Comparative Study of Flat Slab Building with and Without Shear Wall to earthquake Performance

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Abstract: **In last two decades there is a high increase in the number of tall buildings, both residential and commercial, and modern trend is towards high rise structures. Flat slab construction is most widely used systems in RCC in offices, residential and industrial buildings in every parts of the world. This system has wide advantages that it reduces cost of form work and construction time, easy installation and requires the least story height. The flat plate/ slab system, in which columns directly support floor slabs without beams. Shear walls are comparatively thin, vertically deep reinforced column used in structure which provide stability to structures from lateral loads like wind, seismic loads etc. In the present work, the combined effect of with and without shear wall of flat slab building on the seismic behavior of high rise building with various positions of shear wall studied. For that, 11 storey model is created in Etabs. To study the effect of different location of shear wall on high rise structure, linear dynamic analysis (Response spectrum analysis) in software ETABs is carried out. Seismic parameters like time period, base shear, storey displacement and storey drift are checked out.**

Keywords: Flat slab, shear wall, response spectrum method, ETABs, base shear, time period

I. INTRODUCTION

In tall buildings lateral loads are premier one which will increase rapidly with increase in height. The design takes care of the requirements of strength, rigidity and stability. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

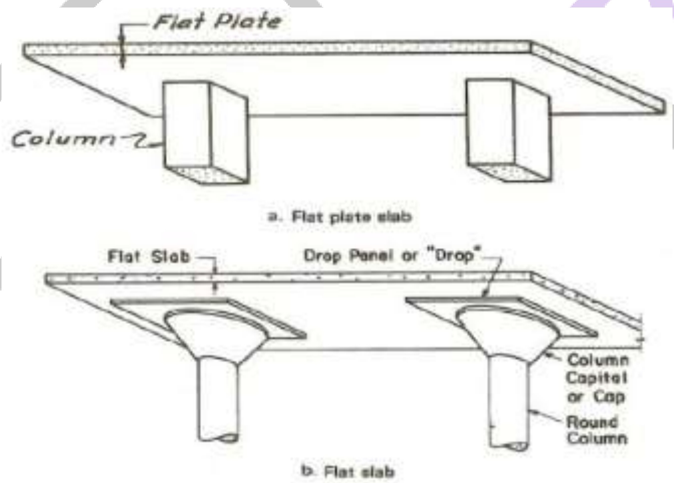

Fig. 1 Building with flat slab and flat plate

I.1 FLAT PLATE STRUCTURE

Flat Plates are solid concrete slabs of uniform depths that transfer loads directly to the supporting columns without the aid of beams or capitals or drop panels. Flat plates are probably the most commonly used slab system today for multi-storey reinforced concrete hotels, motels, apartment houses, hospitals, and dormitories. The main disadvantage in Flat slabs and Flat plates is their lack of resistance to lateral loads, hence special features like shear walls, structural Walls are to be provided if they are to be used in high rise constructions. Flat plate is the term used for a slab system without any column flares or drop panels. Although column patterns are usually on a rectangular grid, flat plates can be used with irregularly spaced column layouts. In flat plate structure the loads directly taking by supporting columns. It requires the simple formwork and flat plates will usually result in such economical construction. Concrete slabs are often used to carry vertical loads directly to walls and columns without the use of beams and girders such a system called a flate plate.

II. ANALYTICAL WORK

Response spectrum method is used for the analysis of structure. An 11 storey building with RC shear wall and without shear wall is taken for this study. The different location of shear wall is used to study the effect of changing location. The presence of Shear Wall is a structural system providing stability against wind, earthquake and blast and deriving its stiffness from inherent structural forms. The behavior of building is studied for different parameters like story drift, story shear, time period; etc.

II.1 TYPES OF CASES USED FOR ANALYSIS OF STRUCTURE

There are different cases considered to analyze 15-storey structure so that proper provision of shear wall can be predicted.

