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Analysis And Design of Earthquake Resisting Building with Shear Walls by Using ETAB Software

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Abstract
The present study shows the seismic behavior of buildings under the action of earthquake load by performing Non-linear Static analysis. Nowadays buildings with shear walls are more popular than buildings without shear walls in earthquake-prone areas due to their resistance during earthquakes. So, the purpose of this study is to find the prime location of the shear wall and then investigate the effectiveness of the best shear wall for the RCC structure. In this study, G+13 & G+5 RCC building is considered for the analysis under zone I to zone IV with suitable load combination. The structure is analyzed for earthquakes in the type of structural system using ETABS software. The shear wall starts from the foundation level and should be continuous throughout the building.

Keywords:RCC building, ETABS, Non-Liner Static Analysis, Shear wall, Seismic analysis

1. Introduction

. A shear wall is a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. When shear walls are designed and constructed properly, they will have the strength and stiffness to resist horizontal forces. Shear walls are especially important in high-rise buildings subject to lateral wind and seismic forces. In the present study, various kinds of research were discussed on the performance of shear walls based on their location, orientation and materials used for construction. Shear walls are vertical elements of the horizontal force-resisting system; they can resist forces directed along the length of the wall. Once shear walls are designed and constructed properly, they will have the strength and stiffness to resist horizontal forces. It is well known to civil and structural engineering systems that the key purpose of all kinds of structural systems used in building structures or any infrastructure is to support gravity loads, the most common loads resulting from the effect of gravity are dead load, imposed live load and climatic snow load. Besides these loads, buildings and any other high-rise structures are also subjected to lateral loads caused by wind; blasting or earthquake and hydrostatic load. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, the structure needs to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. Shear resists mainly two types of forces such as shear and uplift forces. In structural engineering, a shear wall is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on a structure. Wind and seismic loads are the most common loads that shear walls are designed to carry. Vibrations, which are caused under the earth's surface, generate waves, which disturb the earth's surface, termed earthquakes. It was said that earthquakes would not kill humans but structures, which are not constructed without considering the earthquake forces do. Shear walls are built to resist the lateral forces produced during earthquakes or wind. Shear wall behaviour depends upon the material used, wall thickness, wall length, and wall positioning in the building frame. Recently, significant figures of high-rise buildings have reinforced concrete structural systems. It is a fact that shear walls have high lateral resistance. In a shear wall-frame system, this advantage can be used by placing shear walls at convenient locations in the plan of the building. Shear walls are vertical elements of the structure to resist horizontal force. Shear walls are constructed to counter the effects of lateral load acting on a structure. Shear walls are straight external walls that typically form a box in residential construction which provides all the lateral support. When shear walls are designed and constructed properly, they will have the strength and stiffness to resist horizontal forces. The uneven settlement loads, due to the weight of structure and occupants; create powerful twisting (torsion) forces because of lateral forces of wind and earthquake. These forces can exactly tear (shear) a building apart. Placing of reinforcement frame in a rigid wall maintains the shape of the frame and prevents rotation at the joints. Shear walls are important in tall buildings subjected to lateral wind and seismic forces in the previous two decades, shear walls became an important part of mid and high-rise residential buildings. Being a part of earthquake-resistant building design, Shear wall buildings are commonly used for residential purposes and can house from 100 to 500 inhabitants per building. Hear walls are placed in building plans reducing lateral displacements under earthquake loads.

What is a Shear Wall?

A shear wall is a structural member in a reinforced concrete framed structure to resist lateral forces such as wind forces. Shear walls are generally used in high-rise buildings subject to lateral wind and seismic forces. In reinforced concrete framed structures, the effects of wind forces increase in significance as the structure increases in height. Codes of practice impose limits on horizontal movement or sway.

Limits must be imposed on a lateral deflection to prevent:

- Limitations on the use of a building,
- Adverse effects on the behaviour of non-load-bearing elements,
- Degradation in the appearance of the building,
- Discomfort for the occupants.

2. Objectives

1) To model and analyzed G+13 and G+5 having different locations of shear wall in the structure using ETABS software.
2) Comparative study of seismic behaviour of building with shear wall and without shear wall by performing nonlinear time history analysis.
3) To find lateral displacement in the x and y direction
4) To study the displacement of the building

