pass / fail criteria prior to any testing taking place. These test shall include but not limited to EN 50121-1,2,4,5; EN50152, IEC 61000-4-2,3,4,8,9,10; & IEC 61000-2-6,61000-3-2, 3-3 & 3-5.

4.10.2 **Intra-System EMC**

The Concessionaire shall ensure that all intra-system EMI are taken care of through proper design and other special measures. All major sub-systems shall be tested for emissions and immunities in accordance with the appropriate International Standards for equipment operating in Railway or similar industrial environment.

4.10.3 **Inter-System EMC**

The Concessionaire shall ensure that all equipment are designed and constructed in accordance with the latest issues or versions of internationally recognized EMC standards including but not limited to EN 50082, EN50121, EN50152, EN50155, IEC60571 & IEC61000 or equivalent to ensure proper functioning.

4.10.4 **Non-Safety-Related Systems Interference**

The Concessionaire shall take appropriate measures to ensure that all radiated emissions, either via the power cables, transformers or any other system components, shall be minimized in compliance to EN 50121-5, EN 50152, and IEC61000-2.

All power cables shall be properly shielded where applicable and shall conform to IEC 61000-4-6 and IEC 61000-4-16.

4.10.5 **Environment EMC**

The Concessionaire shall ensure that radiated emissions from the power supply cable are maintained at an internationally acceptable level. The Concessionaire shall also ensure that the power cables are protected from Radio Frequency (RF) radiations from all telephone network operators and radio networks. Installation and Mitigation Guidelines stipulated in IEC 61000-5 shall be observed, wherever applicable.

4.10.6 **EMC Management Plan**

The Concessionaire shall prepare and submit for review and comments, if any, by the Independent Engineer, an EMC management plan which shall define the EMC philosophy, activities, and means of control for the engineering processes and the EMC submissions (EMC management plan), shall demonstrate compliance with the Concession Agreement. The management plan shall include management of issues such as surges, interference, transients, magnetic field, radiated emissions etc as prevalent in modern traction environment.

4.10.7 **EMC Engineering**

4.10.7.1 The Concessionaire shall ensure that all electrical; and electronic apparatus are Engineered and constructed to operate without degradation of quality, performance or loss of function and data in the electromagnetic environment of the project.

4.10.7.2 The Concessionaire shall comply with the requirements of the international standards EN 50121-1/-/5 Railway Applications – Electromagnetic compatibility, 2003 and related standards and the IEC 61000 series for Electromagnetic compatibility, or equivalent standards. EMC considerations shall be incorporated in the Concessionaire's procedures for functional safety and engineering verifications.

4.11 Earthing and Bonding

The Concessionaire shall prepare an Earthing & Bonding Management Plan and submit it for the approval of Independent Engineer. This plan shall apply to the Permanent Works on the Project to ensure the structures and equipment are safe from EMI due to 25 KV traction effects.

The design of earthing system shall confirm to IS 3043:1987 and meet the safety standards & limits of touch & step potential as stipulated in EN 50122-1, EN-50522 considering fault having duration of 300 msec as a minimum, subject to backup protection clearing the fault within this period.

4.11.1 **Maximum value of earth resistance shall be as follows:**

Location	Maximum value of earth resistance in Ohms
TSS	0.5
SSP	2.0
SP	2.0
Other locations	To meet the requirements of EN 50122-1

4.11.2 **Bonding**

Bonding shall be done on all exposed metallic parts of all equipment. Direct Bonding shall be used, wherever practicable. Where indirect bonding via bonding strap is used to connect two isolated items, the bond shall satisfy the minimum requirements and prevailing International Standards, for example, IEC 61000-5-2 and EN 50122-1.

4.12 Cabling

The cables used shall be adequately protected against external interference.

A cable routing plan shall be designed to minimize likelihood of coupling between parallel cables. The Concessionaire shall refer to guidelines recommended by IEC61000-5-2.

Proper Bonding & cross Bonding of metallic conduits armour & screening conductor shall be made to ensure that the induced voltage is within safe limits. 25kV AC single core cables shall be insulated with XLPE and shall be armored. The outer sheath of the cables shall be able to protect against ultra violet radiation.

4.13 Proven Design & Cross Acceptance Criteria

4.13.1 The Concessionaire shall develop the designs by using proven and reliable engineering practices. The design details shall be submitted with technical data and calculations to the Independent Engineer for review and consent.

4.13.2 The Concessionaire shall undertake multi train simulations of the whole route using a fully validated computer based multi train simulation package. The simulation study shall model normal operations, first failure and second failure conditions and perturbations.

4.13.3 The system, including all sub-systems and equipment shall be of approved RDSO design/ specifications, wherever applicable and shall be subjected to prototype testing as per relevant RDSO Specifications.

4.13.4 The Concessionaire shall develop designs and firm up detailed specifications for these items for which draft outline specifications or functional requirement have been indicated in this document for consent by the Independent Engineer with the consent of Employer.

4.13.5 Cross acceptance criteria will be applicable on following:

a) Items not covered by RDSO specification

b) Items have RDSO specification but no supplies have been made.

4.13.6 The cross acceptance criteria shall be as under:

a) Three years satisfactory performance on AC Traction system from one month prior to date of second stage of Bid opening or later. (For circuit Breakers Interrupters above 25 kV, 25 kV feeder wire, AEW, BEC as required and SCADA system), three (3) years satisfactory performance on power utility shall also be permitted.

b) The manufacturer should have supplied the equipment of minimum 70% rating of equipment offered. The contractor shall furnish the details of its proven performance (certificate from the user) for such items.

c) The manufacturer should have supplied at least 50% quantity to be used in this contract in last seven years or they can supply, maximum two times the quantity supplied in last seven years (1 month prior to date of Second Stage Bid Opening).

d) Prototype Test Report/Certificate for offered item is to be submitted. Fresh Prototype Test is to be conducted, if the same has not been carried out;

i) In last three years from one month prior to date of Second Stage of Bid opening or later;

ii) Considering the environmental conditions as specified in this manual.

e) The Manufacturer shall have to support maintenance and repair of the equipment in India and supply spares till the design life of the material such

as transformers etc in India. The Contractor shall submit an undertaking in this effect from the Original Equipment Manufacturer (OEM).

f) The Original Equipment Manufacturer (OEM) may transfer technology to any Indian Company for manufacture and supply of 50% quantity used in the project provided the OEM has technology tie up with the Indian manufacturer and the OEM signs Joint Deed of Undertaking by the qualified equipment manufacturer along with the contractor and Indian equipment manufacturer/Indian partner.

g) In order to ensure satisfactory Transfer Of Technology (TOT), the OEM shall provide with DFCCIL and Indian Manufacturer;

(i) Design drawings

(ii) Manufacturing drawings

(iii) Process sheet for manufacturing

(iv) Inspection and Quality Management Procedures

(v) Complete Material Specifications

(vi) Jigs and Fixtures

(vii) List of Machinery and Plants along with their functional specifications, which are needed for manufacturing

(viii) Manufacturing supervision

(ix) Inspection by OEM's representatives

(x) Extended guarantee for 3 years for indigenous equipment after expiry of Defect Notification Period

(xi) Any other assistance, reasonably required

4.13.7 Any approval to the Prototype Tests by the Engineer in no way shall absolve the contractor of his responsibility for the equipment under the terms of contract.

4.13.8 The prototype test already done shall be valid only if it was done on identical equipment (same rating), manufactured with identical component / raw material, at the same manufacturing facility and to identical Quality Standards.

Annexure-A

a) List of Indian Standards:

S.N	IS No	Description
1.	5	Colors for ready mix paints and enamels
2.	814-1974, 816-1969, 823-1964 , 6227-1971	Code of practice for electric welding of mild steel Structures
3.	335-1993/BS-148, D-1473,D-1533-1934, IEC Pub 296-1969	New Insulating Oils
4.	371-1999 (3rd rev)	Ceiling Rose specification
5.	398 -1994	Feeder Wire specification for Hard-drawn All Aluminum conductor
6.	694-1990/IEC 60227	PVC Insulated cables for working voltages up to and including 1100 Volts
7.	732-1989	Code of Practice of Electrical Wiring Installations(System Voltage not exceeding 660V)
8.	1239-2004	Steel Tubes, Tubular and other Wrought Steel Fittings
9.	1248-2003	Direct Acting Electrical Indicating Instruments
10.	1255-1983	Code of Practice for Installation and Maintenance of Power Cables up to and Including 33kV Rating
11.	1271-1958	Classification of Insulating Materials
12.	1293-1988/ IEC 60884-1 (2002)	Plugs and socket outlets of rated voltage up to and including 250 volts and rated current up to and including 16 amperes
13.	1570	Schedule for wrought steels – Part 5; Stainless steel and heat resisting steels
14.	1576	Solid pressboard for electrical purposes
15.	1554-1988/IEC 60502	PVC Insulated (Heavy Duty) Electric Cables
16.	1646-1997	Code of Practice for Fire Safety of Building
17.	1753-1967	Aluminum conductors for insulated cables
18.	1777-1978	Industrial Luminaries with Metal Reflectors
19.	1866-2000	Code of practice for maintenance and supervision of mineral insulating oil in equipment
20.	1913-1978	General Safety Requirements for luminaries
21.	1964-1966	Code of practices for structural safety of building foundations
22.	2026-1977/ IEC76	Specification for Power Transformer
23.	2099-1986	Bushing for Alternating Voltages Above 1000V (2nd revision)
24.	2175-1988	Heat Sensitive Detectors for Use in Automatic Fire Alarm System
25.	2189-1999	Code of Practice for Installation of Automatic Fire Alarm System
26.	2208-1962	HRC cartridge fuses links up to 650 volts

S.N	IS No	Description
27.	2309-2005	Code of practice for the protection of buildings and allied structures against lightning
28.	2312-1976	Propeller type AC ventilating fans
29.	2412-1975	Link clips for electrical wiring
30.	2502 -1963	Code of practice for bending & fixing of bars for concrete reinforcement
31.	2667-1988	Fittings for Rigid Steel Conduits for Electrical Wiring
32.	2675-1983	Enclosed distribution fuse boards, cut outs for voltage not exceeding 1000 V AC & 1200 V DC
33.	2705-1992	Current Transformers
34.	2834-1986	Shunt Capacitors for Power Systems
35.	2927	Brazing alloy
36.	3024-2006	Electrical sheet steel (oriented)
37.	3043-1987	Code of Practice for Earthing
38.	3156-1992/4146-1983	Voltage Transformers/Application guide for Voltage Transformers
39.	3202-1965	Code of Practice for Climate Proofing of Electrical Equipment
40.	3231-1986	Electrical Relays for Power System Protection
41.	3347-1967/ DIN 42531,23,	Dimensions for Porcelain Transformer Bushings for Use in Lightly Polluted Atmospheres
42.	3401-1992	Specification for Silica Gel
43.	3427-1997	Metal Enclosed Switchgear & Control Gear for Voltages Above 1000V up to and Including 52000V
44.	3528-1966	Water Proof Electric Light Fitting
45.	3553-1983	Specification for Watertight Electric Lighting Fitting
46.	3637	Gas operated relays
47.	3639-1966	Fittings and accessories for power transformers
48.	3646-1992	Code of Practice for Interior Illumination
49.	3696-1993	Safety Code for Scaffolds and Ladders
50.	3764-1992	Excavation work- code of safety
51.	3837-1976	Accessories for rigid steel conduit for electrical wiring
52.	3842-1977	Application guide for electrical relays for ac systems
53.	3854-1997/ IEC 60669-1	Switches for domestic and similar purposes
54.	3961-1968 (Part III)	Recommended current ratings for cables
55.	3975-1999	Mild Steel Wires, Strips and Tapes for Armoring of Cables
56.	4160-1967/ IEC 60884-2-6 (1997)	Interlocking switch socket outlet
57.	4253 (Part II)	Cork composition sheets(Rubber and cork)
58.	4615-1968	Switch socket outlets (non-interlocking type)

S.N	IS No	Description
59.	4876-1979	Specification for hot dipped for galvanized coatings on ground steel wires
60.	4889/BS-269	Rules for Method of Declaring Efficiency and Electrical Machines
61.	4984-1985	High Density Polyethylene Pipes
62.	5082-1998	Wrought Al. and Aluminum Alloys, Bars, Rods, Tube and Sections for Electrical Purposes
63.	5133-1969 (Part-I & II)	Boxes for the Enclosure of Electrical Accessories
64.	5138-1978	Enclosure construction with single sheet sturdy frame construction
65.	5216-1993	Recommendations on Safety Procedures and Practices in Electrical Work
66.	5561-1970	Electrical power connectors
67.	5578-1984	Guide for marking of insulated conductors
68.	5613-1985	Code of Practice for Design, Installation and Maintenance of Overhead Power Lines
69.	5819-1970	Recommended short circuit ratings of high voltage PVC cables
70.	5831-1984	PVC insulation and sheath of electric cables
71.	5891-1970	Recommended Short Circuit Rating of High Voltage XLPE Insulated PVC Cables
72.	6209	High voltage test techniques – Partial discharge measurements
73.	6380-1984	Specification of Elastomeric Insulation & Sheath of Electric Cables
74.	6474-1984	Polyethylene insulation and sheath of electric cables
75.	6600-1972/IEC 76	Guide for Loading of Oil Immersed Transformers
76.	6655-1972	Code of Practice for Industrial Lighting
77.	6792-1992/IEC 60156	Method for Determination of Electric Strength of Insulating Oils
78.	7098-1988 (Part-I & II)	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to 33 kV
79.	7671-2001	Requirements for Wiring Installations. IEEE Wiring Regulations – 16th Edition
80.	8130-1984 (1st rev.)	Conductor for insulated electric cables & flexible cords.
81.	8468-1977	On-load tap changers
82.	8478-1977	Application guide for Tap- Changers
83.	8623-1993	Low-Voltage Switchgear and Control gear Assemblies
84.	9537-1980 (Part 1)/ IEC 60614-1 (1978)	Conduits for electrical installations
85.	9974-1981/IEC 662	High Pressure Sodium Vapor Lamps
86.	10028-1985	Code of Practice for Selection, Installation and Maintenance of Transformers

S.N	IS No	Description
87.	10118 (Parts1-4)-1982,	Code of Practice for Selection, Installation and Maintenance of Switchgear
88.	10322-1982	Specification for Luminaries
89.	10418-1982	Drums for Electric Cables
90.	10561-1983/IEC 606	Application Guide for Power Transformers
91.	10593-2006	Mineral Oil-impregnated electrical equipment in services Guide to the interpretation of dissolved and free gases analysis
92.	10810-1984	Methods of Tests for Cables
93.	11353-1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
94.	12021-1987	Control Transformers for Switchgear and Control gear for Voltages not Exceeding 1000 V AC
95.	12676-1989	Oil impregnated paper insulated condensers bushings-dimensions and requirements
96.	12943-1990	Brass glands for PVC cables
97.	13021-1991/IEC 60928	AC Supplied Electronic Ballasts for Tubular Fluorescent lamps
98.	13032-1991	AC Miniature Circuit-Breaker Boards for Voltages not Exceeding 1000 V
99.	13118-1991	High-Voltage Alternating-Current Circuit-Breakers
100.	13234	Guide for short circuit calculations in 3 phase AC system
101.	13340-1993	Power Capacitor of Self-healing Type for AC Systems Having Rated Voltage up to 650 Volts
102.	13341-1992	Requirements for Ageing Test, Self-healing Test and Destruction Test on Shunt Capacitors
103.	13707-1993	Reliable transfer in text communication for information processing systems
104.	13779-1999/ IEC 62056	AC static watt hour meter class 1 and 2
105.	13925-1998	Shunt Capacitor for Power System
106.	13947-1993	Specification for low voltage switchgear & control gear.
107.	15787-2008/ IEC 60884-2-3 (1989)	Switch-Socket outlets (Non-Interlock Type)
108.	60309-2002	Plugs, socket outlets & couplers for industrial purpose

b) List of International Standards (EN/BS/IEC/IEEE/ENV/ISO/UL etc.)

S.N	Standard Number	Description
1.	BS 5308	Instrumentation cables – Part 1 Specification for polyethylene cables
2.	BS 6724	Specification for 600/1000 V and 1900/3300 V armoured electric cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire.
3.	BS 7211	Specification for thermosetting insulated cables (non armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire
4.	BS 7430	Code of Practice for Earthing
5.	BS 7671	Requirements for Electrical Installations
6.	BS 7835	Specification for cables with cross-linked polyethylene or ethylene propylene rubber insulation for rated voltages from 3800/6600 V up to 19000/33000 V having low emission of smoke and corrosive gases when affected by fire
7.	BS 7846	Electric cables 600/1000V armoured fire resistant cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire
8.	BS EN 50082-1	Electromagnetic compatibility – Generic immunity standard Part 1: Residential, commercial and light industry
9.	DD ENV 50121 (All parts)	Railway applications – Electromagnetic compatibility
10.	DIN 43668	Key for the doors of electrical switchgear cubicles and cabinets; double-bit key
11.	DIN 43671	Copper bus bars; design for continuous current
12.	DIN 43761	Temperature Sensors
13.	DIN 53481/1.2 (36)	Determination of Dielectric strength of Plastic & rubber
14.	DIN 53504	Determination of Tensile strength off plastic and rubber
15.	DIN 53577	Compressive strength of flexible cellular material
16.	DIN 7733	Laminated products, pressboard for electrical engineering types
17.	DIN EN 13601	Copper rod, bar and wire for general electrical purposes
18.	DIN EN ISO 1798	Flexible cellular polymeric materials
19.	EN ISO 1856	Flexible cellular polymeric materials
20.	EN ISO 9001	Quality systems: Model for quality assurance in design, development, production, installation and servicing
21.	EN 50119	Railway Applications – Fixed installations-Electric traction overhead lines
22.	EN 50121	Railway applications – Electromagnetic compatibility

S.N	Standard Number	Description
23.	EN 50122	Railway Application – Fixed Installations, Electrical Safety, Earthing and return circuit
24.	EN 50124-1	Insulation Co-ordination in Traction Systems
25.	EN 50125-2	Environmental Conditions for Fixed Installations
26.	EN 50126	Railway applications: The specification and demonstration of dependability, reliability, availability, maintainability and safety (RAMS)
27.	EN 50149	Railway applications. Fixed installations. Electric traction. Copper and copper alloy grooved contact wires
28.	EN 50152	Railway Applications- Fixed Installations – Particular requirements for AC Switchgear. (All parts)
29.	EN 50522	Earthing of Power System exceeding 1 kV/AC
30.	EN 50163	Railway Application – Supply Voltages of traction systems
31.	EN 50267	Common test methods for cables under fire conditions. Tests on gases evolved during combustion of materials from cables
32.	EN 50272 (Part 2)	Safety requirements for secondary batteries and battery installations – Stationary batteries
33.	EN 50327	Railway applications. Fixed installations. Harmonization of the rated values for converter groups and tests on converter groups
34.	EN 50328	Railway applications. Fixed installations. Electronic power convertors for substations
35.	EN 50329	Railway applications. Fixed installations. Traction transformers
36.	EN 50388	Railway applications: Power supply and rolling stock – technical criteria for the coordination between power supply (substation) and rolling stock to achieve operability
37.	EN 60051	Direct acting indicating analogue electrical measuring instruments and their accessories
38.	EN 60073	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
39.	EN 60076	Power Transformers / Reactors
40.	EN 60137	Insulated Bushings for Alternating Voltages above 1 KV
41.	EN 60146	Semiconductor converters
42.	EN 60214	On-load tap-changers
43.	EN 60255	Electrical relays
44.	EN 60269	Low-voltage fuses
45.	EN 60270	High voltage test techniques – Partial discharge measurements
46.	EN 60296	Fluids for electro technical applications. Unused mineral insulating oils for transformers and switchgear
47.	EN 60332	Tests on electrical and optical cables under fire conditions. Test for a vertical flame propagation for a single insulated wire or cable
48.	EN 60417	Graphical symbols for use on equipment

S.N	Standard Number	Description
49.	EN 60445	Basic and safety principles for man-machine interface, marking and identification. Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system
50.	EN 60507	Artificial pollution tests on high-voltage insulators to be used on ac systems
51.	EN 60529	Specification for the degree of protection provided by enclosures (IP code)
52.	EN 60721	Classification of environmental conditions. Environmental parameters and their severities
53.	EN 60726	Dry type power transformers
54.	EN 60896-2	Stationary lead-acid batteries. General requirements and methods of test. Valve regulated types
55.	EN 60947	Specification for low-voltage switchgear and control gear.
56.	EN 61034	Measurement of smoke density of cables burning under defined conditions
57.	EN 61138	Cables for Portable Earthing and Short Circuiting Equipment.
58.	EN 61140	Protection against shock – Common aspects for installation and equipment
59.	EN 61230	Live Working – Portable Equipment for Earthing or Earthing and short circuiting
60.	EN 61325	Insulators for Overhead Lines with Nominal Voltages above 1000 V
61.	EN 61508	Functional safety of electrical/electronic/ programmable electronic safety related systems
62.	EN 61952	Insulators for overhead lines. Composite line post insulators for alternating current with a nominal voltage
63.	EN 62271	High-voltage switchgear and control gear
64.	IEC Hand Book for Temperature Index	Cable in fire regarding temperature Index Chapter-6
65.	IEC 68	Arrangements for the recognition and acceptance of conformity assessment results
66.	IEC 112	Guide on the safety of multimedia equipment
67.	IEC 137	Bushings for alternating voltages above 1000 Volts
68.	IEC 185	Current Transformers
69.	IEC 1508	Functional Safety – Safety related systems
70.	IEC10333	Cable joints and terminations
71.	IEC 60044	Instrument transformers
72.	IEC 60050	International Electro technical Vocabulary
73.	IEC 60076	Power Transformers/Reactors
74.	IEC 60081	Tubular fluorescent lamps for general lighting service
75.	IEC 60214	On Load Tap Changers
76.	IEC60228	Conductors of insulated cables
77.	IEC 60255	Measuring Relays and Protection Equipment
78.	IEC 60269	Low Voltage Fuses

S.N	Standard Number	Description
79.	IEC 60270	High Voltage test techniques - partial discharge measurements
80.	IEC 60287	Calculation of the continuous current rating of cables
81.	IEC 60296	Fluids for electro technical applications – unused mineral insulating oils for transformers and switchgear /new insulating oils
82.	IEC 60298	AC metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 72kV
83.	IEC 60332	Tests on electric and optical fiber cables under fire conditions Part 1-2: Test for vertical flame propagation for a single insulated wire or cable Procedure for 1 kW pre-mixed flame
84.	IEC 60364	Electrical installations of buildings
85.	IEC 60376	Specification of technical grade Sulphur Hexafluoride (SF6) for use in electrical equipment
86.	IEC 60422	Code of practice for electrical maintenance and supervision of mineral insulating oil in equipment.
87.	IEC 60439	Type-test low-voltage switchgear and control gear assembly
88.	IEC 60479	Effects of current on human beings and livestock
89.	IEC 60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV
90.	IEC 60517	Gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above
91.	IEC 60598	Luminaries: General Requirements and Tests
92.	IEC 60616	Terminal and tapping markings for power transformers
93.	IEC60694	Common specification for high voltage switchgear and control gear standards
94.	IEC 60754	Test on gases evolved during combustion of electric cables
95.	IEC60815	Guide for the selection of insulators in respect of polluted conditions
96.	IEC 60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 150 kV) Test methods and requirements
97.	IEC 60850	Railway applications – Supply voltages of traction systems
98.	IEC 60853	Cyclic & emergency current rating of cable
99.	IEC 60898	Circuit-breakers for over current protection for household and similar installations
100.	IEC 60909	Guide for short circuit calculations in 3 phase AC systems
101.	IEC 60929	AC supplied electronic ballasts for tubular fluorescent lamps – Performance requirements
102.	IEC 60947-2	Low-Voltage Switchgear and control gear
103.	IEC 61000	Electromagnetic compatibility
104.	IEC 61024	Protection of Structures against Lightning, Part 1: General Principles
105.	IEC 61243	Voltage Detecting Systems

