Study on Effect of Wind Load and Earthquake Load on Multistorey RC Framed Buildings

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Abstract— Now a day the increase in the construction of tall buildings, residential and commercial sector, and the new trend are towards taller and slender structures. Though the effect of wind and earthquake, forces becoming important for every structural designer to know. Every engineer is facing with the problem of providing stability, strength for loads like lateral loads. That's the reason wind as well as earthquake loading have become the influential factors in tall buildings. Loads that are lateral loads play important role for drift. The drift must be taken into consideration for tall structure. The above mentioned are some of the key issues which affect the behavior of structure and economy of the building. This thesis focuses the effects of lateral loads on medium and tall buildings the storey forces, displacements, storey shear, story drift every part of are analyzed on every level of height on the building, Indian codal provision gives us the basic wind speed at 10m height for some important cities/towns. However it does not provide for all the cities in India. In the following work attempt is made to find the effect of lateral loads i.e. wind load and earth quake loads for various models having shear walls and without shear wall. For the study a symmetrical building plan is used with 16 storeys and 31 storeys are analyzed and designed by using structure analysis software tool ETABS-2013. The study also includes the determination of base shear, displacement, storey drift, storey forces and the results are compared with them. These parameters have also considers the effect of shear wall. In order to design a structure to resist wind and earthquake loads, the forces on the structure must be specified.

Key words: Steel Slag, Waste Limestone Aggregates, M20 grade concrete, Partial replacement etc

I. INTRODUCTION

A. General

Rapid increase in the construction of tall buildings, commercial as well as residential building leads towards the construction of high rise buildings. Lateral loads similar to wind loads and earthquake loads are thus getting importance. Even though all the designers are facing the problems of getting possible strength and stability not in favour of lateral loads, one of the common used wall which is used for lateral load resisting in tall buildings is the shear wall. Vertical winds are known by the same name whereas the wind loads are known as horizontal winds. Anemometers measure the speed of wind, they are installed at the height of approximately 10 to 30 meters at meteorological observatories on the top of the ground. Thunderstorms, dust storms, cyclonic storms are powerful winds. In our Study we are examining ground plus 15 and ground plus 30 storey building and analyzing design under effect of earthquake and wind by the use of ETABS. Six different models are being analyzed, and thus proving that the shear wall models resist earthquake and wind loads. Then the results are compared and analyzed to achieve the most suitable resisting system and economic structure against the lateral forces. The main factor which differentiates the high, medium and low rise buildings is the effect of lateral load because of the wind. For buildings of up to about 10 storied and of typical properties and the design is rarely affected by the wind loads. Above this height, however, the increase in size of the structural members, and the possible rearrangement of the structure to account for wind load, incurs a cost premium that increases progressively with height.

II. LITERATURE REVIEW

Anshuman. S, Dipendu Bhunia and Bhavin Ramjiyani , Civil and Structural Engineering, International Journal of Vol 2, (2011) There study shows in multi storey building the solution of shear wall. In some frame the provision of shear wall gives deflection of shear wall at the top and reduced to allowable deflection. Providing shear wall to some frames it is seen that wind forces and shear forces were reduced. Shear wall based on its elastic and elasto-plastic performance and found that the permissible deflection at the top and can reduce the deflection by giving shear wall to the frame at different location a study was conducted for this.

Alfa Rasikan et al; (2013).In this literature review they shows that a study was conducted behaviour of wind on tall building with inclusion of shear wall and without inclusion of shear wall the study is carried out.the displacement of included shear wall was 20% less than without inclusion of shear wall. The paper shows two models 15 storey and 20 storeys were analyzed and compare their displacement at top deflection. Study shows that results were compared at top of a 15 storey building displacement was reduced when shear wall is provided.