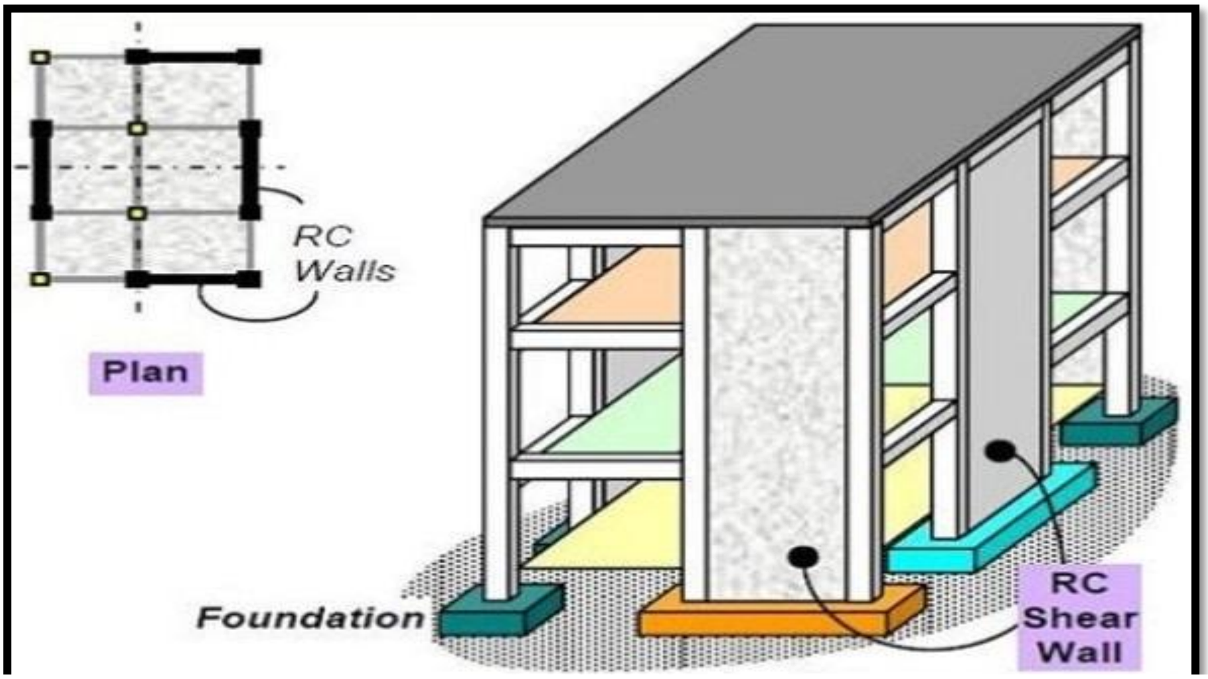
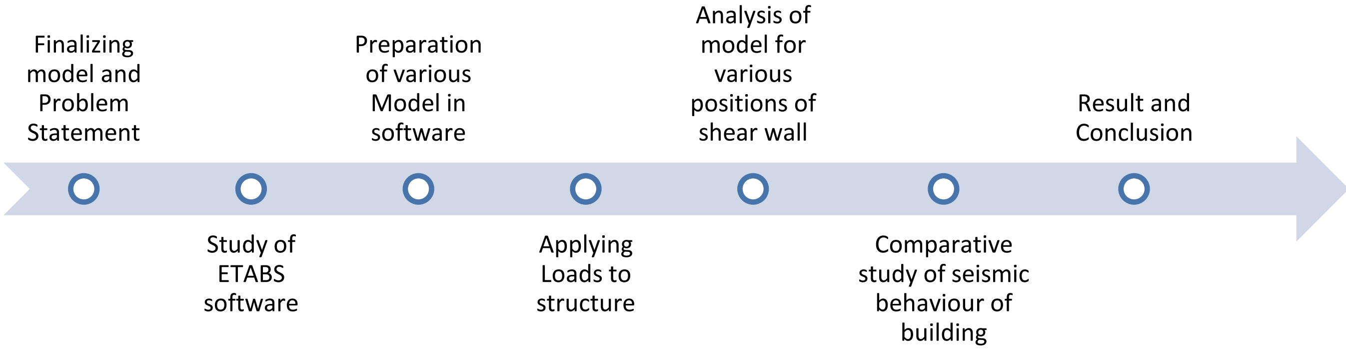


Figure No. 1 Position of Shear Walls

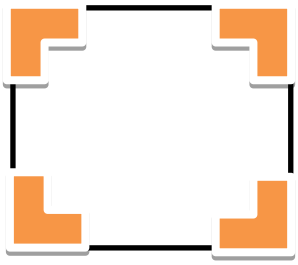
3. Methodology



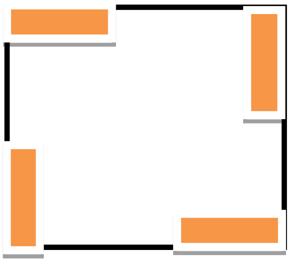
The main aim of this paper is to find an effective location of the shear wall either the inner or outer periphery of the building in the G+13 RC building Structure. And also, a comparative study on the Seismic behaviour of building with shear walls and without shear walls. The following analysis is carried out as per IS: 1893- 2016(Part-I) for G+13 storied building models. For this analysis, Seismic zone-I, zone-II, zone-III and IV are considered. According to IS: 1893-2016 (Part-I) Zone Factor, Z1=0.1, Z2=016, Z3=0.24, Z4=0.36 Importance factor, I=1.5, Response reduction factor, R=5.00, are applied during analysis. Performance is analysed by performing Dynamic Nonlinear Time history analysis Method The analysis is carried out using ETABS software. To find parameters like lateral displacement in the x and y direction. in these, we have considered the high-rise building (G+13) for all four zones to see the effect of the earthquake on the building.

