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Seismic Analysis of Multistorey RC frame structure with shear wall effect and finding its optimal location

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Abstract- *An earthquake is the shaking of the earth surface they are caused by sudden movement of the earth's tectonic plates or seismic waves. Earthquake causes hazardous losses of life as well as structures. To overcome this problem many researchers are focusing on designing the earthquake resistant structure. Shear walls are one of the most commonly lateral load resisting mechanism used in high rise buildings. It has high strength which can be used to simultaneously resist large horizontal loads and support gravity loads. Thus it is very necessary to find out the optimum location of shear wall. Shear wall arrangement must be absolutely accurate, because if not, it will cause deflection as well as many negative forces acting on a building. In this paper seismic analysis of G+6 storey building is carried out in E-Tabs. Study carried for finding the effect of shear wall and choosing it's optimum location in a multistory building frame by changing locations. The responses of building frame are determined with optimum location of shear wall using both Equivalent Static Method and Response spectrum Analysis.*

Keywords-- *Shear Wall, Optimization, Seismic Forces, Concrete Structures*.

I. Introduction

Earthquake is Natural Disaster of Unpredictable Nature. An earthquake is the shaking of the earth surface they are caused by sudden movement of the earth's tectonic plates or seismic waves.

Sudden release of the energy in the earth that creates seismic waves. The main cause of earthquake is that when tectonic plate collide the one side over the other and in the seismic waves, earthquake is usually caused when rock underground suddenly break along the fault. The sudden release of energy caused the seismic waves that make the ground shake and this results in the formation of the earthquake. The effect of the earthquake are surface faulting, tsunamis, soil liquefaction, land slide etc. Vibrations which are caused under the earth's surface generate waves which disturb the earth's surface, termed as earthquakes. It was said that earthquakes will not kill human but structures which are not constructed in considering the earthquake forces do. 60% of India lying in earthquake prone zone at which there is a need of increase of understanding the behaviour of earthquake, constructing and developing earthquake resistant structures.

There are different methods or techniques if earthquake resisting building like levitating foundation , shock absorbance, base isolation , pendulum power , damping devices , bracing system and shear wall.

In structural engineering, a shear wall is a vertical element of seismic force resisting system that is designed to resisting in plane lateral forces typically wind and seismic load shear wall is one of the lateral resisting structure which is used commonly. Shear wall gives the high stiffness structures as the structure will be stable. Applying the shear wall can effectively reduce displacement and storey drift of the structure. Shear walls are used to resist the lateral forces produced during earthquake. Shear walls behaviour depends upon the material used, wall thickness, wall length, wall positioning in building frame also.

Analysis of G+6 Storey building with and without shear wallis carried out and shear wall is modeled at different part of the building to check the optimal location of shear wall to get the minimum reduced base shear and the results are compared. For Analysis ETABS (Software tool) is used.

- The main objective is to check and compare the seismic response of multi-storied building for different location of shear wall, so that one can choose the best alternative for construction in earthquake-prone area.
- Different location of shear wall in R.C.Building is modelled in E-TABS software and the results in terms of storey displacement, storey drift, storey shear are compared.

II. Storey Parameters

- **Base (or) Storey shear**

It is the maximum expected lateral force that will occur due to seismic ground motion at the base of structure.

- **Storey drift**

Storey drift is the displacement of one level relative to the other level above or below it:

$$\text{Storey drift ratio} = \frac{\text{Differance Between Displacement of Two storey}}{\text{Height of One Storey}}$$

- **Storey Displacement**

It is the total displacement of the storey with respect to ground.

$$\text{Allowable displacement} = \frac{\text{Total Height of Building}}{500}$$

For the study G+6 (7 STORY) of residential building is taken which having base dimension of plan 10*10 m^2 with typical floor height of 3 m.The aim of design of building is to resist the building from earthquake as well as the lateral forces.This plan of building is modeled in ETABS software where the shear wall is placed at different locations. There are two model which has been analyzed one is with shear wall and another one is without shear wall. The thickness of shear wall is 150 mm. The plinth height is 3 m above from foundation base.

