THE BEHAVIOUR OF SYMMETRIC AND UNSYMMETRIC TALL BUILDINGS UNDER DIFFERENT POSITION OF SHEAR WALL

Mr. Roshan N. Ugale[1], Mr. Sachin U. Pagar. [2]

(Email ID: roshanugale4@gmail.com[1], pagarsachin2011@gmail.com[2])

[1]*PG student, Department of Civil Engineering, K. C. T. LT. G. N. Sapkal College of Engineering, Nashik*

[2]*Prof, Department of Civil Engineering, K. C. T. LT. G. N. Sapkal College of Engineering, Nashik*

ABSTRACT:

A shear wall is vertical element of system which is designed to resist lateral forces due to wind and earthquake, which is one of the most efficient methods of maintaining the lateral stability of tall buildings. These walls used to absorb shear stresses and avoid construction site relocation and subsequently devastation. In case, if the shear walls are not constructed, we cannot expect the structure to exhibit acceptable tensional behavior. The contribution of the structural elements other than shear wall to the bending moment, shear force, torsion, and axial force, as well as the final design of all structural components, are also impacted by shear wall. Over the last two decades, there has been an exponential growth in the building of towering skyscrapers above 150 meters in height. Also, Numerous identical buildings have been constructed across the Middle East and Asia, and many more are now being planned or constructed. Buildings taller than 300 meters height provide significant engineering challenges, particularly in terms of structural and geotechnical design. Wind analysis is crucial for all tall constructions. Numerous studies have explored the structural behavior of tall buildings with SSI by considering a range of criteria, including foundation type, soil conditions, lateral loads etc. The current study presents G+18-story rectangular building and unsymmetric building with a 3 m floor-to-floor height was evaluated in ETABS in zone III. The structure's resistance to static and dynamic wind and seismic forces has been studied using shear walls in different locations, such as without shear walls, shear walls in the outer center, and shear walls at the corners. The results obtained after this are compared in the form of storey drift, joint displacement and base shear. The research indicates that the shear wall at outer Centre position with firm soil has the best response compared to without shear wall and shear wall at corner condition for symmetrical building. And for unsymmetrical building shear wall at corner condition has best response compared to without shear wall and shear wall at outer centre condition.

Keywords: ETABS, Tall buildings, symmetrical, unsymmetrical, shear wall, lateral loads.

I. INTRODUCTION

Indian population is estimated at 1,413,829,343 as of 1 January 2023 and India has become second most populous country in the world. Vertical growth of built environment is unavoidable for providing shelter and workspace for them. Dynamic analysis of tall buildings with all considered safety factors has become a challenge for Civil Engineers. Earthquake resistant tall buildings behaving well in all type of soil conditions, especially in soft soils are necessary to be constructed. Wind analysis is also important in case of tall buildings.

The last two decades have seen a remarkable increase in construction of tall buildings and an almost exponential rate of growth. A significant number of these buildings have been constructed in the Middle East and Asian countries, and many more are either planned or already under construction. “Super-tall” buildings in excess of 300m in height are also presenting new challenges to engineers, particularly in relation to structural and geotechnical design. Wind analysis is one of the major factor in case of tall buildings. Many of the traditional design methods cannot be applied with any confidence as they require extrapolation well beyond the realms of prior experience, and accordingly, structural and geotechnical designers are being forced to utilize more sophisticated methods of analysis and design.

The investigations have been carried out by many researchers on the structural behavior of tall buildings with SSI by considering many parameters like foundation type, soil conditions, lateral forces, ratio of flexural stiffness of beam and column etc. Very few investigations have been carried out on soil-structure interaction of tall buildings under clayey soil conditions, which are particularly in Indian seismic zones.

There are a number of characteristics of tall buildings which can have a significant influence on foundation design, including the following:

1. The lateral forces which is imposed by wind loading, and the consequent moments on the foundation system, can be very high. These moments can impose increased vertical loads on the foundation system, especially on the outer piles within the foundation system.

