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STRUCTURAL DESIGN BRIEF REPORT FOR BRIGADE ICON AT MOUNT ROAD, CHENNAI.

For

M/s. Brigade Enterprises Ltd
No. 5/142, Rajiv Gandhi Salai, (OMR)
Perungudi, Chennai - 600096.

Structural Design Proof - Checked and Found Satisfactory

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BY

PRASAD CONSULTANTS
STRUCTURAL ENGINEERS

#G - 11 & G - 12 No.37 RAMANASHREE CHAMBERS CUBBON ROAD
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REV NO:	**R0**
DATE:	**12th April, 2023**
REV:	**R0**
REV DATE:	

PRASAD CONSULTANTS # G-1 No.37 CUBBON ROAD BANGALORE 560 001 STRUCTURAL DESIGNERS

STRUCTURAL CONSULTANTS	PEER REVIEW	CLIENTS
PRASAD CONSULTANTS, BENGALURU.	IIT MADARAS.	M/S Brigade Enterprises Ltd., BENGALURU.

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1.Introduction

1.1. Scope

This design basis report sets out the parameters and assumptions used in the design of the structure for Brigade Icon, at Mount Road, Chennai.

1.2. Project details

This report sets out the basic parameters used for the structural design of "Proposed construction of High Rise Group Development consisting of **Block – 1:** Ground Floor + 1st Floor (Utility Block -1), **Block – 2:** Ground Floor + 1st Floor (Utility Block – 2) & **Block – 3:** Extended Triple Basement Floors (1st Basement combined with Utility Block – 1 & Main Block) with **Front Part:** Ground Floor + 18 Floors **(Commercial Building)** & **Rear Part :** Ground Floor + Mezz.Floor (Parking) + 1st Floor (Parking) + 2nd Floor (Parking) + 3rd Floor (Swimming Pool, Gym, and Residential) + 4th Floor to 38th Floor **(Residential Building with 200 Dwelling Units)** at No. 180, 233/1, 233/2, 233/3, 233/5, 233/6, 116/2F66, Anna Salai (Mount Road), Thousand Lights comprised in R.S.No.322/1, Block No. 11, of Triplicane Village, Mylapore Taluk, Chennai – 600002, and Door No. 8/16, Smith Road, comprised in R.S.No. 321/3, Block No. 10 of Triplicane Village, Mylapore Taluk, within the limits of Greater Chennai Corporation.

The project Principal architects are SOG Design, Singapore and the Structural consultancy is being provided by M/s Prasad Consultants, Structural Engineers Bangalore.

The structural system adopted is as below based on preliminary analysis and design.

The building involves Mixed Use Development having 2 Towers: Residential Building and Commercial Building:

The **Residential Building consisting of 3-Basements + Ground floor + 38 Upper Floors & Terrace**

The **Commercial Building consisting of 3-Basements + Ground floor + 17 Upper Floors & Terrace**

A. Residential Building:

Floor to floor height for Residential Building as per Architectural drawing are as follows:

- Basement-3 to Basement-2 = 4.5m (SSL to SSL),
- Basement-2 to Basement-1 = 4.5m (SSL to SSL),
- Basement-1 to Podium Level = 4.5m (SSL to SSL),
- Basement-1 to Ground Floor Level = 5.25m (SSL to SSL),
- Ground Floor to Mezzanine = 3.05m



- Mezzanine level to L1 Floor level = 3.05m
- L1 Floor to L2 Floor = 3.05m,
- L2Floor to L3 Floor = 4.4m,
- L3 Floor to Service Floor = 4.45m,
- Service Floor to L4 Floor = 1.65m,
- Typical floors (L4 to L38) = 3.25m
- L38 to Terrace Level = 3.25m
- Terrace to Service (LMR/SHR/ OHT) = 4.5m.
- The overall height of the structure from Basement-3[86.50m (FFL)] to Terrace [RL=234.00 m (FFL)] is 147.50 m.

B. Commercial Building:

Floor to floor height for Commercial Building as per Architectural drawing are as follows:

- Basement-3 to Basement-2 = 4.5m (SSL to SSL),
- Basement-2 to Basement-1 = 4.5m (SSL to SSL),
- Basement-1 to Podium Level = 4.5m (SSL to SSL),
- Basement-1 to Ground Floor Level = 5.25m (SSL to SSL),
- Ground Floor to L1 Floor level = 5.0m
- L1 Floor to L2 Floor = 5.0m,
- L2 Floor to L3 Floor = 5.0m,
- L3 Floor to L4 Floor = 5.0m,
- Typical floors (L4 to L17) = 4.0m
- L17 to Terrace Level = 4.0m
- Terrace to Service (LMR/SHR/ OHT) = 8.0m.
- The overall height of the structure from Basement-3 [86.50m (FFL)] to Terrace [176.75 m (FFL)] is 90.25 m.

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1.3.Structural System

A. Residential Building:

- The proposed structural system for this project consists of RC Structural Walls, RC Beams and RC Slabs, which is proposed to be constructed by adopting the Aluminum formwork.
- RC Columns/ Shear Walls are spaced according to the framing plans based on the architectural requirement in order to transfer the loads from the Super Structure to the Foundation System.
- Basement to L3 level and extended podium area apart from the tower portion has been proposed with flat slab system (PT/Non-PT).
- As per service requirements, slabs for balconies are sunk by 150 mm. The slabs for utilities are sunk by 100 mm. The slabs for toilet areas are sunk by 100 mm in typical floor level.
- In this project, the Transfer Beams are located at L3 floor and Service floor level in order to support the Mivan structural Walls.
- Core cutting/sleeves shall be considered to accommodate utility services if any. Staircases are provided with mid landing between the floors as per the architectural Layout.

B. Commercial Building:

- The structural system proposed for this commercial building consists of a Flat Slab with drop supported on RC Column/Shear wall.
- For this building Post-tensioned flat slab has been considered on the basis of economy in the structural cost in comparison with conventional flat-slab system in addition to technical advantages. (with special feature as ductile structural wall & perimeter special moment resistance frame (SMRF)).
- RC Columns/Shear walls spaced according to the framing plan to transfer the loads from the superstructure to the foundation system.

Raft/Isolated/Combined footing shall be proposed for this structure.



1.4.Facilities:

The various facilities provided in each of the tower is as below:

Residential Building:

Basement- 3:	*Stack Parking/ Driveway / Ramp/ staircases/ Lifts/ Lobby/pump room / STP/ Store/ Services.*
Basement- 2:	*Stack Parking/ Driveway / Ramp/ staircases/ Lifts/ Lobby/ STP/ Store/ Services.*
Basement- 1:	*Stack Parking/ Driveway / Ramp/ staircases/ Lifts/ Lobby/IT room/ pump room/ UG sump/OWC/ Store/Toilet / Services.*
Ground Floor:	*Entrance Lobby/ Multi-Purpose Hall/ Indoor Games/ Service room/ Management room/ Main electrical room/Parking(Single)/ Two wheeler parking/ Driveway/ Ramp/ staircases/ Lifts/ Lobby/Services/ fire drive way with soil fill/Landscape.*
Mezzanine:	*Parking(Single)/ Two wheeler parking/ Driveway / Ramp/ staircases/ Lifts/ Lobby/Services.*
L1 & L2 Floor:	*Parking (Single)/ Driveway / Ramp/staircases/ Lifts/ Lobby/Toilet/Service rooms.*
L3 Floor:	*Residential units/ Multipurpose hall/ Gym/ Toilets/ Swimming pool/ staircases/ Lifts/Lobby/ Services.*
Service floor:	*Services*
Typical Floor: (L4 to L16, L18 to L25, L27 to L34.	*Residential Unit.*
Refuge Floor: (L17, L26 & L35)	*Residential Units/ Refuge area.*
Pent-Houses (L35 - L36 and L37 - L38).	*Residential Unit.*
Terrace	*Open Terrace with Services(Sky Garden/ SHR/ LMR and OHT as per service requirement)*

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Commercial Building:

Basement- 3	*Stack Parking/ Two wheeler parking/ Driveway / Ramp/ staircases/ Lifts/ Lobby/ pump room / STP/ Store/ Services.*
Basement- 2	*Stack Parking/ Two wheeler parking/ Driveway / Ramp/ staircases/ Lifts/ Lobby/ pump room / STP/ UG Sump/ Store/ Services.*
Basement- 1	*Stack Parking/ Two wheeler parking/ Driveway / Ramp/ staircases/ Lifts/ Lobby/ pump room / UG Sump/ Electrical room/ Services.*
Ground Floor	*Entrance Lobby/Retail shops/ Super Market/ Service rooms/ Plaza/ AHU room/ staircases/ Lifts/fire drive way with soil fill/Landscape.*
L1 Floor	*Retail Shops/ Electrical room /AHU room/ staircases/ Lifts/Toilet*
L2 Floor	*Retail Shops/ Dinning Hall/ staircases/ Lifts/Toilet/Open Terrace*
L3 Floor	*Retail Shops/ Cafeteria/ Restaurant/ Service rooms/Multi-purpose Pavilion/ staircases/ Lifts/Toilet/Outdoor Deck/Landscape.*
Typical Floor (L4, L6, L7, L9, L10, L12, L13, L15, L16)	*Office/ Electrical room/ AHU room/ ODU/ Toilet/ Server room.*
Refuge Floor (L5, L8, L11, L14 & L17)	*Office/ Electrical room/ AHU room/ ODU/ Toilet/ Server room/ Refuge area.*
Terrace	*Terrace with service (Kitchen/ Restaurant/ Service room/ Sky Garden/ SHR/ LMR/OHT as per service requirement/ Landscape).*

Plan Dimensions:

Residential Building:

X- Direction: Around 72.50 m (At Typical Floor lvl)

Y- Direction: Around 37.10 m (At Typical Floor lvl)

Z- Direction: 134.00 m (from Ground Floor to Terrace Level)

Commercial Building:

X- Direction: Around 106.60 m (At Typical Floor lvl)

Y- Direction: Around 26.80 m (At Typical Floor lvl)

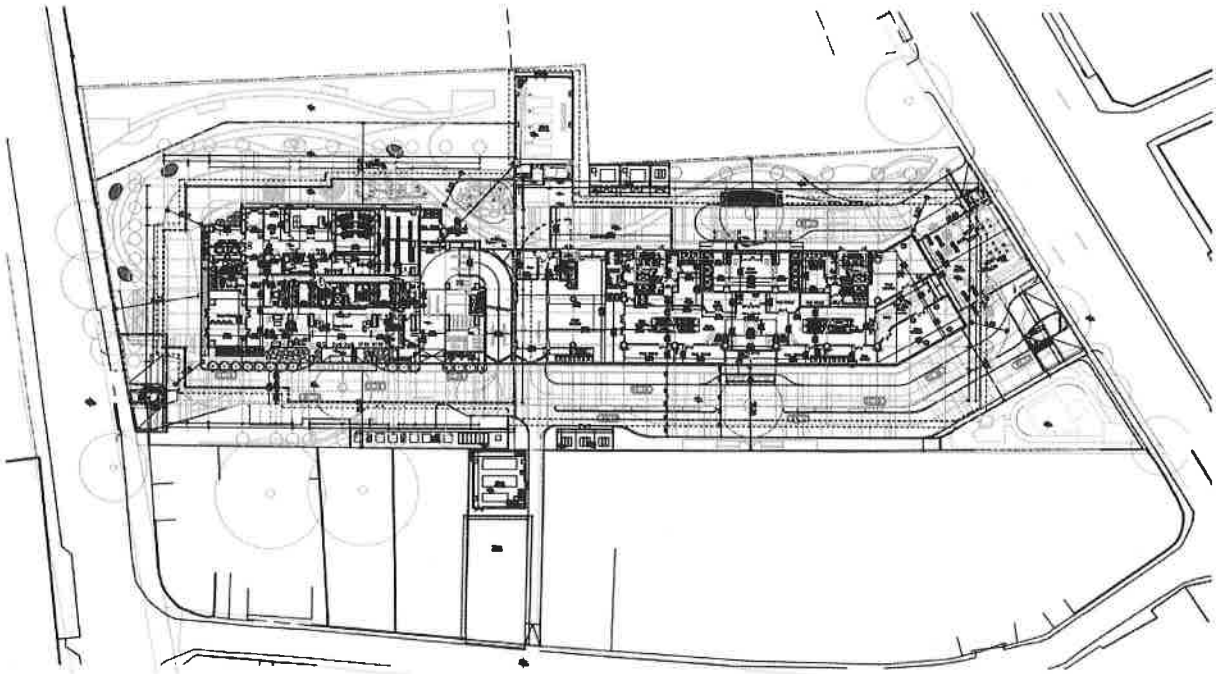
Z- Direction: 76.75m (from Ground Floor to Terrace level)

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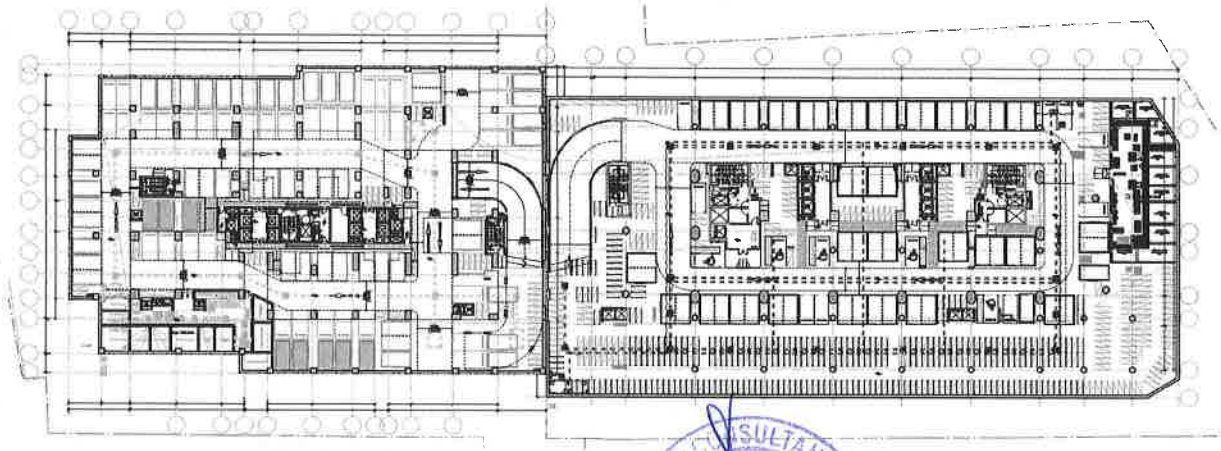
1.5.Key points

Main Municipal drain or any underground services to be identified and many have to be relocated due to construction activities. Our recent past experience in a similar kind of project has necessitated us to caution the client for action to be taken before the start of the excavation.

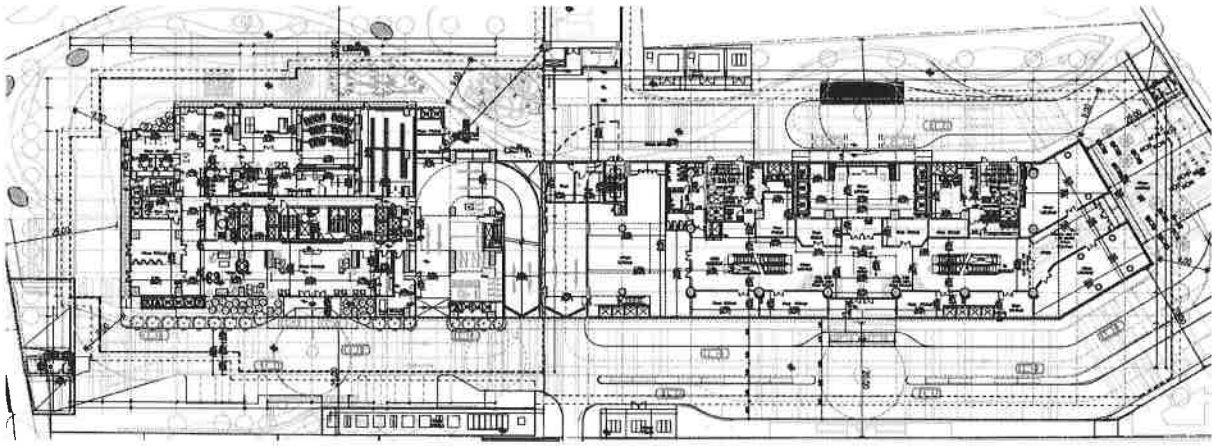
To keep the surface water entering to inside of the plot, proper bund is to be created at entry of the plot, so that the damage due to the same are minimized.



