BANGALORE CANTONMENT RAILWAY STATION REDEVELOPMENT DIVISION OF SOUTH WESTERN RAILWAY

DESIGN BASIS REPORT FOR STRUCTURE WORKS (DBR)

CLIENT

South Western Railway

EPC CONTRACTOR

VARINDERA CONSTRUCTIONS LTD

LEAD DETAILED DESIGNER

muralage
architecture , master planning , interior design
conservation , landscaping , project management
A-3/269 , vibhav khand , gomti nagar , lucknow

M/S MURALAGE

S.NO	REVISION	DATE	DOCUMENT NO.
1			

CONTENTS

1.0 General:

i) Scope and Purpose:

This Report describes in brief the Structural aspects and Design Philosophy including selected construction aspects. The report also deals with considerations relating to seismic design of the building in addition to the structural system of the building.

The structural design will be primarily based on the current Indian Codes of practice. While efforts have been made to incorporate all the structural aspects of the project in this report, a revision of the same at the later stages of the project cannot be ruled out which may be necessary due to some aspects not foreseen now.

ii)Brief about work:

The design of the **PROPOSED BANGALORE CANTONMENT RAILWAY STATION REDEVELOPMENT DIVISION OF SOUTH WESTERN RAILWAY** will be based on the Architectural drawings provided by M/s **MURALAGE.** The structure will be designed as per latest code IS: 1893:2016 for seismic Zone-II.

S. No	Buildings	Floors
1	CAO OFFICE	B+G+9
2	DPWTC HOSTEL	G+4
3	OFFICER REST HOUSE	G+5
4	TRAINING CENTER	G
5	TYPE-2 QUARTERS	G+4
6	CONCOURSE	G+1+ROOF TRUSS
7	NORTH STATION BLOCK	G+2+ROOF TRUSS
8	SOUTH STATION BLOCK	G+2+ROOF TRUSS

9	NORTH BASEMENT	2
10	SOUTH BASEMENT	2
11	UGT, SPT, SUBSTATION, OHT	NA
12	FOOT OVER BRIDGE (F.O.B.)	NA

2.0 Design Scheme / Basis of Design:

i) Type of Structures:

Building Name	**Structural System**
CAO OFFICE	RCC Framed Structure
DPWTC HOSTEL	RCC Framed Structure
NORTH BLOCK+NORTH BASEMENT	RCC Framed Structure
SOUTH BLOCK+SOUTH BASEMENT	RCC Framed Structure
OFFICER REST HOUSE	RCC Framed Structure
TRAINING CENTER	RCC Framed Structure
TYPE-2 QUARTERS	RCC Framed Structure
CONCOURSE	Steel Structure with Deck slab
F.O.B.	Steel Structure
UGT, SPT, SUBSTATION, OHT	RCC Structure
COMBINED ROOF	Steel Truss Structure

The structure of the project is designed in accordance with the Indian Code IS 456:2000, with latest amendments, which is considered mandatory for reinforced concrete structures in the country.

ii) Fire Resistance:

Table 2 Comparative Floor Area Ratios for Occupancies Facing One Public Street at least 9 m Wide
(Clause 3.4.4.2)

Sl No.	Occupancy Classification	Type of Construction			
		Type 1	Type 2	Type 3	Type 4
(1)	(2)	(3)	(4)	(5)	(6)
i)	Residential	UL	2.0	1.4	1.0
ii)	Educational	UL	2.0	1.4	1.0
iii)	Institutional	UL	1.5	1.0	0.8
iv)	Assembly	UL	1.0	0.7	0.5
v)	Business	UL	2.9	2.3	1.6
vi)	Mercantile	8.0	1.8	1.4	1.0
vii)	Industrial	7.5	1.9	1.6	1.3
viii)	Storage (*see* Note 5)	6.0	1.5	1.3	1.0
ix)	Hazardous (*see* Note 5)	2.8	1.1	0.9	NP

UL — Unlimited.
NP — Not permitted.

As per NBC 2016, Table-2 – Page-20 – Part-4 Type-1 construction is to be followed as FAR is more than 1.0 shall be followed. Fire resistance shall be 4.0 hours for columns, Shear walls, Transfer Girders and for slabs fire resistance shall be 2- hours.

Minimum dimension shall be as per clause 21 of IS: 456:2000 and NBC 2016

- Beam – 240mm,
- Slab – 125mm
- Column – 450mm (Fully exposed)
- Column – 350mm (50% exposed)
- Column – 240mm (One face exposed)
- Walls – 240mm

Minimum cover shall be as per clause 26 of IS: 456:2000 and NBC 2016.

Grade of Concrete and Cover to the Reinforcement according to the provisions of the Indian Code

The appropriate grade of concrete and nominal cover to reinforcement is governed by the following main considerations:

i) Durability of Concrete
ii) Corrosion Protection of the Reinforcement
iii) Bar Size
iv) Nominal maximum aggregate size

From Durability requirement, exposure condition is assumed as mild for Structural Elements above ground level and moderate for Structural elements below ground Level.

The Nominal cover to reinforcement to meet Durability requirement shall be based on building FAR defining Type 1.

The Nominal cover to all reinforcement shall be as follows: -

Column	-	40 mm
Footings	-	50 mm
Raft foundation	-	75 mm for bottom and 50mm for top

For any other elements not specified above, cover shall be as per the clause 26.4 of IS: 456-2000 or check as per NBC 2016 based on Type 1.

Structural Element	Nominal Cover to all reinforcement (as per IS 456: 2000)		Nominal Cover Provided for prescribed fire rating & Exposure
	For Exposure condition (Table 16. P-47)	For Fire Resistance as noted above (Table 16A. P-47)	
Beams (Mild)	20mm	60 mm for simply supported 40 mm for continuous	60 mm for simply supported 40 mm for continuous
Slab (Mild)	20mm	35 mm for simply supported 25 mm for continuous	35 mm for simply supported 25 mm for continuous
Stitch Slabs - Top (Mild)	20mm	NA	20mm
Stitch Slabs – Bottom (Moderate)	30mm	NA	30mm
Columns (Mild)	20mm	40mm (as per clause 26.4.2.1)	40mm
Footings (Moderate)	30mm	NA	50mm (top and bottom)
Raft Slab (Moderate)	30mm	NA	75mm for bottom and 50mm for top
Retaining Walls (Moderate)	30mm	NA	Earth Side - 40mm Inside Side – 30 mm
Under Ground Water Tank Wall (Moderate)	30mm	NA	Earth Side - 40mm Water Side – 40mm
Over Head Water Tank Wall (Mild)	20 mm	NA	Outer Side - 30mm Water Side – 40mm

iii) Proposed Grade of Concrete to be used:

a) Foundations - M30

b) R.C.C. Retaining Walls - M30

c) Columns - M40

d) Beam & Slabs for Building - M30

e) Shear walls - M40

Note: For all other miscellaneous & small buildings minimum concrete grade shall be M25.

