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Design of Tall Structures under Low SBC

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ABSTRACT

The present situation of the country aims to construction tall building in a pollution free areas and also sociable environment, people focusing on a rural areas to be urbanized as all the offices and business places are developed nearby so, with this concern the rural areas observed to be having Low SBC and it's a challenge for the structural engineers who aim to have pile foundation and other suitable foundations to make the structures stable. This terminology shows that the tall buildings using these methods are structurally well-built and durable to resist the lateral loads such as seismic, wind, etc. Indian cities are observing enormous development due to construction of multinational companies in rural areas aiming for pollution and environmental free campuses leading urban trend & housing demand etc. considering economy of a project, I have been focused on a 10 floors commercial project on a low SBC and carried out with Etabs software on Pile, raft foundation & different environment conditions on earthquake parameters. The title named "Design of Tall Structures under Low SBC".

KEYWORDS: *SBC, ETABS, Lateral Forces, Earth Quake Loads*

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1. INTRODUCTION

High rise buildings are getting popular day by day. Construction date, technology, and software are key role to play for the construction of high rise building; Safety and overall cost of the project is the main aim and most important criteria to look on. A tall building can be defined as a building whose height is more than 35m above the ground level. The tall building must stand on a hard surface or a condition suitable for the building to stand safely must be created. Tall buildings and short buildings can be differentiated by the height criteria of 35m. There is no particular definition for 'Tall building' but it can be considered as a tall building by the perception of the people and their thinking, in technical terms a tall building is considered to be tall when the seismic condition is considered for the building during the design of the building then it can be said as a tall building.

A. Height Relative to Context:

Talking about the height of the building it's not just about the tallness of the building it also matters about where the building is been located, even a 10 story building in Indian urban cities like Delhi, Bengaluru, Chennai might not look like a tall building concerning the other tall building present in the city.

B. Proportion:

For a tall building it's not just about the height of the building it's also about the proportion of it. Few tall buildings might not look tall because of its slender shape and few buildings which are not tall but looks tall in rural areas. Few tall building might not look tall because of its floor area.

C. Tall Building Technologies:

The number of stories or floors doesn't describe the tallness of a building as the height of each story keeps on varying for different types of building at different locations. About 15m can roughly be considered as a tall building according to the people thinking and perception.

The wall-frame is considered to be fine for the building in the 30 to 50 story range, a shear wall is considered beyond wall frame. In our country with a growing population and rapid growth, the need for tall buildings and high rise structures is gone up. More than 45 % of countries' population is expected to live in the urban cities by 2035, tall building and high rise structure requires a residential and commercial place. Shear walls take up the horizontal or the seismic loads. They are given importance for earthquake (EQX, EQY) design of smaller and high rise buildings. For tall buildings, it mainly consists of lifts, ducts, staircases, and washrooms. For tall buildings, the core is located at the center of the building. This core acts as a Cantilever beam which is coming from the basement and stabilizes the structure mainly concerning horizontal forces like wind and earthquake. Because of the height of the building it has both shear force and bending moment of the building.

2. METHODOLOGY

In today's world buildings with shear-wall standing on low SBC and having improved qualities in the new multi-story construction in India. Such a typical building is very much undesirable construction in seismic active region. In this case, we study the importance of shear in the analysis of tall buildings. "Analysis of Tall structure under Low SBC Using Etabs software" & we perform structural elements as per code IS-456 2000 for the structure with a shear wall. We perform a study using ETABS software for a multi-story building 3D frames with low to get the understanding and responses of the building under seismic loading and wind loads. Shear force-SF, Bending moment-BM, axial-force, inter-story drift, base-shear, story-shear, story-moment will be computed for the buildings having low SBC and comparing the design results graphically.

