Proposed Residential Project for BSCPL,Chennai



PROJECT REFERENCE:

IECP-190

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STRUCTURAL DESIGN BASIS REPORT

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innotech Transform Thoughts

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TABLE OF CONTENTS

1.0 PREAMBLE 3

2.0 STATUTORY REQUIREMENTS 3

3.0 AIM OF THIS REPORT 3

4.0 SALIENT FEATURES OF PROJECT 3

5.0 DESIGN PHILOSOPHY: 5

6.0 CODES AND STANDARDS 6

7.0 MATERIALS 9

8.0 STRUCTURAL ANALYSIS & DESIGNS 24

9.0 DRAWINGS 39

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1.0 PREAMBLE

M/s.BSCPL are developing a Multi-storeyed residential development at Chengalpattu, Chennai with project name called Zion Phase 2. Architecture conceptualized by inhouse architects M/s. RSP Architects, Bangalore. Innotech engineering consult Pvt. Ltd has been appointed as the structural consultant for this prestigious project.

2.0 STATUTORY REQUIREMENTS

The design of the Structure will comply to the requirements of the following:

- National Building Code - NBC 2016
- Bureau of Indian standard codes
- International codes like ACI, Euro & BS Codes wherever required.

3.0 AIM OF THIS REPORT

The Structural engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed civil, architectural and structural design of all structures.

The aim of this design basis report is to identify and record all the provided input, analysis and design to an acceptable probability that the structure is being designed for and will perform satisfactorily during its life span.

This report provides structural concepts/scheme which is compatible with the architectural intent satisfy the services for functional needs and confirming to the Indian standards to achieve safe, stable and optimal economic structure.

4.0 SALIENT FEATURES OF PROJECT

Site Location

The site is located at Chengalpattu, Chennai

Building Description

The phase 2 has 8 Residential Blocks & Retail Space

Residential Tower - B + GF + 28 Floors + Terrace floor

Block N – B + Stilt floor + 16 floor + Terrace

The entire campus is designed for a built up area of 238716 Sq.ft (22177.44 Sqm)

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BLOCK F&G	
Height of the building(From Foundation)	90.05 m
Tower dimension along X-axis	22.72 m
Tower dimension along Y-axis	43.80 m

BLOCK H&J	
Height of the building(From Foundation)	90.05m
Tower dimension along X-axis	46.90 m
Tower dimension along Y-axis	22.62 m

BLOCK L&M	
Height of the building(From Foundation)	90.05m
Tower dimension along X-axis	49.52 m
Tower dimension along Y-axis	23.63 m

BLOCK K	
Height of the building(From Foundation)	90.05m
Tower dimension along X-axis	42.63 m
Tower dimension along Y-axis	22.64 m

BLOCK N	
Height of the building(From Foundation)	90.05m
Tower dimension along X-axis	18.12 m
Tower dimension along Y-axis	39.47 m

Description for Towers	
No. of Floors	1 Basement + Ground + 28 floors + Terrace 1 Basement + Ground + 16 floors + Terrace
Shape of Building	Rectangular
Type of floor slab	Wall Slab system
Basements	Parking and MEP Services

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Ground	Parking+ MEP
First Floor	Transfer floor + Residential Units
Typical Floors	Residential Units
Terrace	Accessible Terrace

Structural description – Residential Tower	
Description of the foundation	Isolated and Combined Footing
Columns, core walls, shear walls, beams and slabs in the	Shear walls –500mm thick upto First Floor, Columns – Varies, As per the Dwg Beams – Varies, As per the Dwg
Ground Floor - Tower Area	Flat Plate System
Ground Floor - Non Tower Area	Waffle Slab
SBC as per soil report	100 T/m^2
Slab on grade for the Basement	150 thick Grade slabs

The basements has been exclusively designed for car park, drive way and water treatment plant. The Ground floor slab is designed for Car park, fire driveway, electrical meter room , swimming pool and landscaping according to architectural/services drawing (Awaited).

Columns/walls in basement will be worked out based on car parking and driveway location.

Typical floor from Second floor and above floors will be of Wall slab system.

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5.0 DESIGN PHILOSOPHY:

5.1 CONCRETE STRUCTURE

The proposed structure is to have a cast in-situ concrete construction. The systems adopted is with Reinforced concrete columns , shear walls and Beam and slab system is adopted .

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The Structural design of the proposed project is based on Indian Standard Codes and is analysed for Dead, Live, Wind and Seismic Load conditions taking into relevant load combinations recommended by the code & the structural elements are designed in limit state design as per IS Code.

The Vertical Loads including the dead and super imposed loads and the Lateral loads due to wind and seismic forces are transferred to the soil through proposed Reinforced Concrete Core Walls/Shear Walls, columns and foundations. Footings/Foundations are sized with consideration to the safe bearing capacity of soil at the level of transfer of load recommended by specialist soil investigation consultants.

5.2 DESIGN LIFE

The design life of the building is assumed as per IS code recommendation satisfying for the criteria of environmental conditions. This requirement is applicable only for concrete works and not applicable to replaceable finishing materials, water proofing membrane and thermal insulations (if any). Hence periodic maintenance / refurbishment are required for all replaceable material for longer life.

5.3 LIQUID RETAINING STRUCTURES

Following are the considerations for the design of liquid retaining structures by limit state method.

- Crack width
- Strength and deflection.

5.4 DESIGN INTERFACE

This structure has physical interface with almost all the disciplines like Geotechnical, MEP Services and Landscape etc. The Structure proposed is of cast in-situ concrete construction with Columns, RC shear walls and suitable slab system at all floor and terrace level.

6.0 CODES AND STANDARDS

Specific applicable codes and standards shall be identified in the Design Philosophy as appropriate. The latest editions of the Codes and Standards shall be used. All design work shall be based on Indian Standards and Codes latest revision, with amendments if any, as on date.

Following are the Indian CODES and STANDARDS followed while designing the structure:

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6.1 LOADINGS

Code of Practice for Design Loads (Other than Earthquake) for Building and Structures

IS: 875 -1987 (Part 1)	Dead Loads –Unit Weights of Buildings Materials and Stored Material.
IS: 875 -1987 (Part 2)	Live loads or Imposed Loads
IS: 875 -2015 (Part 3)	Wind Loads
IS: 875 -1987 (Part 5)	Special Loads and Load Combinations

6.2 DESIGN OF REINFORCED CONCRETE ELEMENTS

IS: 456 – 2000	Code of Practice for Plain and Reinforced Concrete
IS: 1786-2008	Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
SP: 16	Design aid for reinforced concrete to IS: 456.
SP: 23	Hand book on concrete mixes
SP: 24	Explanatory hand book on code of practice for PCC
IS 10262- 2009	Recommended Guidelines for Concrete Mix Design.
SP: 34	Hand book On Concrete Reinforcement and Detailing
IS 13920-2016	Ductile design and detailing of reinforced concrete structures subjected to Siesmic forces.

6.3 STRUCTURAL STEEL ELEMENTS

IS: 800-2007	Code of practice for general construction in steel.
SP: 6-(1)-1964	Hand book on structural steel sections.
IS: 2062 -2011	Indian standard Code of Practice for Hot rolled and high tensile structural steel – specifications

6.4 LIQUID RETAINING STRUCTURES

IS: 3370 (Part-2)-2009	Concrete Structures for Storage of Liquids –code of Practice.

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6.5 DESIGN FOR EARTHQUAKE RESISTANCE

IS: 1893 (Part-1)-2016	Criteria for Earthquake Resistant Design of Structures
IS: 4326: 1993	Earthquake resistant design and construction of buildings code of practice.
IS: 16700: 2017	Criteria for Structural Safety of Tall Concrete Building **(if building height exceeds 50m)**

6.6 EARTHWORK

IS 3764-1992	Code of safety for Excavation work

6.7 SOIL AND FOUNDATION

IS: 8009: 1976	Code of practice for calculation of settlements of foundations.
IS: 1904-1986	Indian Standard Code of practice for Design & Construction foundations in Soil: General Requirements.
IS 2950 (Part1)-1981	Indian Standard Code of Practice for Design & Construction of raft foundation – (Part –1)

6.8 FIRE SAFETY OF BUILDINGS

IS: 1642-1989	Indian Standard Code of practice for Fire Safety of Buildings (General): Details of Construction.
ANSI/UL263	Fire resistance rating

6.9 MECHANICAL COUPLERS

IS: 16172-2014	Reinforcement concrete for Mechanical splices of bars in concrete Specifications.

In case of 'no clarity' or 'non availability, of any regulation/ limitations for any particular criteria, and also to achieve Value Engineering in terms of design and detailing,if there is not enough clarity in Indian Codes, appropriate British standards and ACI-318-2011 shall be followed.

