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STRUCTURAL DESIGN BASIS REPORT

FOR

PROPOSED CONSTRUCTION OF STILT FLOOR + 4 FLOORS COMMERCIAL BUILDING AT EGMORE, CHENNAI

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1. INTRODUCTION

The proposed development consists of **Stilt + 4 Floors + Terrace**. Tower is mean for use as commercial apartments. The Stilt Floor to be used as Parking Area & for Services. The 1st to 4th floor to be used for office purposes. Lift machine rooms are above the terrace level.
The Structural system for building consists of column, shear walls, PT/RC beams & PT/RC slabs. Shear walls are the part of Lateral Load Resistance system.

The floor to floor height of respective floors is as shown below.

Floor level	Floor to Floor Ht (m)
Stilt Floor	3.25
1st Floor to 4th Floor	3.75

The total height of building up to Terrace level is 18.25 meter (excluding parapet) from Stilt Floor level.

2. DESIGN LOADS

2.1 Material Dead Loads as per IS875 (part-1) :

The self-weight of the various elements are computed based on the built weight of materials as given below.
The self-weight of the various elements are computed based on size and density of materials as given below:-

Density of Reinforced Cement Concrete	=	25 kN/m^3
Density of Plain Cement Concrete	=	24 kN/m^3
Density of Steel	=	78.5 kN/m^3
Density of Soil	=	18 kN/m^3
Density of Saturated Soil	=	20 kN/m^3
Density of Water	=	10 kN/m^3
Density of light weight Masonry	=	10 kN/m^3
Density of Plum Concrete	=	24 kN/m^3

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2.2 Weight of Walls:

External Light weight Wall with 200 thk = 2.51 kN/m^2

Internal light weight Wall with 100 thk = 2.00 kN/m^2

Typical calculations for wall load:

External Wall with 200 thick Light Weight wall

Light wall Density = 10 kN/ cu. meter

Plaster Density = 20.4 kN/ cu. meter

Plaster thickness = 25mm (Internal + External)

Wall Load = (0.20x10+0.025x20.4) = 2.51 KN/m^2

Internal Wall with 150 thick Light Weight wall

Light wall Density = 10 kN/ cu. meter

Plaster Density = 20.4 kN/ cu. meter

Plaster thickness = 25mm (Internal+ External)

Wall Load = (0.150x10+0.025x20.4) = 2.00 KN/m^2

Note: For localized design of slabs, wall loading shall be applied as per actual layout..

2.3 DEAD& LIVE LOADS:

The construction load, super imposed dead load that are envisaged to act permanently (wherever applicable) as per IS:875(part-1)–1987 & Live loads for each occupancy category as per IS:875(part-2)–1987 and Live load reduction is considered as per IS:875(part-2) CL.3.2.

2.3.1 PARKING AREA

Description		KN/m^2
Dead Load	Slab & beam	Self-weight
Superimposed Dead Load	Floor Finishes including screed (50mm Thk Tremix)	1.0
	Services	0.5
Live Load	Parking Area	3.0

2.3.2 1ST TO 4TH TYPICAL COMMERCIAL FLOORS

Description		KN/m^2
Dead Load	Slab & Beam	Self-weight
Superimposed Dead Load	Floor Finishes	1
	Toilet Sunk 200 mm (Including Finish)	4
	Services	0.5
Live Load	Offices	4
	Toilet	2
	Balconies	4
	Corridors, Passages, Staircase including fire escapes, Lift lobbies,	4
	Electric Room	5
	Services	3

2.3.3 TERRACE LEVEL

Description		
Dead Load	Slab & Beam	Self-weight
	Water proofing & Floor Finishes including screed (150mm)	3.00 KN/m^2
Live Load	Live	1.50 KN/m^2

Description		
	Lift Machine Room	600KN per lift (as per architectural drawings)
	Head Room	1200KN (Including Self Weight)

2.4 WIND LOADS

The wind pressure is calculated on the basis of data furnished below and other provisions laid in IS875 (Part-3) – 2015

Basic Wind Speed	V_b	=	39 m/sec
Risk Coefficient	K_1	=	1 (Based on 50 years return period)
Terrain, Height Factor	K_2	=	1 (as per Table 2 of IS: 875 (Part 3) – 2015)
Terrain Category		=	II
	K_3	=	1
	K_4	=	1

Design Wind Speed (V_z)

$V_z = V_b \times K_1 \times K_2 \times K_3 \times K_4$

Where,
V_b =Basic Wind Speed
K_1 = Risk Co-efficient for different classes of structures in different wind speed zones.
K_2 = Terrain roughness & height factor.
K_3 = Topography factor.
K_4 = Importance factor for cyclonic region.

Design Wind Pressure

$Pz = 0.6Vz^2$

2.4.1 GUST FACTOR

Gust factor method shall be used as per clause No. 10.0 IS 875 (part 3) - 2015. (If required.)

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2.5 EARTHQUAKE LOAD

The loading due to earthquake is assessed as per the provisions of IS: 1893 (Part-1):2016

Seismic Zone		=	III
Soil type		=	I
Table-2	Zone factor (Z)	=	0.16
Table-6	Importance Factor (I)	=	1.2
Table-7	Response Reduction Factor (R)	=	5.0
	Height of buildings (H)	=	19.75m

Height of building considered from footing level for time period calculation.

