STRUCTURAL DESIGN BASIS REPORT

For

PROPOSED CONSTRUCTION OF BASEMENT + GROUND + 4 FLOORS +TERRACE COMMERCIAL BUILDING AT EGATTUR., CHENNAI

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R0–06 august. 2024

1. INTRODUCTION

The proposed development consists of **Basement + Ground + 4 Floors + Terrace (One floor provision).** Tower is mean for use as commercial apartments. The basement Floor to be used as Parking Area & for Services. The Ground 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)
Basement	4
Ground Floor to 4th Floor	4

The total height of building up to Terrace level is 20 meter (excluding parapet) from Basement 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

2.2 Weight of Walls:

External Light weight Wall with 200 thk = 2.51 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

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
	Fire Van	15

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)	2
	Partition wall	1
	Services	0.5
Live Load	Offices	4
	Toilet	2
	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	400KN 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	=	50 m/sec
Risk Coefficient	K_1	=	1 (Based on 50 years return period)
Terrain, Height Factor	K_2	=	1.05 (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
$P_z = 0.6V_z^2$

2.4.1 GUST FACTOR

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

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
Table-7	Response Reduction Factor (R)	=	4.0
	Height of buildings (H)	=	20m

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.

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

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

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)

9. CONSTRUCTION DETAILS

1. Pile foundation -M: 35
2. Water Tanks -M: 35
3. Columns/Walls -M: 35
4. Beams & Slabs -M: 35

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. Pile capacities & settlements are considered as per soil investigation report provided by Geo-Designer

14. FIRE RATING

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

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.

For

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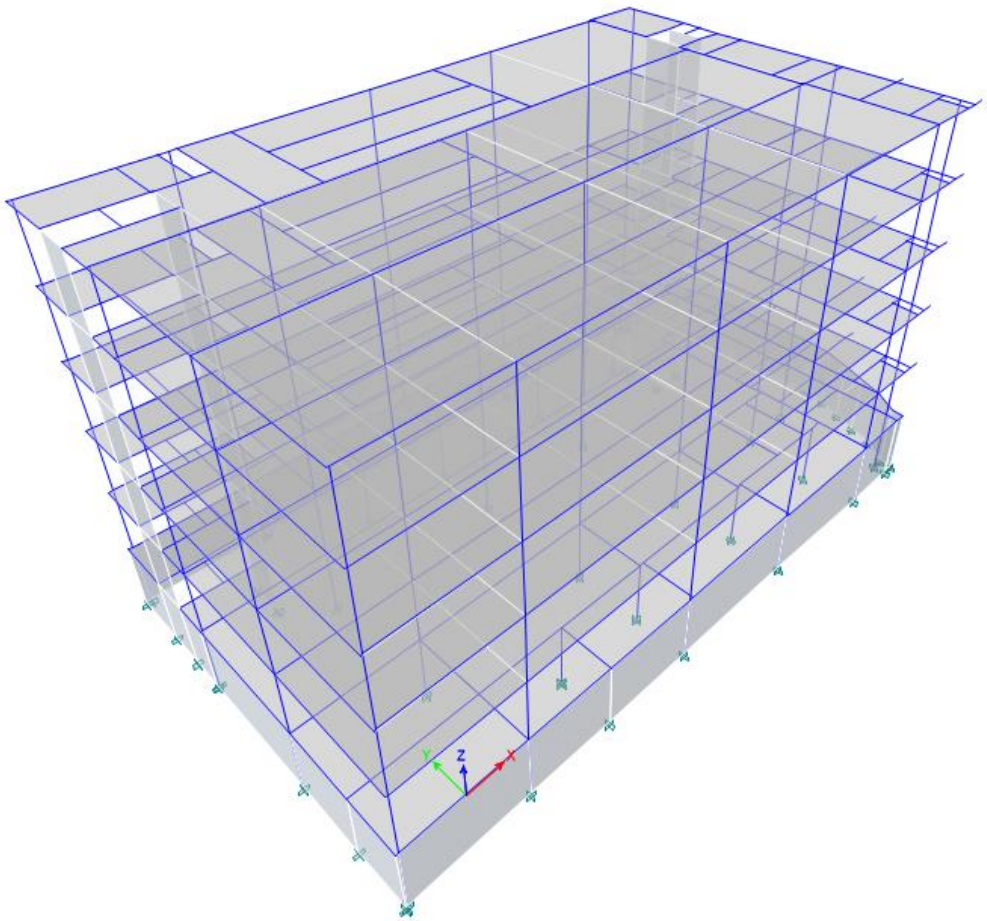
ETABS®