2. The building weight increases non-linearly with increasing height, and thus the vertical load to be supported by the foundation system, can be substantial.
3. The wind-induced lateral loads and moments are considered to be cyclic in nature. Thus, consideration needs to be given to the influence of cyclic vertical and lateral loading on the foundation system, as cyclic loading has the potential to degrade foundation capacity and cause disturbance with increased settlements.
4. High-rise buildings are often surrounded by low-rise podium structures which are subjected to smaller loadings. Thus, differential settlements between the high-rise and low-rise portions need to be controlled.

SHEAR WALL

A shear wall is vertical element of system which is designed to resist lateral forces due to wind and earthquake, which is one of the most efficient methods of maintaining the lateral stability of tall buildings. In practice, shear walls are generally provided in most of the commercial and residential buildings up to thirty storeys beyond which tubular structures are recommended. Shear walls may be provided in one plane or both planes. The typical shear wall system with shear walls located in both the planes and subjected to the lateral loads.

The shear walls are expected to resist large lateral loads (due to earthquake or wind forces) that may strike "in-plane" and "out-of- plane" to the wall. The in-plane shear resistance of the shear wall can be estimated by subjecting the wall to the lateral loads.

Following are the basic terms that we are going to analyze:

Storey drift: Storey drift is the lateral displacement of floor relative to the floor below. Also, it is the difference of displacements between two consecutive storey's divided by the height of that story.

Joint Displacement: It is the displacement of the point on each storey with respect to the base storey or basement

Base Shear: It is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity.

II. LITERATURE REVIEW:

The extensive literature review was carried out by referring standard journals, reference books, I.S. codes and conference proceeding. The major work carried out by different researchers is summarized below.

Yin Zhou and Ahsan Kareem, in this paper "Gust loading factors for design applications" Wind loads on structures under the buffeting action of wind gusts have been treated traditionally by the "gust loading factor" (GLF) method in most major codes and standards around the world. The equivalent static wind loading used for design is equal to the mean wind force multiplied by the GLF. Although the traditional GLF method can ensure an accurate estimation of the displacement response, it fails to provide a reliable estimate of some other response components. In order to overcome this shortcoming, a more realistic procedure for design loads is proposed in this paper.

Wakchaure M. R., Gawali Sayali, in this paper the gust effectiveness factor method takes into account the dynamic properties of the structure, the wind-structure interactions and then determines the wind loads as equivalent static loads. Wind loads are determined based on gust effectiveness factor method. The critical gust loads for design are determined. After the application of calculated wind loads to the building models prepared in finite element software package ETAB's 13.1.1v. Having different shapes are compared in various aspects such as storey displacements, storey drifts, storey shear, axial forces in column etc. Based on the results, conclusions are drawn showing the effectiveness of different shapes of the structure under the effect of wind loads.

Mohammed Asim Ahmed, Moid Amir, Savita Komur, Vaijainath Halhalli, in this paper presents displacement occur in different storey due to wind in different terrain category. Three models are analyzing using ETABS 2015 package. Present works provides a good source of information about variation in deflection as height of model changes and percentage change in deflection of same model in different terrain category.

Jadhav A. A., dr. Kulkarni, S. K. Galatage A. A. in this paper a main objective of study is to determine the position of shear walls in multi-storey building. An earthquake load is applied to a building of twenty sixth storied located in the zone iii. The analysis is performed using Etabs software. Axial forces, shear force, bending moment, storey displacement and time period are computed and location of shear walls is established.

III. METHODOLOGY

Analysis of the different position of shear wall in building is done in following sequence.

1. First, we have to collect all relevant data regarding analysis of building such as seismic zone, terrain, soil type etc.

2. Then we have to do the study of shear wall and its behaviour.
3. Then preparation of G+18 model in E-Tabs.
4. After this we study different models related to our design.
5. Study the base reaction on each column.
6. Result obtained and their discussion.
7. Conclusion.

IV. PROBLEM STATEMENT

In this project, a G+18-storey structure of a rectangular building and unsymmetrical building with 3 m floor to floor height have been analyzed Non-Linear Dynamic Analysis of Multi-storey R.C.C Buildings using Etabs software in zones III. The structure has been analysed for both static and dynamic wind and earthquake forces. The building has been studied for without shear wall, shear wall at corner and shear wall at outer centre position.

