WIND BEHAVIOR OF BUILDINGS WITH AND WITHOUT SHEAR WALL (IN DIFFERENT LOCATION) FOR STRUCTURAL STABILITY AND ECONOMY

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Abstract: In recent decades, shear walls structures are the most appropriate structural forms, which have caused the height of concrete buildings to be soared. So, recent RC tall buildings would have more complicated structural behavior than before. Therefore, studying the structural systems and associated behavior of these types of structures would be very interesting. Shear wall system with irregular openings are utilized under both lateral and gravity loads, and may result some especial issues in the behavior of structural elements such as shear walls, coupling beams and etc. In many respects concrete is an ideal building material, combining economy, versatility of form and function, and noteworthy resistance to fire and the ravages of time. In this project the analysis of G+10 reinforced concrete frame building with and without shear wall has been done. The analysis is done using designing software Staad Pro. Different models with different condition of shear wall has been considered for analysis and study the effects of displacements in different direction, behavior of different story , structural stability and flexibility , economy etc has been observed , same shown with the help of comparison with different models.

I. INTRODUCTION

Shear walls are specially designed structural walls included in the buildings to resist horizontal forces that are induced in the plane of the wall due to wind, earthquake and other forces. They are mainly flexural members and usually provided in highrise buildings to avoid the total collapse of the highrise buildings under seismic forces. Shear wall has high in-plane stiffness and strength which can be used to simultaneously resist large horizontal loads and support gravity loads. However, when the buildings are tall, say more than twelve story or so, beam and column sizes workout large and reinforcement at the beam and column junction works out quite heavy, so that, there is a lot of congestion at these joints and it is difficult to place and vibrate concrete at these places, which does not contribute to the safety of buildings. These practical difficulties call for introduction of shear walls in highrise buildings. Deep straight walls or angular, U shaped and box shaped shear wallswere used based on functional and architectural requirement of the highrise building. Provision of walls helps to divide an enclose space, whereas of cores to contain and convey services such as elevator. Wall openings are inevitably required for windows in external walls and for doors or corridors in inner walls or in lift cores. The size and location of openings may vary from architectural and functional point of view.

Design Wind Speed (V,)
The basic wind speed (V,) for any site shall be obtained from and shall be modified to include the following effects to get design wind velocity at any height (V,) for the chosen structure:
a) Risk level;
b) Terrain roughness, height and size of structure; and
c) Local topography.
It can be mathematically expressed as follows:
Where:
V = Vb * kl * k* ks
Vb = design wind speed at any height z in m/s;
kl = probability factor (risk coefficient)
k = terrain, height and structure size factor and
ks = topography factor

Risk Coefficient (kI Factor)
It gives basic wind speeds for terrain Category 2 as applicable at 10 m above ground level based on 50 years mean return period. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used.

Terrain, Height and Structure Size Factor (k, Factor)
Terrain - Selection of terrain categories shall be made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain category used in the design of a structure may vary depending on the direction of wind under consideration. Wherever sufficient meteorological information is available about the nature of wind direction, the orientation of any building or structure may be suitably planned.

Topography (ks Factor) –
The basic wind speed Vb takes account of the general level of site above sea level. This does not allow for local topographic features such as hills, valleys, cliffs, escarpments, or ridges which can significantly affect wind speed in their vicinity. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliff, steep escarpments, or ridges.

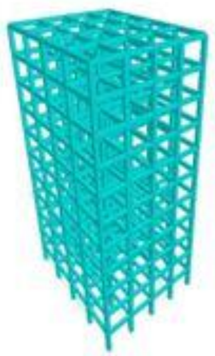
Wind load on structural frames
- The maximum loading effect on each part of the

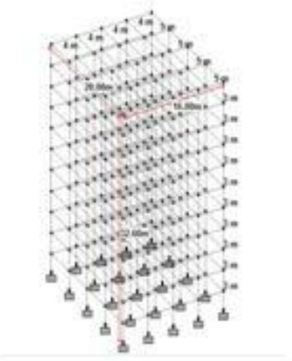
building can be estimated by the dynamic response analysis considering the characteristics of temporal and spatial fluctuating wind pressure and the dynamic characteristics of the building.