A. Problem Statement

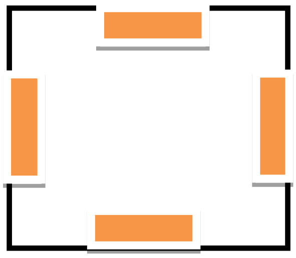
1)Structure: Frame- R.C. Shear wall
2) No. of the storey: G +13
3) Type of building: Public building
4) Foundation and soil Type: Isolated footing and medium soil.
5) Unit weight of concrete: 25 kN/m3
6) Column 450×450mm
7) Beam 230×450mm
8) External wall 300mm
9) Slab 150mm
10) Shear wall 230mm
11) Concrete M25 Grade, HYSD Fe415
12) Storey height 3m
13) Modal damping = 0.05 I.
14) Roof slab: Floor finish 1.5 KN/m2
15) Slab: Floor finishes 1.5 KN/m2. Live load 3 KN/m2.
16) Roof beam: Parapet wall load 5.52 KN/m.
17) Beams: Masonry wall load 13.8 KN/m



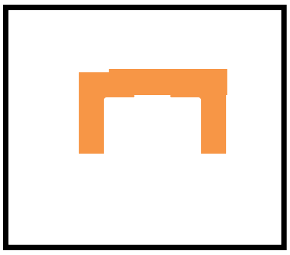
L-SHAPE AT CORNER



I-SHAPE AT CORNER



I-SHAPE AT CENRTE PHASE



U-SHAPE AT CENRTE

WITHOUT SHEAR WALLS

4. BASIC DESIGN OF BUILDING FOR G+13

Design of Base Shear:-

$V_B = A_h \times W$

Design Horizontal Acceleration Coefficient: -

$$Ah = \frac{Z/2 \times Sa/g}{I/R}$$

Z= IV= 0.24

R= 0.5

I= 1.2

Sa/g= $T_a=\frac{0.09\times h}{\sqrt{10}}$=0.34

Sa/g =2.5 (Consider medium soil)

$$Ah = \frac{\frac{0.24}{2}\times 2.5}{\frac{5.0}{1.2}}$$

Ah = 0.072

Calculation of the total weight of the building: -

For 1st to 12th Floors

Member	Numbers	Length	Width	Depth	Volume	Density	Total Weight
Column	25	2.55	0.45	0.45	12.90	25	322.5
Beam	40	2.77	0.23	0.45	11.46	25	286.5
Slab	16	3	3	0.15	21.6	25	540
Shear wall	8	3	2.7	0.3	19.4	25	487

Total Weight = 1635.5 KN

The Dead Load For 1st to 12th Floors is 1635.5 and it is the same for all 12 floors.

For RoofFloors

Member	Numbers	Length	Width	Depth	Volume	Density	Total Weight
Column	25	1.1	0.45	0.45	5.56	25	139.21
Beam	40	2.77	0.23	0.45	11.46	25	286.5
Slab	16	3	3	0.15	21.6	25	540
Shear wall	8	3	1.1	0.3	7.92	25	198

Total Weight =1163.71 KN

Total Dead Load =12 × 1635.5 +1163.76

=20789.71 KN

For Live Load according to given intensity 3.5 KN/M^2

Imposed Load is 50% is assumed

L.L=50/100×3.5 =1.75 KN/M^2

L.L=12×12×1.75=252 KN

Load Calculation: -

1st Floor= DL+LL =1635.5+252 =1887.5KN

For the 1st to 12th Floors is 1887.5KN and it is the same for all 12 floors.