Fundamental natural time period (Ta)

Ta(x) = 0.09H / √ d from CL.7.6.1– IS1893 (part – I):2016

Ta(y) = 0.09H / √ d from CL.7.6.1 – IS1893 (part – I):2016

Sa/g from FIG-2 IS 1893 (part I):2016.

Horizontal Seismic Co-Efficient

$$Ahx = \frac{Z \times I \; Sa}{2 \times R \; g}$$

$$Ahy = \frac{Z \times I \; Sa}{2 \times R \; g}$$

Dynamic analysis is performed using response reduction as per IS-1893(2016) Clause 7.7.

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3. CHECK FOR LATERAL SWAY AS PER IS 456-2000 & IS 1893-2016

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, Overall Height/400 under the 20 year return period wind loads and Overall Height/250 under seismic loads.

4. CHECK FOR LATERAL SWAY (STOREY DRIFT) AS PER IS- 1893-2016

The allowable lateral sway (storey drift) due to earthquake force should not exceed L/250, Where L is the storey height

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5. BASIC LOAD CASES

The various loads are combined in accordance with the stipulations in IS: 875 (Part 5)-1987. Wherever imposed load is combined with earthquake load the appropriate part of the imposed

Load as specified in IS: 1893-2016 is adopted both for evaluating earthquake effect and for combined load effects, used in such combination.

5.1 Basic Load Cases

Load Case Type	Mark	Description
Primary	DL	SELF WEIGHT OF STRUCTURAL MEMBER
Primary	SDL	SUPERIMPOSED DEAD LOAD
Primary	LL1	LIVE LOAD =<3 kN/m^2 (Live 1)
Primary	LL2	LIVE LOAD > 3 kN/m^2 (Live 2)
Primary	LL3	NON REDUCIBLE LIVE LOAD
Primary	EQX	SEISMIC LOAD IN X DIRECTION
Primary	EQY	SEISMIC LOAD IN Y DIRECTION
Primary	WLX	WIND LOAD IN X DIRECTION
Primary	WLY	WIND LOAD IN Y DIRECTION
Primary	SLX	SEISMIC LOAD IN X DIRECTION
Primary	SLY	SEISMIC LOAD IN Y DIRECTION

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6. BASIC LOADS AND LOAD COMBINATIONS

The various loads are combined in accordance with the stipulations in IS: 875 (Part 5)-1987. Wherever imposed load is combined with earthquake load the appropriate part of the imposed load as specified in IS: 1893-2016 is adopted both for evaluating earthquake effect and for combined load effects, used in such combination.

Description of Load Combination	Load Factor for Primary Load Cases				
	Dead Load	Live Load	Wind Load	Seismic Load	Temp Load
Dead load	1.5	0.0	0.0	0.0	0.0
Dead load + Live load	1.5	1.5	0.0	0.0	0.0
Dead load+Wind load	1.5	0.0	±1.5	0.0	0.0
Dead load+Seismic load	1.5	0.0	0.0	±1.5	0.0
Dead load+Live load+Wind	1.2	1.2	±1.2	0.0	0.0
Dead load+Live load+Seismic	1.2	1.2	0	±1.2	0.0
Dead Load + Wind Load	0.9	0.0	±1.5	0.0	0.0
Dead Load + Seismic Load	0.9	0.0	0.0	±1.5	0.0

7. ANALYSIS METHOD

The structure is analyzed for Static loads (both dead and live loads) and Lateral loads due to Earthquake/Wind loads and its combinations. Software used is E-Tabs version 19.0.0 & for foundation safe version 16.0.2.
The structure will be modeled as 3D space frame. Floor slabs shall be modeled as membrane elements for diaphragm effect only.

8. DESIGN METHODOLOGY

All structural members will be designed according to the Limit State Method as specified in IS: 456-2000. Appropriate loads and its combinations, as per relevant clauses in Code IS 456:2000 Code IS 875 (Part-5) 1987, for the most unfavorable effects are chosen for design.
Limit state method is adopted for design of overhead water tanks by using IS-3370(2009)

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9. CONSTRUCTION DETAILS

1. Pile foundation -M: 30
2. Water Tanks -M: 40
3. Columns/Walls -M: 40
4. Beams & Slabs -M: 40

10. REINFORCEMENT

Steel reinforcement shall be of Grade Fe 500 conforming to IS: 1786-1985.

11. EXPOSURE CONDITION

Structural elements below ground level and Exterior External faces of walls are designed for severe exposure condition and internal faces of walls, floor beams and slabs are designed for Mild exposure conditions per Table 16 of IS 456-2000.

12. COVER TO REINFORCEMENT

As per Table 16A-IS: 456-2000.

Member	Clear Cover (mm)
Pile Foundation	75 mm
Column	40 mm
Shear Walls	40 mm
Beams	40 mm
Slabs	20 mm
Staircase waist slab	30 mm
Water Tanks	40 mm

13. FOUNDATION SYSTEM

The building has been supported on pile foundation.