1. Performance of flat slab building with C type shear wall.
2. Performance of flat slab building without shear wall.
3. Building with L type shear wall and flat slab.
4. Building with shear wall along periphery with flat slab.
5. Building with non parallel shear wall along periphery wit flat slab.

Following figures shows the model of different cases done in ETABS software.

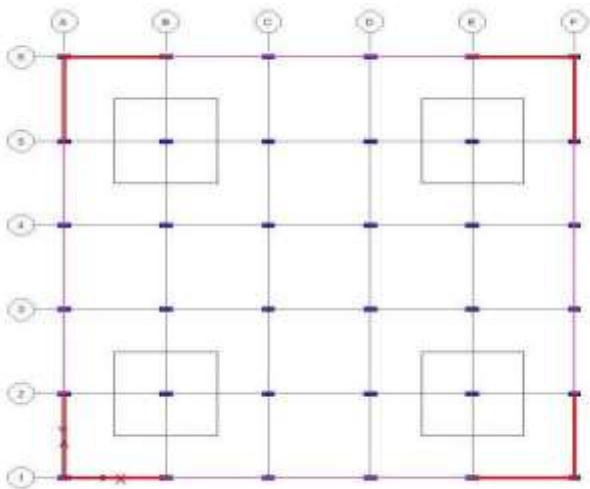

Fig. 2 Building with C type shear wall with flat slab

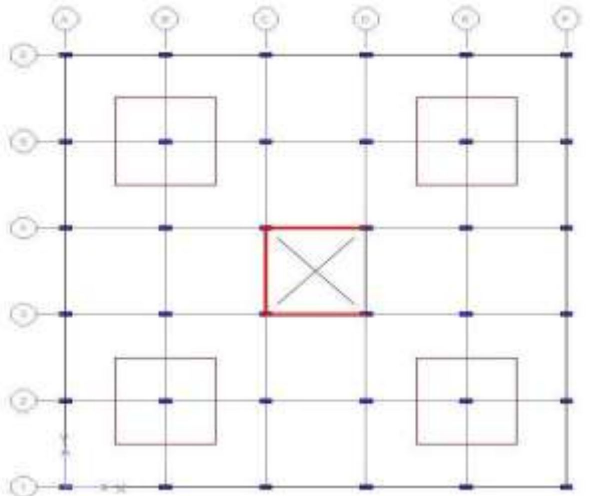

Fig. 3 Building with L type shear wall with Flat Slab

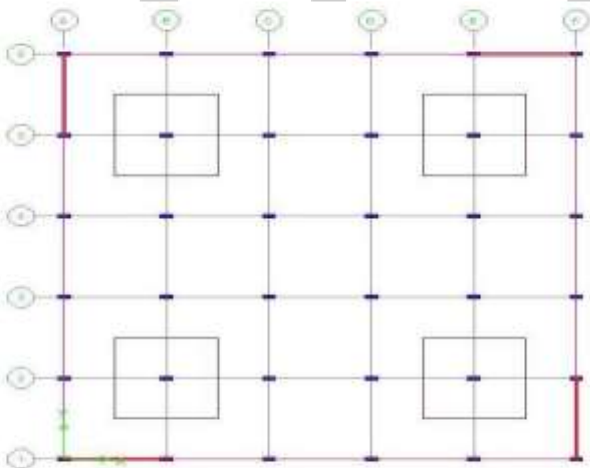

Fig. 4 Building with non parallel wall with flat slab

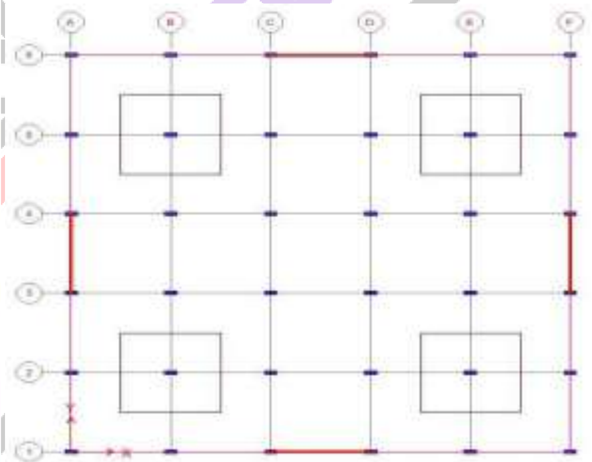

Fig. 5 Building with shear wall at periphery with flat slab

II.2 Structural Data

Table 1 Details of structural data

Type of structure	RCC 11 Story
Zone	III
Floor to floor height	3M
Wall thickness	230MM
Thickness of slab	200 MM
Live load	3 KN/m^2
Floor finish	1 KN/m^2
Column size	500x500 mm

III. RESULTS AND DISCUSSION