13th Floor=DL=1663.71KN

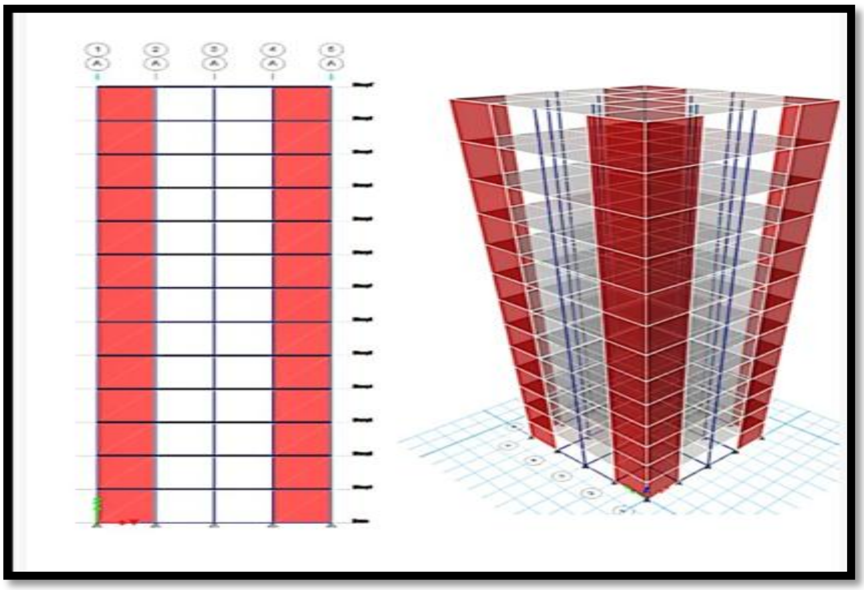
Total Weight= 1887.5×12+1163.71=23813.17KN

$V_B=A_h \times W$

=0.072×23813.17=1714.54

Distribution of Base Shear:-

$$Qi = \frac{Wihi^2}{\sum Wihi^2}\times V_B$$



Floors	Wi	hi	$Wihi^2$	Qi
1	1887.5	3	16987.5	2.27
2	1887.5	6	67950	9.09
3	1887.5	9	152887.5	20.46
4	1887.5	12	27180	36.37
5	1887.5	15	424687.5	56.84
6	1887.5	18	611550	81.85
7	1887.5	21	832387.5	111.40
8	1887.5	24	1087200	145.52
9	1887.5	27	137598.5	184.16
10	1887.5	30	1698750	275.11
11	1887.5	33	2055487.5	275.11
12	1887.5	36	2446200	327.40
13	1163.71	39	1770002.91	236.90

$$\sum Wihi^2 = 12811877.91$$

5. BASIC DESIGN OF SHEAR WALL

H_w=3m

t=300mm=0.3m

L_w=3m

Fck=25 N/mm^2

Fy=415 N/mm^2

Load =487 KN

Effective height of the wall (H_e)=0.75×H_w

=0.75×3

= 2.25m

Effective height of thickness ratio=$\frac{2.25}{0.3}$

=7.5<30 Hence safe

Eccentricity=0.05×t

=0.05×300

=15mm

Hence eccentricity is minimum so we can take the available load.