Reinforcement

TMT bars with Fe = 500D/550D N/mm^2 confirming to IS 1786:2008 with a 14.5% minimum elongation shall be used in the project. Reinforcement Bars of 8,10,12,16,20,25,28,32 mm shall be used. Mechanical couplers can be used for splicing of reinforcement of 20mm diameter bars and above in columns to achieve economy.

Structural Steel

All structural steel shall confirm to IS 2062:2011.

M.S. Rolled/Built up Members	E250 BR
M.S. tubular section ERW type ound, square or rectangular hollow tube sections)	E310 confirming to IS: 4923/IS 1161
Connections plates	E250 BR
Bolts	Gr - 8.8 (or) Approved Equivalent
Nuts	Class – 8 / 10 (or) Approved Equivalent
Washers	As per IS:2016(1967), IS:5369(1975), IS:6649(1985)
Anchor rods (Anchor bolts)	Gr - 8.8 (or) Approved Equivalent (or) ASTM F1554
Welding electrodes	70XX, Low Hydrogen for Grade 350 (Conforming to IS: 814) (or) Approved Equivalent

Note – Fire protection shall be provided for Structural steel, wherever applicable, as per provision given in NBC 2016.

Composite Deck Slab:

For construction of basement level 1, roof over the small areas above the Departure floor like Retails shops, Toilets, Offices, Staircases etc. either RCC slab with beams or composite deck slab with structural steel framing shall be provided based on the Architectural, Services and functional requirements.

The deck slab shall be design based on the various criteria as mentioned in the relevant Indian standard codes.

Material Properties:

Young's Modulus of Elasticity:

For Structural Steel, Es=$2x10^5$ Mpa

For Concrete, $E_c = 5000\sqrt{f_{ck}}$ Mpa (IS456:2000)

Where, fck =28 days characteristic compressive strength of concrete in Mpa.

Stiffness Modifiers:

For Structural Analysis and Design at Ultimate loads, following are the values of Stiffness Modifiers that have to be used as per Clause 6.4.3.1 the IS-1893 (2016).

6.4.3.1 For structural analysis, the moment of inertia shall be taken as:

a) In RC and masonry structures: 70 percent of I_{gross} of columns, and 35 percent of I_{gross} of beams; and

b) In steel structures: I_{gross} of both beams and columns.

iv) Loads:

a) Dead Load (here in after referred as DL)

Dead load shall mean the total weight of structures and/or foundations, and all materials permanently attached there to or supported thereby. The dead loads for the RCC members are considered on the basis of the density of RCC as 25 kN/cum. The density of brick wall in place is taken as 18.0 kN/cum.

The allowance for the floor finish is considered as 75 mm for whole structure from ground floor to below terrace floor level .Floor finish at terrace level to be considered as 100 mm thick. The toilets are considered with 150 mm sunk and light weight material at density of max 1000 kg/cum is taken for filling.

Load of 0.5 KN/sqm shall be considered for False-ceiling and services. The Load taken for railing is 3kN/m and the load for Parapet is 3 kN/m.

The average roof finish is considered to be 200 mm thick.

The self-weight of structure is automatically calculated by the analysis software depending upon the cross-sectional area and density of each member as follows.

Density of R.C.C Members = 25.0 KN/m^3

Density of P.C.C Members = 24.0 KN/m^3

Density of Structural Steel = 78.5 KN/m^3

Density of brick wall = 20.0 KN/m^3

Density of AAC Block wall = 8.0 KN/m^3

Density of Dry wall partitions = 0.5 KN/m^3

Density of Stone = 26.5 KN/m^3

Density of Saturated Soil = 20 KN/m^3

Density of Water = 10.0 KN/m^3

Density of Floor finish = 24.0 KN/m^3

Density of Plaster = 20.4 KN/m^3

Type of Load	**Minimum UDL KN/m^2**
Screed & Finishes with Tiles (Typical Floors) (50 mm)	1.2
Screed & Finishes with Stone (Typical Floors) (75 mm)	2.0
Screed & Finishes(Terrace) (100 mm)	2.4
Mechanical & Electrical Services + Ceiling	0.5
Demount-able partitions	1.0
Brick/ Block work partitions	As per actual

b) Imposed Loads (hereinafter referred as LL)

Following live loads have been considered in analysis:

S.NO.	Buildings	Live Load
1	**CAO Office**	
	➢ Basement	5.0 kN /m^2
	➢ Parking Area	5.0 kN /m^2
	➢ Road	5.0 kN /m^2
	➢ Toilet	2.0 kN /m^2
	➢ Office	2.5 kN /m^2
	➢ Kitchen	3.0 kN /m^2
	➢ Canteen	3.0 kN /m^2
	➢ Passage	4.0 kN/ m^2
	➢ Staircase/Lobby	4.0 kN/ m^2
	➢ Ramp	5.0 kN/ m^2
	➢ Terrace	1.5 kN/ m^2
2	**DPWTC Hostel**	
	➢ Triple Accommodation	2.0 kN /m^2
	➢ Toilet	2.0 kN /m^2
	➢ Staircase/Lobby	3.0 kN/ m^2
	➢ Terrace	1.5 kN/ m^2
3	**North Block**	
	➢ Basement	5.0 kN /m^2
	➢ Arrival Area	5.0 kN /m^2
	➢ Ticketing Area	5.0 kN /m^2
	➢ Staircase/Lobby/Corridor	4.0 kN /m^2
	➢ Railway Offices	3.0 kN /m^2
	➢ Toilet	2.0 kN /m^2
	➢ Waiting Area	4.0 kN /m^2
	➢ Retiring Room	2.0 kN /m^2
	➢ Shop/Food Court	4.0 kN /m^2
	➢ Terrace	1.5 kN /m^2
4	**South Block**	
	➢ Basement	5.0 kN /m^2
	➢ Arrival Area	5.0 kN /m^2
	➢ Ticketing Area	5.0 kN /m^2
	➢ Staircase/Lobby/Corridor	4.0 kN /m^2
	➢ Railway Offices	3.0 kN /m^2
	➢ Toilet	2.0 kN /m^2
	➢ Waiting Area	4.0 kN /m^2
	➢ Rest Room	2.0 kN /m^2
	➢ Electrical Room	5.0 kN /m^2
	➢ Machine Room	10 kN /m^2
	➢ Terrace	1.5 kN /m^2