Shameem Ara Bobby Abdul Rahman, and Sayada Fuadi Fancy (June 2012) Drift analysis due to earthquake and wind loads on tall structures was discussed in this paper. Thus the effects of lateral loads like winds loads, earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. For this reason in recent years wind and earthquake loading have become determining factors in high -rise building design. This lateral loads are mainly responsible for drift. So the design of tall structures must take into consideration of the drift. Therefore the effect of drift has no specific requirement, economy and behavior of building has a huge impact on this issue. In this study the drift effect due to lateral loads like wind and seismic loads on tall buildings are analyzed.

L.P. Swami and B. Dean Kumar (5.May 2010) effect of wind on tall building has discussed in this paper. Gust effectiveness factor method is rational and realistically analyzed and the wind pressure was known. Hence it is an important and valid point to be considered for the design of very tall buildings.

Kareem and T.Kijewski discussed the full-scale study of the behavior of tall buildings under wind and earthquake loads i.e. the fundamental differences between wind and earthquake demand. The study was carried on high rise 54 storied building and 76 storied building. The result obtained from analysis shows that wind and earthquake loads are different from each other and are also different from static load. The result indicate that earthquake load excite higher modes that produce less inter storey drift but higher acceleration which occurs for a relatively short time compare to wind loads. Although the acceleration under wind loads is lower than that of earthquake load. It occurs for longer period that become a comfort issue. However the drift under wind is larger which raises security issues. It seems that tall buildings designed for wind are safe under moderate earthquake loads.

[P.P. Chandurkar et. Al., (2013)], conducted a study a study on seismic analysis of RCC building with and without shear walls. They have selected a ten storied building located in zone II, zone III, zone III, zone IV and Zone V. Parameter like lateral displacement, story drift and total cost required for ground floor were calculated in both the cases

The researchers have mainly focused on wind's characteristics, its properties and variations with respect to wind loads. The scholarly material has a huge gap in research about buildings' overall behaviour under wind loads.

III. METHODS OF ANALYSIS

A. *The Location Of The Building Structure Is In Hyderabad.*

The wind speed suggested by IS 875 (part-3) is 44 m/s for this location. The wind pressure is from the extents of the rigid diaphragms assigned to the slab elements. Also IS 1983(Part-1):2002 states that wind is not to be considered in chorus with earthquake or maximum flood or maximum sea waves. The load case combinations adopted are referred from IS 875(Part-3):1975,

(D.L + L.L + Wx)
(D.L + L.L - Wx)
(D.L + L.L + Wy)
(D.L + L.L - Wy)
(D.L + Wx)
(D.L - Wx)
(D.L + Wy)
(D.L - Wy)

B. *Design Wind Speed (Vz)*

The basic wind speed (Vz) for any shall be obtained and modified to include the following effects to get design wind velocity at any height (Vz) for the chosen structure:

1) Risk Level;
2) Terrain roughness, height and size of structure;
3) Local topography
4) It can be methematically expressed as follows:

Vz=Vb K1 K2 K3

Where,
Vz= design wind speed at any height z in m/s
K1= probability factor (risk coefficient)
K2= terrain, heaight and structure size factor
K3= topography factor

C. *Terrain and Height Factor (K2)*

1) *Terrain*

Terrain category should be selected due to the effect of obstruction and possesses the ground roughness surfaces. The direction of wind consideration depends on terrain catogory. Wherever sufficient meteorological information is available about the wind direction, the orientation of any building or structure may be suitably planned. Terrain in which a specific structure stands shall be assessed as being one of the following terrain categories:

1) Category 1 – structure is less than 1.5 m and has no obstruction at the average height of any object Exposed open terrain. NOTE – This category includes open sea coasts and flat treeless plains.
2) Category 2 – Open terrain with well scattered obstructions having height generally between 1.5 and 10 m. NOTE – This is the criterion for measurement of regional basic wind speeds and includes airfields, open parklands and undeveloped sparsely built-up outskirts of towns and suburbs. Open land adjacent to seacoast may also be classified as Category 2 due to roughness of large sea waves at high winds.
3) Category 3 –In this category Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m in height with or without a few isolated tall structures.

