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Analysis of A Tall Building with Shear Wall of RCC and Steel Plate

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Absrtract:- **Tall Structures are most influenced by lateral forces in seismic prone areas. The most significant basis to be considered in the design of the tall structures is to oppose lateral forces which can cause instability and sudden failure of the structure. In this manner it is necessitated that structure ought to have enough lateral stability to oppose lateral forces and to control the lateral displacement of the building. The shear wall is one of the most generally utilized lateral loads opposing System in elevated structures Shear wall has high in-plane stiffness and quality which can be utilized to all the while opposing enormous horizontal loads and support gravity loads. The incorporation of the Shear wall has turned out to be inescapable in multi-storeys working to oppose lateral forces. It is exceptionally important to decide the successful, effective and ideal location of the shear wall. In this paper, seismic analysis has been done on G+ 10 storeys building in Zone IV. The analysis has been done considering shear wall of RCC and steel plate. Parameters like axial load, displacement, Overturning moment, stiffness etc. are determined for different location of shear wall.**

Keywords – Shear wall, Seismic loading, lateral loading

1. INTRODUCTION

The basic role of all kinds of structural systems utilized in a building type structures is to support gravity loads. The most widely recognized loads resulting from the impact of gravity are dead load, live load and snow load. Other than these vertical loads, buildings are likewise exposed to lateral loads brought about by the wind, impact load or seismic tremors. Following are the various structural systems:

1. Structural frame systems: the structural system comprises of frames. Floor slabs, beams, and columns are the essential components of the structural system. Such frames can carry gravity loads while giving satisfactory stiffness.
2. Structural wall systems: in this kind of structures, all the vertical members are made of structural walls, generally called shear walls.
3. Shear wall–frame systems (double systems): the system comprises of reinforced Concrete frames interacting with reinforced concrete shear walls.

Shear wall is a structural part in a reinforced concrete framed structure to oppose lateral forces, for example, wind forces. Shear walls are commonly utilized in tall structures subject to the lateral breeze and seismic forces. In reinforced concrete framed structures the impact of wind forces increase as the height of the structure increases.

1.1 LITERATURE REVIEW

Author name	Name of Journal	Title name	Research finding
Peter Timler et al. (1998)[1]	The Structural Design of Tall Buildings, 1998 Volume-**7**, PP. 233–249	Experimental and analytical studies of steel plate shear walls as applied to the design of tall buildings	In this study, three variations of a steel framed office building were used as case studies. Competitive reinforced concrete designs were also performed for economic comparisons.
Astaneh-Asl (2001)[2]	SEAONC Seminar, November 2001, San Francisco. PP. 1-18	Seismic Behaviour and Design of Steel Shear Walls	Seismic design of steel shear walls including provisions on how to establish strength of the wall as well as provisions on detailing to ensure sufficient ductility are made.
Burcu Burak (2013)[3]	Journal of Structural Engineering 2013, Volume-139, PP. 1928-1937.	Effect of shear wall area to floor area ratio on the seismic behaviour of reinforced concrete buildings	The results obtained from the nonlinear time history analyses including roof drift, inter story drift, and the base shear responses are evaluated to obtain the effect of shear wall area to floor area ratio on the seismic performance of RC buildings that have no torsional irregularities.

Sumit Pawah (2014)[4]	International Journal of Emerging Technology and Advanced Engineering (IJETAE), 2014, PP. 244- 252	steel plate shear wall - a lateral load resisting system	Provision of part shear walls in zone V is not enough to keep maximum displacements within permissible limits, whether it is a beam slab framed structure or framed structure with flat slabs with drop.
R.Resmi and S.Yamini Roja (2016)[6]	International Journal of Applied Engineering Research, 2016, ISSN NO. 0973-4562 Vol. 11 No.3 , PP. 369-370	A review on performance of shear wall	Shear wall provided along the periphery of the structure is found to be more effective.