S.N	Standard Number	Description
106.	IEC 61312	Protection against lightning electromagnetic pulse (LEMP)
107.	IEC 61439	Low-voltage switchgear and control gear assemblies
108.	IEC 61443	Short Circuit Temp. limits for cables with rated voltage above 36kV
109.	IEC 62128	Railway applications-Fixed installations-Part 1: Protective provisions relating to electrical safety and earthing
110.	IEC 62236	Railway Applications – Electromagnetic Compatibility
111.	IEC 62271	High Voltage Switchgear and Control Gear
112.	IEEE 80	Guide for safety in ac substation grounding
113.	IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Grid System
114.	IEEE 446	IEEE Recommended Practice for Emergency and Standby Power Systems
115.	IEEE 485	IEEE Recommended Practice for Sizing of Large Lead Storage Batteries for generating Station and Substations
116.	IEEE738	Standard for Calculating Current-Temperature of Bare Overhead Conductors
117.	IEEE980	Guide for Containment and Control of Oil Spills in Substations
118.	IEEE1187	Recommended Practice for Installation Design and Installation of Valve-regulated Lead acid Storage batteries for Stationary Applications
119.	IEEE 1188	IEEE Recommended Practice for Maintenance, Testing and Replacement of valve-regulated Lead Acid (VRLA) Batteries for Stationary Applications.
120.	IEEE 1189	IEEE Guide for Selection of Valve-regulated Lead Acid (VRLA) Batteries for Stationary Applications
121.	IEEE 1313.1	Standard for Insulation Coordination
122.	IEEE 1427	Guide for Recommended electrical Clearances and Insulation Levels in Air-insulated Electrical Power Substations
123.	IEEE C2	National Electrical Safety Code
124.	IEEE C37.14	Low-voltage DC Power Circuit Breakers used in Enclosures
125.	IEEE C37.16	Standard for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors used in Enclosures
126.	IEEE C37.20.1	Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
127.	IEEE C37.30	Standard requirements for High-Voltage Switches
128.	IEEE C37.32	HV switches, Bus Supports and Accessories, Schedule of Preferred Ratings, Construction Guidelines and Specifications
129.	IEEE C37.34	Standard Test Code for HV Air Switches, Insulators and Bus Supports
130.	IEEE C37.35	Guide for Application, Installation, O&M of HV Air Disconnecting and Load Interrupter Switches
131.	IEEE C37.37	Standard Loading Guide for AC HV Air switches (in excess of 1000V)

S.N	Standard Number	Description
132.	IEEE C37.20.2	Standard for Metal-Clad Switchgear
133.	IEEE C37.100	Definition of Power Switchgear
134.	IEEE C57.93	Guide for Installation of Liquid Immersed Power transformers
135.	IEEE C57.12.00	Standard General Requirements for Liquid Immersed Distribution, Power and Regulating Transformers
136.	IEEE C57.12.80	Standard Terminology for Power and Distribution Transformers
137.	IEEE C95.1	Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
138.	IEEE C95.6	Standard for Safety Level with respect to Human Exposure to Electromagnetic Fields 0-3 KHz
139.	IEEE PC37.2/D 2.2	Standard for Electrical Power System Device Function Numbers, Acronyms and Contact Designations
140.	ISO 3864	Graphical symbols – Safety colours and safety signs
141.	ISO 17398	Safety colours and safety signs
142.	JIS C 2553	Grain oriented electrical steel sheets and strips
143.	NEC* 300-21	Spread of Fire or Products of Combustion
144.	NEMA 250	Enclosures for Electrical Equipment
145.	NEMA AB1	Moulded Case Circuit Breakers and Moulded Case Switches
146.	NEMA BU1	Bus ways
147.	NEMA SG5	Power Switchgear Assemblies
148.	NEMA SG6	Power Switching Equipment
149.	NEMA TR208	Disconnect Switchgear Insulators
150.	NEMA WC70	Standard for Non-shielded Power Cables Rated 2000V or Less for the Distribution of Electrical Energy
151.	NFPA	National Fire Protection Association
152.	UL 6	Rigid Metal Conduit
153.	UL 924	Emergency Lighting and Power Equipment
154.	UL 925	Fluorescent lamp Ballasts

c) List of RDSO Specifications:

Sl. No.	Specification No.	Description
1	ETI/OHE/3	Technical specification for Annealed stranded copper conductors for jumper wire for Electric Traction
2	ETI/OHE/11	Specification for steel tubes
3	ETI/OHE/13	Specification for Hot dip zinc galvanization of steel masts (Rolled & Fabricated), tube sand fittings used on 25kV ac OHE
4	ETI/OHE/16	Specification for 25kV ac single pole and double pole isolators for Railway Electrification
5	ETI/OHE/18	Specification for Steel and stainless steel bolts, nuts and washers

Sl. No.	Specification No.	Description
6	ETI/OHE/21	Aluminum alloy section and tubes for 25kV Traction Overhead Equipment
7	ETI/OHE/27	Section Insulator assembly without sectioning insulator
8	ETI/OHE/33	Specification for Enameled steel plates
9	ETI/OHE/33A	Provisional specification for retro-reflective structure Number plates
10	ETI/OHE/36	Specification for Galvanized steel wire rope
11	ETI/OHE/42	Technical specification for hard drawn grooved contact wire for electric traction(jointed/welded contact wire)
12	ETI/OHE/48	Technical specification for Winch type regulating equipment for 25kV ac traction
13	ETI/OHE/49	Technical specification for Fittings for 25 kV AC OHE
14	ETI/OHE/50	Technical Specification for cadmium Copper conductors for overhead Railway traction
15	ETI/OHE/51	Specification for Discharge/earthing pole assembly for 25kV AC traction
16	ETI/OHE/52	Specification for Interlocks for AC tractions switchgears
17	ETI/OHE/53	Principles for OHE layout plans and sectioning diagrams for 25kV AC traction
18	ETI/OHE/54	Specification for 19/2.79mm all aluminum alloy, stranded catenary wire
19	ETI/OHE/55	Specification for Bimetallic (aluminum-copper) strip
20	ETI/OHE/58/1	Specification for hand operated lifting and swiveling platform
21	ETI/OHE/64	Specification for solid core cylindrical post insulators for systems with nominal voltages of 220 KV,132 KV,110 KV& 66 KV
22	ETI/OHE/65	Specification for continuous cast copper wire rods
23	ETI/OHE/71	Code of bonding and earthing for 25kV AC 50Hz single phase traction system
24	ETI/OHE/76	Technical Specification for hard drawn Grooved contact wire for electric traction drawn out of continuous cast copper (CCC) wire rods
25	ETI/PSI/1	Battery charger for 110 volt battery, 40Ah
26	ETI/PSI/14	Technical specification for 25kV drop out fuse switch and operating pole for use with 110 KVA and 100 KVA, 25KV/230 V LT supply transformers
27	ETI/PSI/15	Specification for 25 KV/240V, 5 KVA, 10 KVA, 25 KVA & 50 KVA, 50 Hz, single phase, oil filled auxiliary transformers for Railway AC traction system
28	ETI/PSI/15A	25kV/240V L.T. supply Transformer,100kVA
29	ETI/PSI/24	Battery charger for 110V Battery, 200 Ah
30	ETI/PSI/29	Low tension Distribution panels for Railway A.C traction sub-stations
31	ETI/PSI/31	Standard for drawings for power supply Installations
32	ETI/PSI/63	Low tension distribution panels
33	ETI/PSI/71	Metal oxide gapless type lightning arrester for use on 25 KV. side of Railway traction substations and switching stations

Sl. No.	Specification No.	Description
34	ETI/PSI/90	25 KV AC 50 Hz single phase oil filled current transformers with ratio of (i) 1000-500/5A, (for general purposes), (ii) 1500-750/5 (for heavy duty)
35	ETI/PSI/117	Technical specification for current transformers: I. 220kV. 200-100/5A, II. 132kV. 400-200/5A, III. 110kV.400-200/5A, IV. 66kV.800-400/5A for Railway A.C. traction substations
36	ETI/PSI/120	Code of practice for earthing of power supply installations for 25 kV AC, 50 Hz, single phase traction system
37	ETI/PSI/122	Technical Specification for 245 kV, 145 kV, 123 kV, 72.5 KV, Double Pole & Triple Pole Isolator for Railway Traction Sub-Stations
38	ETI/PSI/123	8MVA, 54 KV 50Hz Auto Transformer for Railway 2 x 25kV AT Feeding System
39	ETI/PSI/124	54MVA, 220/2 x 27 KV Scott connected Traction Power Transformer for 27 KV AT feeder system for Railway AC Traction Sub-station
40	ETI/PSI/133	25 KV AC Double Pole Isolators for 2 x 25 kV AT feeding system
41	ETI/PSI/137	Metal oxide gapless type lightning arresters for use of 220/132/110/66 KV side of railway AC traction substation
41	RE/30/OHE/5	Specification for Copper bus bar
42	RE/OHE/25	Standard for drawings for Traction Overhead equipment
43	RDSO/PE/SPEC/AC/0100,(Rev.‘1’) – 2011	Technical Specification for Double capped tubular T5 Fluorescent lamps, T5 luminaire & Electronic ballast
44	RDSO/PE/SPEC/TL/0040-2003(Rev-0)	Specification for low maintenance lead acid batteries for 40 Amp hour and 200 Amp hour cells for traction distribution system
45	TI/SPC/LWTSI/0060	Specification for light weight section insulator assembly
46	TI/SPC/OHE/ATD/0060	Specification for Three pulley type regulating equipment (3:1 Ratio).
47	TI/SPC/OHE/FRPNP/INS/COM/1070	Technical specification for silicon composite insulators for 25 KV AC 50Hz single phase overhead traction lines.
48	TI/SPC/OHE/GALSTB/0040	Technical specification for galvanized steel stranded wire for traction bonds for 25 kV AC Electric traction systems
49	TI/SPC/OHE/GATD/0080	Technical specification for gas Auto Tensioning Device (ATD)
50	TI/SPC/OHE/GSSW/0090	Schedule of technical requirements for manufacture of Galvanized steel stranded wire (GSSW).

Sl. No.	Specification No.	Description
51	TI/SPC/OHE/HDCSCF/0030	Technical specification for 37/2.25 mm Hard Drawn Stranded copper conductor
52	TI/SPC/OHE/INS/0070	Specification of solid core porcelain insulators for 25 KV A.C 50 Hz single phase overhead traction lines
53	TI/SPC/OHE/INS/0700	Specification for stainless steel wire rope
54	TI/SPC/OHE/INSCAT/0000	Insulated Cadmium Copper Catenary 19/2.1 mm diameter for provision under overhead line structures in the 25 KV AC Electric Traction
55	TI/SPC/OHE/INSTEST/0090	Specification for Testing load testing machine 25 KV porcelain & Composite insulator before installation
56	TI/SPC/OHE/POST/0100	Specification for solid core porcelain cylindrical post insulator for systems with nominal voltage of 66 KV, 110 KV, 132 KV & 220 KV.
57	TI/SPC/OHE/SNS/0000	Specification for short Neutral section assembly (Phase Break)
58	TI/SPC/OHE/WR/1060	Specification for solid porcelain insulators for 25 kV AC 50 Hz single phase overhead traction lines
59	TI/SPC/PSI/FC&SR/0100	Technical specification for shunt capacitor & series reactor equipment for traction sub-station
60	TI/SPC/PSI/ISOLTR/1060	25 KV AC Single Pole and Double Pole Motorized Isolators for Railway Traction
61	TI/SPC/PSI/MOGTLA/0100	42 KV Metal oxide gapless type lightning arrester for use on 25 KV side & Railway Traction substation and Switching Station
62	TI/SPC/PSI/PROTCT/1982	Specification for Delta-I type High Resistive fault selective relay for 25 kV AC traction systems.
63	TI/SPC/PSI/PROTCT/2983	Specification for Panto Flashover Protection relay for 25 KV AC traction System.
64	TI/SPC/PSI/PROTCT/6070	Control and relay panel for 25 KV AC TSS including specification for numerical type protection relays for traction transformer, 25 KV shunt capacitor bank and transmission line for 25 KV AC TSS on Indian Railways.
65	TI/SPC/PSI/PROTECT /7100	Technical specification for control and relay panel including numerical type protection relays for Scott connected/ single phase traction transformers, OHE protection and shunt capacitor bank protection for 2x25 KV traction sub-station.
66	TI/SPC/PSI/PTS/0990	Technical specification for 220kV,132kV,110 KV, 66 KV and 25 KV potential transformer
67	TI/SPC/PSI/HVCB/0120(Rev-O) June 2014	Specification for 220kV/132kV/110kV/100kV/66kV, double pole, triple pole outdoor SF6 circuit breakers.
68	TI/SPC/PSI/LVCBIN/0120(Dec 2013) Ver O	Specification for 25kV single pole. Double pole, pole mounted outdoor vacuum circuit breaker (VCB) & vacuum interrupter |(BM)

d) List of Governing Acts, Regulations and Specifications:

1.	Central Electricity Authority Regulations - 2010
2.	Indian Electricity Act 2003
3.	EDFC Schedule of Dimension 2013
4.	IRSOD – (Revised) with updated corrections slips (For Indian Railway) 2004
5.	Latest AC traction Manual with updated correction slips
6.	General Specifications for electrical works Part-1 internal (CPWD) 2005
7.	CBIP Manual
8.	Westinghouse T & D book
9.	ITU-T Standards & guidelines for limits of interference with telecom circuits
10.	All BIS & IEC standards mentioned in the document or relevant / applicable to the subject
11.	All latest rules, regulations, guidelines and codes issued by statutory bodies and regulatory commissions pertaining to Electrical interface with utilities, interference to telecommunication circuits and other emission requirements.

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CHAPTER 5
COMMUNICATION SYSTEM

5.1 General

5.1.1 This section lays down the standards and performance requirements for the telecommunication systems to be designed, supplied, installed, commissioned and maintained by the concessionaire.

5.1.2 The Telecommunications System shall comprise of Optical Fiber Communication (OFC) System, VHF Communication System, Telephone System, Direct Line Communication System; GPS based Clock System and GSM-R based Mobile Train Radio Communication system (MTRC).

5.2 Performance Requirements

5.2.1 General

5.2.1.1 The Concessionaire shall ensure that all equipment, systems and materials used shall be suitable for 25 KV AC AT Feeding system on DFC and 25 KV AC nearby existing IR lines.

5.2.1.2 The system shall be designed to facilitate normal train and station operation, management of incidents and abnormal/emergency operations.

5.2.2 Reliability Requirements

5.2.2.1 Reliability of telecom system shall be in conformity to equipment specifications requirements or any other higher international standards.

5.2.2.2 The Concessionaire shall make equipment/system selections to achieve the required level of System availability to deal with the projected level of traffic density.

5.2.3 Availability Requirements

5.2.3.1 Detailed availability requirements for individual sub-systems are given in relevant para of this chapter.

5.2.3.2 The Concessionaire shall submit and work out availability figures for each sub-system. The availability calculation shall take all possible failure modes into consideration. The calculation shall be based on equipment MTBF & MTTR figures and the configuration of each sub-system.

5.2.3.3 Equipment duplication, hot-standby protection, parallel-run, path diversity, etc. shall be adopted whenever necessary and appropriate to meet the required availability.

5.2.4 Maintainability Requirements

5.2.4.1 The Concessionaire's Response Time during failure of any communication system shall not exceed 2 hours. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at site where the faulty equipment is located.

5.2.4.2 The System shall be designed such that the Mean Time to Repair (MTTR) shall not exceed the time limit set forth in the Concession Agreement. The MTTR shall include the diagnostic time, active repair / replacement time and adjustment / testing time on site, but shall exclude the response time.

5.2.4.3 All plug-in modules shall permit hot swapping so as not to affect the normal or emergency operation of the System.

5.2.4.4 The system shall be suitably designed to minimize the need for frequent preventive maintenance.

5.2.4.5 The system shall be so designed as to avoid the need for a total shutdown for preventive maintenance.

5.2.4.6 The system shall be so designed as to prevent failures or breakdown due to invalid or incorrect inputs.

5.2.4.7 Built-in self-diagnostics, power-up self test and sufficient test points shall be provided in the system to minimize the time required to locate a fault.

5.2.5 System Safety Requirements

5.2.5.1 The Concessionaire shall provide necessary information and relevant analysis where the availability and usability of the Telecommunications System is a contributing factor to the overall system risk.

5.2.5.2 The design of the system shall minimize the risk of fire.

5.2.5.3 The design of the system shall minimize the build-up of static, as well as the effects of static discharge during maintenance.

5.2.6 Electromagnetic Compatibility (EMC)

5.2.6.1 The Concessionaire shall provide detailed calculations and inter-modulation analysis to establish electromagnetic compatibility (EMC) among the sub-systems and with other systems in close proximity.

5.2.6.2 The maximum levels of out-of-band emission shall be such as to ensure that the subsystems perform in conformity with the criteria given in this chapter.

5.2.6.3 The maximum levels of radiated and conducted EMI of the System shall not exceed the levels specified in EN50081-1.

5.2.6.4 Any equipment consisting of sensitive electronic components that is likely to be handled or touched by any person shall be protected against electrostatic discharge and shall be tested as defined in IEC61000-4-2.

5.2.6.5 The Concessionaire shall ensure that all Intra system EMI are taken care of through proper design and other measures. All major subsystems shall be tested for emissions and immunities in accordance with the appropriate international standards for equipment operating in Railway environments.

5.2.6.6 Inter-system EMC

i. The Concessionaire shall ensure that all equipment are designed and constructed in accordance with latest versions of EMC standards including but not limited to EN50082, EN50121, EN 50123, EN50155, IEC60571, IEC61000 or equivalents to ensure proper functioning

ii. Adequate safety margins between the immunity levels of the Telecommunication Systems and the emission levels of other electrical and electronic equipment must be maintained.

5.3 Design Requirements

5.3.1 Design Approach

5.3.1.1 The Concessionaire shall adopt a structured, modular and top-down approach for the design and exercise proper design control to ensure that the designs are in accordance with the requirements given in the Specifications.

5.3.1.2 The technologies adopted for the design of the System shall be :

i. Field proven with past successful applications references.
ii. Conforming to open international standards.

5.3.1.3 The System shall be designed for continuous unattended operation for extended periods of time.

5.3.2 Design Verification and Validation

5.3.2.1 The Concessionaire shall carry out detailed design calculations and keep a record of it along with supporting drawings, documents, etc. for future references of Employer/Independent Engineer.

5.3.2.2 The Design calculations shall demonstrate that the Concessionaire's Design fully complies with the requirements given in the Specifications and shall further demonstrate that the ratings, capacity and quantity of the proposed equipment are adequate.

5.3.2.3 The Concessionaire shall furnish the following calculations and analysis for each Subsystem as a minimum:

i. Estimation of the power consumption and heat dissipation per equipment location

ii. Prediction of the reliability and availability of the Subsystem.

5.4 Equipment Design

5.4.1 General Considerations

All equipment shall be designed and constructed to operate without degradation in quality, performance or loss of function in the electromagnetic environment prevalent in a standard Heavy Freight Railway System.

5.4.2 Fire and Smoke Precautions

5.4.2.1 The cable routes shall be suitably designed to prevent trapping of rubbish which could later become a fire hazard.

5.4.2.2 Every possible precaution must be taken to prevent the flow of fault currents through the cables, especially from the traction power system. Communication cables must be kept away from high tension power supply cables.

5.4.2.3 All necessary measures shall be adopted to prevent the creation of hazardous conditions arising out of overheating and/or ignition of cables.

5.4.2.4 All of the above requirements shall be fully complied to, without compromising any of the mechanical or electrical properties of the cables.

5.4.3 Environmental Conditions

5.4.3.1 All equipment shall be protected from damage or degradation in performance due to shock or vibration as experienced in railway environment.

5.4.3.2 Unless otherwise specified, all telecommunication equipment shall be designed for operation continuously in temperatures of -5 ^{o} C to +55^{o}C.

5.4.3.3 Telecommunication Equipment Rooms shall be provided with 1+1 room air-conditioning.

Telecommunication Power Supply Rooms shall be provided with suitable means for air circulation (1+1 Configuration).

Status of temperature of all Telecommunication buildings and functioning of temperature - regulator equipment and air conditioning equipment shall be centrally monitored.

5.5 OPTICAL FIBRE COMMUNICATION (OFC) SYSTEM REQUIREMENTS

5.5.1 General

5.5.1.1 The OFC System shall be a highly reliable system since it shall be the primary means of communications between OCC, Stations, LC Gates, Auto Signal Locations, GSM-R Locations, TSSs, SPs, SSPs, IMD, IMSD, etc. on which a number of other operationally critical systems will rely.

5.5.1.2 The OFC System shall provide a high degree of availability and redundancy by operating on two independent optical fibre rings. Proven technology of SDH (Synchronous Digital Hierarchy) as per ITU-T Rec. G.803 shall be used.

5.5.1.3 The OFC System shall be capable to transport all of the user communication requirements. The OFC System shall provide sufficient bandwidth to cater for the communication requirements of various systems and shall keep an additional spare bandwidth of at least 50% of the total used bandwidth for future system expansion.

5.5.1.4 Wherever required; TDM Bandwidth(STM-1/STM-4/STM-16) shall be made available to concessionaire outside the limits of Eastern DFC section under this contract.

5.5.2 System Requirements

5.5.2.1 The OFC System shall be a Synchronous Digital Hierarchy (SDH) Optic Fibre Communication Network, based on an open standard and fully conforming to the ITU-T Recommendations.

5.5.2.2 The OFC System shall support voice; data and video signal transmission between various locations and modes of transmission shall include, but not be limited to:

i. Point-to-point;
ii. point-to-multipoint;
iii. drop-and-insert;
iv. Cross-connect; and
v. Any other modes required for the implementation of the Subsystems.

5.5.3 Optical Fibre Cable Network

5.5.3.1 There shall be two separate optical fibre cable back bone networks. Each of the two optical fibre cable networks shall be formed by two outdoor single mode optical fibre cables. The normal and protected routes shall be routed through

different fibre cables with path diversity. The Concessionaire shall submit the Cable Route Plan along with details of methodology to Employer/Independent Engineer for approval before starting the work.

5.5.3.2 Optical fibre cables shall be supplied as per RDSO specification no. IRS: TC 55-2006 from RDSO approved sources only.

5.5.3.3 Both the optical fibre cable networks shall have a minimum fibre count of 24 fibres for each of the two cables. At least 25% of fibre within each cable shall be reserved as spares for future use.

5.5.3.4 First Network shall carry all Voice & Data Communication between OCC and Stations. Second Network shall carry all Voice and Data Communication between Stations, LC Gates, Auto Signal Locations, GSM-R Locations, TSS, SP, SSPs, IMD, IMSD, etc.

5.5.3.5 All Vital & Safety Related System using OFC System shall be implemented as per EN-50159.

5.5.4 SDH Network

5.5.4.1 Each SDH Node of First Network shall be at least STM-16 level in the SDH hierarchy, while each SDH Node of Second Network shall be at least STM-4 in SDH hierarchy. SDH Nodes at Stations shall be common for First & Second Network and equipped with Digital Cross Connect.

5.5.4.2 The SDH Nodes shall be fully equipped minimum for 63(sixty three) 2 Mbps tributaries.

5.5.4.3 Protection switching mechanisms shall be provided for the tributaries of the SDH Node. 2 Mbps tributaries shall be provided with 1:3 (Minimum) Protection and all the other tributaries shall be provided with 1+1 Protection.

5.5.4.4 The SDH Nodes at Stations shall be equipped with minimum 8 Ethernet 10/100 Base T tributaries. SDH Nodes of Second Network shall be equipped with minimum 4 Ethernet 10/100 Base T tributaries.

5.5.4.5 Flexible Access Multiplexers or Primary Order Multiplexer shall be provided to connect to the 2Mbps tributaries of the SDH node for direct access of channel circuits with data rate lower than 2Mbps.