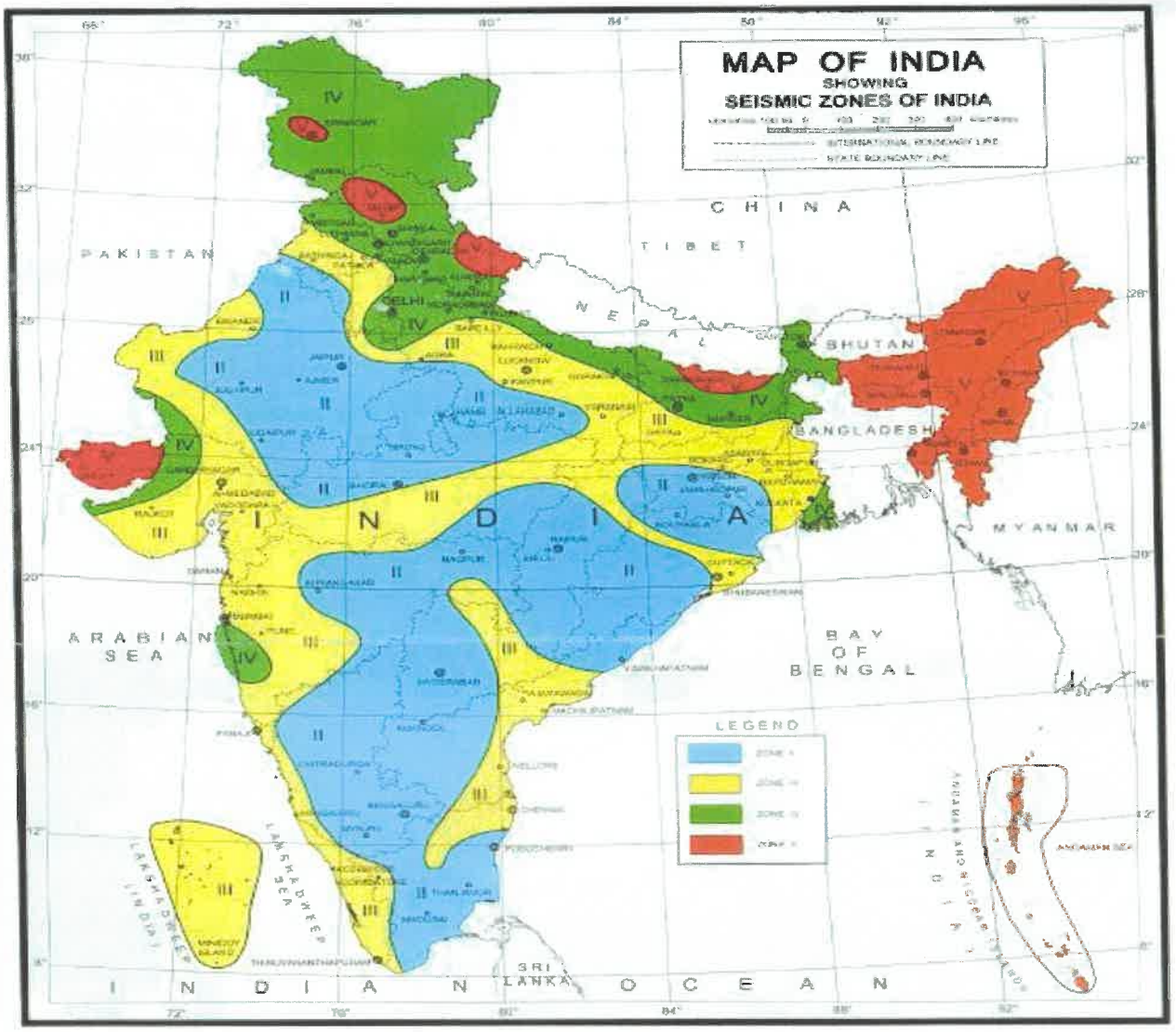
5	**OFFICER REST HOUSE** ➢ Bed Room ➢ Toilet ➢ Corridor ➢ Staircase/Lobby ➢ Store ➢ Terrace	 2.0 kN /m^2 2.0 kN /m^2 3.0 kN /m^2 3.0 kN /m^2 5.0 kN /m^2 1.5 kN /m^2
6	**TRAINING CENTER** ➢ Terrace	 1.5kN /m^2
7	**OFFICER REST HOUSE** ➢ Bed Room ➢ Drawing Room ➢ Toilet ➢ Corridor ➢ Balcony ➢ Staircase/Lobby ➢ Terrace	 2.0 kN /m^2 2.0 kN /m^2 2.0 kN /m^2 3.0 kN /m^2 3.0 kN /m^2 3.0 kN /m^2 1.5 kN /m^2
8	**F.O.B.**	5.0 kN /m^2
9	**UNDERGROUND TANK**	5 kN /m^2
10	**OVERHEAD TANK**	1.5 kN /m^2
11	**CONCOURSE**	5.0 kN /m^2

The slabs are designed for the above-specified loads. In case some specified areas are to be designed for higher loading, the same shall be informed.