Preliminary data:-

1.	Density of concrete	25 kN/m^3
2.	Live load	3 kN/m^3
3.	No. Of storey	G+6
4.	Slab thickness	100 mm
5.	Storey Height	3 m
6.	Total height of building	21 m
7.	Wall thickness	230 mm
8.	Beam -1 in X-direction	230x500 mm
9.	Beam -2 in Y-direction	230x400 mm
10.	Column 1in T –junction	300x500 mm
11.	Column 2 in L-junction	300x400 mm
12.	Column 3 in centre	450x450 mm

Seismic data:-

1. Seismic zone V :- 0.36
2. Important factor :- 1.50
3. Response reduction :-2.25

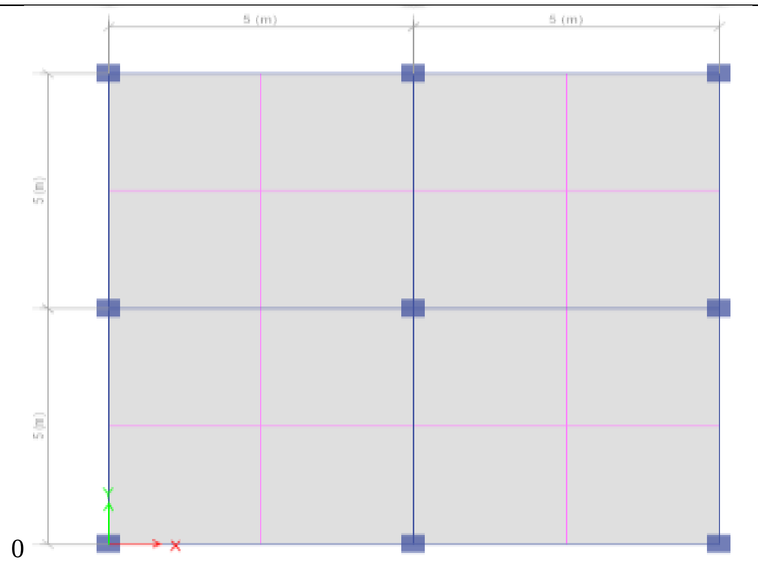


Fig.1: Plan

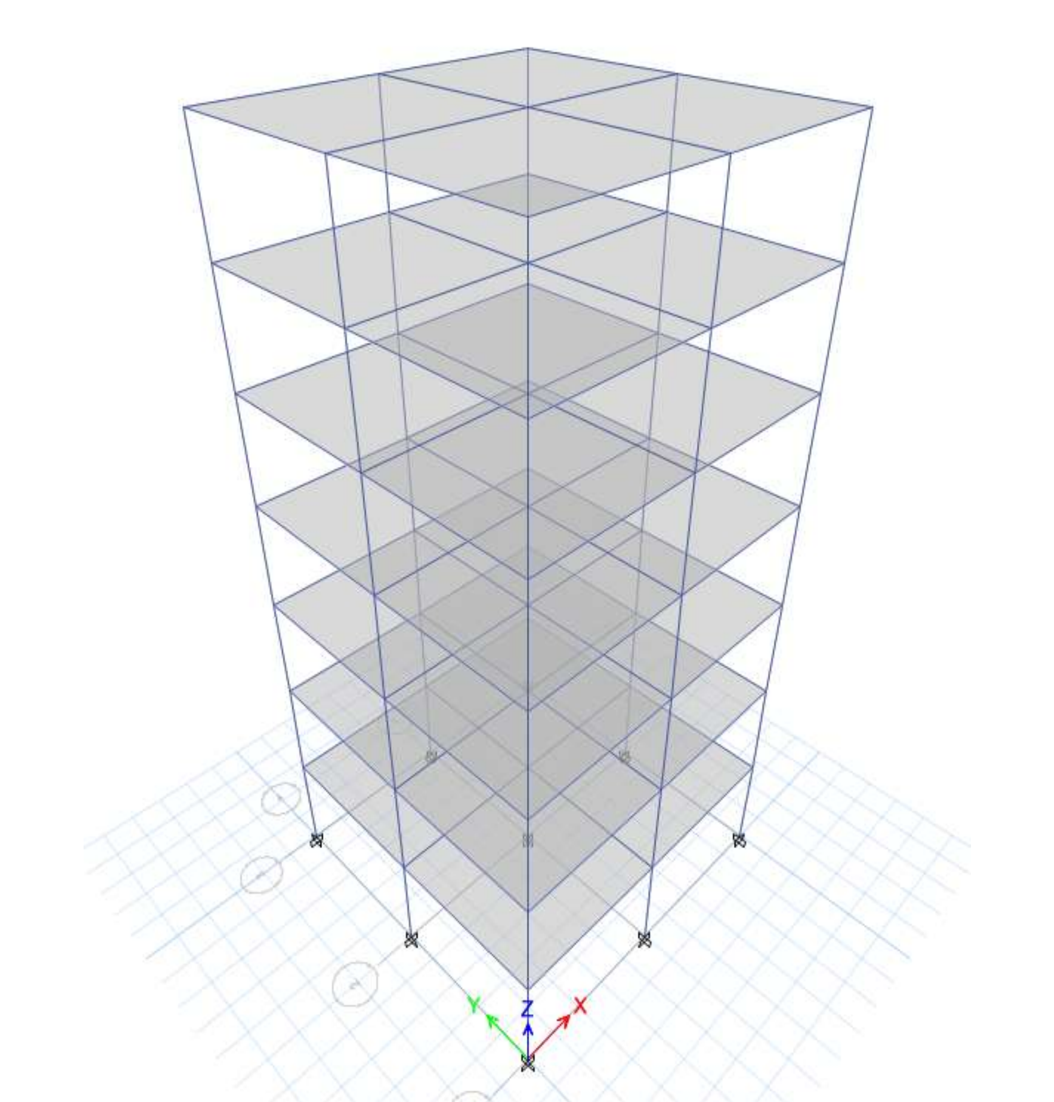


Fig.2: Elevation of Building Model in ETAB Software

Table 1

LOAD CALCULATION (kN/m)			
Load type	**Dead Load**	**Live Load**	**Total**
Theorotical	3510.059	2100	5610.059
E-Tabs	3546.0649	2100	5646.0649