5.5.4.6 The OFC System shall provide Voice and Data Communication Network/Channels/Circuits or bandwidth for the following systems but not limited to:

i. 2 Mbps E1 (ITU-T G.703 and G.823) Channels for the Telephone System;
ii. Other Data Circuits or Ethernet 10/100 Mbps Ports as required for Traction Power SCADA, Hot Axle Detection etc.
iii. Other Data Circuits or Ethernet 10/100 Ports or 4W E&M Circuits or bare fibers for Vital & Safety Related Signal Control Circuits including Track Vacancy Detection.
iv. Sub 2Mbps Voice Circuits for Direct Line Communication System, LC Gate Communication, Emergency Communication, Auto Signal Hut Communication and TSS/SP/SSP Communication.
v. Other Data Circuits or Ethernet 10/100 Mbps Ports as required for TMS.
vi. Ethernet Connections for each application need to be implemented through Ethernet Virtual Private Line Service.
vii. The OFC System also needs to provide a bandwidth management tool to ensure sufficient transmission capacity for each application to function under all traffic circumstances on the OFC System.

5.5.4.7 Service Telephone

Orders wire facility with hand set shall be provided for point to point and multipoint voice communication with maintainer staff. It shall permit selective and group calling function.

5.5.4.8 General

i. A Network Management System (NMS) shall be provided at OCC to carry out Real-Time centralized and remote monitoring and measurement of network status and performance.

ii. The NMS shall provide Operation Administration & Management Protocol (OAM&P) functions in accordance with the Telecommunications Management Network (TMN) concept described in ITU-T Recommendations M-3010.

5.5.4.9 Alarm and Status Monitoring

i. The operational status and performance of all the network elements shall be monitored on a real time basis by the NMS. The status monitoring shall be down to the card level as a minimum.

ii. The network elements shall have alarm logging facilities so that a detailed history of the failure alarms can be retrieved either locally using the portable service terminal or remotely by the NMS.

5.5.5 Cabling and Accessories

5.5.5.1 Optical fibre cables shall be supplied as per RDSO specification no. IRS: TC 55-2006 from RDSO approved sources only.

5.5.5.2 The Optical Fibre Connectors shall comply with IEC 60793 and IEC 60874.

5.5.6 System Expansion

5.5.6.1 It shall be possible to insert additional SDH Nodes into the OFC Network without affecting the performance of the Network, limits on this, if any, shall be specified by the Concessionaire for review by the Employer/Independent Engineer.

5.5.6.2 The OFC System shall be compatible with SDH Equipment from other manufacturers.

5.5.7 Integration of SDH Network

The SDH Network shall be integrated with SDH Network of adjacent sections of DFCCIL.

5.6 DATA NETWORKING SYSTEM

5.6.1 General

5.6.1.1 Data Networking System, which is a Wide Area Network (WAN), shall be provided between the OCC of Eastern DFC and Stations & Depots of entire section. Packet Data Band with OCC from suitable location shall be made available to concessionaire for this purpose.

5.6.1.2 This WAN shall be a highly reliable system since it shall be the primary means of Packet Data Communications between OCC of Eastern DFC and stations of entire section on which a number of operationally critical systems will rely.

5.6.1.3 The WAN shall provide a high degree of availability by operating on an independent optical fibre rings formed using path diversity.

5.6.1.4 The WAN shall provide sufficient bandwidth to cater for the communication requirements of various systems employed on the entire section.

5.6.1.5 At Stations, Wi-Fi Facility. Compliant with IEEE 802.11g Standards shall be provided for WAN Connectivity to users(which also include drivers of passing trains) via Wireless Enabled Devices and Equipment .This Wi-Fi Facility shall as a minimum, cover Station Building and EDFC Tracks upto 500 meters in both directions.

5.6.2 System Requirements

5.6.2.1 WAN shall connect OCC and Stations on entire section in Ring Topology using Optic Fibre Cable laid with path diversity. WAN shall be created using Layer-3 Access Switch. As such Layer-3 Access Switch should be equipped with 4 Nos. 10 GigE Fibre Ports for backbone interconnections. Layer-3 Access Switch should have minimum 24 Nos. 10/100/1000 Base T Ports with RJ45 Connectors. Layer-3 Switch shall be provided in fully duplicated configuration at each site in (1+1) Hot-Standby Configuration.

5.6.2.2 Each Layer-3 Switch Site shall employ, as necessary, Multi-layer Switching comprising a combination of Layer-2 Switching and Layer-3 Protocol Routing. Layer-2 Switch shall be deployed as per Site Requirements.

5.6.2.3 Ethernet Services such as Ethernet Private Line (EPL) Services, Ethernet Virtual Private Line (EVPL) Services, Ethernet Local Area Network (E-LAN) Services, Layer2 Protocol Tunneling (L2PT), Virtual Private Wire Service (VPWS) & Ethernet over MPLS (Ethernet over Multi Protocol Level Switching) shall be available on WAN. Ethernet Services such as EPL, EVPL & E-LAN shall be extended to all the Stations, LC Gates, TSS, SP & SSP using EoS (Ethernet over SDH) of OFC System for meeting the requirements of other Systems used in the entire section.

5.6.2.4 Layer-3 Services such as IPv4 Routing [Border Gateway Protocol (BGP)], Intermediate System-to-Intermediate System (IS-IS) Open Shortest Path First (OSPF), Hot Standby Router Protocol (HSRP), Virtual Router Redundancy Protocol (VRRP), IPv6 Routing, Multi Protocol Label Switching [Label Distribution Protocol (LDP)], Targeted LDP (T-LDP), Primary & Secondary Label Switched Paths, MPLS L3 Virtual Private Network (VPN), Resource Reservation Protocol (RSVP), MPLS Traffic Employering (including TE-FRR), Routed Pseudo-wire, IP-VPN (RFC 2547) and Integrated Routing & Bridging shall be available on the WAN. These services shall be implemented to cater for the communication requirements of various systems used in the entire section.

5.6.2.5 Quality of Service (QoS) features such as Ingress & Egress Marking, Ingress & Egress Policing, Priority Queuing, Class-Based Queuing, Weighted Random Early Detection (WRED), Scheduling and Access Control List shall be available on the WAN.

5.6.2.6 Multicast protocols such as Internet Group Management Protocol (IGMP) and Protocol Independent Multicast (PIM) shall be available on the WAN.

5.6.2.7 Wide Area Network (WAN) should support IPv4 and IPv6 Protocols. It shall support Static as well as Dynamic Host Configuration Protocol (DHCP) based IP Address Management.

5.6.2.8 Security features such as Authentication, Authorization & Accounting (AAA), Secure Shell Protocol (SSH), MAC Limiting per Ethernet Flow-point, Unicast/Multicast/Broadcast Storm Control Blocking, Layer-2 Access Control List

(ACL), Layer-3 ACLs for IPv4 & IPv6 and DHCP Snooping shall be available on the WAN.

5.6.2.9 Operations, Administration & Maintenance (OAM) features such as CFM OAM(IEEE 802.1ag), EFM OAM(IEEE802.3ah), MPLS OAM and OAM Functions & Features as per ITU-T Y.1731 shall be available on WAN.

5.6.2.10 Network Management System shall be provided for WAN at OCC. This Graphic User Interface(GUI) based NMS shall have a complete Data Network, so as to provide the necessary control, supervision, maintenance, configuration and performance management. This NMS shall support Layer-2 & Layer-3 Services. This NMS should support following minimum features:

- Fault Management & Analysis
- GUI & Service Template based Configuration & Provisioning
- Composite L2/L3 Service Creation & Management
- Performance Statistics collection and management
- Security Management
- OAM Testing
- Troubleshooting and Assurance
- Historical and real-time path monitoring
- Path computation for Network Planning/Traffic Employering tools integration

5.7 TELEPHONE SYSTEM

5.7.1 General

5.7.1.1 The Administrative Telephone System shall be provided for voice communications between locations equipped with telephone sets within the DFCCIL premises and other required locations.

5.7.1.2 Private Branch Exchange (PBX) shall be provided as the Administrative Telephone System for the operation, maintenance and administrative staff to set up voice communication.

5.7.2 System Requirement

5.7.2.1 A highly reliable Satellite PBX Switch based Telephone System shall be installed and commissioned to provide communications to digital and analogue telephone sets throughout the project.

5.7.2.2 The link between the Main PBX Switch at OCC and the Satellite EPABX Switches shall be using digital trunk lines at E1 level.

5.7.2.3 Satellite PBX Switches shall support Voice Mail System (VMS). VMS system on entire section shall be integrated with main EPABX Switch to enable EPABX users to leave, retrieve and broadcast voice messages to and from this single message centre.

5.7.2.4 PBX Switch Network

5.7.2.4.1 The Telephone System shall provide non-blocking connection for extension calls within the same switch. The Telephone System shall offer a fully integrated and transparent digital service acting as a single digital switch. For calls through trunks or tie lines, the system shall provide a Grade of Service (GoS) of 1% for EPABX for the required traffic intensity in the entire section.

5.7.2.4.2 Redundancy for the important interfaces/ modules such as power supply, processor etc. shall be provided. The EPABX Network shall be designed such

that there is redundancy and diversity in terms of the communication links for call routing and call establishment.

5.7.2.4.3 The system design shall ensure high system availability with minimum common mode failure allowing graceful degradation.

5.7.2.4.4 Network and system shall be resilient to failure providing automatic reconfiguration of equipment with minimum system loss in particular the avoidance of common mode failure of site equipment, fibre, cable and power supply and software affecting system operation.

5.7.3 **Voice Mail System (VMS)**

5.7.3.1 The VMS shall enable internal and external telephone users to access specific mailboxes using the following peripherals:

i. Analogue telephones using Dual Tone Multi Frequency (DTMF);

ii. Digital telephones;

iii. CO outgoing trunks and Direct Inward Dialing (DID) trunks; and

iv. Digital trunk.

5.7.3.2 Telephone users assigned with VMS shall have a unique voice mailbox which shall be password protected.

5.7.4 **Telephone Network Management System**

The Telephone Network Management System shall provide control, supervision and maintenance functions for the entire Telephone System.

5.7.5 Outdoor Telephone Cable

Polythene Insulated Jelly Filled (PIJF) Telephone Cable as per RDSO Specification No. IRS:TC 41-97 with latest amendments shall be used for extending external telephone lines out of building housing EPABX. The cable will be laid at the depth of 1.0 M below ground level.

5.8 DIRECT LINE COMMUNICATION SYSTEM

5.8.1 General

5.8.1.1 The Direct Line Communication System shall provide instant, uninterruptible, hot line communication between key strategic points, which shall include, but not be limited to:

i. Train Traffic Control Communication: This is provided for direct line communication with selective calling facility between the Traffic Controller in the OCC and Station Controller at Stations and other operationally important locations along the DFC route for the control of train movements and effective utilization of section capacity.

ii. Traction Power Control Communication: This is provided for direct line communication with selective calling facility between Traction Power Controller in the OCC, Stations all switching and feeding points of Traction Power to the Overhead Alignment and maintenance staff at wayside locations.

iii. Empowering Control Communication: This is provided for direct line communication with selective calling facility between OCC and important Civil Empowering maintenance and work related locations along the track as decided by the Employer/Independent Engineer.

iv. S&T Control Communication: This is provided for direct line communication with selective calling facility between OCC and important S&T maintenance and work related locations along the track as decided by the Employer/Independent Engineer.

v. Between adjacent Station Control Rooms for stations.

vi. Between DFCCIL Stations and Interfacing Station Master Room of Indian Railway;

vii. Between OCC/EDFC and IR Sectional Control Centres and Interfacing Station along the route as decided by the Employer/Independent Engineer;

5.8.1.2 Direct Line Communication System shall provide non-blocking, direct line communication between the locations as listed above.

5.8.1.3 Direct Line Communication System shall enable calling destination using one touch buttons on the Direct Line Consoles/Telephones for faster access.

5.8.2 Direct Line Telephones (DLTs)

5.8.2.1 Direct Line Telephone provided in the TSS and other remote locations shall have a minimum direct line capacity of 10 lines and shall be capable of interfacing with Direct Line Telephone Consoles of Controllers in OCC and the required direct line extensions. The Concessionaire shall however determine the exact size of such Direct Line Telephones.

5.8.2.2 It shall be possible from Direct Line Telephone to make normal and emergency direct line calls to the designated controllers in OCC. Different audio and visual indications shall be provided for incoming direct line calls on the Direct Line Consoles or Direct Line Telephone for normal and emergency calls.

5.8.2.3 Direct Line Telephone at Home Signal of Stations.

5.8.2.3.1 Direct Line Telephone shall be provided at the Home Signal of Stations. Through this Direct Line Telephone, Train driver shall be able to contact Station Controller.

5.8.2.3.2 Each Direct Line Telephone shall be self-contained unit consisting of metal box containing a heavy duty telephone hand set and cord and calling facility. The unit will be adaptable to signal Post Mounting. This Telephone Metal Box shall have suitable Lock & Key arrangement with uniform key for entire EDFC.

5.8.2.3.3 Conspicuous audio and visual indications to alert the concerned Station Controllers shall be displayed on Station Controller Console, on the lifting of a hand set from Direct Line Telephone of Home Signal.

5.8.2.4 Digital Voice Recording System (DVRS) shall record all Direct Line telephonic conversations of all controllers in OCC and Stations.

5.8.2.5 Direct Line Communication System shall be synchronized to the clock signal from the Master Clock System.

5.8.3 LC gate Communication:

5.8.3.1 Each L-xing shall be connected with nearest side of station. The communication between Station Master with adjoining L-xing must be possible. Both should be able to call through ringing facility and vice versa.

5.8.3.2 Emergency Control Communication upto Automatic Signals shall be extended using Underground Railway Jelly Filled Telecom Quad Cable as per RDSO Specification No. IRS:TC 30-05 with latest amendments.

5.9 GPS BASED CLOCK SYSTEM

5.9.1 The Master Clock System shall provide synchronized time information for Eastern DFC. Global Positioning System (GPS) shall be the time source for these Master Clock System.

5.9.2 The time source shall be used to synchronize clock units which shall be located throughout the project areas such as offices, control rooms, etc.

5.9.3 The synchronized time information shall be provided to other interfacing systems via the OFC System. Synchronization of the time information of other systems shall be achieved by means of the Network Time Protocol (NTP).

5.9.4 Sub Master Clock

Local display of the time shall be provided. Display shall include hours, and minutes.

5.9.5 Display Clocks

i. All display clocks shall be synchronized by the Central/Station Sub Master Clocks.
ii. All Clocks for indoor use shall be 7 Segments LED type with minimum digit height of 57 mm, with minimum viewing distance of 20 meter.
iii. The displayed time of all display clocks shall be hours and minutes.
iv. The display shall be clear under relevant, frequently occurring lighting conditions, including direct sunlight (from behind and in front) and when there are any reflections in the clock faces.

5.9.6 General requirements

Fault tolerant design with protections against failure shall be provided in order to achieve the system availability. Protections shall include, but not be limited to path diversity, redundancy and duplication of reliability critical equipment, component and circuits.

5.9.7 Reliability

i. The inability to perform any required function, the occurrence of unexpected action or the degradation of performance below the specifications shall be considered as a failure.

ii. Concessionaire shall furnish to the Independent Engineer the reliability figures i.e. MTBF hours from the OEMs of the following sub-system/equipment:
- Master Clock;
- Sub-Master Clock; and
- GPS Receiver.

5.9.8 Availability Requirements

i. The Concessionaire shall implement a RAMS plan defined in accordance with IEC 62278. Concessionaire shall submit to the Independent Engineer for review the RAMS analysis for the Master Clock system to establish the requirements of availability specified herein below.

ii. The Master Clock System shall be considered unavailable if the clock signal is not available at any location or the accuracy of the clock signal is below the specification. The availability of the master clock equipment shall be better than 99.99%

5.9.9 Maintainability Requirements

i. The Concessionaire shall comply with the maintainability requirements.
ii. The service life of the Master Clock System shall not be less than 15 years.

5.9.10 System Safety Requirements

i. All equipment must comply with, and be installed in conformance with IEC 65, IEC 364 or equivalent National Electric code/Uniform Building code of safety standards.
ii. All metallic enclosures shall be provided with an earth terminal
iii. The free run accuracy of the Master Clock units shall never be more than 30 milliseconds different from the GPS reference.
iv. Network time synchronization over the data network shall be using NTP, with an accuracy of + 0.01 s per 24 hours to the reference.
v. The sub- Master Clocks shall have a minimum accuracy of 1s a day when they do not receive signals from the Master Clock.

5.9.11 System Expansion

i. The Master clock system shall be equipped with capacity to provide clock signal and timing reference distribution to 20 additional locations for other System/Subsystem or Sub Master Clocks.
ii. The system shall be able to support the required number of display clocks plus at least 10 additional Slave clocks at each location.

5.10 VHF COMMUNICATION SYSTEM

5.10.1 25 Watt VHF Transceivers

VHF Communication System shall be created at each Stations and using 25 Watt VHF Transceivers.

5.10.1.1 25 Watt VHF Transceivers shall be installed in Station Control Room and any other specified place as decided by Employer. Omni-Directional Antenna for 25 Watt VHF Transceivers shall be mounted on a suitable Pole/Mast at a height of 15 meters from the ground level.

Provision of Voice Recording of conversation taking place on 25 Watt VHF Transceives shall be provided through Voice Recording Equipment.

5.10.1.2 Specification of 25 Watt VHF Transceivers are as given below:

General		
1.	Frequency Range	136-174 MHz (Full Band)
2.	No. of Channels	16 Channels or more
3.	Channel Spacing	12.5 KHz
4.	Frequency spread	5 MHZ or more without degradation in Tx/Rx specifications
5.	Frequency Stability	5 PPM or better
6.	Type of Emission	11 KOF3
7.	Type of Operation	Simplex, press to talk with built in condenser mic and speaker
8.	Type of Antenna	Omni directional antenna complete with cable and other accessories.
9.	Speaker Impedance	To be specified by the firms at internal external speaker point.

10.	Speaker	Internal Speaker as well as Socket for External Speaker to be provided (The Internal Speaker should be cut-off when External Speaker is used).
11.	Output Impedance	50 Ohms and the Aerial Terminal should have VHF Female Socket.
12	Protection	Reverse Polarity protection should be provided. The final transistor should be protected against high Voltage Standing Wave Ratio (VSWR).
13	Power Supply	Switch Mode Power Supply (SMPS) unit with boost Charger 12.0 – 13.6 Volts 10 Amp.
Transmitter		
1.	RF Power output	25W +/- 0.5 dB
2.	Frequency Deviation	+- 2.5 KHz Max. (For 100% at 1 KHz) for 12.5 KHz channel spacing.
3.	Modulation Sensitivity	1 to 10mV at 1 KHz at mic input for +- 1.5 KHz (for 12.5 KHz channel spacing) standard deviation
4.	Modulation Distortion	Less than 5% at 1 KHz reference +/-1.5 KHz (for 12.5 KHz channel spacing) Standard deviation.
5.	Modulation Fidelity	+1, -3 db of 6 dB/Octave pre-emphasis characteristics from 300 Hz to 2700 Hz.
6.	Spurious & Harmonics supersession	Better than 60 dB
7.	VSWR	Better than 1.5
Receiver		
1.	Sensitivity	0.30 micro V for 12 dB Signal to Noise and Distortion (SINAD) Ratio
3.	Squelch Sensitivity	0.25 micro V or better at threshold.
4.	Selectivity	Better than 60 dB
5.	Image Rejection	Better than 65 dB
6.	Audio Output	250mW/500mW with less than 5% distortion at 1 KHz reference measured at specified AF output.
7.	Audio Response	+1, -3 dB or 6dB/ Octave de-emphasis characteristics from 300 Hz to 2700 Hz. With 1 KHz s reference.

5.10.2 5 watt VHF Walkie –Talkie Sets

5.10.2.1 **Requirements**:

General		
1.	Frequency Range	136 – 174 MHZ (Full Band)
2.	No. of Channels	16 Channels or more
3.	Channel Spacing	12.5 KHZ
4.	Frequency Spread	5 MHZ or more without degradation in Tx/Rx specifications
5.	Frequency Stability	5 PPM or better
6.	Type of Emission	11 KOF3
7.	Type of Operation	Simplex, press to talk with built in condenser mic and speaker

8.	Type of Antenna	Helical Antenna suitable for Frequency Range specified.
9.	Speaker Impedance	To be specified by the firms at internal external speaker point.
10.	Speaker	Internal Speaker as well as Socket for External Speaker to be provided (The Internal Speaker should be cut-off when External Speaker is used).
11.	Output Impedance	50 Ohms and the Aerial Terminal should have VHF Female Socket.
12.	Protection	(i) Reverse Polarity protection should be provided. (ii) The final transistor should be protected against high VSWR
13.	Power Source	2000 MAH 7.2-7.4 V, NiMH or Li-Ion Battery.
14.	Weight	600g Maximum with Battery.
Transmitter		
1.	RF Power output	25W +/- 0.5 dB 1W/5W+/- 0.5 dB switchable/programmable
2.	Frequency Deviation	+/- 2.5 KHz Max. (For 100% at 1 KHz) for 12.5 KHz channel spacing.
3.	Modulation Sensitivity	1 to 10 mV at 1 KHz at mic input for +/- 1.5 KHz (for 12.5 KHZ channel spacing) Standard deviation
4.	Modulation Distortion	Less than 5% at 1Khz reference +/- 1.5 KHz (for 12.5 KHz channel spacing Standard deviation)
5.	Modulation Fidelity	+1, -3 dB of 6 db/Octave pre-emphasis characteristics from 300 Hz to 2700 Hz with 1 KHz as reference.
6.	Spurious & Harmonics supersession	Better than 60 dB
7.	VSWR	Better than 1.5
Receiver		
1.	Sensitivity	0.30 micro V for 12 dB SINAD
2.	Squelch Sensitivity	0.25 micro V or better at threshold
3.	Selectivity	Better than 60 dB
4.	Image Rejection	Better than 65dB
5.	Audio Output	250mW/500mW with less than 5% distortion at 1 KHz reference measured at specified AF output
6.	Audio Response	+1, -3dB or 6dB octave de-emphasis characteristics from 300 Hz to 2700 Hz. With 1 KHz s reference
Feature – wise Configurations		
1.	Simple Press - to - Talk	
2.	Protection against high VSWR	
3.	Low Battery Alert	
4.	Capable of VOX for Hands – free Operation	

5.	PTT ID (Push To Talk Identification) Encode
6.	CTCSS/DCS
7.	Busy Channel Lockout
8.	Channel Scanning with Call Quieting facility
9.	2 Tone/DTMF/5-Tone Signaling
10.	Selective Call Decoder
11.	Capable of being killed/Unkilled

5.10.3 Environmental Requirements

5.10.4 All equipment shall be suitable for operation in the following environmental conditions:-

Operation temperature Range : -10 deg. C to +55 deg. C
Storage Temperature Range : -40 deg. C to +70 deg. C
Relative Humidity : 95% Max +40 ^{0}C non condensing

5.11 MOBILE TRAIN RADIO COMMUNICATION SYSTEM REQUIREMENTS

5.11.1 System Requirement

5.11.1.1 Where track alignment of the Section of EDFC under the control of concessionaire is running parallel to the existing Indian Railway network, Base Station Sub-Systems (BSSs) of Indian Railway will be shared by DFCCIL. However in sections, where track alignment of these Sections is taking a detour and cannot be served by Base Station Sub-systems (BSSs) of Indian Railway, new Base Station Sub-systems (BSSs) shall be provided by Concessionaire with Base Station Controllers (BSCs) at OCC.

5.11.1.2 Network Sub-systems (NSSs) of MTRC System of Indian Railway used for existing network shall also be used for MTRC System of this Section of EDFC. As such Network Sub-systems (NSSs) of MTRC System of Indian Railway shall be suitably upgraded by the Concessionaire to meet the requirements of this Section under the control of Concessionaire.

