Study of Effect of Orientation of Column and Position of Shear Wall on G+13 Storeyed Earthquake Resistant Structure

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***Abstract*— This study is based on comparative analysis. Shear walls are reinforced concrete structural walls which resists lateral loads. Shear wall system is one of the most commonly used lateral load resisting technique in high-rise structures. This paper presents the study and comparison difference in earthquake and wind force behavior on a building with and without shear wall along with the change in column orientation of a G+13 multistoried building in STAAD pro. The structure is assumed to be located in seismic zone -III (Mumbai). The floor to floor height has been taken as 3.5m. Damping ratio is taken as 0.05. Response reduction factor is taken as 1.5. The Importance factor is 1. The load calculations are based on Indian standards for wind (IS 875:2015 (part 3)) and for seismic (1893:2002 (part 1)). Eight different models with same loading structure is taken into consideration. Graphical representation is done based on the results and analysis. A comparative analysis is done in terms of lateral Displacement, Storey drift, Quantity of concrete in m3.**

Keywords*— Staad pro, Lateral displacement, Storey drift, Shear wall, seismic load, wind load, etc.

INTRODUCTION

Earthquake is one of the most disastrous natural calamities faced by mankind. History has been evident of various techniques and technologies being implemented by engineers and architects of the past to tackle and to reduce the impact of this catastrophe on various structures. To design a structure seismic resistant, it is important to understand the reason for seismicity as well as the propagation, nature and type of seismic waves being emitted.

Earthquakes are caused by sudden slip on the fault. This sudden slip emits a tremendous amount of energy which propagates in the form of waves throughout the medium. These waves can be differentiated as body waves and surface waves. Surface waves are like sound waves, they move along the surface of the earth. Body waves, on the other hand, goes through the earth's interior.

Structures undergo lateral movement when under seismic waves, if these structures are designed only for vertical loads (dead load and live load) then under seismic activity due to lateral loads they might collapse. Hence to eradicate a probable risk of structures, they are designed to resist lateral loads. The design is specified depending upon the Zone in which the structure lie.IS code 1893 has specified zones as II, III, IV, V.

As with the construction of high-rise structures, the wind load became a problem. It was observed that as the height of structure increases the wind load characteristics has to be implemented in design.IS 875 specifies the design for wind loads. Hence the stiffness of structure was observed while designing for wind and seismic resistance.

Shear walls are one of the lateral load resisting elements. It was first started to be in use from 1940.They are deeply cantilevered reinforced concrete beams. They resist both vertical and lateral forces on a structure due to wind and earthquake. Structural walls are considerably deeper than typical beams or columns, this attribute gives a considerable in-plane stiffness which makes these walls a natural popular choice for resisting lateral loads. Shear wall size can vary from 150 mm to 400 mm in thickness. They are commonly located along the lift, staircase and core regions. The buildings incorporated with properly designed and detailed shear walls increases safety and lowers the property damage during earthquakes. Behavior of structure during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and vertical planes of building. When shear walls are situated in advantageous positions, they can form an efficient lateral force resisting system.

I. LITRATURE REVIEW

P. P. Chandurkar, Dr. P. S. Pajgade, Seismic Analysis of RCC Building with and Without Shear Wall. In this paper a study was conducted on seismic analysis of RCC building with and without shear walls using Etabs. They have selected a ten storied building located in zone II, zone III, zone IV and zone V Effectiveness of shear wall is studied using four different models. Parameters like Lateral displacement, story drift and total cost required for ground floor are calculated.

Alfa Rasikan, M G Rajendran, Wind Behaviour of Buildings with and without Shear Wall, in this paper a study is conducted on a 15-storey building and a 20-storey building with and without shear wall. Wind behavior on these models are specified using Staad pro. It has been observed from the study that the model with shear wall had less displacement as compared to model without shear wall, hence the shear wall resists wind load effectively.