User Report 1

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	Color
T1	TERRACE	4	Yes	None	No	Cyan
T1	FOURTH FLOOR(PROV)	4	Yes	None	No	Magenta
T1	THIRD FLOOR	4	Yes	None	No	Gray8Dark
T1	SECOND FLOOR	4	No	THIRD FLOOR	No	Green
T1	FIRST FLOOR	4	No	THIRD FLOOR	No	Red
T1	GROUND FLOOR	4	No	THIRD FLOOR	No	Yellow

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
~LLRF	Yes	Other	0	
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	
Live<3	No	Reducible Live	0	
Live>3	No	Reducible Live	0	
LMROHWT	No	Super Dead	0	
Roof Live	No	Live	0	
Service load	No	Dead	1	
Sunk	No	Super Dead	0	
Wall	No	Super Dead	0	
WindX	No	Wind	0	Indian IS 875:2015
WindY	No	Wind	0	Indian IS 875:2015

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		$h_n = 20\ \text{m}$
Coefficient, C_t [IS 7.6.1]		$C_t = 0.075\text{m}$
Approximate Fundamental Period, T_a [IS 7.6.2]	$T_a = C_t h_n^{0.75}$	$T_a = 0.709\ \text{sec}$

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3]	$Z = 0.16$
Response Reduction Factor, R [IS Table 9]	$R = 4$
Importance Factor, I [IS Table 8]	$I = 1$

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

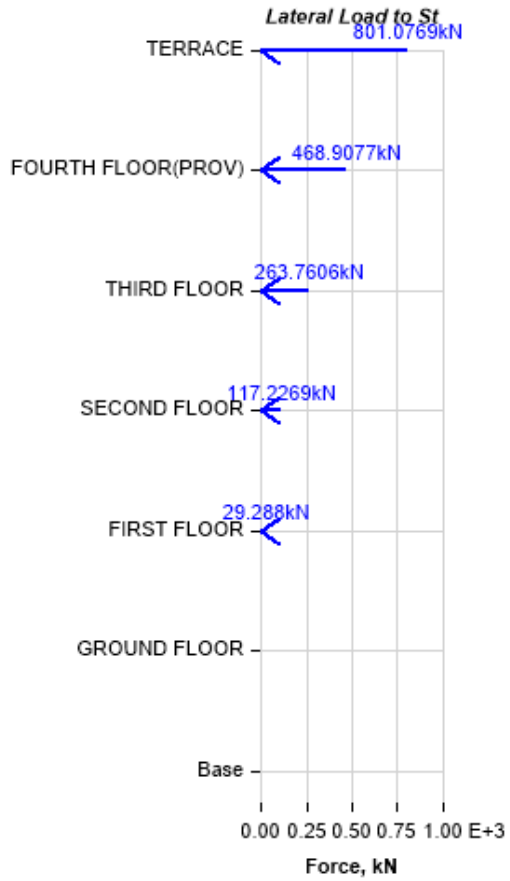
Seismic Coefficient, A_h [IS 6.4.2]

$$A_h = \frac{ZI\frac{S_a}{g}}{2R}$$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.709	59590.9465	1680.2601
X + Ecc. Y	0.709	59590.9465	1680.2601
X - Ecc. Y	0.709	59590.9465	1680.2601

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
TERRACE	20	801.0769	0
FOURTH FLOOR(PROV)	16	468.9077	0
THIRD FLOOR	12	263.7606	0
SECOND FLOOR	8	117.2269	0
FIRST FLOOR	4	29.288	0
GROUND FLOOR	0	0	0
Base	-4	0	0

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQY 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		$h_n = 20\ \text{m}$
Coefficient, C_t [IS 7.6.1]		$C_t = 0.075\text{m}$
Approximate Fundamental Period, T_a [IS 7.6.2]	$T_a = C_t {h_n}^{0.75}$	$T_a = 0.709\ \text{sec}$

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3]	$Z = 0.16$
Response Reduction Factor, R [IS Table 9]	$R = 4$
Importance Factor, I [IS Table 8]	$I = 1$