5.11.1.3 The Concessionaire shall facilitate all operation and maintenance activities from OCC of new Base Station Sub-systems (BSSs), added by him. This Operation & Maintenance Centre shall also facilitate all operational activities of Network Sub-systems (NSSs) pertaining to this Section of EDFC.

5.11.1.4 Base Station Sub-systems (BSSs) network shall be planned with an appropriate radio network planning tool and an appropriate propagation model for the terrain being covered. The coverage level shall be designed to provide satisfactory indoor and outdoor coverage in detour sections for an operational and general purpose radio for all areas. Accordingly minimum coverage level of -78 dBm at 4 meter above ground in outdoor terrain shall be available 200 meters on both side of track.

5.11.1.5 Concessionaire shall liaise with Wireless Planning and Coordination (WPC) for issues of import license. Concessionaire shall also coordinate with DFCCIL & all concerned authorities including WPC, SACFA, Civil Aviation authorities, local authorities etc. and obtain necessary clearances/sanctions for installation and commissioning of the MTRC System.

5.12 System details of MTRC of Indian Railway are as under:

5.12.1 The concessionaire shall provide Mobile Train Radio Communication (MTRC) System based on Global System for Mobile Communications - Railway (GSM-R)

for wireless voice and data communication to support the operational and maintenance requirements of the entire Section.

5.12.2 The details of NSSs Subsystem shall be collected from concerned Railway.

5.12.3 The system shall be designed based on European Integrated Railway Radio Enhanced Network (EIRENE)'s Functional Requirements Specification (EIRENE FRS v7.3.0) and System Requirements Specification (EIRENE SRS v15.3.0).

5.13 Functional Requirement

5.13.1 System Services

5.13.1.1 Operational & maintenance requirements as well as supports of the following services by MTRC system shall conform to EUROPEAN Telecommunication Standards Institute (ETSI), Global System for Mobile (GSM) Standards and additional requirements specified in EIRENE FRS & SRS documents:

i. Voice services:
ii. Data services:
iii. Call related services:
iv. Railway specific applications:
v. Railway specific features:

5.14 Radio Network Management System(NMS)

5.14.1 The Radio Network Management System shall be a centralized control system with management workstation, system database and mass storage device to be located at OCC.

5.14.2 The Radio Network Management System shall facilitate all management function mentioned below for Network Elements pertaining to Base Station Subsystems [consisting of Base Station Controllers(BSCs)], Base Transceiver Stations (BTSs), TRAU, Interfaces, Radio Dispatcher Consoles and Voice Recording System.

5.14.3 Configuration Management: The NMS shall be provided with a user view of all administrable data stored in each managed Network Element that accurately reflects the actual data stored in the managed Network Element in real or near-real time.

i. The NMS shall provide the possibility to perform configuration management (addition/changes/deletion), directly and by using command files.
ii. The NMS shall provide the possibility to manage command files (creation/changes/deletion).
iii. The NMS shall provide the possibility to add/change/ delete the configuration data for physical equipment and connections simply by choosing the concerned item (e.g. drop down menu).
iv. In case a user action has an impact on the operational service, a dialog box shall warn the user and give the possibility to cancel the last action.
v. The NMS shall not allow adding/changing/deleting a connection without verification (end to end consistency check).

5.15 Fault Management:

5.15.1 The Radio Network Management System shall provide following fault management functionality.

i. The NMS shall collect, display and manage alarms and notification with severity level for all the BSS equipment, interfaces and its own equipment;

ii. It shall be possible to define alarms category and severity level and their display shall be customizable;

iii. The alarms and notifications shall indicate the network element in which the event occurred, time, data, level, reason (description) and other important data;

iv. The alarms shall be automatically cleared from the display when impacted equipment is again in nominal service;

v. User shall have the possibility to easily get information about each displayed alarm and clear or acknowledge a displayed alarm;

vi. All the alarms and notification shall be stored during at least 30 days and it shall be possible to search in the alarm history for certain alarms by filtering on any alarm information;

vii. Information about the state of the network element shall be displayed with the maximum delay of 10 seconds (in respect of the event origination moment).

5.15.2 The following alarm conditions shall be provided to the Radio Network Management System as a minimum:

i. Loss of communication links;
ii. Loss of master clock synchronization;
iii. Failure of power supply unit;
iv. Changeover to redundant central equipment;
v. Base station health status;
vi. Central equipment health status;
vii. Low power and no power alarms for all transmitters; and
viii. Indication of receiver failures.

5.15.3 Performance Management :

5.15.3.1 The NMS shall provide data concerning the performance of the individual element of BSS and individual channels with respect to traffic volume so as to optimize the system configuration, equipment deployment, user grouping and future sizing of the system.

5.15.3.2 The NMS shall produce statistical reports on the channel usage and system performance. It shall have the facility to monitor base station channel traffic on real time basis. It shall allow flexible adaption of traffic configurations to the dynamic traffic requirements.

5.15.3.3 The NMS shall give detailed information about handover (successful/ unsuccessful/retry), all type of calls, all type of call drop, traffic and congestion, group calls (successful/failed/cells per GC) etc. These data shall be stored for a minimum of 1 week. The collected data shall be “transparent” i.e. workable without additional calculation.

5.16 Security Management: As part of the NMS solution the functions related to security is of high importance. Such function(s) shall be provided to avoid and

protect against unauthorized access and manipulation in conformance to governing security policy.

5.17 Restoration: The Network Management System shall provide following restoration features

i. The NMS shall be equipped with data media capable of storing information to be used for saving the software and settings.
ii. In case of the program failure of any NMS component, restoration of data saved in that medium before the failure shall be ensured.

5.17.1 The NMS shall support integrated trace management function for end to end call tracing. It shall be possible to specify the call to be traced by setting the caller number or called number. It shall be possible to save the result of the tracing to the NMS console for future reference. Any performance limitation related to tracing during live traffic shall be described.

5.18 Subscriber Management

5.18.1 The day-to-day administration, management and control of MTRC System shall be carried out in real-time from Operation & Maintenance Centre at OCC through suitable Client Terminal(s) to be provided by Concessionaire.

5.18.2 The Radio system shall have an overall availability of better than 99.99%.

5.18.3 Service life of the Radio system/equipment shall not be less than 15 years.

5.19 Technical Requirements

5.19.1 The MTRC System shall be designed based on European Integrated Railway Radio Enhanced Network (EIRENE)'s Functional Requirements Specification (EIRENE FRS v7.3.0) and System Requirements Specification (EIRENE SRS v15.3.0). The main components of the system are:

i. Base Station Sub-system (BSSs) of Base Station Controllers (BSCs) controlling Base Transceivers Stations (BTSs) each containing a number of transceivers (TRXs).

In sections, where track alignment of the Section of EDFC is running parallel to the existing IR lines, Base Transceivers Stations (BTSs) of Indian Railway will be shared by DFCCIL. Any up-gradation or strengthening required for smooth handover, at BTSs of Indian Railway shall be done by concessionaire.

However in sections, where track alignment of the Section is taking a detour and cannot be served by Base Transceivers Stations (BTSs) of Indian Railway, new Base Transceivers Stations (BTSs) of DFCCIL shall be provided by concessionaire for adequate Radio Frequency (RF) coverage. These BTS shall be controlled by Base Station Controllers (BSCs) to be installed at OCC. These BSCs will be linked to the existing Network Sub-systems (NSSs) of MTRC System of Indian Railway. Accordingly BSCs and associated network elements constituting the Base Station Sub-system (BSSs) shall be compatible with this Network Sub-systems (NSSs) of MTRC System of Indian Railway used for existing parallel IR network in the Section. The Base Station Subsystem (BSSs) should fulfill all interoperability criteria with existing Network Sub-systems (NSSs) of MTRC System of Indian Railway and should be supported with IOT documentation.

Base Station Sub-system (BSSs) to be provided under this Contract shall be capable of supporting data communications for train control system i.e. European Train Control System (ETCS) Level-2.

ii. Network Sub-systems (NSS) containing Mobile Services Switching Centres with primary responsibility for call control is supported by a Visitor Location Register (VLR) containing temporary details of subscribers active within the Mobile Services Switching Centre area, a Group Call Register (GCR) containing attributes of voice group and broadcast call configurations for the related Mobile Services Switching Centre area, Home Location Registers (HLRs) holding subscribers details on a permanent basis and IN platform based on CAMEL (Customized Application for Mobile Enhanced Logic).

iii. Telephone Interface Equipment to facilitate call between GSM-R Users (RDC, Cab Radio, OPH & GPH) and Telephone System (PBX Network).

iv. Voice Recording System (VRS) interfaced to above Network Sub-systems (NSS) for recording voice communications taking place on RDC, Cab Radio and OPH.

v. Mobile equipment which includes Cab Radios, Operation Purpose Handset & General Purpose Handset interfacing to the BSSs.

5.20 Frequency Planning

5.20.1 The use of radio frequency spectrum in India is regulated by the Wireless Planning and Co-ordination (WPC) Wing of the Ministry of Communications, Government of India (GoI). MTRC System shall operate within the frequency band of 952.8-954.4/907.8909.4 MHz. The Employer has been authorized the use of eight frequency pairs in band 952.8-954.4/907.8-909.4 MHz for MTRC System. However, based upon frequency plan separate clearance for the use of specific frequencies shall be obtained from WPC by Employer. The concessionaire shall provide necessary documentary support for this purpose.

5.21 System Radio Channel Requirements

5.21.1The MTRC System shall not provide traffic blocking exceeding 1%. Traffic calculations considering all radio communication needs of fixed and mobile radio subscribers to establish these requirements shall be submitted as part of detailed design. Requirements of radio communications during emergencies and crisis management should also be considered. The MTRC System shall support the communications during emergency operations.

5.21.2 Radio system shall as a minimum be equipped with 6 traffic channels, both for voice & data.

5.21.3 Controller position exclusively used for the section at OCC shall be provided with Radio Dispatcher Consoles.

5.22 Operational Purpose Radio

5.22.1 Operational Radios shall meet all mandatory system requirements as defined in EIRENE SRS v15.3.0. Besides, it shall also meet all system requirements required to comply with this Specification.

5.23 General Purpose Radio

5.23.1 General Purpose Radios shall meet all mandatory system requirements as defined in EIRENE SRS v15.3.0. Besides, it shall also meet all system requirements required to comply with this Specification.

5.24 Antenna Towers at Radio Base Stations

5.24.1 The towers shall be designed and constructed for working and installation in the geographical and environmental conditions.

5.24.2 All towers shall comply with the requirements of Standard EIA/TIA-222-E and Indian Standard IS-800, 808, 226/2062, 1367, 1161, 2629, 5358. In case of any conflict between the two standards, the Indian Standards shall prevail. Concessionaire shall always immediately seek advice from the Employer / Independent Engineer in the event of conflict.

5.24.3 The Concessionaire shall design/build/erect the base/foundations/earthing/ fencing of the tower. It is expected that the foundations can be constructed from standard concrete and reinforcing steel. However, the Concessionaire shall ensure the adequacy of the soil bearing pressure to support the weight of the tower including all accessories; antennae support structures and live load of installation and maintenance staff and to resist the overturning moments generated in the survival wind speed. During construction of the Tower foundation, the Concessionaire shall be responsible for the safety of the site and the structures nearby. The earthing design shall be as per IS 3043 or better standard for Radio Towers and the foundation and earthing design shall be got approved from the Independent Engineer before implementation.

5.24.4 A rest platform with guard railing and seat every 20 m. and a 400mm wide climbing ladder with 20 mm diameter rungs at intervals of 300 mm to the top of the tower shall be provided. Design of ladder, the platforms and the tower shall also consider the live load of a number of installation/maintenance personals at different levels. Working platforms at the levels where antennas are installed shall be such that these will facilitate installation and maintenance personal to work on the antennas without any additional supports and without any undue risk.

5.24.5 The ladder shall be securely and rigidly fixed so that the tower faces form a safety cage. Backward tilt shall not be acceptable.

5.24.6 The linear and torsional sway of the tower under the worst loading conditions shall be restricted to a value such that no degradation of system performance is experienced.

5.24.7 All tower connection nuts and bolts shall be made of steel conforming to the requirements of IS 6639, IS 13634 or ASTM A-325 or an equivalent international standard, and shall be hot dip galvanized. Lock nuts shall be provided and installed for all bolts without exception.

5.24.8 All towers shall be equipped with a suitable cable rack to house the feeder cable to antenna, and cable clamps of suitable design shall be provided and installed.

5.24.9 The towers shall be equipped with Aviation Warning Lights in conformity with the relevant requirements of International Civil Aviation Organization (ICAO).

5.24.10 Pockets and depressions likely to hold water shall be avoided, and where unavoidable, shall have suitable draining facility.

5.24.11 For earthling of the tower, holes of suitable diameter shall be made near the base of the tower. At least two earths at adequate distance apart interconnected shall

be provided. The earth resistance shall be less than one ohm under all weather conditions.

5.24.12 The tower shall have lightning conductors of appropriate design and size, which shall be earthed through dedicated copper conductors of suitable cross section coming down from the top of the tower to the base of the tower to be grounded.

5.24.13 Life of the tower shall be at least 40 years.

5.24.14 A means of preventing unauthorized access onto the ladder shall be provided.

5.25 Base Station Outdoor Antenna

5.25.1 The outdoor antenna shall be of robust construction utilizing corrosion resistant aluminum alloy and shall be protected from lightning. The feeder cable connection shall be weatherproof and fully sealed. Concessionaire shall submit complete specifications/OEM's datasheets of various types of base station antennas considered in the RF coverage design.

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CHAPTER 6

STATION PLANNING AND DESIGN

6.1 General

6.1.1 Stations will be required for:-

a) Transferring traffic to and fro from Indian Railway network. Such stations will be termed as Junction Stations.

b) For crossing the trains running on DFC system. Such stations will be termed as Crossing Stations.

6.1.2 Junction stations have been identified based upon the traffic needs. The concessionaire shall provide the necessary facilities as per yard plan already developed and approved.

6.1.3 Crossing stations will be provided at suitable locations in consultation with DFCCIL at inter station distance of around 35-40 Km with automatic blocks in between. Each crossing stations should have minimum two loops (one UP and one DN) with 1500 m CSR (Provision of 750 m for present and 750 m for future shall be kept). The concessionaire shall provide the necessary facilities as per yard plan already developed and approved.

6.1.4 Detailed engineering plans as required for Junction and Crossing stations shall be prepared by Concessionaire.

6.2 Centralized control of the Station Equipment

All station buildings shall have BMS for supervision and control of all major E&M equipment so that O&M staff can have control over them. The BMS shall also interface with the requirements of control, monitoring and supervision as required at RCC. The BMS facility shall be provided in accordance with chapter-8

6.3 Features for Station Design

6.3.1 **General**

a) Stations shall be open, spacious and well lit so as to maximize visibility of people, platform, other building/structure areas, and parking areas.
b) Hiding areas shall be minimized.
c) Access points to parking area shall be minimized.
d) Adequate lighting shall be provided, minimizing shadows and avoiding dark areas.
e) Shatter guard protection shall be provided for glass windows/doors.
f) Planning shall provide for open lines of sight to as much area as possible.
g) Make efficient use of space which aesthetically integrates lighting, ventilation and electrical system and provision of natural light.
h) Provide Lightning protection and primary surge protection system for incoming power supply to the building and for sensitive relays and electronic equipment
i) Fire protection system to be located in Station offices complete with firefighting equipment as per requirement of concerned authorities.
j) Provision of Signage, name boards.

6.3.2 **Fire Precautions**

a) The station design shall conform to the following standards;

- BIS Codes
- National Building Code;
- NFPA codes wherever subject matter is not covered under relevant BIS Codes/NBC;

b) The choice of materials in Stations should be such as to keep the fire load and the smoke and toxic gas generation in the event of a fire to the minimum practicable level.

c) An electrical fire detection and alarm system shall be installed in accordance with IS 3218: Code of Practice for Fire detection and Alarm Systems.

d) Firefighting equipment should be provided as per Applicable Law.

e) All S&T equipment rooms on station as well as block sections shall be provided with suitable fire detection and alarm system along with suitable firefighting equipment.

6.3.3 **Platform/Walkway**

Platform/Walkway shall have clearances as per DFC Schedule of Dimensions.

6.3.4 **Stairs**

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

a) Tread of steps should be minimum 300 mm.
b) Riser shall not be more than 150 mm.
c) Hand rails shall be provided at a height of about 900 mm.
d) Step noses shall be rounded and color contrasted.
e) Minimum width of stairs shall be 1500 mm
f) Minimum head room over a stair shall be 3.0 m.
g) The stairway must be well lit.
h) For fire escape stairs, relevant BIS Codes shall apply

6.3.5 **Fencing**

The Concessionaire shall provide appropriate vandal-proof perimeter fencing at suitable locations, determined in consultation with the Independent Engineer.

6.3.6 **Environmental Protection Requirements**

The Concessionaire shall implement the environmental protection requirements applicable to the Works. All parts, including non-structural parts, of the structures shall minimize as far as practicable the radiation of noise due to vibration caused by the passage of trains. Particular attention shall be paid to the minimization of noise at the low end of the acoustic frequency spectrum.

6.3.7 **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 local bodies, State and the Central Government

6.3.8 **Station Architecture**

The Stations shall be visually appealing, tastefully designed reflecting local culture and flavor, functional aesthetics, user friendly, energy efficient and with a Station architecture that is site specific and environmentally compatible. The design should identify significant architectural features which should be taken into account.

6.3.9 **Facilities for Differently Abled Persons**

Facilities to staff and other users with mandatory requirement as per Indian Disability Act for differently abled persons shall be provided.

6.4 Materials and Station Finishes

The materials selected and finishes adopted for floors, 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, fire resistant, vandal resistant, environment friendly and pleasing. Basic requirement are as under:-

a) Fire Resistance and Smoke Generation

Materials with minimum burning rates, smoke generation, and toxicity characteristics for station finishes, consistent with requirements of Fire/Life Safety requirements to be used. Interior finishes including doors/windows shall meet requirements of the code and the fire/life safety requirement:

b) Attachment

Eliminate hazard from dislodgment due to temperature change, vibration, wind, seismic forces, aging, or other causes, by using proper attachments of adequate bond strength.

c) Skid resistant (for walking surfaces)

Entrances, stairways, platform edge strips, and areas around equipment shall have flooring having high skid-resistant properties. Following static coefficients of friction shall be provided as a minimum:

(i) horizontal surfaces, interior-0.5;

(ii) horizontal surfaces, exterior-0.6;

(iii) stairs, ramps, sloping sidewalks-0.8; and

(iv) area around equipment-0.6.

d) Durability

Materials shall have 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 colorfast.

e) Ease of Maintenance.

(i) **Cleaning**: Materials should not soil or stain easily, have surfaces that are easy to clean in a single operation, and minor soiling should not be apparent. Materials shall be cleanable with standard equipment and cleansing agents.

(ii) **Repair or Replacement**: Materials, if damaged, are easily repairable or replaceable without undue interference with the operation of the System.

f) Resistance to Vandalism

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. The Concessionaire is required to describe procedures for removal of more serious defacement for each finish in public areas and within 3 m of the floor surface, as part of the Maintenance Manual.

g) Aesthetic Qualities

Create feeling of warmth, attractiveness, quality, and civic pride in the facility.

h) Cost

Materials shall be selected for long life, low maintenance, easy to replace and overall aesthetic and functional qualities.

i) Availability

Materials selected should be easily available.

j) Installation Standards

Materials shall be detailed and specified to be installed in accordance with industry standards and manufacture's printed directions.

6.5 Non- Traction power supply and Station Lighting

6.5.1 Power for station will be received from the local power grid at 11/33 kV by two independent feeders (double circuit) from single source at initial stage with provision for second source in future. The interconnection of receiving sub-stations shall be through feeders. These receiving stations should be remote controlled from Centralized operation control centre through Supervisory Control & Data Acquisition system (SCADA). In the event of total power failure, DG sets will be automatically switched on and feed the station.

The station designer will prepare a load analysis for determining the total power requirements. The load analysis should include but are not limited to:

(i) Capacity
(ii) All domestic electrical consumption (fixtures, outlets, switches etc.)
(iii) All mechanical equipment (pumps, compressors, etc).
(iv) All Signal and Telecom equipment.
(v) All internal and external lighting

The load analysis shall be prepared in conformance with the National Building Code of India and the Bureau of Indian Standards and submitted to Independent Engineer for review and approval. Station metering and sub-metering shall be designed so as to be able to do the following:

a) Distinguish power consumption by mechanical equipment, lighting and other equipment by major station components and areas.

b) Monitor all energy efficiency protocols and consumption as required by energy management plan for the station.

c) The non- traction power supply system, and ancillary services shall be in accordance with Chapter 8.

6.5.2 Lighting shall be energy efficient. The following general guidelines shall be followed:

a) Lighting levels shall be uniformly distributed throughout as far as possible and be designed to prevent glare, dark recesses and areas of poor lighting levels. Lighting levels should be graduated consistent with safety and comfort, avoiding abrupt changes in illumination levels. Station Control Rooms shall be positioned so that no reflected glare from dials or monitor screens interferes with the operator's vision;
b) Stairways shall be well illuminated;
c) All Station premises, including foot bridges, subways, stairways, steps and ramps should be permanently lit when there is no day light;
d) Lighting shall not blind Train operators(TOs);
e) outdoor lighting shall be provided as required outside Stations;

6.5.3 Station lighting and other building services shall be in accordance with Chapter 8.

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CHAPTER 7

INSPECTION AND MAINTENANCE OF ASSETS

7.1 General

7.1.1 Maintenance Philosophy and Objective

The entire infrastructure created under the concession agreement will also be maintained by the concessionaire for the entire concession period. Concessionaire will follow the latest maintenance practices best suited to Indian Conditions for the maintenance of the assets and delivering a safe and reliable infrastructure. Instead of traditional reactive maintenance, concessionaire shall adopt a proactive, "predict and prevent" approach, using asset monitoring and high output mechanized techniques to minimize human intervention and to develop an efficient maintenance system on minimum life cycle cost basis.

An inspection and maintenance program covering schedule of inspections and periodical program of preventive, breakdown and unscheduled maintenance of the Rail System shall be prepared by the concessionaire and incorporated in Maintenance Manual after approval by Independent Engineer/Employer. The inspection and maintenance plan shall aim at achieving following objectives:-

- Periodical inspections of the assets so as to objectively record their position and to plan the necessary maintenance inputs required well in advance. To cover interfacing issues, joint inspections will be identified and specified in the Maintenance Manual.
- To optimize maintenance performance but at the same time avoid excessive and unplanned train disruptions to operations.
- To provide railway infrastructure and carry out its activities with safety risk managed to be As Low as Reasonably Practicable (ALARP).
- To ensure that maintenance activities have minimal impact on the natural environment.
- To ensure compliance with relevant standards and statutory requirements.
- To manage and maintain infrastructure to support an economic and efficient approach to overall service delivery.
- To prevent premature degradation of assets and provide assured asset condition.

7.1.2 Comprehensive Inspection and Maintenance Approach

Concessionaire shall optimize the maintenance efforts without compromising safety. Asset management policies will include:-

- An initial fit-for-purpose asset or system design that requires low maintenance on a whole life cycle cost basis.
- Ensuring strict quality control during construction and procurement or equipment.
- An inspection regime to monitor asset condition and identify actual or potential defects that could compromise the performance of the asset during the operation period.

- The assets which will be subjected to joint inspections by other than one inspecting agency shall be identified.
- Maintenance activities to address asset degradation shall be identified at the time of inspection to address predictable asset degradation.
- As far as possible, an integrated maintenance approach will be followed thereby keeping all the assets in a reasonably uniform level and to optimize the maintenance efforts.
- Renewal criteria that identify the period of time when the current asset or system should be replaced as ongoing maintenance is considered to be uneconomical.