D. *Design Wind Pressure*

The wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind speed:

Pz = 0.6 V^2z

Where,
Pz= wind pressure in N/m2 at height z,
Vz = design wind speed in m/s at height z.

E. *Wind Load on Individual Members*

The necessary formula is adopted for calculating the wind load on individual structural elements such as roofs and walls, and individual cladding units and their fittings, it is necessary to take account of the pressure difference between opposite faces of such elements or units. Therefore, it needed to know the internal pressure as well as the external pressure. Then the wind load, F, acting in a direction normal to the individual structural element or cladding unit is:

F = (Cpe-Cpi) A Pz

Where, Cpe = exterbnal pressure coefficient
Cpi = internal pressure coefficient
A = surface area of structureal element or cladding unit
Pz = design wind pressure

F. *Linear Static Method (Equivalent Static Method)*

Earthquake analyses for the structure are carried by considering assumption that lateral (horizontal) forces are equivalent to the dynamic or actual loading. The overall horizontal force also called as base shear on the building is computed by considering fundamental period of vibration, structural mass and mode shapes. The total seismic base shear is divided along the total height of the structure by means of lateral or horizontal force according to the formulae specified by the code. The following method is suitable for building with low to medium height and steady conformation.

This method is the simplest approach for seismic analysis of multistoried structures. In this method, the structure is considered to be elastic when contacted with static force. The lateral static forces are placed individually in two principal axes i.e. transverse and longitudinal and resulting interior forces are mixed up using combination methods.

The building which is to be analyzed by linear static method should contain some criteria relating to its stiffness and geometrical regularity.

1) All members such as columns and walls which are resisting lateral loads should move from bottom to top.
2) The lateral stiffness and mass should not vary suddenly from bottom to top.
3) The certain values are to be maintained in the geometrical asymmetries in the height or in the layout plans.

This procedure is very suitable and simple for structural engineer to execute a seismic analysis for reasonable outcomes. This method is widely used for the buildings and structures which are having regularity conditions.

IV. RESULTS AND DISCUSSION

A. Displacement Result

Storey No.	WIND LOAD		EARTHQUAKE LOAD	
	U_X	U_Y	U_X	U_Y
16	96.1	106.7	30.9	33.9
15	94.5	105.3	30.2	33.3
14	92.3	103.2	29.2	32.4
13	89.3	100.3	28	31.1
12	85.6	96.5	26.5	29.5
11	81.1	91.7	24.6	27.6
10	75.7	86.1	30.9	25.4
09	69.5	79.5	22.6	22.9
08	62.6	72.2	20.3	20.4
07	54.9	64	17.9	17.6
06	46.5	55	15.3	14.8
05	37.6	45.3	12.7	11.9
04	28.3	35	10	9
03	19	24.4	7.4	6.1
02	10.2	13.8	4.9	3.4
01	3.2	4.6	2.6	1.1
BASE	0	0	0.8	0

Table 4.1: storey displacements for model 1 along longitudinal and transverse directions

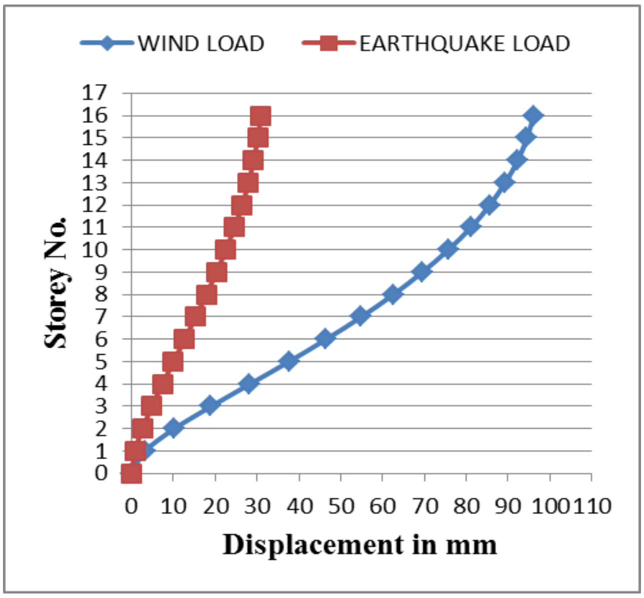

Fig. 1: Chart. 4.1: Storey wise displacement for building model-1 along longitudinal direction