1.2 OBJECTIVES OF THE PRESENT STUDY

1. To prepare 3D model of a tall building for detailed analysis.
2. To perform analysis of a tall building without shear wall.
3. To perform analysis of the tall building using RCC shear wall.
4. To perform analysis of the tall building using steel plate shear wall.
5. To compare the results of analysis of the tall building with and without shear walls.
6. To draw suitable conclusion from the above analysis.

1.3 SCOPE OF STUDY

The accuracy and the ability of the proposed structure are tested by static lateral load analysis in shear wall-frame system. In order to check the validity of the proposed models are executed on taken into consideration structural systems, in which shear walls are modelled via wall factors of ETABS [2015]. This analysis of lateral load resisting members in a building will assist us to increase the stability of structure against displacement and to decreases bending moment in vertical members (column).

2. METHODOLOGY

Table 1. Description of member used

	RCC Frame	**Steel Frame**
Design data of building	Dimension	Dimension
Plan dimension	25m*25m	25m*25m
No. of bay x-direction No. of bay Y-direction	5 Bay 5 Bay	5 Bay 5 Bay
No. of storey	G+10	G+10
Typical storey height	3000mm	3000mm
Bottom storey height	3000mm	3000mm
Size of column	800*800(auto selected)	ISHB400-2(auto selected)
Size of beam	200*600(auto selected)	ISHB400-2(auto selected)
Thickness of slab	200mm	200mm
Thickness of shear wall	200mm (concrete Shear wall)	200mm (steel plate shear wall)

Table 2. Material property

Material	**Concrete Frame**	**Steel Frame**
Concrete	M-30	
Steel	HYSD500	HYSD500
Shear Wall	M-30	HYSD500

2.1 STEPS FOR ANALYSIS AND DESIGN OF STRUCTURAL ELEMENTS

1. We choose Indian code for design.
Etabs>file>new model>use built -in setting with>set (display unit, steel design code, concrete code section database)
2. Selection of Grid Plan. No. of Grid Lines in X and Y-Direction are 5. Spacing in X and Y-Direction is 5m. No. Of Storeys in Building are 10. Height of typical Storey and Bottom Storey is 3m.
3. Selection of grid dimensions and defining the material properties of the building section.
Define>Material Properties>Add New Material>Material Properties Data
4. Defining material properties and section properties of the building section.
Define>sectional properties>frame section>frame properties>add new properties >choose concrete>frame section properties data
5. Defining the slab properties of the building section.
Define>sectional properties>slabs properties>slabs properties data

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6. Selection of beam and column section from toolbar, draw the building frame section.
   Quick draw beam>properties of beam section>select beam properties> draw the beam>Quick draw column>properties of column section>select column properties>draw the column>Quick draw slab>properties of slabs>select the slabs properties>draw the slab
7. Drawing the wall of the building.
   Quick Draw wall> properties of wall section>select wall properties> draw the wall
8. Designing the shear wall.
   Wall of the building>assign>shell>pier label>choose>P1>apply>select wall of building>assign>shell>spandrel label>choose S1>select wall of building>assign>shell>wall auto mesh option>shell assignment wall auto mesh option>advanced modify/auto mesh rectangular>select wall of building>assigning the load

3. THREE-DIMENSIONAL MODELING FOR ANALYSIS

The following eight models are taken for analysis purpose:

Model 1: In this model, no shear wall has been provided at the concrete frame building.

Model 2: In this model, the Concrete Shear wall has been provided at the corners of the buildings.

Model 3: In this model, the Concrete shear wall has been provided at the corner of the R.C.C building in the tubular form throughout ten storeys.