7.1.3 Implementation of maintenance

The maintenance plan may be based on four level of preventive maintenance, which differ according to the nature and scope of the interventions carried out there:

- **Level-1:** Systematic in-service examination, which provide a means of detecting (without any specific tools and by personnel who are not necessarily skilled) any anomalies which may have occurred in service according to a random or fortuitous process, and which may affect traffic and safety.

- **Level-2:** Systematic periodic inspections, which allow skilled personnel to ensure that, taking account of the service to be provided until the next scheduled intervention of similar importance, the equipment or the element inspected offers predetermined guarantees of reliability.

- **Level-3:** The replacement of elements which are triggered within the framework of systematic preventive maintenance (when the element reaches the end of the programmed potential) or conditional maintenance (when it is noted in the course of an inspection that the normal operation threshold criteria have been reached), but also within the framework of corrective maintenance.

- **Level-4:** Interventions on dismantled elements and structural equipment carried out to restore the elements concerned to the same level of operation as an identical new one. These interventions (or overhaul operations) usually involve resources related to a reconstruction of the element in question.

7.1.4 Maintenance Management Information System (MMIS)

Concessionaire shall provide Maintenance Management Information System(MMIS) and which can be accessed from appropriate locations such as Maintenance Depots, RCC and OCC. The system shall address, but not be limited to, the following items:

- Failure recording and analysis;
- Maintenance Manual and diagnostic;
- Maintenance planning and recording;
- Staff schedules;
- Stock control; and
- Interface to the asset database.

7.1.5 Benchmarks during maintenance phase

KPIs and maintenance response time shall be as per benchmarks set forth in the Concession Agreement.

7.2 Maintenance Depot: General

7.2.1 The integrated maintenance depots and sub depots will be set up at suitable interval and locations. The depots and sub depots will be common to Civil, Electrical, Signal and Telecom Engineering. The Depot lay out shall be planned to optimize the maintenance activities and facilities. Location and plan of IMSD's and IMD's shall be as approved and included in the Concession Agreement.

7.2.2 The Depot design shall be based on operational requirements and maintenance activities required.

7.2.3 The Depot shall be equipped with all maintenance plants, tools and equipments required for the maintenance of assets. Maintenance of wagons and locos are not included in these depots as same will be carried out by DFCCIL/IR separately.

7.2.4 The Depot infrastructure shall be designed and built in compliance with applicable local building byelaws/codes and services provided to proven international standards. The details contained in Chapter 8 regarding Building Services shall be applicable for designing / construction of maintenance depot.

7.2.5 Electric Sub-Station of adequate capacity shall be provided in the Depot, for supplying auxiliary power.

7.2.6 Facilities in the Depot shall be ergonomically designed and arranged in a logical manner in order to optimize the routine workflow and the capability for coping with abnormal situations.

7.2.7 The Depot facilities shall be designed to accommodate facilities as detailed in the approved plan of respective IMD's and IMSD's. Some of the indicative facilities are as under:-

a) Stabling facilities for On Track Machines, rail grinding car, ultrasonic testing vehicle, push trolleys, motor trolleys, inspection and maintenance vehicles/tower wagons as per yard plan approved by DFCCIL;
b) Maintenance and repair facilities for civil, electrical and S&T assets;
c) Electric repair shop with miscellaneous testing and repair;
d) Covered and open storage for civil, electrical, signaling and communication materials and equipment;
e) Auxiliary sub-station;
f) Diesel generator;
g) Fuel storage and fuelling facilities;
h) Service buildings, office buildings and other buildings;
i) Track layout and / or Pit track to enable access to undercarriage equipment of tower wagon and ON Track Machines.

7.2.8 Depot facilities shall allow access by road vehicles and mechanical handling equipment, including emergency service vehicles and equipment. As far as possible, access shall avoid conflicts with Train movements.

7.2.9 The Depot layout shall facilitate security and smooth flow for pedestrian and vehicular access and perimeter protection, with least interference to normal maintenance and operation activities.

7.2.10 Water shall be recycled to the maximum possible extent and effluents shall be handled as per environmental norms.

7.2.11 Safe access to vehicle mounted equipment shall be provided.

7.2.12 Maintenance activities shall cover but not restricted to, the following:

a) Routine servicing;
b) Testing and investigation;
c) Routine preventive maintenance;
d) Corrective maintenance;
e) Quality assurance testing.

7.2.13 Depot Signages shall be provided including but not restricted to the following:

a) Directional;
b) Information;
c) Identification;
d) Accessibility;
e) Safety;
f) Emergency;
g) Regulatory; and
h) Operational.

7.3 Maintenance Depot: Track and Structures

7.3.1 Track system including rails, sleepers, rail fastenings, resilient pads and insulating spacer blocks shall be capable of easy removal and replacement and shall be of proven type.

7.3.2 Ballasted tracks shall be free-draining and rainwater shall be carried away from the formation by grading the formation and drainage layers and discharged into the existing storm water drains.

7.3.3 The walkways shall be positioned to prevent personnel from inadvertently coming in contact with moving vehicles or from straying into a position where they might be struck by a Train. Personnel moving about the Depot always shall have a clear view of moving rail vehicles.

7.3.4 Walkways shall provide safe surfaces under all weather conditions, adequate electrical insulation properties where necessary, and enable track maintenance where adjacent to ballasted track.

7.3.5 Internal Depot vehicular roads and pathways shall be suitably paved. Where roads and pathways cross ballasted track, the crossings shall be designed to permit maintenance of the track with the minimum of disturbance to the Depot operation.

7.3.6 Internal storm water drain system shall be developed. Sewerage water shall be discharged into the municipal sewerage system and if same is not available at site sewage disposal system in form of septic tank, soak pit/filter bed will be provided in terms of environmental norms.

7.3.7 All materials shall be selected with the highest regard for safety and security. They shall be non-combustible and non-toxic, and conform to all applicable Indian codes and standards. Materials shall be selected for their wear, strength and weathering qualities to withstand abrasion, impact, humidity, sunlight and temperature changes. Materials shall be stain resistant and non-water absorbent, easy to clean, repair and replace.

7.3.8 The rain water harvesting of the runoff water within the Depot areas shall be planned as per the applicable policy, rules, norms, requirements and methods of the local bodies, State and the Central Governments.

7.3.9 Trees, shrubs and ground covers shall be suitably used around the perimeter, administrative building, parking areas, Depot entrances etc.

7.4 Maintenance of equipment/ machine and inspection vehicle

The achievement of the objectives assigned to the maintenance division with regard to quality, safety and regularity for the lowest possible overall costs requires the implementation of a number of resources which must be perfectly tailored to the requirements.

7.4.1 **Civil**

Concessionaire shall provide adequate no of requisite track maintenance machine and inspection vehicle as determined in comprehensive Inspection and maintenance policy.

7.4.2 **Electrical**

The Concessionaire shall make provision for mechanized maintenance of the OHE system using latest technology prevalent globally. This includes OHE inspection car, rail road vehicle, mobile testing van, GPS based system, infrared devices.

The Concessionaire shall make provision for availability of essential spares & Tools for the system. Following tools and vehicles are normally required for maintenance purpose:

a) **Catenary Maintenance Vehicle with recording Car:** The catenary maintenance vehicles shall be used for periodical maintenance, breakdown attention and other occasional construction activities like replacements of Masts, portals, replacement of overhead lines, provision of splices, cutting insulators, section insulators etc.

b) **Over Head Maintenance Vehicle:** The Overhead maintenance vehicle is basically designed to unroll one contact wire and/ or one messenger wire of traction overhead line and is provided with powered reel stands and a hydraulic guiding device for this purpose. The vehicle ensures tensioning during setting of the wires. In addition, a lifting and swiveling platform is also provided, which can hold a maximum load of 500 Kgf including personnel and tools.

c) **5Tonne Rail Mounted Crane:** The 5-tonne Rail mounted diesel hydraulic crane including the railway wagon, the crane, crane hook, shackles and all necessary fixtures and mounting etc.

d) **Road Trucks:** The Road Trucks shall be of reputed manufactures and shall be complete with tool box and other essential accessories, complete in all respects, ready for operation on road with adequate capacity and quantity.

7.4.3 Signal and Telecom

7.4.3.1 'On line monitoring' shall be provided to monitor the performance and operations of all the signaling equipment and transfer information to OCC in real time, where it shall be processed and suitable indications and alarm shall be generated for planning, preventive and predictive maintenance as well as take steps to repair any signal failure affecting traffic.

7.4.3.2 Monitoring terminals shall be provided at all the signal equipment rooms, stations and IMDs which shall be networked with the 'Online Monitoring' system to provide continuous real time information to the maintenance staff.

7.4.3.3 Network Monitoring Systems (NMS) shall be provided for monitoring all Telecom equipment with monitors at OCC, IMDs and telecom equipment rooms.

7.4.3.4 The Concessionaire shall prepare a comprehensive maintenance plans to meet the RAMS requirements of the system. Sufficient spares, test and measuring equipment and tools shall be stocked at IMDs, Signal and Telecom equipment rooms at stations or in sections as per the maintenance plans to carry out preventive and predictive maintenance and to attend to signal failures.

7.4.3.5 Mobile Teams shall be suitably located to attend to emergency breakdown and signal failures.

7.4.3.6 A suitable renewal / rehabilitation plan based on usage and service life of the equipment shall be prepared and implemented so as to keep the S&T system in desired working condition throughout the Concession period. The renewal/ rehabilitation plan shall be in line with the manuals, rules and regulations prescribed by the Railway administration.

7.5 Maintenance Depot Security Office

A Depot Security Office (DSO) shall be provided at the Depot main entrance. It shall be designed to provide automated security systems as follows:

- Vehicular and pedestrian access control and recording entrance and exit within the Depot;
- Access control to offices, technical rooms, stores; and
- Fire alarm control panel.

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CHAPTER 8

BUILDING SERVICES

8.1 General

This section lays down the standards and performance requirements for the building services. The basic design criteria for power supply and distribution system shall be based on NEC 2011, NBC, ECBC 2007 and Central Electricity Authority (measures relating to safety and electric supply) Regulations, 2010.

8.2 Electrical Services

8.2.1 Non- traction power supply

(a) The electrical power design shall comply with the relevant current international standards, local codes and statutory requirements;

(b) The E&M equipment shall be classified into the following categories;

(i) Essential equipment; and
(ii) Non-essential equipment.

(c) Essential equipment shall comprise the following

(i) Those required to maintain the Rail System safety; and
(ii) Operationally critical facilities.
(iii) Life saving circuit.

(d) The electrical power system shall consist of TNS, 415 V, 3-phase, 50 Hz, 4-wire low voltage power distribution system, commencing from incoming LV cables connecting to the LV terminals of the 33/0.415 kV or 11/0.415 KV transformers.

(e) Emergency backup supply shall be in the form of a DG set of adequate capacity and UPS system. The LV power supply system shall include:

i) MDB/LV switchboards / sub-distribution boards, associated cabling, internal wiring including fault detection/ protection system;
ii) All LV supply routes for designated services, systems and cable galleries/ways;
iii) Lighting;
iv) Automatic Power Factor Correction system;
v) Earthing and bonding system; and
vi) Lightning and Surge Protection system.
vii)

(f) A power system analysis shall be provided to verify that all equipment chosen are rated for the voltage, current and fault duty to which they are exposed.

(g) Illumination of buildings and installations shall be as per standards laid in this manual.

(h) Building structure and roof shall be able to accommodate equipment for solar power.

(i) Energy efficient fittings shall be provided.

(j) Air conditioning and other facilities shall be provided as mentioned below:

Matrix of required facilities at various locations								
SN	Parameters	Station Building	Ancillary Building	IMD	IMSD	Staff Qtr	OCC	Signaling & telecom installations between stations
1	Solar Panel	√	NA	√	√	NA	√	NA
2	DG set supply	√	NA	√	√	NA	√	NA
3	Fire alarm Control panel	√	NA	NA	NA	NA	√	NA
4	Air-conditioning	√	NA	NA	NA	NA	√	√
5	Exhaust Fans	√	√	√	√	√	√	√
6	Ceiling Fan	√	√	√	√	√	√	NA
7	Traction Supply (AT)	√	√	√	√	NA	√	√
8	Fire extinguisher	√	√	√	√	NA	√	√

8.2.2 Low Voltage Distribution

(a) The power supplies shall be distributed at either 415V three phase and neutral or 230V single phase and Neutral as necessary. Where any other voltage is required for a particular purpose, the conversion shall be carried out via transformers of adequate capacity to allow the use of power from this source.

(b) The distribution system shall be designed to supply power with a variation of +/- 10% in the worst case, including regulation of the transformer. All equipment, cables and components comprising the distribution system shall be designed to operate at a nominal temperature of 50°C.

(c) The distribution system shall comply with national and international standards with respect to electromagnetic compatibility, corrosion protection, stray current corrosion and Radio Frequency (RF) interference criteria, EN 50121-2, EN 50081 and EN 50082 for electronic equipment and CENELEC EN 50121 for fixed power supplies.

(d) The 415V 3-phase 50Hz power supply shall be connected to the main distribution board (MDB) at each installation. From there it shall be distributed as required and shall include the provision of feeders for emergency supply.

(e) Incoming power supply from Utility Sub-Station to Building shall be arranged by the Concessionaire liasioning with the Utility. Necessary duty/charges shall be paid by the Concessionaire.

Reference Standards:

(i)	IEC 60076	MV/LV Transformer
(ii)	IEC 726	Dry Type Power Transformer
(iii)	IEC 62271	PART 200 & 201 High-voltage switchgear and control gear
(iv)	IEC 60890	A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and control gear
(v)	IEC 60947	Low-voltage switchgear and control gear
(vi)	IEC 60408	Low-voltage air-break switches, air-break disconnectors, air-break switch-disconnectors and fuse-combination units
(vii)	IEC 60898	Circuit-breakers for over current protection for household and similar installations
(viii)	IEC 60439	Low-voltage switchgear and control gear assemblies
(ix)	BS 5486-12	Low-voltage switchgear and control gear assemblies. Specification for type-tested and partially type-tested assemblies
(x)	IS 2026	Specifications of Transformer
(xi)	IS 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
(xii)	IS 8623	Low-Voltage Switchgear and Control gear Assemblies
(xiii)	IS 5039	Distribution Pillars
(xiv)	IS 2675	Enclosed distribution fuse boards and cutouts Electricity Act 2003
(xv)	IS 1641	General Principal and Fire Grading
(xvi)	IS 13118	High-Voltage Alternating-Current Circuit-Breakers
(xvii)	IS 3427	A.C. Metal Enclosed Switchgear and Control Gear for Rated Voltages Above 1 kV and Up to and Including 52 kV
(xviii	IS 10601	Dimensions of terminals of high voltage switchgear and control gear

8.2.3 Switchboards and Circuit Breakers

Switchboards shall be located in dedicated electrical equipment rooms, battery rooms and closets. Switchboards shall have sufficient space to house switchgear, control gear and components. Sufficient spare space capacity shall be provided for anticipated future expansion. Adequate degrees of protection shall be provided for the equipment depending on their location. These shall confirm to relevant standards.

8.2.4 Cabling

Reference Standards:

(i)	IS	694, 1255, 1554, 1641, 3961, 3975, 5831, 5891, 7098, 8130, 10418, 10810
(ii)	IEC	189, 331, 754, 60228, 60502, 60331, 60332, 60754
(iii)	BS	5308, 5467, 6360, 6387, 6746, 7655, 7846

i. Cables for circuit comprising non-essential equipment shall have multi stranded copper conductors PVC ST2 insulated, PVC sheathed with flame retardant low smoke (FRLS) compound, 1100 V grade and colour coded.

ii. Cables for circuit comprising essential equipment i.e. emergency circuit shall be of Fire Survival type, stranded plain annealed copper wires, over the conductor the mica tape shall be applied as the fire barrier tape. Insulation shall be low smoke & zero halogen LSZH cross-linked polyethylene thermosetting compound. Cables shall not generate hazardous, corrosive gases when burnt.

iii. **Rising mains & Bus ducts:**
It shall consist of compact Sandwich Type Aluminum conductor Bus Trunking Systems (Rising Mains with Tap Off facilities and Bus Ducts) suitable for indoor installation. In addition the relevant clauses of the Indian Electricity Act 2003, Indian Electricity Rules 1956, National Building Code 1994, National Electric Code 1985, Code of Practice for Fire Safety of Building (General): General principal and Fire Grading - IS 1641 as amended up to date shall also apply. Wherever appropriate Indian Standards are not available, relevant British and/or IEC Standards shall be applicable.

iv. **Busbars:**
Busbar shall be fabricated from aluminum or 99.9% pure Electrolyte Tough Pitch (ETP) grade copper as applicable. Rating of busbar shall be as specified in drawings / Schedule of quantities.

v. **Wiring:**
All internal wiring shall be multi-stranded copper conductor with FRLS insulation for normal application & FRLSZH insulation for fire safety. Minimum size of the conductor shall be 2.5 sqmm. Internal Wiring Installation in concealed/surface conduit /raceways shall cover following:

- Lights and fans
- Convenience socket outlets
- Control wiring
- Sub main wiring

vi. **Degree of Protection**:
The degree of protection for enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. shall be as under:-

- Installed Outdoor: IP- 55
- Installed Indoor in air conditioned area: IP-31
- Installed in covered area: IP-52
- Installed Indoor in non air conditioned area where possibility of entry of water is limited: IP-41.
- For LT Switchgear (AC & DC distribution Boards) : IP-52.

8.2.5 Protection Circuits

(a) Protection circuits shall be provided for all main and sub circuits against the following:

- Overload/ short circuit Under and over voltage;
- Residual current; and
- Earth faults.

(b) The protective devices shall be capable of interrupting (without damage to any equipment or the mains or sub circuits) the short specified maximum short circuit.

(c) Discrimination shall be in accordance with BS 88, BS EN 60898, BS 7375 and any other applicable Standards.

8.2.6 Metering

Metering shall be provided and monitored through BMS. All instruments and meters shall be completely segregated in instrument compartments.

8.2.7 Lighting

8.2.7.1 Lighting Standards

The lighting system requirements shall comply with the following standards;

i) National Lighting Code 2010;
ii) National Electric Code-2007;
iii) IS 3217-Emergency Lighting;
iv) EN 13201-Road Lighting;
v) BS-EN 60598 – Luminaries;
vi) IS 10322 (Part V) – Luminaries for Road and Street Lighting;
vii) National Building Code;
viii) GRIHA (Green Rating for Integrated Habitat Assessment)
ix) TERI (Recommendations and Mandates; and
x) Leadership in Energy and Environment Design (LEED), USA.

8.2.7.2 General

a) Lighting shall be energy efficient. Only LED light fittings shall be used for Building Services.
b) Stairways shall be well illuminated;
c) Outdoor lighting shall be provided as required;
d) Lighting design shall take into consideration the use of daylight as far as possible to energy conservation.
e) Lighting system shall be designed, such that, 30% of the lighting shall be sourced from Renewable Energy Sources.
f) Lighting system shall be integrated with architecture and artwork;
g) Intelligent systems/concepts/sensors shall be used for automatic switching ON and OFF of lighting fixtures.

8.2.7.3 Emergency Lighting

i) Emergency lighting shall be defined as the lighting that is required to be provided for use when the LV power supply falls.

ii) Emergency lighting at critical locations such as ASM room, control room, switch room, relay room etc. shall have UPS backup.

iii) In each room at least one luminary shall be connected to the emergency supply.

8.2.7.4 Illumination Levels

The Concessionaire shall design lighting system for both normal and emergency lighting considering illumination level as given below:

Areas	Normal Level in lux	Emergency Lighting in lux
Plant / Switching station / Service Rooms	200	30
Operations/control rooms/ office rooms	300 (panel face)	100
Escape routes and stairs	50	20
Platform (Edge)	250	37.5
Staff rooms	150	30
Toilets	75	15
First Aid room	300	45
Other Rooms	35	30

8.2.8 Earthing and Bonding

a) Earthing and bonding shall accomplish the following minimum requirements:
- Protect personnel and equipment from electrical hazards;
- Achieve a reduction in potential to the system neutrals;
- Reduce or eliminate the effects of electrostatic and electromagnetic interference on equipment arising from auxiliary electrical systems;
- Provide a clean zero-volt reference point for signals in computer and related equipments.

b) Earthing and equi-potential bonding shall be provided for all electrical installations, to prevent the possibility of dangerous voltage rises and to ensure that faults are rapidly cleared by the installed circuit protection.

c) The earthing shall be designed to comply with the local and international building regulations to ensure safety of persons. In particular Users and staff shall be protected from the possibility of high potential to structural earth potentials and carrying fault current to earth. Other design requirements of the earthing systems are to ensure correct operation of breakers and tripping devices and limitation of damage to plant, equipment or system failure and protection against interference. The provision of equi-potential bonds shall ensure that touch voltages (between conducting components accessible to persons) during a fault condition do not exceed 60V and avoid electrolytic corrosion of metal parts and structural elements.

d) Earthing system shall comply with the following:

(i)	BS 7671	Requirements for Electrical Installations;
(ii)	BS 7430	Code of Practice for Earthing;
(iii)	BS EN 50122-1	Protective Provisions relating to Electrical Safety & Earthing;
(iv)	BS EN 50122-2	Protective Provisions against the effects of Stray Currents on DC systems;
(v)	BS 7375	Code of Practice for Distribution of Electricity on Construction sites;
(vi)	IEEE S 80	Guide for Safety in AC Substation Grounding; and
(vii)	IEEE 1100	Recommended Practice for Powering and Grounding of Sensitive Electronic Equipment.
(viii)	IS 3043	Code of Practice for Earthing of Traction System

8.2.9 Lightning Protection

8.2.9.1 General :

Lightning protection shall be provided to:

a) Protect above ground structures, Stations and ancillary buildings from direct lightning strike;
b) Protect the equipment located within the zone of protection; and
c) Protect personnel working within the zone of protection.

8.2.9.2 System Design

The lightning protection system shall be designed to comply with;

a) IS 2309 of 2010: Code of Practice for the protection of buildings and allied structures against lighting
b) BS 6651: Code of Practice for protection of Structures against lightning;
c) BS 7430: Code of Practice for Earthing; and
d) BS 7671: Wiring Regulations for Electrical Installations in Buildings.

8.2.10 Uninterrupted Power Supply (UPS)

8.2.10.1 Design of UPS

a) The UPS shall be dual redundant, on-line type.
b) Sufficient installed spare capacity shall be provided to enable the UPS systems functionality to be increased to maintain a further 20% load
c) The UPS systems shall be suitable for continuous operation allowing for a system availability of 99.9% as minimum.
d) The minimum levels of illumination shall be maintained for at least three hours during the failure of the normal supply of electricity.
e) UPS shall be provided as per provisions of NBC-2005.

8.2.10.2 Codes and Standards

The UPS shall be designed to comply with RDSO SPECIFICATION No. RDSO/PE/SPEC/PS/0023– 2001 (Rev-0) Amendment No. 3 and other relevant national/international standards.

8.2.10.3 Interfaces with other subsystems

The design of the UPS systems shall interface with the following high security sub-systems in the event of loss of main supply. Such sub systems shall include, but not be limited to:

a) Emergency exit signage;
b) Emergency lighting and signages;
c) Safety equipment;
d) Fire detection and fire pumps;
e) Control and communications;
f) OCC/RCC equipment including SCADA; and
g) Master Clock System

8.2.11 Diesel Generator Set

The DG set shall provide a 415 Volt 3 – phase, 4 wire, 50 Hz power supply in the event of a loss of supply from the electrical supply provider. The DG set shall be adequate to supply the essential light and power requirements and activate automatically in case of normal supply failure as well as the provision of normal and automatic switch over to main supply after the main supply resumes.
Average power factor shall be maintained at 0.92 lagging. The engine and alternator shall have an overload capacity of 10% for one hour.

Diesel Generator Set shall be suitable for continuous round the clock operation at up to rated output with permissible overload along with associated works. PLC based DG control Panel for Automatic operation of the DG sets is incorporated in the Main LT Panel. The equipment offered shall conform to the latest revision of relevant Indian or International Standards and Codes together with the requirements of the Local Supply Authority and Department of Explosive etc. The DG set capacity shall be estimated considering emergency load and 30% spare capacity to be kept for future demand.