6.10 INTERNATIONAL STANDARDS FOR REFERENCE

ACI: 318-2014	Building Code Requirement for Structural Concrete.
ASCE: 7-05	Minimum Design Loads for Buildings and other structures.
UBC: 1997	Uniform Building Code.
BS 8110 -1: 1997	Code of Practice for design and Construction.

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7.0 MATERIALS

Materials specified will confirm to the latest edition of the relevant Indian Standards or other accepted standard. Specifications for materials will include for sampling and testing as stipulated in the design standards. Detailed material specifications will be included in the Technical Specification.

7.1 REINFORCEMENT STEEL

All reinforcement shall confirm to IS: 1786–2008 having minimum yield strength of 500 N/sq mm,550D N/sq mm can also be used however all design will confirm to 500 N/ Sqmm

Young's Modulus	: Es	200,000 N/Sq mm
Yield Stress	: fy	500 N/Sq mm
Diameters [in mm]	: d	8, 10, 12, 16, 20, 25 & 32
Density	:	78.5kN/cum

7.2 STRUCTURAL STEEL

All structural steel shall confirm to IS -2062-2011.

Grade : E-350	
Tensile Strength	350 N/Sq.mm
Yield Stress	250 N/Sq.mm (for t<20mm) 240 N/Sq.mm (for 20mm < t < 40mm) 230 N/Sq.mm (for t > 40mm)

7.3 CONCRETE

Compressive Strength of concrete:

Durability provisions for concrete structures shall be as per "Severe" conditions of environment in –accordance with IS 456: 2000. However, water retaining structures (UG sump, STP) and earth retaining structures (retaining wall & compound wall) is designed for "Moderate" condition.

Keeping the durability and structural requirement, the proposed Compressive Strength of structural concrete at 28 days, for various structural elements/ members are as indicated in the below table.

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Structural elements		Compressive strength at 28 days	Concrete grade
Minimum grade of concrete for any structural member considered as		30 N/Sq.mm	M30
All structural concrete for :			
Columns,Shear walls Core walls	Foundation to Third floor	50 N/Sq.mm	M50
	Third Floor to Eigth Floor	40 N/Sq.mm	M40
	Eigth floor to Terrace Floor	30 N/Sq.mm	M30
	Footing Stitch slab / Grade slab	30 N/Sq.mm 30 N/Sq.mm	M30 M30
	Beams Slabs	30N/Sq.mm 25N/Sq.mm	M30 M30
	UG Sump STP Rain Water Tank	30N/Sq.mm 30N/Sq.mm 30N/Sq.mm	M30 M30 M30
	Plain cement concrete	10 N/Sq.mm	M10

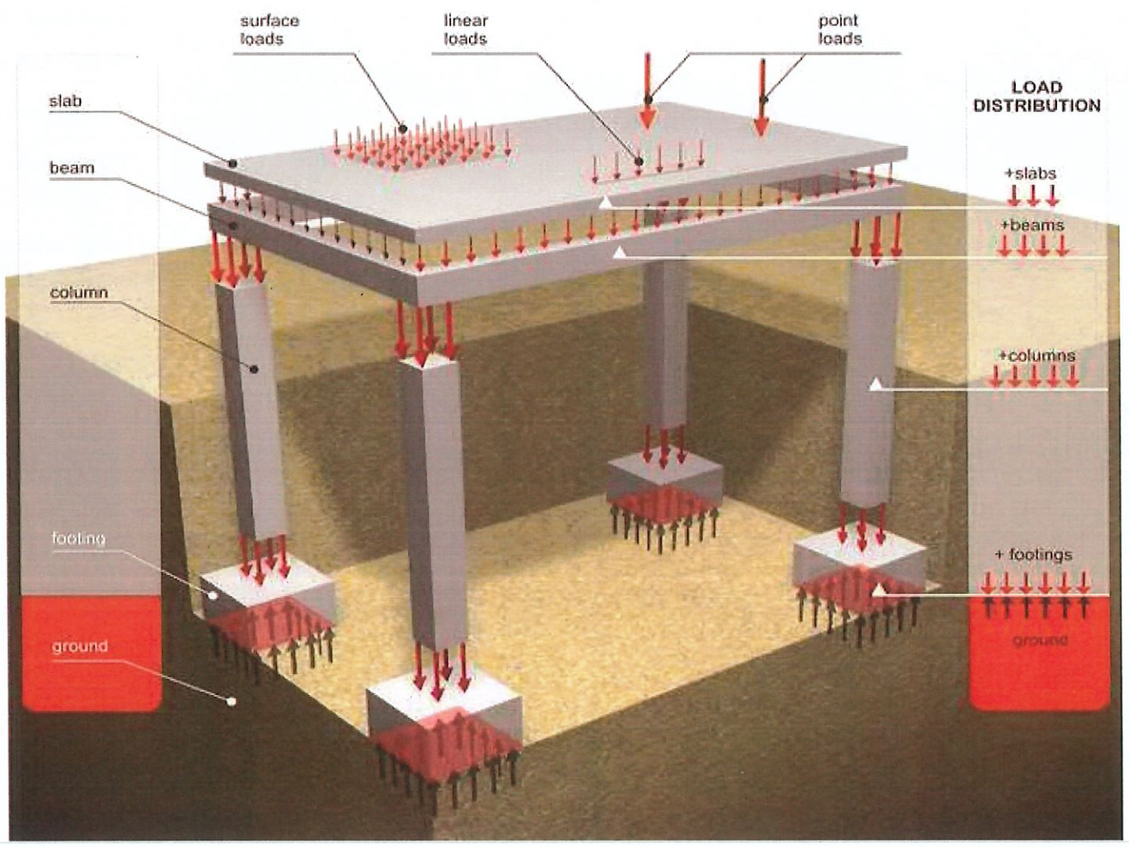
7.4 MASONRY WALL

The detailing of the masonry walls to the RCC elements both vertical and horizontal along with RCC bands will be provided by architects.

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7.5 DESIGN DATA

Dead Loads, Live Loads, Wind Loads, Seismic Loads, Temperature Loads



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7.6 DEAD LOADS & LIVE LOAD

Dead load shall include weight of all structural and Architectural components. Self-weight of the materials shall be calculated based on unit weights given in IS: 875(part 1)-1987.

Unit weight of Reinforced cement concrete	2500Kg/cum – 25 kN/cum
Unit weight of reinforcement steel	7850Kg/cum – 78.5 kN/cum
Water	1000Kg/cum – 10 kN/cum
Glass	2720Kg/cum – 27.2 kN/cum
Stainless steel	7850Kg/cum – 78.5 kN/cum
Solid Block Masonry (SBM) Including plastering.	2200Kg/cum – 22 kN/cum
Light weight filling material	1000Kg/cum – 10 kN/cum
Soil –Dry	1800Kg/cum – 18 kN/cum
Soil – Perfectly Wet	2195Kg/cum – 21.95kN/cum
Unit weight of screed(finishes)	2400Kg/cum – 24 kN/cum
Reinforced cement concrete precast member	2500Kg/cum – 25 kN/cum
Aluminium composite panels (6mm thick)	3.5Kg/sq meter –0.03 kN/sqm
Thermocole	25Kg/cum – 0.25 kN/cum

Following loads are considered while designing the structural elements apart from dead load (self-weight) as per code. Blockwork wall loads shall be considered as per actuals

BASEMENT FLOOR				
Load components		Thickness (mm)	UDL (kN/sqm)	Annotations
Staircase	Dead load	Actuals		
	Live load	-	3.00	
	Finishes	50	3.6	Waist slab load + steps load
	Services	-	-	
Lift Lobby	Dead load	Actuals		
	Live load	-	3.00	
	Finishes	50	1.2	
Parking & Driveway	Dead load	Actuals		
	Live load	-	3.00	
	Stack	-	-	

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	Finishes	100	2.4	
	Services	-	0.50	Service Ducts + Fire Sprinklers
Ramp without fire truck movement	Dead load	Actuals		
	Live load	-	5.00	
	Finishes	100	2.4	