Shear Stress

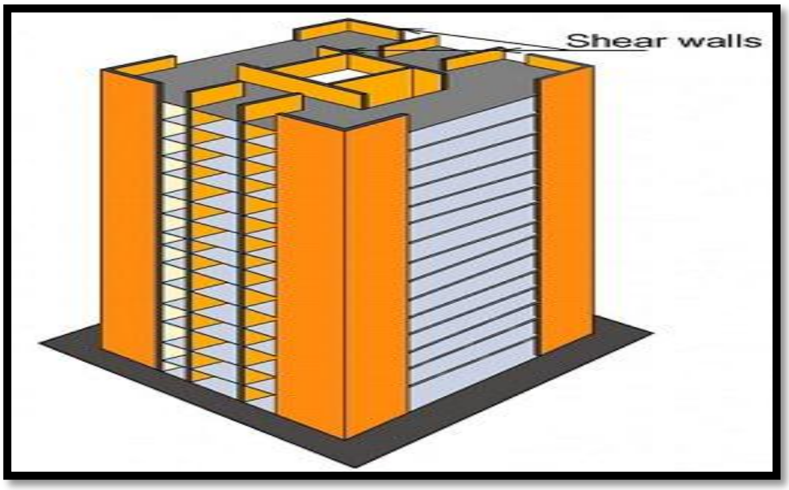
$$\tau_{vw} = \frac{V_u}{td}$$

$$\tau_{vw} = \frac{487 \times 10^3}{200 \times 0.8 \times 3000}$$

=1.01<0.12fck

0.12×25=3

1.01<3 Hence safe



Shear strength of Concrete

$$\tau_{cw} = (3.0 - \frac{H_w}{L_w}) \times k\sqrt{fck}$$

$$\frac{H_w}{L_w} = \frac{3}{3} = 1 \leq 1$$

$$\tau_{cw} = (3.0 - \frac{3}{3}) \times 0.2 \times \sqrt{25}$$

$$\tau_{cw} = 1.79$$

Reinforcement

Vertical Reinforcement

=0.12%=0.0012×b×d

=0.0012×3000×300

=1080mm^2

Provide 16mm Día bars @300mm C/C

Horizontal Reinforcement

=0.2%=0.002×b×d

=0.002×3000×300

=1800mm^2

Provide 16mm Día bars @250mm C/C

6. RESULT AND ANALYSIS

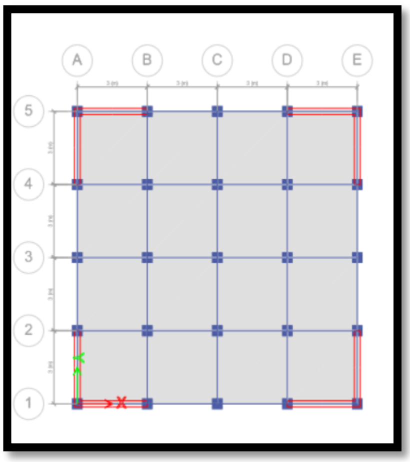
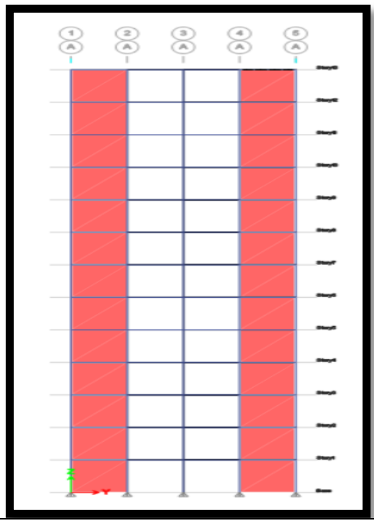
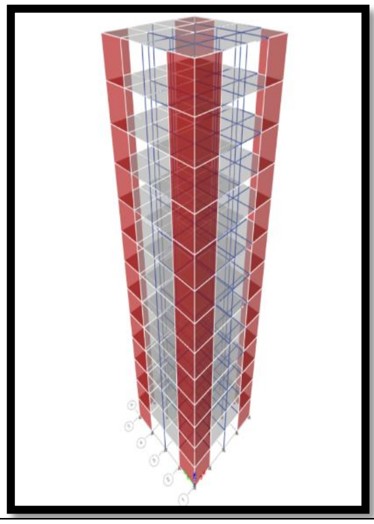
		
Plan	Elevation	3D View

Table No.1 Drawing of the Building in ETAB Software

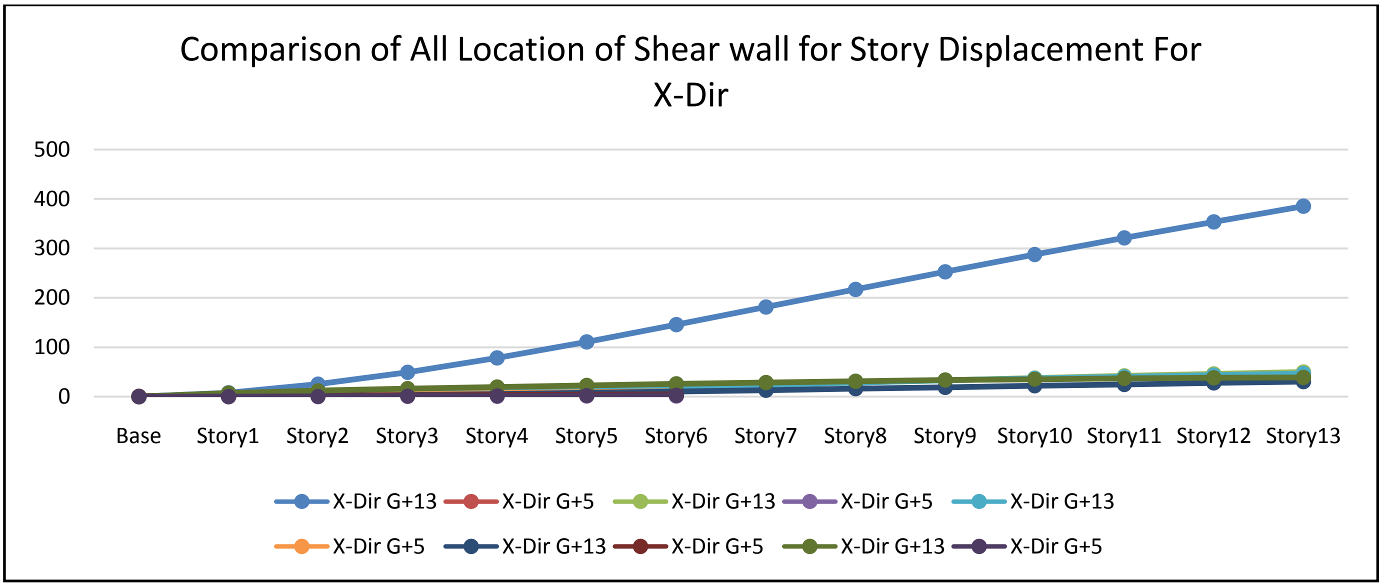


Figure No. 2 Comparison of All Location of shear walls for Story Displacement

Table No. 2 Comparison of All Location of shear walls for Story Displacement

SHAPE OF SHEAR WALLS			L-SHAPE		I-SHAPE		C-SHAPE		CENTRE		WITH-OUT	
Story	Eleva-tion	Loca-tion	X-Dir		X-Dir		X-Dir		X-Dir		X-Dir	
	m		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
			G+5	G+13	G+5	G+13	G+5	G+13	G+5	G+13	G+5	G+5
Base	0	Top	0	0	0	0	0	0	1.2	0	0	0

