IMPACT OF WIND LOAD ON TALL STRUCTURE WITH SHEAR WALL

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Abstract : Due to Immense increase in population of India, especially in urban areas and other Indian cities which is considerably increasing in population due to this there is less space for livings for this reason the HIGH RISE STRUCTURES are being constructed, while designing of such structure there is a high pressure on engineers to design a structure with safety factors, the most important factor are Natural calamities (LATERAL FORCES) such as Wind effect and Earthquake effect . Today's tall buildings are becoming more and more slender, which lead to the possibility of more sway in comparison with earlier high rise buildings Thus improving the structural Members of tall buildings can control their dynamic Effects With more appropriate structural forms by Providing shear walls and improved material properties.

In the present study we done a deep analysis of structure to study the behavior of RC structure , an investigation has been carried out to study the Best Suitable location & Shapes of shear wall in multistoried building subjected to extreme wind load , the structure is located in Terrian category 2 & also the investigation has been performed to see the behavior of structure with & without Soft storey at different levels in the structure. The modelled Building in this case Study of G+20 Storey with a storey height of 12 feet (3.65m) and 10 different models are prepared to analysis the structure with & without Shear wall and Also with & without Soft storey at different levels.

The multistoried building has been analyzed using the E-TABS software which has guided in a adequate manner to determine the various parameters like , Storey drifts, Storey displacement & Time periods. The obtained results have been performed and have been plotted in graphs and charts.

I. INTRODUCTION

The basic role of different types of structural systems utilized in the building type of structures is to move gravity Loads successfully. The most well-known burdens coming about because of the impact of gravity are dead load, live load , snow load etc. Other than these vertical Loads, structures are likewise exposed to horizontal load brought about by wind, earthquake powers. Lateral loads can develop high stresses,which leads to sway movement or cause vibration. Therefore, it is Necessary for the structure to have sufficient strength against vertical loads to resist lateral forces.

The impact of wind forces acting on High rise buildings becomes an important aspect for the designing &.Improving the structural system of tall buildings can control their Stability of building with more appropriate structural elements such as shear walls and by using improving material properties; the max. height of concrete buildings has been increased in recent decades. Under the large overturning effects caused by horizontal Wind forces, The edges of shear walls developes high stresses. To ensure that shear walls behave in a ductile way, concrete in the wall end regions must be reinforced in special manner to sustain these load reversals without losing strength.

The shape and location in plan for the shear wall influences the greater performance of the structures. Structurally, the suitable position for location of the shear walls is at the centre of each midspan of the building. This is rarely in practical, since on the other hand, it dictates the utilization of the space, so they are preferably positioned at the corner of buildings.

II. OBJECTIVES

The following are the main objectives of this study:

1) To perform analysis on G+20 story building and To study the behavior of Rcc multistory building under The action of wind loading.
2) To study the structural behavior by Adopting SW at different locations.
3) To identify the Best Suitable Location Of Shear wall which can be effective on the tall buildings under the action of wind loading.
4) To study the effect of story displacement, story drift and the time period of the Rcc structure subjected to wind loads.
5) To Know the effect of loading on structure by Adopting SW at different locations.
6) Studying the comparative results of different models and Adopting the best model for real project Execution.

III. BUILDING DEFINITION

3.1 DESCRIPTION OF BUILDING

Building Input Data:

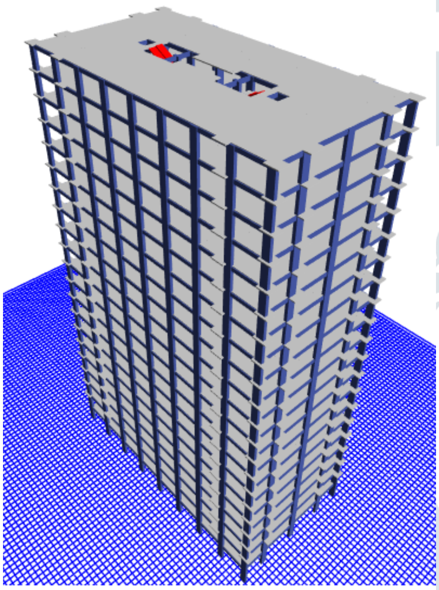
- **General**

1)	Plan Dimension	25 x 48 m
2)	No. of storeys	G+20
3)	Grade of concrete	M-40 for columns & Shear walls M-30 for beams, slabs
4)	Grade of reinforcement	Fy-500
5)	Size of columns	500 X 1200 mm
6)	Size of beams	300 X 550 mm
7)	Slab thickness	150 mm

