Northern Railway

Office of the
Dy.Chief Engineer/Const/Doubling,
Jammu Tawi.

No. Dy.CE/C/D/JAT/Redevelopment JAT
TATA Consulting Engineers Ltd.
Jammu-Tawi Project.

Dated 26.08.2023

Sub:- Submission of hard copy of approved DBR of FOB's and Concourse level plan in c/w redevelopment of Jammu-Tawi railway station.

With reference to the subject matter, The DBR is approved from HQ. with following conditions-

1. Approval is only for those items/clauses related to overhead structures i.e. Foot Over Bridge & air-concourse over the tracks/platforms
2. Indian railway standard (IRS) codes corrected up to date shall be given 1st preference. Other codes shall be referred only for those clauses which are not specified in IRS codes.
3. Response reduction factor for seismic analysis shall be considered as 2.0 for superstructure, 4.0 for reinforced conc. framed construction in sub-structure, 2.5 for steel framed construction in sub-structure, 2.0 for foundation. Roofing shall be considered as part of superstructure.
4. Structure shall also be checked for load combinations for construction stage as given in clause 7.2 (c) of IRS seismic code.
5. Structural steel shall be high tensile steel, preferably, Grade designation E350, Quality B0, with yield stress of 350 MPa conforming to IS: 2062. However, Grade designation E410, Quality B0, with yield stress of 410 MPa conforming to IS: 2062 & IRS fabrication specification may be used with valid justification certified by Construction Organisation. No higher grade than E410 shall be used.
6. Nominal concrete clear cover to all reinforcement including links shall be provided considering fire resistance of 4 hrs & environment exposure condition (moderate/ severe) as decided by the construction organisation depending upon field conditions w.r.t. clause 5.4.1 of IRS CBC.

Decision regarding use of steel of grade E-450 and above shall be communicated in due course. Approved DBR has also emailed to your office email id i.e kanwars@tce.co.in for your information.

DA:- DBR.

26/08/23.

Dy. Chief Engineer/Const/Doubling,
N. Railway, Jammu Tawi

Copy to:- GLCPL.

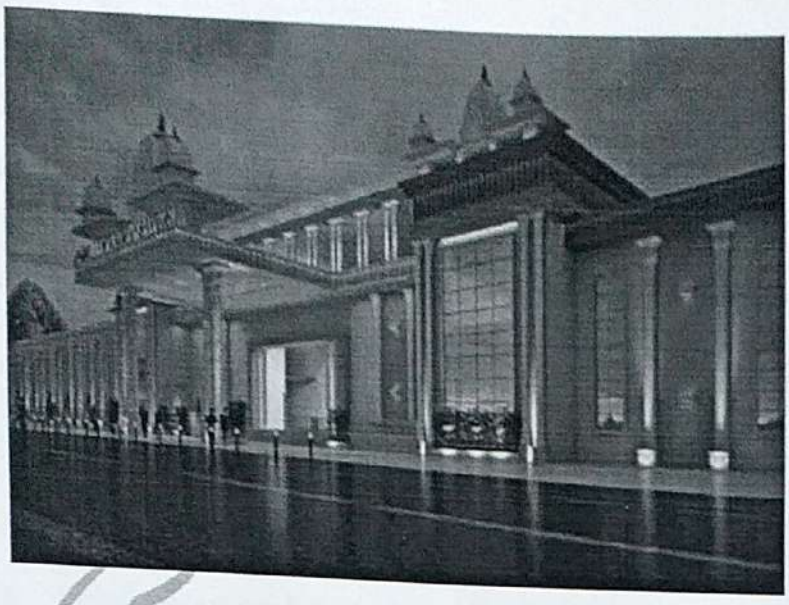
PROJECT NAME: - Redevelopment of Jammu Tawi Railway Station

CLIENT/AUTHORITY: - INDIAN RAILWAYS

AUTHORITY ENGINEER: - Tata Consulting Engineers LTD.

EPC CONTRACTOR: Girdhari Lal Constructions Pvt. Ltd.

ARCHITECT: - Rajiva Kumar & Associates



Structural Consultant(DDC):-

CONSTRUCTURE DESIGNS PVT. LTD.

DESIGN BASIS REPORT

REDEVELOPMENT OF JAMMU TAWI RAILWAY STATION
FOB AND CONCOURSE

SN.	Revision no. & Reason	Date	Document No.	Author	Checker
01	R0	26-05-2022	CDPL/RP/JAM/DBR/R0	RAVI	HARIOM GERA
02	R1	17-07-2022	CDPL/RP/JAM/DBR/R1	RAVI	HARIOM GERA

17-07-23 R1

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Project Manager
GLC Pvt. Ltd.

CONTENTS

Project Manager
GLC Pvt. Ltd.

TATA CONSULTING ENGINEERS LIMITED

List of Figures

List of tables

Project Manager
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1. Project Brief

Brief Description & Salient features:

Project consists of 2 station building blocks comprising of Ground floor, Ist, Mezzanine floor, Concourse floor & terrace. The two blocks are connected by a concourse; besides there are 2 no. Foot Over Bridges, through roofs, Cover over platform

The Structural system will be based on Modular Concept. Modular design represents the repetition of Modulus which in turn, guarantees the speed of construction. It becomes a tool for bringing together and setting out all individual elements. The following Modular elements will be used in this project.

- Grid system used
- Modularity of columns/Beams/Slabs.
- Modularity of through roof.
- Modularity of foundations.

Scope:

Our scope of work for this projects is as follows:

i) To prepare Design Basis report
ii) To suggest economical structural system.
iii) To prepare the 3D analysis model.
iv) To perform the structural design in accordance with the provision of the relevant codes.
v) To coordinate the structural design with the architectural/services requirements.
vi) To prepare structural drawings for the design performed.

Applicable Structures for this DBR:

STRUCTURE NAME	STRUCTURE TYPE
Air Concourse	Permanent
FOBs	Permanent
Through Roof	Permanent
Cover over platform	Permanent

Design Life:

The design life of the structure is assumed as 100 years for Air concourse, Through Roof, Cover over Platform (for general buildings in Table-1, IS 875(part3):2015) and 100 year for FOBs (IRC 112:2020 Cl 5.8.1) as per concept DBR. This requirement is applicable for concrete works as well as for the composite design/steel construction and not applicable to replaceable finishing materials, water proofing membranes and thermal insulations (if any). Hence periodic maintenance/refurbishment is required for all replaceable material for longer life.

Basic Dimensional Clearances:

Basic dimensional clearances as required by Railways to be followed as per Indian Railways schedule of dimensions (IRSOD). (Attached in Annexure-A)

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Building Location:

Site for the proposed project of Jammu Tawi Junction railway station is located at Jammu.

Structural System:

Concourse & FOBs:

The floor plan layout of the building is such that it is largely symmetrical (in plan) with respect to both axes. Steel-concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction has the biggest advantage of combined action of steel and concrete in structural design as well as construction. This system results in speedy construction with a possibility of working on parallel front.

A composite steel frame structural system has been proposed for all floors with enough stiffness by providing shear walls to keep lateral displacements within limits. Steel–concrete composite columns have been chosen to reduce the column sizes. Further, composite floor system has been introduced using trapezoidal profile composite steel deck sheeting for economy and fast construction execution.

The lateral loads will be resisted by shear walls, Braces and the columns, thus the connecting beams being moment connected with the columns. The proposed system will comply with the provisions of IS 1893 suitably considering aspects force transfer mechanism suggested as well as like lateral vertical/lateral displacement provisions of the elements/frame.

Encased-steel columns ("I" Section) laid out in a rectangular/Square grid according to architectural and structural needs. The floor system consists of primary and secondary steel beams supporting an overlaid deck slab. Column to column beams are moment resisting beam and all secondary beams are moment released beams and shall be modelled accordingly in the ETABS. In RCC walls & composite columns.

Through Roof & Platform Cover:

Hollow section steel columns for platform cover and encased columns have proposed for through roof. Colour coated sheet with thermal insulation for through roof and corrugated colour coated sheet for platform have been proposed. Z/Box Purlin shall be used for both roofs. The lateral resistance system shall be SMRF, with R=2 in line with provisions of Table 9 of IS-1893:2016, Part-1).

Grid System Used:

Typical grid size in the structure is kept strategically to go with the concept of modularization. 12m/24m/36m grid size are proposed for vertical (perpendicular to platform), and horizontal grids are places as per site (distance between platform).