Story1	3	Top	0.358	8.053	0.124	1.098	1.074	1.621	1.453	0.584	0.214	0.214
Story2	6	Top	1.027	25.252	0.314	3.241	2.592	4.036	1.877	1.699	0.595	0.595
Story3	9	Top	1.945	49.346	0.579	6.398	4.589	7.36	2.445	3.33	1.11	1.11
Story4	12	Top	2.992	78.409	0.878	10.244	6.792	11.258	3.096	5.375	1.694	1.694
Story5	15	Top	4.091	110.875	1.199	14.558	9.002	15.502	3.79	7.742	2.304	2.304
Story6	18	Top	5.161	145.45	1.502	19.161	10.919	19.918	4.451	10.352	2.917	2.917
Story7	21	Top		181.081		23.9		24.364		13.13		
Story8	24	Top		216.94		28.653		28.725		16.013		
Story9	27	Top		252.408		33.322		32.909		18.943		
Story10	30	Top		287.073		37.837		36.851		21.877		
Story11	33	Top		320.719		42.162		40.517		24.78		
Story12	36	Top		353.351		46.328		43.913		27.649		
Story13	39	Top		385.048		50.209		46.851		30.426		

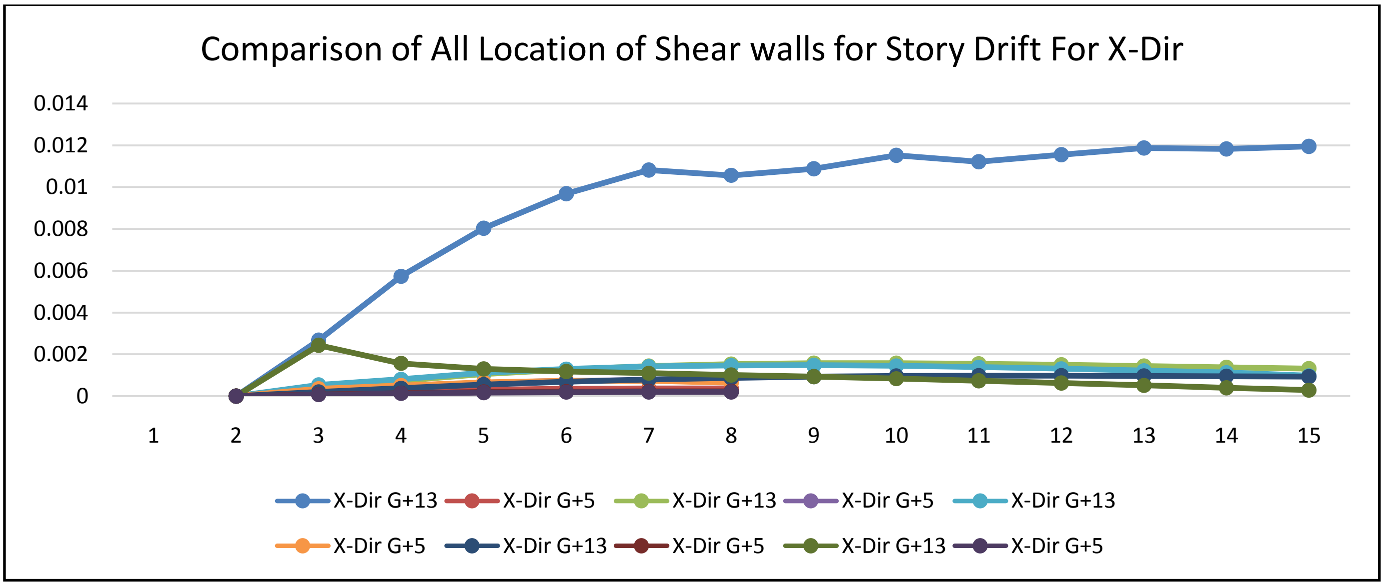


Figure NO.3 Comparison of All Location of shear walls for Story Drift

Table No. 3Comparison of All Location of shear walls for Story Drift

SHAPE OF SHEAR WALLS			L-SHAPE		I-SHAPE		C-SHAPE		CENTRE		WITHOUT	
Story	Elevavation	Locacation	X-Dir		X-Dir		X-Dir		X-Dir		X-Dir	
	m											
			G+5	G+13	G+5	G+13	G+5	G+13	G+5	G+13	G+5	G+13
Base	0	Top	0	0	0	0	0	0	0	0	0	0
Story1	3	Top	0.000119	0.002684	0.000262	0.000366	0.000358	0.00054	0.000084	0.000195	0.000071	0.002436
Story2	6	Top	0.000231	0.005733	0.000488	0.000744	0.00051	0.00081	0.000146	0.000377	0.000134	0.00157
Story3	9	Top	0.000307	0.008031	0.000649	0.001056	0.000666	0.001109	0.000193	0.000547	0.000174	0.001299
Story4	12	Top	0.000349	0.009687	0.000734	0.001285	0.000735	0.0013	0.00022	0.000684	0.000197	0.001182
Story5	15	Top	0.000367	0.010822	0.000764	0.001441	0.000737	0.001415	0.000231	0.000792	0.000205	0.001098
Story6	18	Top	0.000366	0.010566	0.000736	0.001536	0.000642	0.001473	0.000226	0.000873	0.000207	0.001016
Story7	21	Top		0.010877		0.001581		0.001482		0.000929		0.00093
Story8	24	Top		0.011525		0.001586		0.001454		0.000964		0.000838
Story9	27	Top		0.011215		0.001557		0.001395		0.00098		0.000738
Story10	30	Top		0.011555		0.001505		0.001314		0.000981		0.000631
Story11	33	Top		0.011877		0.001442		0.001223		0.000971		0.000515
Story12	36	Top		0.011823		0.001389		0.001132		0.000956		0.000396
Story13	39	Top		0.011953		0.001324		0.000982		0.000937		0.000287