III.1 Story Displacements for Flat Plate Building with and without Shear Wall

Table 2 Story displacements for flat plate building with and without shear wall

Storey level (mm)	Storey displacements without shear wall (m)	Storey displacements with shear wall(m)
0	0	0
3000	0.0107	0.0018
6000	0.0235	0.005
9000	0.0367	0.0093
12000	0.05	0.0145
15000	0.0633	0.0203
18000	0.0764	0.0265
21000	0.0892	0.0331
24000	0.1016	0.0398
27000	0.1133	0.0464
30000	0.1242	0.053
33000	0.1341	0.0593

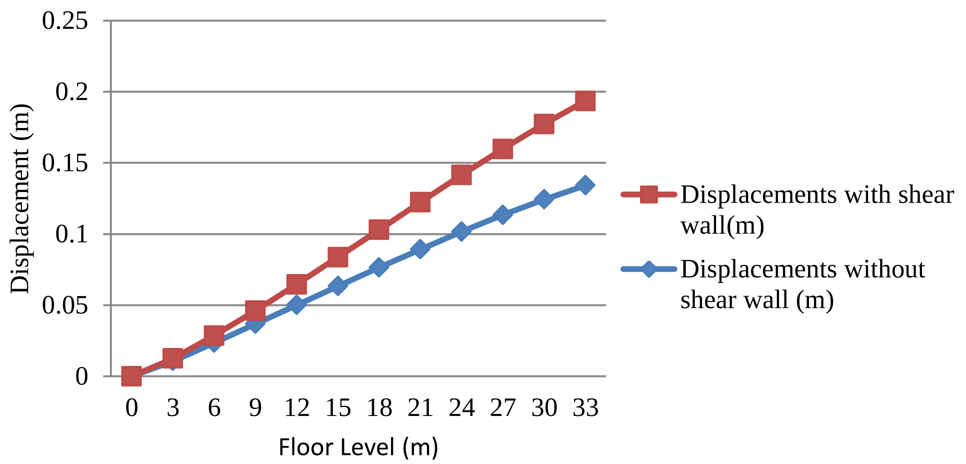

Fig 6 Story displacement (m) graph for building with and without shear wall

III.2 Story Shear for Flat Plate Building with and without Shear Wall

Table 3 story shear with and without shear wall

Storey level (mm)	story shear without shear wall (KN)	story shear with shear wall (KN)
0	3973.52	4096.20
3000	3970.29	4092.87
6000	3962.75	4085.10
9000	3957.38	4079.52
12000	3928.33	4049.49
15000	3876.67	3996.11
18000	3795.97	3912.69
21000	3679.75	3792.57
24000	3521.57	3629.08
27000	3314.96	3415.54
30000	3053.47	3145.28
33000	2730.65	2811.62