Besides this grid dimension is also optimal for seating arrangement & furniture layout as desired in the structure environment. With this grid choice, the beams (depth wise, maximum 300/500/550/650/1250 mm drop below deck sheet) & column (plan sizes-wise) are also obtained with suitable clearance for services & best space savings in carpet area.

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Basic Structural Framing:

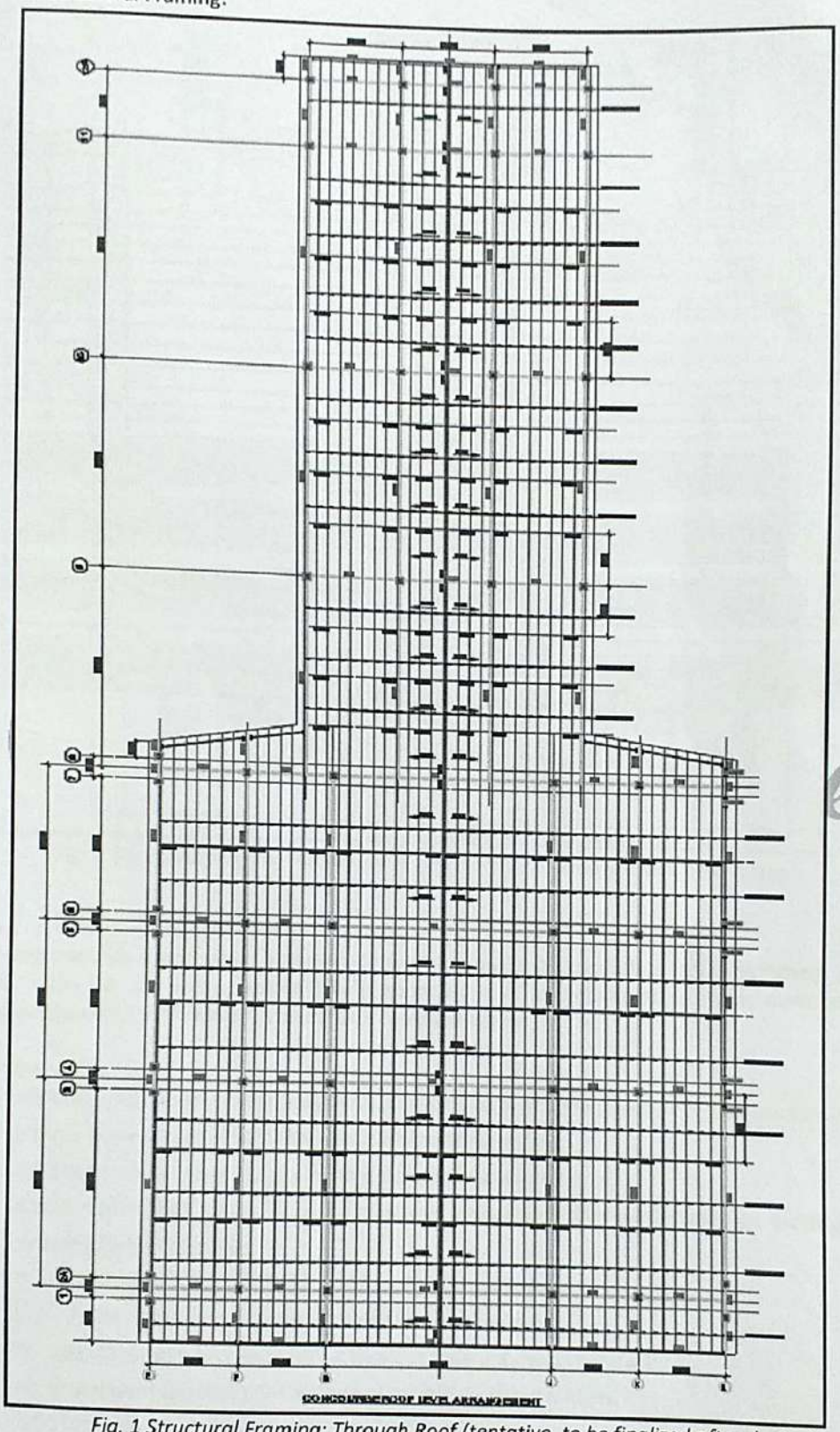

Fig. 1 Structural Framing: Through Roof (tentative, to be finalized after design)

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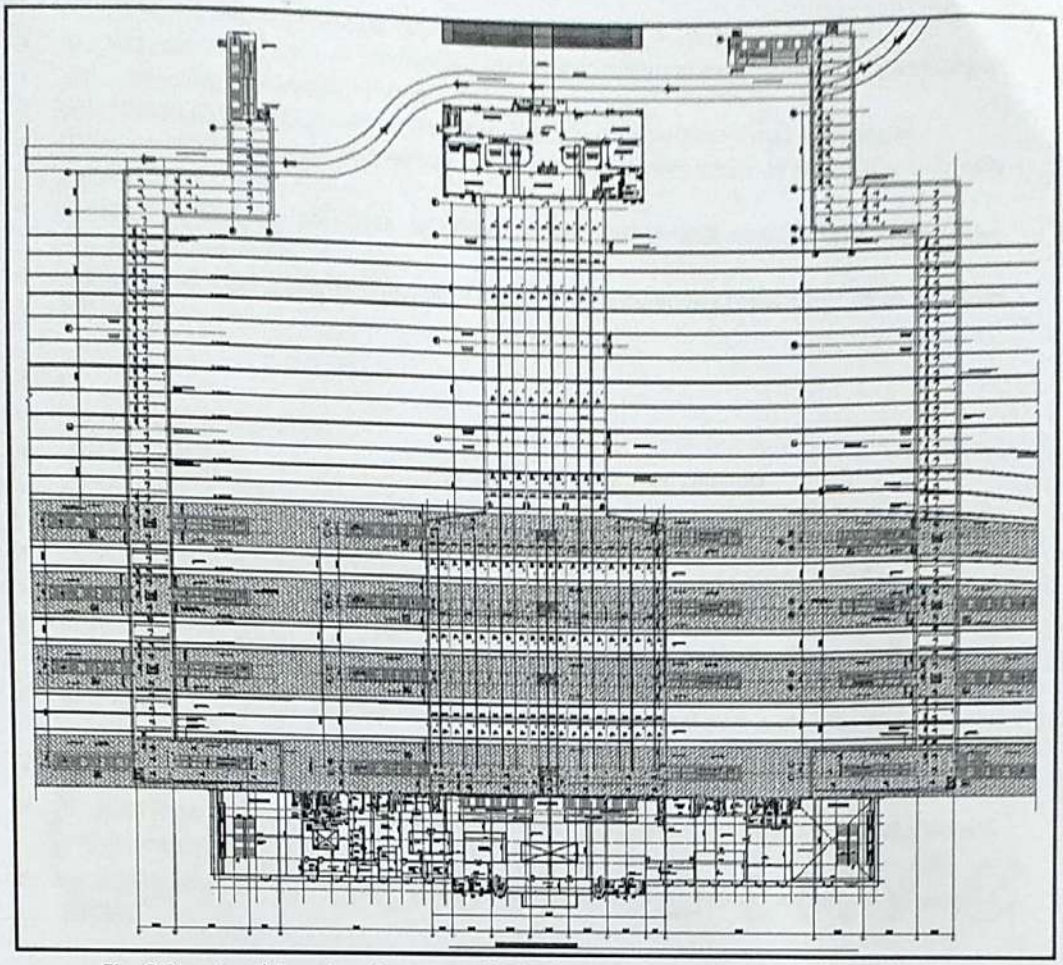

Fig. 2 Structural Framing: Concourse & FOB (tentative, to be finalized after design)

2. Codes & Standards

Throughout this specification, references have been made to appropriate Indian Standards & AISC code (as and when required) with approved level of workmanship and/or materials comprehensive list of relevant standards is compiled below:

Loads:

- IRS Bridge Rules: Rules specifying the loads for Design of Superstructure & Substructure of bridges & for assessment of the strength of existing bridges.
- IRS Seismic Code: Earthquake resistant design of Railway Bridges.
- IS:875 -1987/2015 Code of Practice for design loads (other than earthquake) for Buildings and structure (All parts)
- IS: 1893-2016(R2021) Criteria for earthquake resistant design of structure.
- IRC: SP: 114: Guidelines for Seismic Design of road bridges.
- IS: 1893-2016(Part-3) Criteria for earthquake resistant design of structure.
- IRC 6: Standard specifications & Code of practice for road bridges.
- IRC 112: Code of practice for concrete road bridges.