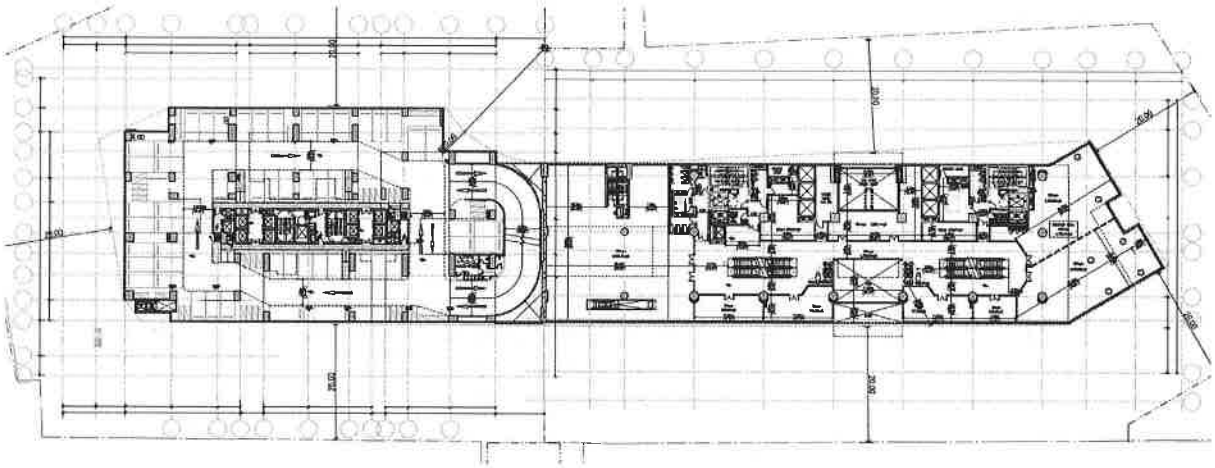
Key Plan



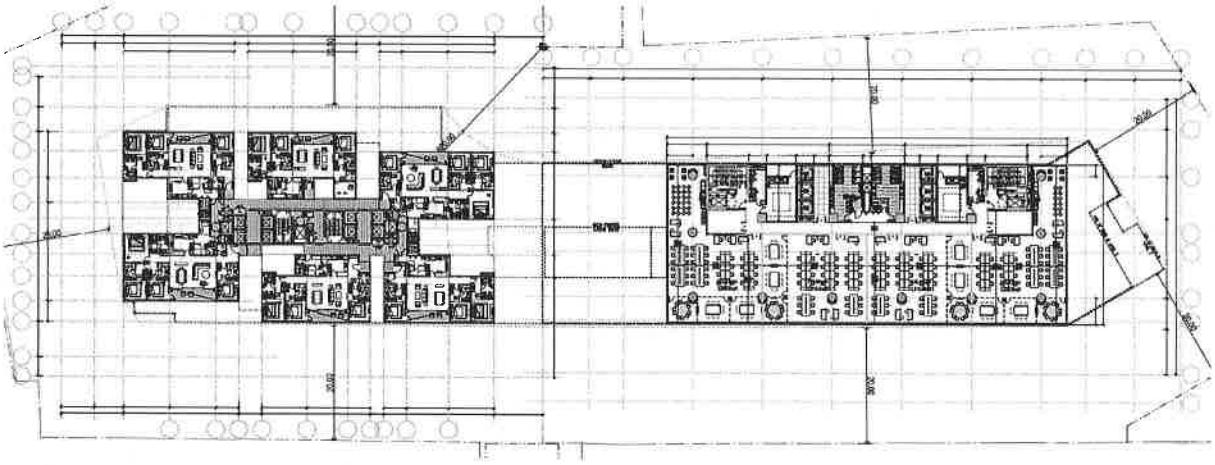
Basement Floor Plan



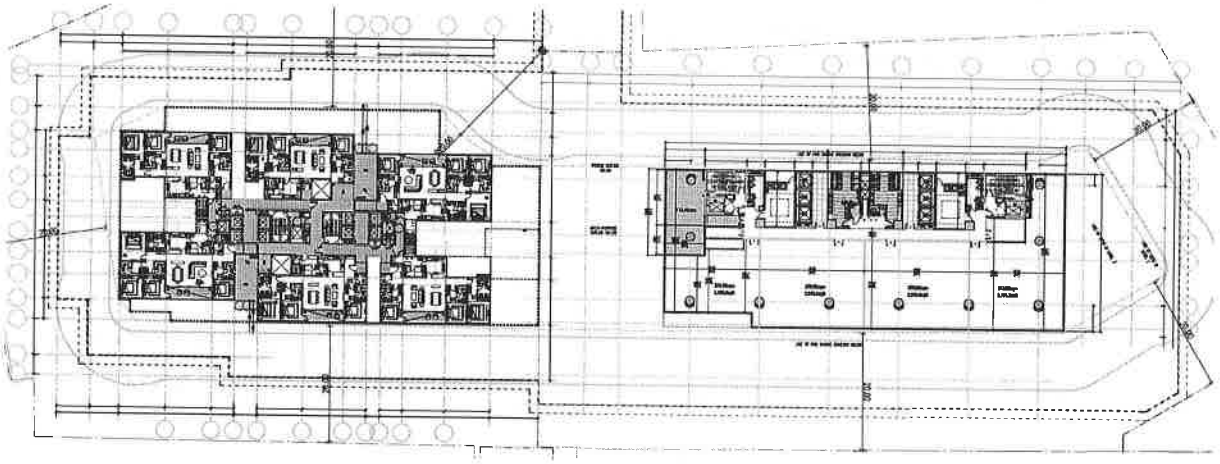
Ground Floor Plan:



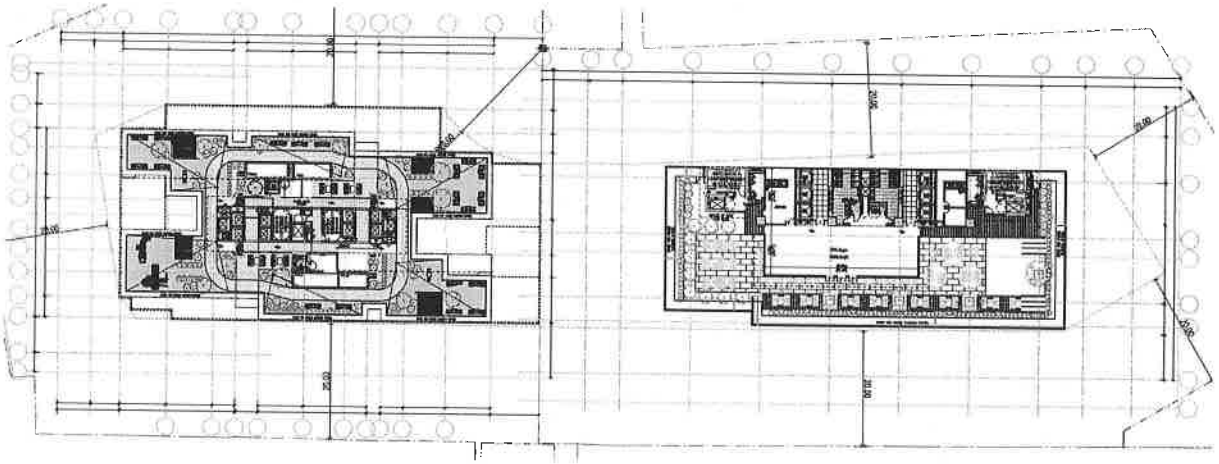
First Floor Plan:



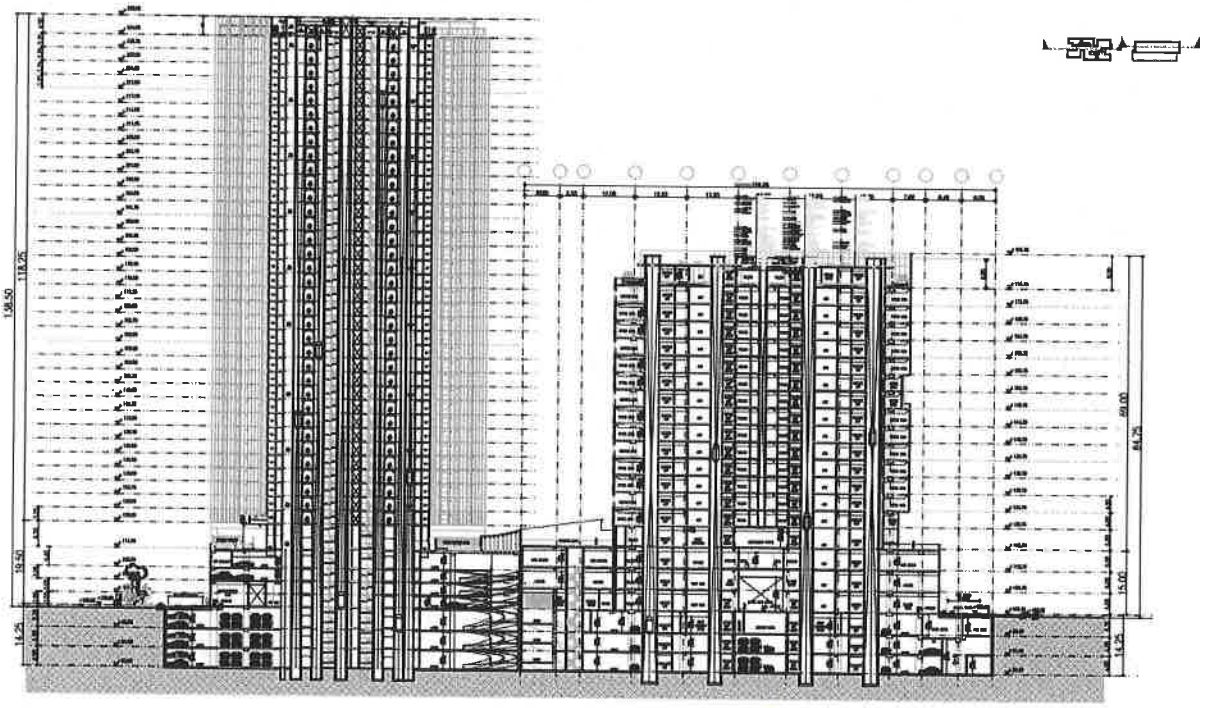
Typical Floor Plan:



Refuge Floor Plan:



Terrace Level Plan:



Section:

2. Codes and Standards

2.1 Statutory Requirements:

The design of structural and other building services will comply with the following requirements:

- National Building Code
- The Building Regulations
- The Environmental Protection Act in liaison with the Environmental Agency
- Fire prevention and detection in compliance with the local Fire Regulation

2.2 Design standards:

Specific applicable codes and standards will be identified and adopted in the design philosophies as appropriate to the structural elements. The latest editions of the Codes and Standards will be used in designs. All design work shall be based on Indian Standards and Codes with latest revision, with amendments if any, as on date.

The relevant Indian Standard Codes, as given below, shall be followed for structural design:

Publication Reference	Publication Title	Application of Publication
IS:875 Part 1–1987	Unit Weight of Materials	General & Loadings
IS:875 Part 2–1987	Live Loads	
IS:875 Part 3–2015	Wind Loads	
IS:875 Part 4–1987	Snow Loads	
IS:875 Part 5–1987	Special Loads and Combinations	
IS:456 - 2000	Plain and Reinforced Concrete – Code of Practice	Concrete
IS 1080 :1985	Code of Practice for Design and Construction of Shallow Foundations	
IS:1904–1986	Code of Practice for Structural Safety of Building Foundations	
IS:3370–2009 Part I & II	Code of Practice for Concrete Structure for the Storage of Liquids	
SP 16	Design Aid for Reinforced Concrete to IS 456:2000	
SP 23	Handbook on Concrete Mixes	
SP 24	Explanatory Handbook on Indian Standard Code of Practice for Plain and Reinforced Concrete	
IS:1893–2016	Criteria for Earthquake Resistant Design of Structures	Seismic
IS:13920–2016	Ductile Detailing of RCC Structures subjected to Seismic forces – Code of Practice	
SP 22	Explanatory hand book on codes for Earthquake Engineering	
IS 4326–1993	Code of Practice for Earthquake Resistant Design and Construction of building	
IS:1641–1988	Fire Safety of Buildings (General) : General Principles of fire grading and Classification	Fire
IS:1642–1989	Fire Safety of Buildings (General) : Details of Construction Code of Practice	
IS:2502–1963	Code of Practice for Bending and Fixing of bars for concrete reinforcement	Detailing
SP 34	Handbook on Concrete Reinforcement and Detailing	
IS:800–2007	General Construction in Steel – Code of Practice	
IS:2062–2011	Hot rolled medium and high tensile structural steel –	

	Specifications	
IS:816–1969	Use of metal arc welding for general construction in mild steel	Structural Steel
IS:9595–1996	Metal arc welding of carbon and carbon manganese steel	
IS:2950(Part:1) –1981	Code of Practice for Design & Construction of Raft foundation	Others
IS:1786–2008	Specification for High Strength deformed steel bars and wires for concrete reinforcement	
IS:16700:2017	Criteria for Structural Safety of Tall Concrete Building	

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3. Loading Criteria:

3.1.Dead Loads

All Dead Loads are established based upon the self – weight of the structure.

Weight of materials shall be calculated based on IS:875 Part 1

Description of Dead Loads of Materials	Load Magnitude (kN/m^3)
Unit weight of reinforced cement concrete	25.0
Unit weight of plain cement concrete	24.0
Unit weight of solid concrete block with plaster	22.0
Unit weight of steel	78.5
Unit weight of cement mortar/plaster	20.5
Filling material of sunken floors (Soil)	20.0
Filling material of landscaping (Soil)	20.0
Water load	10.0
Lime concrete with burnt clay aggregates	18.8
Unit Weight of Light Wt. Blocks	10.0

3.2. Superimposed Dead Loads [Ref: IS: 875 (Part-1) 1987]

The Superimposed Dead Loads are established based upon the type of finishes, services, Waterproofing type, glazing material, machinery type adopted in the structure

Description of Dead Loads of Materials	Load Magnitude (kN/m^2)
Floor finishes 50mm thk	0.05x24 = 1.2
Services @ Upper Floors	0.5
Services @ Ground floor and Basements	1.75 / 0.5
Main Electrical Panel Room at GF	10.0
AHU	5.0
Electrical Room (Typical floor)	5.0
Server Room/ UPS/Battery room	10.0
Glazing	6.0 (kN/m)
Movable Partition	1.0
Sunken Load – Toilet (100 mm) & Utility	2.0
Sunken Load –Balcony (150 mm)	3.0
Filling on Podium for fire driveway area (600 mm)	12.0
DG-Room	15.0
Store Room	4.0

Amenities	5.0
Collab space	12.0
Spare/BMS/ command room	5.0
Refuge Balcony	3.0 (150 mm)
Waterproofing at Terrace (150mm thk)	3.5
Lift Machine Room	15.0
Water tank Load/ Chillers	As per actuals
RCC Parapet 1.2m + Facade 1.2m (2.4m height)	12
Pump Room	10
Service platform	4
Solar Panels	4.0

3.3. Live Loads [Ref: IS: 875 (Part-2) 1987]

The Live Loads are established based upon the occupancy type in the structure.