The imposed and super imposed loads shall be considered as per IS: 875 (Part 2) – 1987, depending upon the finishes and occupancy classifications. The Equipment Load on the roof of the building shall be as per Vendor's data. Water tank loads shall be as per MEP Consultants requirement.

c) Earthquake load and Wind loads:

Earthquake Map of India



Based upon Survey of India Political map printed in 2002
The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate baseline
The international boundaries between Arunachal Pradesh, Assam and Meghalaya shown on this map are as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but have yet to be verified
The state boundaries between Uttarakhand & Uttar Pradesh, Bihar & Jharkhand, and Chhattisgarh & Madhya Pradesh have not been verified by the Governments concerned
The administrative headquarters of Chandigarh, Haryana and Punjab are at Chandigarh
The external boundaries and coastlines of India agree with the Record/Master Copy certified by Survey of India
The responsibility for the correctness of internal details rests with the publisher
NOTE – Towns falling at the boundary of zones demarcation line between two zones shall be considered in higher zone

FIG. 11 SEISMIC ZONES OF INDIA

The structure is to be designed for the minimum static seismic base shear set out by IS 1893 (Part 1):2016 using the parameters shown in the table below. These forces are treated as ultimate forces.

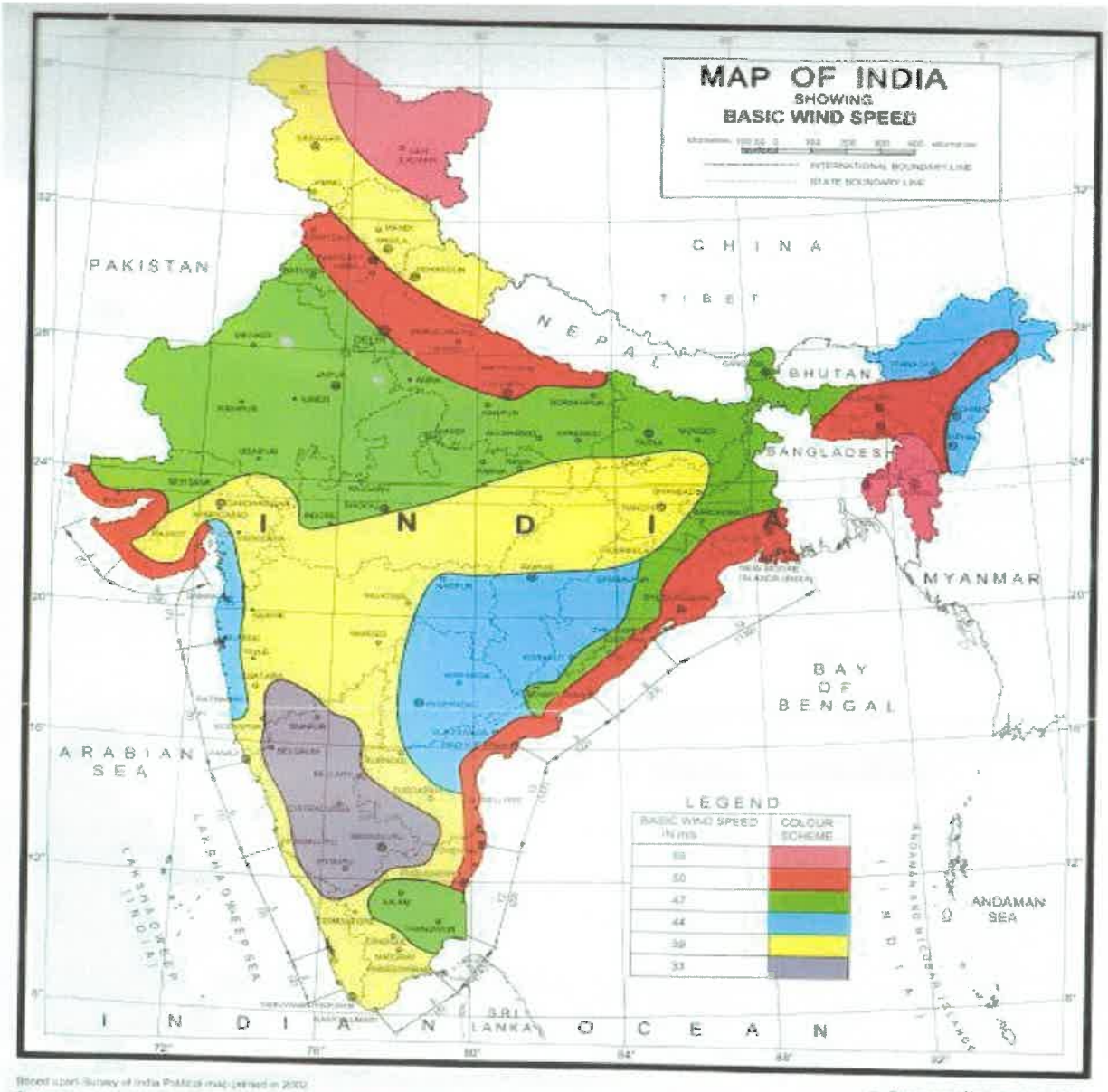
Design horizontal seismic coefficient (Ah) = ZI (Sa)/ 2Rg

S. No.	Load		Reference
1)	**Design Earthquake:**	10% chance of being exceeded within a 50 year return period	
2)	**Earthquake load:**		
a)	Zone	II	
b)	Importance factor	As per Table: 8	IS-1893-2016(Part-01)
c)	Type of structure	RC building with ordinary moment resisting frame(OMRF)	
d)	Response Reduction Factor	3	
e)		II	
f)	Soil type Time period to be used	0.075(h)^0.75 H = Height of building, in m (from GROUND FLOOR to Terrace)	According to clause 7.6.2 of IS 1893(PART 1)2016
g)	Seismic Building Weight	To include all components of Self Weight, Superimposed Dead load, any other permanent weight 50% of Live Load	

S. No	Buildings	Floors	Importance Factor
1	CAO OFFICE	B+G+9	1.5
2	DPWTC HOSTEL	G+4	1.5
3	NORTH STATION BLOCK	G+2	1.5
4	SOUTH STATION BLOCK	G+2	1.5
5	OFFICER REST HOUSE	G+5	1.5
6	TRAINING CENTER	G	1.5
7	TYPE-2 QUARTERS	G+4	1.5
8	NORTH &SOUTH BASEMENT	2B	1.5
9	CONCOURSE	G+1	1.5
10	F.O.B.	NA	1.5
11	UGT, SPT, OHT, ESS	NA	1.5

Wind Map of India:

The wind pressure shall be calculated based on basic wind speed, risk coefficient, terrain category, topography factor and other provisions laid in IS: 875 (Part 3) – 2015.



