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Comparative Study of Shear Wall Shape and Location under the Earthquake Loading

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ABSTRACT
In this paper, the optimum or suitable location of shear wall in a high rise unit shaped building is determined. The criteria of choosing suitable location are well mentioned with suitable examples. We have tested several models in dynamic analysis with the help of ETABS ver. 16. Both Time History and Response Spectrum Methods are performed in the analysis. The paper clearly specifies shear wall optimum location in a high rise building, on basis of result obtain in form of displacement, story drift, story shear.
Key words: (ETABS, RESPONSE SPECTRUM METHOD, SHEAR WALL, STORY DRIFT)

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I. INTRODUCTION

- Earthquake causes the random ground motions in all directions, radiating from the epicenter. These ground motions causes structure to vibrate and induces inertia forces in them. For the structure to perform better during the earthquakes, it must be analyzed and designed as per the Indian seismic code IS 1893 (Part 1) 2002. In the past, several major earthquakes have exposed the shortcomings in buildings, which had caused them to damage or collapse. It has been found that regular shaped buildings perform better during earthquakes. Earthquakes causes ground to vibrate and structures supported on ground are subjected to this motion. Thus the dynamic loading on the structure during an earthquake is not an external loading, but due to motion of support. The building can be designed to resist earthquake with certain amount of damage, but without causing the collapse and affecting the livelihood. The response spectrum represents an interaction between ground acceleration and the structural system, by envelope of several different ground motion records. For the purpose of the seismic analysis the design spectrum given in fig.2 of IS 1893 (Part 1): 2002 is used. Response spectrum analysis of the building model is performed using STAADPRO & ETABS. The lateral loads generated by STAADPRO correspond to the seismic zone III and 5% damped response spectrum given in IS 1893 (Part1): 2002.

- **Response Spectrum Analysis**

The response spectrum method (RSM) was introduced in 1932 in the doctoral dissertation of Maurice Anthony Biot at Caltech. It is an approach to finding earthquake response of structures using waves and vibration mode shapes. The concept of the “response spectrum” was applied in design requirements in the mid-20th century in building codes of various countries. The computational advantages in using the response spectrum method of seismic analysis are the prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode using smooth design spectra that are the average of several earthquake motions.

- **Storey Drift Ratio**

Story drift is the displacement of one level relative to the other level above or below. In Software value of story drift is given in ratio. Storey drift ratio =difference between displacement of two stories / height of one story thebuilding may collapse due to different response quantities. For example at local levels such as strains, curvatures, rotations and at global levels such as interior story drifts. Individual stories may exhibit excessive lateral displacement. Therefore it can be concluded that by decreasing the story drifts of structure, the probability of collapse of the building can be reduced.

➢ **Shear wall**

Shear wall is a concrete wall made to resist lateral forces acting on high rise buildings. It is provided, when the centre of gravity of building area & loads acted on it differs by more than 30%. In order to bring the center of gravity in the range of 30% concrete wall is provided i.e. lateral forces may not increase much.

II. MODELLING IN ETABS

➢ For the purpose of knowing the optimum location of shear wall have to add the shear wall in different places in the building under sesmic loading and study the impact of the base shear, storey drift, shear force by changing the location, type of shear wall Four types of shear wall were selected and placed in different locations in the building. Nine different cases buildings were modelled using four types of shear wall, one case building were modelled without shear wall to understand the effect of shear wall in the building and behaviour of the building with and without shear wall. The models had carried out for general unit building with and without shear wall using ETABS Software.

➢ **Building properties**

The geometrical properties of the structure :-

1. Height of typical storey:-3 m
2. Height of ground storey:- 3 m
3. Length of the building :- 25 m
4. Width of the building:- 25 m
5. Span in both the direction:- 5 m
6. Height of the building:- 30 m
7. Number of storey's:- G +10
8. Dimension of beams :- 0.55 m × 0.23 m
9. Dimension of columns:- 0.5 m × 0.5 m
10. Wall thickness:- 0.23 m.
11. Slab Thickness:- 0.13m
12. Grade of the concrete:- M 25
13. Grade of the steel:- Fe 415
14. Thickness of shear wall:- 0. 23 m
15. Support fixed