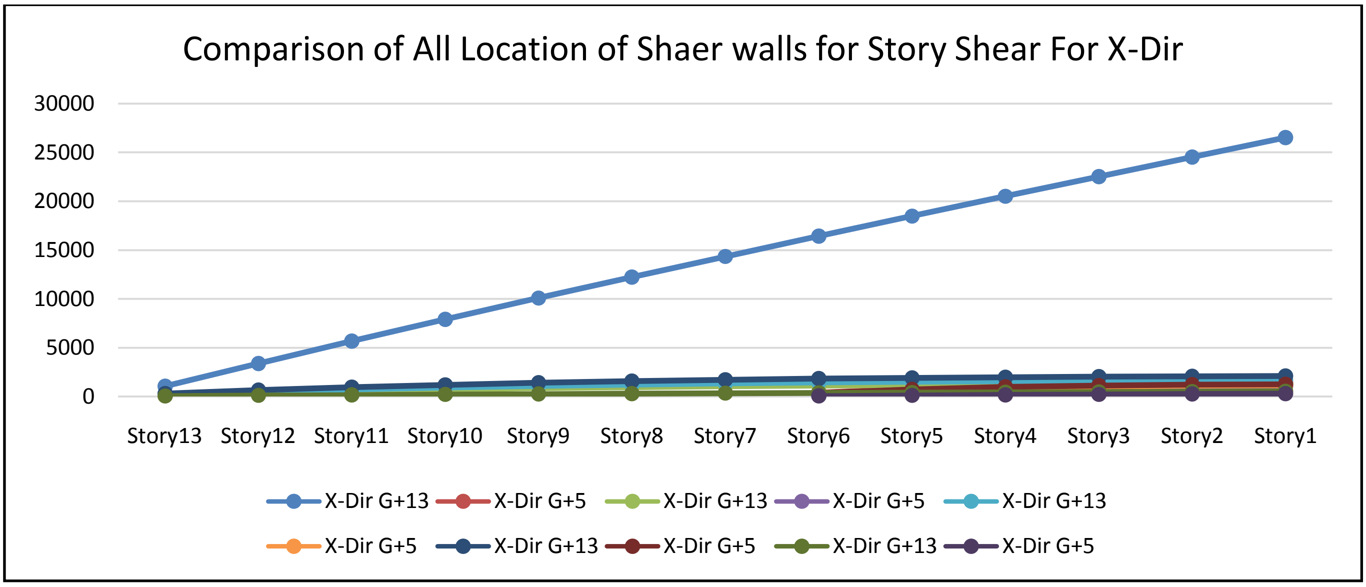


Figure NO. 4Comparison of All Location of shear walls for Story Shear

Table No.4 Comparison of All Location of shear walls for Story Shear

SHAPE OF SHEAR WALLS			L-SHAPE		I-SHAPE		C-SHAPE		CENTRE		WITHOUT	
Story	Elevavation	Locacation	X-Dir		X-Dir		X-Dir		X-Dir		X-Dir	
	m		kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
			G+5	G+13	G+5	G+13	G+5	G+13	G+5	G+13	G+5	G+13
Base	0	Top	0	0	0	0	0	0	0	0	0	0
Story1	3	Top	1449.141	26534.77	1036.283	1355.282	1166.756	1668.953	1246.923	2108.808	302.5071	538.8166
Story2	6	Top	1373.511	24536.8	996.0368	1324.047	1124.739	1637.314	1203.815	2076.587	260.4799	508.6287
Story3	9	Top	1258.188	22531.7	925.0522	1289.105	1046.668	1600.761	1121.383	2037.703	215.258	477.877
Story4	12	Top	1076.713	20514.72	802.8366	1247.984	908.5093	1556.015	973.4124	1987.715	166.4655	446.1857
Story5	15	Top	802.6234	18481.12	608.8979	1198.215	686.2271	1499.801	733.6863	1922.18	113.7266	413.1789
Story6	18	Top	409.4585	16426.14	322.7437	1137.325	355.7861	1428.841	375.9894	1836.656	56.6653	378.4808
Story7	21	Top		14345.04		1062.844		1339.859		1726.703		341.7155

Story8	24	Top		12233.06		972.3001		1229.578		1587.877		302.5071
Story9	27	Top		10085.45		863.2224		1094.721		1415.737		260.4799
Story10	30	Top		7897.47		733.1397		932.0117		1205.842		215.258
Story11	33	Top		5664.36		579.5809		738.1727		953.7484		166.4655
Story13	39	Top		1043.759		192.15		243.9995		305.2011		56.6653

7. CONCLUSIONS

In this studythe shear wall shape at different positions for the different zone for the low-rise building i.e. G+5 and high-rise building i.e. G+13. When providing the Shear walls at the Centre. it has been seen that it has story displacement, story drift and story share less than the other shape of the shear wall for low-rise and high-rise buildings. after Analysis it is found that, the building for the L-shape shear wall and without a shear wall for the low-rise and high-rise buildings. it has more story displacement, story drift and story shear than the other shape of shear walls. Centre phase and L-shape at cornerhave more story displacement, story drift and story share than the other shape of shear walls for different zones. After we analyzed the I-shape of the shear wall provided at the corner of the building. We have seen that it has more story displacement, story drift and story than the Centre shapes of the shear walls. L-shape shear walls and the without shear walls it has more Story displacement, story drift and story shear than the other shape of shear walls. We concluded that if the shear walls are provided at the center of the walls it holds like a clamp and there are fewer chances of collapsing the building in the earthquake zones also there is no mere effect on