GROUND FLOOR				
Load components		Thickness (mm)	UDL (kN/sqm)	Annotations
Parking & Driveway	Dead load	Actuals		
	Live load	-	3.00	
	Stack	-	-	
	Finishes	100	2.4	
	Driveway filling	300	7.2	
	Services	-	0.50	Service Ducts + Fire Sprinklers
Staircase	Dead load	Actuals		
	Live load	-	3.00	
	Finishes	50	3.6	Waist slab load + steps load
	Services	-	-	
Lift Lobby	Dead load	Actuals		
	Live load	-	3.00	
	Finishes	50	1.2	
	Services& false ceiling	-	-	
Electrical Room	Dead load	Actuals		
	SIDL	-	7.5	Non Reducible live load
	Finishes	100	2.4	
	Services	-	0.50	Service Ducts + Fire Sprinklers
DG	Dead load	Actuals		
	Live load		15	Non Reducible live load.
	Finishes	100	2.4	
	Services	-	0.50	Service Ducts + Fire Sprinklers
Landscape Filling	Dead load	Actuals		

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	Live load		-	
	Fire Tender	-	15	
	Finishes			As per landscape details
	Services	-	0.5	

TYPICAL FLOOR				
Load components		Thickness (mm)	UDL (kN/sqm)	Annotations
Staircase	Dead load	Actuals		
	Live load	-	3.00	
	Finishes	50	3.6	Waist slab load + steps load
	Services	-	-	
Lift Lobby / Corridor	Dead load	Actuals		
	Live load	-	3.00	
	Finishes	50	1.2	
	Services& false ceiling	-	-	
Rooms /Living Space	Dead load	Actuals		
	Live load	-	2.00	
	Finishes	50	1.20	
	False ceiling/Services	-	-	
Balconies	Live load	-	3.0	
	Finishes	75	3.0	75mm sunk + Finishes load
	False ceiling/Services	-	-	
Utilities	Live load	-	3.0	
	Finishes	150	4.8	150mm sunk + Finishes load
	False ceiling /Services	-	-	
Toilets	Dead load	Actuals		
	Live load	-	2.00	
	Finishes	75	3.0	75mm sunk + Finishes load.

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Terrace & Above Terrace				
Load components		Thickness (mm)	UDL (kN/sqm)	Annotations
Accessible terrace	Dead load	Actuals		
	Live load	-	3.00	
	Finishes	150	3.60	Average thickness including water proofing
OHT bottom slab	Dead load	Actuals		
	SIDL	As per MEP		
	Finishes	100	2.40	
	Services	-	-	
OHT roof	Dead load	Actuals		
	Live load	-	2.0	
	Finishes	100	2.40	Average thickness including water proofing
Staicase Headroom	Dead load	Actuals		
	Live load	-	0.75	Non Accessible Roof
	Finishes	100	3.6	Average thickness including water proofing
	Services	-	-	

Non – Tower Area				
Load components		Thickness (mm)	UDL (kN/sqm)	Annotations
Podium Floor	Dead load	Actuals		
	Live load	-		
	Fire Tender	-	15	
	Finishes			As per landscape details
	Services	-	0.5	

Wall load

200mm S.B.M wall load per meter ht.	4.4 kN/m
150mm S.B.M wall load per meter ht.	3.3 kN/m
100mm S.B.M wall load per meter ht.	2.2 kN/m

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12 mm thick glazing load per meter	0.34 kN/m

Fire tender load on Podium slab .

Fire tender load = 60Tonnes

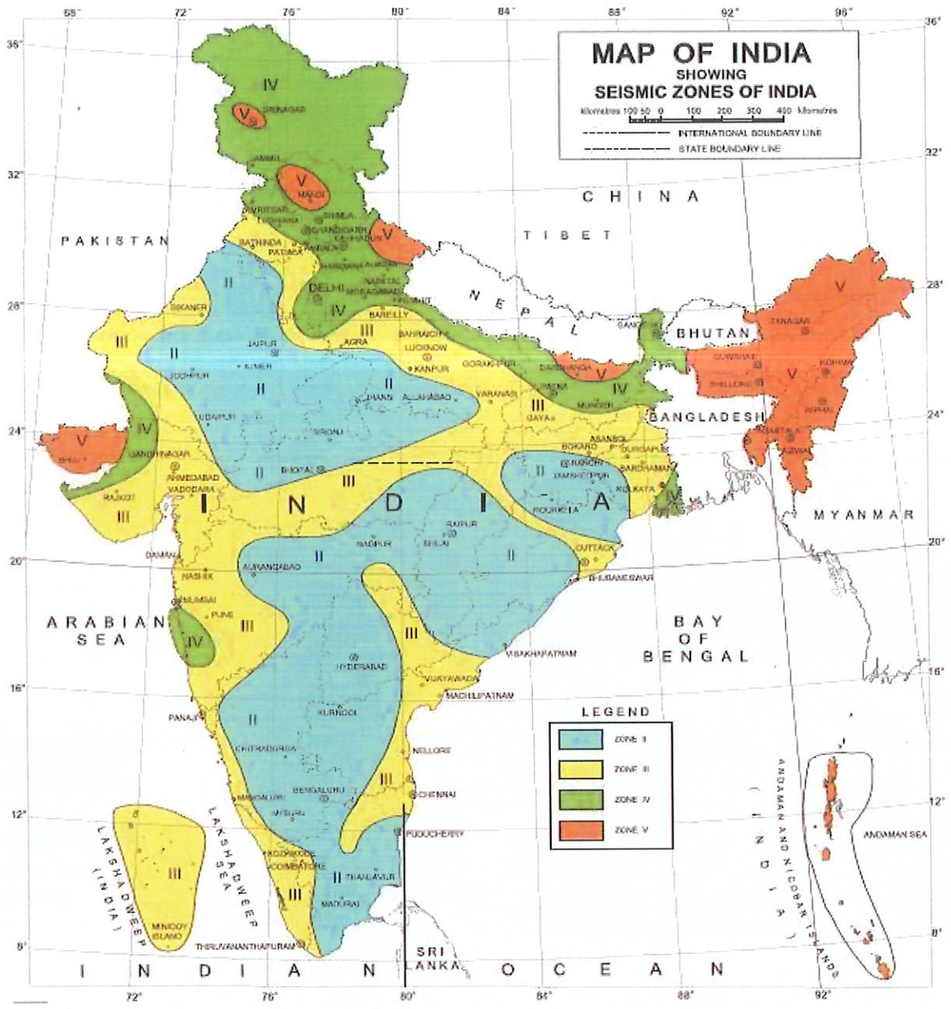
Filling Depth = 300mm

However, as far as moving loads are considered, fire tender load of 1500Kg/m² (15 kN/m²) shall be considered for design of column, footings and slabs.

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7.7 SEISMIC LOAD AS PER IS-1893-2016

SEISMIC MAP OF INDIA



Bureau of Indian Standards, based on the past seismic history, grouped the country into four seismic zones, viz. Zone-II, -III, -IV and –V. Of these, Zone V is the most seismically active region, while zone II is the least. The Modified Mercalli (MM) intensity, which measures the impact of the earthquakes on the surface of the earth, broadly associated with various zones, is as follows

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7.8 Seismic Zone Intensity on MM scale

Zones	Intensity
II (Low intensity zone)	VI (or less)
III (Moderate intensity zone)	VII
IV (Severe intensity zone)	VIII
V (Very severe intensity zone)	IX (and above)

Since Bangalore is in zone II(Low intensity zone), Zone co-efficient is considered 0.1 f or design

Seismic load as per IS:1893 -2016		
1	Location	Bangalore
2	Seismic Zone – (Annex – E)	III
3	Zone co-efficient 'Z' (Table -02)	0.1
4	Importance factor 'I' (Table – 06)	1.2
5	Response reduction factor 'R' (Table-09)	3
6	Fundamental Natural period (Clause 7.6.2)	As per IS 1893(I):2016, clause 7.6.2
7	Ductile detailing As per IS-13920-2016	Not Required
8	N Values from Bore Logs Report	Awaiting
9	Soil Type- Table -01 of IS-1893:2016	Awaiting
10	Damping ratio	5%

e time period of the building is to be calculated as per Clause 7.6.2. In this clause, the definition of h is given. The value of h to be taken from the ground of the structure.

Percentage of imposed load to be considered in seismic weight calculation as per IS-1893-2016 (cl. 7.3.1)

Impose uniformity distributed floor loads(kN/m2)	Percentage of imposed loads
Up to and including 3.0	25
Above 3.0	50

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7.9 Design lateral force (IS-1893:2016)

The inertia forces are to be distributed along the height of the building as per Clause 7.7.1. The base shear shall be applied from ground of the building, which corresponds to the level of building where the forces are transferred to the foundation. In the case of non-uniform connections of retaining wall at ground floor, the height of the building for seismic loads shall be taken from the basement level.

7.10 Fundamental natural time period (Ta) with rc walls:

As per IS 1893 (Part-I) 2016; clause - 7.6.2

$Ta = 0.075\ h^{0.75}/\sqrt{Aw} > 0.09h/\sqrt{d}$

Where h is the height of structure including basement storey

d base dimension of the building at plinth level along the considered direction of earthquake shaking.