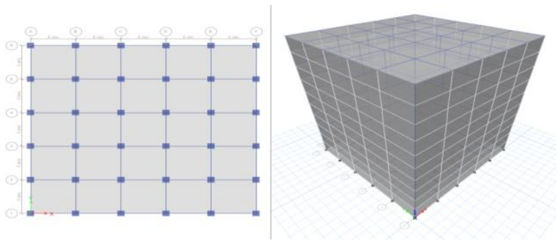
Model 4: In this model, the concrete shear wall has been provided at the middle (tubular form) and at the corners of the R.C.C building throughout ten storeys.

Model 5: In this model, no shear wall has been provided at steel frame building.

Model 6: In this model, the steel plate shear wall has been provided at the corner of the steel building.

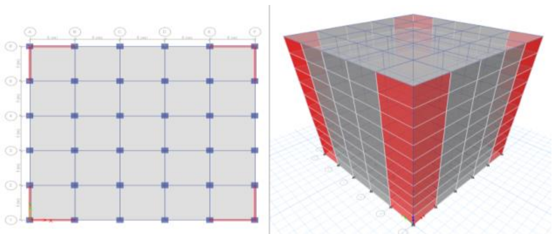
Model 7: In this model, the steel plate shear wall has been provided at the corner of the building in the tubular form.

Model 8: In this model, the steel plate shear wall has been provided at the middle (tubular form) and corner of the building.



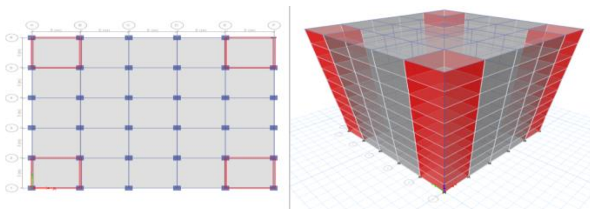
Plan Elevation

MODEL-1



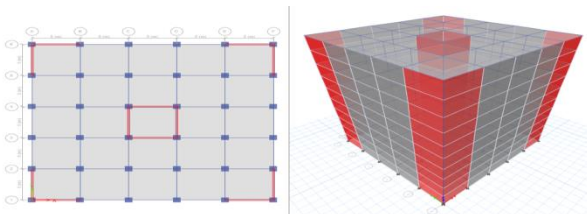
Plan Elevation

MODEL-2



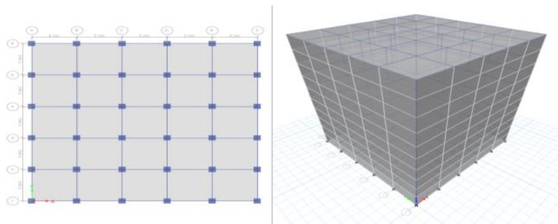
Plan Elevation

MODEL-3



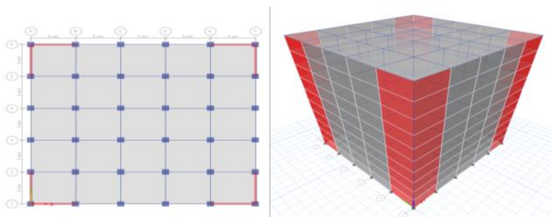
Plan Elevation

MODEL-4



Plan Elevation

MODEL-5



Plan Elevation

MODEL-6

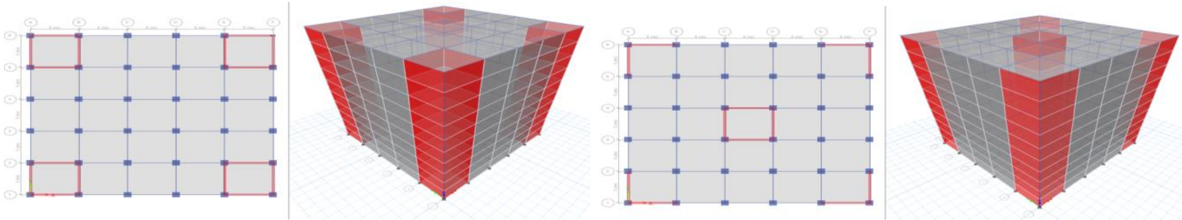


Figure1. Various models taken for analysis purpose

4. ANALYSIS AND RESULTS

Structural analysis is done for all the eight models. Parameters obtained through analysis include maximum storey deflection, maximum storey drift, storey shear, overturning moments generated while applying earthquake load on the structure. Results are shown below in tabular and graphical form.