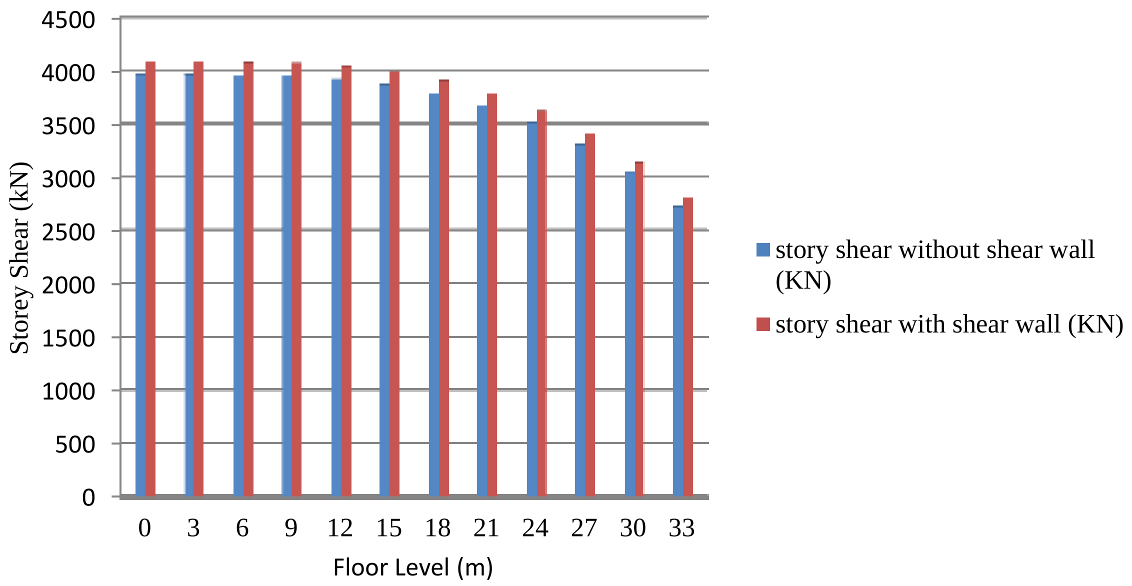

Fig. 7 Storey shear with and without shear wall

III.3 Time Period for Flat Plate Building with and without Shear Wall

Table 4 Time period with and without shear wall

Parameter	Structure without shear wall	Structure with shear wall
Time	2.7486 sec	2.6175 sec

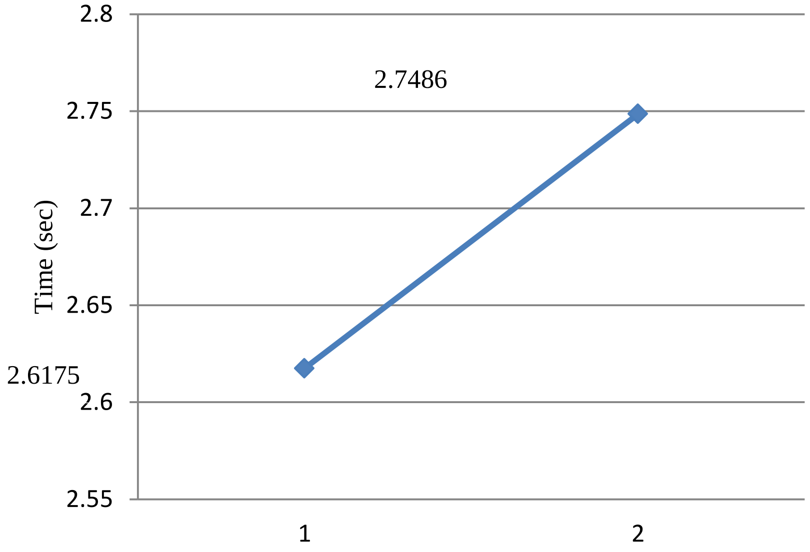

Fig. 8 Time period (sec) with and without shear wall

III.4 Story Drift for Flat Plate Building with and without Shear Wall

Storey level (mm)	Drift without shear wall	Drift with shear wall
0	0.0001324	0.0001229
3000	0.003581	0.001372
6000	0.004236	0.001806
9000	0.004402	0.002235
12000	0.00444	0.002517
15000	0.004427	0.002696
18000	0.004372	0.002798
21000	0.004273	0.002835
24000	0.004122	0.002818
27000	0.003914	0.00275
30000	0.003642	0.002636
33000	0.003299	0.002481