As per above calculation maximum time period is considered for design based on 0.075 h 0.75/√Aw formula.

Vb = Ah * W

W= Seismic weight of the structure

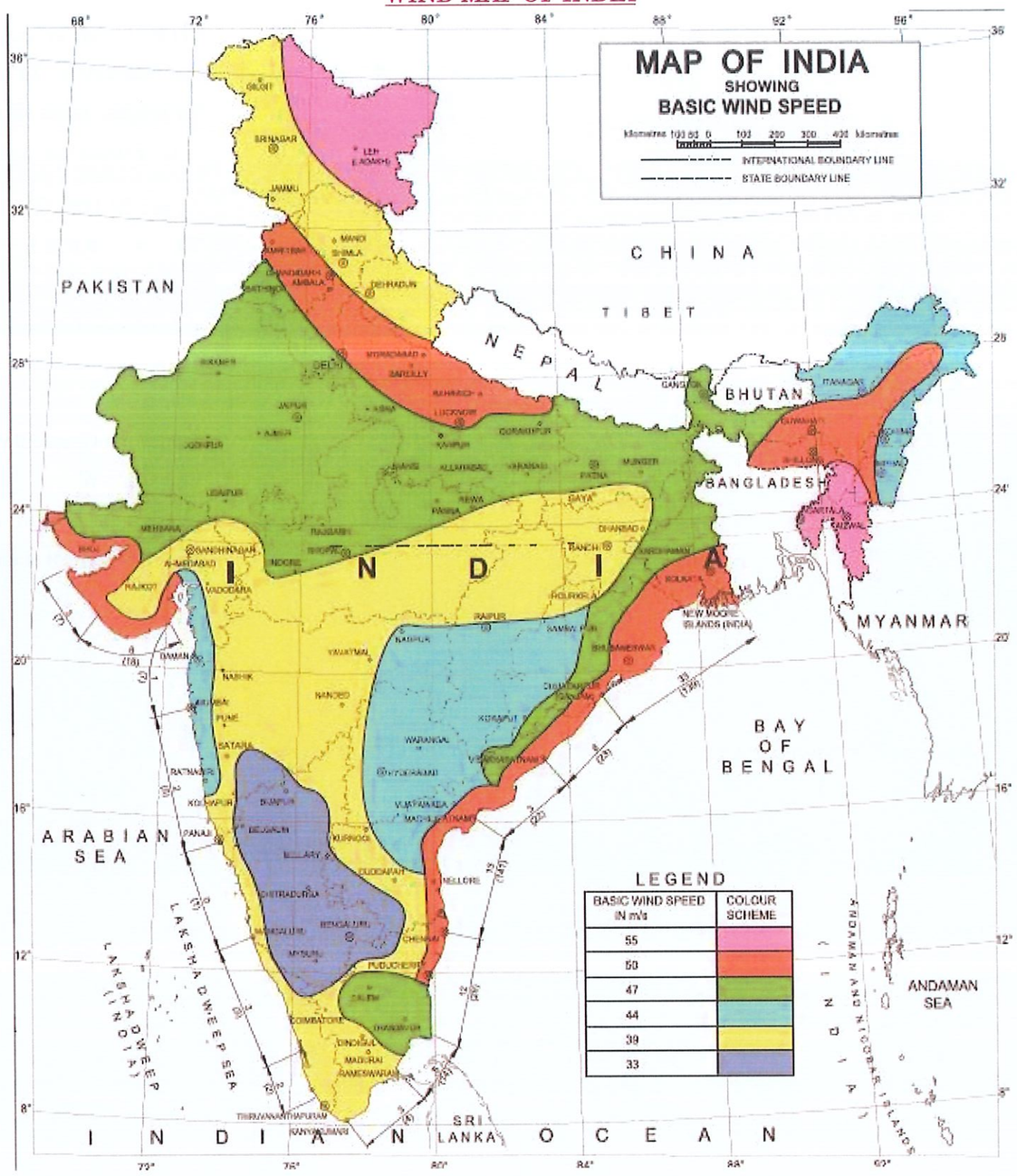
Ah = Horizontal seismic coefficient

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7.11 WIND LOADING AS PER IS:875 (PART III) -2015

WIND MAP OF INDIA



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Wind load as per IS:875 (Part iii)-2015		
1	Zone	Bangalore
2	Basic wind speed (Vb) m/sec- Appendix-A	33 m/sec
3	Category of Building	03
4	Risk co-efficient (k1)-Table-01	1.0 (for general buildings)
5	Terrain, roughness and height factor(k2)	As per table 02 of cl 6.3.2.2
6	Topography factor (k3)	1.0
7	Importance factor for the cyclonic region(k4)	1.0
8	Design wind speed (Vz)	Vz = Vb*k1*k2*k3*k4
9	Design wing pressure (Pz)	Pz =0.6*Vz^2
10	Internal and External co-efficient as per IS:875 (part 3)	Not Required As per Closed Structure

It is generally recognized that absolute sway is not a perceivable parameter; however limiting sway is used to provide a reasonable level of stiffness and in order to limit damage to non-structural elements as well as limit size of curtain wall joints, etc.

Generally tall building lateral load resisting systems are sized on the basis of limiting overall lateral sways to limits of approximately Overall Height/500 under the 50 year return Period wind loads.

Height of Building = 44.5 m from Ground Level

Permissible Deflection = 44500/500

= 89 mm

a) Calculation of design wind pressure (Pz) and wind speed (Vz)

The wind pressure has been calculated based on the data furnished below and other provisions laid in IS 875 (Part-3) – 2015

Design wind speed Vz=Vb*K1*K2*K3*K4

Design wind pressure Pz=0.6*Vz^2

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b) Dynamic wind analysis check as per is 875 part iii clause 7.1

Detailed procedure and preliminary gust coefficients for the wind forces is enclosed below.

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Flexible slender structures and structural elements shall be investigated to ascertain the importance of wind induced oscillations or excitations along and across the direction of wind. In general, the following guidelines may be used for examining the problems of wind induced oscillations:

- Buildings and closed structures with a height to minimum lateral dimension ratio of more than about 5.0,
- Buildings and closed structures with natural frequency in the first mode less than 1.0 Hz.
- Any building or structure which satisfies either of the above two criteria shall be examined for dynamic effects of wind.

7.12 FIRE RATING:

- All structural elements are dessigned to satisfy the fire requirement specified in NBC 2016.
- As per NBC 2016, The structure comes under Type 2 construction.
- All vertical elements and horizontal elements shall be designed accordingly.

7.13 TEMPERATURE LOADS:

The effect of temperature will be considered wherever applicable in accordance with relevant Indian codes. The coefficient for thermal expansion and contraction will be in accordance with IS : 456 and IS : 800 for concrete and steel respectively.

The maximum and minimum temperatures for city of Bnagalore are published by the metrological department are According to IS : 875 (part 5) the following climatic data is assumed:

Maximum mean temperature	36°C
Minimum mean temperature	16°C
Assumed temperature during construction	26°C

Therefore, a constant temperature variation is applied considering room temperature minus maximum mean temperature is +10°C, -10°C

7.14 SPECIAL LOADS:

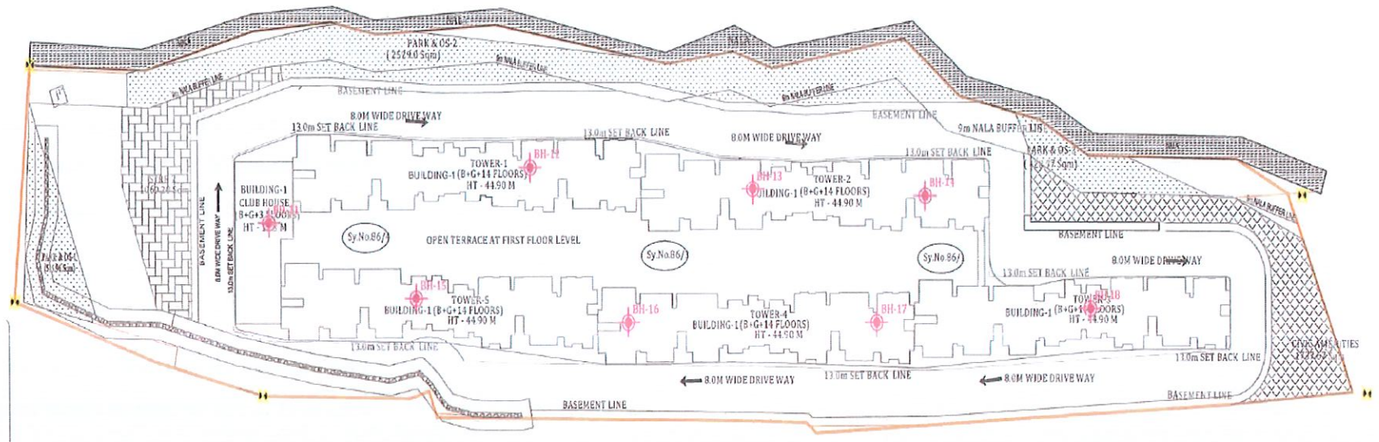
Load due to the following catastrophe scenarios are not considered in the design.