MODEL DESCRIPTION FOR ANALYSIS:

Preliminary data required for Analysis:

Table 1: Parameters to be consider for rectangular geometry analysis

SR NO	Parameters	Design Values
1.	No of stories	G+18
2.	Base to plinth	1.5m
3.	Grade of concrete	M30
4.	Grade of steel	Fe 500
5.	Floor to floor height	3m
6.	Total height of building	58m
7.	Dead load	1.5 kn/m^2
8.	Imposed load	4 kn/m^2
9.	Assumed city	Nashik
10.	Basic wind speed	39 m/s^2
11.	Terrain category	Type 2
12.	Size of column	500mm*500mm
13.	Size of beam	300mm*500mm
14.	Depth of slab	125mm

Models:

There are six different types of models used for analysis:

1. Model 1: G+18 Rectangular building without shear wall
2. Model 2: G+18 Rectangular building with shear wall at corner position
3. Model 3: G+18 Rectangular building with shear wall at outer center position
4. Model 4: G+18 Unsymmetrical building without shear wall
5. Model 5: G+18 Unsymmetrical building with shear wall at outer center position
6. Model 6: G+18 Unsymmetrical building with shear wall at corner position

Following are the models for analysis:

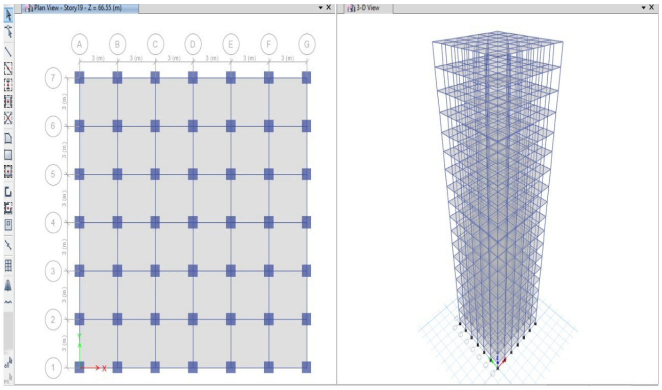

Fig 1. Rectangular building without shear wall

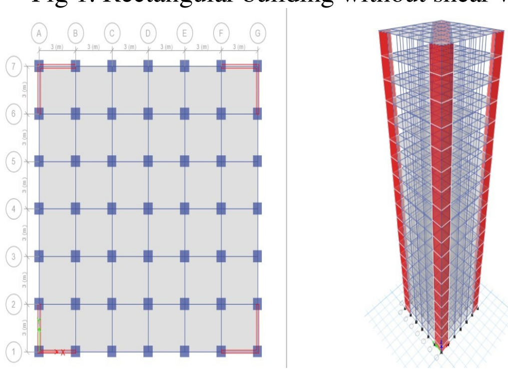

Fig 2. Rectangular building with shear wall at corner position

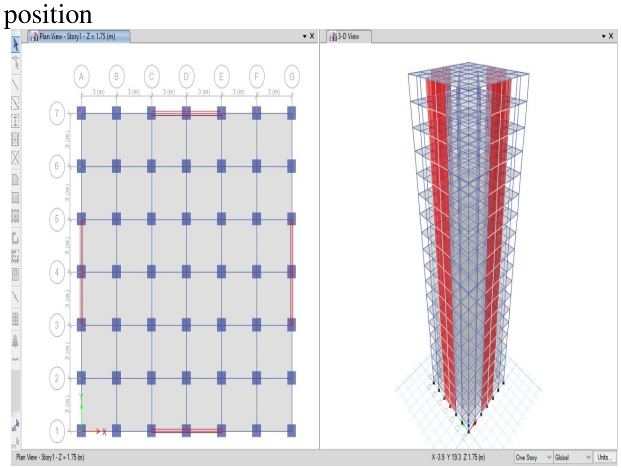

Fig 3. Rectangular building with shear wall at outer centre position

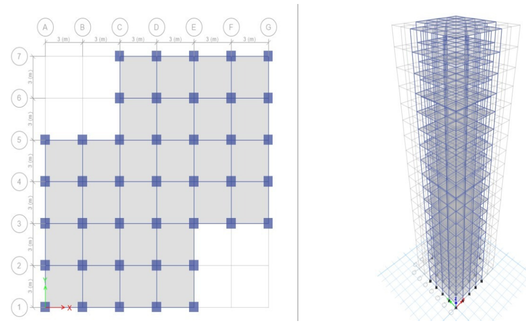

Fig 4. Unsymmetrical building without shear wall

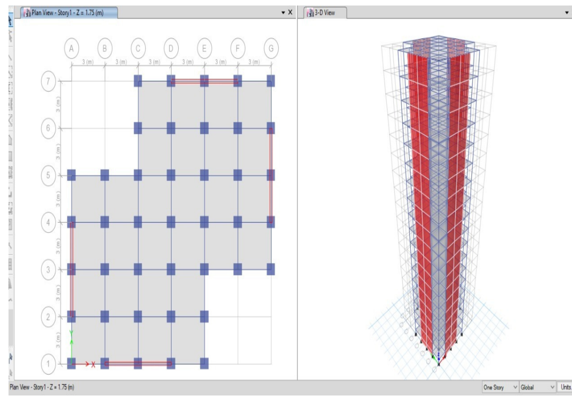