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

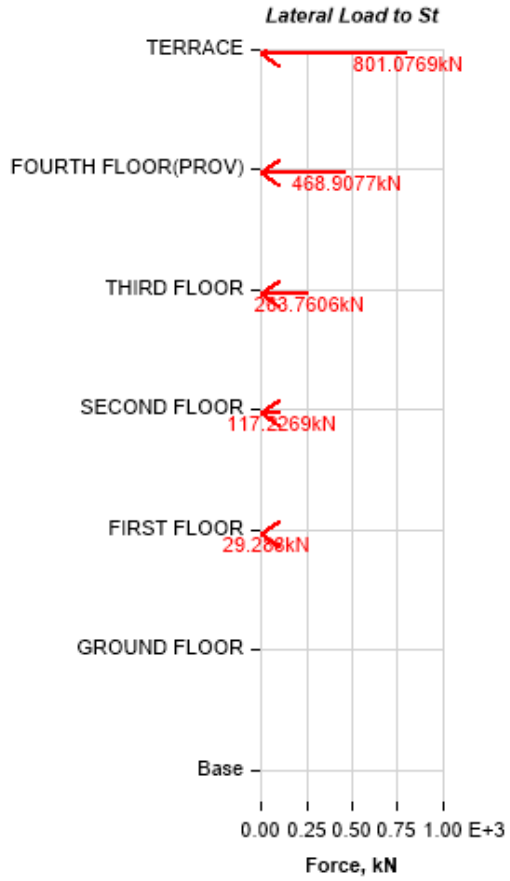
Seismic Coefficient, A_h [IS 6.4.2]

$$A_h = \frac{ZI\frac{S_a}{g}}{2R}$$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.709	59590.9465	1680.2601
Y + Ecc. X	0.709	59590.9465	1680.2601
Y - Ecc. X	0.709	59590.9465	1680.2601

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
TERRACE	20	0	801.0769
FOURTH FLOOR(PROV)	16	0	468.9077
THIRD FLOOR	12	0	263.7606
SECOND FLOOR	8	0	117.2269
FIRST FLOOR	4	0	29.288
GROUND FLOOR	0	0	0
Base	-4	0	0

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	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m
Dead	LinStatic			-4.684E-06	-1.045E-06	43105.5781	502411.9029	-681810.0876
Live<3	LinStatic			0	0	827.8449	7582.5545	-18715.5996
Live>3	LinStatic			-2.664E-06	0	16727.6047	193480.4364	-264909.6027
Roof Live1	LinStatic			0	0	1152.4511	12444.2858	-17970.0783
Finish	LinStatic			-8.789E-07	-5.571E-07	7266.2929	83049.5309	-115507.4448
Sunk	LinStatic			0	0	290.3804	1470.1693	-9446.5234
Wall	LinStatic			-2.409E-06	-1.999E-06	13880.5806	161486.6088	-246110.4611
LMROHWT	LinStatic			0	2.164E-06	3000	48172.4136	-44637.4491
EQX	LinStatic	Max		-1680.2602	1.84E-06	0	-1.571E-05	-34465.1982
EQX	LinStatic	Min		-1680.2602	7.323E-07	0	-3.798E-05	-34465.1982
EQY	LinStatic	Max		1.461E-06	-1680.2602	0	34465.1995	2.776E-05
EQY	LinStatic	Min		0	-1680.2602	0	34465.1995	-9.188E-07
SPECX	LinRespSpec	Max		1676.7258	71.4745	0	1330.1946	23205.5688
SPECY	LinRespSpec	Max		70.1843	1678.733	0	22266.1483	1274.5013
WindX	LinStatic			-691.4068	0	0	-4.807E-06	-6756.6126
WindY	LinStatic			0	-1189.2165	0	11500.589	2.883E-06
Service load	LinStatic			-4.684E-06	-1.045E-06	43105.5781	502411.9029	-681810.0876

Table 3.1 - Base Reactions (Part 2 of 2)

MZ kN-m	X m	Y m	Z m
-5345.0309	0	0	-4
3995.4659	0	0	-4
2.914E-05	0	0	-4
1.496E-06	0	0	-4
1.916E-05	0	0	-4
1.963E-06	0	0	-4
7.248E-07	0	0	-4
1.478E-06	0	0	-4
-4.339E-06	0	0	-4
2.815E-05	0	0	-4
21361.6233	0	0	-4
19432.3082	0	0	-4
-24797.5943	0	0	-4
-28057.633	0	0	-4
19070.7069	0	0	-4
25628.6302	0	0	-4
7891.7936	0	0	-4
-19145.3987	0	0	-4
2.914E-05	0	0	-4