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Foundations: -

- IRS: Code of practice for the design of sub-structures & Foundations of bridges.
- IS:1080-1985(2016) Code of Practice for design and construction of shallow foundations on soils (other than raft, ring and shell)
- IS:2950-1981(2013) Code of Practice for design and construction of raft foundations
- IS:1904-1986(2020) Code of Practice for design and construction of foundations in soils general requirement
- IS:2974-1998(2013/2015) Code of Practice for design and construction of machine foundations (All parts)
- IS:8009-1976/1980(2013/2015) Code of Practice for calculation of settlement of foundations (All parts)

RCC: -

- IRS: Concrete bridge code.
- IS:456 -2000(2021) Code of Practice for plain and reinforced concrete.
- IS:4326-2013 (R2018) Code of Practice for earthquake resistant design and construction of buildings.
- IS:5525-1969(2013) Recommendation for detailing of reinforced concrete works.
- IS:458 -1988 Specification for precast concrete pipes.
- IS:3370-2021(Part i-iv) Code of Practice for concrete structures for the storage of liquids:(All parts).
- IS: 1786-2008 Specification for high strength deformed steel bars and wires for concrete reinforcement.
- IS:10262-2009 Recommended guidelines for concrete mix design.
- IS: 1893 (Part-1)-2016(R2021) Criteria for earthquake resistant design of structures (General provisions and building).
- IS: 13920-2016 (R2021) ductile design & detailing of RC structures subjected to seismic forces.

Structural Steel & Composite Construction: -

- IRS Steel bridge code: Code of practice for the design of steel or wrought iron bridges carrying rail, road or pedestrian traffic.
- IS 11384 Code of Practice for Composite Construction in Structural Steel and Concrete
- IRS: Specification for fabrication & Erection of steel girder bridges & locomotive turn tables.
- IS: 800 -2007(2012) Code of Practice for general construction in steel.
- IS:808 -1989 Dimensions for hot rolled steel beam, column channel and angle section.
- IS:816 -1998 Code of Practice for use of metal arc welding for general construction in mild steel
- IS:1161-1998 Steel tubes for structural purposes.
- IS:4000-1998 High Strength bolts in steel structures – Code of Practice.
- IS:7215 -1995 Tolerances for fabrication of steel structures.
- EC-4 Design of composite steel and concrete structures Part.
- AISC:360-10 Specification for Structural Building (Only Chapter-I refer for composite beam and column design).

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Miscellaneous: -

- IS: 432(part 2)-1995 Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement
- IS: 6313(part II) 2001 Standards for anti-termite treatment
- IS:1905-1998 Code of Practice for structural use of unreinforced masonry
- IS: 3067-1995 Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings.
- SP:6 -1998 Handbook for structural engineers (all parts)
- SP:7 -2016 National Building Code of India
- SP:16-1999 Design Aids for reinforced concrete to IS:456-1978
- SP:22-1982 Explanatory handbook on codes for earthquake engineering and IS:4326-1976
- SP:24-1983 Explanatory handbook on Indian Standard code of Practice for plain and reinforced concrete
- SP:34-1987 Handbook of concrete reinforcement and detailing (SCIP)

Material: -

- RDSO report no. BS-115(Rev 2): Guidelines for composite construction including shear Connectors
- RDSO report no. BS-111(Rev 6): Guidelines for use of high strength friction grip (HSFG) bolts on bridges on Indian Railways.
- IS: 269 -2015 Specification for Ordinary, rapid hardening and low heat Portland cement.
- IS: 4031-1991 Method of physical tests for Portland cement.
- IS: 383 - 2016 Specification for coarse and fine aggregates from natural sources for concrete.
- IS: 516 – 1999 Method of test for strength of concrete.
- IS: 1199-1999 Method of sampling and analysis of concrete.
- IS: 1566-2000 Specification for plain hard drawn steel wire fabric for concrete reinforcement.
- IS: 4990-1998 Specification for plywood for concrete shuttering works.
- IS: 2645-1999 Specification for integral cement water proofing compounds.

Soil and Foundation: -

- IS: 8009:1976 Code of practice for calculation of settlements of foundation.

Welding standards: -

- B-1 specifications /AWS D1.1 - American Welding Society (AWS): Structural Welding (Steel).
- ASME Sec II –Part C Specifications for welding Rods, Electrodes and Filler Metals.

Many of above listed standards may not be directly used in detailed design, however, the comprehensive list is captured so that an approval for their use is obtained at DBR stage itself. Wherever appropriate Indian standard does not exist for any item, appropriate British standards/American standards will be used.

Code Hierarchy: -

Order of preferences of codes shall be as follows:

1. IRS
2. IRC
3. IS
4. AISC/BS/EURO
5. Other references listed in section 2

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3. Materials of construction

Reinforced Concrete:

The cement used for RCC work in the sub structure & super structure will be OPC (Grade 43 and 53) with IS: 8112-1989. The design mix requirements and in line with stipulations of IS456.

All RCC works will be mechanically vibrated to produce dense, sound and durable concrete as per specifications. The water quality used in all stages of construction shall strictly confirm to IS: 456-2000.

The grade of concrete in the location at beam/slab-column junction shall be kept matching with the column grade below. However, the extent of this concrete into the slab shall be limited to 1000mm surrounding the column outline.

The following grades of Reinforced concrete shall be adopted:

Table 1 Grade of RCC elements

Description	**Grade** *[≥Min. grade as per cl. 6.1.2, table 5, IS 456:200]*	**Max. Size of Aggregate (mm)** *[Cl. 5.3.3 IS456:2000]*	**Type of Cement used in Design Mix.** *[Cl. 5.1 IS456:2000]*
Raft foundation/ Combined Footing/Isolated foundation	M40	20	OPC
Shear Walls & Columns	M75/M60/M 40/M-35 (Self-Compacting Concrete)	12	OPC
Retaining Wall	M40	20	OPC
Slab	M35/M40	20	OPC

- All reinforcing steel to be used in the structural elements shall be:

High yield strength deformed TMT bars with a minimum yield stress of 500 MPa, a minimum elongation of 16% with a provision of UTS/YS ratio >1.10 and other specifications conforming to cl. 8.1, table 3 of IS: 1786 shall be adopted for 8mm to 32mm dia. bars.

Structural Steel:

- Structural steel encased column shall be built up in high tensile steel with a yield stress of E450 MPa conforming to IS: 2062.
- Structural steel beam shall be Rolled/built up section high tensile steel with yield stress of E450 MPa and UB rolled section shall be E450/E350 MPa conforming to IS: 2062.

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- Deck sheet shall be TR-60/TR-80 of 1-1.2mm thick. With yield stress of E350 MPa with minimum 275 gsm galvanization of Corus/Jindal make.

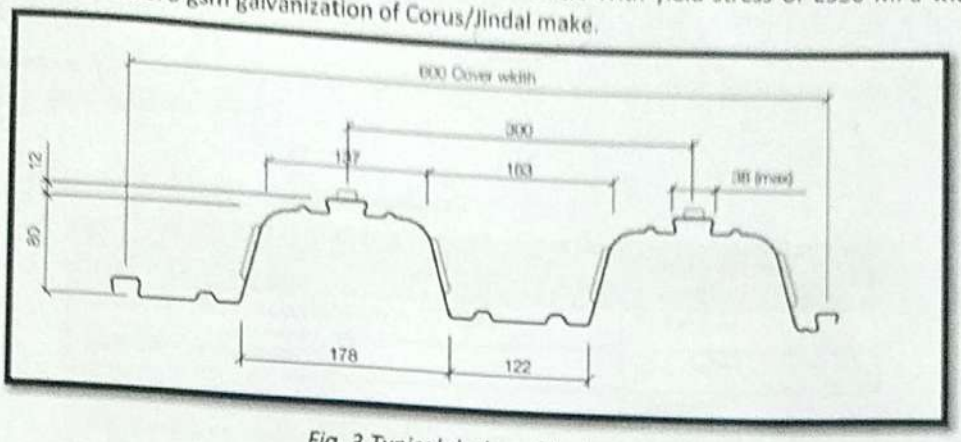

Fig. 3 Typical deck profile sheet (TR80)

- Shear studs shall have yield stress of E350 MPa. Dia. of 19/22/25mm shall be used based on the modular requirements of beam spans / spacing/ forces etc.
- Bolts of grade 8.8 as per IS: 4000 to be used which after torque application will develop friction grip. Anchor rods/bolts shall be E250 MPa conforming to IS standard
- Welding electrodes shall be E8018 conforming to B-1 specifications/AWS D1.1. Welding procedure, specification sheet (WPSS) and Welding Procedure Specification Record (WPSR) as per stipulation as per B-1 specifications /AWS D 1.1 should be approved from the competent authority of the field before start of the execution of work.