Description of Live Loads	Load Magnitude (kN/m^2)
Residential Unit (Living hall, Bed rooms, Kitchen & Dining)	2.0
Residential Unit (Corridors/Balcony/Utility/Refuge)	3.0
Residential Unit (Staircase)	3.0
Workspace/Office	4.0
Office (Lobby / Corridor / Passage)	4.0
Toilets	2.0
Office Staircases	4.0
Parking (Single) With impact factor	3.125
Parking (Double) With impact factor	6.25
Ramp	5.0
Fire Tender (for 60MT)	20.0
Office Refuge Balcony	4.0
Ventilation panel/Communication room	4.0
Collab space	5.0
AHU	2.0
Spare room/facility room/BMS	2.0
Sports Area	4.0
Terrace	4.0

3.3.1 Live Load Reduction:

In accordance with IS 875: Part 2 – Section 3.2 Live load reduction is applied & has been considered in the ETABS model.

Sr. No	Number of floors (including the roof) to be carried by member consideration	Live Load reduction
1	1	0%
2	2	10%
3	3	20%
4	4	30%
5	5 – 10	40%
6	>10	50%

3.4. Wind Loads [Ref: IS: 875 (Part-3) 2015]

The Wind Loads are established based upon Location of structure, Geometry, Structure Class and Terrain category.

Wind Load Design Parameter Description	Symbol	Magnitude
Basic Wind Speed	V_b	50 m/s
Terrain Category	-	2.0
Risk Coefficient	k_1	1 (For design life of 50 years)
Terrain, Height & Structure Size factor	k_2	To suit the height of structure
Topography factor	k_3	1.0
Importance factor	k_4	1.0
Design Wind Speed	V_Z	$V_b X k_1 X k_2 X k_3 X k_4$
Design Wind Pressure	P_Z	$0.6V_Z^2$



3.4.1 Dynamic Analysis as per Cl.9

A. Residential Building:

Case a: Natural frequency criteria

$T_a = \frac{0.09h}{\sqrt{d}}$ $f_a = \frac{1}{Ta}$

h: Un-Supported Height of structure (Taken from Ground Floor to Terrace)

Along Direction	Dimension (m)	Height (m)	Time Period (s)	Frequency Hz	Gust factor Method Required
X-dir	75.50	134.00	1.388	0.720	YES
Y-dir	37.10	134.00	1.980	0.505	YES

Case b: Height To Minimum Lateral Dimension Ratio

Along Direction	Dimension (m)	Height (m)	Height/Length in consider direction	Gust factor Method Required
X-dir	75.50	134.00	1.77	No
Y-dir	37.10	134.00	3.61	No

Hence Dynamic analysis required as per Frequency criteria.

A. Commercial Building:

Case a: Natural frequency criteria

$T_a = \frac{0.09h}{\sqrt{d}}$ $f_a = \frac{1}{Ta}$

h: Un-Supported Height of structure (Taken from Ground Floor to Terrace)

Along Direction	Dimension (m)	Height (m)	Time Period (s)	Frequency Hz	Gust factor Method Required
X-dir	106.60	76.75	0.66	1.494	No
Y-dir	26.80	76.75	1.33	0.749	YES

Case b: Height To Minimum Lateral Dimension Ratio

Along Direction	Dimension (m)	Height (m)	Height/Length in consider direction	Gust factor Method Required
X-dir	106.60	76.75	0.72	YES
Y-dir	26.80	76.75	2.86	No

Hence Dynamic analysis required as per Frequency criteria.

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3.5. Seismic Loads [Ref: IS: 1893 (Part-1) 2016]

Dynamic analysis for earthquake forces in both the directions is carried out by Response Spectrum Method. Response Spectrum values are calculated based on the T/ (Sa/g) equations as per clause no 6.4.2 of IS: 1893 (Part 1)-2016. Base shears of the analysis are scaled to a factor of ($\overline{V_B}$/ V_B) as per clause no 7.7.2. Seismic loads for design of structures shall be considered as per IS: 1893 – 2016.

The following table provides the Seismic Load design parameters for the structure.

Seismic Load Design Parameter Description	Symbol	Magnitude
Zone Considered	-	III
Seismic Zone Factor	Z	0.16
Importance Factor	I	1.2
Response Reduction Factor	R	5
Soil Type	-	I (Hard Rock)
Damping Ratio	DM	1.05
Fundamental Period	T_a	$\frac{0.075h^{0.75}}{\sqrt{A_w}} \geq \frac{0.09h}{\sqrt{d}}$
Horizontal Seismic Coefficient	A_h	(Z/2)X(I/R)X(S_a/g)

Time period calculation as per Cl 7.6.2 IS 1893-2016

A. Residential Building:

T_x = 1.53sec

T_y = 2.197sec

Where, h = 134.0m from GF to Terrace level.

B. Commercial Building:

T_x = 1.075sec

T_y = 1.275sec

Where, h = 76.75m from GF to Terrace level.

As per 1893-2016, for flat slab system : Cl.7.2.6 Table-9-V shall be apply

a) Ductile RC Structural Walls (which are designed to resist 100% of the design lateral force) both X &Y-direction upto ground floor level.

b) Perimeter RC SMRF's designed for to resist 25%design lateral load independently upto GF level considering retaining wall and column along X and Y-direction.

Whenever imposed load is combined with earthquake load, the appropriate part of imposed load as specified in IS: 1893 – 2016 will be used for both evaluating earthquake effect and for combined load effects used in such combination.

Mass from Live Load for seismic load is considered as

If Live load ≤ 3kN/Sqm = 25%

If Live Load > 3kN/Sqm = 50%

The full weight from Self Weight and Super Dead Load are considered.

As per IS 1893 (Part 1):2016 (Clause 6.4.3.1) Stiffness modifiers of 70% shall be considered for Columns/Walls, 35% for beams and 25% for slabs

* Fire tender load is not considered for seismic mass in both ULS/SLS.

3.6. Temperature Loads

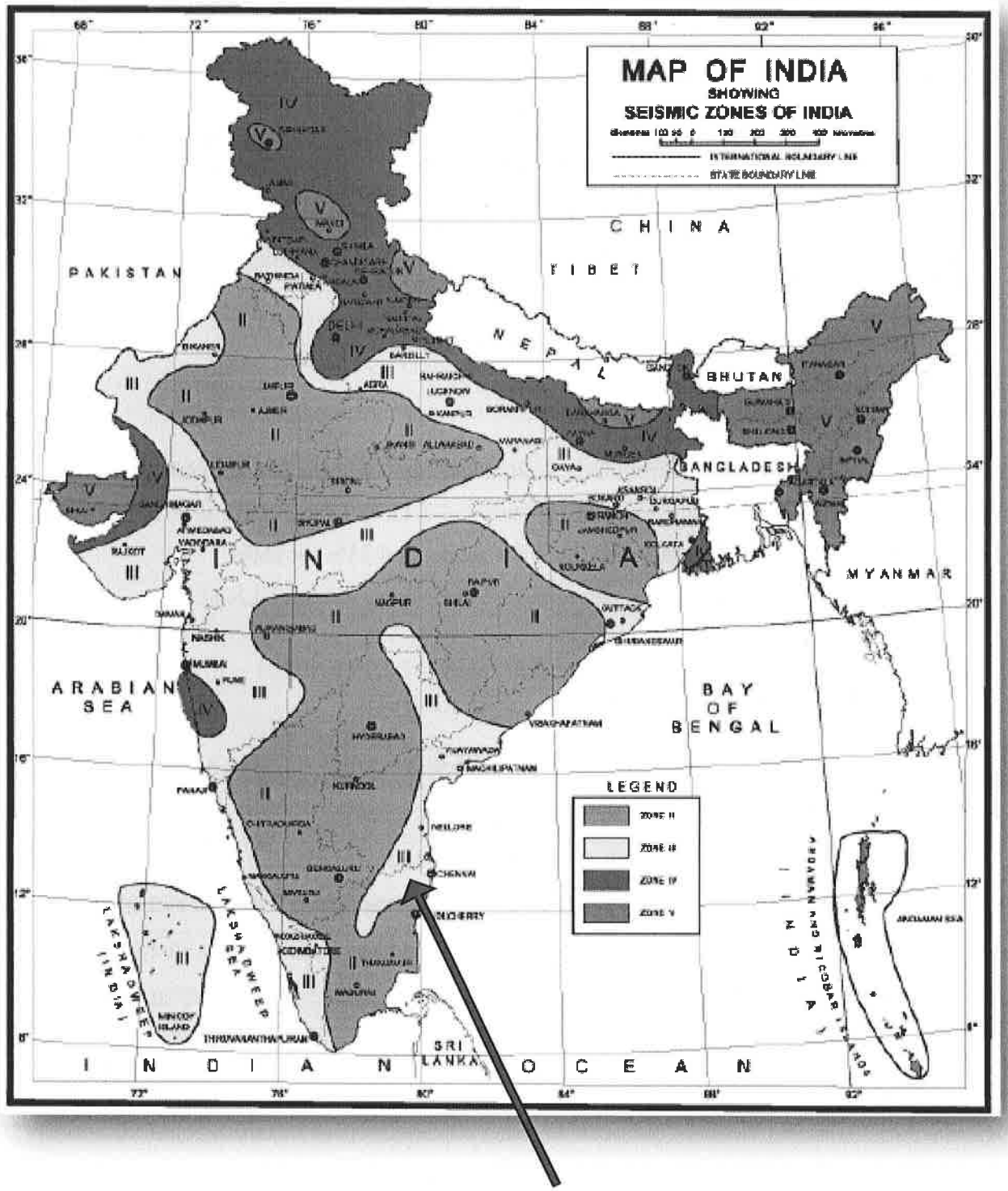
If length in plan exceeds by 45m, then either expansion joints needs to be provided or it is recommended to carryout temperature analysis for the same.