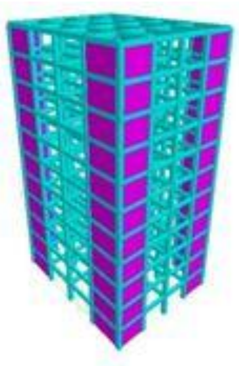
- The equivalent static wind load producing the maximum loading effect is given as the design wind load. For the response of the building against strong wind, the first mode is predominant and higher frequency modes are not predominant for most buildings.
- The horizontal wind load (along-wind load) distribution for structure frames is assumed to be equal to the mean wind load distribution, because the first mode shape resembles the mean building displacement.
- Specifically, the equivalent wind load is obtained by multiplying the gust effect factor, which is defined as the ratio of the instantaneous value to the mean value of the building response, to the mean wind load.
- The characteristics of the wind force acting on the roof are influenced by the features of the fluctuating wind force caused by separation flow from the leading edge of the roof and the inner pressure, which depends on the degree of sealing of the building. Therefore, the characteristics of roof wind load on structural frames are different from those of the along-wind load on structural frames.

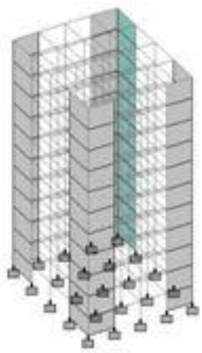
Geometry of Building Without and With Shear Wall in Different Location & Parameters

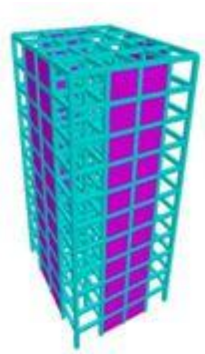
- Length of building:- 20 mtr
- Width of building :- 15 mtrs
- Height of building :- 47.6 mtrs

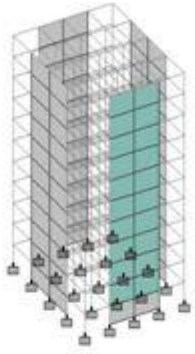












II. SPECIFICATION FOR DESIGN OF BUILDING

1) All columns = 0.6 x0.6 m
2) All beams = 0.5 X0.3 m
3) Parapet = 0.115 m wall.

Live load on the floors is 4 KN/m2
Grade of concrete and steel used: Used M25 concrete and Fe 500 steel for main & Fe 415 for secondary.

MATERIALS FOR THE STRUCTURE

The materials for the structure were specified as concrete with their various constants as per standard

LOADING CALCULATION

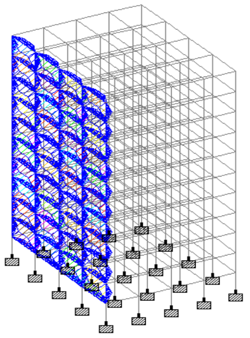
The Indian Standard (IS) code used for the design:
Minimum design loads for Buildings other than seismic loads
a) IS 875 (Part 1): 1987 Dead loads
b) IS 875 (Part 2): 1987 Imposed loads
c) IS 875 (Part 3): 1987 Wind loads
d) IS 875 (Part 5): 1987 Special loads and load combinations

LOADING CALCULATION:-

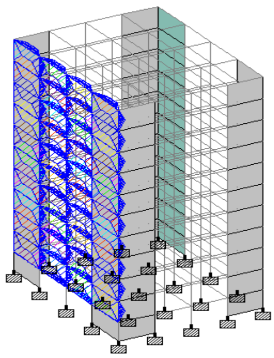
DEAD LOAD OF BEAM –COLUMN :-
GIVEN BY SELF WEIGHT (Y -1)
DEAD LOAD OF SLAB:- 0.15 x 25 = 3.75 KN/M 2
DEAD LOAD OF WALL :- 3 X 0.23 X 20 = 13.8 KN/M