4.1 MAXIMUM STOREY DISPLACEMENT

The values of maximum storey displacement, as mentioned in IS 1893(part 1): 2002, for various models are given below.

Table 3. Maximum storey displacement (mm)

Storey	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8
Storey10	25.95	25.816	25.239	21.24	13.005	9.959	8.949	7.738
Storey9	24.827	24.713	24.155	20.179	11.68	8.884	7.938	7.227
Storey8	23.058	22.966	22.437	18.682	10.161	7.7	6.838	6.484
Storey7	20.773	20.701	20.213	16.737	8.566	6.476	5.715	5.605
Storey6	18.102	18.05	17.613	14.407	6.954	5.243	4.597	4.667
Storey5	15.162	15.126	14.75	11.786	5.367	4.036	3.516	3.725
Storey4	12.051	12.029	11.721	8.98	3.862	2.897	2.507	2.819
Storey3	8.852	8.841	8.606	6.115	2.496	1.87	1.608	1.974
Storey2	5.632	5.63	5.473	3.373	1.337	1.007	0.858	1.202
Storey1	2.577	2.478	2.399	1.092	0.468	0.356	0.301	0.509
Base	0	0	0	0	0	0	0	0

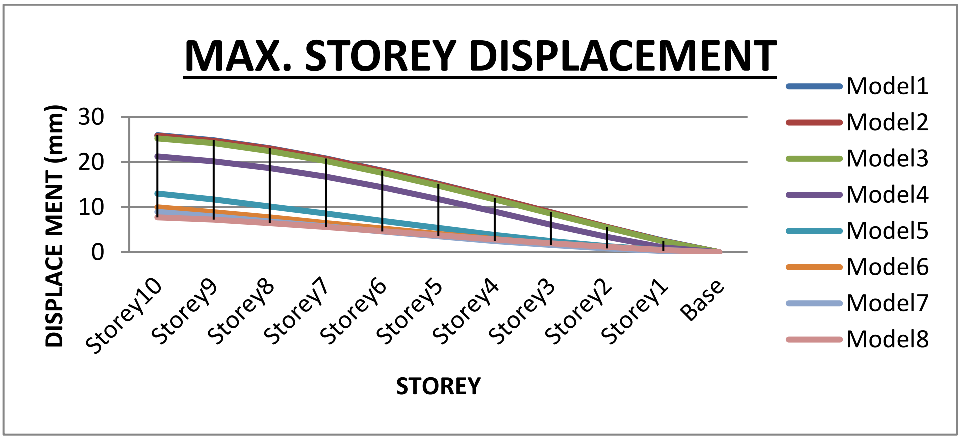


Figure 1. Maximum Storey Displacement at different storeys for various models

Comparing all the models, it has been found that the highest displacement value occurred at the 10th storey in model-1 & lowest value in model-8. The value of displacement increases with height, There is abrupt reduction in the values of displacement, as shown in the table 3 due to the replacement of concrete shear wall with the steel plate shear wall (SPSW).

4.2 MAXIMUM STOREY DRIFT

The values of maximum storey drift obtained for various models after analysis, as per IS 1893(part 1): 2002, are given in table 5 and shown graphically in figure 3.