Design Seismic Base Shear (V_b)

Total load (W) = Dead load + 25% live load

Total load (W) = (1750 + 1086.75 + 677.512) + (0.25 x 2100)

Total load (W) = 4039.26 kN/m

$A_h = \frac{Z}{2}\frac{I}{R}\frac{S_a}{g}$	(1)

Calculation of acceleration constant(S_a/g)

TIME PERIOD (Ta) = 0.075

= 0.075 x 210.75

Thus, T_a = 0.7357S

Zone factor for Zone V =0.36
Importance factor =1.5
Average Acceleration Coefficient = $\frac{S_a}{g}$ = 1.84 (Medium Soil)
Design lateral force

Eqn (1) Becomes, $A_h = \frac{0.36}{2} x \frac{1.5}{5} x1.84$

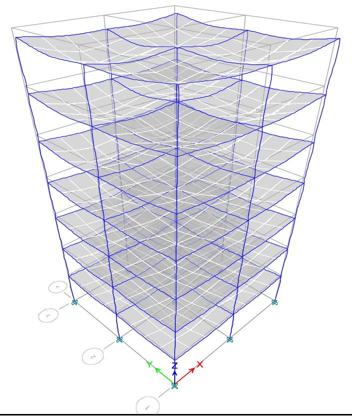
Therefore, A_h=0.093
Base shear (Vb) = Ah xW
= 0.0993 x4093.23
Base Shear(Vb) = 401.09 kN
Design Seismic Base Shear V_b & Software Validation

Table 2

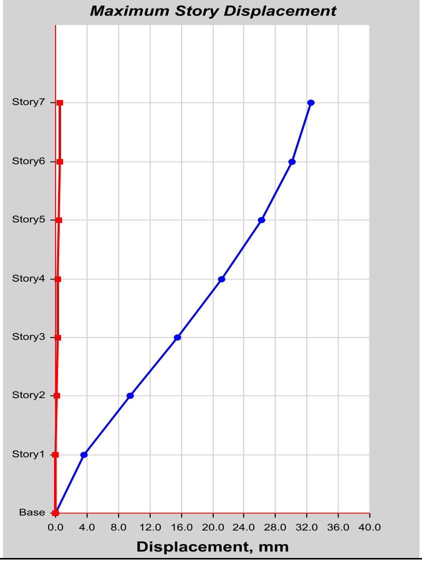
Theorotical	**401.8622 kN**
E-Tabs	401.8622 kN