3. ANALYTICAL MODELS AND DESIGN PROCEDURES PROPERTIES

Length of building = 23.5 m
Width of building = 10.46 m
Height of building = 36.70m

A. Beam sizes

Beam 1 = 250X450
Beam 2 = 250X600
Beam 3 = 250X750
Beam 4 = 150X225

B. Column sizes

Column 1 = 300X600
Column 2 = 300X750
Column 3 = 300X900
Column 4 = 350X1000

C. Shear wall and slab type

One way slab = 100 mm
Two way slab = 125mm
Stair slab = 150mm
Pile cap slab = 1500mm

D. LOAD CALCULATIONS

Name	Type	Self Weight Multiplier	Auto Load
Dead	Dead	1	
Live	Live	0	
Floor Finish	Super Dead	0	
Wall Load	Super Dead	0	
Roof Live Load	Roof Live	0	
EQX	Seismic	0	IS 1893 2002
EQY	Seismic	0	IS 1893 2002

Table 1: Load Pattern

E. ASSIGNED LOAD TO THE STRUCTURE

1. Dead Load

FLOOR FINISH 1.5KN/m^2

2. Live Load

FOR ALL FLOORS 2KN/ m^2
LIFT 5KN/ m^2
UTILITY AREA 3KN/ m^2
LOBBY AREA 3KN/ m^2

3. Wall Load

FOR B250X450 11KN/ m^2
B150X225 11.9KN/ m^2
B250X600 10.4KN/ m^2
B250X750 9.8KN/ m^2

4. Wind load calculations

Basic Wind Speed	Vb	=	33m/sec	
Height of Building above G.L		=	36.7	M
Width of Building		=	10.46	M
Length of Building		=	23.58	M

Design Wind Speed Vz = Vb. K1. K2. K3
K1=Probability Factor = 1
K2=Terrain, Height, structure size factor
(IS875(part3)-1987,Class B and Category 2) = 1.125
K3 =Topography Factor = 1
Design Wind Speed Vz = Vb. K1. K2. K3 = 41.25 m/ Sec
Design Wind Pressure Pz = 0.6 Vz^2 = 1020 .2 N/m^2
= 1.02 KN/m^2

5. Seismic Parameters

Zone Factor (Z) (Seismic Zone 2 - Table-2 Clause 6.4.2) = 0.10
Importance Factor (I) (Table-6 Clause 6.4.2) = 1
Response Reduction Factor (R) (Table 7 Clause 6.4.2) = 3.0
Structural Soil (SS) (Fig 2 Type III Soft Soil) = 1.0 Structure Type (ST) (RC Frame Building) = 3.0
Damping Ratio (Dmp) = 0.05
Depth of Foundation (DT) =2 m

1. Calculation of Horizontal Seismic Coefficient for 10 Story Building

A. X Direction

Base dimension in x-direction (Lx) = 23.58m Height of building (H) = 36.7 m

$T = \frac{0.09XH}{\sqrt{}} = 0.68$

(Sa/g) = 2.45
(from fig 2 IS 1893:2002)

Ah= Horizontal seismic coefficient = $\frac{ZI}{2R}\frac{Sa}{g}$

Z = Zone Factor = 0.10 (From Annex E)
I = Importance Factor = 1 (From Table 6.0)

R = Response Reduction Factor = 3 (From Table 7.0)
Ah = Horizontal Seismic Coefficient = 0.10 x 1 x 2.45 / (2x 3) = 0.0408

B. Y Direction

Base dimension in Y-direction(Ly) = 10.46 m
Height of building (H) = 36.7 m

$T = \frac{0.09XH}{\sqrt{Ly}} = 1.02$

(Sa/g) = 1.63
(From Fig 2 IS 1893 - 2002)

Ah= Horizontal seismic coefficient = $\frac{ZI}{2R}\frac{Sa}{g}$

Ah= 0.1x1x1.63/(2x3)=0.0271

F. LOAD COMBINATONS

1.50 DL + 1.50 LL
1.50 DL + 1.50 EQX
1.50 DL- 1.50 EQX
1.50 DL + 1.50 EQY
1.50 DL - 1.50 EQY
1.20 DL + 1.20 LL + 1.20 EQX
1.20 DL + 1.20 LL - 1.20 EQX