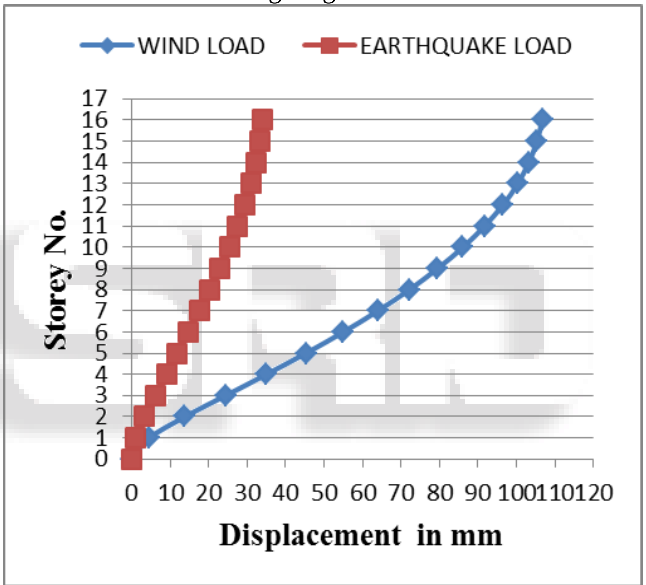

Fig. 2: Chart. 4.1.1: Storey wise displacements for building model-1 Along transverse direction

B. Storey Displacements For Model 2 Along Longitudinal And Transverse Directions

Storey No.	WIND LOAD		EARTHQUAKE LOAD	
	U_X	U_Y	U_X	U_Y
16	16.7	14.8	15.8	15.9
15	15.5	13.8	14.6	14.7
14	14.3	12.7	13.4	13.5
13	13.1	11.6	12.2	12.3
12	11.8	10.5	10.9	11
11	10.6	9.4	9.7	9.8
10	9.3	8.3	8.4	8.5
09	8	7.2	7.2	7.3
08	6.8	6	6	6
07	5.6	5	4.8	4.9
06	4.4	3.9	3.8	3.8
05	3.3	2.9	2.8	2.8
04	2.3	2.1	1.9	1.9
03	1.4	1.3	1.2	1.2

02	0.7	0.7	0.6	0.6
01	0.2	0.2	0.2	0.2
BASE	0	0	0	0

Table 4.2: storey displacements for model 2 along longitudinal and transverse directions

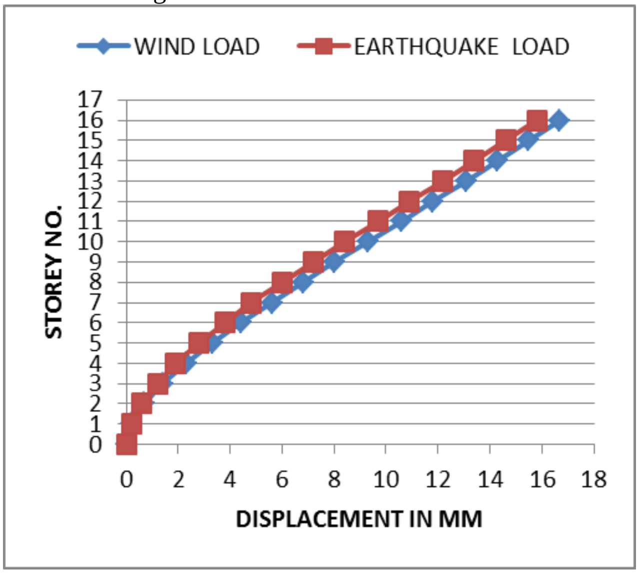

Fig. 3: Chart 4.2: Storey wise displacement for building model-2 along longitudinal direction