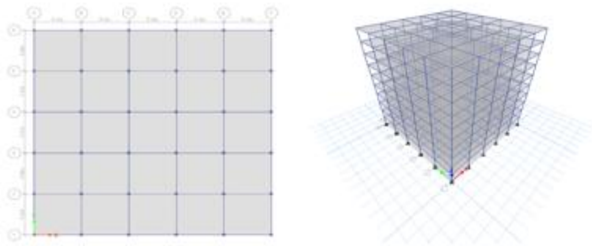
➢ **Loadings**

Live load:- 4 kN/m²
Floor finish:- 1.5 kN/m²
Wall weight :- 13.8 kN/m/6.9 kN/m on roof
Seismic loading- : IS 1893
Zone factor:- 0.16 (zone**III**)
Soil type:- II
Importance factor:- 1.2
Response reduction R:- 5

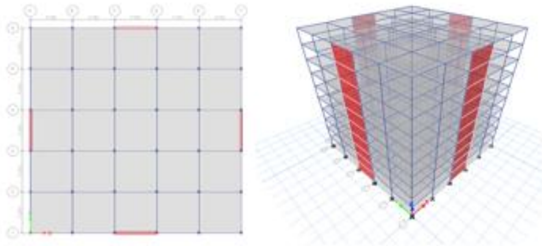
III. ANALYSIS IN ETABS

➢ The behaviour of all the structures is taken as a basic study on the shear structure. The lateral drift is checked against the clause 7.11.1 of IS-1893:2002 (i.e. under transient seismic loads). The three parameters considered to present a comparison between the different cases are Maximum Storey Drift, Maximum displacement and Storey Shear. Many load combinations were considered during the analysis of the model, however for asserting the simplest yet most reliable method for analysis, the combined action of DL, LL & EQ forces was considered (i.e. 1.2 DL + 1.2 LL + 1.2 EQX). The structures with different framing system have been modeled using ETABS with the above mentioned load conditions and combinations:-

CASE 1:



CASE 2:



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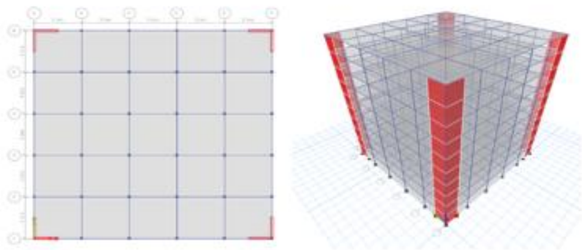
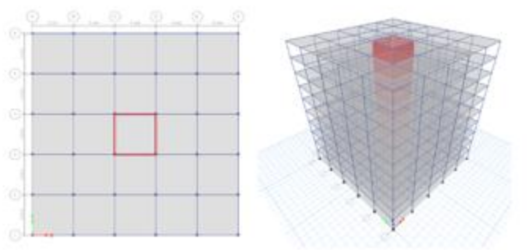


CASE 4:



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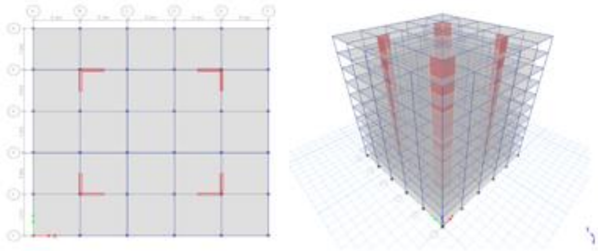

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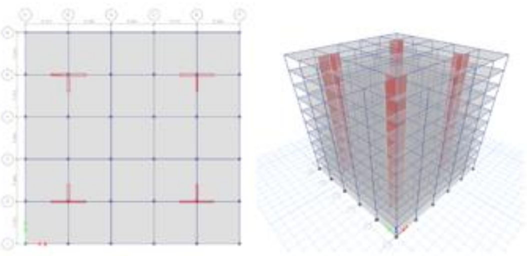
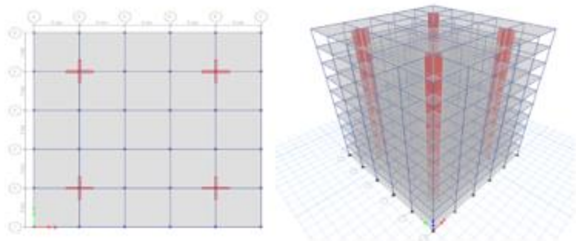
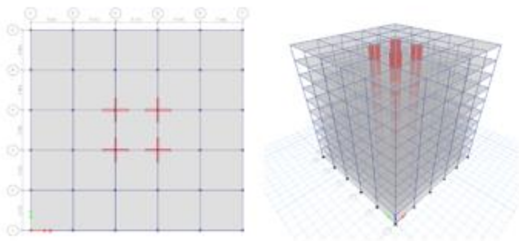