Anshul Sud, Raghav Singh Shekhawat, Poonam Dhiman, Best placement of Shear walls in an RCC space frame based on seismic response. In this paper they conducted an analysis on a five storey RC office building in Zone V on medium soil (as per IS (1893 : 2002).Various analysis like bending moment in columns, shear force, axial forces ,storey drift with respect to the position of shear walls were carried out .Different placements of shear walls are considered and the best one is selected.

Amita baghel, Urvashi, Kesherwani, Gaurov Sachdeva, Best position of RC shear wall due to seismic loads, the study was conducted on a G+2 structure using staad pro. The building is in seismic zone III, special moment resisting frame (SMRF) and hard rock type is used in work. Four models are considered, Nodal displacement and maximum reaction values are compared.

Sumit Singh Bhadauria, Asst. Prof. Rashmi Singh, Performance of building for different orientation of shear walls, In this paper an analysis on G+12 building having 9 bays in X direction and 7 bays in Z direction with different orientation of shear walls. Lateral displacement, Base shear, Storey drift on 4 models were calculated and compared.

Kanchan Rana, Vikas Mehta, Seismic analysis of RCC building with shear wall at different location using staad pro, in this paper the behavior of RC walls was analyzed with shear wall. Three models were considered and story drift of each are
compared. The least storey drift is observed in the model with shear walls placed at center of sides of the structure.

II. BUILDING MODELING

For this study, a 14-story building with a 3.5-meters height for each story, regular in plan is modeled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings. Storey heights of buildings are assumed to be constant including the ground storey. The buildings are modeled using Staad pro. Eight different models were studied with different positioning of shear wall in building with different column orientation. The models are numbered from 1 to 8. Modals 1-4 are analyzed with size of column as 0.6 x.0.9 m. Modal 5-8 are analyzed with changing the orientation of column to 0.9 x 0.6m. In model 1 to 4 greater dimension of column is perpendicular and smaller dimension is parallel to the lateral forces, whereas in models 5 to 8 the larger column dimension is parallel and smaller dimension is perpendicular to the lateral forces. Models are studied in seismic zone III (Z=0.16) comparing lateral displacement, story drift, Total volume of concrete required.

Table 1(A) -Geometric details of building.

Sr.no	Description	
1	No. of Storey	Fourteen(G+13)
2	Floor to floor height	3.5m
3	Column size	0.9 x 0.6 m 0.6 x 0.9 m
4	T-Beam size	0.6x0.7x0.3x0.5 m
5	Slab thickness	150 mm
6	Wall thickness	200 mm
7	Shear wall thickness	200 mm
8	Grade of concrete and steel	M45 and Fe 500

Table 2(B) --Loads acting on the structure are.

Dead Load (DL)	As per IS 875 (Part 1) (1987) A. Self-weight of the structure, B. Floor load (6 KN/sq.m), C. Wall loads (14 KN/m).
Live load (LL)	As per IS 875 (Part 2) (1987) A. Live load 5 KN/sq.m is considered for floor weight.
Seismic load (SL)	As per IS 1893 (Part 1) (2002/2005) A. Zone: -III (Z=0.16) B. Rock/ soil type: Medium C. Rock and Soil site factor: 1 D. Response reduction factor: 1.5 E. Importance factor: 1 F. Damping: 0.05%.
Wind load (WL)	As per IS 875 (Part 3) (2015) With Basic wind speed (VB) =44 m/s

Below is the model of a G+13 structure which is to be analyzed.

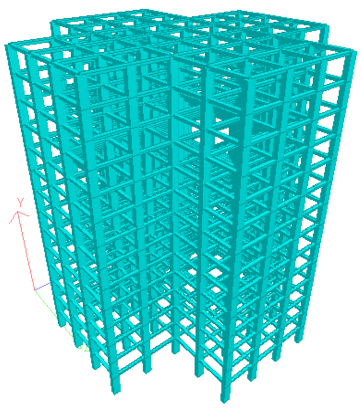

Fig. 1. 3D view of G+13 commercial building

III. LOAD COMBINATION AND PARAMETERS

1) *Load combinations*

Staad pro. v8 takes following load combinations.