The flooring and waterproofing is used as per specifications.

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4. Loadings

Dead Loads:

Following unit weights of building materials have been considered in accordance with Cl. 2.1, table 1IS: 875 (Part I) -1987:

Table 2 Unit weights of building materials

Description	Density of material
Reinforced cement concrete (up to 5% steel)	26.5 KN/m^3
Plain cement concrete	23.5 KN/m^3
Screed concrete floor	20 KN/m^3
Brick masonry including plaster (12mm plaster)	22 KN/m^3
Cement mortar / plaster	20 KN/m^3
Floor finish (stone/tile)	24 KN/m^3
Brick bat Cuba for terracing/waterproofing roof	20 KN/m^3
Glass	25.0 KN/m^3
Façade Load	2.5 KN/m/R/m height
Moist, sweet earth for filling of planters	20 KN/m^3
Foam Concrete	10 KN/m^3
AAC Block Masonry	7.5 KN/m^3
Thermo Col 25 kg/cum	0.25 KN/m^3
TR-80(1.2 thk.)	0.148 KN/ m^2

Super Imposed Dead Loads:

Following SIDL weights have been considered in accordance with unit weights given in Cl. 2.1, table 1IS: 875 (Part I) -1987:

Table 3 Superimposed Dead Loads

LEVELS	LOAD TYPE	SIDL(Kn/m 2)
Air Concourse		
Floor (125mm floor finish)	Floor Finish	0.125*23.5=3.0
Platform		
Floor (40mm floor finish)	Floor Finish	0.04*23.5=1.0
FOBs		
Floor (62.5mm floor finish)	Floor Finish	0.0625*23.5=1.5

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Live Loads: Live loads considered in design are in accordance with table 1, IS:875 (Part II)-1987 for type-Assembly Buildings. (Live loads used are ≥ those mentioned in code)

Table 4 Live load

LEVELS	LOAD TYPE	LL(Kn/m2)	LL(KN)
Air Concourse			
	Typical floor	5	3.6
	Staircase	5	4.5
	Roof	0.75	1.9
Platform			
	Roof	0.75	1.9
FOBs			
	Floor	5	3.6

Services Loads:

Services load of 1.0 KN/m² taken on all floors for Concourse. (Except staircase)

Partition Loads:

Partition load of 1.0 KN/m² taken on all floors of Concourse. (Except staircase)

Collateral Loads:

Wherever applicable, following Collateral loads are taken:
1. Solar Panel (or as per actual if higher)- 0.35KN/m²

Wall Load- Fly ash blocks:
Considering plaster of 12mm on one face and 12mm on other face.

- 200mm.thk. Wall = (0.2mx1mx1mx7.5KN/m³)+((0.012m+0.012m)x20KN/m³)=1.98 KN/m ht
- 100mm.thk. Wall = (0.1mx1mx1mx7.5KN/m³)+((0.012m+0.012m)x20KN/m³)=1.25 KN/m ht

Wind Loads:

Wind loads have been worked out based on basic wind speed of 39 m/s, terrain of category-3 structure as per cl 4.2.2 NBC 2016 vol-1, part6, section1 (as per IS 875 part-3 2015, basic wind speed for Jammu is 39 m/s but it was updated in NBC 2016 vol-1.) Basic input data for the wind analysis assumed as follows:

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Table 5 Wind parameters

	Wind Parameter
Basic Wind speed, Vb	39 m/s (as per cl 4.4.2)
Terrain category	3
Risk coefficient factor, k1	1.06
Terrain, height & structure size factor, k2	1.01 up to 20m, then Varies with height as per code.
Topography factor, k3	1.0
Importance factor for cyclonic region, k4	1.0
Wind directionality factor Kd	0.9-As per clause 7.2.1
Area averaging factor Ka	Varies from 0.8 to 1 as per clause 7.2.2
Combination factor Kc	0.9-As per clause 7.3.3.13

Basic Wind speed upto 10m height is 39m/s as per per cl 4.2.2 NBC 2016 vol-1, part-6, section-1 Annex-C.

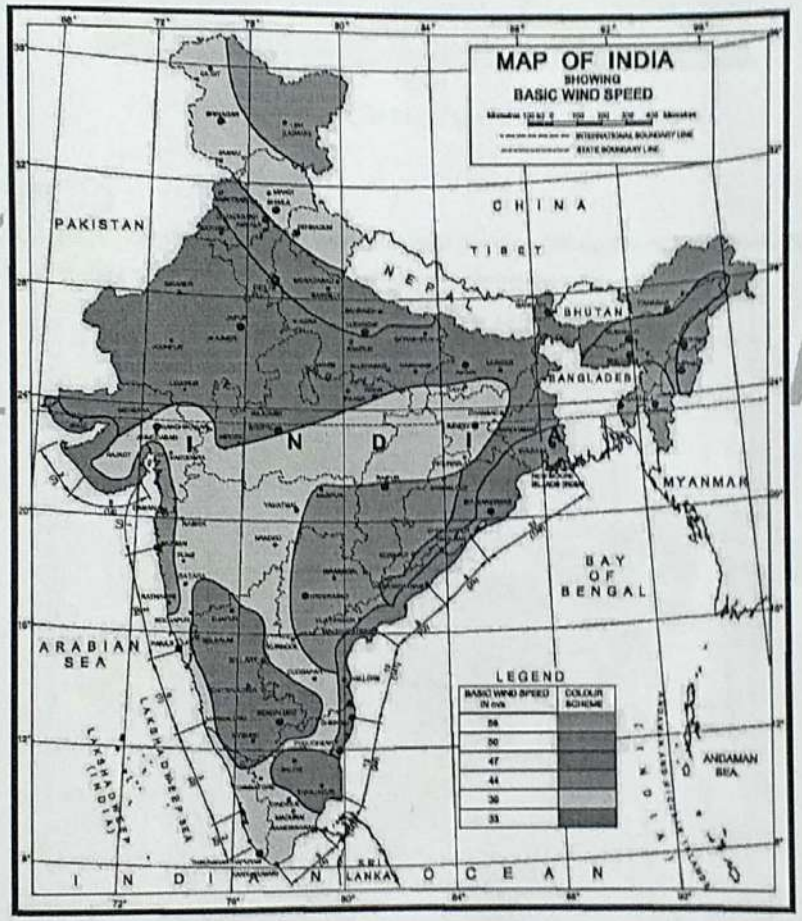

Fig. 4(a)

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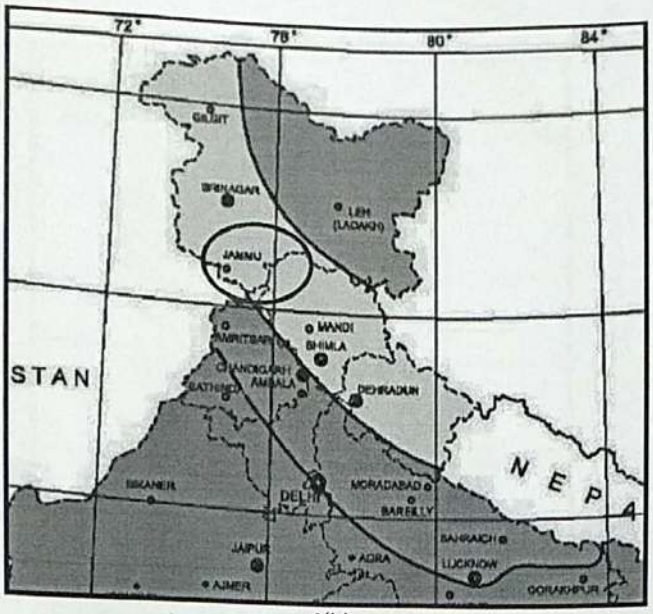

4(b)

Fig. 4(a) & 4(b) Wind speed as per IRC

Seismic Loads:

As per IS1893-2016 (Reaffirmed 2017) the proposed building fall under seismic zone-IV.