3.2 Story Results

Table 3.2 - Story Max Over Avg Displacements

Story	Output Case	Case Type	Step Type	Step Number	Direction	Maximum mm	Average mm	Ratio
TERRACE	WindX	LinStatic			X	4.28	4.131	1.036
FOURTH FLOOR(PROV)	WindX	LinStatic			X	4.077	3.949	1.032
THIRD FLOOR	WindX	LinStatic			X	3.628	3.529	1.028
SECOND FLOOR	WindX	LinStatic			X	2.624	2.563	1.024
FIRST FLOOR	WindX	LinStatic			X	1.131	1.109	1.019
GROUND FLOOR	WindX	LinStatic			X	0.026	0.026	1.012
TERRACE	WindY	LinStatic			Y	7.125	7.095	1.004
FOURTH FLOOR(PROV)	WindY	LinStatic			Y	6.236	6.09	1.024
THIRD FLOOR	WindY	LinStatic			Y	5.036	4.826	1.043
SECOND FLOOR	WindY	LinStatic			Y	3.326	3.156	1.054
FIRST FLOOR	WindY	LinStatic			Y	1.346	1.305	1.031
GROUND FLOOR	WindY	LinStatic			Y	0.107	0.103	1.042

Table 3.3 - Story Drifts (Part 1 of 2)

Story	Output Case	Case Type		Step Type	Step Number	Direction	Drift	Label	X m
TERRACE	EQX	LinStatic		Max		X	0.001474	9	30.6732
TERRACE	EQX	LinStatic		Min		X	0.001397	54	34.3232
TERRACE	EQY	LinStatic		Max		Y	0.002411	13	35.0232
TERRACE	EQY	LinStatic		Min		Y	0.002204	69	14.4788
TERRACE	SPECX	LinRespSpec		Max		X	0.001033	2	-3.4381
TERRACE	SPECX	LinRespSpec		Max		Y	0.000124	13	35.0232
TERRACE	SPECY	LinRespSpec		Max		Y	0.001406	117	-3.5506
FOURTH FLOOR(PROV)	EQX	LinStatic		Max		X	0.001957	2	-3.4381
FOURTH FLOOR(PROV)	EQX	LinStatic		Min		X	0.001872	54	34.3232
FOURTH FLOOR(PROV)	EQY	LinStatic		Max		Y	0.002484	13	35.0232
FOURTH FLOOR(PROV)	EQY	LinStatic		Min		Y	0.002339	69	14.4788
FOURTH FLOOR(PROV)	SPECX	LinRespSpec		Max		X	0.001281	2	-3.4381
FOURTH FLOOR(PROV)	SPECY	LinRespSpec		Max		Y	0.001448	117	-3.5506
THIRD FLOOR	EQX	LinStatic		Max		X	0.00223	2	-3.4381
THIRD FLOOR	EQX	LinStatic		Min		X	0.002144	54	34.3232
THIRD FLOOR	EQY	LinStatic		Max		Y	0.002467	117	-3.5506
THIRD FLOOR	EQY	LinStatic		Min		Y	0.002279	69	14.4788
THIRD FLOOR	SPECX	LinRespSpec		Max		X	0.001441	2	-3.4381
THIRD FLOOR	SPECY	LinRespSpec		Max		Y	0.001406	117	-3.5506
SECOND FLOOR	EQX	LinStatic		Max		X	0.002093	2	-3.4381
SECOND FLOOR	EQX	LinStatic		Min		X	0.002024	54	34.3232
SECOND FLOOR	EQY	LinStatic		Max		Y	0.002059	117	-3.5506
SECOND FLOOR	EQY	LinStatic		Min		Y	0.001872	69	14.4788
SECOND FLOOR	SPECX	LinRespSpec		Max		X	0.001437	2	-3.4381
SECOND FLOOR	SPECY	LinRespSpec		Max		Y	0.00124	117	-3.5506
FIRST FLOOR	EQX	LinStatic		Max		X	0.001169	9	30.6732
FIRST FLOOR	EQX	LinStatic		Min		X	0.001137	54	34.3232
FIRST FLOOR	EQY	LinStatic		Max		Y	0.00103	117	-3.5506
FIRST FLOOR	EQY	LinStatic		Min		Y	0.00097	69	14.4788
FIRST FLOOR	SPECX	LinRespSpec		Max		X	0.00087	2	-3.4381
FIRST FLOOR	SPECY	LinRespSpec		Max		Y	0.000678	117	-3.5506
GROUND FLOOR	EQX	LinStatic		Max		X	1.9E-05	133	35.0232
GROUND FLOOR	EQX	LinStatic		Min		X	1.8E-05	63	-3.4381
GROUND FLOOR	EQY	LinStatic		Max		Y	6.5E-05	57	37.7052
GROUND FLOOR	EQY	LinStatic		Min		Y	6.1E-05	57	37.7052
GROUND FLOOR	SPECX	LinRespSpec		Max		X	1.6E-05	12	34.3232
GROUND FLOOR	SPECX	LinRespSpec		Max		Y	3E-06	57	37.7052
GROUND FLOOR	SPECY	LinRespSpec		Max		Y	4.5E-05	57	37.7052