Table 4. Maximum storey drifts (mm)

Storey	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8
Storey10	0.000356	0.000479	0.000352	0.000374	0.000367	0.000362	0.000391	0.000360
Storey9	0.000499	0.000507	0.000367	0.000395	0.000583	0.000573	0.000595	0.000378
Storey8	0.000649	0.000532	0.000374	0.000408	0.000755	0.000741	0.000762	0.000393
Storey7	0.000777	0.000538	0.000372	0.000411	0.000884	0.000867	0.00089	0.000400
Storey6	0.000874	0.000529	0.00036	0.000412	0.000975	0.000954	0.00098	0.000402
Storey5	0.000935	0.000502	0.000337	0.000415	0.001032	0.00101	0.001037	0.000406
Storey4	0.000956	0.000455	0.0003	0.000342	0.001070	0.001038	0.001066	0.000362
Storey3	0.000915	0.000389	0.00025	0.000289	0.001063	0.001045	0.001073	0.000287
Storey2	0.000762	0.000301	0.000191	0.000223	0.001051	0.001025	0.001054	0.000231
Storey1	0.000364	0.000156	0.0001	0.000119	0.000826	0.0008	0.000859	0.00017
Base	0	0	0	0	0	0	0	0

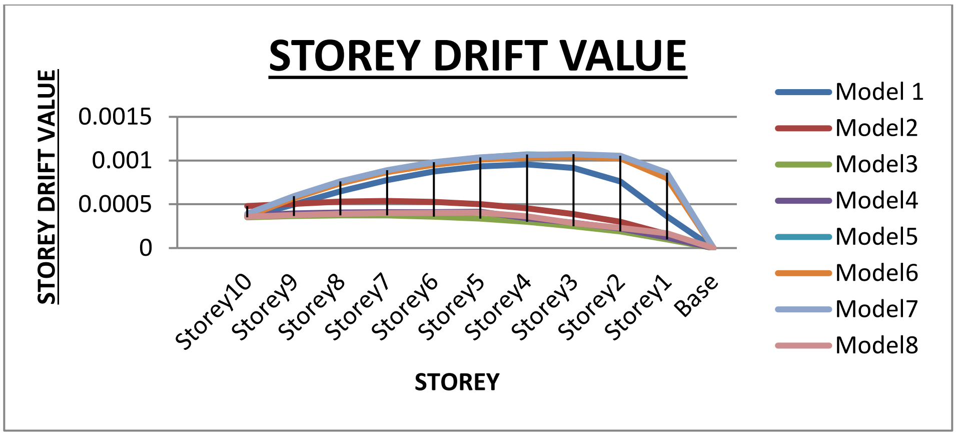


Figure 3. Maximum Storey Drift at different storeys for various models

The highest values of drift occurred at 3rd storey in model-7 and the lowest value at the 1st storey in model-3.

4.3 STOREY SHEARS

The values of maximum storey shear obtained for various models, as per IS 1893(part1): 2002, are given in table 5 and shown graphically figure 4.

Table 5. Storey shear (KN)