III. Result & Disscussion:

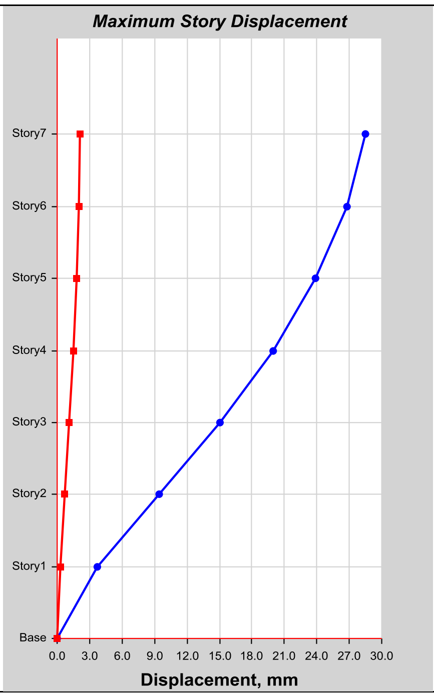
After analyzing building without shear wall we compared it with different parameters providing shear wall for its optimum location the results for different parameters are as follows , by comparing the results with each other there is specific location for shear wall to resist the lateral forces acting on a structure**.**



Model 1 (Structure without shear wall)