8) Storey height	3.65 m
9) Shear wall	300 mm thick
• **Wind load Parameters**	(As per IS 875 Part-3)
1) Location	Hyderabad
2) Basic wind Speed	44 m/sec
3) Terrain category	2
4) Class of structure	c
5) Risk coefficient, k1	1
6) Topography factor, k3	1
7) Diaphragms	Rigid
• **Loading Parameters**	(As per IS 875 Part 2)
1) Live Load	2 KN/m2 for Floors 3KN/m2 for Corridors, stairs
2) Floor Finish	1.2 KN/m2
3) Wall Load	5.22 KN/m2

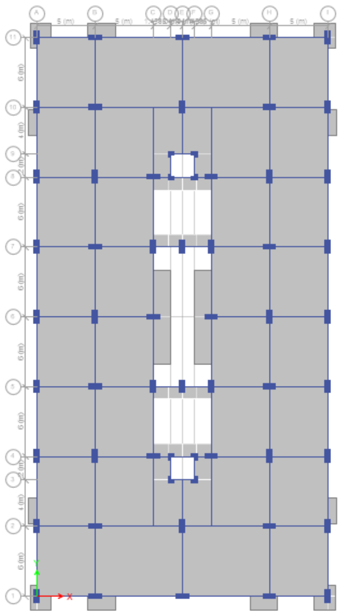
BASIC MODEL

Regular Model, in this model only Regular frame model is considered for analysis which consists of simple beams-columns moment frames.



RENDERED VIEW

Fig 3.1.1: 3D view



PLAN

Fig 3.1.2: Plan view

1) **Model 1**: Regular Regular Model G+20 Storey
2) **Model 2**: Regular Model G+20 Storey, along with Shear wall at the corner edges.
3) **Model 3**: Regular Model G+20 Storey, along with Shear wall at the corner edges in x-direction.
4) **Model 4**: Regular Model G+20 Storey, in along with Shear wall at the corner edges in Y-direction.
5) **Model 5**: Regular Model G+20 Storey, in along with Shear wall along Corner edges & Core wall at the center.
6) **Model 6**: Regular Model G+20 Storey, in along with Shear wall along X-Dir & Core wall at the center.
7) **Model 7**: Regular Model G+20 Storey, in along with Shear wall along Y-Dir & Core wall at the center.
8) **Model 8**: Regular Model G+20 Storey, along with Soft storey At 1, 2 storeys only.
9) **Model 9** : Regular model G+20 Storey, along with Soft storey At 11,12,13 storey has been considered as soft storey's.
10) **Model 10** : Regular Model G+20 Storey , Soft storey has been considered on different storey Height Along With Shear wall & Core wall.

IV. RESULTS AND DISCUSSIONS

4. Wind Load Calculation:

4.1.1 Design Wind Pressure (Pz)

For any structure in a location, acquired primary wind speed (Vz) will be custom designed to incorporate the following outcomes to obtained design wind speed for any elevation (Vz).

Design Wind Pressure (Pz) = $0.6 * Vz^2$

The design wind velocity at any elevation vz, may be found by using equation,

$$Vz = Vb * k1 * k2 * k3$$

Where ,

$Vz = Design\ \ wind\ speed\ at\ any\ height\ in\ m/s$

$Vb = Fundamental\ wind\ speed\ in\ m/s$

$k1 = probability\ factor\ (risk\ coefficient)$

$k2 = terrain\ roughness\ \&\ peak\ component$

$k3 = topography\ factor$

Table 4.1.1 Wind Load calculations.