1.20 DL + 1.20 LL + 1.20 EQY
1.20 DL + 1.20 LL - 1.20 EQY

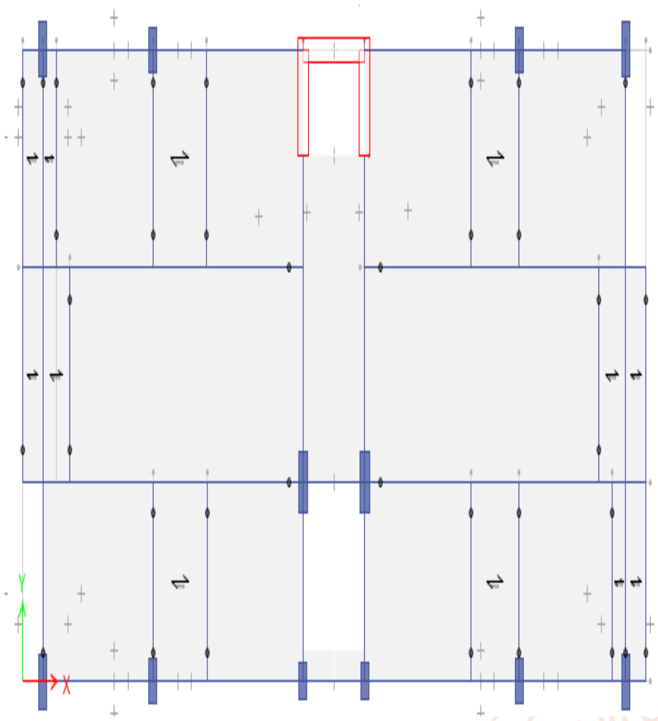


Fig. 1: Plan View of High Rise Structure

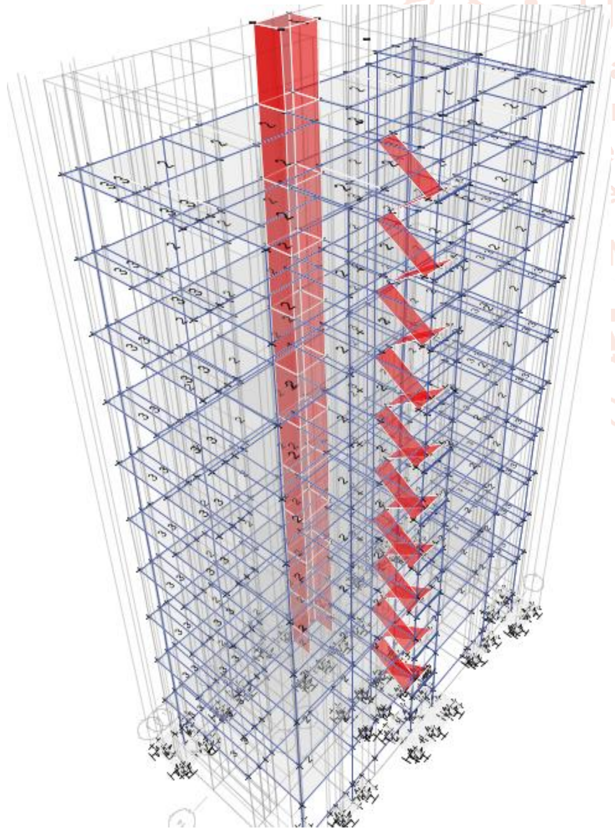


Fig 2: 3-D View of the high rise structure

G. RESULTS AND DISCUSSIONS FOR PILE FOUNDATION

1. DISPLACEMENT

The analysis is carried out for the study of Rigid Core and Floor Rigidity of Irregular Shape buildings. The analysis is carried with all the load combinations for the particular earthquake zone. But the wind load is governing among all the load cases.

Story Response - Maximum Story Displacement is given,

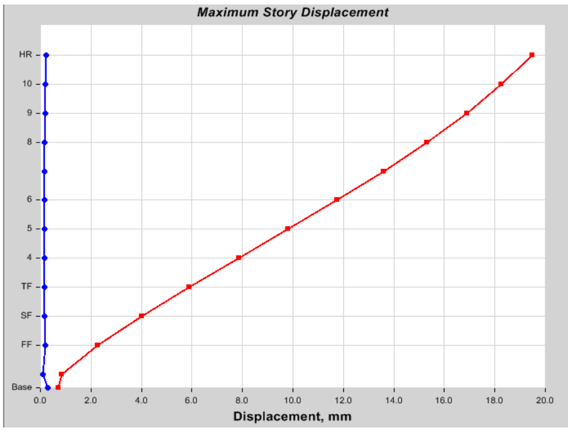
TABLE: Story Response				
Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
HR	36.7	Top	49.9	0.4
10th	33.5	Top	46	4.1
9th	30.3	Top	42.1	4.3
8th	27.1	Top	37.8	4.3
7th	23.9	Top	33.2	4.2
6th	20.7	Top	28.4	3.9
5th	17.5	Top	23.5	3.4
4th	14.3	Top	18.5	2.9
3rd	11.1	Top	13.7	2.3
2nd	7.9	Top	9.2	1.7
1st	4.7	Top	5.1	0.9
GF	1.5	Top	1.6	0.5
Base	0	Top	0.8	0.2