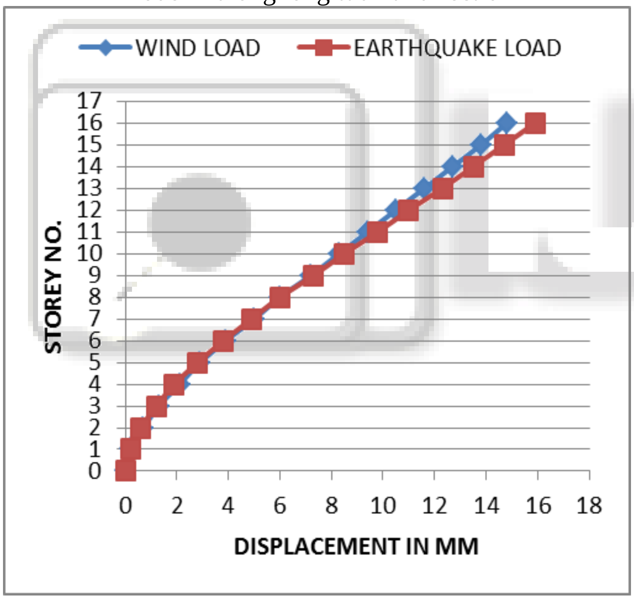

Fig. 4: Chart. 4.2.1: Storey wise displacement for building model-2 along transverse direction

C. Storey Displacements For Model 3 Along Longitudinal And Transverse Directions

Storey No.	WIND LOAD		EARTHQUAKE LOAD	
	U_X	U_Y	U_X	U_Y
16	22.2	19.5	24.1	20.2
15	21.2	18.5	23.2	19.4
14	19.9	17.2	22	18.2
13	18.2	15.4	20.2	16.4
12	16	13.3	17.9	14.2
11	13.5	10.9	15	11.6
10	10.8	8.4	11.8	8.8
09	8.2	6.1	8.6	6.1
08	6.2	4.4	6.1	4.1
07	5.1	3.5	5.1	3.3
06	4	2.8	4	2.6
05	3	2.1	3.1	2
04	2.1	1.4	2.2	1.4
03	1.3	0.9	1.4	0.8
02	0.7	0.4	0.7	0.4
01	0.2	0.1	0.2	0.1
BASE	0	0	0	0

Table 4.3: storey displacements for model 3 along longitudinal and transverse directions

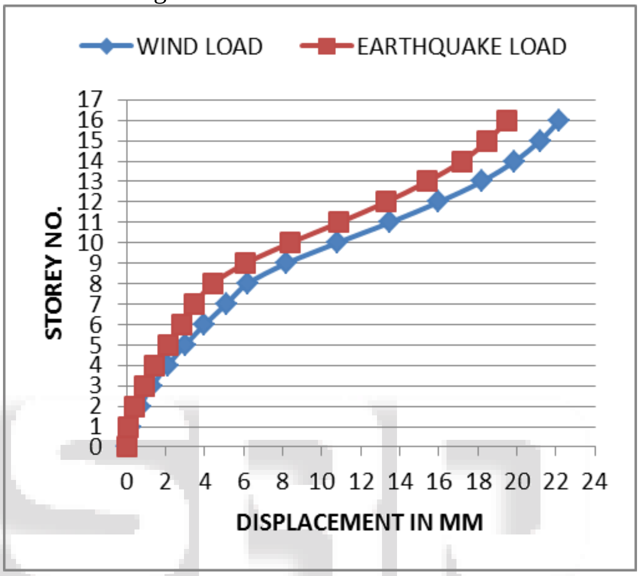

Fig. 5: Chart. 4.3.1: Storey wise displacement for building model-3 along longitudinal direction