Wind Load calculations								
Height	**Vb**	**k1**	**k2**	**k3**	**Vz**	**Pz (N/m)**	**wind load (F) (N/m)**	**F (Kn/m)**
10	44	1	0.93	1	40.92	1004.66784	6429.87	6.42
15	44	1	0.97	1	42.68	1092.94944	6994.87	6.99
20	44	1	1	1	44	1161.6	7434.24	7.43
30	44	1	1.04	1	45.76	1256.38656	8040.87	8.04
50	44	1	1.1	1	48.4	1405.536	8995.43	8.99
78	44	1	1.13	1	49.72	1483.24704	9492.78	9.49

4.1.2 Force Coefficient Calculation:

$\boldsymbol{F\ = Cf * Ae * Pd}$

$F = wind\ load$

$Cf = Force\ coefficient$

$Ae = Effective\ \ frontal\ area$

$Pd = Design\ wind\ Pressure$

$$\frac{a}{b} = \frac{25}{48} = 0.52 \qquad \frac{h}{b} = \frac{76.65}{48} = 1.6$$

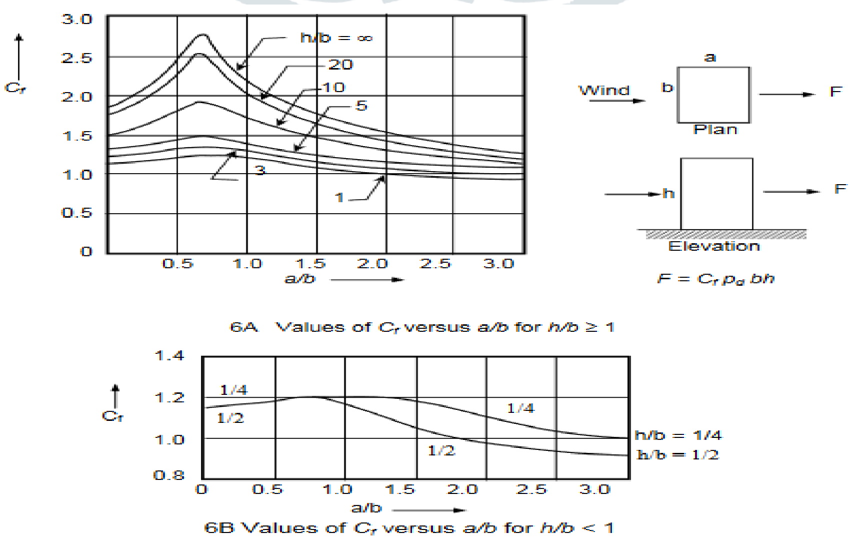


Figure:4.1.2 Force Coefficient Graph

From above Fig. the value of Cf is

Cf = 1.2

$$Ae = \frac{length\ of\ building}{no.of\ rows\ of\ column} = \frac{48}{9} = 5.33\ m^2$$

$$\therefore F = 1.2 * 5.33 * Pd$$

$$\boldsymbol{F = 6.4 * Pd}$$

Table 4.1.2 Force Coefficients calculations.

Wind Force Coefficients calculations					
Storey	**Storey Ht. (m)**	**Nodal Point**	**loading Levels (m)**	**Load (Kn/m)**	**Force on storey (Kn)**
20	76.65	76.4	74.57 to 78	9.49	9.49 x 3.43 = 32.55
19	73	72.75	70.92 to 74.57	9.43	34.41
18	69.35	69.1	67.27 to 70.92	9.38	34.23
17	65.7	65.45	63.62 to 67.27	9.31	33.98
16	62.05	61.8	59.97 to 63.62	9.24	33.72
15	58.4	58.15	56.32 to 59.97	9.17	33.47
14	54.75	54.5	52.67 to 56.32	9.1	33.21
13	51.1	50.85	49.02 to 52.67	9.02	32.92
12	47.45	47.2	45.37 to 49.02	8.94	32.63
11	43.8	43.55	41.72 to 45.37	8.79	32.08
10	40.15	39.9	38.07 to 41.72	8.64	31.53
9	36.5	36.25	34.42 to 38.07	8.44	30.8
8	32.85	32.6	30.77 to 34.42	8.24	30.07
7	29.2	28.95	27.12 to 30.77	8.05	29.38
6	25.55	25.3	23.47 to 27.12	7.86	28.68
5	21.9	21.65	19.82 to 23.47	7.73	28.21
4	18.25	18	16.17 to 19.82	7.41	27.04
3	14.6	14.35	12.52 to 16.17	7.05	25.73
2	10.95	10.7	8.87 to 12.52	6.7	24.45
1	7.3	7.05	5.22 to 8.87	6.42	23.43
GL	3.65	3.4	1.57 to 5.22	6.42	23.43
Base	0	0	0 to 1.57	0	0