14. FIRE RATING

Fire rating of 2 hours is considered for columns and 1.5 hours for beam and slabs.

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15. CODES AND STANDARDS

All the designs are conforming to the relevant Indian Standards. Some of the relevant Indian Standard Codes, which have been followed for the structural designs, are given below.

Code	Description
IS:875 (Part-1)-1987	Code of Practice for Design Loads (Other than Earthquake) for Building and Structures-Unit Weights of Buildings Materials and Stored Material.
IS:875 (Part-2)-1987	Code of Practice for Design Loads (Other than Earthquake) for Building and Structures-Imposed loads
IS:875 (Part-3)-2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Wind Load.
IS:875 (Part-5)-1987	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Special Loads and Load Combinations
IS:456-2000	Code of Practice for Plain and Reinforced Concrete
IS:1893 (Part-1)-2016	Indian Standard Criteria for Earthquake Resistant Design of Structures
IS:432 (Part-1)-1982	Specification of Mild Steel and Medium Tensile Steel bars and Hard drawn Steel Wire for concrete reinforcement -Mild Steel and Medium Tensile Steel Bars
IS:432 (Part-2)-1982	Specification of Mild Steel and Medium Tensile Steel bars and Hard drawn Steel Wire for concrete reinforcement -Hard drawn Steel Wire.
IS:1786-1985	Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
IS:13920-2016	Ductile Detailing of reinforced concrete structures subjected to seismic forces - code of practice.
IS:1904	Indian Standard Code of practice for Design & Construction foundations in Soil: General Requirements.
IS:1642-1989	Indian Standard Code of practice for Fire Safety of Buildings (General): Details of Construction.
IS:3370-2009	Indian Standard Code of practice for Concrete Structures for Storage of Liquids.
IS:1343-1980	Indian Standard Code of practice for Pre-stressed Concrete.

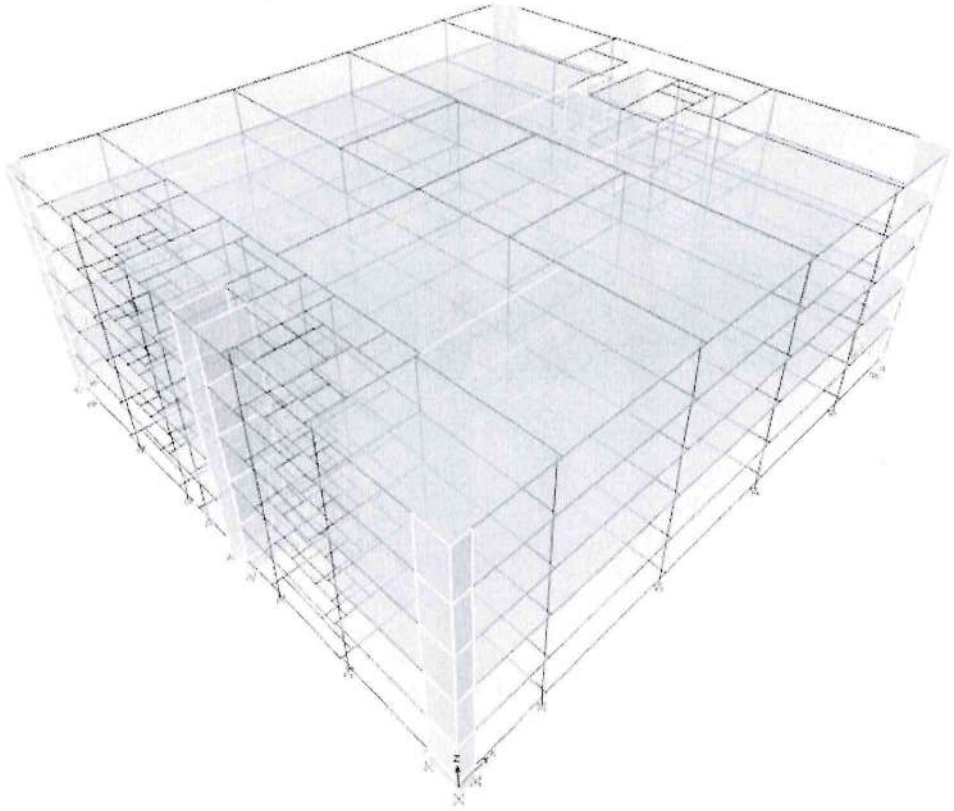
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1 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

1.1 Story Data

Table 1.1 - Story Definitions

Tower	Name	Height m	Master Story	Similar To	Splice Story	Splice Height m	Color
T1	Terrace	3.75	Yes	None	No		Cyan
T1	4th Floor	3.75	No	2nd Floor	No		Magenta
T1	3rd Floor	3.75	No	2nd Floor	No		Gray8Dark
T1	2nd Floor	3.75	Yes	None	No		Green
T1	1st Floor	3.25	No	2nd Floor	No		Red
T1	Plinth	1.5	No	None	No		Yellow

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2 Loads

This chapter provides loading information as applied to the model.