- Exceptional loads due to terrorist attacks. (Explosions)
- Accidental loads. (Falling of aircraft on the building).
- Accidental hitting of vehicle on the façade.
- Snow load

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7.15 GEOTECHNICAL INVESTIGATION

-SBC consideration as per soil report:



Based on the investigation data and analysis of the same, the following allowable bearing pressures are recommended for the design of Raft Foundations by allowing a total allowable settlement of 75mm.

Borehole Number#	Structure#	Block#	Existing GL RL# (m)	LBFL RL# (m)	Depth of founding level below LBFL (m)	Allowable Bearing Pressure (t/m^2)	Modulus of Subgrade reaction value, $k_{0.3}$ (kg/cm^3)
						Raft	
BH 11	B+G+3F	Club House	96.890	96.300	3.0	18	1.40
BH 12	B+G+14F	Tower 1	96.360			28	2.00
BH 13			96.590				
BH 14		Tower 2	96.700			31	2.20
BH 18		Tower 3	97.090			24	1.70
BH 16		Tower 4	96.620			25	1.90
BH 17			96.900				
BH 15		Tower 5	97.387			24	1.40

#- As furnished by client *LBFL – Lower Basement Floor Level*

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8.0 STRUCTURAL ANALYSIS & DESIGNS

The structural analysis is carried out by finite element method using the commercially available latest software **ETABS/ STAAD Pro V8i , RCDC , DraftWin & SAFE** for the load combinations as per standards. The designs of the RCC elements are made using the Limit State method with appropriate load factors as per IS: 456-2000 using spread sheet/E-Tab, etc. Designs of structural steel members are made using elastic method as per IS: 800-2007 with relevant allowable stresses.

8.1 SERVICIABILITY LIMIT STATE (SLS)

Permissible sway/Drift: As per IS 456, the lateral sway due to wind at the top of the structure shall not exceed **H/500** where H is the height of the building.

As per IS 1893: 2016 (part-1) the story drift due to minimum specified lateral force with partial load factor of 1.0 shall not exceed **Hs/250**, where H_s is the story height under consideration.

The vertical deflection under imposed load should be limited as follows:

L/250 taking into account all imposed loading, including temperature and creep/shrinkage.

L/350 taking into account all imposed loading, including temperature and creep/shrinkage after erecting the finishes or 20mm whichever is less.

Analysis method adopted for model on ETABS

Generation of ETABS model

- Initial preliminary analysis for each structural member shall be carried out and accordingly the shuttering layout shall be prepared.
- Preliminary sized cad formatted shuttering drawing of each floor shall be created and exported to E-tab and 3D model shall be generated.
- Sectional properties are assigned to all the structural elements as per preliminary drawings.
- Mesh size assigned for shell area is 1m x 1m as mesh size or finer mesh sizes
- External wall loads are assigned as line loads wherever the walls are well defined.
- Internal partition walls are assigned under SIDL load case.

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- Slabs shall be modelled as shell elements and assigned as rigid/flexible diaphragm.
- Staircase flight / ramp slabs are modelled as horizontal element at respective floor levels
- Mechanical / Electrical / other equipment loads are applied as SIDL in the respective bays.
- Machine rooms, overhead tanks, staircase head rooms and parapet walls are not modelled however the loads are considered.
- Architectural features are not modelled, however the respective SIDL are accounted into analysis.
- Live load reduction is considered for designing of columns, shear walls and foundations.
- All lateral loads applied as per IS codes (wind and earthquake loads).
- 3D model shall be analysed by dynamic analysis.
- Temperature loads are applied to terrace and some part of podium area. Which are directly exposed to sun.
- Since Bangalore is in zone II, Ductile detailing is Not required.
- Covers to reinforcement shall be in accordance with IS: 456-2000 corresponding to moderate exposure conditions.
- All vertical walls elements are assigned with auto meshing to achieve accurate designs.
- As per IS 456 Clause: 41.1 beams where torsion is required to maintain equilibrium will be designed for torsion in accordance with 41.2, 41.3 and 41.40. However, for all other beams torsional stiffness is neglected in the analysis by applying stiffness modifier as 0.35 to torsional constant "J". Hence no specific design for torsion is required for these beams.
- Foundation shall be designed with spread sheet /SAFE.
- Long term deflection are checked using excel spread sheet.
- Crack width calculation is checked using excel spread sheet.
- Water pressure is considered on the footings/ grade slab and designed and also subsoil soil drainage system is proposed and the same to be confirmed by soil consultants.
- Actual OHT, staircase head room loadings are considered in the 3D analysis.

8.2 LOAD COMBINATIONS

The results obtained from the computer analysis in the form of member forces and reactions will be used for design the structural members. The following load combinations of the member forces will be considered for arriving at the design forces.

Live Load reductions are considered as per IS 875 Part –II for Column, Shear wall and Footing Design.

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Dynamic Load Combinations

As per IS 1893-2016 cl 6.3.2.1 lateral load resisting elements are oriented along two mutually orthogonal directions, structure shall be designed for the effects due to full design earthquake load in one horizontal direction at a time and not in both directions simultaneously.

Since the structure has Re entrant corners Three Dimensional Dynamic analysis has been carried out.

TABLE1: Static Load Combinations		
Name	Load Case/	Scale Factor
	Combo	
DCon1	DEAD	1.5
	SIDL	1.5
DCon2	DEAD	1.5
	LIVE	1.5
	SIDL	1.5
DCon3	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	WX	1.2
DCon4	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	WX	-1.2
DCon5	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	WY	1.2
DCon6	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	WY	-1.2
DCon7	DEAD	1.5
	SIDL	1.5

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	WX	1.5
DCon8	DEAD	1.5
	SIDL	1.5
	WX	-1.5
DCon9	DEAD	1.5
	SIDL	1.5
	WY	1.5
DCon10	DEAD	1.5
	SIDL	1.5
	WY	-1.5
DCon11	DEAD	0.9
	SIDL	0.9
	WX	1.5
DCon12	DEAD	0.9
	SIDL	0.9
	WX	-1.5
DCon13	DEAD	0.9
	SIDL	0.9
	WY	1.5
DCon14	DEAD	0.9
	SIDL	0.9
	WY	-1.5
DCon15	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	EQX	-1.2
DCon16	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	EQX	-1.2
DCon17	DEAD	1.2

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	LIVE	1.2
	SIDL	1.2
	EQY	1.2
DCon18	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	EQY	1.2
DCon19	DEAD	1.5
	SIDL	1.5
	EQX	1.5
DCon20	DEAD	1.5
	SIDL	1.5
	EQX	1.5
DCon21	DEAD	1.5
	SIDL	1.5
	EQY	1.5
DCon22	DEAD	1.5
	SIDL	1.5
	EQY	1.5
DCon23	DEAD	0.9
	SIDL	0.9
	EQX	1.5
DCon24	DEAD	0.9
	SIDL	0.9
	EQX	1.5
DCon25	DEAD	0.9
	SIDL	0.9
	EQY	1.5
DCon26	DEAD	0.9
	SIDL	0.9
	EQY	1.5

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TABLE : Dynamic Load Combinations		
Name	Load Case/Combo	Scale Factor
DCon27	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	SPECX	1.2
DCon28	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	SPECY	1.2
DCon29	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	SPECZ	1.2
DCon30	DEAD	1.5
	SIDL	1.5
	SPECX	1.5
DCon31	DEAD	1.5
	SIDL	1.5
	SPECY	1.5
DCon32	DEAD	1.5
	SIDL	1.5
	SPECZ	1.5
DCon33	DEAD	0.9
	SIDL	0.9
	SPECX	1.5
DCon34	DEAD	0.9