Location	Max. Outside Temperature	Min. Inside Temperature	Temperature gradient to be consider in design
Terrace(With 150mm water proofing)	45^0 C	15^0 C	(30-15) = 15^0 C (30^0 at top of slab)
Podium level (With 600mm Filling)	45^0 C	15^0 C	(25-15) = 10^0 C (25^0 at top of slab)

As the length of the building is about 110m, and shrinkage strips are provided at regular intervals (about 45m) in all slabs to minimize shrinkage cracks.

100 mm expansion joint provided between residential and commercial building.



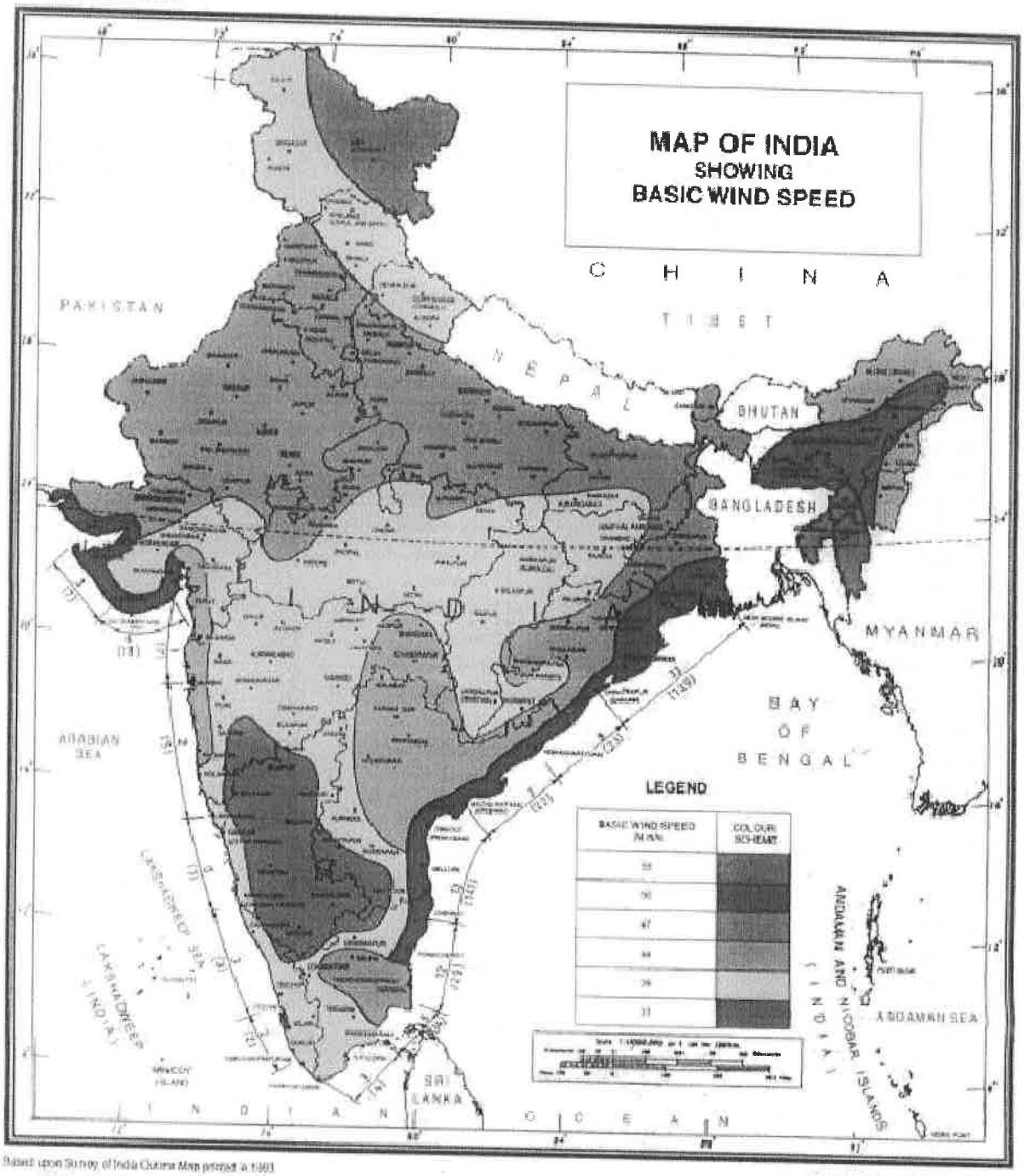


(Chennai falls under Zone-III)

Seismic Map of India

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IS 875 (Part 3) : 2015



Based upon Survey of India Outline Map printed in 1963

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The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.
The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.
Responsibility for correctness of internal details shown on the map rests with the publisher.
The state boundaries between Uttarakhand & Uttar Pradesh, Bihar & Jharkhand and Chhattisgarh & Madhya Pradesh have not been verified by Governments concerned.

FIG. 1 BASIC WIND SPEED IN m/s (BASED ON 50-YEARS RETURN PERIOD)

height of any object surrounding the structure is less than 1.5m. The equivalent aerodynamic roughness height, ($z_{o,t}$) for this terrain is 0.002 m. Typically this category represents open sea-coasts and flat plains without trees.

b) *Category 2*- Open terrain with well scattered obstructions having heights generally between 1.5 m and 10 m. The equivalent aerodynamic roughness height, ($z_{o,t}$) for this terrain is 0.02 m.

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ANNEX A

(Clause 6.2)

BASIC WIND SPEED AT 10 m HEIGHT FOR SOME IMPORTANT CITIES / TOWNS

City/Town	Basic wind Speed m/s	City/Town	Basic wind Speed m/s
Agra	47	Kanpur	47
Ahmedabad	39	Kohima	44
Ajmer	47	Kolkata	50
Almora	47	Kozhikode	39
Amritsar	47	Kurnool	39
Asansol	47	Lakshadweep	39
Aurangabad	39	Lucknow	47
Bahraich	47	Ludhiana	47
Bengaluru	33	Madurai	39
Barauni	47	Mandi	39
Bareilly	47	Mangalore	39
Bhatinda	47	Moradabad	47
Bhilai	39	Mumbai	44
Bhopal	39	Mysore	33
Bhubaneshwar	50	Nagpur	44
Bhuj	50	Nainital	47
Bikaner	47	Nasik	39
Bokaro	47	Nellore	50
Chandigarh	47	Panjim	39
Chennai	50	Patiala	47
Coimbatore	39	Patna	47
Cuttack	50	Puducherry	50
Darbhanga	55	Port Blair	44
Darjeeling	47	Pune	39
Dehradun	47	Raipur	39
Delhi	47	Rajkot	39
Durgapur	47	Ranchi	39
Gangtok	47	Roorkee	39
Guwahati	50	Rourkela	39
Gaya	39	Shimla	39
Gorakhpur	47	Srinagar	39
Hyderabad	44	Surat	44
Imphal	47	Tiruchirappalli	47
Jabalpur	47	Trivandrum	39
Jaipur	47	Udaipur	47
Jamshedpur	47	Vadodara	44
Jhansi	47	Varanasi	47
Jodhpur	47	Vijayawada	50
		Vishakapatnam	50

Basic Wind Speed Table for different cities

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4.0. Load Combinations

4.1. Load Resistance Factor Design for RC Members

The various loads shall be combined with the stipulations in IS: 875 (part 5 – 1987). The combination whichever is critical shall be considered for designing the structure.