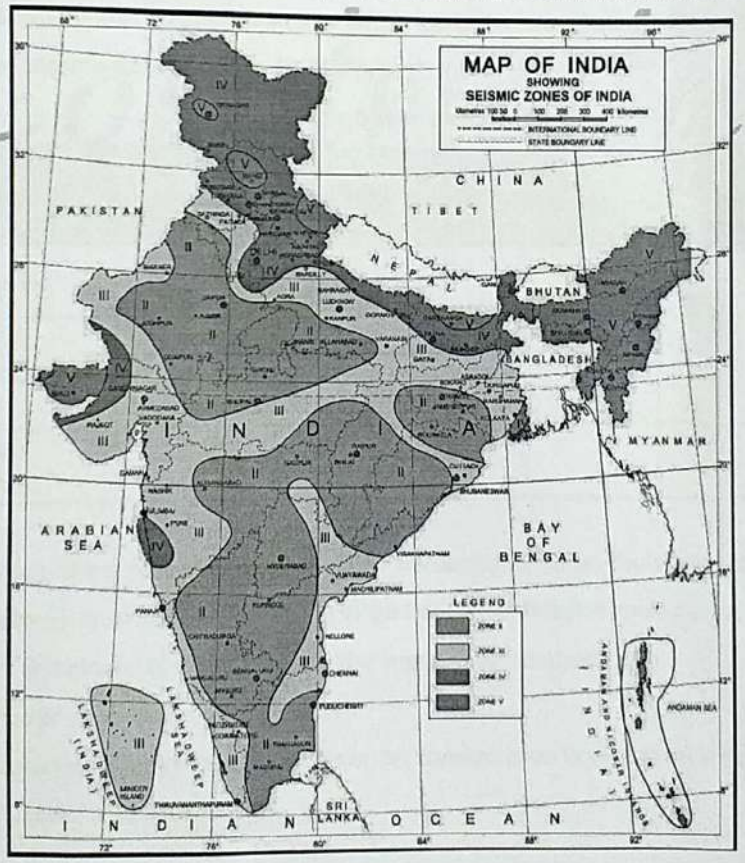

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Fig. 5(a)

5(b)

Fig. 5(a) & 5(b) Seismic zone as per IRS seismic code: 2020

Time period calculation

The approximate fundamental translational natural period Ta of oscillation of structure will be Calculated in accordance with clause 7.6.2 of IS 1893:2016:

Table 6 Time period

Structure	Type	Height of structure h (m)	Time period calculation formula
Air concourse	RC-Steel Composite MRF	20	$T = 2\pi\sqrt{\frac{\delta}{g}}$
Through roof	Steel MRF	20	$T = 2\pi\sqrt{\frac{\delta}{g}}$
	RC-Steel Composite MRF	20	
Cover on platform	Steel MRF	5	$T = 2\pi\sqrt{\frac{\delta}{g}}$

Natural periods of the foot over bridges will be calculated based on the assumption that the structure behaves as an inverted pendulum in the transverse direction and a portal, fixed at the base of piers and pinned at the bearings, in the longitudinal direction.

Importance factor calculation

The importance factor for various structures under consideration in this report is derived based on table 8 (Clause 7.2.3) IS 1893:2016.

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Table 7 Importance factor

Structure	Importance factor	Lateral load resisting system
Air concourse	1.5	Important service & community buildings or structures
Through roof	1.5	Important service & community buildings or structures
Cover on platform	1.5	Important service & community buildings or structures
Foot over bridges	1.5	Important service & community buildings or structures

Response reduction factor calculation

Depending upon lateral load resisting system of the structure, response reduction factor is given as per table below in compliance with Table 23 IS800:2007:

Table 8 Response reduction factor

Structure	Response reduction factor	Lateral load resisting system
Air concourse Foot over bridges	2 for super structure 4 for substructure(columns) 2 for foundations	As per table 3 of IRS Seismic code.
Cover on platform	2	As per table 3 of IRS Seismic code.
Through roof	2	As per table 3 of IRS Seismic code.

Category of Bridge Type is Special Regular and Method of Seismic Analysis of Bridges is RSM (Response spectrum method).

Soil Type

Types of soils are classified as Type I, Type II and Type III according to IRS Seismic code, (Clause 7.2). Type I, II and III soils refer to rock or hard soils, medium or stiff soils and soft soils respectively.

It is necessary to determine the type of soil on which the structure will be placed in order to determine the correct spectrum to be used for estimating Sa/g.

Based on the type of foundation and soil, the net bearing pressure in soils can be increased as per IRS Seismic code.

A Ground Type II is assumed for this project. Annex C of IS 1893-Part 1: 2016 provides an indication of the range of geologies of India. Allowing for superficial weathered rocks and superficial deposits such as alluvium, which is shown to be extensive in northern India, Ground Type II has been assumed. This applies to medium stiff ground profiles and also assumes that

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the ground is not susceptible to liquefaction or cyclic softening under the design earthquakes.

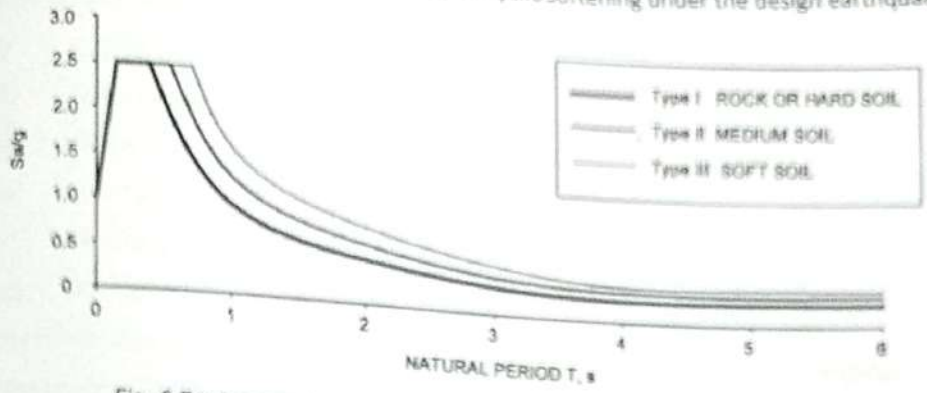

Fig. 6 Design acceleration coefficient (Sa/g) as per IRS Seismic code cl. 6.4.2

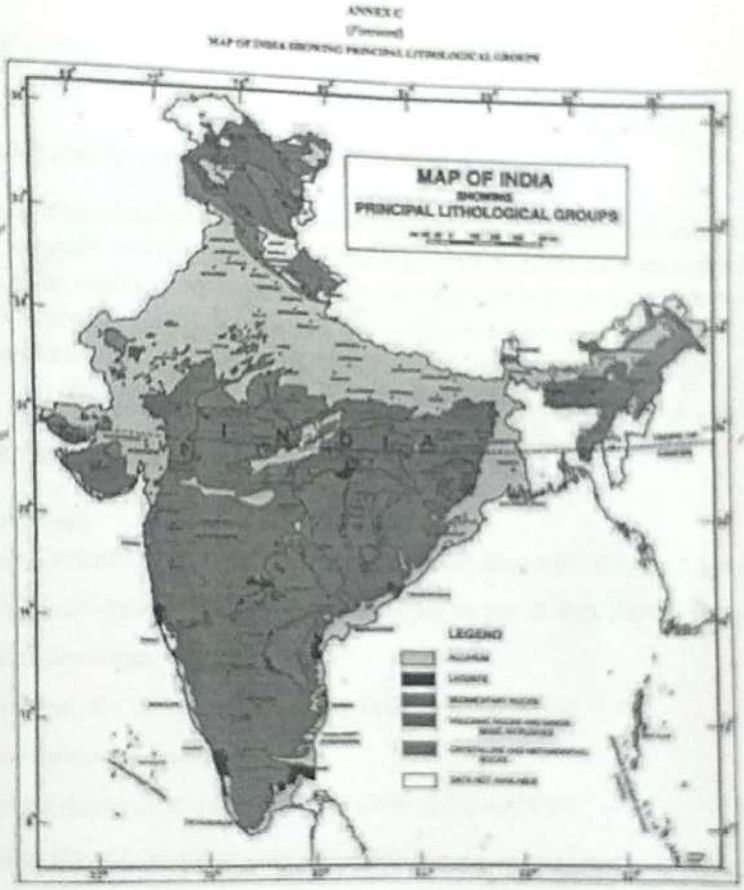

Fig. 7 Lithological groups as per ANNEX-C, IS 1893(part1):2016

Damping Ratio

According to clause 7.2.4 of IS1893:2016, irrespective of the material of construction, the value of damping shall be considered as 5% of critical damping for estimating horizontal seismic coefficient Ah.