CALCULATION OF WIND LOADS
Wind loads are calculated as per IS 875 Part II (1987) [5], in this example. For the Present work, the basic wind speed (Vb) is assumed as 44 m/s and the building is considered to be open terrain with well scattered obstructions having height less than 10m with maximum dimension more than 50m and accordingly factors
K1,K2, K3 have been calculated as per IS 875 Part II (1987).
Terrain Category- 2, Class- C
K1- Probability factor- 1.0
K2- Terrain, height and size factor- 1.03
K3- Topography factor- 1.1
Design wind speed, $V_z = V_b (K_1 \times K_2 \times K_3)$ (3)
$V_z = 53.24$ m/s
Design pressure, $P = 0.6 V_z^2$ (4)
$= 1.7 kN/m^2$

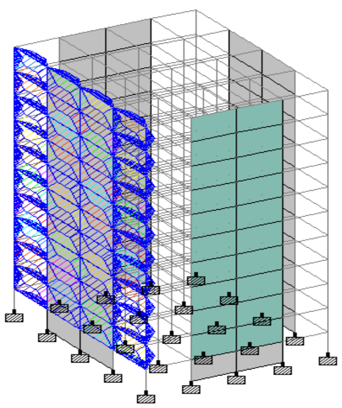
WIND LOADS



Without Shear Wall

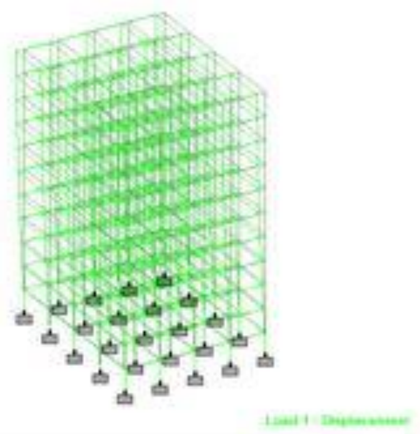


With Shear Wall I



With Shear Wall II

DISPLACEMENT IN X DIRECTION OF NODES



Without Shear Wall

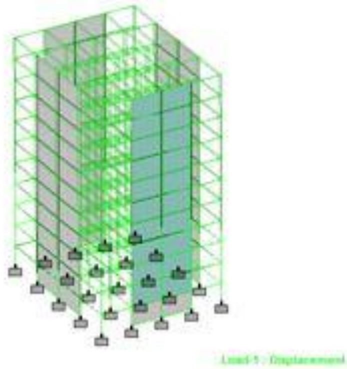
Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	286	5:DEAD LOAD	**0.099**	-7.233	0.000	7.233	0.000	-0.000	-0.000
Min X	286	1:WIND LOAD	**-19.484**	-0.426	0.000	19.488	0.000	-0.000	0.000
Max Y	290	1:WIND LOAD	-19.453	**0.428**	-0.000	19.458	-0.000	0.000	0.000
Min Y	288	5:DEAD LOAD	-0.000	**-9.646**	0.000	9.646	0.000	-0.000	0.000
Max Z	278	5:DEAD LOAD	0.000	-6.683	**0.149**	6.685	0.001	-0.000	0.000
Min Z	298	5:DEAD LOAD	0.000	-6.683	**-0.149**	6.685	-0.001	-0.000	0.000
Max rX	278	5:DEAD LOAD	0.000	-6.683	0.149	6.685	**0.001**	-0.000	0.000
Min rX	298	5:DEAD LOAD	0.000	-6.683	-0.149	6.685	**-0.001**	-0.000	0.000
Max rY	196	1:WIND LOAD	-14.744	-0.397	0.011	14.750	-0.000	**0.000**	0.000
Min rY	176	1:WIND LOAD	-14.744	-0.397	-0.011	14.750	0.000	**-0.000**	0.000
Max rZ	61	1:WIND LOAD	-4.497	-0.191	0.000	4.501	0.000	-0.000	**0.001**
Min rZ	286	5:DEAD LOAD	0.099	-7.233	0.000	7.233	0.000	-0.000	**-0.000**
Max Rst	286	1:WIND LOAD	-19.484	-0.426	0.000	**19.488**	0.000	-0.000	0.000