Storey	Location	MODEL1	MODEL2	MODEL3	MODEL4	MODEL5	MODEL6	MODEL7	MODEL8
Storey10	Top	679.712	1216.1166	1280.79	1206.65	314.68	348.432	381.77	330.241
	Bottom	679.712	1216.1166	1280.79	1206.65	314.68	348.432	381.77	330.241
Storey9	Top	1330.53	2428.4462	2594.65	2436.34	570.691	655.902	740.816	609.864
	Bottom	1330.53	2428.4462	2594.65	2436.34	570.691	655.902	740.816	609.864
Storey8	Top	1844.76	3386.3363	3632.77	3407.94	772.972	898.841	1024.51	830.8
	Bottom	1844.76	3386.3363	3632.77	3407.94	772.972	898.841	1024.51	830.8
Storey7	Top	2238.46	4119.7209	4427.58	4151.83	927.843	1084.84	1241.71	999.954
	Bottom	2238.46	4119.7209	4427.58	4151.83	927.843	1084.84	1241.71	999.954
Storey6	Top	2527.71	4658.534	5011.52	4698.35	1041.63	1221.49	1401.28	1124.23
	Bottom	2527.71	4658.534	5011.52	4698.35	1041.63	1221.49	1401.28	1124.23
Storey5	Top	2728.58	5032.7099	5417.03	5077.89	1120.64	1316.39	1512.1	1210.53
	Bottom	2728.58	5032.7099	5417.03	5077.89	1120.64	1316.39	1512.1	1210.53
Storey4	Top	2857.14	5272.1824	5676.56	5320.79	1171.21	1377.13	1583.02	1265.77
	Bottom	2857.14	5272.1824	5676.56	5320.79	1171.21	1377.13	1583.02	1265.77
Storey3	Top	2929.45	5406.8857	5822.54	5457.42	1199.66	1411.29	1622.92	1296.84
	Bottom	2929.45	5406.8857	5822.54	5457.42	1199.66	1411.29	1622.92	1296.84
Storey2	Top	2961.59	5466.7538	5887.43	5518.15	1212.3	1426.47	1640.65	1310.65
	Bottom	2961.59	5466.7538	5887.43	5518.15	1212.3	1426.47	1640.65	1310.65
Storey1	Top	2969.63	5481.7208	5903.65	5533.33	1215.46	1430.27	1645.08	1314.1
	Bottom	2969.63	5481.7208	5903.65	5533.33	1215.46	1430.27	1645.08	1314.1
Base	Top	0	0	0	0	0	0	0	0
	Bottom	0	0	0	0	0	0	0	0

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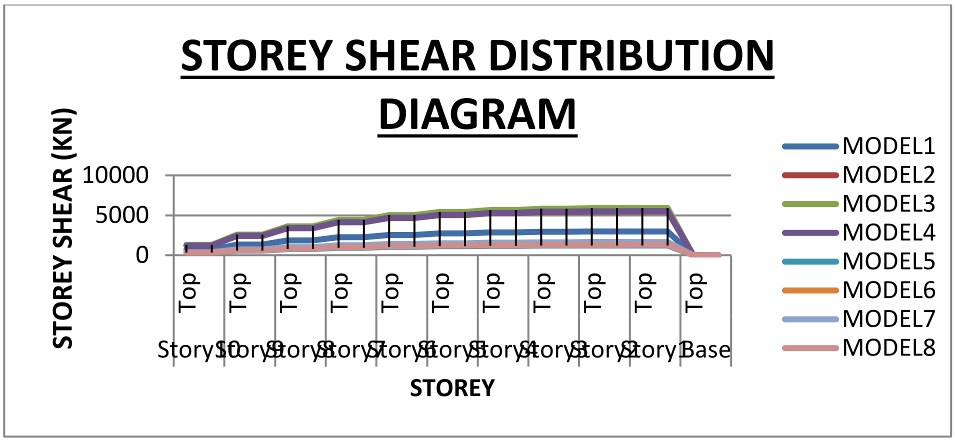

Figure 4. Storey Shear at different storeys for various models

The highest value of storey shear at the 1st storey in model-3 and the lowest value at the 10th storey in model-5.

4.4 OVERTURNING MOMENTS

The values of maximum overturning moments obtained for various models, as per IS 1893(part 1): 2002, are given table 6 and shown graphically figure 5.

Table 6. Overturning moments (KN-m)

Storey	MODEL1	MODEL2	MODEL3	MODEL4	MODEL5	MODEL6	MODEL7	MODEL8
Storey10	0	0	0	0	0	0	0	0
Storey9	2039.14	3648.35	3842.36	3619.9418	944.039	1045.3	1145.31	990.724
Storey8	6030.73	10933.7	11626.3	10928.9472	2656.11	3013	3367.76	2820.31
Storey7	11565	21092.7	22524.6	21152.7682	4975.03	5709.52	6441.28	5312.71
Storey6	18280.4	33451.9	35807.3	33608.245	7758.55	8964.05	10166.4	8312.58
Storey5	25863.5	47427.5	50841.9	47703.3057	10883.4	12628.5	14370.3	11685.3
Storey4	34049.3	62525.6	67093	62936.9662	14245.4	16577.7	18906.6	15316.9
Storey3	42620.7	78342.1	84122.7	78899.3307	17759	20709.1	23655.6	19114.2
Storey2	51409	94562.8	101590	95271.5911	21358	24943	28524.4	23004.7
Storey1	60293.8	110963	119253	111826	24994.9	29222.4	33446.3	26936.6
Base	69202.7	127408	136964	128426	28641.2	33513.2	38381.5	30878.9