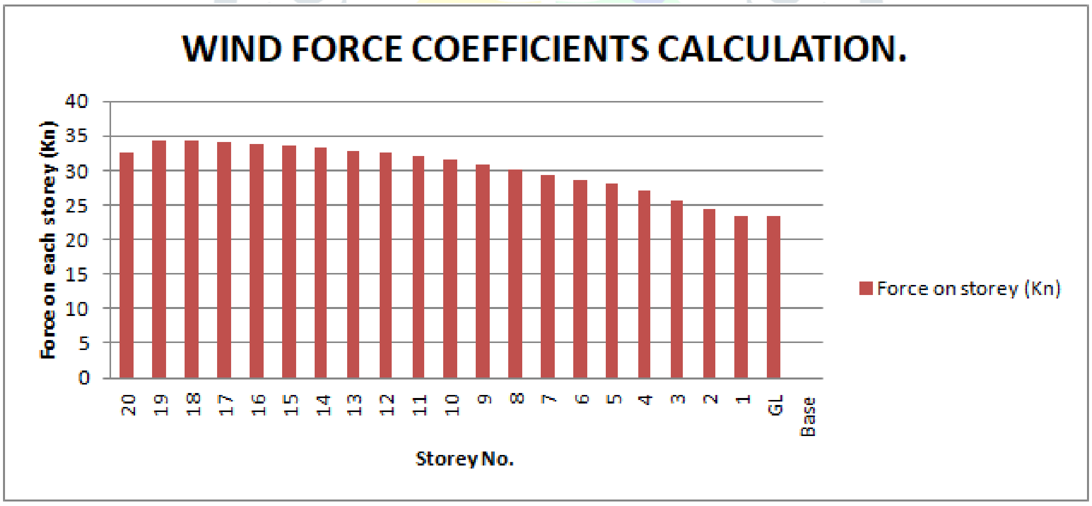


Chart 4.1.2 Force Coefficients calculations.

4.2 TIME PERIOD

It is defined as the undamped free vibration in a structure. Since Every structure has its own natural frequency. When a structure is Subjected with Wind Force it starts to sway. The below table Shows that time period of Models which is gradually changes with the different analysis method. As the structure is not similar and hence time period varies accordingly to structures. The table below represents the values of time period of all models obtained by the analysis using E-tabs

Following are the Time periods of differently configured models analyzed by Equivalent static method.

TIME PERIOD CALCULATION	
MODEL NO	TIME IN SECONDS
1	2.564
2	2.004
3	2.476
4	2.584
5	1.916
6	1.992
7	2.234
8	2.568
9	2.569
10	1.918

Table 4.2 Time Period of all models

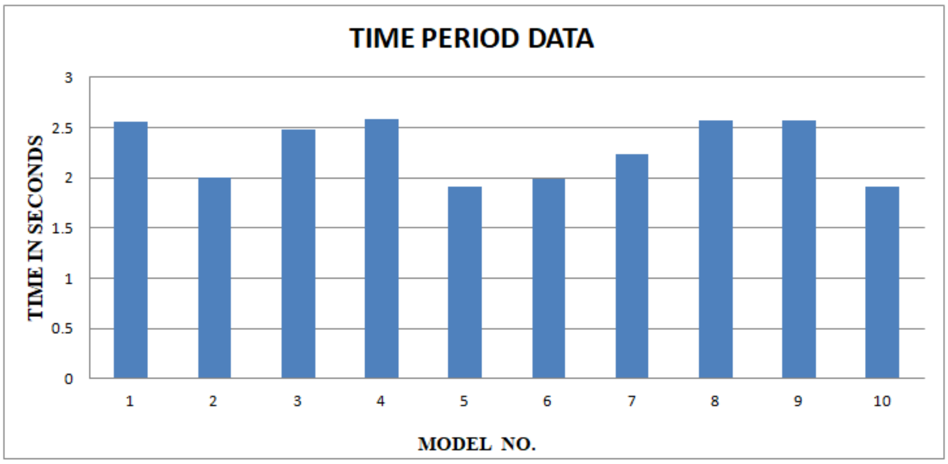


Chart 4.2 Time Period of all models

4.3 STOREY DISPLACEMENT

Storey displacement is nothing but the lateral displacement of the Storey relative to the base or it is displacement caused by the Lateral Force on the each storey level of structure. It is total displacement of its Storey with respect to ground. Lateral displacement will be more on top storey.The storey displacements of different models are obtained by analyzing them in ETABS using Equivalent Static Method. The values obtained are in the X and Y direction. The different displacement values for the different models have been plotted and noted below.