Fig 6. Unsymmetrical building with shear wall at outer centre position

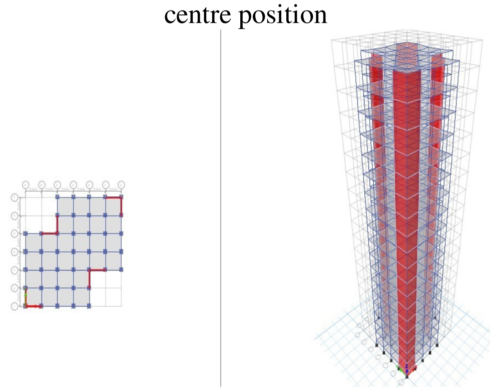

Fig 5. Unsymmetrical building with shear wall at corner position

V. RESULT AND DISCUSSION

In this project, a G+18-storey structure of a rectangular building and unsymmetrical building with 3 m floor to floor height has been analysed Non-Linear Dynamic Analysis of Multi-storey R.C.C Buildings using Etabs software in zones III. The structure has been analysed for both static and dynamic wind and earthquake forces.

Results are given below:

RESULTS FOR RECTANGULAR BUILDING:

1) Storey drift

STOREY	without SW	SW at corner	SW at outer centre
18	1.285	2.134	2.055
17	1.704	2.312	2.223
16	2.13	2.522	2.411
15	2.477	2.702	2.558
14	2.747	2.861	2.691
13	2.97	2.999	2.807
12	3.164	3.101	2.879
11	3.338	3.199	2.947
10	3.492	3.28	2.999
9	3.631	3.34	3.033
8	3.756	3.375	3.046
7	3.865	3.377	3.034
6	3.956	3.336	2.984
5	4.035	3.232	2.882
4	4.1	3.041	2.705
3	4.098	2.727	2.425
2	3.85	2.238	2.007
1	2.865	1.492	1.389
G	0.962	0.546	0.542
BASE	0	0	0

2) Joint displacement

STOREY	without SW	SW at corner	SW at outer centre
18	190.506	172.614	158.234
17	186.638	165.874	151.939
16	181.785	158.741	144.96
15	175.802	151.036	137.514
14	168.758	142.739	129.597
13	160.74	133.852	121.206
12	151.824	124.383	112.367
11	142.076	114.374	103.108
10	131.562	103.866	93.469
9	120.336	92.911	83.49
8	108.449	81.58	73.229
7	95.947	69.968	62.766
6	82.872	58.204	52.209
5	69.253	46.467	41.715
4	55.114	35	31.496
3	40.54	24.144	21.847