Load Combination	Limit State of Collapse				Limit State of Serviceability			
	DL	LL	TL	WL/EL	DL	LL	TL	WL/Resp
DL+LL	1.5	1.5	-	-	1.0	1.0	-	-
DL+/-WL(+/-El)	1.5 / 0.9	-	-	1.5	1.0	-	-	1.0
DL+/- TL	1.4	-	1.4	-	1.0	-	1.0	-
DL+/- EL	1.5 / 0.9	-	-	1.5	1.0	-	-	1.0
DL+LL+/-WL(+/-EL)	1.2	1.2	-	1.2	1.0	1.0	-	0.8
DL+LL+/-TL	1.05	1.275	1.05	-	1.0	0.8	0.8	-

This value is to be considered when stability against overturning or stress reversal is critical. Wind and Earthquake load shall be considered for both X and Y direction.

Note: 1.05 load factors considered for fire tender in load combinations and fire tender load is not considered in lateral load combinations.

Notations -

DL - Dead Load

LL - Live / Imposed Load

WL - Wind Load (Either X or Y Direction)

EL - Earthquake Load (Either X or Y)

TL - Temperature Load

Resp – Response/Spectral Case (Either X or Y).



5.0. Materials

5.1. Design Life

In accordance with the Contract Documentation all the buildings defined under Section 1.2 of this report shall achieve a design life of 50 years.

5.2. Concrete

The following provides the principle materials specification for concrete adopted for the buildings defined under Section 1.2 of this report. This covers concrete strength, reinforcement, Concrete cover provisions and durability recommendations.

5.2.1. Concrete Strength

The following table provides the principle materials specification for concrete adopted for the buildings defined under Section 1.2 of this report. In the event that specific values are higher than those specified opposite, these are defined on the associated General Notes Drawings.

Type of Structural Member	Design Cube Compressive Strength, F_{ck} (MPa)
Foundation (Tower Area)	M50
Foundation (Non – Tower Area)	M50
Stitch Slab	M30
Retaining wall	M35
Columns	M70/M60/M55/M50/M40*
Shear Walls/ Lift Wall	M70/M60/M55/M50/M40*
Tower Drop Panels (PT/Non-PT)	M70/M60/M55/M50/M40*
Non-Tower Drop Panels (PT/Non-PT)	M40
Beams & Slabs (PT/Non-PT)	M40
Staircase / Ramp	M30
UG Sump / STP	M35
OHT	M30

*Residential Building:

M70 – Foundation to L8 Floor level.

M60 – L8 Floor leveltoL15 Floor level

M55 – L15 Floor level to L20 Floor level

M50 – L20 Floor level to L25 Floor level

M40 – Above L25 Floor level

M40 – Non-Tower Area Columns

Commercial Building:

M70 – Foundation to L4 Floor level.

M60 – L4 Floor level to L8 Floor level.

M55 – L8 Floor level to L12 Floor level

M50 – L12 Floor level to L15 Floor level

M40 – Above L15 Floor level

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5.2.2. Concrete Cover

The following table provides the principle Concrete Cover to reinforcement for the buildings defined under Section 1.2 of this report. In the event that specific values are higher than those specified here, these are defined on the associated General Notes Drawings.

Type of Structural Member	Concrete Cover(mm)
Raft / Footing	50 in contact with soil 75 exposed to atmosphere
Columns	40
RC Walls/ Shear Walls	30
Slabs	25
Beams	30
Staircase / Ramp	25
Retaining Wall	50 on earth retaining side 30 on non-earth retaining side
Water Tank	50

For the design of sub structure moderate type of exposure condition and super structure mild exposure condition is considered.

5.2.3. Reinforcement Material

All reinforcement steel shall conform to IS: 1786 – 2008 having minimum yield strength of 550 N/sq.mm. (Fe550D) Bar size 8, 10, 12,16,20,25 & 32mm.

5.2.4. Structural Steel

Structural Steel grade for columns, beams and braces considered combination of E350 and E410 and the material shall be as per the structural specifications.

5.2.5. Reinforcement Dimensions

The following table provides the principle concrete Reinforcement Dimensions for the building facilities under defined under Section 1.2 of this report.

Diameter of Reinforcement (mm)	Area in (mm^2)	Weight in (kg/m)
8	50.3	0.395
10	78.54	0.617
12	113.09	0.888
16	201.06	1.579
20	314.18	2.467
25	490.87	3.855
32	804.24	6.316

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6.0. Geotechnical

6.1. Soil Recommendation by Geo Marine Consultants (P) Ltd.

Following are the soil recommendations given by **Geo Marine Consultants (P) Ltd.**

GEOMARINE

CHAPTER-6

RECOMMENDATIONS

6.1 RECOMMENDATION FOR THREE BASEMENT FLOOR:

- For the kind of sub soil conditions and the proposed construction with three basement floors, R.C.C Raft can be provided as foundation system.
- The raft can be located at a depth of 13.0m below the existing ground level and shall be designed for an allowable safe net bearing pressure of 1200 kPa.
- Since the formation at the founding level is dense to very dense formation and beyond being rock formation, the settlement will be of immediate in nature and the estimated settlement for the corresponding safe bearing pressure is within the permissible limit as per IS 1904.
- The present project site falls in seismic zone-III as per IS 1893-P-I
- The recommended modulus of subgrade modulus ks is 75,000 kN/m3

6.2 GENERAL RECOMMENDATIONS:

- The chlorides content in ground water & soil-water extract is less than the permissible limit of 500 mg/l as per IS 456 Table 1.0. Hence no special reinforcement is required for the construction.
- Corresponding to the sulphate content in 2:1 Water-Soil extract and ground water use Table 4.0 of IS 456 Clause 1.0 for minimum cement content and maximum water cement ratio. Hence ordinary Portland cement can be used.
- *Before excavation is started a workshop shall be conducted including the Owner, Architect, Structural Engineer, Geotechnical Engineer and Execution agency to ensure the proposal given by the contractor is workable and safe.*
- *Before construction activities are initiated, a scientific due-diligence of the condition of the neighbouring structures shall be carried out and authenticated. This is required to ensure that no undue claims or interpretations are made by the neighbourhood that the construction activities cause damages to their structures*

AUTHORISED SIGNATORY

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DR. C.V. PRASAD,
GEOMARINE CONSULTATNS PVT LTD.,

The recommended allowable bearing pressure for Raft type of foundation is 120 T/m^{2}at founding level (i.e. at 2m from Basement-3 level), as per soil report.

Based on the soil report, Uplift / water pressure to be considered at EGL for design of stitch slab & retaining wall.



7.0. Serviceability Performance

7.1. Dead Loads & Live Loads Deflections

The maximum short-term deflection will be limited to span/350 or 20mm whichever less is considered. And the overall deflection including the effects of creep and shrinkage will be limited to span/250.

7.2. Lateral Drift at roof

Description	Load Combination	Limit
Lateral Drift	Wind (Overall Building)	H/500
	Seismic Lateral force (Inter Story drift)	0.4% of Floor to Floor height

Lateral drift at the roof under design lateral force shall not exceed 0.1 percent.