CHECK FOR ALLOWABLE DEFLECTION:

Max. Deflection against wind allowed is given as

$$\frac{H}{500} = \frac{76.65}{500} = 0.153 = 153mm$$

From Below Table it is less than **153** hence it is ok.

Comparison of Maximum Storey displacement on the top storey for all models.

MAX. STOREY DISPLACEMENTS ON TOP STOREY OF ALL MODELS		
MODEL	WIND - X	WIND - Y
1	90.451	26.852
2	41.172	12.663
3	57.549	23.462
4	73.717	17.105
5	36.569	8.645
6	50.076	12.453
7	59.26	11.539
8	90.745	26.88
9	91.138	26.895
10	36.632	8.65

Table 4.3 : Comparison of Maximum storey displacement

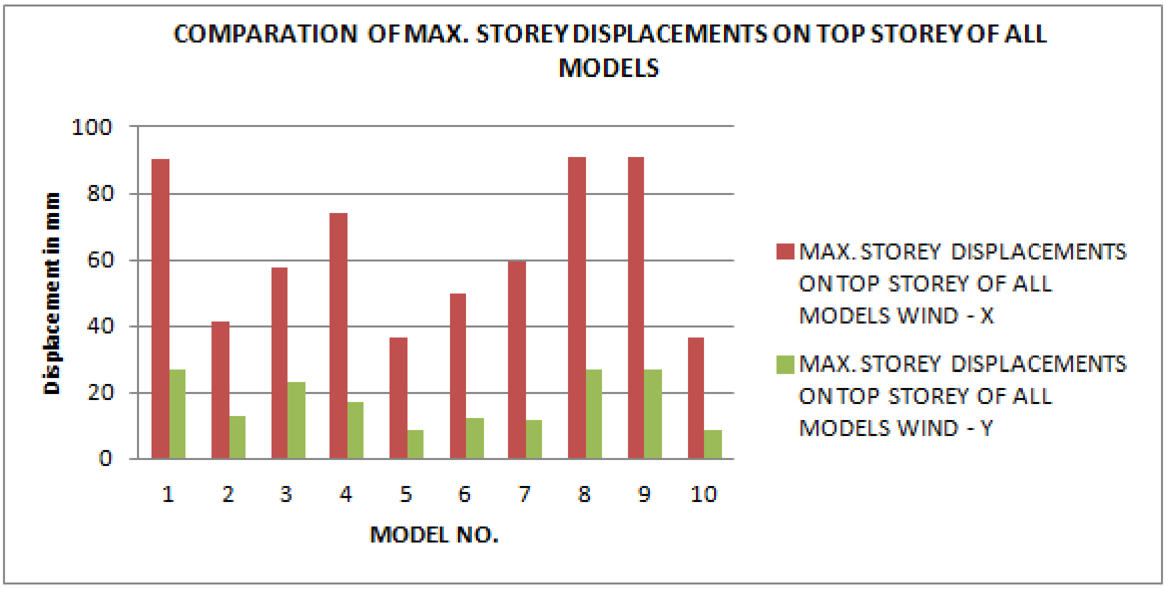


Chart 4.3 Comparison of Maximum storey displacement

4.4 STORY DRIFT:

Story Drift is nothing but the difference in one level relative of the other Level which can be above or below in terms of displacements. It is usually interpreted as the inter story drift between two stories. The drift values are designed and Mention below, these values are Obtained By performing analysis on different Models by using E-tabs. Hence after analyzing the Building the results obtained for model in both longitudinal and transverse direction and there comparison is presented in tabular form. It is seen that the drift values differ as the structure model is changed by adding or positioning of SW & CW. The storey Drift in any storey shall not exceed 0.004 times the height of storey height.

Height of Storey = 7665mm

0.004(h) = 30.66mm

From Below Table it is less than **30.66** hence it is ok.

Comparison of Maximum storey displacement at the top storey of all models

MAX. STOREY DRIFT ON TOP STOREY OF ALL MODELS		
MODEL	**WIND - X**	**WIND - Y**
1	0.000369	9.30E-05
2	0.000545	0.000163
3	0.000679	0.000112
4	0.000464	0.000185
5	0.000503	0.000112
6	0.000618	0.000116
7	0.000518	0.000126
8	0.000367	9.30E-05
9	0.000367	9.30E-05
10	0.000504	0.000112

Table 4.4 : Comparison of Maximum storey Drift.