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Vertical Earthquake Effect

In compliance with IRS seismic code-2020, when the structure is

(i) Located in seismic zone IV or V or

(ii) Having vertical or plan irregularities or

(iii) Rested on soft soil or

(iv) A bridge or

(v) Having long spans or

(vi) Having large horizontal overhangs of structural members or subsystems

The effects due to vertical earthquake shaking shall be considered. Therefore, due to the length of span vertical effects shall be considered for both the Zone II and Zone IV case.

The design seismic acceleration spectral value Av shall be calculated as:

$$T_V = \frac{2}{\pi} l^2 \sqrt{\frac{m}{EI}}$$

(cl. 7.4.2 IRS seismic Code)

Temperature & Shrinkage Loads:

The temperature load has been applied in case length of structure is more than 45m for seasonal and diurnal variation and for shrinkage effects; it is converted into equivalent temperature for applying in ETABs model. In view of maximum and minimum peak temperature data available, temperature load will be considered as per IRC-6:2017 in design of open terrace and shrinkage load. Temperature load is not required for intermediate floor due to constant temperature load.

5. Method of Design

Design Methodology:

The design of Composite Columns & beam is being done using AISC: 360-2010 and IRS concrete bridge code. Limit state method is being followed as per IS 800-2007 for design of steel structures and connection designs.

The considerations for the design of structure should be as follows:

(a) Structure safety and stability.

(b) To meet the demands of aesthetics conceived by the Architect.

(c) Availability of material, equipment and expertise.

(d) Constructability and ease of maintenance.

(e) Durability.

(f) All structural members should conform to provisions laid in IS 13920.

- The design of RCC columns, beam & slabs will be done using IRS concrete bridge code.
- The design of Composite Columns & beam is being done using AISC:360-2010
- Limit state method is being followed as per IS 800-2007 for design of steel structures.

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LOAD COMBINATIONS:

Serviceability load combinations and Ultimate load combinations used for analysis and design as per IRS Seismic Code , table 18 of IS 456:2000, cl. 6.3.4.1 of IS 1893(part1):2016 and table 4 of IS 800:2007.

Load combinations Used for Strength, Serviceability are tabulated below:
For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be considered as applicable.

(A) Ultimate limit state design
1) 1.25DL+1.5DL(S)+1.5EQ
2) 1.25DL+1.5DL(S)+0.5(LL+LL(F))+1.2EQ
3) 0.9DL+0.8DL(S)+1.5EQ

(B) Serviceability Limit State
1) 1.0DL+1.2DL(S)+1.0EQ
2) 1.0DL+1.2DL(S)+0.5(LL+LL(F))+1.0EQ

Table 9 Load Types and notation

Dead Load	DL+SIDL
Live loads	LL
Non-Reducible Live load	NRLL
Seismic Loads in X-Dir	EQX
Seismic Loads in Y-Dir	EQY
Wind Load in X-Dir	WLX
Wind Load in Y-Dir	WLY
TEMP Rise	TR
TEMP Fall	TF
Scaled Seismic Loads in X-Dir	RX
Scaled Seismic Loads in Y-Dir	RY

Serviceability load combinations and Ultimate load combinations used for analysis and design as per IS 456 and IS 1893 is as follows:
Serviceability Limit State Load Combinations

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Table 8 Serviceability Limit State Load Combinations

Load Combination	Dead Load (DL)	Live Load (LL)	Seismic Load (EQ)	Wind Load (WL)	Temp load(TR/TF)
DL+LL/Temp	1.0	1.0	-	-	0.6
DL+ EQ	1.0	-	1.0	-	-
DL+WL	1.0	-	-	1.0	-
DL+LL+EQ/WL	1.0	0.8	0.8	0.8	

Ultimate Limit State Load Combinations

Table 9 Ultimate Limit State Load Combinations

Load Combination	Dead Load (DL)	Live Load (LL)	Seismic Load (EQ)	Wind Load (WL)	Temp load(TR/TF)
DL+LL/Temp	1.5	1.5	-	-	0.9
DL+ EQ	1.5 or 0.9	-	1.5	-	-
DL+WL	1.5 or 0.9	-	-	1.5	-
DL+LL+EQ/WL	1.2	0.6	1.2	1.2	-

Notes:

- Earthquake and wind loads are reversible
- Wind load and earthquake loads are considered for both x & y directions. Whenever imposed load is combined with earthquake load, the appropriate part of imposed load as specified in IS: 1893-2016 / Clause 7.3.3 of seismic code will be used both for evaluating earthquake effect and for combined load effects used in such combination.
- Serviceability loads combinations with suitable live load reduction factor as per IS: 875 (Part-2) will be used for foundation design.
- For construction stage loading, 1 DL + LL of 100kg/m^2 to be considered.

Foundation Design:

Foundation shall be designed accordance to IRS BRIDGE SUB-STRUCTURES & FOUNDATION CODE. Analysis and design of raft/combined/isolated foundation shall be done by safe and design of isolated footing, retaining wall base to be prepared in excel sheet and provided in pdf format. The foundation has been designed by considering max allowable net bearing pressure (qa net) of 13.7 T/sq. m at 2.0 m depth w.r.t railway track for (Loc1 to Loc3 Station Building B) & max allowable net bearing pressure(qa net) of 14.1 T/sq. m at 1.5 m depth w.r.t railway track

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for Loc5 (FOB 2) as per latest soil investigation report. As per soil investigation report maximum allowed settlement is 75mm for raft and 50 mm for Isolated footing and Code (IS 1904) Table 1 is also taken in consideration for differential settlement.

Based on calculated safe bearing capacity in accordance with IS codes, Isolated/combined footing may be used for Air concourse, Through roof, COPs and FOBs.

- For the lift core areas based on lift pit depth requirements the foundation may go deeper.
- For Machine foundations (if any such as for DG sets/Pumps etc.) Block foundation

Design shall be done as per codal recommendations.

**Soil report attached in Annexure B

Design of composite element:

Composite Column

The steel columns (comprising of the two structural forms namely structural steel & structural concrete) shall start from approx. 2.5m below the 1st floor level thus ensuring that the composite beam framing for plinth level is facilitated. The AISC: 360-2010 Specification provides simple and practical methodology for composite column by permitting design of composite columns by LRFD (Load and Resistance Factor Design). The design methodology is well adapted in ETAB software modelling and the resulting sections are safe and practical. Composite column design will be done as per AISC: 360-2010 and calculations shall be submitted in pdf format of excel sheet.

The construction methodology is execution friendly as well as time saving since structural steel columns up to 4 floors can be erected & tied with floor structural beams. Decking work can be taken up on these floors. The sufficiency of structural column alone is checked for the loading of these four levels subsequently, floor wise, the reinforcement is put in position & columns RCC executed to get 'composite action'. Of course, the composite column design caters to the full loading which shall be incident only after all floors construction.

This construction sequence facilitates parallel working (in up to 4 levels at a time)

Secondary beam

Directly designed using ETABS. Pre-camber may be used where necessary, so that the deflection is suitably addressed. The web openings will be strategically provided for provision closure to point of inflection, where moments will be minimal & shear will also not be at its peak

Primary beam (Moment Redistribution in beams design)

The redistribution up to 100% is accepted by way of 'plastic design'. Accordingly, the primary analysis of beams is done conventionally & then moments redistributed using plastic design only up to 50% so that the hogging (support moments) are controlled within the designed limits & the sagging moments are increased for which the section provision is efficiently made. A separate model will be prepared in ETABS (only for the primary beams) where the redistributed moments of design only- thus ensuring that the assumption of rigid joints is maintained. An innovative deck placement with an eye towards best beam depths will be adopted where the beams will not necessarily span in the direction opposite to the corrugations of the sheet. The extent of moments obtained (after redistribution using plastic theory) will be checked for 'no-overstressing' condition,

Connections design

The connections should have the required capacity considered after redistribution of moments.