8.2.11.1 Design

a) The generator set shall be designed to provide the following:

(i) Low specific fuel consumption;
(ii) Low weight (kg) to KVA capacity ratio; and
(iii) Low space (sqm) to KVA capacity ratio.

b) The diesel engine shall conform to BS 5514 or equivalent.

c) The alternator shall be 4-pole, 3-phase, salient pole, revolving field, brushless type, self regulating, continuously rated and manufactured in accordance with IEC 60034.

d) The alternator shall be screen protected, fan ventilated and vertical drip proof to not less than IP 21.

e) The smoke, noise and vibration emitted & radiated from DG set shall meet the requirement of National Building Code & Central Pollution Control Board (CPCB).

f) DG set shall comply with Central Pollution Control Board-II norms for noise & pollution control.

g) DG set should have facility for remote operation & monitoring.

8.2.11.2 Automatic Testing

When the DG set is on automatic control and has not been run for 7 days, the set shall actuate an alarm. It should be started and run for a pre-determined period on load conditions at ideal speed.

8.3 Fire Detection and Suppression Systems

8.3.1 General

a) An electrical fire detection and alarm system shall be installed in accordance with IS 3218: Code of Practice for Fire detection and Alarm Systems.

b) The fire suppression, hydrant and hose reels system shall comply with the relevant Indian Standards, NBC-2005 and with the necessary approval of local fire authorities.

8.3.2 Fire mains

a) The design of the fire mains shall comply with the local fire authority's regulations, National Building Code–2005, and relevant Indian / International Standards.

b) The fire main and hydrants shall be fed with sufficiently reliable water supplied from the local mains supply via storage tanks.

c) The hydraulic design of the fire main and hydrant system shall comply with the NFPA 14.

8.3.3 Hand held portable fire extinguishers

Portable fire extinguishers shall be located at strategic positions as agreed with the local fire authorities. The type of fire extinguishers shall be appropriate for the risk at that location. Portable fire extinguishers shall comply with NFPA 10.

8.3.4 Fire Buckets

Fire buckets filled with sand shall be provided on covered steel stand in necessary areas. IS specifications 1646, IS 3034, and IS 1948 etc shall be adhered to for these works.

8.4 Solar System

The Grid connect Solar Generating system of adequate capacity shall be used in conformity with RDSO specification No. RDSO/PE/SPEC/PS/0092-2008 (Rev '0'), Amendment - 4' or latest. The Lighting system shall be designed, such that, 30% of the lighting load shall be sourced from renewable energy sources.

8.5 Ventilation & Air-conditioning System

8.5.1 General:

The purpose of providing Ventilation and Air conditioning (VAC) in building is to prevent temperature stratification, to remove contaminated air, to remove heat dissipated from various equipments/systems, to provide clean air and to provide

outside air necessary for human comfort. The system is required to provide required design condition in all the required areas but not limited to:-

a) **Ventilation System :** Auxiliary supplies room, LT room, Battery room, Toilet, Kitchen etc. by mechanical ventilation system

b) **Air Conditioning System :** Air Conditioning (AC) requirement shall be met using individual split AC units of suitable capacity. AC units shall be highest star rated wherever applicable.

8.5.2 Standards and Codes

- IS : 3103-1975 Code of Practice for Industrial Ventilation
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

8.6 Green Building

8.6.1 General :

The common objective of Green Buildings is to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

8.6.2 **GRIHA** (Green Rating for Integrated Habitat Assessment) :

GRIHA is a tool for Green Building i.e. for designing, evaluating and minimizing the energy and resource consumption of buildings during their entire life cycle. The building shall be designed in conforming the norms of GRIHA.

8.7 Water Supply System

8.7.1 Water Supply System shall include the incoming water supplies and the systems they supply, which shall be as per NBC-2005 and shall include cold water supply and hose reel supply. Water supply system shall include source of supply and intake arrangements, conveyance of water from source, storage and pumping arrangements, treatment (for drinking water only where separate supply systems for drinking and non drinking purposes are available) and distribution of water.

8.7.2 Drinking water shall be clear, potable and free from pathogenic organisms and odour. Physical and Chemical standards for drinking water shall conform to IS 10500.

8.7.3 Various types of sources like municipality water supply source, open wells, shallow/deep tube wells, impounding reservoirs, infiltration galleries/wells and radial collector wells may be utilized as per availability and local conditions. The source/s should be of adequate capacity and should be able to supply, in eight hours period, the one day requirement of water in summer season.

8.7.4 Requirement of water may be estimated as per scale given in Indian Railway Work Manual.

8.7.5 Suction pipe should be as short and straight as possible. Any bends or elbows should be of large radius.

8.7.6 Pumping arrangements should be adequate and capable of supplying:-

a) In a period of 12 hour or less, the normal quantity of water required in 24 hours.

b) In a period of 16 hours or less, the present maximum quantity of water in 24 hours.

c) In a period of 20 hours, the estimated maximum future requirement of water in 24 hours

8.7.7 Suitable type of pumps i.e. reciprocating pumps, centrifugal pumps, vertical spindle deep well turbine pumps and submersible pumps etc. may be used. Pumping units should be so selected that they could be operated continuously at rated loads.

8.7.8 Rate of pumping shall not exceed the yield of the source, so as not to damage the strata through which water filtrates into the source.

8.7.9 Near the pump, non return (reflux) valve and a delivery valve (sluice or butterfly valve) should be provided. Non return valve is to be provided between the pump and delivery valve.

8.7.10 Delivery pipe shall be of such size to limit the velocity of water to 2.5 m/s.

8.7.11 The storage system should have adequate capacity equal to the higher of following figures:-

a) With efficient stand by pump: one quarter of maximum water consumption in 24 hours & one third of normal water consumption in 24 hours.

b) Without standby pumps: one third of maximum water consumption in 24 hours & one half of normal water consumption in 24 hours.

8.7.12 The layout and design of distribution system should be based upon maximum estimated daily consumption being supplied in 10 to 16 hours. To take into account the daily and seasonal fluctuations in demand, the average demand should be multiplied by a peak factor of 2.5.

8.7.13 The economical diameter of pipe line is based on considerations of head losses and velocities under conditions of maximum flow. A reserve of at least 3 m head should be ensured at the tail end of every service line under conditions of maximum discharge.

8.7.14 Rising Mains are not to be used for distribution purposes.

8.7.15 Thrust blocks shall be installed wherever there is a change in the direction/size of pipe line or when the pipe line ends at a dead end. If required, thrust blocks may also be constructed at valve locations.

8.7.16 Adequate precautions are to be taken to avoid the likelihood of ingress of polluted water in water supply system. For this purpose, water main shall be laid in a manner to have adequate horizontal and vertical separation from any drain or sewer line.

In case where horizontal separation of 3 m between water main and sewer line/drain is not available, then laying of water main in separate trench and an elevation of 0.5 m of bottom of water main from top of sewer is to be ensured.

In situations, where water mains have to cross house sewer, storm drain or sanitary sewer, an elevation of 0.5 m of bottom of water main from top of sewer is to be ensured. In such situation, joint in water main should be away from sewer. The vertical separation of 0.5 m is to be maintained for a distance of 3 m on either side of sewer/drain.

8.7.17 Following types of pipes may be used in water supply network depending upon flow of water, supply pressure and nature (hard/soft) of ground:-

- Galvanized steel pipe : IS 1239
- Hot dip Zinc coatings on mild steel tubes : IS 4736
- Cast iron centrifugally cast (spun) pipe: IS 1536
- Centrifugally cast (spun) ductile iron pressure pipes : IS 8329
- HDPE pipes : IS 4984
- Unplasticized rigid PVC pipe : IS 4985
- Asbestos Cement pressure pipe : IS 1592
- Butterfly valves for general purposes : IS 13095
- Sluice valve for water work purpose (50 to 1200 mmsize) : IS 14846
- Cast Iron Screw-down stop valves and stop and check-valves for water supply purpose : IS 9338

8.7.18 After a new pipe line is laid and jointed, in order to check the quality of pipe and workmanship of laying, it shall be subjected to pressure test at least double the maximum working pressure. Pipes and joints shall be water tight under the test.

8.8 Drainage and Sewerage

8.8.1 Sanitary sewers are not expected to receive storm water and hence sanitary sewer system and storm water drainage system should be designed separately.

8.8.2 Size of sanitary sewer shall depend upon quantity of sanitary sewage, variation in peak and average flows, limiting velocities of flow, topography of area and construction material used.

8.8.3 For estimating quantity of sewage:-

- Population to be served is to be assessed including future growth.
- 80% of the water supplied may be considered to reach sewers.
- Lean and peak flow of sewage may be considered as 50% and 150% respectively.

8.8.4 Size of storm water sewer shall depend upon storm water runoff, self cleansing velocity and construction material.

8.8.5 Subject to the minimum size of 100 mm, the sizes of pipes shall be decided in relation to the estimated quantity of flow and the available gradient.

8.8.6 In designing drainage system, the aim shall be to provide self cleansing conduits for the conveyance of soil, waste, surface or subsurface waters, and the removal of such wastes speedily and efficiently to a sewer or other outlet, without risk of nuisance and hazard to health.

8.8.7 Normally, the sewer shall be designed for discharging three times the dry weather flow flowing half full with a minimum self cleansing velocity of 0.75 m/s. In no case, minimum velocity of flow shall be less than 0.61 m/s.

8.8.8 Maximum velocity of flow shall not be allowed to exceed 2.4 m/s. Where it is unavoidable, cast iron pipes shall be used.

8.8.9 As far as possible, the pipes shall be laid in straight lines with uniform gradients. Abrupt changes of direction are to be avoided and bends/junctions whatsoever

shall not be permitted in sewers except for manhole and inspection chambers.

8.8.10 All junctions shall be oblique and the contained angle shall not be more than 60 degree.

8.8.11 Drains may be laid under the buildings only when avoidable and when it is not possible to obtain otherwise a sufficient fall in the drain.

8.8.12 Where it is necessary to lay a drain under a building or exposed locations within the building, following conditions shall be observed:-

a) Pipes shall be of cast iron as per IS 1536 and IS 1537.

b) The drains shall be laid in straight line and at a uniform gradient.

c) It is desirable that drains should not be taken through a living room or kitchen and shall preferably be taken under a staircase room or a passage.

d) In case the pipe or any part of it is laid above the natural surface of the ground, it shall be laid on concrete supports, the bottom of which goes at least 150 mm below the ground surface.

8.8.13 Distance between inspection chamber & gully chamber shall not exceed 6m.

8.8.14 Drainage pipes shall be kept clear of all other services. Provisions shall be made during the construction of the building for the entry of the drainage pipes.

8.8.15 All soil pipes, waste pipes, ventilating pipes and all other pipes, when above ground shall be gas tight. All sewers and drains laid below ground shall be water tight.

8.8.16 Following types of pipes may be used:-

S.n	Pipe Material	IS code
1.	Slat Glazed Stoneware pipes	IS 651, IS 3006
2.	Cement Concrete Pipe	IS 458
3.	Cast Iron Pipes	IS 1536, IS 1537
4.	Asbestos Cement Pipe	IS 1626 (Pt 1 & 2), IS 1592
5.	Lead pipes	IS 404 (part 1)
6.	PVC Pipes	IS 4985
7.	HDPE Pipes	IS 4984

8.8.17 The pipes are to be laid at sufficient depths in trenches with adequate width.

8.8.18 For the purpose of inspection, testing, cleaning and removal of obstructions in pipes, manholes are to be provided with spacing of manholes as per IS 4111.

8.8.19 Sewage shall be collected and disposed to municipal sewerage system. In case, same is not available site disposal method i.e. septic tank along with soak pit/filter bed may be used. Detention period of 24 to 48 hours for septic tanks serving less than 50 persons and detention period of 10 to 8 hours for septic tanks serving more than 50 persons may be adopted.

8.8.20 The bottom of soak pit/filter bed must be well above the surrounding water table. Rain water from the surface should not interfere with the functioning of soak pit/filter bed.

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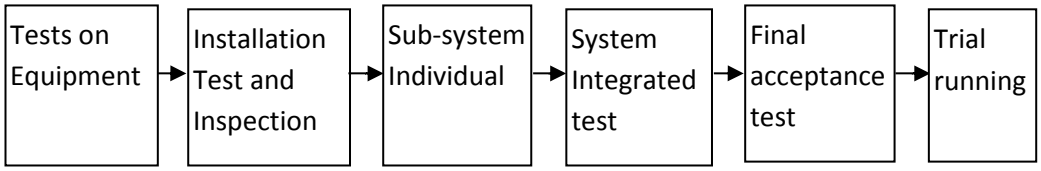
CHAPTER 9

TESTING AND COMMISSIONING

9.1 General

9.1.1 The concessionaire shall provide and perform all forms of testing procedures applicable to the works and various components including all necessary factory, site and acceptance tests required therein and for the interfacing of the works with the other contract works. Concessionaire shall make a consolidated list of all the tests required for testing and commissioning along with the testing procedures and applicable codes/manuals and submit the same to the Independent Engineer for enabling a joint program of testing.

9.1.2 The commissioning activity shall include a period of Integrated Testing of System followed by a period of trial running certified by statutory authority. A typical test sequence as shown below may be adopted by the concessionaire:-



9.1.3 Integrated Testing and Commissioning refers to those tests undertaken in order to demonstrate that the various components of the DFC systems operate satisfactorily in an integrated manner and meet all specified requirements for design, operability, safety and integration with other works and systems. The final Integrated Testing and Commissioning shall be carried out after the SCADA system and OCC have become operational. All testing procedures shall be submitted at least twenty eight (28) days prior to conducting any test. The testing procedures shall show unambiguously the extent of testing covered by each submission, the method of testing, the acceptance criteria, the relevant drawing (or modification) status and the location.

9.1.4 Those systems that can be tested without depending on the running of trains, such as SCADA system etc. will have their integration tests scheduled to commence as early as possible. It is preferable that any interface problems associated with these “trainless” system tests be identified and resolved prior to the commencement of test running.

9.1.5 All testing equipment shall carry an appropriate and valid calibration labels.

9.1.6 No work or part of work shall be covered up or put out of view, without the prior approval of the Independent Engineer. The concessionaire shall uncover any part or parts of the works, or make openings in or through the same, as the Independent Engineer may from time to time direct, and shall reinstate and make good such part or parts, to the satisfaction of the Independent Engineer.

9.2 BATCHES, SAMPLES AND SPECIMENS

9.2.1 A batch of material is a specified quantity of the material that satisfies the specified conditions.

9.2.2 If one of the specified conditions is that the material is delivered to the site at the same time, then 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 other specified conditions applying to batch apply to all of the material delivered over the period.

9.2.3 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.

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

9.3 SAMPLES FOR TESTING

9.3.1 Samples shall be of sufficient size and in accordance with relevant standards to carry out all specified test.

9.3.2 Unless otherwise agreed, samples taken on the site shall be selected by, and taken in the presence of, the Independent 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 Independent Engineer.

9.3.3 Concessionaire shall ensure that samples are 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.

9.3.4 Samples shall be delivered by the concessionaire, under the supervision of the Independent Engineer, to the specified place of testing. Samples on which nondestructive tests have been carried out shall be collected from the place of testing after testing and delivered to the site or other locations instructed by the Independent Engineer.

9.3.5 Samples which have been tested may be incorporated in the permanent works provided that:

(a) The samples comply with the specified requirements;

(b) The samples is not damaged; and

(c) The sample is not required to be retained under any other provision of the contract.

(d) Independent Engineer is in agreement with the proposal of contactor.

9.3.6 Additional samples shall be provided for testing if in the opinion of the Independent Engineer :

(a) Material previously tested no longer complies with the specified requirement;

(b) Material has been handled or stored in such a manner that it may not comply with the specified requirements.

9.4 Testing

9.4.1 Unless otherwise permitted or required by the Independent Engineer, all appropriate laboratory tests shall be carried out in the site/field laboratories set up by the concessionaire. Where the laboratory is not appropriately equipped and/or staffed for some test, or if agreed to by the Independent 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 Independent Engineer and

b) Particular of the proposed laboratory is submitted to the Independent Engineer for his consent.

c) Prior intimation to the Independent Engineer shall be given regarding the date/time and location of testing.

9.4.2 Unless otherwise agreed, in-situ tests shall be done in the presence of the Independent Engineer .

9.4.3 The equipment and apparatus shall be calibrated before the first testing starts and then at regular intervals as permitted by the Independent Engineer.

9.5 COMPLIANCE OF BATCH

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

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

9.5.3 If additional tests are permitted or required by the Independent Engineer but separate compliance criteria for the additional tests are not stated, the modalities will be proposed by the concessionaire and approved by Independent Engineer .

9.6 RECORDS OF TESTS

9.6.1 Records of in-situ tests and laboratory compliance tests shall be kept by the concessionaire on the site.

9.6.2 In addition to any other requirements, the report shall contain the following details:

a) Material or part of the works tested.
b) Location of the batch from which the samples were taken or location of the part of the works.
c) Place of testing.
d) Date and time of tests.
e) Weather conditions in the case of in-situ tests.
f) Technical personnel supervising or carrying out the test.
g) Size and description of samples and specimens.
h) Method of sampling.
i) Properties tested.
j) Method of testing.
k) Readings and measurements taken during the tests.
l) Tests results, including any calculations and graphs.
m) Specified acceptance criteria.
n) Other details stated in the contract.

9.7 FACTORY ACCEPTANCE TESTS (FAT)

a) FAT shall comprise Type Tests, Sample Tests, Routine Tests, Life, Endurance and Destruction Tests, and any additional tests requested by the Independent Engineer .

b) The testing shall be conducted such as to simulate the extreme working conditions as closely as possible.

c) Upon the request of the Independent Engineer, destructive tests shall be got carried on components and assemblies to verify the design loading as required according to the relevant specification and factory acceptance test.

d) Type testing and factory acceptance tests of equipment shall be witnessed by Independent Engineer based on test program approved by Independent Engineer .

9.8 POST INSTALLTION TESTS (ON SITE)

9.8.1 During and on completion of the installation, concessionaire shall undertake testing of all civil, electrical, signaling and communication equipments and other devices, in a progressive sequence and in accordance with the overall testing programme.

9.8.2 These tests shall culminate in functional tests to verify the correct operation of full apparatus and, where appropriate, correct response to the respective control and physical operation of the device/ components.

9.9 ACCEPTANCE TESTS

The concessionaire shall prepare and organize a comprehensive programme of acceptance tests to demonstrate to the Independent Engineer that all system, sub-system and apparatus defined under the contract meet the specified performance requirements in all respects.

9.10 TESTS ON COMPLETION

9.10.1 COMPLETION TESTS FOR TRACK WORKS

For the purpose of assessing the riding quality of track and recording combined values of various track parameters an electronic Track Recording Car (TRC) will be used. This run will be scheduled after the floating parameters as mentioned in chapter 2 are found to be within acceptable limits. The readings of the trial run shall fall within the following category limits:-

- Track Lengths outside station limits – Minimum 90% length in Category “A”
- Track Lengths within station limits – Minimum 90% length in Category “B” and above.

The station limit for this purpose shall mean the length between the two outer most stop signals. In case the track fails to qualify within the respective categories or the thresholds of TGI laid down, then a rerun of the recording car shall be scheduled after a month to record these parameters.

The Track Geometry Index (TGI) calculated based on Track recording car run, including track within Station limits shall follow the KPI as included in Concession Agreement.

9.10.2 COMPLETION TESTS FOR ELECTRIC TRACTION

9.10.2.1 OHE

OHE commissioning shall include as a minimum:-

(a) Visual inspection: This shall include check for accuracy of construction for ensuring that all the structures, equipment, insulators, jumpers and conductors have been erected as provided in approved Drawings and they are not damaged and remain in healthy state.

(b) Dimensional Checks: This shall include dimensional checks to ensure the execution of permanent Works are within the limits of tolerance permitted so as to permit the current collection by locomotives to be satisfactory. The Structure Erection Dimension shall be checked by using the Tower Wagon.

c) Final Physical Check: This shall validate as a minimum that all Earths are removed, wires are present in good condition, nothing infringes with OHE, all insulators are undamaged, auto-tensioning devices are functional and all jumpers are correctly installed.

d) Clearance for Test Charging: This test shall be undertaken to ensure that each Electrical Section can be successfully isolated from adjacent Electrical Sections and correct OHE alive indications are available in the TSS control rooms and on the SCADA system.

e) Test Charging: The test charging shall be done as per provisions of ACTM.

f) Antitheft Charging: In the theft prone area, energisation of OCS for 2.2 kV as an anti-theft measure to be done to avoid theft of contact/catenary wire. Detail procedure for antitheft measure shall be followed as per Appendix VII of ACTM of IR.

9.10.2.2 Power Supply Installation Tests

a) Power Supply Installation shall be tested as per provisions of ACTM.

b) Partial Acceptance Test: These tests form part of on-site and System Acceptance Tests (SAT) as part testing of the equipment and system. Partial acceptance tests shall include:-

- Functional Tests and Interlock Tests
- All control and protection functions and electrical/mechanical interlocking tests.
- Primary Injection Tests: The Concessionaire shall carry out primary injection tests on each protective system, to prove the auxiliary circuit connections, the relay fault setting values, the correct metering indications and the stability limits.
- AC/DC Pressure Tests: The insulation resistance of all circuits shall be measured before and after the DC pressure test. The minimum phase-to-phase and phase-to-earth insulation resistance shall be 100 mega ohms. Pressure tests shall be carried out on completed cable lengths of High Voltage cables in accordance with IEC 60502.

9.10.2.3 System Acceptance Tests (SAT)

a) Energisation

- The Concessionaire shall submit operation safety rules and procedures to Independent Engineer before Energisation.
- All power equipment shall be subject to inspection by EIG before Energisation.

b) Testing: System Acceptance Testing shall include but not be limited to:-

- Functional tests of SCADA system.
- Integrated Tests with Employer's Train Operator (TO).
- Short Circuit Tests on OCS: Short Circuit Tests on Overhead Catenary System (OCS) shall be carried out to prove correct operation of protection equipment and to ensure that the dynamic strength

requirements of overhead equipment are met. Short Circuit Tests shall be carried out on every overhead equipment line feeder.

- Current Collection test: The Concessionaire shall conduct current collection tests as per EN 50317 to demonstrate that a newly installed overhead contact line satisfies the quality requirement for 100 kmph speed.

9.11 INTEGRATED SYSTEM TESTS

The concessionaire shall submit to the Independent Engineer requirements and procedures for the integrated system tests in conjunction with the interface units/agencies to demonstrate that the system provided by the concessionaire is fully operational in an integrated manner and meets the specified performance criteria. The conducting of these integrated system tests, shall include a period of test and/or trial running.

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CHAPTER 10

WORK SITE SAFETY, ENVIRONMENT, REINSTATEMENT AND TRAFFIC REGULATION

10.1 General

10.1.1 Goals and Targets

This Chapter lays down the specifications and standards for traffic diversions/regulations and work site safety. The objective of the requirements and guidelines included in this Section is to ensure that adequate precautions are taken to avoid unsafe and unhealthy environment at the construction site, to eliminate accidents, and to minimize environmental degradation during construction. Specific goals that the Concessionaire shall strive to achieve include:

a) Zero total reportable injuries and zero reportable environmental incidents.

b) 100% incident recording and reporting.

c) 100% initial and periodic training of all personnel in construction safety, occupational health and environmental considerations

d) 100% compliance with all Plans submitted by the Concessionaire and approved by Independent Engineer , such as the Diversion Plans, Quality Assurance Plan, etc.

e) 100% usage of Personal Protective Equipment (PPE), such as safety helmets, shoes, glasses, fall protection, and other measures such buddy system where appropriate when working in confined spaces, etc.

f) Total compliance with site inspections and audits, and timely correction of any deficiencies discovered.

g) Usage of all possible and practicable means to minimize the damage, disturbance and annoyance to the environment, traffic, adjoining road users, and residents, and immediate corrective actions.