Beam Displacement Detail Summary

Displacements shown in italic indicate the presence of an offset

	Beam	L/C	d (mm)	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	661	5:DEAD LOAD	3E+3	**0.099**	-7.234	0.000	7.234
Min X	697	1:WIND LOAD	2.5E+3	**-19.495**	-0.425	-0.002	19.500
Max Y	600	1:WIND LOAD	1.5E+3	-18.782	**0.429**	0.000	18.787
Min Y	705	5:DEAD LOAD	2.5E+3	0.000	**-10.384**	0.041	10.384
Max Z	416	1:WIND LOAD	2E+3	-14.738	-0.186	**0.159**	14.740
Min Z	432	1:WIND LOAD	2E+3	-14.738	-0.186	**-0.160**	14.740
Max Rst	697	1:WIND LOAD	2.5E+3	-19.495	-0.425	-0.002	**19.500**



With Shear Wall I

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	286	5:DEAD LOAD	**0.21**	-3.12	0.00	3.12	0.000	-0.000	-0.001
Min X	286	1:WIND LOAD	**-8.18**	-0.07	-0.00	8.18	-0.000	-0.000	0.000
Max Y	204	1:WIND LOAD	-2.93	**0.58**	-0.00	2.95	0.000	-0.000	0.000
Min Y	288	5:DEAD LOAD	-0.00	**-9.43**	0.00	9.43	0.000	-0.000	0.000
Max Z	278	5:DEAD LOAD	-0.00	-3.16	**0.24**	3.17	0.001	-0.000	0.000
Min Z	298	5:DEAD LOAD	-0.00	-3.16	**-0.24**	3.17	-0.001	-0.000	-0.000
Max rX	278	5:DEAD LOAD	-0.00	-3.16	0.24	3.17	**0.001**	-0.000	0.000
Min rX	298	5:DEAD LOAD	-0.00	-3.16	-0.24	3.17	**-0.001**	-0.000	-0.000
Max rY	196	1:WIND LOAD	-2.50	-0.24	0.01	2.51	0.000	**0.001**	0.000
Min rY	176	1:WIND LOAD	-2.50	-0.24	-0.01	2.51	-0.000	**-0.001**	0.000
Max rZ	290	5:DEAD LOAD	-0.21	-3.12	0.00	3.12	0.000	0.000	**0.001**
Min rZ	286	5:DEAD LOAD	0.21	-3.12	0.00	3.12	0.000	-0.000	**-0.001**
Max Rst	288	5:DEAD LOAD	-0.00	-9.43	0.00	**9.43**	0.000	-0.000	0.000

Beam Displacement Detail Summary

Displacements shown in italic indicate the presence of an offset

	Beam	L/C	d (m)	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	697	5:DEAD LOAD	2.5	**0.25**	-3.68	-0.03	3.69
Min X	661	1:WIND LOAD	3.0	**-8.18**	-0.07	0.00	8.18
Max Y	459	1:WIND LOAD	3.0	-2.93	**0.58**	-0.00	2.99
Min Y	705	5:DEAD LOAD	2.5	0.00	**-10.10**	0.07	10.10
Max Z	678	5:DEAD LOAD	2.0	0.02	-3.37	**0.25**	3.38
Min Z	693	5:DEAD LOAD	2.0	-0.02	-3.37	**-0.25**	3.38
Max Rst	705	5:DEAD LOAD	2.5	0.00	-10.10	0.07	**10.10**