7.3. Crack Width

Crack width is considered to be satisfactory if its value calculated corresponding to the applied loads on the structure and the actual reinforcement ratio does not exceed the acceptable limits.
For reinforced concrete structures, the crack width will be limited to the following:

Exposure Condition	Crack Width (mm)
Normal	0.2
Severe	0.1



8.0. Fire Resistance

8.1. Fire Resistance Ratings

As per IS: 456-2000 for RC members

As per IS: 456-2000, under heading 2.1 Fire Resistance, the minimum thickness should be as follows (Table 16-A):

Fire Endurance (Hours)	Minimum Concrete Cover for RC Beam	
	Support Type	
	Simple Supported	Continuous
2	40	30
Fire Endurance (Hours)	**Minimum Concrete Cover for RC Slab**	
	Support Type	
	Simple Supported	**Continuous**
2	35	25
Fire Endurance (Hours)	**Minimum Concrete Cover for RC Columns**	
2	40	
Fire Endurance (Hours)	**Minimum Beam Width (mm)**	**Minimum Slab thickness (mm)**
2	200	125
Fire Endurance (Hours)	**Exposure Type**	**Minimum Column Dimension (mm)**
2	Fully Exposed	300
	50% Exposed	200
	One face Exposed	160

As per IS:456-2000 21.3, the reinforcement detailing should reflect the changing pattern of structural sections & ensure that both individual elements & structure as a whole contain adequate support, bonds & anchorages for the required resistance.

For 2hr fire rating the minimum percentage of vertical reinforcement is 0.4%. However, considering 500^0 C isothermal. The minimum percentage of 0.25% can be adopted as per Euro code.

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9.0. Structural Modeling

9.1. Design Software

The following table provides details of the Design Software that will be used for the structural design of the building facilities defined under Section 1.2 of this report.

Software Details	Developer	Design Use
ETABS	CSI Berkeley	General Structural Analysis & Design
SAFE	CSI Berkeley	Concrete Structural Analysis & Design
ETABS	CSI Berkeley	Lateral Structural Analysis



10.0. Structural Analysis and Design

10.1 Super Structure:

- The building has been analyzed as a 3-dimensional skeletal structure using **ETABS 19.1.0**
- Beams and columns shall be assigned as frame elements while RC walls and Slabs are assigned with shell elements.
- The columns shall be restrained against rotation/translations at foundation.
- The slab has been considered as a rigid diaphragm.
- Appropriate load and its combinations, as per relevant clauses in the latest IS codes for most unfavorable effects are chosen for design.

P-Delta effect:

In high-rise buildings, the P-delta effect can have a big impact on the overturning moment. The P-delta effect is a second order effect and is caused by the axial force and the displacement of the structure. When designing high-rise buildings in seismic zones this effect is of even greater importance due to the swaying of the buildings. If the swaying of the building is large and therefore creates a large displacement, the overturning moment could cause damage to the building. To avoid damage or collapse due to the P-delta effect, the lateral stiffness or the strength of the building must be increased. Since this phenomenon is most common in seismic zones, calculations on the P-delta effect will not be included in this dissertation. **P-delta analysis done as per Cl.7.3.9 IS: 16700-2017**

Stiffness Modifiers:

As per IS 16700:2017 Clause 7.2.C. Table-6, stiffness modifiers are applied on structural elements to consider the effect of cracked section in checking the lateral displacements and drift of the structure. Two identical geometry models with & without stiffness modifier will be used for design & serviceability check.

Structural Element	Un-Factored Loads		Factored Loads	
	Area	Moment of Inertia	Area	Moment of Inertia
Slabs	1.0 Ag	0.35 Ig	1.0 Ag	0.25 Ig
Beams	1.0 Ag	0.70 Ig	1.0 Ag	0.35 Ig
Columns	1.0 Ag	0.90 Ig	1.0 Ag	0.70 Ig
Walls	1.0 Ag	0.90 Ig	1.0 Ag	0.70 Ig

10.2 Sub-Structure:

For the Tower Area plate on the Winkler bed (FEM) has been adopted for the analysis of the RAFT/ Strip /Isolated foundation using RCDC/SAFE 20.0.0 and for Non-Tower area isolated footings with stitch slabs analyzed and designed.

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10.3 Design Methodology

- All RCC Structures shall be designed according to Limit State Method as specified in IS: 456 – 2000 and checked for serviceability.
- As per Clause 5.7.2.3 of IS 16700, no lapping of bars shall be allowed in R.C columns and walls when diameter of bars is 16mm or higher. Mechanical couplers as per IS 16172 shall be used to extend bars
- Steel structures if any, shall be designed as per IS: 800-2007.
- Water retaining structures such as Overhead water tank, Sump tanks and STP are designed as per IS: 3370 – 2009.
- For design of retaining walls and other earth retaining structures, the loads considered will be based on the soil properties of the filling materials and the design will conform to IS: 456 – 2000 with maximum crack width of 0.3mm.

10.4 Conceptual Design Examples and Calculation Methods:

10.4.1 Design of Foundation.

Based on the soil parameters given in the soil test report, foundation for the tower and non-tower columns are designed as Raft/isolated foundations with Stitch slabusing SAFE/ RCDC/Spread sheets.

10.4.2 Design of Columns/Walls:

The thickness of all RC Walls are 250/200/160 mm for MIVAN, IS 456 provides minimum wall thickness requirements based on the specified Fire Resistance Rating. Figure indicates the current requirements for specified FRR.

Based on typical design considerations for high-rise buildings in the range of 70-150 m, the reinforcement requirement in the walls generally ranges from 0.25%– 0.8% except for the base level walls of the first few floors. Thus, considerations for a reinforcement ratio of 0.4 – 1.0% are looked at. For 2 HR FRR, minimum wall thickness is noted at 160 mm.

Fire Resistance h	Minimum Beam Width b	Rib Width of Slabs b_w	Minimum Thickness of Floors D	Column Dimension (b or D)			Minimum Wall Thickness		
				Fully Exposed	50% Exposed	One Face Exposed	p<0.4%	0.4%≤p≤1%	p>1%
	mm	mm	mm	mm	mm	mm	mm	mm	mm
0.5	200	125	75	150	125	100	150	100	100
1	200	125	95	200	160	120	150	120	100
1.5	200	125	110	250	200	140	175	140	100
2	200	125	125	300	200	160	–	160	100
3	240	150	150	400	300	200	–	200	150
4	280	175	170	450	350	240	–	240	160

NOTES

1 These minimum dimensions relate specifically to the covers given in Table 16A.

2 p is the percentage of steel reinforcement.

FIG. 1 MINIMUM DIMENSIONS OF REINFORCED CONCRETE MEMBERS FOR FIRE RESISTANCE

Fig – 2: IS 456 – Fig. 1 on Page 34 – Minimum Dimensions of RCC Members for Fire Resistance

Columns are designed using design module of ETABS software. Ductile detailing is done for the columns since Special Moment Resisting Frame (SMRF) as per code.

The Core walls and concrete walls are modelled in ETABS along with building model as shear walls. The designs are made using ETABS/spread sheet and ductile detailing is done for the shear walls as per code.

10.4.3 Design of Ramps and Staircases

Loads due to stairs and ramps are taken care in the analysis model by modelling them as slab elements. However, the analysis and design of the same are made using spread sheets or manual calculations.

10.4.4Design of Beams

The RC beams are designed using design module of ETABS as per IS: 456-2000 and ductile detailing is done as per code.

Torsion in Beams:

Except for the locations where there is an unbalanced moment either due to large cantilevered slabs, or due to presence of some openings, or due to long span beam resting on the cantilever beam, we should release the torsional effect from the beams. Slabs, in general case, nullify the effect of torsion in beams.

10.4.5 Design of Slabs

Slab panels resting on beams/walls are designed using excel calculation sheets confirming to IS: 456-2000 and flat slab using SAFE.

10.4.6 Design of Retaining walls

Retaining walls are modelled in Staad-Pro/ETABS/Prokon. The designed are made using excel calculation sheets confirming to IS: 456-2000.

Detailing of RCC Structures:

Detailing of the RCC elements are done as per Indian Standard handbook SP-34-1987 and IS 13920 :2016

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Zoning & Land Use Analysis

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Property Documentation & Workflow Tools

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