10.1.2 Site Safety Plan

Site safety plan shall cover the following:-

a) Safety Personnel
b) Site safety Inspections
c) Reporting of accidents/unusual occurrences
d) Safety meetings
e) Safety equipment
f) First Aid
g) Safety Training
h) Fire regulation and safety
i) Interfacing with IR operations
j) Dangerous goods and radiation
k) Hazard and risk assessment
l) Explosives

10.1.3 Environmental management process

Environmental management is based on the potential impacts assessed for the project. Assessment of potential impacts is based on the review of data substantiated by site visits – environmental monitoring, public consultation, household survey and discussion with concerned govt. Dept. The implementation of Environmental Management Plan (EMP) requires the following:-

a) An organizational structure
b) Assign responsibilities
c) Define timing of implementation
d) Define monitoring responsibilities

Concessionaire shall prepare the EMP within the framework of DFCCIL SHE Manual.

10.2 Site Management

10.2.1 The following work as included in the scope of concessionaire in the concession document, shall be undertaken by the Concessionaire as part of development of the Rail System, in accordance with the requirements of applicable Laws.

a) Cutting/transplantation of trees;

b) Construction/diversion of utilities such as storm water drains, sewer lines, water lines, communication lines, power lines etc;

c) Dismantling of existing roads and structures including alterations to tracks and layouts and shifting boundary wall to a desired location and restoring it back after completion of works;

d) Construction/diversion or roads/tracks required for development of rail system and their maintenance;

e) Reinstatement of services such as street lighting, traffic signaling system, footpaths including kerb stones, boundary walls, horticulture work and restore the site to its original position.

f) Provision of barricading of works and the areas occupied by the concessionaire to segregate them from public area;

g) Supporting/diverting of all utilities within the Right of Way (ROW);

h) Surveying, monitoring of vulnerable buildings for protection, risk analysis, and preventive and corrective actions;

i) Traffic management including signage and/or traffic marshals.

j) For works to be carried under or near rail traffic, all precautions as applicable and in force at the time of work shall be observed.

The Concessionaire shall obtain relevant certificates and/or clearances from local authorities in relation to the foregoing. Employer will provide necessary assistance in this regard.

10.2.2 Protection of work sites

Any construction activity involving the existing embankment/formation/running track of the Indian Railways shall be carried out only with the prior specific authorization of the Independent Engineer/Employer/Railway authorities. Work area is divided into 3 sub groups depending upon their distance from the IR track. If a work site is located far away from the existing track but the vehicles in connection with the work are required to ply within the distance from centre of track as mentioned below, it will be construed that the work in being executed under above classification. This includes even occasional plying of vehicles/machineries for short durations. Safety precautions to be observed shall be as under:-

a) Works being done within 3.5 meters from centre of track.

All works planned within 3.5 meters from centre of running line or which involve working of machineries and vehicles within this zone are to be done essentially under block protection and necessary safety precautions for protection of track as per Para 806 and 807 of IRPWM and sketch A of this chapter shall be taken.

b) Works being done between 3.5 m and 6 m from centre off track

Following precautions be taken when works are required to be done between 3.5 meters to 6 meters from track centre or machines/vehicles are required to work/ply within this zone.

i. Before start of work demarcation should be done parallel to running track at a distance of 3.5 meters from centre of track in advance, as per sketch B, by 150 mm wide white line of lime. Any work or movement of machinery infringing this line will need block protection. Barricading should be put up at such locations, as per sketch C, to ensure that even by carelessness or over sight, vehicles do not infringe fixed dimensions. Barricading design shall be approved by the Independent Engineer.

ii. In case vehicles have to ply or machineries have to work within this zone, railway's and concessionaire's supervisors be positioned as shown in sketch D.

iii. Additional trained staff of the Concessionaire shall be posted where turning of vehicles is required during working e.g. earth work, bridge work, ballasting etc. Location for reversing vehicles should be nominated and it should be selected in such a way that there is no danger to running trains at such a location. Such trained staff of the Concessionaire should be available with hand flags so that vehicles do not come closer to track by 3.5 meters. Wherever vehicles have to take turn, it should be done in such a way that the driver is invariably facing the running track at all times.

iv. Look out men should be posted along the track at a distance of 800 meters from location of work with red flag and to whistle in face of road vehicles and approaching trains. Look out men shall also be suitably trained staff of Concessionaire.

v. In addition to look out men, caution order needs to be issued to trains and speed restrictions imposed wherever considered necessary through Independent Engineer.

vi. Arrangements should be made to protect the track in case of emergency at work site.

vii. All temporary arrangements required during execution should be done in a manner that moving dimension is not fringed.

viii. Individual vehicle/machinery shall not be left unattended at site of work. If it is unavoidable and essential to stable it near running track, it shall be properly secured and manned even during non working hours with all arrangements to protect the track from infringement.

ix. Any materials unloaded or shifted along the track should be kept clear of moving dimensions and stacked at a specified distance from running track.

x. Movement of vehicle/working of machineries should be prohibited at night. However, in case of emergency when night working is unavoidable, adequate lighting shall be provided with all protection measures as mentioned above in full force. All night working near IR track shall require prior approval of Independent Engineer.

xi. The work site should be suitably demarcated to keep public and passengers away. Necessary signages, boards, such as “work in progress” etc should be provided at appropriate location to warn public/passengers.

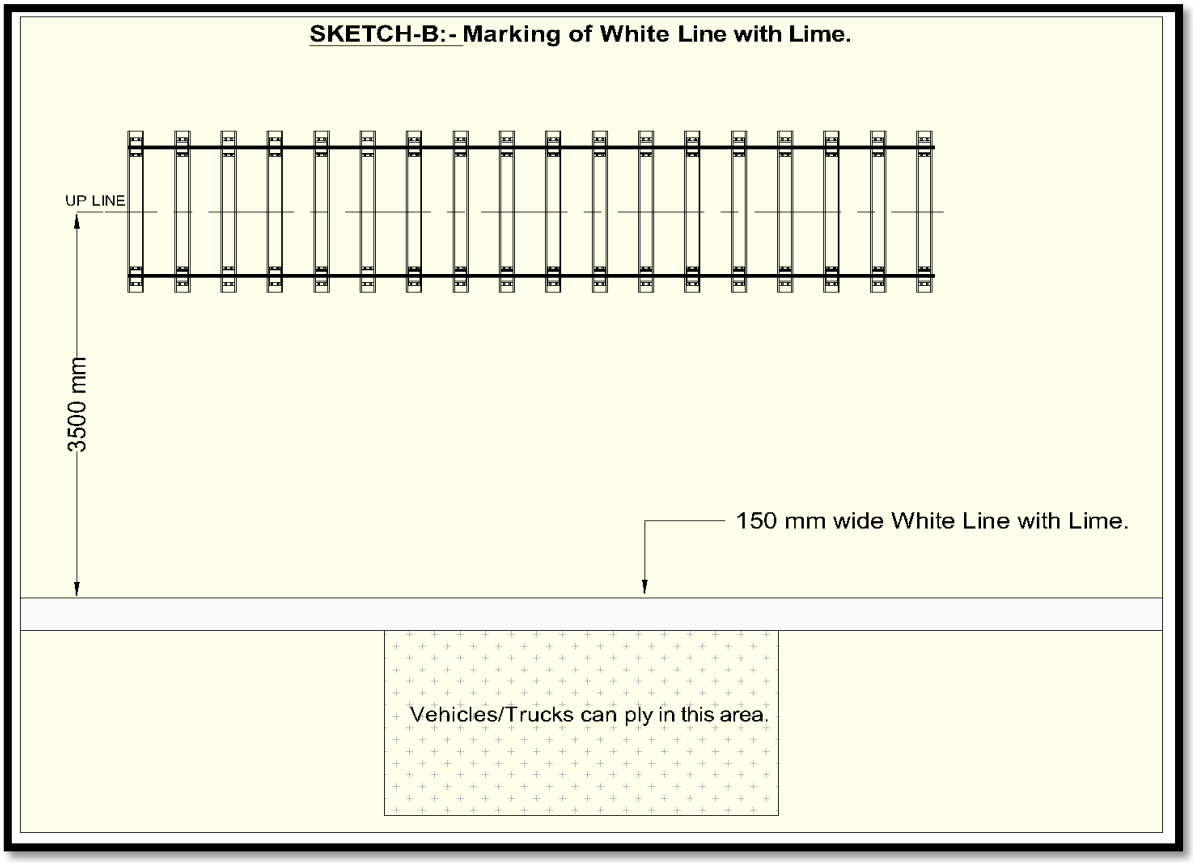
xii. Concessionaire’s drivers/operators handling vehicles/machineries shall be issued a fitness certificate by the safety officer of the Concessionaire after educating them about safety norms and after taking assurance in writing for working within vicinity of railway’s track.

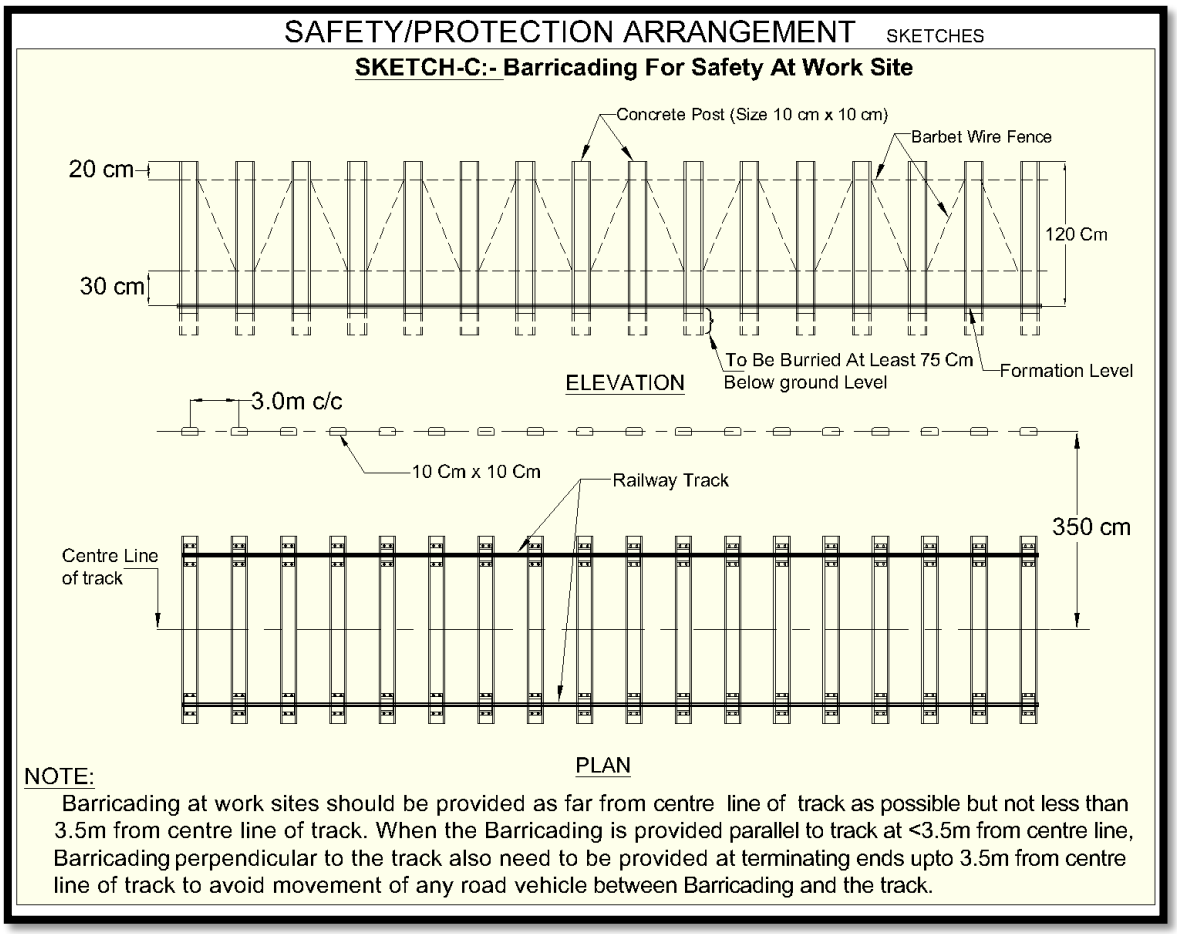
xiii. While working on cuttings with machineries or when there is movement of vehicles above cutting, if there is possibility of any of the following circumstances, work has to be done under block protection:

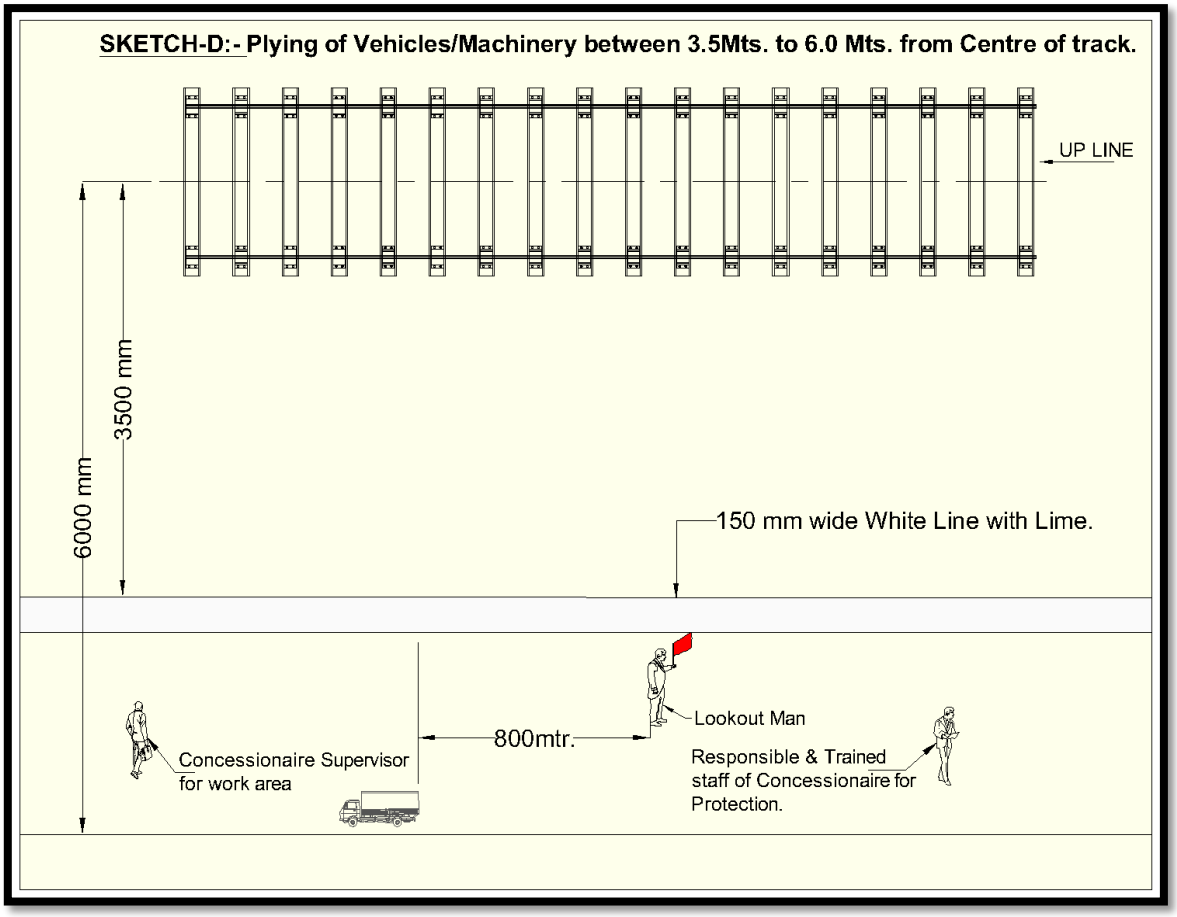
a) If there is any possibility of the vehicle / machinery of infringement of the track due to toppling or otherwise losing control.
b) High probability of machineries/vehicles to come within 3.5 meters from track centre though ordinarily working beyond it.

c) Works being done beyond 6 meters from centre of IR track.

No precautions are needed except in cuttings or where the work can affect train running in any way.


SKETCH-B:- Marking of White Line with Lime.
UP LINE
3500 mm
150 mm wide White Line with Lime.
Vehicles/Trucks can ply in this area.


SAFETY/PROTECTION ARRANGEMENT SKETCHES
SKETCH-C:- Barricading For Safety At Work Site
Concrete Post (Size 10 cm x 10 cm)
Barbet Wire Fence
20 cm
30 cm
120 Cm
To Be Burried At Least 75 Cm Below ground Level
Formation Level
ELEVATION
3.0m c/c
10 Cm x 10 Cm
Railway Track
350 cm
Centre Line of track
PLAN
NOTE:
Barricading at work sites should be provided as far from centre line of track as possible but not less than 3.5m from centre line of track. When the Barricading is provided parallel to track at <3.5m from centre line, Barricading perpendicular to the track also need to be provided at terminating ends upto 3.5m from centre line of track to avoid movement of any road vehicle between Barricading and the track.



10.2.3 Flood protection

During construction, the concessionaire shall provide and maintain adequate protection of the works against floods.

10.2.4 Temporary Power Supply

The Concessionaire shall arrange temporary power supply at the Site during the construction period.

10.2.5 Traffic management

(a) A proper rail/road traffic management plan during construction shall be formulated by the Concessionaire, as per guidelines given in railway Manuals/IRC:SP55 and in consultation with concerned railway authorities/traffic police and the Independent Engineer, and submitted to the Independent Engineer for his review and comments, if any. The traffic management plan shall be put in place before the start of any construction activity.

(b) The basis for the plan shall take into consideration the following principles:
   (i) To minimize the inconvenience to rail/road users and the interruption through the area impacted by the construction activities;
   (ii) To facilitate access to the construction site, and to maintain reasonable construction progress; and
   (iii) To ensure traffic safety at each construction site.

(c) Concessionaire shall submit his design for the reinstatement to the relevant authorities and obtain their prior approval to carry out the work. Reinstatement works shall include, but not be limited to:

(i) Parking bays;
(ii) footpath and kerbs;
(iii) Road signage;
(iv) Street lighting;
(v) Landscaping;
(vi) Traffic lights sand control cable; and
(vii) Road Painting, site utilities and access.

10.3 Design of Temporary works

The Concessionaire shall submit design of temporary works to the Independent Engineer.

10.3.1 Preliminary design submission, which shall cover the following:

(i) The utility diversion plan:
(ii) The preliminary ground treatment and building protection proposal;
(iii) The preliminary reinstatement drawings.

10.3.2 Definitive design submission, which shall cover the following:

(i) Existing and proposed utilities
(ii) Utilities to be diverted/supported;
(iii) Prediction of effect on structures due to ground movements and the proposed protective measures to limit the effects;
(iv) Prediction of lowering of water table and its effect;
(v) Effect on rail traffic and temporary works required to carry out the activities
(vi) Rail traffic management plan in consultation with railway authorities
(vii) Access roads and temporary road works;
(viii) Pumping systems;
(ix) Traffic or other civic service affected;
(x) Road works and works related to traffic management; and
(xi) Proposals for traffic control devices and rail/road safety works.

10.3.3 Utility Diversion

The utilities required to be removed for the project work shall be identified by the employer and scope of Concessionaire in this regard will be included in the Concession Agreement. Such utilities shall be termed as Chartered Utilities. All the chartered utilities, as included in the scope of concessionaire in the concession document, shall be diverted in consultation with owner after obtaining due permission/approvals. Proper support shall be provided to utilities which do not need diversion but require support. The utilities not listed in the concession agreement and known during course of execution of work shall be termed as Unchartered utilities and its removal will be decided in consultation with Employer. Precautions to be taken while handling the utilities are mentioned as under:-

(i) The construction of structures will have to be planned in such a manner that they do not obstruct or interfere with the existing Roads/railways and other utilities. Where work is required to be carried out at locations adjacent to such roads/railways, utilities, structures, monuments etc. safety and protection arrangements will have to be ensured.

(ii) If due to some or other reasons, damage to utilities occurs, it should be rectified immediately by the concessionaires.
(iii) Extra care is required to protect vast network of various power supply, signalling, communication and other cables as well as gas pipe lines while carrying out any activity.
(iv) Manholes of the trunk sewer should be kept freely accessible for cleaning and removal of blockages and debris should not be dumped over these manholes.
(v) Concessionaires shall arrange substitute arrangement for sewer pumping and its disposal as per directions of concern civic authority.
(vi) Infringing Signal & Telecommunication cables, Signals, Location Boxes (Apparatus cases) or any other Signal & Telecommunication gears/equipment shall be shifted/relocated by the Concessionaire only after obtaining the permission /approval of competent authority of S&T Division of IR.

10.4 Construction Requirements

10.4.1 Access to the Site

The Concessionaire shall ensure that any access or egress through the Site boundaries are controlled such that minimum disturbance to other users/residents or damage to public or private property occurs.

10.4.2 Traffic Control devices

Traffic control devices shall comprise traffic signs, road markings, safety barriers, pedestrian railings etc. Guidelines given in IRC:35, IRC:67 and section 800 of the MOSRTH specifications shall be followed in adopting appropriate road markings and traffic signs unless otherwise specified in this section.

10.4.3 Road Markings – specification

All road markings shall conform to IRC:35. Road markings shall comprise of carriageway markings such as longitudinal markings on intersections, hazardous locations, parking, etc. and object markings such object within the carriageway, adjacent to carriageway and marking on kerbs.

10.4.4 Road Signs

There are three types of road signs viz., mandatory/regulatory signs, cautionary/warning signs, and informatory signs. Locations of signs shall conform to IRC: 67 and section 800 of MOSRTH

10.4.5 Safety Barriers

With the approval of Independent Engineer, depending upon the location and protection required, suitable type of safety barrier will be used for due protection of work site. There are broadly three types of longitudinal safety barriers:

(i) Flexible types (like luminous safety tape fencing);
(ii) Semi rigid type, like: "W" beam type steel barriers/Thrie beam type steel barrier
(iii) Rigid type (like concrete crash barriers).

In addition to luminous tape/ red colour nylon rope 12mm thick shown in Sketch C, barbed wire fencing is also to be provided.

10.4.6 Relevant provisions of Railway Board policy letter no. 97/CE-I/BRO/158(Policy) Pt. II dated 31.07.2009 shall to be observed during execution of RUB works.

10.5 Survey Points

The Concessionaire shall carefully protect all the survey reference points, bench marks, setting out points, monuments, towers and the like from any damages and shall maintain them and promptly repair or replace any points damaged from any causes whatsoever. The Concessionaire shall regularly recheck the position of all setting out points, bench marks and the like to the satisfaction of the Independent Engineer.

10.6 Protection of the Works from Weather

Suitable protection measures shall be taken by the concessionaire to secure and protect the partially completed and ongoing constructions in all weather conditions as and when required.

10.7 Structures, Railway, Roads and Other Properties

The Concessionaire shall immediately inform the Independent Engineer of any damage to structures, roads or other properties.

10.8 Access

Alternative access shall be provided to all premises if interference with the existing access, public or private, is necessary to enable the Works to be

carried out. The arrangements for the alternative access shall be as agreed by the Independent Engineer and the concerned agency. Unless agreed otherwise, the permanent access shall be reinstated as soon as practicable after the work is complete and the alternative access shall be removed immediately and the ground surfaces reinstated.

10.9 Trees

Felling/re-plantation of trees shall be limited to those which cause a material adverse effect on the construction of Works. Felling/re-plantation of trees shall be governed by the relevant preservation of trees legislation of the Government of India or the concerned Sate Government and other Applicable Laws. The Concessionaire is not permitted to cut any trees except in accordance with all applicable Laws. Scope of this activity will be as per details mentioned in the Concession Agreement.