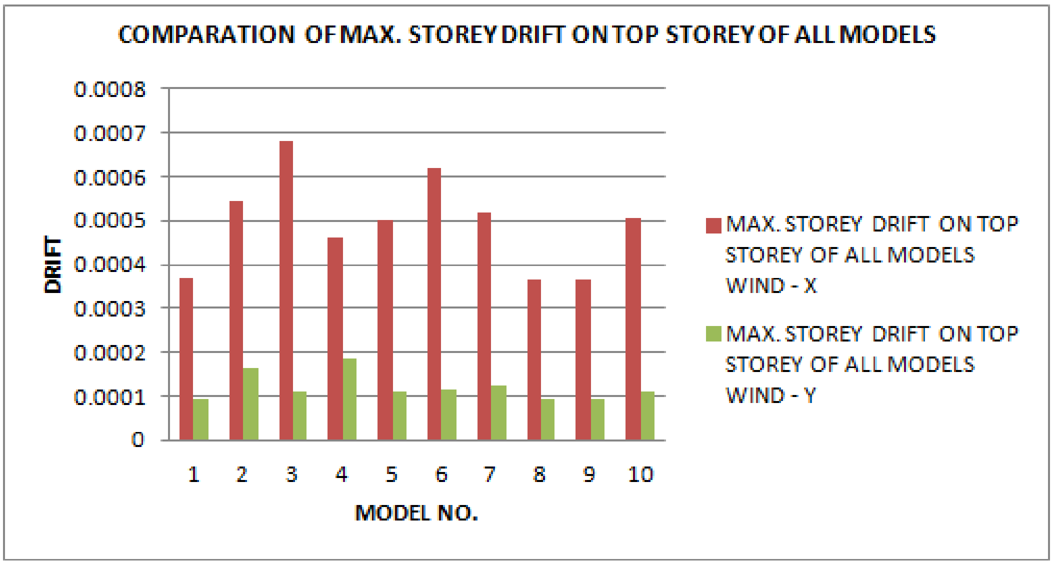


Chart 4.4 Comparison of Maximum storey Drift.

V. OBSERVATIONS AND FUTURE SCOPE.

5.1. OBSERVATIONS:

Shear walls are considered to be most suitable for the upcoming construction industry. Shearwalls are the structures usually build for stability of lateral forces/loads occurring on the structure. Where the lateral loads are most Dangerous for wind loads effect on the building structures. Hence in order to prevent from the effects of these Wind forces Effective Location of SW(shear wall) should be studied.

5.2 FUTURE SCOPE OF WORK:

- Further research works should be prepared to find a better way to Know the behavior of shear walls under any Circumstances.
- Different types of shear walls with improved material Properties should be studied.
- Above Models can be further analyzed for different terrain categories.
- Above Models can be further analyzed with earth quake loads.
- Above Models can be further analyzed for more Height of storey greater than 100m.
- Above Models can be further analyzed with Steel Bracing.
- Above Models can be further analyzed for more than G+20 Stories.
- Further study can also be done by providing soft storey to study effect in structure.
- Further we can study the wind load effects of on irregular shape of buildings.

VI. CONCLUSIONS

- The Time Period decreases when shear and core wall are being considered.
- It is observed that model analysis with Shear wall is very effective under wind loads.
- As the height of the storey increases, deflection on top storey also increases.
- Model analyses with shear wall at corner and Core wall at center having minimum displacement values.
- It is observed that maximum displacement on Top storey due to load of wind -X is more when compared with Load of wind - Y.
- Storey drift of all Models is within the limit as specified by code clause no 7.11.1 of IS-1893 (Part-1):2002
- Opting for different terrain category can leads to the change in response of structures under wind loads.
- Shear wall are to be used to control the deflection over the moment resisting frame.

- The Max Storey Deflection / lateral Displacements at the top storey of all Models against wind forces is within the limit.
- Shear wall is very useful for resisting horizontal forces coming from wind forces. if the structure (in multi-storey) properly oriented the effect of storey deflection will gradually reduced.

“Hence for a developing nation like India shear wall construction is considered to be a back bone for construction industry.”

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