Maximum Storey Displacement in EQX

TABLE: Story Response				
Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
HR	36.7	Top	0.2	19.7
10th	33.5	Top	0.2	18.5
9th	30.3	Top	0.2	17.1
8th	27.1	Top	0.2	15.6
7th	23.9	Top	0.2	13.8
6th	20.7	Top	0.2	12
5th	17.5	Top	0.2	10
4th	14.3	Top	0.2	8.1
3rd	11.1	Top	0.2	6.1
2nd	7.9	Top	0.2	4.2
1st	4.7	Top	0.2	2.4
GF	1.5	Top	0.1	0.9
Base	0	Top	0.3	0.8

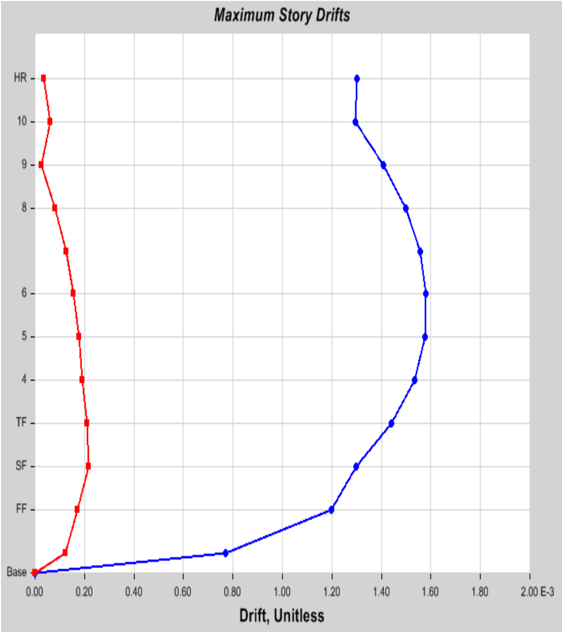
Maximum Storey Displacement in EQY

Max story displacement
Load Case Earth Quake X - direction

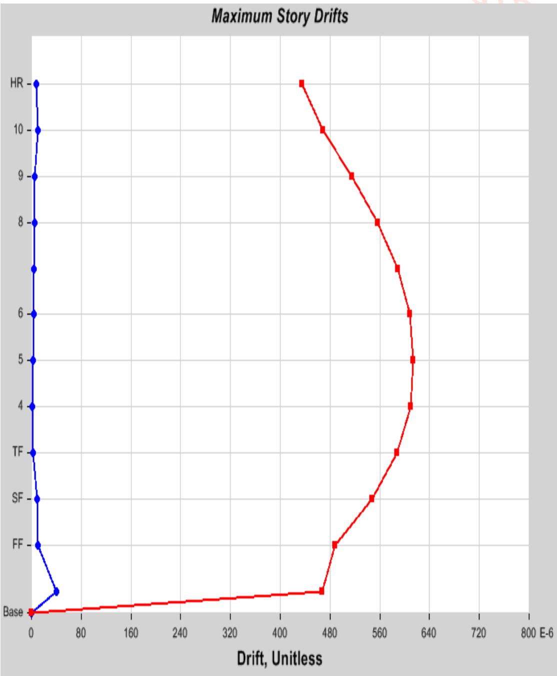


Max story displacement
Load Case Earth Quake Y - direction

2. STORY DRIFT

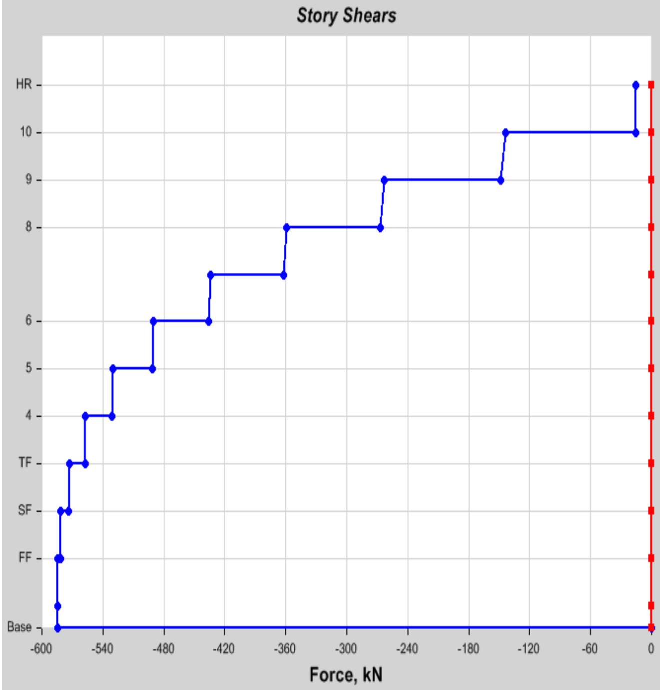


Maximum story drift
Story - All Stories
Load type WIND FORCE X- direction

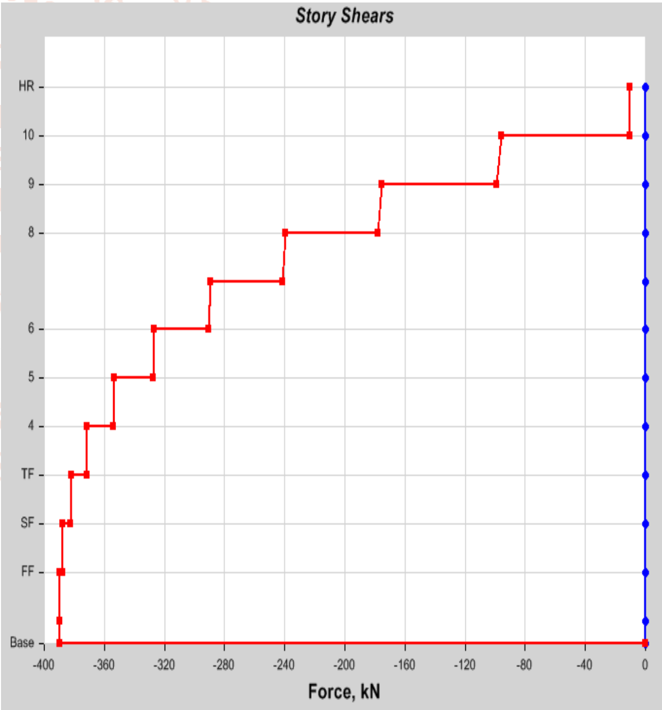


Maximum story drift
Story - All Stories