2	25.847	14.368	13.16
1	11.998	6.325	5.949
G	1.683	0.956	0.949

3)Base shear

STOREY	without SW	SW at corner	SW at outer centre
18	1800.7282	2838.9208	3033.1344
17	3902.2814	5810.1537	6302.6077
16	5473.5115	7732.7963	8498.2071
15	6551.1643	8966.665	9942.3165
14	7318.5726	9856.4101	10957.2771
13	7977.9282	10554.8005	11694.1765
12	8619.7062	11129.9169	12239.6095
11	9228.7953	11675.0271	12722.5025
10	9787.0953	12235.2137	13234.2724
9	10319.4464	12793.9317	13792.4995
8	10845.8288	13360.3078	14420.12
7	11341.6273	13992.0212	15176.104
6	11783.6045	14718.6013	16075.8448
5	12218.9638	15524.4002	17066.5708
4	12739.6303	16409.3093	18103.9349
3	13357.1085	17354.4511	19151.7528
2	13930.1871	18207.6427	20075.4245
1	14264.7449	18727.5393	20647.8514
G	14308.9432	18810.3708	20743.6346

RESULTS FOR UNSYMMETRICAL BUILDING

1) **Storey drift**

STOREY	without SW	SW at corner	SW at outer centre
18	0.927	1.283	1.541
17	1.198	1.372	1.635
16	1.473	1.467	1.751
15	1.696	1.553	1.84
14	1.867	1.626	1.91
13	2.006	1.685	1.962
12	2.126	1.726	1.978
11	2.232	1.761	2.002
10	2.325	1.786	2.015
9	2.407	1.803	2.016
8	2.48	1.808	2.005
7	2.542	1.8	1.978
6	2.593	1.77	1.928
5	2.636	1.711	1.845
4	2.67	1.608	1.715
3	2.66	1.441	1.522
2	2.49	1.182	1.244
1	1.843	0.788	0.849
G	0.616	0.294	0.334

2) **Joint displacement**.

STOREY	without SW	SW at corner	SW at middle
18	126.296	93.708	106.662
17	123.477	89.893	102.026
16	120.008	85.689	96.823
15	115.825	81.219	91.316
14	110.971	76.482	85.556
13	105.505	71.479	79.545
12	99.478	66.219	73.292
11	92.937	60.741	66.893
10	85.922	55.052	60. 324
9	78.471	49.171	53.607
8	70.616	43.129	46.778
7	62.388	36.966	39.887
6	53.813	30.742	33.002
5	44.909	24.544	26.221
4	35.689	18.491	19.679
3	26.206	12.759	13.56
2	16.67	7.596	8.108
1	7.713	3.35	3.639
G	1.079	0.515	0.585
BASE	0	0	0

3) **Base shear.**

STOREY	without SW	SW at corner	SW at outer centre
18	965.1636	1455.7167	1684.6466
17	2092.2578	3025.1913	3560.7589
16	2922.9587	4038.8038	4835.4029
15	3479.739	4629.1753	5637.726
14	3866.3054	4991.4164	6147.3756
13	4196.6885	5276.1279	6497.3006
12	4521.478	5528.2626	6754.0001
11	4831.1743	5744.0763	6970.7092
10	5114.8595	5942.0949	7196.0582
9	5386.3771	6169.5037	7479.9297
8	5656.8552	6454.2393	7856.8432
7	5912.0907	6784.7431	8328.0583
6	6139.0898	7151.8221	8874.0614
5	6365.4837	7583.376	9480.2968
4	6644.3028	8105.3562	10131.5729
3	6981.9951	8669.2293	10773.8834
2	7297.9758	9147.8135	11300.8838
1	7482.6469	9419.9967	11604.9606
G	7506.9193	9461.9952	11654.3203

VI. CONCLUSION:

In this study G+18-storey structure of a rectangular building and unsymmetrical building with shear wall provided at different location at corner, at outer centre and without shear wall analysed. Based on this study following conclusion can be drawn for the different positions of shear wall:

- The provision of shear wall can impact the seismic behavior of a rectangular structure to a large extent, and shear wall increases the strength and stiffness of the structure.
- When shear wall is provided at middle of outer, the joint displacement reduce by larger value for rectangular buildings.
- The utilization of shear wall significantly reduces the inter storey drift So shear wall at middle of outer centre should be optimum location.
- Base shear increases when shear wall is provided and it is maximum when shear wall is provided at middle of outer.
- The provision of shear wall enhances the lateral stability of the building specially for unsymmetrical structure.
- The joint displacement, inter storey drift reduces by greater value when shear wall provided at corner of structure in unsymmetric building.
- In view of unsymmetrical structure and eccentricity base shear increases at middle of the outer structure due to increases in mass and stiffness.
- By considering all the parameters shear wall at corner should be a better position due to immense decrement in interstorey drift and joint displacement.