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	SIDL	0.9
	SPECY	1.5
DCon35	DEAD	0.9
	SIDL	0.9
	SPECZ	1.5
DCon36	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	SPECX	1.2
	SPECY	0.36
	SPECZ	0.36
DCon37	DEAD	1.2
	LIVE	1.2
	SIDL	1.2
	SPECY	1.2
	SPECX	0.36
	SPECZ	0.36
DCon38	DEAD	1.5
	SIDL	1.5
	SPECX	1.5
	SPECY	0.45
	SPECZ	0.45
DCon39	DEAD	1.5
	SIDL	1.5
	SPECY	1.5
	SPECX	0.45
	SPECZ	0.45
DCon40	DEAD	0.9
	SIDL	0.9
	SPECX	1.5
	SPECY	0.45

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	SPECZ	0.45
DCon41	DEAD	0.9
	SIDL	0.9
	SPECY	1.5
	SPECX	0.45
	SPECZ	0.45

Temperature Load Combinations

Combinations Load Combination	Load Factor							
	D.L	L.L	WL_X	WL_Y	EL_X	EL_Y	EL_Z	TL
DL+TL	1.5	-	-	-	-	-	-	1.0
DL+LL+WX+TL	1.2	1.2	1.2					1.0
DL+LL-WX+TL	1.2	1.2	-1.2					1.0
DL+LL+WY+TL	1.2	1.2		1.2				1.0
DL+LL-WY+TL	1.2	1.2		-1.2				1.0
DL+WX+TL	1.5		1.5					1.0
DL-WX+TL	1.5		-1.5					1.0
DL+WY+TL	1.5			1.5				1.0
DL-WY+TL	1.5			-1.5				1.0
DL+WX+TL	0.9		1.5					1.0
DL-WX+TL	0.9		-1.5					1.0
DL+WY+TL	0.9			1.5				1.0
DL-WY+TL	0.9			-1.5				1.0
DL+LL+Spec X+TL	1.2	1.2			1.2			1.0
DL+LL- Spec X +TL	1.2	1.2			-1.2			1.0
DL+LL- Spec Y +TL	1.2	1.2				-1.2		1.0
DL+ Spec X +TL	1.5				1.5			1.0

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DL- Spec X +TL	1.5				-1.5			1.0
DL+ Spec Y +TL	1.5					1.5		1.0
DL- Spec Y +TL	1.5					-1.5		1.0
DL+ Spec Y +TL	0.9				1.5			1.0
DL- Spec X +TL	0.9				-1.5			1.0
DL+ Spec Y +TL	0.9					1.5		1.0
DL- Spec Y +TL	0.9					-1.5		1.0

Service load combinations

DL + LL+WLX	1	1	1					
DL+LL - WLX	1	1	-1					
DL +LL+ WLY	1	1		1				
DL+LL-WLY	1	1		-1				
DL + WLX	1		1					
DL - WLX	1		-1					
DL + WLY	1			1				
DL - WLY	1			-1				
DL + LL + SPECX	1	1			1			
DL + LL + SPECY	1	1				1		
DL + LL + SPECZ	1	1					1	
DL+SPECX	1				1			
DL+SPECY	1					1		
DL+SPECZ	1						1	

DL-Dead load, LL – Live load, WL- Wind load, EL – Seismic load, TL – Temperature Load.

Note: Live Load reductions is considered as per IS 875 Part –II for Column, Shear wall and Footing Design.

Three-dimensional dynamic analysis combinations are considered for substructure only other than tower.

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8.3 DESIGN METHODOLOGY

The structure shall be designed according to the Limit State Method as specified in IS: 456-2000.Appropriate loads and its combinations, as per relevant clauses in Codes IS 456:2000 , IS 875 (Part-5) 1987 &IS 1893 part-1 2016, for the most unfavourable effects are chosen for design.

Foundation:

- The footings are designed to resist the bending moments and shear forces developed due to soil reaction as specified in Indian standard code IS: 456-2000.
- The main purpose of the footing is to effectively transfer the super structure load to the soil without exceeding the safe bearing capacity and the settlement of the structure should be within tolerable limits.
- Isolated/Strip footings– Forces are derived from ETABS and component elements are designed using spread sheets.
- Combined footing-Combined footing will be designed using SAFE and subgrade modulus shall be based on geotechnical report.
- Raft foundation-Designed using SAFE and in-house spread sheets.
- The foundations are designed based on the results and forces obtained from ETABS for the critical condition using modulus of sub grade reactions for designs both for independent and raft foundations.
- The depth of the footings has chosen in order to avoid the necessity for punching shear reinforcement.
- Live load reduction is considered for the design.

Columns

Columns will be designed using ETABS software and in-house spread sheets and manual calculations where necessary.

The columns were designed by considering with live load reducing factors.

The design of the reinforcement shall be considering the limits for maximum reinforcement ratio as per standards as well as construction requirement.

Rcc core wall / shear wall

- Core walls are designed for critical of two cases,

✓ Case 1 – Check individual legs with respect to gravity loads (DL + SIDL+LL)

✓ Case 2 – Check combined wall for lateral load combination

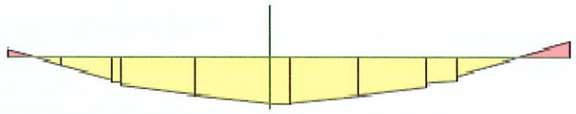
- The RC core wall / Shear wall design is carried out by finite element method using the commercially available latest software ETABS the walls are mainly designed for vertical as well as horizontal load from structure and also ensure the overall structural stability.

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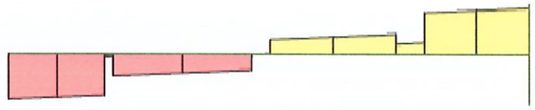
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Beams

Beams will be designed using ETABS software and in-house spread sheets.The RC beam design is carried out by finite element method using the commercially available latest software ETABS and also using by spread sheet wherever complexity in ETABS designs.



Bending Moment Diagram



Shear Force Diagram

Slabs:

Slabs designs will be using SAFE software and in house spread sheets.

The RCC slab analysis and design is carried out by finite element method using the commercially available latest software SAFE-12.1.3 and in house spread sheets.

The Slab is designed based on the results and forces obtained from ETABS for the critical condition.

Staircase:

Staircase is designed using STAAD pro/ manually as per limit state method as specified in IS: 456-2000.

Wherever possible going will be supported on landing slabs & effective span shall be applied as per the IS Code.

The RCC Staircase slab analysis and design is carried out by 3D finite element method using the commercially available latest software STAAD PRO V8i and in house spread sheets

8.4 COVER FOR ENVIRONMENTAL CONDITIONS, CORROSION AND FIRE PROTECTION FOR CONCRETE AND STRUCTURAL STEEL.

As per clause 8.2.2 IS 456:2000, the general environment to which the concrete will be exposed during its working life is classified into five levels of severity, that is, mild, moderate, severe, very severe and extreme as described in below table.

Cover for steel to protect from fire and corrosion, moderate environment condition is considered.

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- As per table 16, IS 456-2000, nominal cover to meet durability requirement is for moderate condition is 30mm (type of exposure-Concrete surfaces sheltered from saturated salt air in coastal area) is considered for all internal structural element.
- Nominal cover to meet durability requirement is for severe condition is 45mm (type of exposure- Concrete exposed to coastal environment) is considered for all external structural element.

Table 3 Environmental Exposure Conditions

(*Clauses* 8.2.2.1 *and* 35.3.2)

Sl No. (1)	Environment (2)	Exposure Conditions (3)
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet
		Concrete exposed to condensation and rain
		Concrete continuously under water
		Concrete in contact or buried under non-aggressive soil/ground water
		Concrete surfaces sheltered from saturated salt air in coastal area
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.
		Concrete completely immersed in sea water
		Concrete exposed to coastal environment
iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet
		Concrete in contact with or buried under aggressive sub-soil/ground water
v)	Extreme	Surface of members in tidal zone
		Members in direct contact with liquid/ solid aggressive chemicals

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Concrete cover for structural elements

Structural Elements		Environment Conditions	Fire resistance		Cover to Reinforcement adopted	Remarks Refer clause 26.4.2,21.4 and 26.4.3 and Table16& 16A
		Severe	1.5 hours	2 hours		
Footing		50	-	-	50	
Interior columns		-	40	40	40	Concrete surfaces sheltered from saturated salt air in coastal area
Exterior columns		45	40	40	45	
Shear wall/core wall(interior)		-	-	25	30	
Beams interior (simply supported)		-	20	40	40	
Beams exterior (simply supported)		45	40	40	45	
Beams interior (continuous)		-	20	30	30	
Beams exterior (continuous)		45	30	30	45	
Slabs (simply supported)		-	25	35	30	
Slabs (continuous)		-	20	25	30	
Staircase		-	25	25	30	
Retaining wall Earth side		-	45	45	45	
Water Retaining wall	Inner face	45			45	
	Exterior face	45			45	

8.5 EXPANSION JOINTS:

Expansion joints are normally provided when structure exceeds 45m length. The width of the joints is being calculated as per IS-1893-2016, clause 7.11.3.