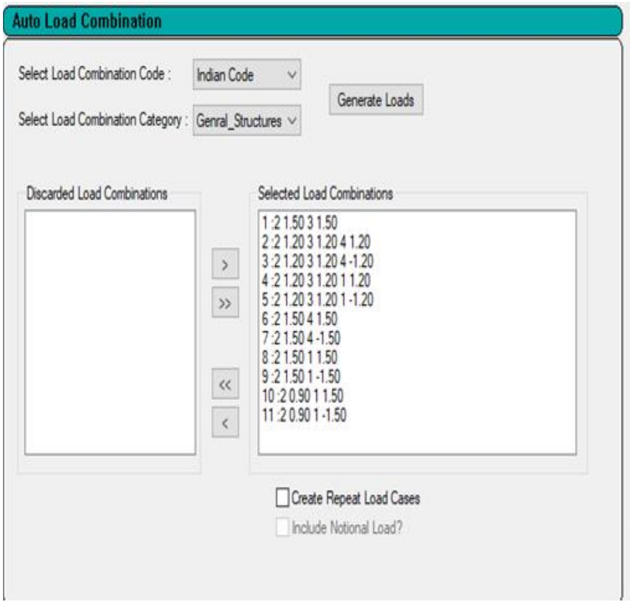

Fig.2 : Load combinations

2) *Seismic Parameters*
Following sesimic parameters has been specified.

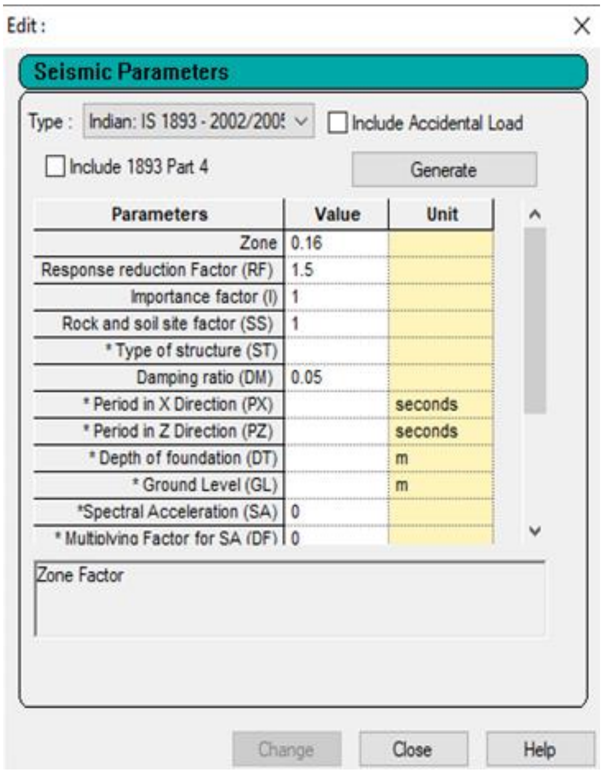

Fig.3 Seismic parameters

3) *Wind load Direction and Intensity*

The Wind has been subjected from X&Z -direction.

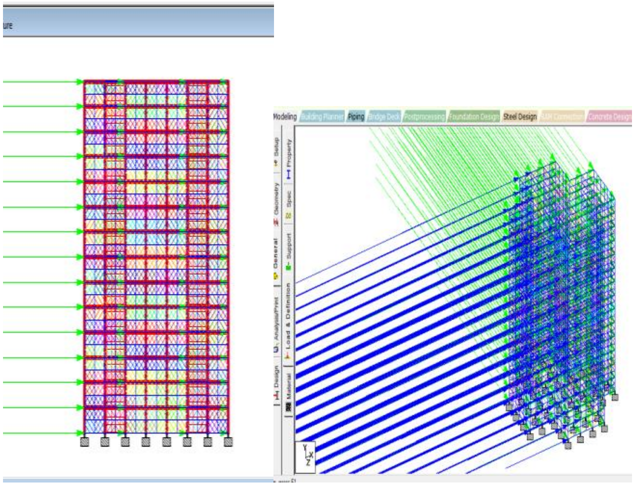

Fig.4 Wind from X&Z - direction

Wind load has been applied to the models as per IS 875(PART3) (2015).