REFERENCES

1. Mohammad Jafari, Alice Alipour, (2021) “Methodologies to mitigate wind-induced vibration of tall buildings: A state-of-the-art review”, Engineering Journal of building engineering.
2. Vahid Mohseniana, Ali Nikkhooa, Farzad Hejazi, (2019) “An investigation into the effect of soil-foundation interaction on the seismic performance of tunnel-form buildings”, Science Direct Vol 125.
3. Amer Hassan, Shilpa Pal, (2018) “Effect of soil condition on seismic response of isolated base buildings”, International journal of Advanced Structural Engineering 10, 249-261.
4. Mohammed Elwi, Bassman Muhammed and Nada Alhussiny, (2018) “Evaluation of soil-structure interaction for structures subjected to earthquake loading with different types of foundation”, MATEC Web of Conference Vol 162.
5. Pahwa Sumit P, Devkinandan Prajapati, Utkarsh Jain (2017) “A Study of 30-Storey Dual System Building with Different Soil Conditions”, International Journal of Engineering Research and Applications.
6. Sangtiani Suraj, Simon J (2017) “Performance of tall buildings under Lateral loads with different type of Structural systems”, International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 3, March 2017, pp. 1014–1022.
7. Uma maheshwara. B, Nagarajan.P (2016) “Design Optimization and Analysis of Shear Wall in High Rise Buildings Using ETABS”, International Journal for Research in Emerging Science and Technology.
8. Susheel S M, Sanjith J, Vidyashree B S, Ranjith A (2016) “Analysis of tall building in chikkamagaluru region”, International Research Journal of Science Engineering and Technology, Vol 3, Issue 6.
9. M. Mallikarjun, Dr P V Surya Prakash (2016) “Analysis and design of a multi storied residential building of by using most economical column method”, International Journal of Science Engineering and Advanced Technology, Vol 4, Issue 2.
10. Jadhav A. A., Dr. Kulkarni, S. K. Galatage A. A. (2016) “Comparison of the effect of earthquake and wind loads on the performance of rc framed shear wall building with its different orientation”, IJARIIE-ISSN(O) Vol-2 Issue-6.
11. Wakchaure M. R., Gawali Sayali (2015) “Effects of Shape on Wind Forces of High-Rise Buildings Using Gust Factor Approach”, International Journal of Research in Engineering and Technology.
12. Mohammed Asim Ahmed, Moid Amir, Savita Komur, Vaijainath Halhalli (2015) “Effect of wind load on tall buildings in different terrain category”, International Journal of Engineering Research and Technology, Vol 10, Issue 10.
13. M Roopa, H. G. Naikar, Dr. D. S. Prakash, (2015) “Soil Structure Interaction Analysis on a RC Building with Raft foundation under Clayey Soil Condition”, International Journal of Engineering Research and Technology, Vol 4, Issue 12.
14. Ketan Bajaj, Jitesh T Chavda, Bhavik M Vyas (2013) “Seismic Behaviour of Buildings on Different Types of Soil”, Proceedings of Indian Geotechnical Conference December 22-24.
15. K. Vishnu Haritha, Dr. I. Yamini Srivalli (2013) “Effect of Wind on Tall Building Frames Influence of Aspect Ratio”, International Journal of Research in Civil Engineering, Architecture & Design Volume 1, Issue 1.
16. K. Rama Raju, M.I. Shereef, Nagesh R Iyer, S. Gopalakrishnan (2013) “Analysis and design of rc tall building

subjected to Wind and earthquake loads", National Conference on Emerging Technologies in Civil Engineering.
17. Singla Sarita, Kaur Taranjeet, Kalra Megha and Sharma Sanket (2012) "Behaviour of R.C.C. Tall Buildings Having Different Shapes Subjected to Wind Load", International Conference on Advances in Civil Engineering.
18. B. Dean Kumar and B.L.P. Swami (2010) "Wind effects on tall building frames-influence of dynamic parameters", International Journal of Science and Advanced Technology, Vol 3, Issue 5, Pages 583-586.