2.1 Load Patterns

Table 2.1 - Load Pattern Definitions

Name	Is Auto Load	Type	Self-Weight Multiplier	Auto Load
Dead	No	Dead	1	
Eqx	No	Seismic	0	IS 1893:2016
Eqx(1/3)	Yes	Seismic	0	IS 1893:2016
Eqx(2/3)	Yes	Seismic	0	IS 1893:2016
Eqx(3/3)	Yes	Seismic	0	IS 1893:2016
Eqy	No	Seismic	0	IS 1893:2016
Eqy(1/3)	Yes	Seismic	0	IS 1893:2016
Eqy(2/3)	Yes	Seismic	0	IS 1893:2016
Eqy(3/3)	Yes	Seismic	0	IS 1893:2016
Finish	No	Super Dead	0	
Live1	No	Reducible Live	0	
Live2	No	Reducible Live	0	
LMR OHWT	No	Super Dead	0	
Roof Live	No	Live	0	
Services	No	Super Dead	0	
Sunk	No	Super Dead	0	
Wall	No	Super Dead	0	
Wind	No	Wind	0	Indian IS 875:2015
Wind(1/2)	Yes	Wind	0	Indian IS 875:2015
Wind(2/2)	Yes	Wind	0	Indian IS 875:2015

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IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern Eqx according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = Multiple

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Approximate

Structure Height Above Base, h_n		$h_n = 19.75$ m
Coefficient, C_t [IS 7.6.1]		$C_t = 0.075$m
Approximate Fundamental Period, T_a [IS 7.6.2]	$T_a = C_t h_n^{0.75}$	$T_a = 0.703$ sec

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3]	$Z = 0.16$
Response Reduction Factor, R [IS Table 9]	$R = 5$
Importance Factor, I [IS Table 8]	$I = 1.2$

Site Type [IS Table 1] = I

Seismic Response

Spectral Acceleration Coefficient, S_a/g [IS 6.4.2]	$\frac{S_a}{g} = 2.5$	$\frac{S_a}{g} = 2.5$

Equivalent Lateral Forces

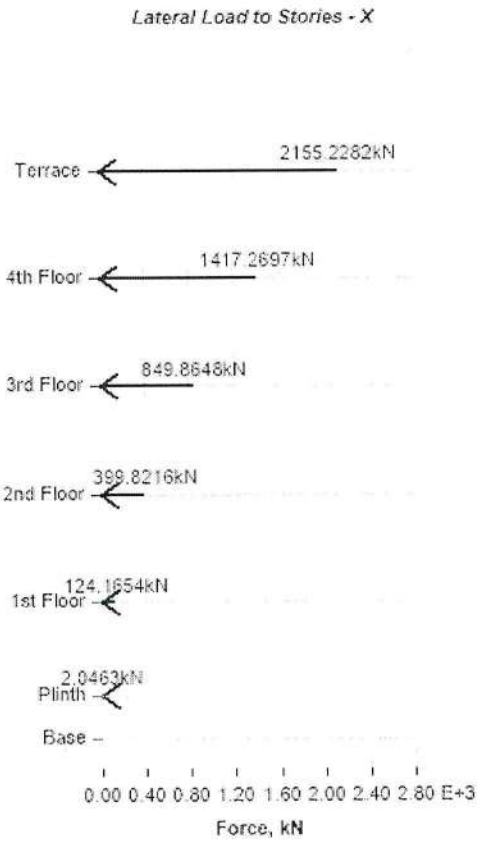
Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.703	181092.2202	4948.3958
X + Ecc. Y	0.703	181092.2202	4948.3958
X - Ecc. Y	0.703	181092.2202	4948.3958

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Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Terrace	18.25	2155.2282	0
4th Floor	14.5	1417.2697	0
3rd Floor	10.75	849.8648	0
2nd Floor	7	399.8216	0
1st Floor	3.25	124.1654	0
Plinth	0	2.0463	0
Base	-1.5	0	0

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IS 1893:2016 Auto Seismic Load Calculation

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Direction and Eccentricity

Direction = Multiple

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Approximate

Structure Height Above Base, h_n		$h_n = 19.75$ m
Coefficient, C_t [IS 7.6.1]		$C_t = 0.075$m
Approximate Fundamental Period, T_a [IS 7.6.2]	$T_a = C_t h_n^{0.75}$	$T_a = 0.703$ sec

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3]	$Z = 0.16$
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Seismic Response

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Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.703	181092.2202	4948.3958
Y + Ecc. X	0.703	181092.2202	4948.3958
Y - Ecc. X	0.703	181092.2202	4948.3958

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Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Terrace	18.25	0	2155.2282
4th Floor	14.5	0	1417.2697
3rd Floor	10.75	0	849.8648
2nd Floor	7	0	399.8216
1st Floor	3.25	0	124.1654
Plinth	0	0	2.0463
Base	-1.5	0	0

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3 Analysis Results

This chapter provides analysis results.