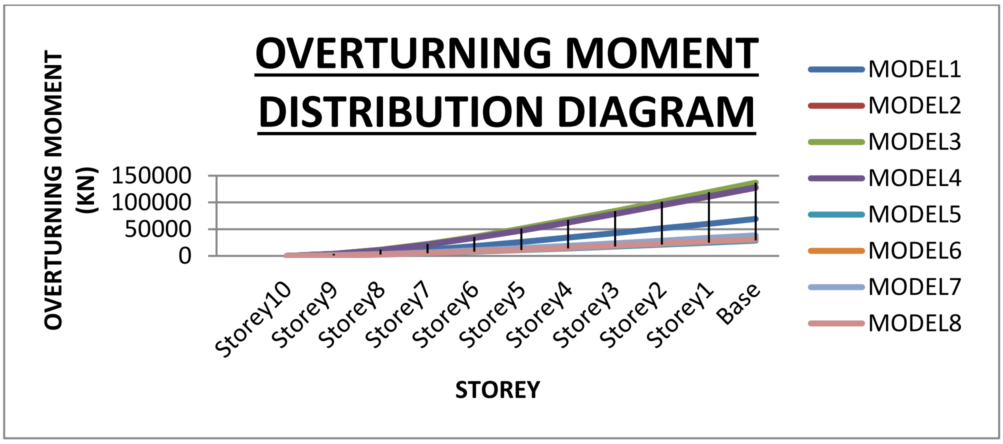

Figure 5. Overturning Moment at different storeys for various models

Comparison of the models, the value of highest overturning moment is at the base in model-3 while the lowest value at the base in model-5. The value of maximum overturning moment decreases with increase in height.

4.5 Storey Stiffness

The values of maximum storey stiffness obtained for various models, as per IS 1893(part 1): 2002, are given table 7 and shown graphically figure 6.

Table 7. Storey Stiffness (KN/m)

Storey	MODEL1	MODEL2	MODEL3	MODEL4	MODEL5	MODEL6	MODEL7	MODEL8
Storey10	322178.9	329596.1	332595.012	647128.9	639558.3	881041.3	1101660	1245556
Storey9	375357.8	393139.1	419925.28	1020658	890550	1603579	2067826	2372875
Storey8	389595.4	421260.3	454527.297	1243490	948562.8	2138608	2797246	3253574
Storey7	396738.9	436274	472419.336	1435918	960919.7	2568590	3383377	3982339
Storey6	401333.7	446609.7	484843.069	1627437	964577.7	2952517	3912037	4655721
Storey5	405097.2	455624.9	495518.152	1839425	972456.2	3360201	4477972	5388334
Storey4	408927.5	465284.8	506519.868	2095096	996908.1	3883161	5206674	6338711
Storey3	413826.9	477508	519658.077	2426784	1067743	4682063	6325502	7798968
Storey2	425504.1	496227.2	538402.522	2899211	1297464	6198207	8385944	10513960
Storey1	555872.2	611972.5	651917.075	4352119	2731866	12227370	16045927	20206529
Base	0	0	0	0	0	0	0	0