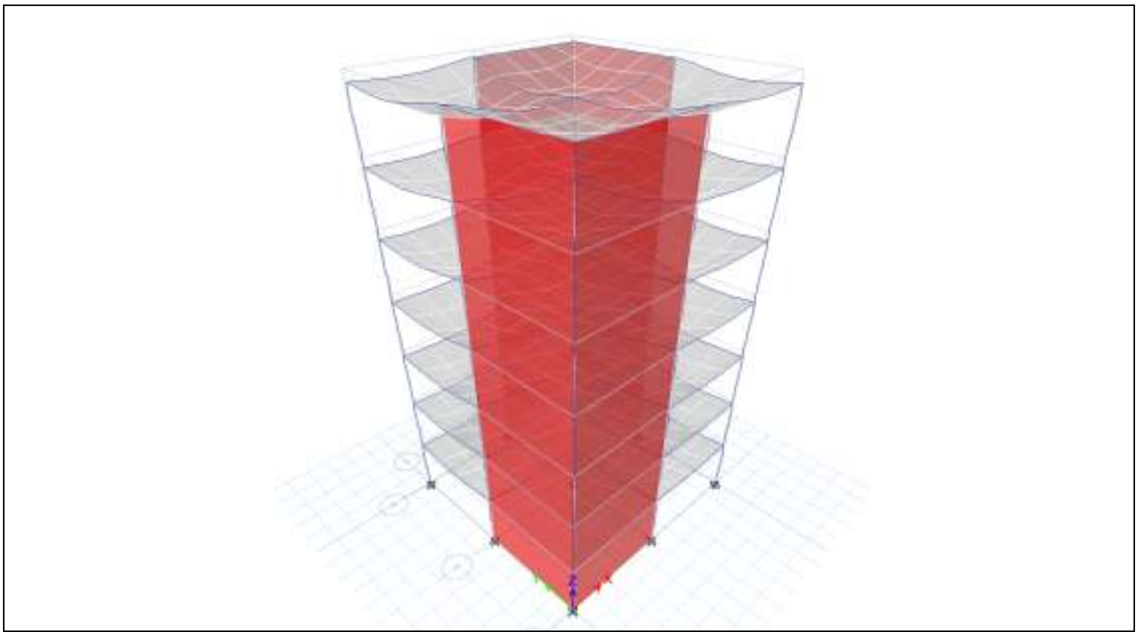


1.1 Storey displacement plot of earthquake in x direction Without shear wall by ESM

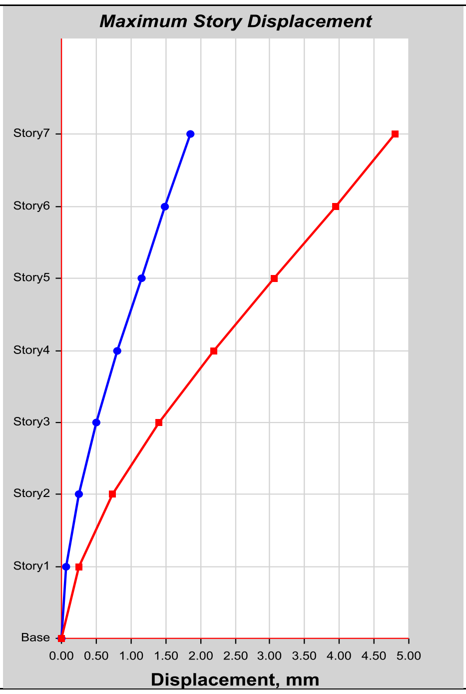


1.2 Storey displacement plot of Response Spectrum Analysis in X direction Without shear wall

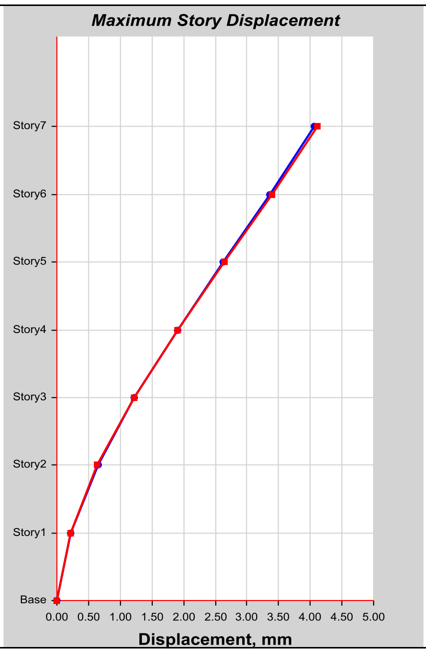
- **Providing RC shear wall at extreme corners of the building of 150 mm thickness & analysed it by ESM and RSM**