Table 5 Story drift with and without shear wall

4 EFFECT OF FLAT PLATE BUILDING FOR DIFFERENT POSITION OF SHEAR WALL

4.1 Story Displacement:

Table 6 Variation of Storey displacement in both X and Y directions

Storey level (mm)	Structure with L type shear wall (m)		Structure with shear wall along periphery (m)		Structure with non parallel shear wall along periphery (m)	
	EQ	WL	EQ	WL	EQ	WL
33000	0.0808	0.0128	0.057	0.009	0.0629	0.0097
30000	0.0708	0.0113	0.0498	0.0079	0.0549	0.0085
27000	0.0608	0.0099	0.0427	0.0069	0.047	0.0074
24000	0.0509	0.0084	0.0357	0.0059	0.0392	0.0063
21000	0.0414	0.0069	0.029	0.0048	0.0318	0.0052
18000	0.0323	0.0055	0.0227	0.0039	0.0248	0.0041
15000	0.024	0.0042	0.0168	0.0029	0.0183	0.0031
12000	0.0165	0.0029	0.0116	0.0021	0.0126	0.0022
9000	0.0101	0.0018	0.0071	0.0013	0.0077	0.0014
6000	0.005	0.0009	0.0036	0.0007	0.0039	0.0007
3000	0.0015	0.0003	0.0012	0.0002	0.0013	0.0002
000	0.00	0.00	0.00	0.00	0.00	0.00

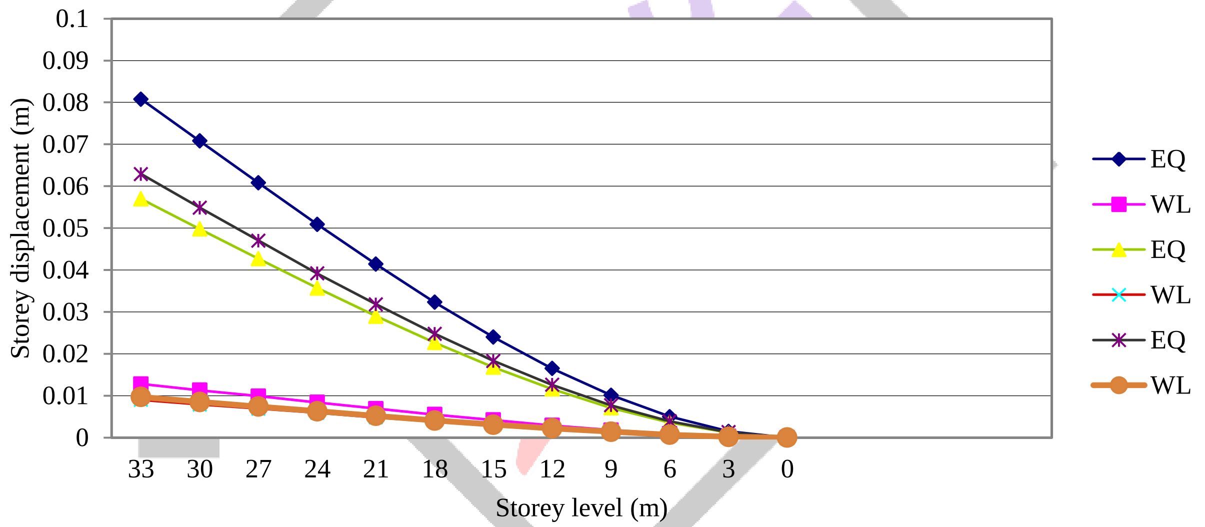

Fig. 9 Variation of story displacement (M) graph in both X and Y direction for Earthquake and Wind load

4.2 Time Period

Table 7 Variation of time period in both X and Y directions

Structure with L type shear wall	Structure with shear wall along periphery	Structure with non parallel shear wall along periphery
2.1192 sec	1.7806 sec	1.8619 sec