3.4 Modal Results

Table 3.5 - Modal Periods And Frequencies

Case	Mode	Period sec	Frequency cyc/sec	CircFreq rad/sec	Eigenvalue rad2/sec2
Modal	1	1.688	0.592	3.7212	13.8474
Modal	2	1.647	0.607	3.8144	14.5494
Modal	3	1.305	0.767	4.8165	23.1986
Modal	4	0.473	2.115	13.2889	176.5949
Modal	5	0.387	2.586	16.2478	263.9921
Modal	6	0.305	3.283	20.6289	425.5496
Modal	7	0.228	4.393	27.602	761.8699
Modal	8	0.154	6.482	40.7269	1658.6773
Modal	9	0.136	7.371	46.3102	2144.6374
Modal	10	0.12	8.335	52.3713	2742.751
Modal	11	0.098	10.228	64.2656	4130.065
Modal	12	0.083	12.074	75.864	5755.346
Modal	13	0.064	15.59	97.9572	9595.6091
Modal	14	0.055	18.112	113.8021	12950.9197
Modal	15	0.044	22.609	142.0547	20179.549
Modal	16	0.041	24.264	152.4537	23242.1259
Modal	17	0.039	25.611	160.9211	25895.6161
Modal	18	0.029	34.918	219.3935	48133.5212

Table 3.6 - Modal Participating Mass Ratios (Part 1 of 2)

Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ
Modal	1	1.688	0.0201	0.5873	0	0.0201	0.5873	0	0.4272	0.0127	0.002
Modal	2	1.647	0.6222	0.0192	0	0.6423	0.6065	0	0.0139	0.3922	0.0002
Modal	3	1.305	0.001	0.0002	0	0.6433	0.6067	0	0.0002	0.0015	0.5945
Modal	4	0.473	0.1008	3.947E-05	0	0.7442	0.6067	0	2.713E-05	0.1824	0.0001
Modal	5	0.387	3.592E-05	0.1356	0	0.7442	0.7424	0	0.1377	0.0001	0.0061
Modal	6	0.305	2.043E-05	0.0094	0	0.7442	0.7518	0	0.0083	0.0001	0.122
Modal	7	0.228	0.044	3.704E-06	0	0.7882	0.7518	0	4.09E-06	0.0384	1.16E-05
Modal	8	0.154	2.276E-06	0.0569	0	0.7882	0.8087	0	0.0636	2.22E-06	0.0062
Modal	9	0.136	0.0224	0	0	0.8106	0.8087	0	0	0.0319	3.108E-05
Modal	10	0.12	8.844E-06	0.0096	0	0.8106	0.8183	0	0.013	1.222E-05	0.0481
Modal	11	0.098	0.0077	0	0	0.8184	0.8183	0	0	0.0102	9.601E-06
Modal	12	0.083	0	0.0388	0	0.8184	0.8571	0	0.0599	0	0.0039
Modal	13	0.064	1.087E-06	0.0122	0	0.8184	0.8693	0	0.0214	2.075E-06	0.0278
Modal	14	0.055	0	0.0271	0	0.8184	0.8964	0	0.0479	6.305E-07	0.0031
Modal	15	0.044	1.15E-05	0.0688	0	0.8184	0.9652	0	0.1366	2.062E-05	0.0083
Modal	16	0.041	1.386E-05	0.0321	0	0.8184	0.9973	0	0.0649	2.545E-05	0.0079
Modal	17	0.039	0.1794	1.924E-05	0	0.9978	0.9974	0	3.607E-05	0.3265	0.0001
Modal	18	0.029	8.974E-07	0.0005	0	0.9978	0.9978	0	0.001	1.816E-06	0.1584