Model 2

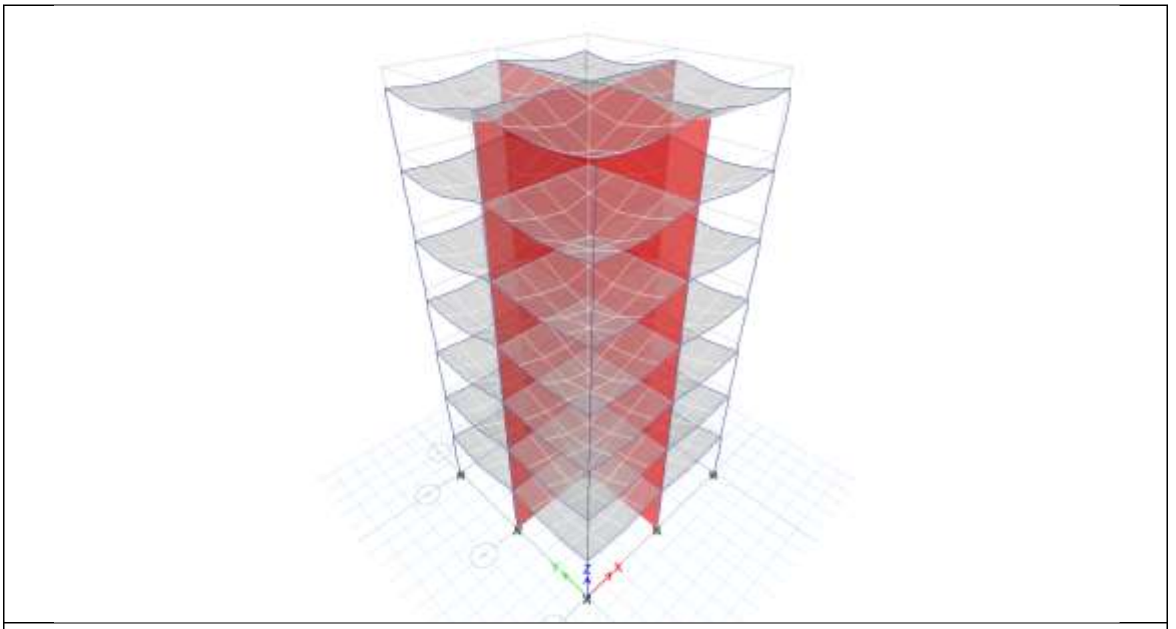


2.1 Storey displacement plot of earthquake in x direction

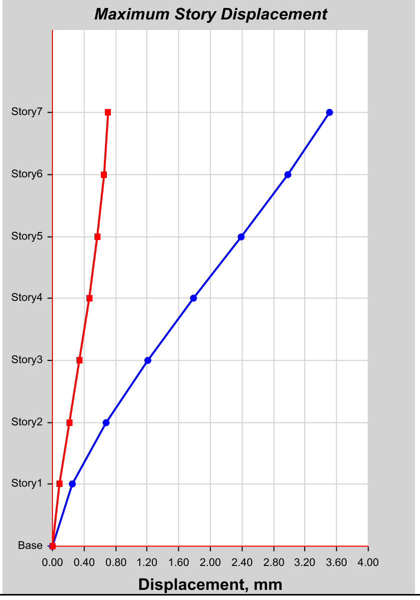


2.2 Storey displacement plot of Response Spectrum Analysis in Y direction

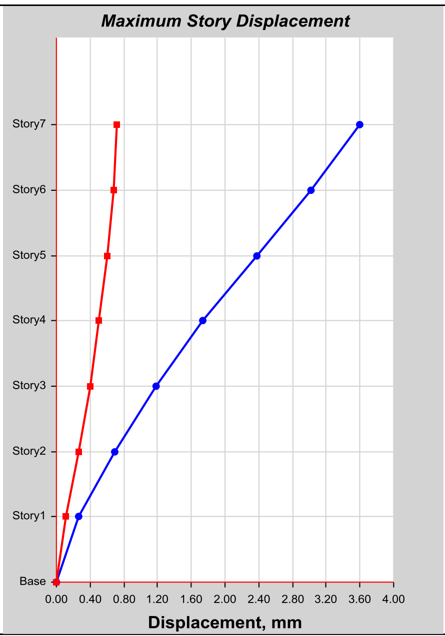
- **Providing RC shear wall at center of the building of 150mm thickness & analysed it by ESM and RSM**



Model No 3



3.1 Storey displacement plot of earthquake in X direction by ESM



3.2Storey displacement plot of Response Spectrum Analysis in X direction

Table 3

Storey	Maximum Displacement (mm) by ESM					
	Without Shear wall		With Shear wall			
	Model 1		Model 2		Model 3	
	EQX	EQY	EQX	EQY	EQX	EQY
7	32.515	33.442	4.492	6.488	3.515	3.905
6	30.066	31.06	3.706	5.333	2.986	3.242
5	26.185	27.148	2.883	4.136	2.396	2.543
4	21.192	22.104	2.078	2.97	1.79	1.852
3	15.49	16.344	1.332	1.895	1.206	1.208
2	9.458	10.224	0.699	0.988	0.68	0.655
1	3.631	4.161	0.235	0.33	0.252	0.247
Base	0	0	0	0	0	0

Table 5

Storey	Maximum Displacement (mm) by RSM					
	Without Shear wall		With Shear wall			
	Model 1		Model 2		Model 3	
	RSA-X	RSA-Y	RSA-X	RSA-Y	RSA-X	RSA-Y
7	28.544	28.646	4.061	3.874	3.59	2.944
6	26.816	27.028	3.36	3.192	3.017	2.457
5	23.923	24.221	2.622	2.484	2.379	1.937
4	19.926	20.334	1.901	1.792	1.731	1.427
3	15.006	15.535	1.226	1.149	1.181	0.953
2	9.416	10.02	0.647	0.601	0.688	0.532
1	3.693	4.175	0.219	0.2	0.264	0.201
Base	0	0	0	0	0	0

IV. Discussion:

- As above **table 3**, it is seen that displacement is less in structure with shear wall than in without shear wall.
- As we change the position of shear wall in two ways. It is seen that Model 3(shear wall at centre)can resist the seismic forces and lateral forces better than the model 2(shear wall at extreme).
- So for better resisting property providing shear wall at centre.

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