Load type WIND FORCE Y- direction

3. STORY SHEAR



Story shear
Story Range- All Stories
Load Case WIND FORCE X- direction



Story shear
Story Range- All Stories
Load Case WIND FORCE Y- direction

4. BASE SHEAR

Load case/Combo	FX (KN)	FY(KN)
EQX	-584.63	0
EQY	0	-389.75

Base shear of the building
Load combination- Earthquake X and Y- Dir

5. TIME PERIOD OF THE STRUCTURE

Time period of the building with pile foundation = 1.649 SEC.

H. RESULTS AND DISCUSSIONS FOR RAFT FOUNDATION

1. DISPLACEMENT

The analysis is carried out for the study of Rigid Core and Floor Rigidity of Irregular Shape buildings. The analysis is carried with all the load combinations for the particular earthquake zone. But the wind load is governing among all the load cases.

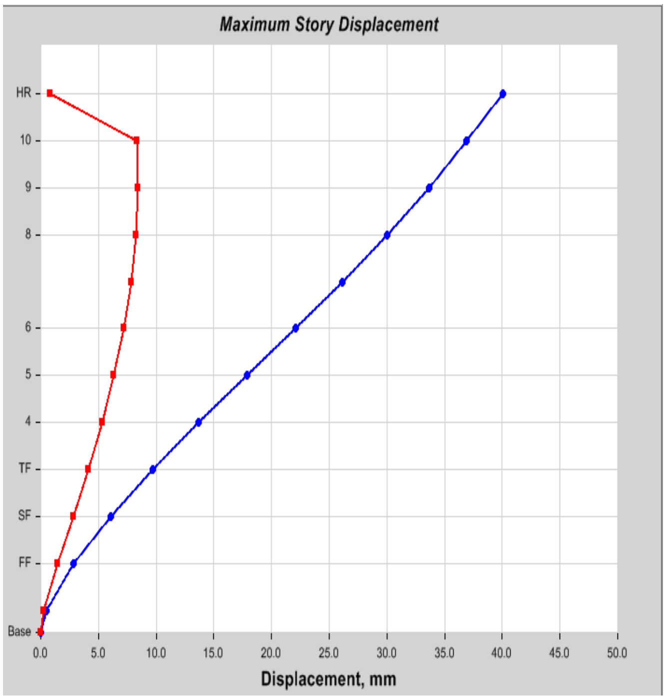
Story Response - Maximum Story Displacement is given