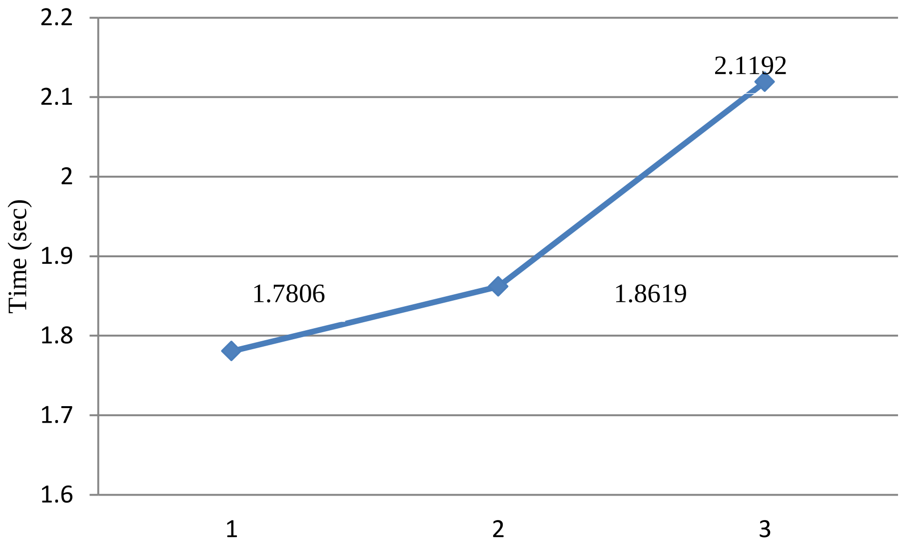

Fig. 10 Variation of Time period (Sec) for earthquake in both X and Y direction

4.3 Storey Drifts

Table 1.8 Variation of Storey drift in both X and Y directions

Storey level (mm)	Structure with L type shear wall		Structure with shear wall along periphery		Structure with non parallel shear wall along periphery	
	EQ	WL	EQ	WL	EQ	WL
33000	0.003349	0.00048	0.002387	0.000343	0.002668	0.000374
30000	0.003337	0.000487	0.002369	0.000346	0.00264	0.000378
27000	0.003281	0.00049	0.00232	0.000346	0.002578	0.000379
24000	0.003177	0.000485	0.002237	0.000341	0.002479	0.000377
21000	0.003015	0.000472	0.002116	0.00033	0.002337	0.00037
18000	0.002792	0.000449	0.001952	0.000313	0.00215	0.000356
15000	0.002501	0.000414	0.001743	0.000287	0.001913	0.000306
12000	0.002135	0.000364	0.001485	0.000252	0.001623	0.000267
9000	0.001689	0.000298	0.001176	0.000206	0.00128	0.000218
6000	0.001152	0.000211	0.000806	0.000148	0.000872	0.000155
3000	0.000512	0.000101	0.000393	0.000079	0.000419	0.000081
000	0.0000635	0.0000091	0.0000194	0.0000194	0.0000145	0.0000021

V. CONCLUSION

Analysis of 11 stories RCC multistoried flat plate building is carried out by using response spectrum method. The following conclusions are drawn from the study.
The seismic responses namely base shear in X and Y directions for structure with shear wall are found to be 3.08% more than structure without shear wall, story displacement without shear wall along EQX is 48.52% more and along EQY is 53.36% more than displacement with shear wall.

1. For Structure with shear wall along periphery have story displacement is minimum. It is 29.13 % and 10.06 % less for Structure with shear wall along periphery than Structure with L type shear wall and Structure with non parallel shear wall along periphery respectively.
2. The values of storey drift for all the stories are found to be within the permissible limit i.e. not more than 0.004 times to storey height according to IS 1893 : 2002 (Part I)

3. Building with shear wall is preferred because of considerable difference in storey displacement, time period, base shear and storey drift.
4. Structure with shear wall along periphery is suitable for the effect of wind load and earthquake load on the performance of building.

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