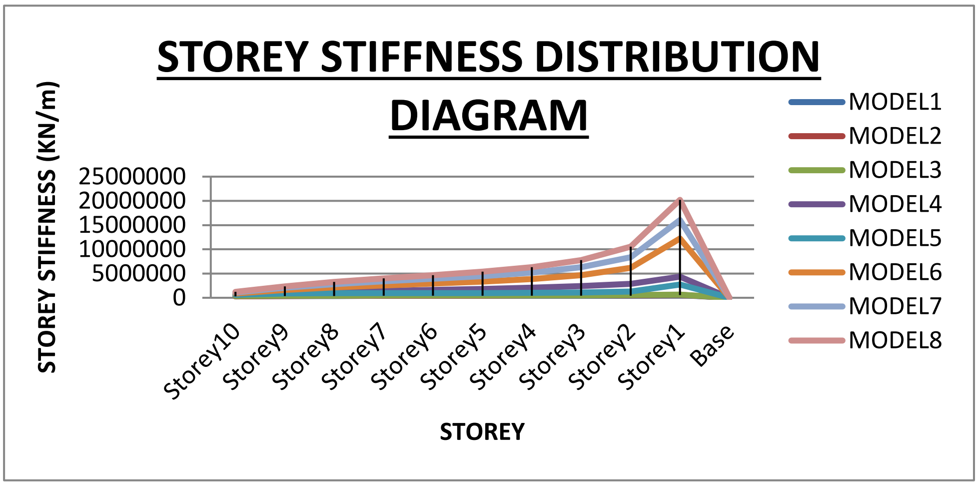

Figure 6. Storey stiffness at different storeys for various models

Comparison of the models, the value of highest storey stiffness is at the first storey in model-8 while the least value at the storey first in model-1. The value of maximum storey stiffness decreases with increase in height.

5. SUMMARY AND CONCLUSION

Total 8-Models of the building were analysed. Model 1 to Model 4 consisted of concrete frame while Model-5 to Model-8 were of steel frame. Model-1 of concrete frame and Model-5 of steel frame were provided with no shear wall. Models 2 to 4 of concrete frame were provided with shear walls on different locations. Shear walls were provided in the models 6 to 8 of steel frame, on the same locations as for models 2 to 4. The various concrete and steel frame models 1 to 8 were analysed and compared for various parameters through linear static analysis method considering seismic effect.

It has been observed that the values of storey displacement in concrete shear wall are more than steel plate shear walls (SPSW) while the values of storey stiffness in steel plate shear wall are more than concrete shear wall. When compared all 8-models for the best location in the building, the steel plate shear wall (SPSW) provided at the middle (tubular form) and corner of the building has been found the best. It has been concluded that steel plate shear wall system is comparatively more suitable than concrete shear wall system in a building.

6. REFERENCES

[1] **Peter Timler, Carlos E.Ventura and Reza Anjam (1998),** "Experimental and analytical studies of steel plate shear walls as applied to the design of tall buildings", The Structural Design of Tall Buildings, 1998, Volume-**7**, PP. 233–249.
[2] **Astaneh-Asl (2001)** "Seismic Behaviour and Design of Steel Shear Walls", SEAONC Seminar, November 2001, San Francisco. PP. 1-18.
[3] **Burcu Burak (2013)**, "Effect of shear wall area to floor area ratio on the seismic behaviour of reinforced concrete buildings" Journal of Structural Engineering, 2013, Volume-139, PP. 1928-1937.
[4] **Sumit Pawah (2014),** "Steel plate shear wall - a lateral load resisting system" International Journal of Emerging Technology and Advanced Engineering IJETAE,2014, PP. 244- 252
[5] **Chandra Shekar and Raj Shekar (2015),** "Analysis and design of multi storied building by using Etabs software" International journal of scientific research, 2015, Volume-4, ISSN No. 2277-8179.
[6] **R.Resmi and S.Yamini Roja (2016),** "A review on performance of shear wall" International Journal of Applied Engineering Research, 2016, Volume-11, ISSN NO. 0973-4562, PP. 369-370.