The wind intensity varies in ascending from ground to top floor. The following specifies the values.

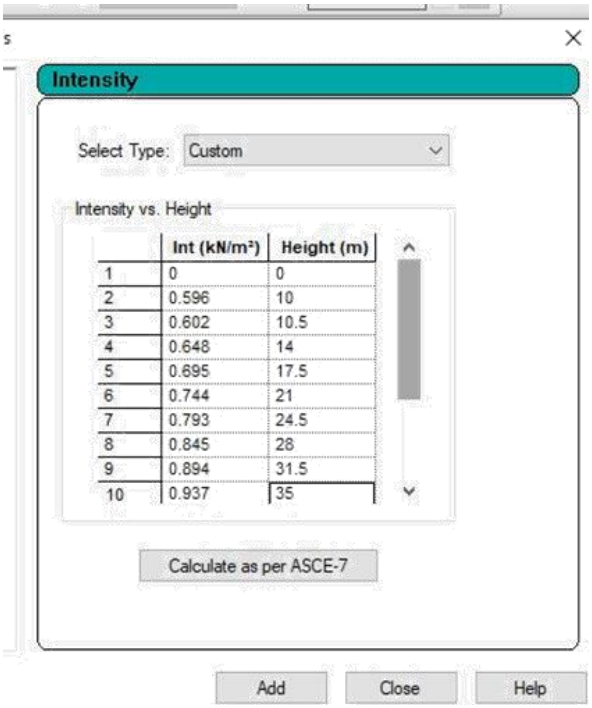

Fig..5 Wind intensity

IV. POSITIONING WITH AND WITHOUT SHEAR WALLS

1) *Model 1&5 without shear wall.*

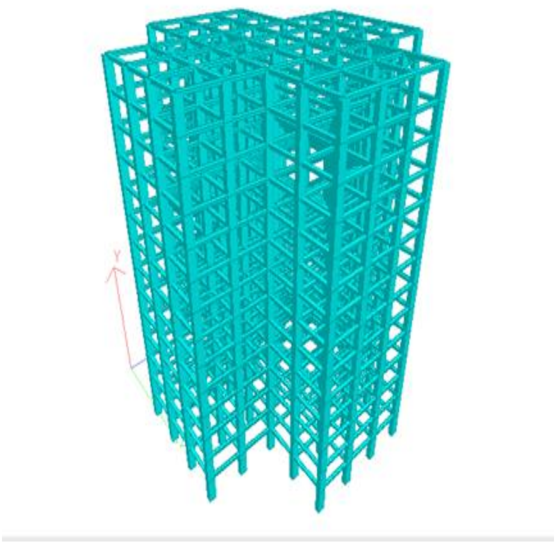

Fig..6

2) Model 2&6 with Shearwall positioning at all four corners

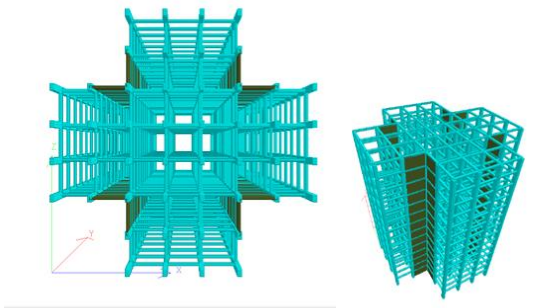

Fig.7

3) Model 3&7 with position of shear wall at each side faces

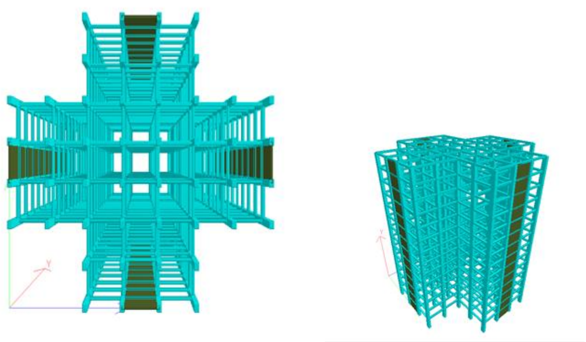

Fig.8

4) Model 4&8 with position of shear walls at each face sides and edges

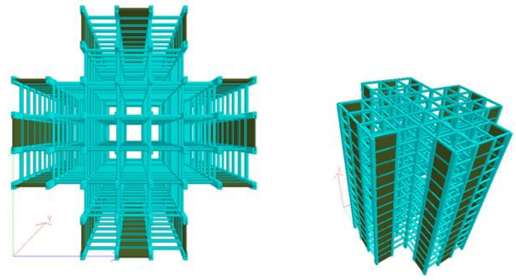

Fig..9

V. RESULT AND DISCUSSION

A. LATERAL DISPLACEMENT

1) Lateral displacement in the models of G+13 Multistorey building in X direction.

Table 3

HEIGHT(m)	Lateral Displacement in X direction (in cm)							
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8