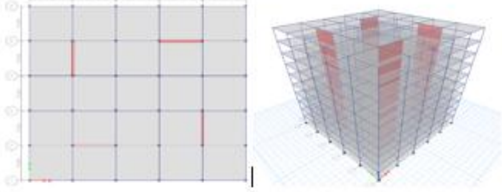
CASE 7:



CASE 8:



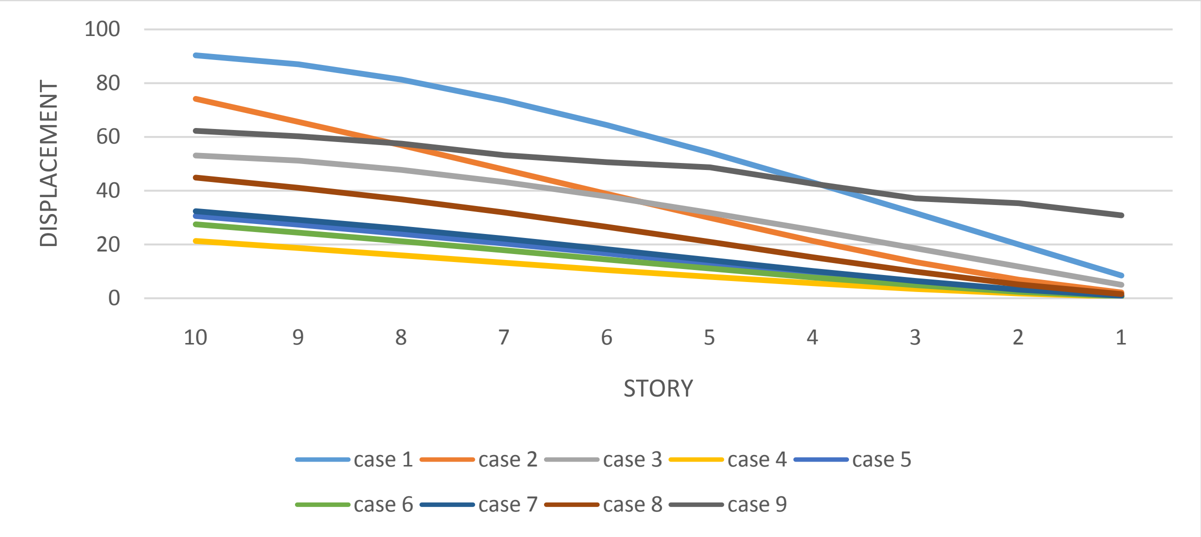
CASE 9:

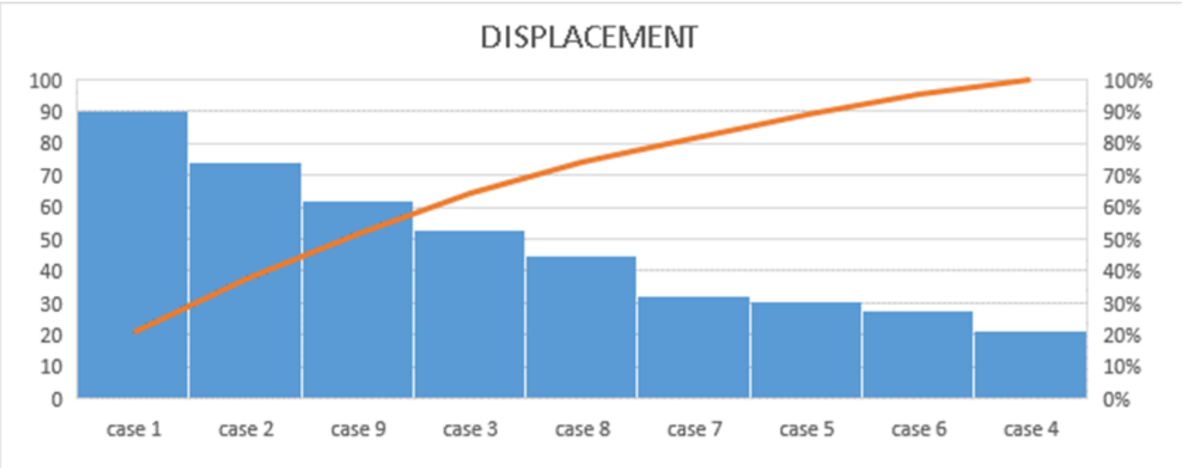


IV. RESULT

➢ DISPLACEMENT

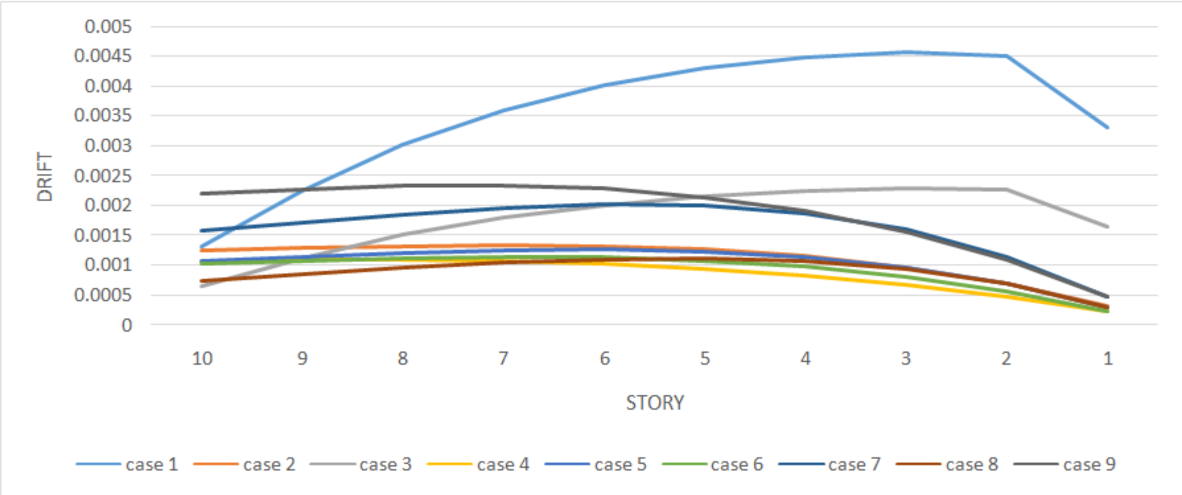
	case 1	case 2	case 3	case 4	case 5	case 6	case 7	case 8	case 9
10	90.2938	74.15467	53.114	21.266	30.597	27.476	32.347	44.9089	62.258
9	86.9618	65.618	51.154	18.615	27.399	24.404	29.18	41.0958	60.289
8	81.2413	56.84867	47.789	15.902	23.995	21.196	25.763	36.7897	57.512
7	73.5624	47.88133	43.272	13.175	20.387	17.856	22.065	31.9362	53.189
6	64.3858	38.816	37.874	10.492	16.634	14.438	18.139	26.6118	50.636
5	54.1178	29.85133	31.834	7.926	12.843	11.04	14.103	20.9882	48.746
4	43.1069	21.27267	25.357	5.559	9.163	7.793	10.123	15.3017	42.683
3	31.6387	13.46133	18.611	3.483	5.782	4.858	6.411	9.8719	37.215
2	19.958	6.897333	11.74	1.795	2.931	2.423	3.237	5.1017	35.321
1	8.4405	2.164	4.965	0.594	0.887	0.722	0.955	1.5589	30.851