Table 3.7 - Modal Participating Mass Ratios (Part 2 of 2)

SumRX	SumRY	SumRZ
0.4272	0.0127	0.002
0.4411	0.4049	0.0023
0.4412	0.4064	0.5968
0.4413	0.5888	0.5969
0.5789	0.5889	0.603
0.5872	0.5889	0.7249
0.5872	0.6274	0.7249
0.6509	0.6274	0.7311
0.6509	0.6592	0.7311
0.6639	0.6592	0.7793
0.6639	0.6694	0.7793
0.7238	0.6694	0.7832

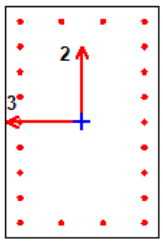
SumRX	SumRY	SumRZ
0.7452	0.6694	0.8111
0.7931	0.6694	0.8141
0.9297	0.6694	0.8224
0.9946	0.6694	0.8303
0.9947	0.996	0.8304
0.9957	0.996	0.9889

Table 3.8 - Modal Load Participation Ratios

Case	ItemType	Item	Static %	Dynamic %
Modal	Acceleration	UX	100	99.97
Modal	Acceleration	UY	100	99.97
Modal	Acceleration	UZ	0	0

ETABS Concrete Frame Design

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



Column Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
SECOND FLOOR	C13	462	C900X600M35	UDConS32	0	4000	1

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
600	900	58	30

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

γ_c	γ_s
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

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	Rebar % %
2308.1026	894.1181	238.5007	61.8571	84.9382	5148	0.95

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)	1.2	3400	97.371	0	84.9382
Minor Bend(M2)	1.2	3400	69.3678	0	61.8571

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}	68.3859	347.5085	202.0792	0	665.06
Minor, V_{u3}	445.7839	339.9001	195.1188	445.7839	997.59

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
5400	51.5	10435.567	4074.086	2308.1026	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.85	900	4.533	12	No	0
Minor Bending (M_2)	Yes	0.85	600	6.8	12	No	0

Notes:

N/A: Not Applicable

N/C: Not Calculated

N/N: Not Needed

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
SECOND FLOOR	P7A	-3550.6	18414.1	2200	250	1

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
24855.58	27.58	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	-3550.6	17314.1	-3550.6	19514.1	2200	250
Bottom	Leg 1	-3550.6	17314.1	-3550.6	19514.1	2200	250

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

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	1375	0.0025	0.0029	DWalS32	1407.9565	-40.0626	-610.2756	550000
Bottom	2745	0.005	0.0029	DWalS26	540.0074	34.2952	-1443.7089	550000

Shear Design

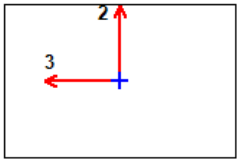
Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	625	DWalS22	1149.1346	11.4748	-342.1263	156.6002	553.5567
Bottom	Leg 1	625	DWalS22	1304.6512	-1192.3373	-342.1263	201.9243	598.8808

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	250	DWalS30	2110.3937	-535.5625	6.49	5.52
Top–Right	Leg 1	375	DWalS30	2110.3937	909.1281	8.35	5.52
Bottom–Left	Leg 1	375	DWalS30	2265.9103	-737.3133	7.78	5.52
Botttom–Right	Leg 1	375	DWalS30	2518.5679	1742.1581	13.22	5.52

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
SECOND FLOOR	B49	422	B600X900M35	UDConS2	10611	10911	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
900	600	900	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

γ_c	γ_s
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
-1149.5552	29.6608	698.5763	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-1149.5552	29.0792	0	-1178.6344

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)	-1178.6344		5656	0	5656	1414
Bottom (-2 Axis)		0	2828	0	0	2828

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
698.5763	344.7267	406.5799	237.7352	2086.42

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
29.6608	698.5763	800	500	2086.42