0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3.5	0.3668	0.0637	0.2242	0.1440	0.2468	0.0513	0.1653	0.1083
7	0.9361	0.1515	0.5627	0.3571	0.6862	0.1296	0.4441	0.2869
10.5	1.5147	0.2479	0.9278	0.5879	1.1609	0.2175	0.7585	0.4880
14	2.0694	0.3479	1.2993	0.8236	1.6264	0.3096	1.0835	0.6966
17.5	2.5920	0.4502	1.6681	1.0592	2.0688	0.4030	1.4079	0.9055
21	3.0780	0.5520	2.0274	1.2897	2.4819	0.4955	1.7247	1.1101
24.5	3.5237	0.6516	2.3711	1.5114	2.8618	0.5856	2.0283	1.3070
28	3.9255	0.7470	2.6943	1.7207	3.2053	0.6715	2.3141	1.4928
31.5	4.2801	0.8369	2.9927	1.9148	3.5092	0.7522	2.5784	1.6653
35	4.5841	0.9201	3.2629	2.0915	3.7710	0.8265	2.8181	1.8223
38.5	4.8349	0.9957	3.5023	2.2490	3.9882	0.8936	3.0310	1.9623
42	5.0299	1.0627	3.7090	2.3859	4.1592	0.9828	3.2158	2.0993
45.5	5.1676	1.1201	3.8822	2.5012	4.2840	1.0034	3.3723	2.1879
49	5.2537	1.1660	4.0235	2.5948	4.3693	1.0451	3.5029	2.2740