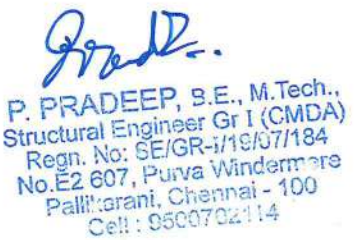
3.1 Structure Results

Table 3.1 - Base Reactions (Part 1 of 2)

Output Case	Case Type	Step Type	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m	X m
Dead	LinStatic		0	0	116089.1559	2555947.6575	-2819238	0	0
Finish	LinStatic		0	0	14493.4675	319398.6558	-353304.2495	0	0
Sunk	LinStatic		0	0	1074.1156	23695.6624	-3705.6739	0	0
Wall	LinStatic		0	0	27422.9007	603161.4583	-600213.7737	0	0
Services	LinStatic		0	0	2337.8193	51585.5192	-57744.9861	0	0
LMR OHWT	LinStatic		0	0	4200	92283.705	-101556.9684	0	0
Live1	LinStatic		0	0	0	0	0	0	0
Live2	LinStatic		0	0	32112.5578	707849.0171	-764245.4934	0	0
Roof Live	LinStatic		0	0	3098.2501	68427.0461	-77333.85	0	0
Eqx	LinStatic	Max	-4948.3958	0	-3.984E-06	-0.0001	-79644.2534	113188.2684	0
Eqx	LinStatic	Min	-4948.3958	0	-4.104E-06	-0.0001	-79644.2534	104724.2951	0
Eqy	LinStatic	Max	0	-4948.3958	7.129E-06	79644.2536	-0.0002	-114293.1839	0
Eqy	LinStatic	Min	0	-4948.3958	6.997E-06	79644.2536	-0.0002	-123590.3273	0
Specx	LinRespSpec	Max	4948.3952	14.3707	134.7761	3012.3959	35207.7326	109979.3441	0
Specy	LinRespSpec	Max	14.7285	4948.3966	23.9321	43085.5475	924.6034	116307.7085	0
Wind	LinStatic	Max	0	0	1.043E-06	13439.8896	-3.205E-05	24427.6282	0
Wind	LinStatic	Min	-1100.6445	-1208.9889	-5.367E-07	-9.76E-06	-12235.4644	-29080.2765	0

Table 3.1 - Base Reactions (Part 2 of 2)

Y m	Z m
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5
0	-1.5



3.2 Story Results

Table 3.2 - Story Max Over Avg Displacements

Story	Output Case	Case Type	Step Type	Step Number	Step Label	Direction	Maximum mm	Average mm	Ratio
Terrace	Wind	LinStatic	Max			X	4.557	4.476	1.018
Terrace	Wind	LinStatic	Max			Y	2.966	2.938	1.009
4th Floor	Wind	LinStatic	Max			X	3.622	3.557	1.018
4th Floor	Wind	LinStatic	Max			Y	2.368	2.363	1.002
3rd Floor	Wind	LinStatic	Max			X	2.599	2.552	1.018
3rd Floor	Wind	LinStatic	Max			Y	1.728	1.721	1.004
2nd Floor	Wind	LinStatic	Max			X	1.549	1.521	1.019
2nd Floor	Wind	LinStatic	Max			Y	1.051	1.043	1.008
1st Floor	Wind	LinStatic	Max			X	0.613	0.602	1.019
1st Floor	Wind	LinStatic	Max			Y	0.423	0.422	1.003
Plinth	Wind	LinStatic	Max			X	0.094	0.082	1.147
Plinth	Wind	LinStatic	Max			Y	0.071	0.062	1.147
Terrace	Wind	LinStatic	Min			X	0.033	0.007	4.401
Terrace	Wind	LinStatic	Min			Y	0.095	0.006	14.989
4th Floor	Wind	LinStatic	Min			X	0.01	0.005	2.004
4th Floor	Wind	LinStatic	Min			Y	0.076	0.004	17.828
3rd Floor	Wind	LinStatic	Min			X	0.009	0.003	3.625
3rd Floor	Wind	LinStatic	Min			Y	0.054	0.002	22.998
2nd Floor	Wind	LinStatic	Min			X	0.008	0.001	6.992
2nd Floor	Wind	LinStatic	Min			Y	0.032	0.001	29.199
1st Floor	Wind	LinStatic	Min			X	0.002	0.0004291	3.528
1st Floor	Wind	LinStatic	Min			Y	0.013	0.0004165	31.334
Plinth	Wind	LinStatic	Min			Y	0.014	0.002	6.988