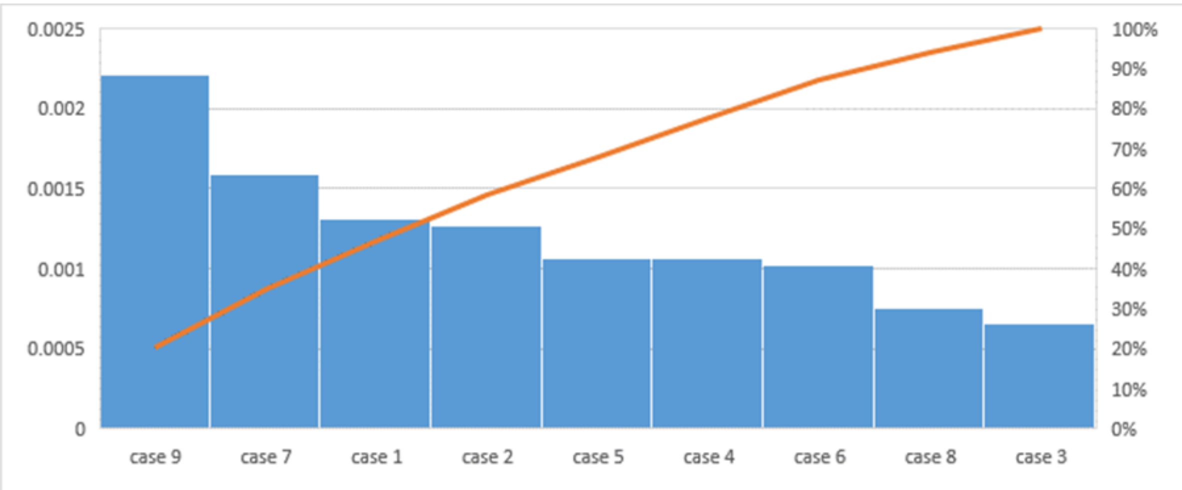




➢ STORY DRIFT

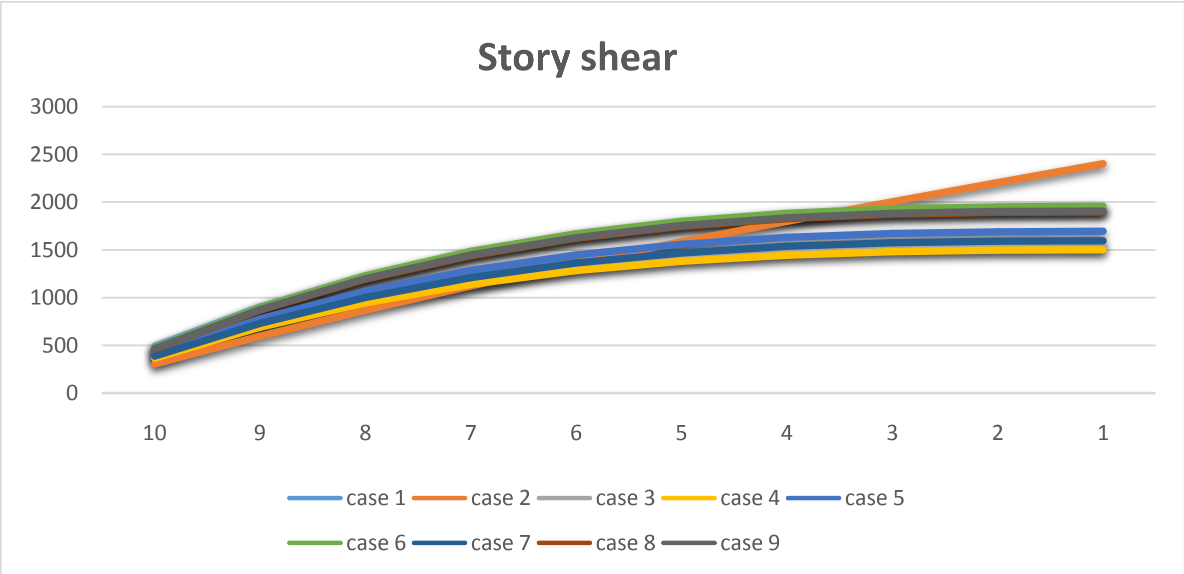
	case 1	case 2	case 3	case 4	case 5	case 6	case 7	case 8	case 9
10	0.001308	0.001263	0.000654	0.001061	0.001068	0.001025	0.001586	0.000748	0.00221
9	0.002244	0.001297	0.001122	0.001085	0.001135	0.00107	0.001709	0.000844	0.002282
8	0.003012	0.001327	0.001506	0.001091	0.001203	0.001113	0.00185	0.000952	0.002334
7	0.003598	0.001341	0.001799	0.001073	0.001251	0.001139	0.001962	0.001044	0.002344
6	0.004026	0.001326	0.002013	0.001026	0.001264	0.001133	0.002019	0.001103	0.00229
5	0.004318	0.001269	0.002159	0.000947	0.001227	0.001083	0.001992	0.001115	0.002154
4	0.004498	0.001156	0.002249	0.00083	0.001128	0.000981	0.001859	0.001067	0.00192
3	0.00458	0.000971	0.00229	0.000676	0.000953	0.000814	0.00159	0.000938	0.001574
2	0.004516	0.0007	0.002258	0.00048	0.000685	0.000572	0.001148	0.0007	0.001102
1	0.00331	0.00032	0.001655	0.000238	0.000296	0.000241	0.000477	0.000306	0.00048