the building. Based on Non-linear analysis, it can be observed that the center phase shear wall showed better performance in terms of reduction of displacement, with the reduction of displacement in the shear wall model overall of 52% as compared to the building without the shear wall. Results show that displacement both in X & Y directions is considerably reduced by using shear walls. The maximum story drift in most of the cases produced is found on the seventh floor. In all building models (Non-linear analysis), it has been found that large c/s area of shear walls concerning the total length of the structure shows lesser displacement as compared to the other models. Without shear walls gives less performance as compared to other models. Providing shear walls at buildings that coincide with CG locations substantially reduces the displacements in earthquakes. The presence of a shear wall can affect the seismic behavior of the frame structure to a large extent, and the shear wall increases the strength and stiffness of the structure. It has been found that the model of the Centre phase, when the shear wall is provided at the corner of the building is the better location of the shear wall. The concentration of stresses in shear walls increases. It follows that a centerphase Shear wall should be provided. Shear walls are more effective when located along the exterior perimeter of the building. Such a layout increases the resistance of the building to torsion. Based on the analysis and discussion, a shear wall is very much suitable for resisting earthquake-induced lateral forces in multistoried structural systems when compared to multistore structural systems without shear walls. The vertical reinforcement that is uniformly distributed in the shear wall shall not be less than the horizontal reinforcement. Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces.

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6. S.K. Duggal in his Earthquake resistant design of structures " 8.16 Design of Shear walls which is also given in Is code 139203993
7. I.S 456: 2000. As per clause 32, the design for the wall describes, the design of horizontal shear in clause 32-4 given
8. Details of how the shear wall has to be constructed.
9. Bureau of Indian Standers, IS 456: 2000, ―Plain and Reinforced Concrete-Code of practice‖, New Delhi, India.
10. Bureau of Indian Standards: IS 875(part 1): 1987, ―Dead loads on buildings and Structures‖, New Delhi, India.
11. Bureau of Indian Standards: IS 875(part 2): 1987, ―Live loads on buildings and Structures, New Delhi, India.
12. Bureau of Indian Standards: IS 1893 (part 1): 2002, ―Criteria for earthquake resistant design of structures: Part 1 General provisions and buildings‖, New Delhi, India