However, the length of building in this project is more than 45m and expansion joints are provided accordingly.

8.6 CONSTRUCTION JOINTS:

Construction joints and shrinkage strips will be planned with the coordination of construction agencies.

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8.7 EXCAVATION METHODOLOGY:

- Sloping will be carried out depending on the Soil condition & its texture and as per Soil consultants advice.
- Slush formed by any water accumulation should be removed and refilled by lean concrete.
- If water accumulates in the pile cap trenches, necessary dewatering should be done by pumping out water from a level lower than the pile cap level to maintain downward flow of water.

5.6 Excavation:

The excavation up to the required foundation depth can be carried out using mechanical excavators neither rock breakers nor chemical spitting are not only required but do not feasible for this kind of formation.

No special treatment for the excavation face is required and near vertical cut can be made without undergoing any slope failure of the formation. However, if any set back distance is available a mild slope is advisable as a precaution measure up to a depth of 5.0m below the existing ground level and the slope could be 1 Vertical: 0.5 Horizontal.

5.7 Excavation ground water lowering:

In the project site, during the period of geotechnical investigation no ground water table exists within the proposed basement depth, hence based on the sub soil characteristics if any seepage is encountered during excavation, the same can be lowered by conventional collection pit pumping system, with water training shallow ditches connecting the collection pit at the bottom of excavation.

innoTECH Transform Thoughts

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8.8 STRUCTURAL SLAB SYSTEM:

The structure for proposed development buildings shall be designed with below mentioned data.

Floors	Recommended structural slab system
Ground floor (Tower area)	• Flat Plate System
Ground Floor - Podium	• Waffle Slab
First floor (Transfer)	• Voided Slab System
Typical Floor	• Wall Slab System

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8.9 ETABS 3D MODEL

9.0 DRAWINGS

9.1 ARCHITECTURAL DRAWING

MASTER DRAWING



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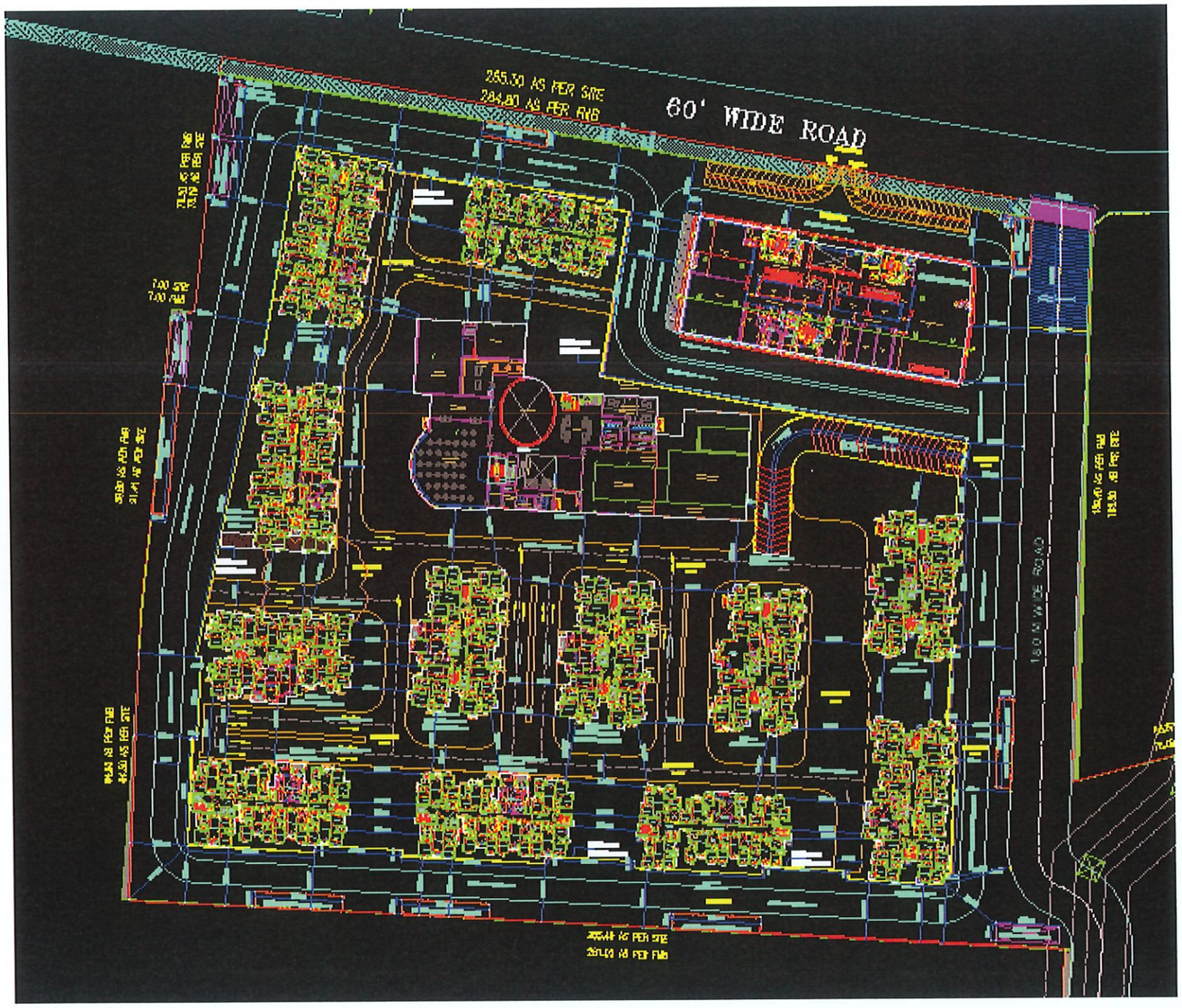
STILT FLOOR PLAN