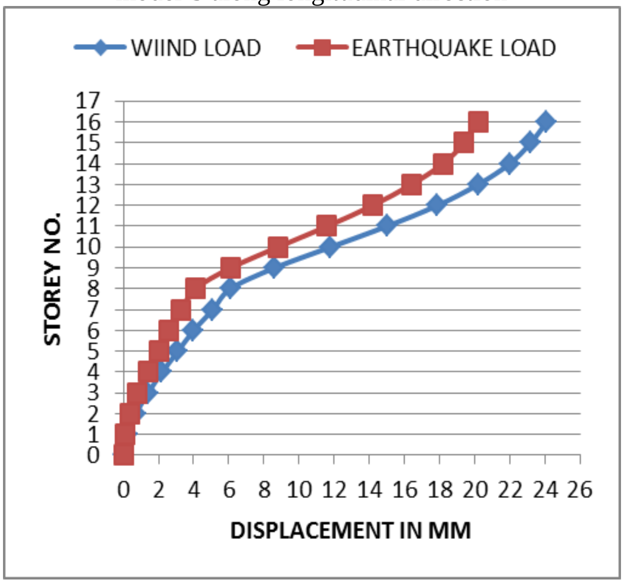

Fig. 6: Chart. 4.3.2: Storey wise displacement for building model-3 along transverse direction

D. Storey Drifts

The permissible storey drift according to IS 1893 (Part 1) : 2002 is limited to 0.004 times the storey height, so that minimum damage would take place during earthquake and pose less psychological fear in the minds of people. The maximum storey drifts of different models along longitudinal and transverse directions obtained from equivalent static analysis (ETABS) and fro, loads are shown in tables below.

Storey No.	WIND LOAD		EARTHQUAKE LOAD	
	Ux	Uy	Ux	Uy
16	0.4	0.35	0.175	0.15
15	0.55	0.525	0.25	0.225
14	0.75	0.725	0.3	0.325
13	0.925	0.95	0.375	0.4
12	1.125	1.2	0.475	0.475
11	1.35	1.4	0.5	0.55
10	1.55	1.65	0.575	0.625
09	1.725	1.825	0.6	0.625
08	1.925	2.05	0.65	0.7
07	2.1	2.25	0.65	0.7
06	2.225	2.425	0.675	0.725
05	2.325	2.575	0.65	0.725
04	2.325	2.65	0.625	0.725
03	2.2	2.65	0.575	0.675
02	1.75	2.3	0.45	0.575
01	0.8	1.15	0.2	0.275
BASE	0	0	0	0

Table. 3:

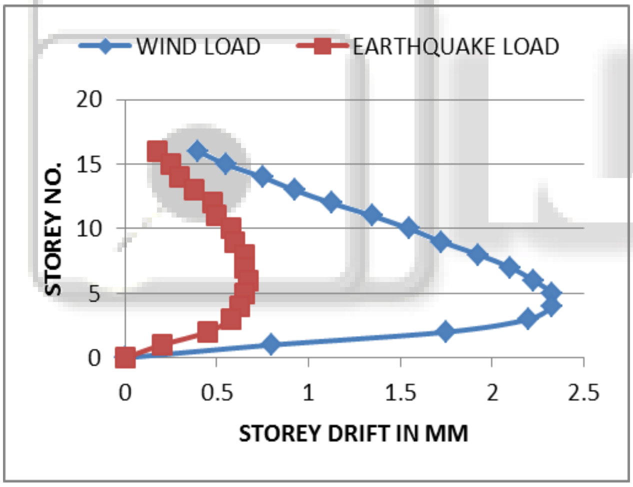

Fig. 7: Chart. 4.4: Inter storey drift of models along with longitudinal direction