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There is no possibility of brittle failure since the ductile connections will permit rotation at the joint resulting in no possibility of sudden failure.

Stability:

Stability of structure against overturning and sliding as per Clause 20.0 of IS: 456-2000 is followed in the design and listed as below:

- Factor of safety against overturning:
  Restoring moment to be at least 1.2 times the maximum overturning moment due to the characteristic dead load and 1.4 times the maximum overturning moment due to the characteristic imposed loads.
- Factor of safety against sliding: 1.4
  In both the above cases, 0.9 times of characteristic dead load only to be considered in the design.

Serviceability Requirement:

This is given with following limitations:

- For Vertical deflections (Total load deflections) =Span/250 for Serviceability.
- Span/360 for material susceptible to braking.
- Lateral displacement of Structure=Height/ 500.
- Drift shall be 0.4% of story height.
- For Cracking-

For all RCC elements shall be cracked section and limiting crack width to 0.2 mm.

Drift- The maximum horizontal relative displacement due to earthquake forces between two successive floors shall not exceed 0.004 times the difference in level between these floors.

Floor vibrations:

- Walking vibrations:

Floors can be subjected to impulse loading due to a variety of sources in buildings resulting in vibrations being felt by building occupants. Typically, in buildings, the most significant cause of floor vibrations is walking excitation, and levels must be kept within certain limits to ensure that adverse comments from building occupants are kept to a minimum, walking acceleration shall be less than $\frac{a0}{g} = 0.005$ and calculation shall be adopted direct from Etab.

- Vibrations due to train movement:

Vibrations due to movement of trains to be checked and kept in accordance with the relevant sections of design national/international codes and relevant literature will be referred for adequate vibration-controlled floor design.
For the same, EPC contractor will appoint a consultant which specializes in Vibration Control systems.
The vibration control documentation can be provided at a later stage.

Property Modifier Used in ETAB:

Cracked RC section properties shall be modified separately for serviceability limit state (SLS)and ultimate limit state(ULS) design as per the Table-6 of clause 7.2.C of IS 16700-2017 or as per clause 6.4.3.1 of IS1893-2016.

Table 12 Property modifiers used

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S.No.	Structural Element	For SLS Condition		For ULS Condition	
		Area	Moment of Inertia	Area	Moment of Inertia
1	Slabs	1.0 Ag	0.35 Ig	1.0 Ag	0.25 Ig
2	Beams	1.0 Ag	0.70 Ig	1.0 Ag	0.35 Ig
3	Columns	1.0 Ag	0.90 Ig	1.0 Ag	0.70 Ig
4	Shear Walls	1.0 Ag	0.90 Ig	1.0 Ag	0.70 Ig

Where,

- Ag Represent gross area of member
- Ig Represent gross moment of Inertia of member

6. Analysis methodology and software used

The building shall be analyzed as composite steel structure using Etab software for Tower considering the relevant Indian Standard Codes. Applicable Dead, Live, Wind and Seismic Loads along with appropriate load combinations have been considered. Software like ETABS, STAAD, and SAFE shall be used for analysis and design. All secondary composite steel beam connections to main beams are simple connection and primary beam and cantilever to columns are considered as moment connection.

The floors comprise of RCC slabs over deck sheet, which is supported over structural beams (plate girders) in a composite manner. This mechanism will ensure that the in-plane stiffness is so large that no two nodes can move relatively to each other. That is, they all translate or deform together as well as there is no elongation/strain developed. Therefore, a Rigid Diaphragm action shall be assumed in the ETABS analysis so that the transfer of load to frames and shear walls is facilitated depending on their flexibility and their location in the structure. All nodes within the diaphragm extents shall be tied together in the model to the centre of rigidity of the system with infinite in-plane stiffness. This facility is available in ETABS modelling.

For design of individual elements suitable excel spreadsheets are to be used.

Additional Considerations to design method

Expansion Joint:

Expansion joints are recommended when structure exceeds 45m length. The width of the joints is being calculated as per IS-1893-2016, clause7.11.3.
However even if the length of building this project is more than 45m, the expansion joints can be avoided by carrying out thermal analysis to ascertain their effect and accordingly the design shall be carried out. Construction joints will be planned with the coordination of construction agencies.

1. Non-Tower Area shall be analyzed and designed separately by considering horizontal supports at Tower Periphery wherever there is connection of Non-Tower and Tower Area. Non-Tower Area is designed by considering Response Reduction Factor as 3 and ductile detailing shall be avoided.

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2. Structurally, it is suggested to take up Tower first with compensatory strip by leaving dowels all around the peripheral of towers.

3. Casting of retaining wall in length to be done in stretch of 30m, shrinkage strip to be provided as per structural drawings.

4. Design Philosophy for Thermal & Shrinkage effects:

- To avoid shrinkage stresses in Non-Tower slabs, compensatory strip to be provided as per structural drawings.
- The compensatory strips shall be suitably located in the region of length beyond minimum 45m and maximum within 55m.
- Compensatory Strips shall be casted after minimum 30 days to maximum two months of adjacent side castings completion.
- Long term shrinkage effects are suitably considered by taking 5degree variation in the ETABS model analysis.

Weld technology & allowable stresses:

- Welding technology & allowable stresses to be as per AWS D1.1 American Welding Society (AWS): Structural Welding (Steel).

7. Concrete Cover

Nominal concrete Clear Cover to All Reinforcement Including Links (As per Clause26.4 of IS: 456-2000) considering Environment condition is Moderate & fire resistance of 2 hrs.

Table 13 Concrete Cover

Structural Element	Face	Nominal Cover
Foundation	All sides	50 mm
Column	All sides	40 mm
Shear Wall	All sides	30 mm
Beams	For Continuous For Simply Supported	30 mm 40 mm
Slabs	Continuous floor Simply supported floor	25 mm 35 mm
Retaining wall	Earth side Inside Water Side (Water Tank) STP wall Liquid face	30 mm 30 mm 30 mm 40 mm
Deck Slab	Top side Bottom side	30 mm 50 mm

8. Equipment (DG Set & Others)

- DG set- this is kept clear from the main framing by way of suitable separation gap so that the possibility of vibration transmission does not arise.
- Other equipment- which is either static or those with insignificant vibrations such as cooling towers will be kept directly on the floors by way of vibration isolation pads.

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9. Façade Cleaning System

Structure support system for Façade cleaning at terrace shall be provided as per vendor requirement.

10. Structural Maintenance

Periodical inspection of the structure should be done to identify repair work and take necessary action accordingly. Maintenance should be done in accordance with IRS Bridge manual. Some of the common maintenance works have been listed below:

For Structural Steel:

1. **Paintwork:**
   - Periodical Thorough Paint: The entire steel work should be painted at regular intervals which vary from six years in arid zones to one year in highly corrosive areas. The chief engineer shall prescribe the periodicity of painting.
   - Patch Paint: When small area of paint show pronounced deterioration, which requires immediate remedy, it is not desirable to wait for the girder or the member as a whole becoming due for periodic painting. The affected areas must be patch painted.
   - Paint schedule & methodology to be followed as per IRS Bridge Manual.

2. **Bolts:**
   - Loose bolts should be identified and fixed.
   - If a bolt is found to be cracked, cause of crack should be identified and bolt should be replaced immediately.
   - For HSFG bolts, painting schedules and methodologies to be followed as specified in IRS bridge manual for the girder as a whole.

For RCC:

1. The areas around bearings shall be kept free of ballast, debris dust, oil / grease etc.
2. Drainage system shall be thoroughly cleaned and repaired as necessary before the onset of monsoon.
3. Protective surface coat, where provided, shall be maintained
4. Superstructure and bearings shall be maintained as per the design requirements and any deficiencies/defects noticed during inspection shall be attended to.

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ANNEXURE-A

(SOD)

Constructure

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MAXIMUM MOVING DIMENSIONS (SOD)

DIAGRAM NO:- 1D (EDO/T-2202)1676MM GAUGE OF SOD, REVISED , 2004

MAXIMUM MOVING DIMENSIONS.

NOTE:- ALL DIMENSIONS ARE IN MILLIMETRES.
EXCEPT WHERE OTHERWISE SHOWN.