With Shear Wall II

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	291	5:DEAD LOAD	**0.20**	-2.67	-0.19	2.68	-0.000	0.000	-0.001
Min X	286	1:WIND LOAD	**-9.10**	-0.21	-0.00	9.10	-0.000	-0.000	0.000
Max Y	177	1:WIND LOAD	-3.41	**0.52**	0.02	3.45	0.000	-0.000	0.000
Min Y	288	5:DEAD LOAD	-0.00	**-9.52**	0.00	9.52	0.000	-0.000	0.000
Max Z	279	5:DEAD LOAD	-0.14	-2.61	**0.22**	2.62	0.001	-0.000	0.000
Min Z	297	5:DEAD LOAD	0.14	-2.61	**-0.22**	2.62	-0.001	-0.000	-0.000
Max rX	277	5:DEAD LOAD	0.14	-2.61	0.22	2.62	**0.001**	0.000	-0.000
Min rX	297	5:DEAD LOAD	0.14	-2.61	-0.22	2.62	**-0.001**	-0.000	-0.000
Max rY	195	1:WIND LOAD	-6.30	0.26	-0.03	6.31	0.000	**0.000**	0.000
Min rY	185	1:WIND LOAD	-6.30	0.26	0.03	6.31	-0.000	**-0.000**	0.000
Max rZ	285	5:DEAD LOAD	-0.20	-2.67	0.19	2.68	0.000	0.000	**0.001**
Min rZ	281	5:DEAD LOAD	0.20	-2.67	0.19	2.68	0.000	-0.000	**-0.001**
Max Rst	288	5:DEAD LOAD	-0.00	-9.52	0.00	**9.52**	0.000	-0.000	0.000

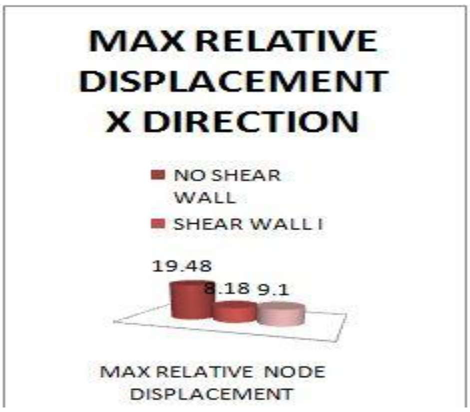
Beam Displacement Detail Summary

Displacements shown in italic indicate the presence of an offset

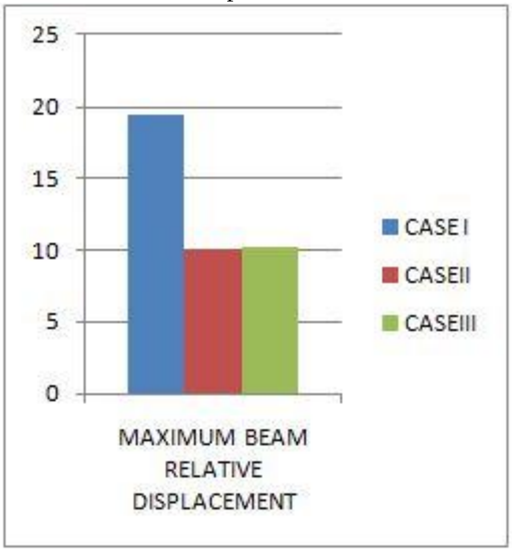
	Beam	L/C	d (m)	X (mm)	Y (mm)	Z (mm)	Resultant (mm)
Max X	699	5:DEAD LOAD	2.5	**0.23**	-3.08	-0.19	3.10
Min X	661	1:WIND LOAD	3.0	**-9.10**	-0.21	0.00	9.10
Max Y	392	1:WIND LOAD	3.0	-3.41	**0.52**	0.02	3.45
Min Y	706	5:DEAD LOAD	2.5	0.00	**-10.18**	-0.05	10.18
Max Z	679	5:DEAD LOAD	2.0	-0.15	-2.69	**0.22**	2.71
Min Z	692	5:DEAD LOAD	2.0	0.15	-2.69	**-0.22**	2.71
Max Rst	706	5:DEAD LOAD	2.5	0.00	-10.18	-0.05	**10.18**