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The administrative headquarters of Chandigarh, Haryana and Punjab are at Chandigarh.

The external boundaries and coastlines of India agree with the Record Master Copy certified by Survey of India.

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NOTES

1 The occurrence of a tornado is possible in virtually any part of India. They are particularly more severe in the northern parts of India. The recorded number of these tornadoes is too small to assign any frequency. The devastation caused by a tornado is due to exceptionally high winds about its periphery, and the sudden reduction in atmospheric pressure at its centre, resulting in an explosive outward pressure on the elements of the structure. The regional basic wind speeds do not include any specific allowance for tornadoes. It is not the usual practice to allow for the effect of tornadoes unless special requirements are called for as in the case of important structures such as nuclear power reactors and satellite communication towers.

2 The total number of cyclonic storms that have struck different sections of east and west coasts are indicated in Fig. 1 based on available records for the period from 1877 to 1982. The figures above the lines (between the stations) indicate the total number of severe cyclonic storms with or without a core of hurricane winds (speeds above 47 m/s) and the figures in the brackets below the lines indicate the total number of cyclonic storms. This effect on land is already reflected in the basic wind speeds specified in Fig. 1. These have been included only as additional information.

Wind Load as per –IS:875(Part-03)-2015		
1	Basic wind speed (Vb) m/sec- Appendix-A	33 m/sec
2	Risk co-efficient (k1)-Table-01	1.05 (for important buildings)
3	Terrain, height and size factor (k2)	As per table - 02, IS 875 (Part-3)
4	Topography factor (k3)	1.0
5	Importance factor for the cyclonic region (k4)	1.0
6	Design wind speed (Vz)	Vz = Vb*k1*k2*k3*k4
7	Design wind pressure (Pz)	Pz =0.6*Vz2

Design Wind Pressure (pd) calculated as per IS 875 (part 3)-2015 clause 7.2. Dynamic effects shall be considered in analysis as per IS 875 (part 3)-2015 clause 9.1.

Temperature loading:

In the temperature load max. temperature as T1 = 40 deg C & minimum temp. as T2 = 17 deg C.

TL2 = [- 2/3 (T1-T2)]-15 = 0.67 x (40 -17) = -1 deg C

TL1 = [+ 2/3 (T1-T2)]-7.5 = 0.67 x (40 -17) = +8 deg C

So, a temperature load of -1 and +8 degree Celsius shall be applicable in the design if the building length is greater than 45 meters

Expansion Joint Requirement:

Expansion joints are normally provided when structure exceeding 45m length or minimize the structural irregularities such as Vertical Irregularity, torsional irregularity etc. The width of the joints is being calculated as per IS 1893-2016 clause 7.11.3. Locations of the same are proposed in such a way that it would take care of functional as well as operational aspect and would minimize the structural irregularity. Wherever length is more than 45m, thermal analysis shall be conducted.

Analysis and Designs:

The buildings shall be analyzed as 3-D structures with shear walls/columns as vertical members and Beam and slab as horizontal members. Analysis will be carried out both for vertical (dead and live loads) as well as horizontal loads (earthquake /wind loads) for different load combinations. The analysis & design of idealized model is carried using **"ETABS" 19.0.2** computer program providing design for beam & RCC walls/columns as per IS 456-2000. For Seismic analysis slab at each floor has been idealized as rigid diaphragm so that all frames sway equally under lateral loads, with masses lumped at the joints with 5% damping. Seismic Coefficients as applicable to Seismic Zone II as per IS 1893-2016. Response spectrum analysis shall be done for the structural performance of these buildings.

For Foundation design **"SAFE"16.0.2** and Manual spread sheets will be used.

v) Load Combinations:

All structural designs are carried out by Limit State method of design. For this purpose, the Load factor for various load combinations indicated in IS-875 (Part5)–1987 and IS 456:2000 are as follows:

a) <u>Service Load Combination</u> [For Checking of Deflection & Crack Width]:

DL + LL
DL + SPECX
DL - SPECX
DL + SPECY
DL- SPECY
DL + SPECX +TL
DL + SPECY+TL

DL + TL
DL + LL+TL
DL + 0.8LL + 0.8 SPECX
DL + 0.8LL - 0.8 SPECX
DL + 0.8LL + 0.8 SPECY
DL + 0.8LL - 0.8 SPECY
DL + LL + SPECX +TL
DL + LL + SPECY+TL
DL + WLX
DL - WLX
DL + WLY
DL- WLY
DL + WLX+TL
DL + WLY+TL
DL + 0.8LL + 0.8WLX
DL + 0.8LL - 0.8WLX
DL + 0.8LL +0 .8WLY
DL + 0.8LL - 0.8WLY
DL + LL + WLX+TL
DL + LL +WLY+TL

b) Response Spectrum Analysis *(For Design)*

As per clause 6.3.3.1 of IS 1893(PART 1):2016, effects due to vertical earthquake shaking shall be considered because the structure has vertical or plan irregularities and the structure has long spans.