TABLE: Story Response				
Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
Head Room	36.7	Top	40.1	0.8
10F	33.5	Top	36.9	8.4
9F	30.3	Top	33.7	8.4
8F	27.1	Top	30.1	8.3
7F	23.9	Top	26.2	7.9
6F	20.7	Top	22.1	7.2
5F	17.5	Top	17.9	6.3
4F	14.3	Top	13.7	5.3
3F	11.1	Top	9.7	4.1
2F	7.9	Top	6	2.8
1F	4.7	Top	2.9	1.5
GF	1.5	Top	0.5	0.2
Base	0	Top	0	0

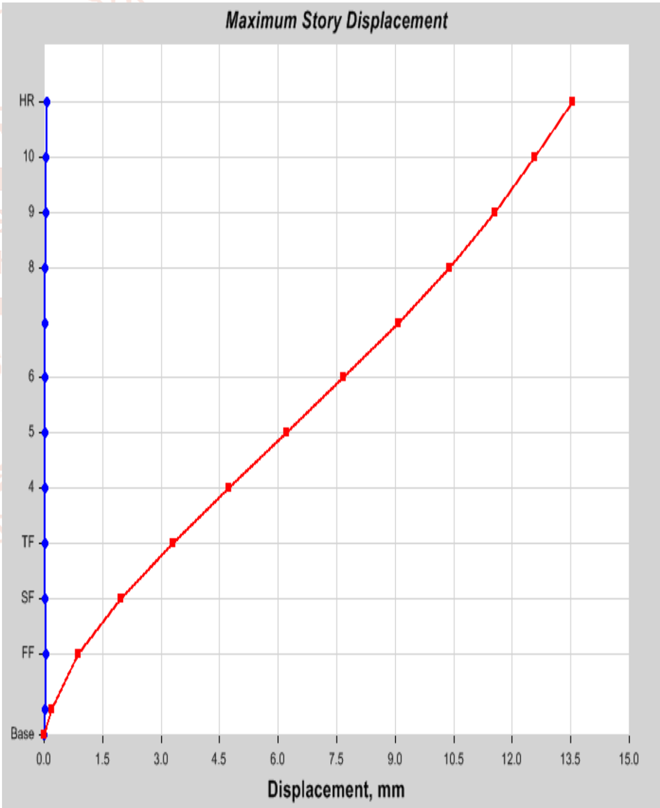
Maximum Storey Displacement in EQX

TABLE: Story Response				
Story	Elevation	Location	X-Dir	Y-Dir
	m		mm	mm
HR	36.7	Top	0.1	13.6
10th	33.5	Top	0.1	12.6
9th	30.3	Top	0.04772	11.6
8th	27.1	Top	0.03574	10.4
7th	23.9	Top	0.03145	9.1
6th	20.7	Top	0.02853	7.7
5th	17.5	Top	0.02741	6.2
4th	14.3	Top	0.02832	4.7
3rd	11.1	Top	0.03091	3.3
2nd	7.9	Top	0.03315	2
1st	4.7	Top	0.04334	0.9
GF	1.5	Top	0.01567	0.2
Base	0	Top	0.001867	0.003363