2) Graph with lateral displacement for model 1,2,3 &4

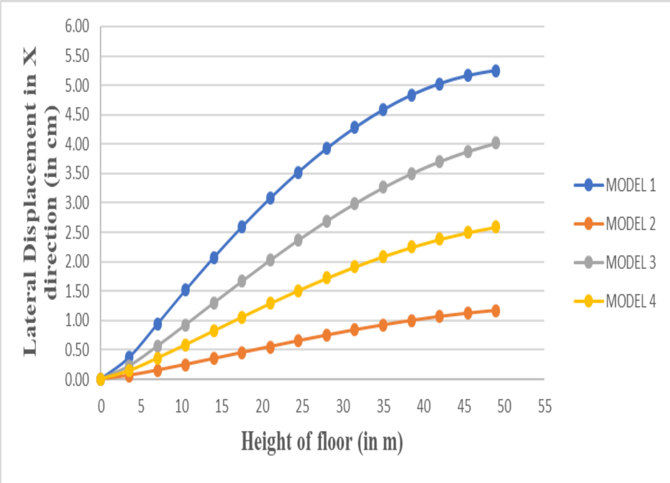

Fig 10

3) Graph with lateral displacement for model 5,6,7&8

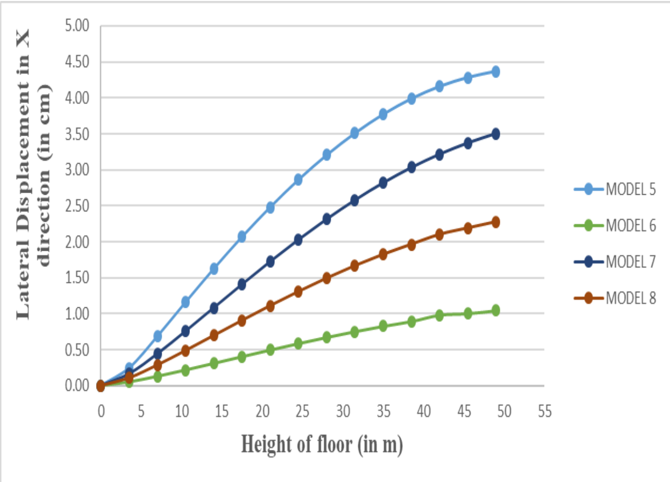

Fig. 11

4) Lateral displacement in the models of G+13 Multistorey building in Z direction

Table 4

HEIGHT(m)	Lateral Displacement in Z direction (in cm)							
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8
0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3.5	0.1632	0.0513	0.1202	0.0858	0.2446	0.0637	0.1617	0.1127
7	0.5047	0.1296	0.3567	0.2432	0.7094	0.1515	0.4529	0.3022
10.5	0.9189	0.2175	0.6436	0.4306	1.2401	0.2475	0.7850	0.5163
14	1.3562	0.3096	0.9462	0.6279	1.7784	0.3479	1.1215	0.7347
17.5	1.7930	0.4030	1.2470	0.8250	2.2986	0.4502	1.4490	0.9496
21	2.2066	0.4955	1.5370	1.0163	2.7878	0.5520	1.7618	1.1569
24.5	2.5959	0.5856	1.8113	1.1985	3.2388	0.6516	2.0569	1.3543
28	2.9526	0.6715	2.0665	1.3690	3.6468	0.7470	2.3315	1.5393
31.5	3.2727	0.7522	2.3001	1.5262	4.0081	0.8369	2.5831	1.7100
35	3.5540	0.8265	2.5099	1.6682	4.3204	0.9201	2.8088	1.8645
38.5	3.7956	0.8936	2.6942	1.7939	4.5823	0.9957	3.0061	2.0009
42	3.9981	0.9528	2.8525	1.9027	4.7939	1.0627	3.1729	2.1178
45.5	4.1652	1.0034	2.9861	1.9948	4.9585	1.1201	3.3092	2.2147
49	4.3051	1.0451	3.1015	2.0733	5.0859	1.1660	3.4215	2.2938