S. No.	Orthogonal Load Combinations						
1	1.5DL	+	1.5LL	+	TL1		
2	1.5DL	+	1.5LL	+	TL2		
3	1.2DL	+	1.2LL	+	1.2SPECX	+	TL1
4	1.2DL	+	1.2LL	+	1.2SPECX	+	TL2
5	1.2DL	+	1.2LL	-	1.2SPECX	+	TL1
6	1.2DL	+	1.2LL	-	1.2SPECX	+	TL2
7	1.2DL	+	1.2LL	+	1.2SPECY	+	TL1
8	1.2DL	+	1.2LL	+	1.2SPECY	+	TL2
9	1.2DL	+	1.2LL	-	1.2SPECY	+	TL1
10	1.2DL	+	1.2LL	-	1.2SPECY	+	TL2
11	1.5DL	+	1.5SPECX	+	TL1		
12	1.5DL	+	1.5SPECX	+	TL2		
13	1.5DL	-	1.5SPECX	+	TL1		
14	1.5DL	-	1.5SPECX	+	TL2		
15	1.5DL	+	1.5SPECY	+	TL1		
16	1.5DL	+	1.5SPECY	+	TL2		
17	1.5DL	-	1.5SPECY	+	TL1		
18	1.5DL	-	1.5SPECY	+	TL2		
19	0.9DL	+	1.5SPECX	+	TL1		

20	0.9DL	+	1.5SPECX	+	TL2		
21	0.9DL	-	1.5SPECX	+	TL1		
22	0.9DL	-	1.5SPECX	+	TL2		
23	0.9DL	+	1.5SPECY	+	TL1		
24	0.9DL	+	1.5SPECY	+	TL2		
25	0.9DL	-	1.5SPECY	+	TL1		
26	0.9DL	-	1.5SPECY	+	TL2		
27	1.5DL	+	1.5WLX	+	TL1		
28	1.5DL	-	1.5WLX	+	TL2		
29	1.5DL	+	1.5WLY	+	TL1		
30	1.5DL	-	1.5WLY	+	TL2		
31	0.9DL	+	1.5WLX	+	TL1		
32	0.9DL	-	1.5WLX	+	TL2		
33	0.9DL	+	1.5WLY	+	TL1		
34	0.9DL	-	1.5WLY	+	TL2		
35	1.2DL	+	1.2LL	+	1.2WLX	+	TL1
36	1.2DL	+	1.2LL	-	1.2WLX	+	TL2
37	1.2DL	+	1.2LL	+	1.2WLY	+	TL1
38	1.2DL	+	1.2LL	-	1.2WLY	+	TL2

EQX = Static EQ Load in X direction
EQY = Static EQ Load in Y direction
WLX = Wind Load in X-direction
WLY = Wind Load in Y-direction
DL = Dead Load
LL = Live Load

TL1 = Positive temperature load
TL2 = Negative temperature load

The appropriate part of imposed load as specified in IS: 1893 (Part-1): 2016 is used only for evaluating earthquake effects. Load combination as per IS 1904 shall apply in which Live Load Reduction shall be done as per procedure give in Appendix A of IS 875 Part 2 for the design of columns and foundations

vi) Foundation Recommendations:

Soil report has been received from **CIVIL LAB AND GEOTECH CONSULTANT** with dated 09.03.2023

Following is synopsis of report.

It is observed that among all the eight boreholes, BH-1 and BH-2 are having loose soil in varying depth of 3.0m to 4.5m. It is not recommended to lay the foundation on loose soil unless the loose soil is removed up to the hard soil and re-compacted up to the required level of foundation. It **is recommended to have a minimum depth of foundation of 3.0m below existing ground level (below the loose soil) after laying one layer of CRUSH STONE compaction up to refusal and one layer of structural fill material**. The minimum recommended depth BH-3 is 2.5m, BH-4 & BH-5 is 2.0m and BH-6,7&8 is 2.5m and the type of foundation for all these structures is **spread foundation of isolated footing with Square/Rectangular shape.**

Weakest Borehole in the group is considered for designing the Safe bearing capacity of soil, hence the SBC at different depth of foundation has be calculated and given in below tables.

TABLE- 1- SAFE BEARING CAPACITY OF SHALLOW FOUNDATION
After Soil re-compaction of existing condition
Type-2 Quarters (G+4F) (BH-1 & BH-2)

Footing depth below the ground level (m) (Elevation)	Weighted/ corrected N values below footing influence zone	SOIL Parameters	Type of Footing	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Allowable settlement (mm)
3.0	N ≤ 17	Cohesion c=0 KPa , Angle internal friction Ø =20, Bulk density considered γ = 1.77 g/cm3	Square/ Rectangular	**150.0**	32.5	50.0
4.0	N ≤ 21	Cohesion c=0 KPa , Angle internal friction Ø =22, Bulk density considered γ = 1.8 g/cm3	Square/ Rectangular	**170.0**	32.0	50.0
5.0	N ≤ 24	Cohesion c=0 KPa , Angle internal friction Ø =23, Bulk density considered γ = 1.8 g/cm3	Square/ Rectangular	**190.0**	32.6	50.0

TABLE- 2- SAFE BEARING CAPACITY OF SHALLOW FOUNDATION

DTWTC Hostel (G+4F) (BH-3)

Footing depth below the ground level (m) (Elevation)	Weighted/ corrected N values below footing influence zone	SOIL Parameters	Type of Footing	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Allowable settlement (mm)
2.5	N ≤ 23	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**170.0**	31.6	50.0
3.5	N ≤ 24	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**190.0**	33.1	50.0
4.5	N ≤ 26	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**200.0**	33.2	50.0

TABLE- 3- SAFE BEARING CAPACITY OF SHALLOW FOUNDATION

Proposed Training Centre (GF) (BH-4 & BH-5)

Footing depth below the ground level (m) (Elevation)	Weighted/ corrected N values below footing influence zone	SOIL Parameters	Type of Footing	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Allowable settlement (mm)
2.0	N ≤ 23	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**160.0**	31.2	50.0
3.0	N ≤ 23	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**180.0**	32.2	50.0
4.0	N ≤ 29	Cohesion c=0 KPa, Angle internal friction Ø =24, density γ = 1.8 g/cm3	Square	**210.0**	32.9	50.0

TABLE- 4- SAFE BEARING CAPACITY OF SHALLOW FOUNDATION

Officer Rest House (G+5F) (BH-6,7&8)

Footing depth below the ground level (m) (Elevation)	Weighted/ corrected N values below footing influence zone	SOIL Parameters	Type of Footing	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Allowable settlement (mm)
2.5	N ≤ 23	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**170.0**	32.1	50.0
3.5	N ≤ 25	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**190.0**	32.2	50.0
4.5	N ≤ 28	Cohesion c=0 KPa, Angle internal friction Ø =23, density γ = 1.8 g/cm3	Square	**210.0**	33.5	50.0