Maximum Storey Displacement in EQY

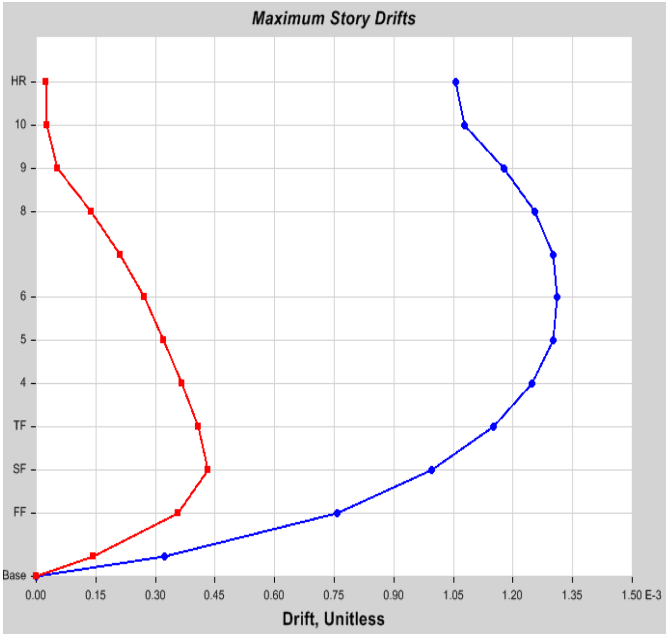


Max story displacement
Load Case Earth Quake X - direction

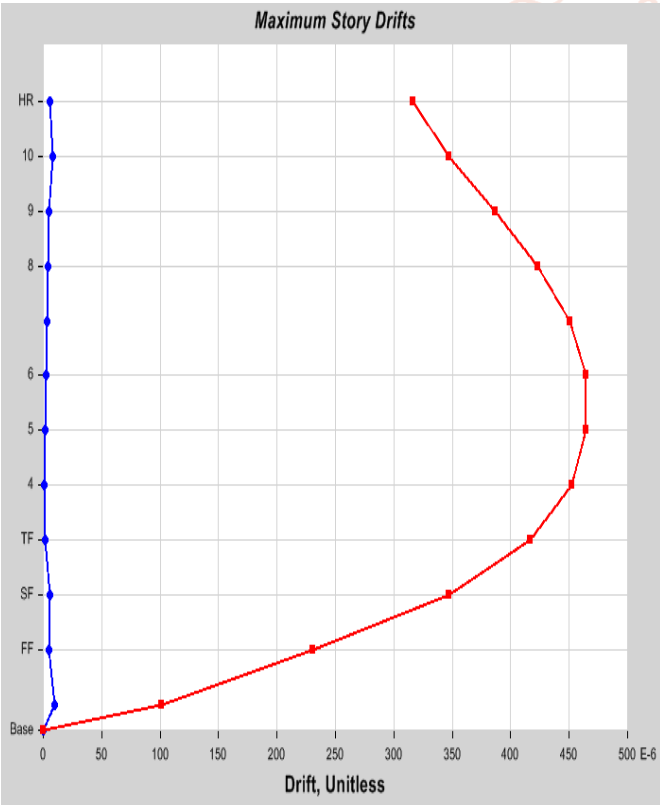


Max story displacement
Load Case Earth Quake Y - direction

2. STORY DRIFT

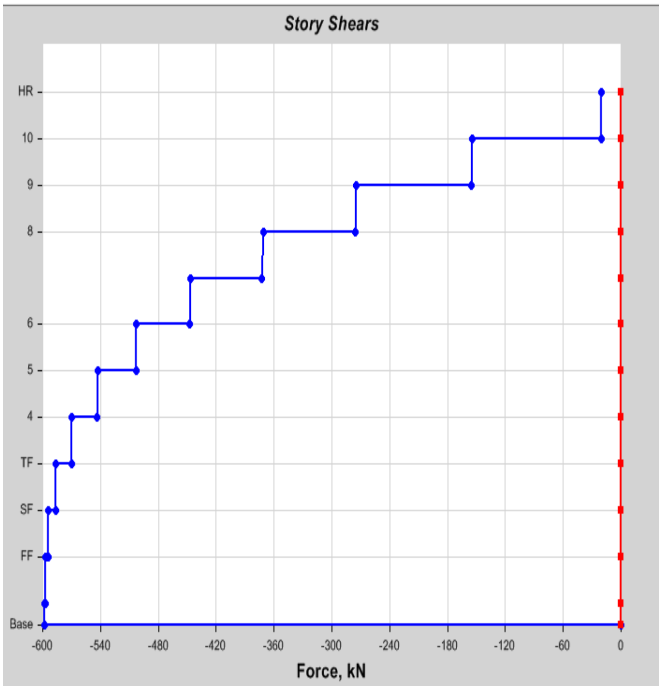


Max story drift w
Story - All Stories
Load type WIND FORCE X- direction

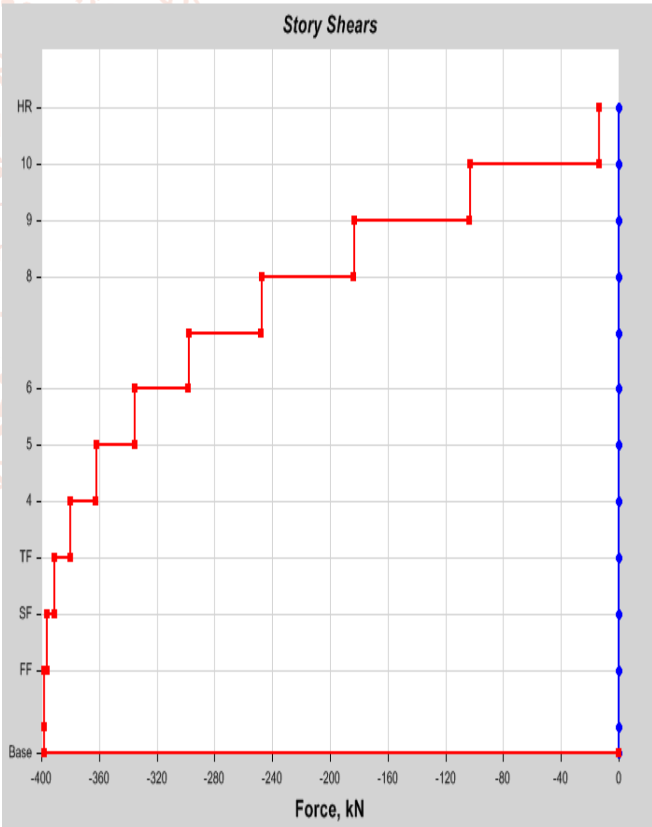


Max story drift w
Story - All Stories
Load type WIND FORCE Y- direction

3. STORY SHEAR

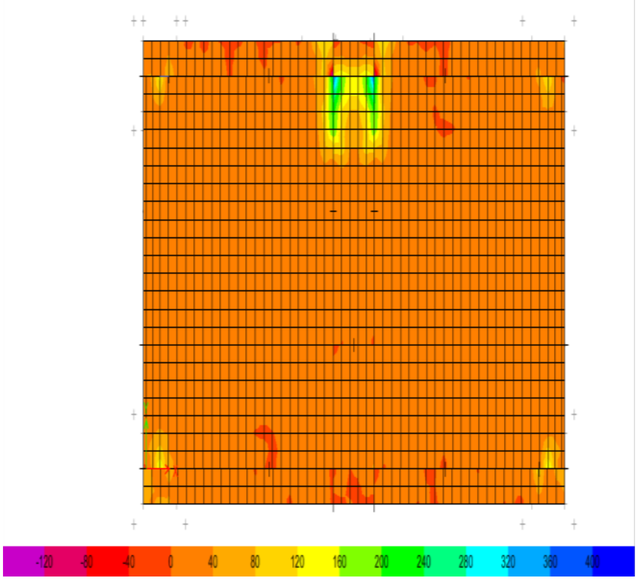


Story shear
Story Range- All Stories
Load Case WIND FORCE X- direction



Story shear
Story Range- All Stories
Load Case WIND FORCE Y- direction

4. BASE STRESSES AND FORCES



Base stresses and forces for the structure with Raft foundation

I. TIME PERIOD OF THE STRUCTURE

Time period for the structure with raft foundation=1.474 sec

CONCLUSION

The project has been executed and designed as per the code provisions and comparative study on pile footing and raft footing are being performed to find the effect of story drifts on low SBC and In lateral direction with floor rigidity, story shears and BM.

From the investigation made of the Data, the subsequent conclusions have been made that

1. With the effects of story drifts and usages of shear walls on their core areas, the structure is stiffened, and also reflected in story displacements shows the durability of the building. However, additional stiffness in-floor diaphragm is increasing story axial force and story moment even though drift and displacement are reduced.
2. It can be concluded that floor rigidity is not required to be increased beyond that required for the load-carrying of DL and LL on floors. Also, the beam helps transfer lateral forces to the double shear wall. Hence the moments in columns nearer core are reduced.
3. Building with raft foundation and pile foundation structures achieves the low SBC soils into the durable and determinate structure and safer.

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