Table 3.3 - Story Drifts

Story	Output Case	Case Type	Step Type	Step Number	Step Label	Direction	Drift	Drift/	Label	X m	Y m	Z m
Terrace	Eqx	LinStatic	Max			X	0.002053		139	0.2	43.9304	18.25
Terrace	Eqx	LinStatic	Min			X	0.001973		71	0.1	21.465	18.25
Terrace	Eqy	LinStatic	Max			Y	0.001224		71	0.1	21.465	18.25
Terrace	Eqy	LinStatic	Min			Y	0.001127		10	17.8648	0.5	18.25
Terrace	Specx	LinRespSpec	Max			X	0.00095		139	0.2	43.9304	18.25
Terrace	Specy	LinRespSpec	Max			Y	0.000648		71	0.1	21.465	18.25
4th Floor	Eqx	LinStatic	Max			X	0.002157		140	1.45	43.9304	14.5
4th Floor	Eqx	LinStatic	Min			X	0.002074		71	0.1	21.465	14.5
4th Floor	Eqy	LinStatic	Max			Y	0.001291		71	0.1	21.465	14.5
4th Floor	Eqy	LinStatic	Min			Y	0.001203		10	17.8648	0.5	14.5
4th Floor	Specx	LinRespSpec	Max			X	0.000933		140	1.45	43.9304	14.5
4th Floor	Specy	LinRespSpec	Max			Y	0.000665		71	0.1	21.465	14.5
3rd Floor	Eqx	LinStatic	Max			X	0.00208		140	1.45	43.9304	10.75
3rd Floor	Eqx	LinStatic	Min			X	0.002		71	0.1	21.465	10.75
3rd Floor	Eqy	LinStatic	Max			Y	0.00125		71	0.1	21.465	10.75
3rd Floor	Eqy	LinStatic	Min			Y	0.001181		11	29.075	0.5	10.75
3rd Floor	Specx	LinRespSpec	Max			X	0.000841		140	1.45	43.9304	10.75
3rd Floor	Specy	LinRespSpec	Max			Y	0.000626		71	0.1	21.465	10.75
2nd Floor	Eqx	LinStatic	Max			X	0.001716		140	1.45	43.9304	7
2nd Floor	Eqx	LinStatic	Min			X	0.001649		71	0.1	21.465	7
2nd Floor	Eqy	LinStatic	Max			Y	0.001053		14	48.135	2.5	7
2nd Floor	Eqy	LinStatic	Min			Y	0.000997		11	29.075	0.5	7
2nd Floor	Specx	LinRespSpec	Max			X	0.000732		140	1.45	43.9304	7
2nd Floor	Specy	LinRespSpec	Max			Y	0.000539		71	0.1	21.465	7
1st Floor	Eqx	LinStatic	Max			X	0.001046		134	48.135	41.6304	3.25
1st Floor	Eqx	LinStatic	Min			X	0.001006		159	44.3275	25.9152	3.25
1st Floor	Eqy	LinStatic	Max			Y	0.000656		145	46.8891	43.9299	3.25
1st Floor	Eqy	LinStatic	Min			Y	0.000619		113	29.075	30.1314	3.25

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Story	Output Case	Case Type	Step Type	Step Numb er	Step Label	Directio n	Drift	Drift/	Label	X m	Y m	Z m
1st Floor	Specx	LinRespSpec	Max			X	0.000535		133	0.2	41.6304	3.25
1st Floor	Specy	LinRespSpec	Max			Y	0.000384		140	1.45	43.9304	3.25
Plinth	Eqx	LinStatic	Max			X	0.00036		73	3.4011	21.465	0
Plinth	Eqx	LinStatic	Min			X	0.000356		73	3.4011	21.465	0
Plinth	Eqy	LinStatic	Max			Y	0.000248		61	0.1	19.2153	0
Plinth	Eqy	LinStatic	Min			Y	0.000228		61	0.1	19.2153	0
Plinth	Specx	LinRespSpec	Max			X	0.000226		73	3.4011	21.465	0
Plinth	Specy	LinRespSpec	Max			X	3E-05		64	3.4038	19.2153	0
Plinth	Specy	LinRespSpec	Max			Y	0.000173		61	0.1	19.2153	0

3.3 Modal Results

Table 3.4 - Modal Periods And Frequencies

Case	Mode	Period sec	Frequenc y cyc/sec	CircFreq rad/sec	Eigenvalu e rad2/sec2
Modal	1	1.544	0.647	4.0682	16.5503
Modal	2	1.198	0.835	5.2462	27.5222
Modal	3	1.036	0.966	6.0669	36.8069
Modal	4	0.448	2.23	14.0101	196.282
Modal	5	0.448	2.233	14.0322	196.9028
Modal	6	0.447	2.236	14.0497	197.3942
Modal	7	0.447	2.238	14.0604	197.6958
Modal	8	0.447	2.239	14.0674	197.8904
Modal	9	0.446	2.24	14.0739	198.0755
Modal	10	0.446	2.243	14.0948	198.6635
Modal	11	0.445	2.246	14.111	199.1198
Modal	12	0.442	2.263	14.2166	202.1117
Modal	13	0.442	2.264	14.2276	202.4256
Modal	14	0.441	2.268	14.2506	203.0808
Modal	15	0.44	2.271	14.2676	203.5638
Modal	16	0.544	1.839	11.5534	133.481
Modal	17	0.361	2.768	17.3929	302.5127
Modal	18	0.814	1.229	7.7216	59.6233

Table 3.5 - Modal Participating Mass Ratios (Part 1 of 2)

Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX
Modal	1	1.544	0.729	1.044E-05	1.096E-05	0.729	1.044E-05	1.096E-05	5.866E-07	0.0321	0.0006	5.866E-07
Modal	2	1.198	1.509E-05	0.7364	2.909E-06	0.729	0.7364	1.387E-05	0.0357	6.105E-07	0.0001	0.0357
Modal	3	1.036	0.0005	0.0003	0	0.7295	0.7367	1.387E-05	3.052E-05	4.716E-05	0.718	0.0357
Modal	4	0.448	3.864E-06	0	0.0001	0.7295	0.7367	0.0001	0	0.0003	0	0.0357
Modal	5	0.448	1.071E-05	0	0.0031	0.7295	0.7367	0.0032	7.797E-07	0.0079	0	0.0357
Modal	6	0.447	2.99E-06	5.014E-07	0.0027	0.7295	0.7367	0.006	0.0001	0.003	0	0.0357
Modal	7	0.447	0.0001	2.349E-06	0.0057	0.7296	0.7367	0.0117	0.0007	0.0001	0	0.0365
Modal	8	0.447	9.397E-06	0	0.002	0.7296	0.7367	0.0137	3.964E-05	0.0019	0	0.0365
Modal	9	0.446	0.0001	5.558E-06	0.0259	0.7297	0.7367	0.0396	0.0035	0.0011	0	0.04
Modal	10	0.446	4.219E-05	1.69E-06	0.0031	0.7298	0.7367	0.0428	0.0004	0.0001	0	0.0404
Modal	11	0.445	3.647E-05	0	0.0064	0.7298	0.7367	0.0492	0.0009	0.0002	0	0.0413
Modal	12	0.442	2.854E-05	3.901E-06	0.0029	0.7299	0.7367	0.052	0.0034	0.0001	1.148E-06	0.0448
Modal	13	0.442	3.33E-05	5.774E-06	0.0079	0.7299	0.7367	0.06	0.0094	0.0004	1.859E-06	0.0542
Modal	14	0.441	9.01E-06	1.313E-06	0.0007	0.7299	0.7367	0.0607	0.0008	3.852E-05	0	0.055
Modal	15	0.44	1.554E-05	0	0.0016	0.7299	0.7367	0.0623	0.0017	0.0001	0	0.0568
Modal	16	0.544	0.1748	0	0.0006	0.9047	0.7367	0.0629	1.135E-06	0.0448	0.0001	0.0568
Modal	17	0.361	0	0.1773	1.126E-05	0.9047	0.914	0.0629	0.0591	0.0001	4.068E-05	0.1159
Modal	18	0.814	0	0	0.221	0.9047	0.914	0.2839	0.0001	0.0087	0	0.116

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Table 3.6 - Modal Participating Mass Ratios (Part 2 of 2)

SumRY	SumRZ
0.0321	0.0006
0.0321	0.0007
0.0321	0.7186
0.0325	0.7186
0.0404	0.7186
0.0434	0.7186
0.0436	0.7186
0.0454	0.7186
0.0465	0.7186
0.0466	0.7186
0.0468	0.7186
0.047	0.7186
0.0474	0.7186
0.0474	0.7186
0.0476	0.7186
0.0924	0.7187
0.0924	0.7187
0.1012	0.7187

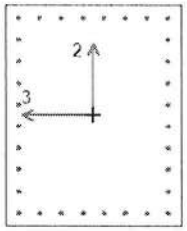
Table 3.7 - Modal Load Participation Ratios

Case	ItemType	Item	Static %	Dynamic %
Modal	Acceleration	UX	101.67	90.47
Modal	Acceleration	UY	100.81	91.4
Modal	Acceleration	UZ	257.74	28.39

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ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design



Column Element Details Type: Ductile Frame (Summary) (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc
3rd Floor	C27	320	C1000X800M40	UDConS2	0

Column Element Details Type: Ductile Frame (Summary) (Part 2 of 2)

Length (mm)	LLRF
3750	0.8

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
800	1000	58	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	415

Design Code Parameters

Yc	Ys
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3} (Part 1 of 2)

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²
6637.3655	-217.8162	1700.2949	217.8162	262.0653	6400

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3} (Part 2 of 2)

Rebar % %
0.8

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Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.968299	3075	680.118	0	262.0653
Minor Bend(M2)	1.2	3075	-29.5004	0	217.8162

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	928.8983	532.199	396.6993	0	1166.98
Minor, V_{u3}	17.8198	527.8487	296.7986	0	1108.43

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	N/A	N/A	N/A	N/A	N/A	N/A
Minor Shear, V_{u3}	N/A	N/A	N/A	N/A	N/A	N/A

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
N/A	N/A

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
8000	64	16800	6931.3484	6637.3655	1

Additional Moment (IS 39.7.1) (Part 1 of 2)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded
Major Bending (M_3)	Yes	0.82	1000	2.978	12	No
Minor Bending (M_2)	Yes	0.82	800	4.613	12	No

Additional Moment (IS 39.7.1) (Part 2 of 2)

M_a Moment (kN-m)
0
0

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ETABS Shear Wall Design

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Terrace	PW17A	41802.5	24865.2	2100	200	1