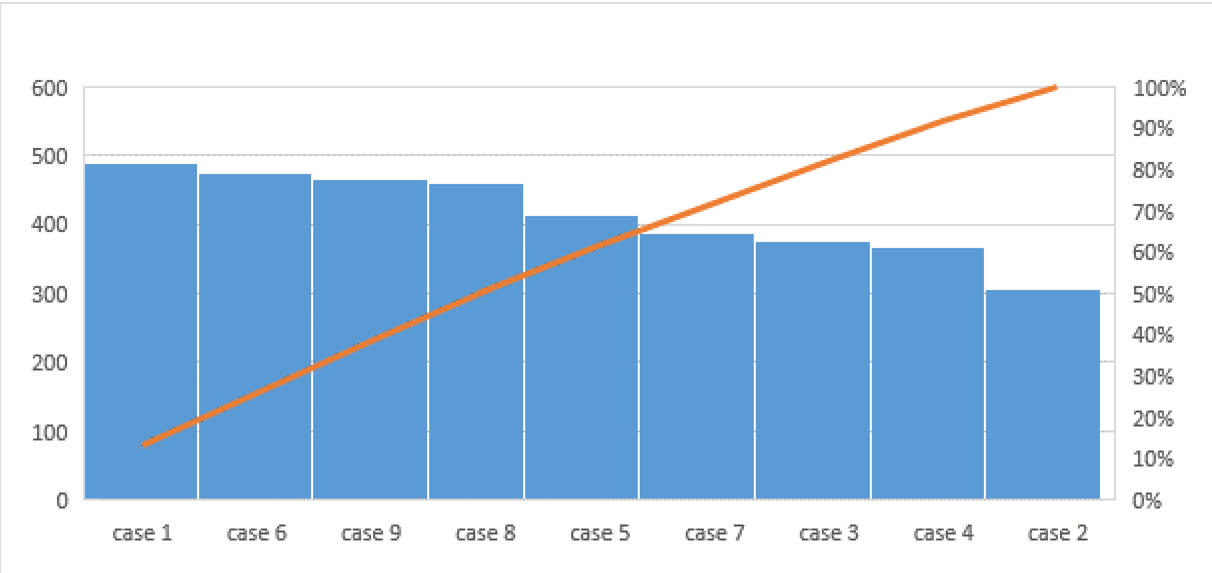




➢ STORY SHEAR

	case 1	case 2	case 3	case 4	case 5	case 6	case 7	case 8	case 9
10	490.408	305.4397	375.5787	367.4211	414.6905	475.5607	388.5247	461.5456	466.9622
9	901.5129	597.4739	705.5103	690.1171	778.9017	896.8043	732.2207	870.3748	877.0824
8	1226.337	869.2085	966.1971	945.0866	1066.674	1229.639	1003.783	1193.4	1201.128
7	1475.03	1123.032	1165.785	1140.298	1286.999	1484.465	1211.698	1440.717	1449.225
6	1657.743	1361.332	1312.422	1283.718	1448.871	1671.685	1364.452	1622.419	1631.501
5	1784.627	1586.496	1414.252	1383.316	1561.281	1801.698	1470.531	1748.601	1758.081
4	1865.833	1800.914	1479.424	1447.058	1633.224	1884.907	1538.421	1829.357	1839.093
3	1911.512	2006.974	1516.083	1482.913	1673.692	1931.711	1576.61	1874.782	1884.662
2	1931.813	2207.063	1532.376	1498.849	1691.678	1952.514	1593.582	1894.972	1904.914
1	1936.889	2403.569	1536.449	1502.833	1696.175	1957.714	1597.826	1900.019	1909.978





V. CONCLUSION

The present study has been carried out the earthquake response of tall building by using varying thickness shear wall and its position. The main objectives of the study to investigate which case model provides adequate performance. The following conclusions were drawn from the analysis:

➢ For displacement, CASE 4showed lowest amount of displacement among all other cases of experiment In terms of the Storey Drift, it was CASE 3- (closely followed by CASE 8,4), which showed better results when compared to other models. This leads us to believe that when Shear Walls are placed at the center of the geometry in the form of a box or at the corners, the structures behave in a more stable manner. This practice of providing Box-type Shear Walls is becoming more popular now-adays as high rise structures generally have a lift system. The main difference in the behaviours of CASE 4 and CASE 2 can be noticed when comparing the Storey Shear. CASE 2 displayed much higher values of storey shear as compared to the other models. Here CASE 4 proved to be the best. It is therefore safe to conclude that among all other considered possibilities, CASE 4 (Building with Box-type Shear Wall at the center of the geometry) is the ideal framing technique for medium & high rise buildings. To further increase the effectiveness of the structure, earthquake resisting techniques such as Seismic Dampers & Base Isolation can be use.

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