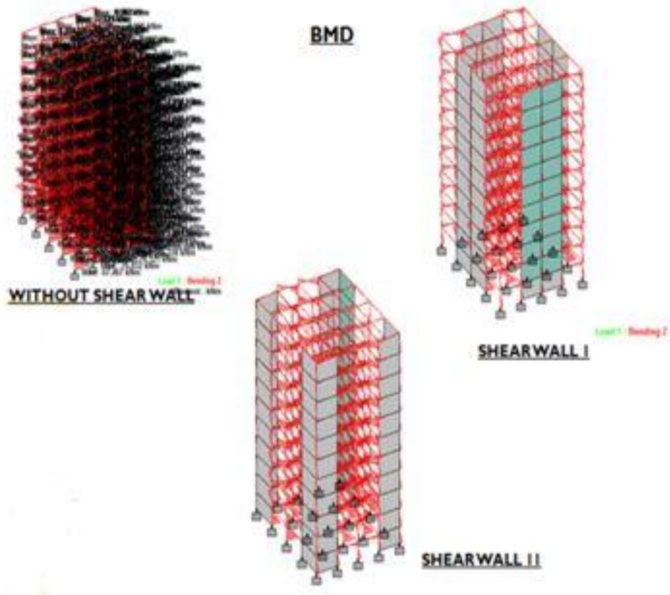
III. ANALYSIS RESULTS COMPARISION OF ALL MODELS & CONCLUSION

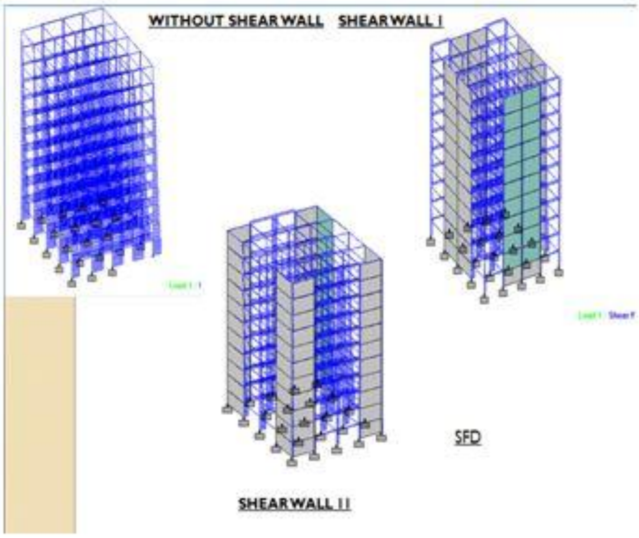
Maximum nodal displacement has been observed in case I (Without shear wall) which is 19.48 mm in X direction followed by case III and case II. It has been found that case II model having minimum displacement with the position of shear wall showed in model. Hence model II in this comparison showing more stable behavior under applied load.



- Maximum relative displacement has been observed in case I (Without shear wall) which is 9.6 mm in Y direction followed by case III and case II.
- It has been found that case II model having minimum relative displacement with the position of shear wall showed in model.
- Hence model II in this comparison showing more stable behavior under applied load.
- Maximum resultant displacement in case of beam has been observed in case I (Without shear wall) which is 19.6 mm in X direction followed by case II and case III.
- It has been found that case III model having minimum resultant displacement with the position of shear wall showed in model.
- Hence model II in this comparison showing more stable behavior under applied load in case of maximum resultant displacement and more economical as compare with two other models.







CONCLUSIONS

The above study shows the idea about the location for providing the shear wall which was based analyses in the Staad pro. It has been observed that the top deflection was reduced and reached within the permissible deflection after providing the shear wall in 2 & 3rd model. It has been also observed that the both bending moment and shear force in the 2nd and 3rd frame were reduced after providing the shear wall. It is evident from the observing result that the shear wall are making value of torsion very low. For the columns located away from the shear wall the torsion is high when compared with the columns connected to the shear wall.
Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. For the columns located away from the shear wall the Bending Moment is high and shear force is less when compared with the columns connected to the shear wall. The vertical reinforcement that is uniformly distributed in the shear wall shall not be less than the horizontal reinforcement after a general study of ductility levels in shear walls; we will conclude the optimality and conceptuality of provision of shear wall. RC shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. Shear walls are more effective when located along exterior perimeter of the building such a layout increases resistance of the building to twisting.

REFERENCES

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