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	415

Design Code Parameters

γ_s	γ_c	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	41802.5	23815.2	41802.5	25915.2	2100	200
Bottom	Leg 1	41802.5	23815.2	41802.5	25915.2	2100	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	1050	0.0025	0.0024	UDWalS26	308.2936	8.5786	-49.5482	420000
Bottom	1050	0.0025	0.0024	UDWalS26	343.7206	-9.824	-101.6235	420000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	UDWalS24	504.651	-37.6937	50.1533	109.8837	413.0142
Bottom	Leg 1	500	UDWalS24	563.6961	144.4062	50.1533	110.9465	414.077

Boundary Element Check

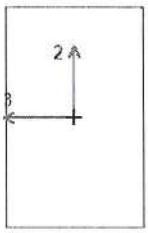
Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	UDWalS23	544.3791	-35.0627	1.53	8
Top–Right	Leg 1	0	UDWalS23	0	0	0	0
Bottom–Left	Leg 1	0	UDWalS24	570.5748	-90.9279	1.98	8
Botttom–Right	Leg 1	0	UDWalS24	603.4241	43.056	1.73	8

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ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Beam Section Design



Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
3rd Floor	B106	263	B600X375M35	UDConS23	5550	5950	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
375	600	375	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
29580.4	35	1	500	415

Design Code Parameters

ɣc	ɣs
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-247.4919	0.1207	182.0195	-1.7708

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Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-247.4919	0.1846	0	-247.6765

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-247.6765		1116	2	1116	575
Bottom (-2 Axis)		0	575	2	0	575

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
270.6621	0	273.1252	125.1256	1401.58

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
0.5773	182.0195	275	500	415.15

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DESIGNAGE Consulting structural Engineer.	**Project:**	EGMORE	**Date:-**	31-Jul-2024
Office No-402, 4th Floor, Wing-C, Audumbar Apartments	**Floor Level**	FIRST	**Revision -**	
Pune-411052, Maharashtra.	**Job No.**	1244	**Sheet No. -**	

Design Of One Way Slab

Slab Marked : S1

span = 2.650 m

Thickness of slab D = 150 mm

d_{eff} = 150 - 25 = 125 mm

Loading :

Self wt. Of slab	=	0.15 x 2.5 =	0.375	t/m^2
L.L.	=		0.2	
F.F	=		0.1	
Filling/steps	=		0.4	
			1.075	t/m^2

Bending Moment :

$$M = \frac{1.075 \times 2.65^2}{8} = 0.944 \text{ tm}$$

$$Qu = \frac{Mu}{b \times d^2} = \frac{0.944 \times 1.5 \times 10^7}{1000 \times 125 \times 125} = 0.906 \text{ N/mm}^2$$

fck = 40 N/mm^2 & fy = 500 N/mm^2

Main Reinforcement.

$$pt = \frac{50 x fck}{fy}\left[1 - \sqrt{1 - ((4.6 x Qu)/(fck))}\right]$$

pt = 0.214 %

Ast = pt x 1000 x deff. = 267.61 mm^2

Min Steel Reqd = 0.12 % of c/s. area

Min Ast Reqd = $\frac{0.12 \times 1000 \times 150}{100}$ = 180 mm^2

Main steel Reqd. 8 Tor @ 187.8 mm c/c.

Main steel Provided 8 Tor @ 100.0 mm c/c.

Ast provided = 502.656 mm^2 > 267.61 mm^2

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DESIGNAGE Consulting structural Engineer.	**Project:**	EGMORE	**Date:-**	31-Jul-2024
Office No-402, 4th Floor, Wing-C, Audumbar Apartments	**Floor Level**	FIRST	**Revision -**	
Pune-411052, Maharashtra.	**Job No.**	1244	**Sheet No. -**	

Distribution Reinforcement.

= 0.12 % of c/s. area

Ast = 180 mm^2

Dist steel Reqd. 8 Tor @ 279.3 mm c/c.

Dist steel Provided 8 Tor @ 275 mm c/c.

Check for Shear.

$$Vu = \frac{1.075 \times 1.5 \times 2.650}{2} = 2.137 \text{ t}$$

$$Tv = \frac{Vu}{b \times d}$$

$$= \frac{2.137 \times 10^4}{1000 \times 125} = 0.1709 \text{ N/mm}^2$$

$$\% \text{ steel provided} = \frac{502.656 \times 100}{1000 \times 125} = 0.402 \%$$

Tc = 0.462 N/mm^2 (Refer Table 19 of IS 456 : 2000)

For D = 150

K = 1.3 (Refer Cl : 40.2.1.1 of IS 456 : 2000)

∴ K Tc = 1.3 x 0.462 = 0.601 N/mm^2

Tv < K Tc Hence OK

Check for Deflection.

Refer fig.4 page. 38 of IS 456 : 2000

$$fs = 0.58 \times fy \times \frac{\text{Area of cross-section of steel required}}{\text{Area of cross-section of steel provided}}$$

$$= 0.58 \times 500 \times \frac{267.61}{502.656}$$

= 154.39 N/mm^2

% steel provided = 0.402 %

Modification factor = 1.94

$$\frac{\text{Span}}{d} < 20 \times M.F$$

$$\text{Required d} = \frac{2650}{1.94 \times 20} = 68.42 \text{ mm}$$

Required D = 68.42 + 25 = 93.42

Provided D = 150 mm Hence OK

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