10.10 Removal of Graves and Other Obstructions

If any graves and other obstructions are required to be relocated in order to execute the works and such relocation has not already been arranged for, the Concessionaire shall draw the Independent Engineer's/Employer's attention to them in good time to allow all necessary authorization for such relocation. The modalities of relocation shall be decided after mutual discussion between the Concessionaire, Independent Engineer/Employer, local authorities and other concerned stakeholders.

10.11 Security

(a) For ensuring security of site and to check the entry of unauthorized persons on the site, provision of gates/barriers/fencing/deployment of security guard and other security personnel/patrolling shall be undertaken in consultation with Independent Engineer.

(b) In consultation of Independent Engineer, notices shall be displayed at appropriate locations around the site to warn the public of the dangers of entering the site.
(c) Identity card / Passes shall be issued by concessionaire to its bona-fide workers and staff to check the entry of unauthorized users to site.

10.12 Temporary Power Supply

10.12.1 General Requirement

Temporary Electrical Site installations and distribution systems shall be in accordance with:

i) Indian Electricity Rules 1956
ii) Indian Electricity Act 2003
iii) The Power Companies Supply Rules
iv) Electricity and its subsidiary regulations
v) IEE Wiring Regulations (16th edition)
vi) BS 7375 Distribution on construction and Building sites
vii) BS 4363 distribution Assemblies for Electricity Supplies for construction and building Sites and
viii) Any other applicable national standard

10.12.2 Materials, Appliances and Components

All materials, appliances and components used within the distribution system shall comply with best industry practices.

10.12.3 Design Constructions

a) Distribution equipment utilized within the temporary electrical distribution system shall incorporate the following features:
    i) Flexibility in application for repeated use
    ii) Suitability for transport and storage
    iii) Robust construction to resist moisture and damage and
    iv) Safety in use
b) All cabling for temporary power supply shall be firmly secured to ensure that they do not present a hazard or obstruction to people and equipment.
c) The installation on site shall allow convenient access to authorized and competent operators to work on the apparatus contained within.

10.12.4 Mains Voltage

a) The Site mains voltage shall be as per the Electricity Authority, 415V/ 3 phase 4-wire system
b) Single phase voltage shall be as per the Electricity Authority, 230 V supply and preferably reduced voltage shall be used to eliminate risk and injury as per provision of BS 7375.

10.12.5 Protection of Circuits

a) Protection shall be provided for all main and sub-circuits against excess current, under and over voltage, residual current and earth faults. The protective devices shall be capable of interrupting (without damage to any equipment or the mains or sub-circuits) any short circuit current that may occur.
b) Discrimination between circuit breakers and fuses shall be in accordance with:

i) IS 3703, BS 88
ii) EN 60898
iii) Any other appropriate Standards.

10.12.6 Earthing

a) Earthing and bonding shall be provided for all electrical installations and equipment to prevent the possibility of dangerous voltage rises and to ensure that faults are rapidly cleared by installed circuit protection.

b) Earthing systems shall conform to the following standards:
i) IS 3043
ii) IEEE Standard 80.
iii) BS 7430
iv) BS 7375

10.12.7 Plugs, socket outlets and Couplers

Low voltage plugs, sockets and couplers shall be colour coded in accordance with BS 7375, and constructed to conform to BS EN 60309. High voltage couplers and 'T' connections shall be in accordance with BS 3905.

10.12.8 Cables

a) Cables shall be selected after full consideration of the conditions to which they will be exposed and the duties for which they are required.

b) All cables which have a voltage to earth exceeding 65V (except for supplies from welding transformers to welding electrodes) shall be of a type having a metal sheaths and/or armour which shall be continuous and effectively earthed.

c) Armoured cables having an Over sheath of polyvinyl chloride (PVC) or an oil resisting and flame retardant compound shall be used whenever there Is a risk of mechanical damage occurring.

d) Cables subjected to voltage with respect to earth exceeding 12V but not normally exceeding 65V shall be of 'A'Class insulation and sheathed with a general purpose or heat resisting elastomer.

10.12.9 Lighting Installation

a) Where site inspection of the works is required during the nights, the lighting circuits shall be run separate from other sub-circuits and shall be in accordance with BS 7375 and BS 4363.

b) Voltage shall not exceed 55V to earth except when the supply is to a fixed point and where the lighting fixture is fixed in position.

c) Luminaries shall have a degree of protection not less than IP 54. In particularly bad environments where the luminaries are exposed to excess of dust and water, a degree of protection to IP 65 shall be employed.

d) The lighting level of minimum of 200 lux shall be provided by localized lighting in all work areas where required.

e) Mechanical protection of luminaries against damage by impact shall be provided by use of wire guards or other such devices whenever risk of damage occurs.

10.12.10 Identification

Identification labels of a type reviewed by the Independent Engineer shall be affixed to all electrical switches, circuit breakers and motors to specify their purpose.

10.12.11 Maintenance

a) Strict maintenance and regular checks of control apparatus and wiring distribution systems shall be carried out by an electrician (duly qualified to carry out the said checks) to ensure safe and efficient operation of the systems. The Concessionaire shall submit for review by the Independent Engineer details of his maintenance schedule and maintenance works record.

b) All portable electrical appliances shall be permanently numbered (scarf labels or similar) and a record kept of the date of issue, date of the last inspection carried out and the recommended inspection period.

10.13 System Safety Plan

a) The Concessionaire shall develop a System Safety Plan as an integral part of the design.

b) The Plan shall address the general safety aspects associated with the Overhead Catenary System (OCS) design and peripheral features.

c) The Plan shall include, Hazard Operability Studies (HAZOP) and Fault Tree Analysis (FTA) which shall fall into the following three categories:

   i. Subsystem Hazard Analysis (SSHA).
   ii. Interface Hazard Analysis (IHA).
   iii. Operating and Support Hazard Analysis (O&SHA).

d) Each of the above shall identify four degrees of risk:

   i. Catastrophic.
   ii. Critical.
   iii. Marginal.
   iv. Negligible.

e) The above items related to safety do not necessarily cover the full requirements.

f) It is the Concessionaire's responsibility to address all aspects of safety and comply with legislation.

10.13.1 Risk on functional Safety

The risks on functional safety System will include, but not be limited to the following items:-

a) Explosion or fire at TSS, ASS, SP, SSP, ATs and SCADA equipment room and other rooms;

b) Equipment safety;

c) Damage to overhead conductors;

d) Damage to overhead current collection system equipment;

e) Damage to 25kV feeder and return cables;

f) Electrical safety including safety clearance from exposed live conductors;

g) Safety of the Independent Engineer/Engineer/Employer's staff and public, including trespassers as far as is reasonably practicable;

h) Occupational repetitive injuries.

10.13.2 Safety During Commissioning

During the commissioning works several safety hazards are present. It is the duty of the Concessionaire to ensure that the commissioning personnel are made aware of the possible dangers and that the necessary action is taken to remove or limit the risks.

When working at site which is partially energised during the commissioning, it is very important to clearly mark the border between the existing (energised) installation and the new one under commissioning. The accidentally switching operations resulting energising the parts under commissioning has to be reliably prevented by the means of pad locks or similar methods. The possibility to carry out switching operations from remote or from any supervisory systems has to be also prevented.

When the "live parts" (i.e. non earthed parts under normal operation) of the outdoor components are touched, it is important to protect against induced voltages. This has to be kept in mind specially when working with parts that are generally connected to the outgoing overhead lines.

Energising of a substation, or a part of it, should always be done by the operational people and not by the commissioning engineers

10.14 List of Document

10.14.1 List of Fire Safety Acts and Codes

a) Acts and Rules related to Fire Safety

- Inflammable Substances Act 1962
- The Petroleum Act, 1934 and Rules, 1976 (India)
- Gas Cylinder Rules, 2003 (India)
- Indian Explosives Act, 1884, along with the Explosives Substance Act 1998
- The Explosives Rules 1983
- The (Indian) Boilers Act, 1923

b) List of BIS Codes related to Fire Safety

DOCUMENT NUMBER	DOCUMENT YEAR	DOCUMENT_TITLE
IS 884	1985	First-Aid Hose-Reel For Fire Fighting
IS 908	1975	Fire Hydrant, Stand Post Type
IS 940	2003	Portable Fire Extinguisher, Water Type (Gas Cartridge) -
IS 1641	1988	Code of practice for fire safety of buildings (general): General principles of fire grading and classification
IS 1642	1989	Code of practice for fire safety of buildings (general): Details of construction
IS 1643	1988	Code of practice for fire safety of buildings (general): Exposure hazard
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 1734 : Part 3	1983	Methods of test for plywood (Parts 1 to 20 in one volume) Part 3 Determination of Fire Resistance
IS 2171	1999	Portable fire extinguishers, dry powder (cartridge type)
IS 2175	1988	Heat sensitive fire detectors for use in automatic fire alarm system
IS 2189	2008	Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System Code of Practice
IS 2190	2010	Selection, Installation and Maintenance of First-Aid Fire Extinguishers — Code of Practice
IS 2878	2004	Fire Extinguisher, Carbon Dioxide Type (Portable and Trolley Mounted) -
IS 3016	1982	Code of practice for fire precautions in welding and cutting operations
IS 3034	1993	Fire Safety of Industrial Buildings: Electrical Generating and Distributing Stations - Code of Practice
IS 3594	1991	Code of practice for fire safety of industrial buildings :General storage and warehousing including cold storage
IS 3809	1979	Fire resistance test for structures
IS 3844	1989	Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises
IS 5714	1981	Hydrant Stand-Pipe for Fire Fighting
IS 6234	2003	Portable Fire Extinguishers Water Type (Stored Pressure) -
IS 7673	2004	Fire Fighting Equipment - Glossary of Terms
IS 8090	1976	Couplings, Branch Pipe, Nozzle Used in Hose Reel Tubing for Fire Fighting
IS 8149	1994	Functional requirements for twin co2 fire extinguishers (trolley mounted)
IS 8757	1999	Glossary of Terms Associated with Fire Safety
IS 9668	1990	Code of practice for provision and maintenance of water supplies and fire fighting
IS 9972	2002	Automatic Sprinkler Heads for Fire Protection Service
IS 10204	2001	portable fire extinguisher mechanical foam type
IS 10658	1999	Higher Capacity Dry Powder Fire Extinguisher (Trolley Mounted)
IS 10810 : Part 62	1993	Methods of test for cables: Part 62 Fire resistance test for bunched cables
IS 10810 : Part 63	1993	Methods of test for cables: Part 63 Smoke density of electric cables under fire conditions
IS 11000 : Part 1 : Sec 1	1988	Fire hazard testing: Part 1 Guidance for the preparation of requirements and test specifications for assessing fire hazard of electronic and electrical items, Sec 1 General guidance
IS 11000 : Part 1 : Sec 2	1988	Fire hazard testing : Part 1 Guidance for the preparation of requirements and test specifications for assessing fire hazard of electronic and electrical items, Sec 2 Guidance for electronic components
IS 11000 : Part 2 : Sec 3	1994	Fire hazard testing: Part 2 Test methods, Sec 3 Bad-connection test with heaters
IS 11108	1984	Portable Fire Extinguishers - Halon 1211 Type
IS 12349	1988	Fire protection-safety signs
IS 12407	1988	Graphic symbols for fire protection plans

IS 12456	2004	Fire Protection of Electronic Data Processing Installation - Code of Practice
IS 12459	1988	Code of Practice for Fire Safety in Cable Runs
IS 13385	1992	Fire extinguisher 50 litre capacity wheel mounted water type (Gas Cartridge)
IS 13386	1992	Fire extinguisher 50 litre capacity , mechanical foam type
IS 13849	1993	Portable fire extinguisher dry powder type (constant pressure)
IS 14203	1999	Fire Resisting Record Protection Cabinets
IS 14505	1998	Fire resisting magnetic media protection cabinets
IS 14561	2007	Fire resisting (insulating) filing cabinets
IS 14562	1998	Fire resisting computer media protection cabinets
IS 14851	2000	Maintenance of Fire Hose - Code of Practice
IS 14951	2001	Fire Extinguisher - 135 Litres Capacity Mechanical Foam Type -
IS 15103	2002	Fire Resistant Steel
IS 15105	2002	Design and Installation of Fixed Automatic Sprinkler Fire Extinguishing Systems - Code of Practice
IS 15222	2002	Carbon Dioxide as Fire Extinguishing Media for Fire Protection -
IS 15301	2003	Installation and Maintenance of Fire Fighting Pumps - Code of Practice
IS 15397	2003	Portable Fire Extinguisher Mechanical Foam Type (Stored Pressure) -
IS 15493	2004	Gaseous Fire Extinguishing Systems - General Requirements
IS 15496	2004	Inspection and Maintenance of Gaseous Fire Extinguishing Systems - Code of Practice
IS 15497	2004	Gaseous Fire Extinguishing Systems - IG 01 Extinguishing Systems
IS 15501	2004	Gaseous Fire Extinguishing Systems - IG 541 Extinguishing Systems
IS 15505	2004	Gaseous Fire Extinguishing Systems - HCFC Blend A Extinguishing Systems
IS 15506	2004	Gaseous Fire Extinguishing Systems - IG 55 Extinguishing Systems
IS 15517	2004	Gaseous Fire Extinguishing Systems - HFC 227ea (Hepta Fluoro Propane) Extinguishing Systems
IS 15519	2004	Water mist fire protection systems - Systems design, installation and commissioning - Code of practice
IS 15525	2004	Gaseous Fire Extinguishing Systems - IG 100 Extinguishing Systems
IS 15528	2004	Gaseous Fire Extinguishing Systems - Carbon Dioxide Total Flooding and Local Application (Sub-Floor and In-Cabinet), High and Low Pressure (Refrigerated) Systems
IS 15683	2006	Portable fire extinguishers - Performance and construction -
IS 15908	2011	Selection, Installation and Maintenance of Control and Indicating Equipment for Fire Detection and Alarm System - Code of Practice

c) List of NFPA Codes related to Fire Safety

- NFPA 10 – Fire extinguishers
- NFPA 14 – Sprinklers
- NFPA 30 – Combustible materials
- NFPA 70 – Electrical Installations
- NFPA 72 – Alarm and sprinklers
- NFPA 90 – Station work shops
- NFPA 91 – Ventilation
- NFPA 101 – Life Safety Code
- NFPA 110 – Emergency backup power
- NFPA 220 – Construction Materials
- NFPA 251– Ancillary spaces

11.14.2 List of documents related to Occupational Safety and Environment

a) List of Acts, Rules and other documents

- Ancient Monuments Preservation Act (India)
- Ancient Monuments and Archaeological Sites and Remains Act, 1958
- Building and other Construction Workers' Welfare Cess Act, 1996 and Central Rules, 1998 (India)
- The Workmen's Compensation Act, 1923 along with Allied Rules (India)
- The Payment of Wages Act, 1936 (India)
- The Minimum Wages Act, 1948 and Rules 1950 (India)
- Contract Labour Act, 1970 and Rules 1971 (India)
- Child Labour (Prohibitions and Regulations) Act, 1986 and Rules 1950 (India)
- The Factories Act (India)
- Motor Vehicle Act 1988 with latest amendments and the Central Motor Vehicle Rules, 1989(India)
- The Public Liability Insurance Act, 1991 and Rules 1991 (India)
- The Mines Act, 1952 (India)
- Environment Protection Act, 1986 and Rules 1986 (India)
- Air (Prevention and Control of Pollution) Act, 1981 (India)
- Water (Prevention and Control of Pollution) Act, 1974 (India)
- The Noise Pollution (Regulation and Control) Rules, 2000 (India)
- Fly Ash Utilization Notification, Sept 1999 as amended in August 2003 (India)
- Notification, Central Ground Water Board, Act January 1997
- Notification on Control of Noise from Diesel Generator (DG) sets, 2002 (India)
- Energy Conservation Building Code (India), 2007
- Recycled Plastic Usage Rules, 1998
- Manufacture, Storage, and Import of Hazardous Chemicals Rules, 1989
- The Hazardous Waste (Management and Handling) Rules, 1989
- Batteries (Management and Handling) Rules
- E-Waste Manual 2005
- Municipal Solid Waste Management rules 2001
- Water (prevention and Control of Pollution) Cess Act 1977 and rules 1978

- ISO 14001, International Standards Organization, Standard for Environmental Management System
- SHE Manual of DFCCIL
- Environmental Management Plan of DFCCIL
- Environment Impact Assessment (EIA) Report of DFCCIL
- Social Impact Report of DFCCIL

b) **List of BIS Codes related to Occupational safety**

DOCUMENT NUMBER	DOCUMENT YEAR	DOCUMENT_TITLE
SP 70	2001	Handbook on Construction Safety Practices
IS 302 : Part 2 : Sec 2	1997	Safety of household and similar electrical appliances: Part 2 Particular requirements: Section 2 Vacuum cleaners and water suction cleaning appliances
IS 302 : Part 2 : Sec 21	2011	Safety of Household and Similar Electrical Appliances: Part 2 Particular Requirements, Section 21 Stationary Storage Type Electric Water Heater
IS 302 : Part 2 : Sec 30	2007	Safety of household and similar electrical appliances: Part 2 Particular requirements, Section 30 Room Heaters
IS 302 : Part 2 : Sec 35	2011	Safety of Household and Similar Electrical Appliances - Part 2 : Particular Requirements - Section 35 : Electric Instantaneous Water Heaters
IS 302 : Part 2 : Sec 80	2003	Safety of Household and Similar Electrical Appliances - Part : 2 Particular Requirements - Section : 80 Fans
IS 302 : Part 2 : Sec 201	2008	Safety of household and similar electrical appliances: Part 2 Particular requirements, Section 201 Electric immersion water heater
IS 818	1968	Code of Practice for Safety and Health Requirements in Electric and Gas Welding and Cutting Operations
IS 1991 : Part 1 to 10	1987	Safety requirements for the use, care and protection of abrasive grinding wheels: Part 1 to 10
IS 2925	1984	Specification for Industrial Safety Helmets
IS 3233	1965	Glossary of terms for safety and relief valves and their parts
IS 3521	1999	Industrial safety belts and harnesses – Specification
IS 3594	1991	Code of practice for fire safety of industrial buildings: General storage and warehousing including cold storage
IS 3696 : Part 1	1987	Safety code of scaffolds and ladders: Part 1 Scaffolds
IS 3696 : Part 2	1991	Scaffolds and Ladders - Code of Safety - Part 2 : Ladders
IS 3764	1992	Code of safety for excavation work
IS 4014 : Part 2	1967	Code of Practice for Steel Tubular Scaffolding - Part II : Safety Regulations for Scaffolding
IS 4081	1986	Safety code for blasting and related drilling operations
IS 4130	1991	Safety code for demolition of buildings
IS 4312	1967	Code of safety for lead and its compounds

IS 4912	1978	Safety Requirements for Floor and Wall Openings, Railings and Toe Boards
IS 5121	1969	Safety code for piling and other deep foundations
IS 5216 : Part 1	1982	Recommendations on Safety Procedures and Practices in Electrical Work - Part I : General
IS 5216 : Part 2	1982	Recommendation on Safety Procedures and Practices in Electrical Work - Part II : Life Saving Techniques
IS 5916	1970	Safety code for construction involving use of hot bituminous materials
IS 6609 : Part 5	1972	Methods of test for commercial blasting explosives and accessories: Part V Safety fuses
IS 6922	1973	Criteria for safety and design of structures subject to underground blasts
IS 7155 : Part 1 to 8	1986	Code of recommended practice for conveyor safety: Part 1 to 8
IS 7205	1974	Safety code for erection of Structural Steelwork
IS 7293	1974	Safety code for working with construction machinery
IS 7738	1975	Safety fuse for commercial use
IS 7969	1975	Safety code for handling and storage of building materials
IS 8218 : Part 1	1976	Safety code for plant railways Part 1 Layout
IS 8218 : Part 2	1982	Safety code for plant railways Part 2 Locomotives, wagons and their movements
IS 8519	1977	Guide for selection of industrial safety equipment for body protection
IS 8520	1977	Guide for selection of industrial safety equipment for eye, face and ear protection
IS 8989	1978	Safety code for erection of concrete framed structures
IS 10291	1982	Safety code for dress divers in civil engineering works
IS 11057	1984	Industrial Safety Nets
IS 11451	1986	Recommendations for Safety and Health Requirements Relating to Occupational Exposure to Asbestos
IS 11972	1987	Code of practice for safety precautions to be taken when entering a sewerage system
IS 13063	1991	Code of practice for structural safety of buildings on shallow foundations on rocks
IS 13430	1992	Code of practice for safety during additional construction and alteration to existing buildings
IS 14489	1998	Code of practice on Occupational Safety and Health (OS&H) audit
IS 15793	2007	Managing environment, Occupational health and safety legal compliance - Requirements of good practices
IS 18001	2007	Occupational Health and Safety Management Systems - Requirements with Guidance for Use

c) List of BIS Codes related to Environment		
DOCUMENT NUMBER	**DOCUMENT YEAR**	**DOCUMENT_TITLE**
IS 9000 : Part 17	1985	Basic environmental testing procedures for electronic and electrical items: Part 17 Radiation test
IS 9001 : Part 1	1984	Guidance for environmental testing: Part 1 General
IS 9001 : Part 11	1973	GUIDANCE FOR ENVIRONMENTAL TESTING-Part 11 solar radiation test
IS 9001 : Part 13	1981	Guidance for Environmental Testing - Part 13 : Vibration (sinusoidal) Test
IS 9001 : Part 16	1985	Guidance for environmental testing: Part 16 Acoustic noise test
IS 9679	1980	Code of practice for work environmental monitoring (air borne contaminants)
IS 12746 : Part 2	1989	Telecontrol equipment and systems: Part 2 Environmental conditions and power supplies
IS 13736 : Part 3 : Sec 1	1993	Classification of environmental conditions: Part 3 Classification of groups of environmental parameters and their severities, Sec 1 Storage
IS 13736 : Part 3 : Sec 5	1993	Classification of environmental conditions: Part 3 Classification of groups of environmental parameters and their severities, Sec 5 Ground vehicle installations
IS/ISO 14001	2004	Environmental management systems - Requirements with guidance for use
IS/ISO 14004	2004	Environmental management systems - General guidelines on principles, system and supporting techniques
IS/ISO 14015	2001	Environmental Management - Environmental Assessment of Sites and Organizations (EASO)
IS/ISO 14020	1998	Environmental labels and declarations - General principles
IS/ISO 14021	1999	Environmental Labels and Declarations - Self-Declared Environmental Claims (Type II Environmental Labelling)
IS/ISO 14024	1999	Environmental Labels and Declarations - Type I Environmental Labelling - Principles and Procedures
IS/ISO 14025	2006	Environmental Labels and Declarations - Type III Environmental Declarations - Principles and Procedures
IS/ISO 14031	1999	Environmental Management - Environmental Performance Evaluation - Guidelines
IS/ISO 14040	2006	Environmental Management - Life Cycle Assessment - Principles and Framework
IS/ISO 14044	2006	Environmental Management-Life Cycle Assessment-Requirements and Guidelines
IS/ISO 14050	2002	Environmental Management - Vocabulary
IS/ISO 14063	2006	Environmental Management-Environmental Communication-Guidelines and Examples
IS 14700 : Part 6 : Sec 1	2008	Electromagnetic compatibility (EMC) : Part 6 Generic Standards, Section 1 Immunity for residential, commercial and light-industrial environments

IS 14700 : Part 6 : Sec 2	2008	Electromagnetic compatibility (EMC) : Part 6 Generic standards , Section 2 Immunity for industrial environments
IS 14700 : Part 6 : Sec 3	2002	Electromagnetic Compatibility (EMC) - Part 6 Generic Standards - Sec 3 : Emission Standards for Residential, Commercial and Light-Industrial Environments
IS 15793	2007	Managing environment, Occupational health and safety legal compliance - Requirements of good practices
IS 15832	2008	Glossary of technical terms related to environmental impact
IS/ISO 19011	2002	Guidelines for Quality and/or Environmental Management Systems Auditing

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