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FIRST FLOOR

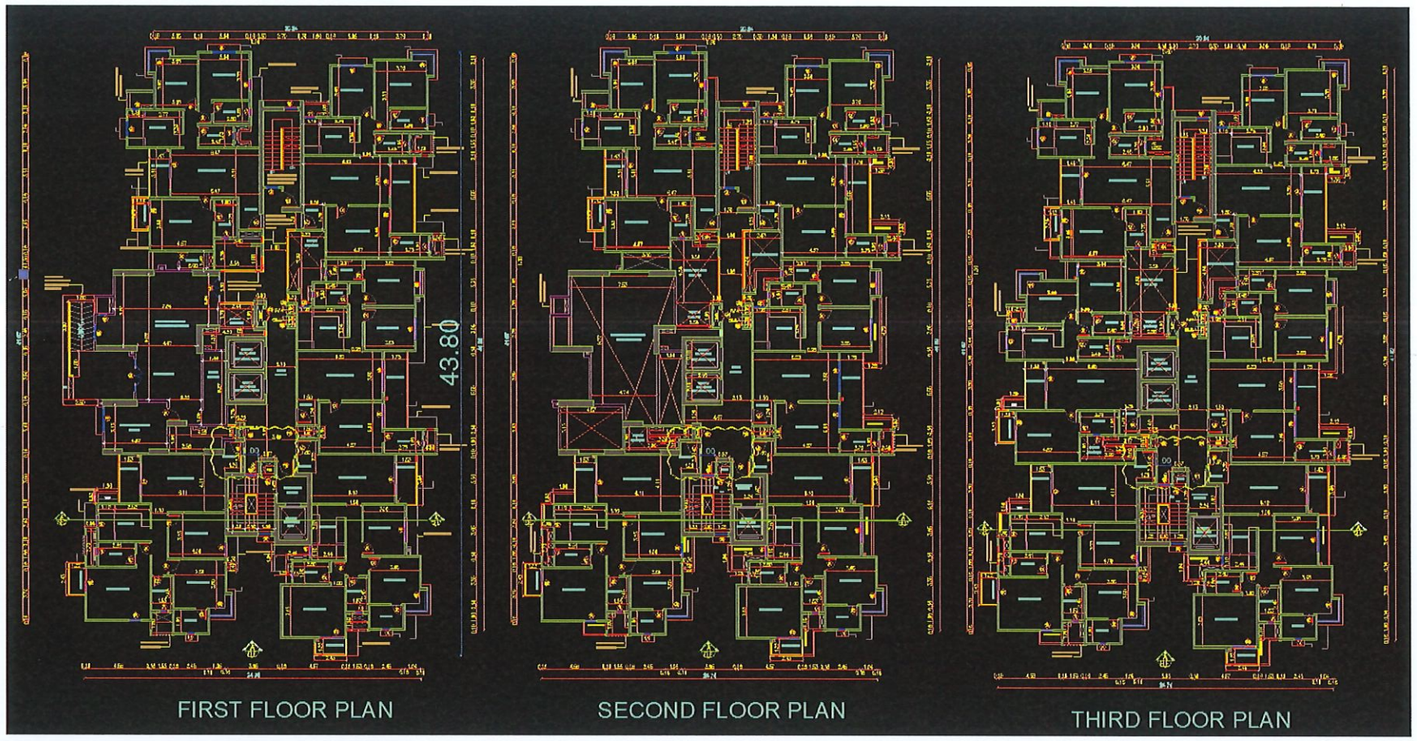


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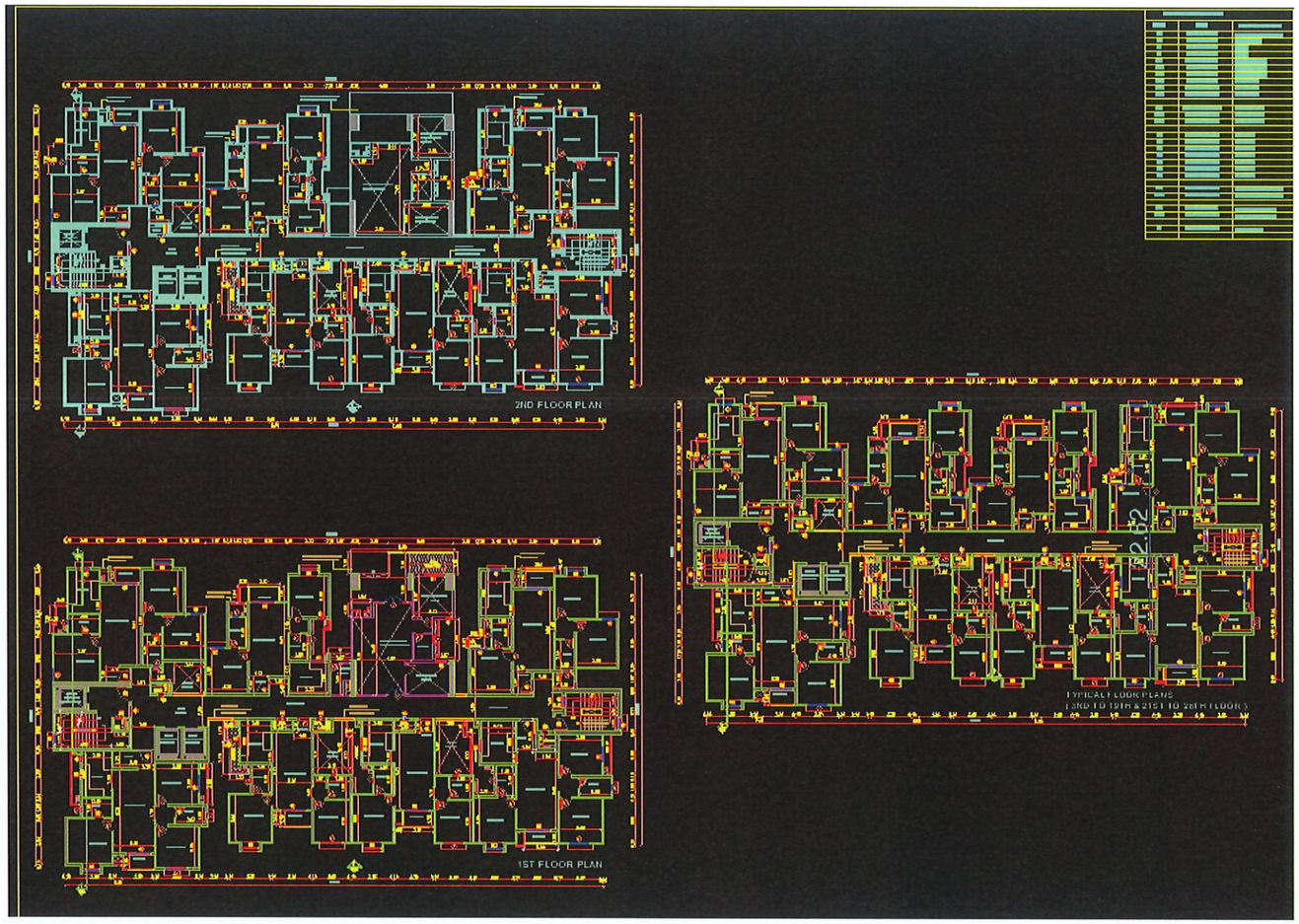
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TYPICAL FLOOR F&G



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1ST 2ND 3RD FLOOR – BLOCK H&G

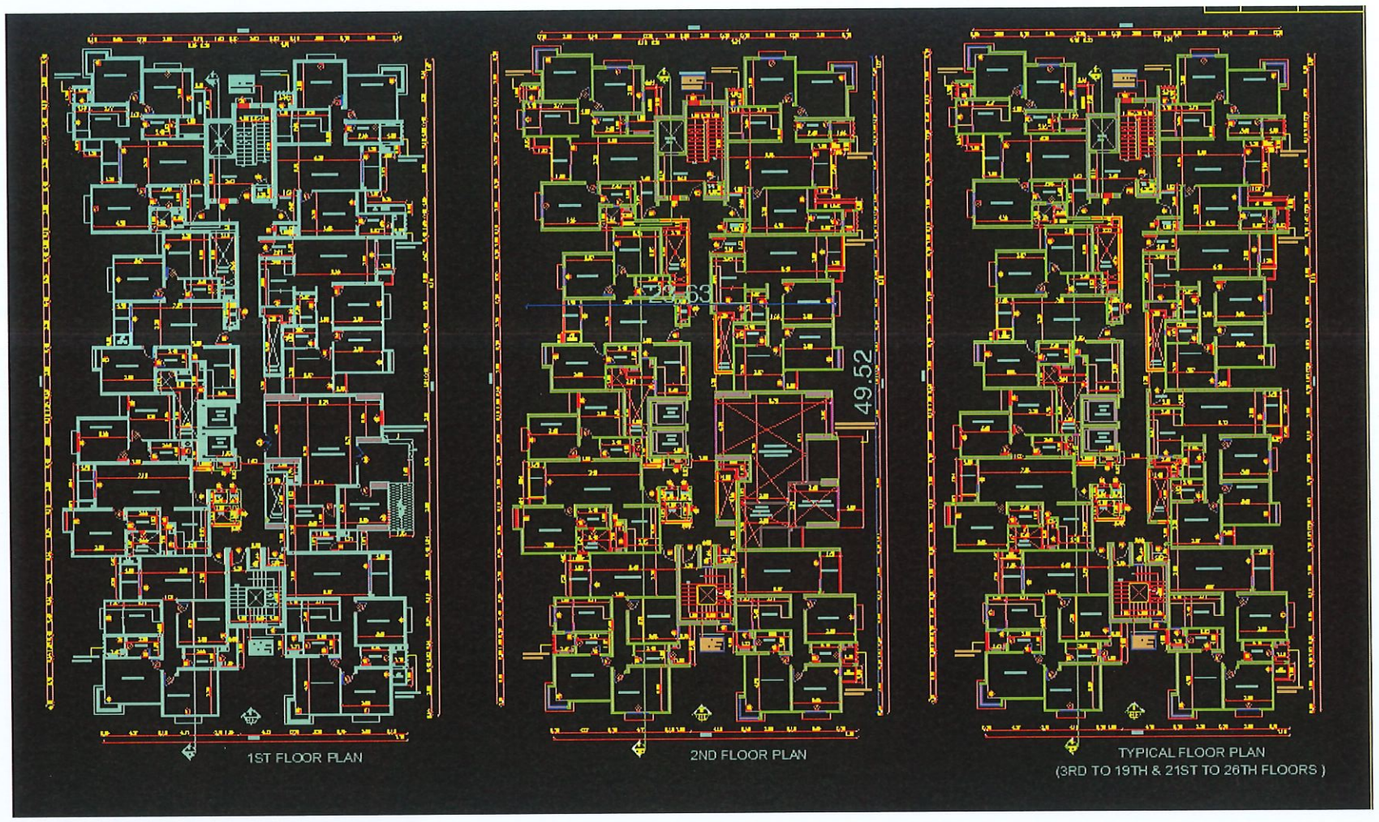


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1ST 2ND 3RD FLOOR – BLOCK L&M



4TH 8TH 12TH FLOOR

TERRACE FLOOR

---------- **END OF REPORT**----------

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