5) Graph with lateral displacement for all models

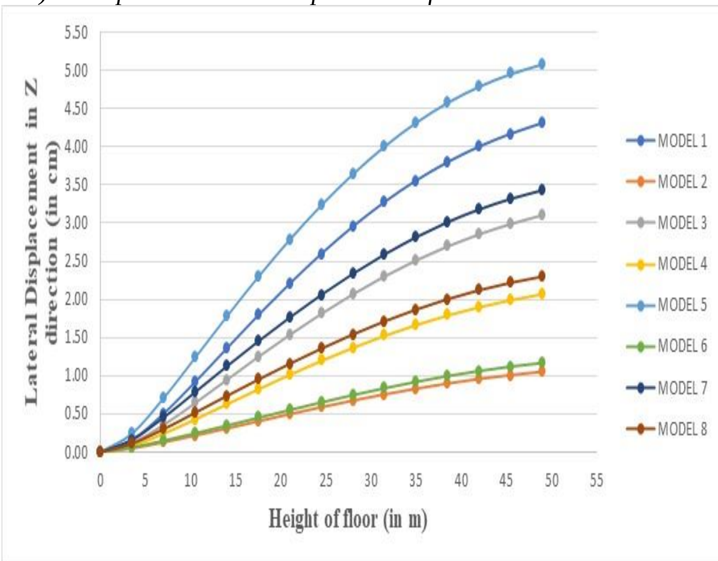

Fig.12

B. STOREY DRIFT

Values for storey drift are given in the following table and plotted in the following fig. By analyzing the values, we conclude that the model 2&6 have the maximum reduction. storey drift in x direction as shown in the table.

Table 5

STOREY NUMBER	Storey Drift in X direction (in mm)							
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7	MODEL 8
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	1.632	0.087	0.388	0.238	2.468	0.063	0.239	0.151
2	3.415	0.161	0.737	0.449	4.395	0.130	0.497	0.314
3	4.142	0.205	0.909	0.557	4.746	0.173	0.627	0.400
4	4.373	0.229	0.954	0.592	4.655	0.199	0.650	0.425
5	4.342	0.240	0.901	0.571	4.424	0.212	0.586	0.399
6	4.162	0.242	0.775	0.509	4.131	0.216	0.455	0.336
7	3.893	0.238	0.595	0.417	3.799	0.214	0.274	0.244
8	3.567	0.231	0.373	0.302	3.434	0.208	0.057	0.133
9	3.202	0.220	0.117	0.169	3.039	0.198	0.191	0.195
10	2.813	0.204	0.169	0.187	2.618	0.183	0.465	0.324
11	2.41	0.18	0.49	0.33	2.17	0.16	0.76	0.46

	5	2	0	6	3	2	7	5
12	2.025	0.150	0.851	0.501	1.710	0.132	1.102	0.617
13	1.670	0.102	1.265	0.684	1.248	0.090	1.475	0.783
14	1.399	0.033	1.748	0.891	0.853	0.034	1.900	0.967

1) *Fig with storey drift for model 1,2,3&4*

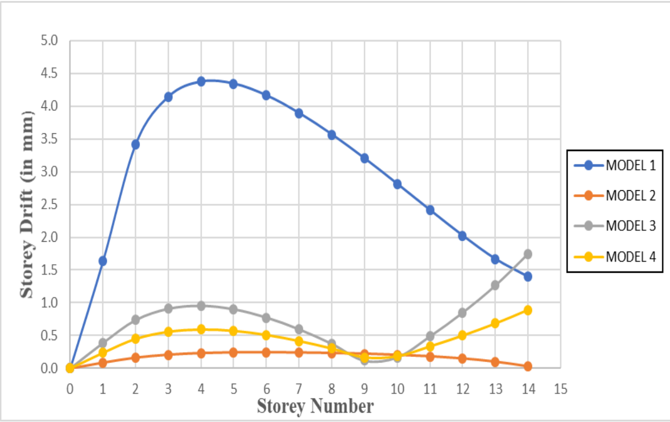

Fig.13

2) *Fig with storey drift for model 5,6,7&8*

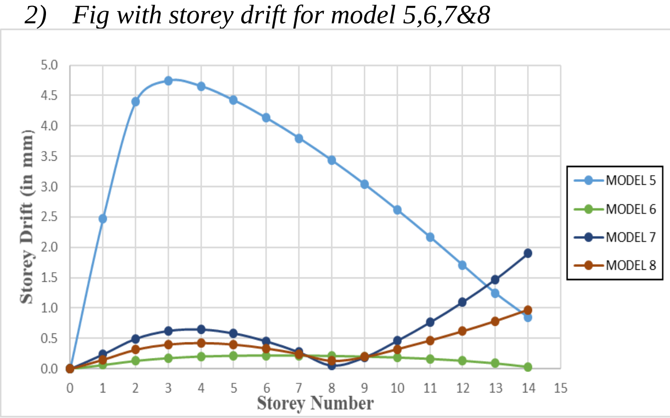

Fig.14

VI. VOLUME OF CONCRETE

The quantity of concrete used in the G+13 multistory building is given following table. Hence using the values, the bar chart has been plotted