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION
Platform 1B/1D/1C/1E Air Concourse (BH-9 to BH- 11)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
2.0	N ≤ 12	Cohesion c=0 KPa , Angle internal friction Ø =20, Bulk density considered γ = 1.75 g/cm3	103	27.3	100
3.0	N ≤ 22	Cohesion c=0 KPa , Angle internal friction Ø =23, Bulk density considered γ = 1.8 g/cm3	234	41.3	230
4.0	N ≤ 28	Cohesion c=0 KPa , Angle internal friction Ø =25, Bulk density considered γ = 1.8g/cm3	320	48.6	Limited to 300

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION
Air Concourse (BH-24 to BH- 25)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
2.0	N ≤ 10	Cohesion c=0 KPa , Angle internal friction Ø =19, Bulk density considered γ = 1.75 g/cm3	93	26.6	90
3.0	N ≤ 13	Cohesion c=0 KPa , Angle internal friction Ø =20, Bulk density considered γ = 1.77 g/cm3	153	35.7	150
4.0	N ≤ 17	Cohesion c=0 KPa , Angle internal friction Ø =21, Bulk density considered γ = 1.8g/cm3	240	49.0	240

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION

Integrated Station Building (Southside) G+2UF (BH-12, BH-13, BH-14)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
2.0	N ≤ 30	Cohesion c=0 KPa , Angle internal friction Ø =26, Bulk density considered γ = 1.8 g/cm3	231	36.8	230
3.0	N ≤ 66	Cohesion c=0 KPa , Angle internal friction Ø =30, Bulk density considered γ = 2.0 g/cm3	370	11.1	370
4.0	N ≤ 100	Cohesion c=0 KPa , Angle internal friction Ø =32, Bulk density considered γ = 2.2g/cm3	1000	11.3	1000

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION

Integrated Station Building (Southside) G+2UF (BH-15)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
2.0	N ≤ 17	Cohesion c=0 KPa , Angle of internal friction Ø =21, Bulk density considered γ = 1.78g/cm3	141	31.6	140
3.0	N ≤ 20	Cohesion c=0 KPa , Angle of internal friction Ø =22, Bulk density considered γ = 1.8 g/cm3	208	38.8	200
4.0	N ≤ 29	Cohesion c=0 KPa , Angle of internal friction Ø =25, Bulk density considered γ = 1.8g/cm3	330	49.0	Limited to 300

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION

Drop of Zone south side (G-2B) (BH-16, BH-17, BH-18, BH-19, BH-21, BH-22, BH-23 & BH-26)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
7.5 (1.5) 6.0m excavation for basement	N ≤ 26	Cohesion c=0 KPa , Angle of internal friction Ø =24, Bulk density considered γ = 1.8 g/cm3	280	44.6	260
8.5 (2.5) 6.0m excavation for basement	N ≤ 31	Cohesion c=0 KPa , Angle of internal friction Ø =26, Bulk density considered γ = 1.8g/cm3	330	46.9	Limited to 300

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION

Northside Station Building (G+2UF) (BH-27, BH-28, BH-29 & BH-30)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
2.0	N ≤ 14	Cohesion c=0 KPa , Angle internal friction Ø =21 Bulk density considered γ = 1.76 g/cm3	122	30.1	120
3.0	N ≤ 15	Cohesion c=0 KPa , Angle internal friction Ø =21, Bulk density considered γ = 1.77 g/cm3	178	38.8	175
4.0	N ≤ 17	Cohesion c=0 KPa , Angle internal friction Ø =21, Bulk density considered γ = 1.78 g/cm3	240	49.0	240

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION

Drop of Zone North side (G-2B) (BH-31)

Foundation resting completely on ROCK

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
6.5 (0.5) 6.0m excavation for basement	UCS - 90N/mm2	As per IS 12070 and IS 13365 p-1	2960	<12.0	2960
7.0 (1.0) 6.0m excavation for basement	UCS – 80 N/mm2	As per IS 12070 and IS 13365 p-1	2853	<12.0	2850

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION

Drop of Zone North side (G-2B) (BH-32 & BH-33)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
7.5 (1.5) 6.0m excavation for basement	N ≤ 29	Cohesion c=0 KPa , Angle of internal friction Ø =25, Bulk density considered γ = 1.8 g/cm3	300	44.6	300
8.5 (2.5) 6.0m excavation for basement	N ≤ 35	Cohesion c=0 KPa , Angle of internal friction Ø =26, Bulk density considered γ = 1.8g/cm3	350	46.9	Limited to 300

SAFE BEARING CAPACITY OF SHALLOW SQUARE/RECTANGULAR FOUNDATION
Proposed FOB -01 BH-20, BH-34)

Footing depth below the ground level (m) (Elevation)	Weighted N values below footing influence zone	SOIL Parameters	Net SBC (KN/m2) computed from general shear failure criteria with design WT@ the base of the footing, FOS as 3.0	Estimated Settlement (mm)	Recommended SBC (KN/m2) Based on complete utilization of 50mm settlement as per as IS: 1904
2.0	N ≤ 19	Cohesion c=0 KPa , Angle internal friction Ø =22 Bulk density considered γ = 1.76 g/cm3	142	29.9	140
3.0	N ≤ 23	Cohesion c=0 KPa , Angle internal friction Ø =23, Bulk density considered γ = 1.77 g/cm3	234	40.2	230
4.0	N ≤ 32	Cohesion c=0 KPa , Angle internal friction Ø =32, Bulk density considered γ = 1.78 g/cm3	340	47.3	Limited to 300

NOTE

- No foundation shall be placed on LOOSE SOIL, if any loose soil encountered shall be removed up to hard soil and raise the level by compaction with external soil and crush stone in layers till the required foundation level.
- Thorough verification of strata at founding level before laying PCC by Engineer in charge shall be done. If there is a significant variation in strata from that mentioned in Geotechnical report, bring it to notice of Soil consultant.
- Avoid over-excavation and loosening of strata at founding level. Same if done shall be replaced by lean /plumb concrete
- Avoid placement of foundation on localized soft soil/erratic soil-rock interfaces and foundations shall rest on single type of strata.
- If water table encountered during excavation of the site for foundation, please refer to clause 7.3 for method of dewatering.

vii) Applicable Computer Software:

- ETABS 18.0.2
- SAFE 16.0.2

3.0 General Codal Provision & Detailing

i) **Minimum percentages, maximum & minimum spacing of Reinforcement in Structural members**: Shall be as per the IS 456:2000 and IS 13920:2016

ii) **Minimum Utilization Ratio in Structural Steel members**: Shall be as per the IS 800:2007

iii) **Miscellaneous**

Column Beam Junction:

Columns shall have higher grade than the beams. Site shall take care to concrete the column beam junction with the column grade only.