DIMENSIONS OF IR / BG STOCK

DIMENSIONS	ICF / RCF			LHB	EMU	
	STD COACH	D.DECK	LONG COACH		MOTOR COACH	TRAILER COACH
GAUGE	1676	1676	1676	1676	1676	1676
LENGTH OVER BUFFERS	22297	22297	24125	24000	----	----
LENGTH OVER BODY	21337	21337	23165	23540	20726	20726
COACH WIDTH	3250	3050	3250/3100	3240	3660	3660
HEIGHT OF COACH BODY	3111	3360/4055	3111	2941	2895	2895
WHEEL-BASE	2896	2896	3200	2560	2896	2896
DISTANCE BETWEEN BOGIE CENTERS	14783	14783	15543	14900	14630	14630
DISTANCE BETWEEN SIDE BUFFERS	1956	1956	1955	----	----	----
HEIGHT OF BUFFER/ CBC FROM RL.	1105	1105	1105	----	1035	1035

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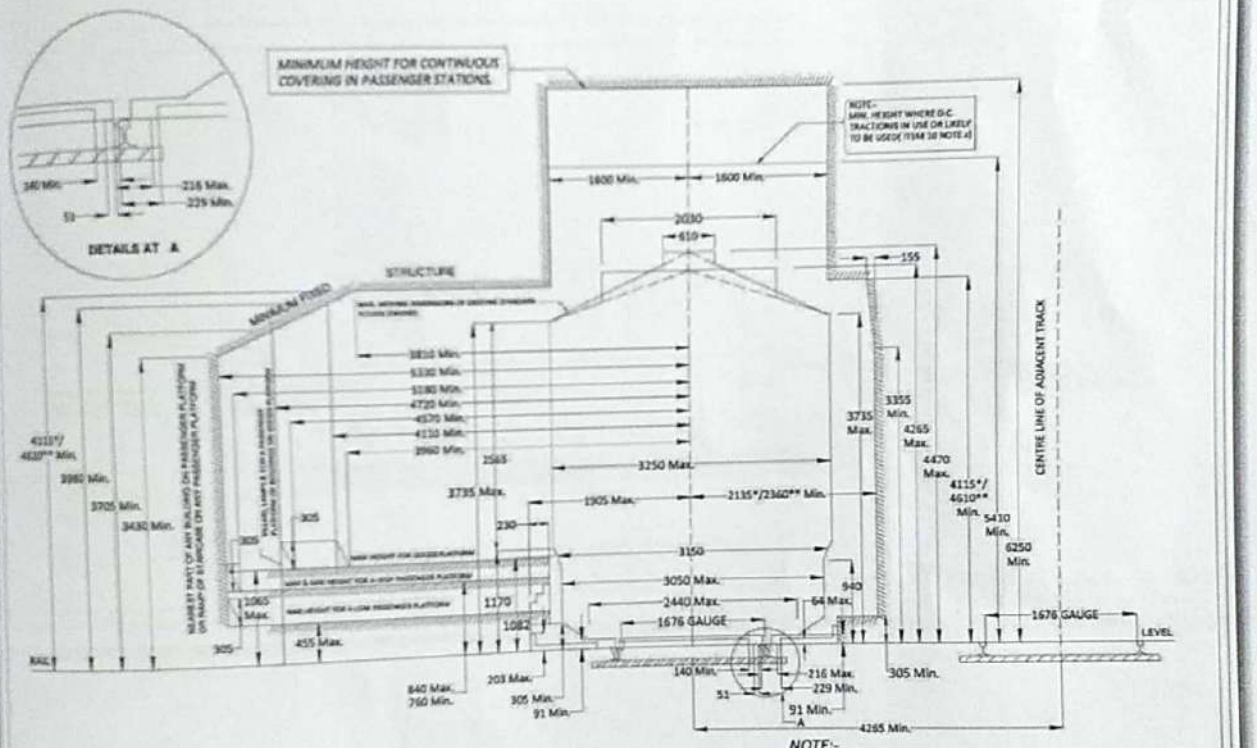
DIAGRAM NO. 2
1676 mm GAUGE

STANDARD DIMENSIONS IN STATIONS
TO SUIT 25 kV.A.C. TRACTION SCHEDULE I-CHAPTER II

NOTE:- THE DISTANCES SPECIFIED, APPLY ONLY IN CASE OF STRAIGHT TRACK. ON CURVES, THE HORIZONTAL DISTANCE SHOULD BE INCREASED BY AN AMOUNT 'D' TO ALLOW FOR THE LEAN DUE TO SUPER-ELEVATION CALCULATED BY THE FOLLOWING FORMULA, WHERE 'H' IS THE HEIGHT OF THE CONTACT WIRE, 'S' THE SUPERELEVATION AND 'G' THE GAUG OF THE TRACK, ALL DIMENSIONS BEING IN METRES $D = \frac{H \times S}{G}$



NOTE:- ALL DIMENSIONS ARE IN MILLIMETRES EXCEPT WHERE OTHERWISE SHOWN.

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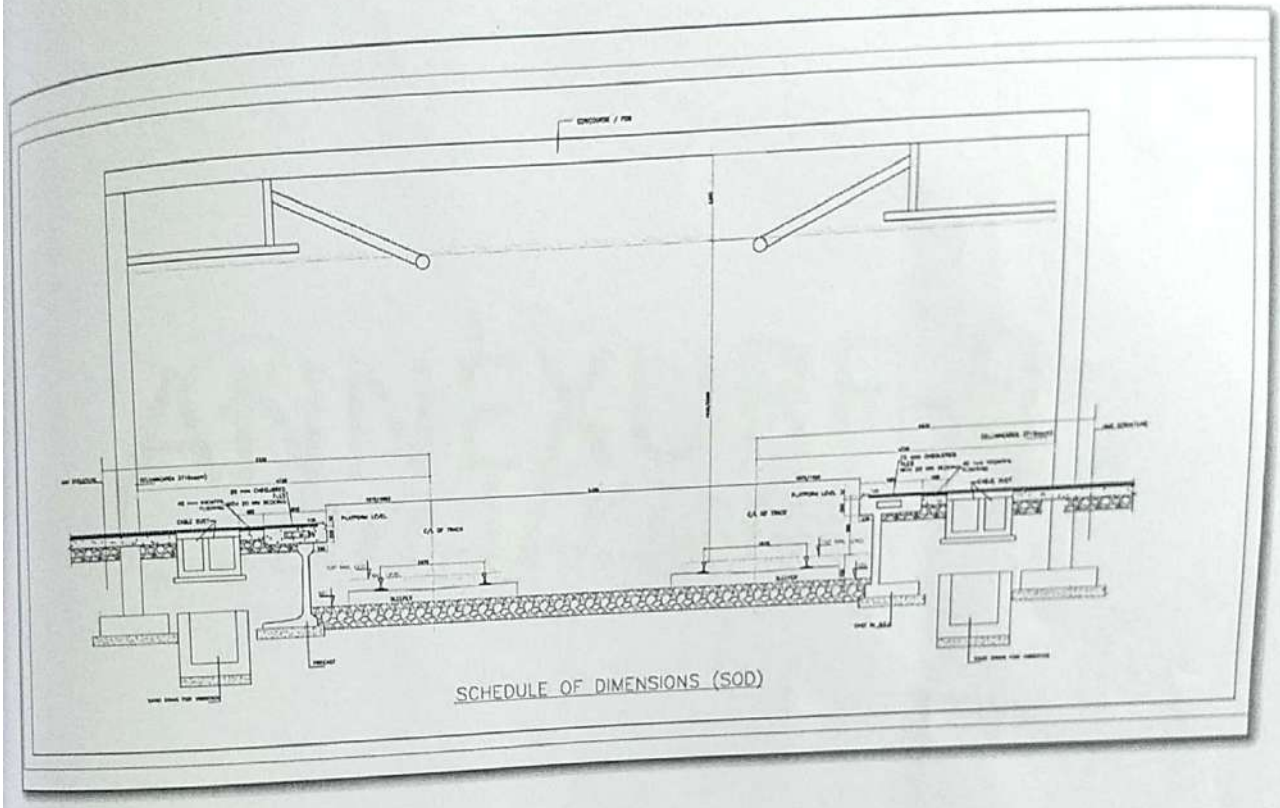

SCHEDULE OF DIMENSIONS (SOD)

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ANNEXURE-B

(Soil Report)

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