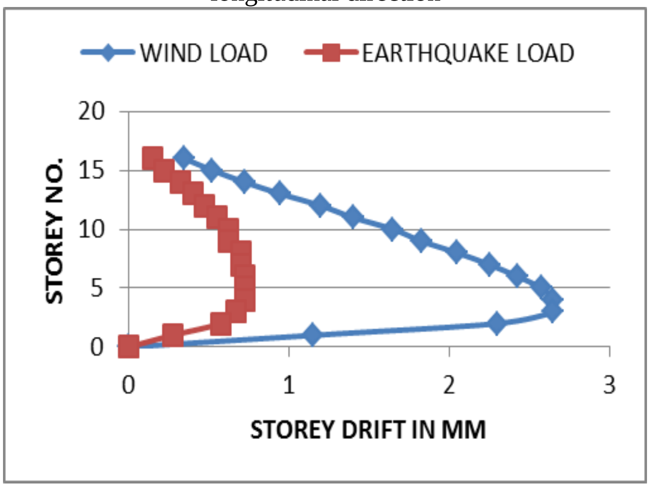

Fig. 8: Chart. 4.4.1: Inter storey drift of models along with transverse direction

V. CONCLUSIONS

1) A 16 storey building having model 1 model 2 model 3 when compare with wind and earth quake displacements in longitudinal direction. The wind displacements of model 2 and model 3 is reduced by 82.62% and 76.90% and earth quake displacement of model 2 and model 3 is reduced by 48.87% and 22.01%when compared with model 1.hence it is found that building with shear wall i.e. model 2 resist wind and earth quake load effectively.
2) A 16 storey building having model 1 model 2 model 3 when compare their wind and earth quake displacements in transverse direction. The wind displacements of model 2 and model 3 is reduced by 86.13% and 81.73% and earth quake displacement of model 2 and model 3 is reduced by 53.10% and 40.05%when compared with model 1.hence it is found that building with shear wall i.e. model 2 resist wind and earth quake load effectively.
3) Although A 31 storey building having model 4 model 5 model 6 when compare their wind and earth quake displacements in longitudinal direction. The wind displacements of model 5 and model 6 is reduced by 52.42% and 48.48% and earth quake displacement of model 5 and model 6 is reduced by 48.77% and 42.26%when compared with model 4.hence it is found that building with shear wall i.e. model 4 resist wind and earth quake load effectively.
4) A 31 storey building having model 4 model 5 model 6 when compare their wind and earth quake displacements in transverse direction. The wind displacements of model 5 and model 6 is reduced by 55.92% and 50.84% and earth quake displacement of model 5 and model 6 is reduced by 51.90% and 44.33%when compared with model 4.hence it is found that building with shear wall i.e. model resist wind and earth quake load effectively.
5) Lateral displacement values obtained from static method of analysis indicate that shear wall provision along longitudinal and transverse directions are effective in reducing the displacement values in the same directions.
6) The result show that wind and earth quake loads are different from each other indicates that earth quake loads produce less inter storey drift compare with the wind load. Even if inter story drift ratios in tall buildings may be relatively small with no significant apparent issue for main force resisting system of structure similar conclusion were obtained with both the 16 storey and the 31 storey buildings.
7) From the comparison of story drift values it can be observed that maximum reduction in drift values is obtained when shear walls are provided at corners of the building.
8) Buildings should be designed in both directions independently for the critical forces of wind or earthquake separately. The total shear force and the moment at the base result from seismic analysis when loads acting normal to the short side may be greater than the other direction.
9) Composite structures are the best solution for high rise structure.

10) With improved understanding of tall building performance, the next generation in design can truly evolve from the perspectives of performance, economy and efficiency to advance the growing development of tall buildings around the globe.
11) For severe lateral loads caused by wind load and or earthquake load, the reinforced shear wall is obvious. Because, it produces less deflection and less bending moment in connecting beams under lateral loads than all others structural system

VI. ACKNOWLEDGEMENT

My heart full thanks to PROF. Dr.Shreenivas Reddy Shahpur my beloved guide, PROF. BRIJ BHUSHAN S, PROF. Rohan Gurav, PROF. Shaik Abdulla for their valuable Suggestions and Last but not the least I am indebted to my Parents, Brother, Friends and my colleagues for their support and supplications.

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