Drift & Deflection limits for earthquake and wind:

The story drift in any story due to the minimum specified design lateral force arrived with fundamental time period, with factor of 1.0, shall not exceed 0.004 times the story height.

The deflection at the top shall be limited h/250 deflection limits for earthquake forces and for wind, h/500.

Vertical Deflection of beams / slabs will be limited to following:

The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members, should not normally exceed span/250.

The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and the application of finishes should not normally exceed span/350 or 20 mm whichever is less.

Although, these criteria are generally satisfied by providing span / depth ratios given in clause 23.2.1 of IS 456, deflection of critical members will be checked by calculating actual deflections.

Recommended limits for vertical deflection from IS 800:2007 :

Roof and Roofing Beams Main Beams 1/250

Purlins 1/180

Vertical framework elements

Posts/wall columns, collar beams 1/20

Side Runners

Recommended limits for vertical deflection (IS 800:2007) 1/250

Crane girders as per IS S00:2007

Runway beams 1/600 or 25 mm

Runway beam of a monorail hoist block 1/500

Note: Where the deflection due to the combination of dead load and live load is likely to be consideration excessive should be given to pre-chamber the beams, trusses and girders. The value of desired camber shall be specified in the design drawing. Generally, for spans greater than 25 m, a camber approximately equal to the deflection due to dead loads plus half the live load may be used. The deflection of a member shall be calculated without considering the impact factor or dynamic effect of the loads on the deflection.

Dynamic analysis:

Dynamic analysis is being performed by the Response Spectrum Method. The design base shear (V_B) shall be compared with a base shear (V_{BT}) calculated using a fundamental period, T_a. Incase V_B is less than V_{BT}, all the response quantities are multiplied by scale factor. Time period shall be as per point 2.iv.(c)

Percentage of Live loads to be considered in seismic weight calculations:

Shall be taken as per the Table 8 of IS 1893 (Part 1): 2016.

Crack width in water retaining structures:

For water tanks and Underground

Sumps crack width shall be limited to 0.2mm and for STP it shall be limited to 0.1mm as per Clause 35.3.2 of IS 456:2000. Minimum Concrete grade shall be M30 for water tanks and M35 for STP.

A. Punching shear checks in flat plates and Raft foundation: Shall be as per clause 31.6 of IS 456:2000.

B. Slab depth requirements: Shall be confirming to the clause of 23.2 of IS: 456.

C. Minimum Percentage in shear walls / columns: 0.4% of shear walls and 0.8% of for columns.

Single layer of reinforcement in 150 mm thick wall and two layers of reinforcement for walls more than 150mm.

4.0 Reference Codes:

S. No.	Code	Description
1	IS: 456 – 2000	Code of Practice for Plain and Reinforced Concrete
2	IS-875 (Part 1)-1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Unit weights of buildings materials and stored materials
3	IS-875 (Part 2)-1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures-Imposed loads
4	IS-875 (Part 3)-2015	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Wind loads. (Amended 2016) Using 44 m/sec as base wind speed.
5	IS-875 (Part 5)-1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Special loads and load combinations
6	IS: 1786 – 2008	Specification for High Strength Deformed Bars and Wires for Concrete Reinforcement
7	IS: 432 (Part 2)-1982	Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement – Hard Drawn Steel Wire
8	IS: 2062 –2011	Steel for General Structural Purposes. Specification
9	IS: 1161 –1998	Specification for Steel tubes for Structural Purposes
10	IS: 4923- 1997	Specification for Hollow steel section for structural use
11	IS: 800 – 2007	Code of Practice for General Construction in Steel
12	IS:1893-2016	Criteria for Earthquake resistant design of structures
13	IS :269 –1989	Specification for Ordinary, rapid hardening and low heat Portland cement
14	IS :455 -1989	Specification for Portland blast furnace slag cement
15	IS :1489 -1991	Specification for Portland Pozzolona Cement
16	IS :383 -1970	Specification for coarse and fine aggregates from natural sources for concrete
17	IS :516 -1959	Method of test for strength of concrete

18	IS:432-1982	Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel wire for Concrete Reinforcement
19	IS:4990-1993	Specification for plywood for concrete shuttering works
20	IS :2645 -1975	Specification for integral cement water proofing compounds
21	IS :2950 (Part 1)-1981	Code of Practice for Design & Construction of Raft Foundations
22	IS :1904-1986 Reaffirmed 2006	Code of Practice for Design and Construction of Foundations in Soil
23	IS: 1905	Code of practice for structural use of unreinforced masonry
24	IS :3370 (Part 2)-2009	Code of Practice for Concrete structures for storage of liquids
25	IS :4326-2013	Earthquake Resistant Design and Construction of Buildings
26	SP 16	Handbook for Structural Engineers
27	NBC 2016	National Building Code of India 2016
28	SP 34	Handbook on Concrete Reinforcement & Detailing
29	IS:16700-2016*	Criteria of structural safety of tall concrete building
30	IS 2911-1998	Code of Practice for Design and Construction of Pile Foundation
31	IS: 2950-1973	Code of Practice for Design and Construction of Raft Foundation
32	IS: 8009	Code of Practice for Calculation of Settlement of Foundation
33	IS: 6403-1981	Code of Practice for Determination of bearing Capacity of Shallow Foundation on Rock
34	SP: 20 -1981	Explanatory Handbook on Masonry Code.
35	SP: 22 -1982OMRF	Explanatory Handbook on Codes for Earthquake Engineering
36	IS: 15988: 2013	Seismic Evaluations and Strengthening of Existing Reinforced Concrete Buildings Guidelines

Note: The above list is suggestive and not exhaustive. Apart from these basic codes, any other related codes shall also be followed wherever required.

ANNEXURE – III