Table 6

	Volume of Concrete (in cubic meter)
Model-1	2653.2576 cu.m
Model-2	2944.4576 cu.m
Model-3	2798.8576 cu.m
Model-4	3090.0576 cu.m
Model-5	2712.288 cu.m
Model-6	3003.488 cu.m
Model-7	2857.888 cu.m
Model-8	3149.088 cu.m

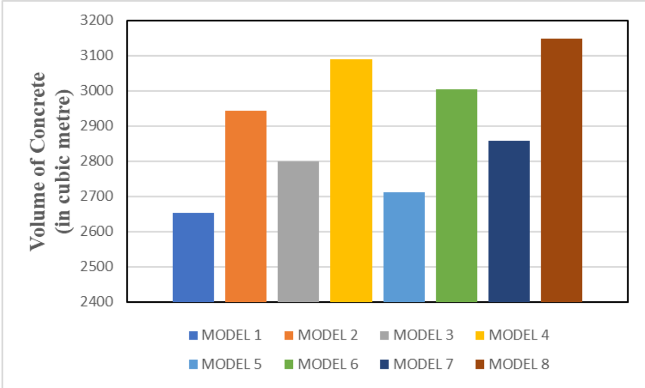

Fig15.Bar chart

VII. CONCLUSION

A G+13 storey building without shear wall, a G+13 storey building with shear walls at different positions were analyzed with same loading pattern and same cross section. Shear wall elements are very much efficient in reducing lateral displacement of frame as drift and horizontal deflection induced in shear wall frame are much less than that induced in plane frame. The location of shear-wall and brace member has significant effect on the seismic response than the plane frame. Shear wall construction will provide large stiffness to the building by reducing the damage to the structure. From the above result it is seen that top displacement and storey drift of model 1 & model 5 is high compared to other models.

1. Top displacement in X direction of model 2 is 78% less compared to model 1, model 3 is 24% less compared to model 1, model 4 is 61% less compared to model 1.
2. Top displacement in X direction of model 6 is 76% less compared to model 5, model 7 is 20% less compared to model 5, model 8 is 48% less compared to model 5.
3. Top displacement in Z direction of model 2 is 77% less compared to model 1, model 3 is 28% less compared to model 1, model 4 is 51% less compared to model 1.
4. Top displacement in Z direction of model 6 is 77% less compared to model 5, model 7 is 33% less compared to model 5, model 8 is 55% less compared to model 5.
5. By comparing model 1, model 2, model 3 & model 4 the Minimum storey drift in X direction is in model 2(0.242 mm).
6. By comparing model 5, model 6, model 7 & model 8 the Minimum storey drift in X direction is in model 6(0.216 mm).
7. From the following results it can be concluded that model 2 & model 6 has minimum lateral displacement in X & Z direction and storey drift in X direction.
8. The location of shear wall at the inner edges of building in "L shaped (model 2&6) is favourable as they are effective in reducing actions induced in frame with less horizontal deflection and drift.
9. While comparing model 2&6, in model 2 greater dimension is perpendicular and smaller dimension is parallel to a lateral force in column, in model 6 greater dimension is parallel and smaller dimension is perpendicular to a lateral force in column. Top displacement in X direction of model 6 is less compared to model 2. As in model 6 , most of lateral forces are resist by depth (0.9 m) of column.

10. From Table no 5, model 2 require a less volume of concrete with compared to model 6.

Providing shear walls at adequate locations substantially reduces the displacements due to earthquake and wind loading. Therefore, the overall conclusion is shedding light toward the Model 2 &6 (shear wall at the inner edges of building in "L shaped) that it is the most effective location among all other locations

VIII. REFERENCE

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