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The Impact of Different Shear Wall Structure Position on Symmetric and Unsymmetric Tall Buildings

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Abstract: The shear wall is a structural component used to withstand lateral stresses. These walls will absorb shear stresses and avoid construction site relocation and subsequently devastation. For instance, if the shear walls are not constructed, we cannot expect the structure to exhibit acceptable tensional behavior. The contribution of the remaining structural elements 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 almost exponential increase in the building of towering skyscrapers above 150 meters in height.

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 provide significant engineering challenges, particularly in terms of structural and geotechnical design. Wind analysis is crucial for 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. The current study presents G+18-story rectangular building and a asymmetric 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 various locations, such as without shear walls, shear walls in the outer center, and shear walls at the corners. The results obtained are compared in the form of storey drift, joint displacement and storey drift. The research indicates that the shear wall at outer Centre with firm soil has the best response compared to without shear wall and shear wall at corner condition for symmetrical building. And for asymmetrical 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, shear wall, lateral loads.

I. INTRODUCTION

A. *Tall Buildings*

The last two decades have seen a remarkable increase in construction of tall buildings in excess of 150m in height, and an almost exponential rate of growth. A significant number of these buildings have been constructed in the Middle East and Asia, and many more are either planned or already under construction. “Super-tall” buildings in excess of 300m in height are presenting new challenges to engineers, particularly in relation to structural and geotechnical design. Wind analysis is important in case of tall buildings.

Figure 1 shows the significant growth in the number of such buildings either constructed.Many of the traditional design methods cannot be applied with any confidence since 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. In particular, geotechnical engineers involved in the design of foundations for super-tall buildings are increasingly leaving behind empirical methods and are employing state-of-the art methods.

The investigations have been carried out by many researchers on the structural behaviour 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, particularly in Indian seismic zones.

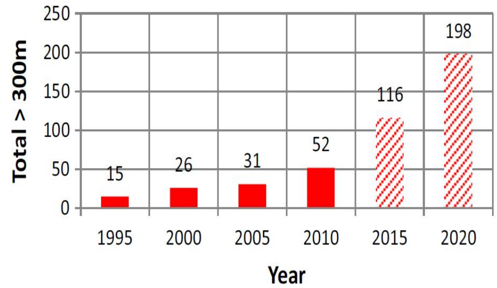

Fig 1: Total number of buildings in excess of 300 m tall

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

1) The building weight increases non-linearly with increasing height, and thus the vertical load to be supported by the foundation, can be substantial.
2) High-rise buildings are often surrounded by low-rise podium structures which are subjected to much smaller loadings. Thus, differential settlements between the high and low-rise portions need to be controlled.
3) The lateral forces 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, especially on the outer piles within the foundation system.
4) The wind-induced lateral loads and moments are 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 increased settlements.

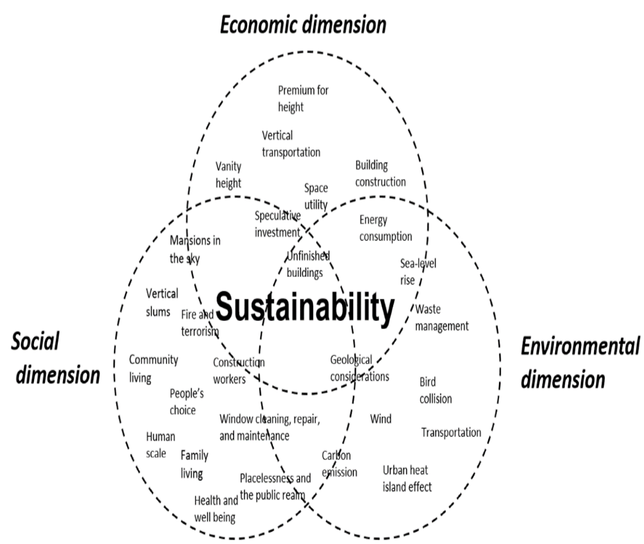

Fig 2: Development of Tall buildings

B. Typical High-Rise Foundation Settlements

Before discussing details of the foundation process, it may be useful to review the settlement performance of some high-rise buildings in order to gain some appreciation of the settlements that might be expected from two foundation types founded on various deposits. Table 1.1summarizes details of the foundation settlements of some tall structures founded on raft or piled raft foundations. The average foundation width in these cases ranges from about 40m to100m. The results are presented in terms of the settlement per unit applied pressure, and it can be seen that this value decreases as the stiffness of the founding material increases. Some of the buildings supported by piled rafts in stiff Frankfurt clay have settled more than100mm, and despite this apparently excessive settlement, the performance of the structures appears to be quite satisfactory. It may therefore be concluded that the tolerable settlement for tall structures can be well in excess of the conventional design values of 50-65mm. Amore critical issue for such structures may be overall tilt, and differential settlement between the high-rise and low-rise portions of a project.

Table 1: Examples of Settlement of Tall Structure Foundations

Sr no.	Foundation type	Founding condition	Location	No. of cases	Settlement per unit pressure mm/MPa
1	Raft	Stiff clay	Houston	2	227-308
		Limestone	Amman; Riyadh	2	25-44
2	Piled Raft	Stiff clay	Frankfurt	5	218-258
		Dense sand	Berlin; Niigata	2	83-130
		Weak Rock	Dubai	5	32-66
		Limestone	Frankfurt	1	38

C. Shear Wall

The lateral forces due to wind and earthquake are generally resisted by the use of shear wall system, which is one of the most efficient methods of maintaining the lateral stability of tall buildings. In practice, shear walls are 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 orin both planes. The typical shear wall system with shear walls located in both the planes and subjected to lateral loads.

The shear walls are expected to resist large lateral loads (due to earthquake or wind) 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.

Sometimes, shear walls are pierced with openings to fulfill the functional as well as architectural requirements of buildings. The structural response of shear wall may be influenced by the presence of openings, depending upon their sizes and their positions. The present study aims to accomplish this task by investigating the different position of shear walls.

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.

Dr.P.A.Krishnan, Anjaly Francis, V.N.Pradeep, In this study, an analysis of a twenty story building, irregular in plan, in zone IV is performed by changing the location of the shear wall and the effects of the parameters like story drift and displacement are determined using standard package ETABS. Four different models have been considered and analysis is performed using time history analysis method, by considering different earthquakes.

P. Mary Williams* and R. K. Tripathi, The study concludes that provision of a box type shear wall at the core gives the best behavior but it is not desired from architectural point of view. Hence shear wall on the outer edges is more advisable to improve the behavior of asymmetric buildings. The location of shear wall do not have significant effect on the nonlinear behavior except that the position of hinges vary. Novelty: The study of effect of shear wall location in eccentrically loaded structures, especially its nonlinear behaviour gives a more precise idea on provision of shear wall.

K. Vishnu Haritha, Dr.I. Yamini Srivalli , Effect of Wind on Tall Building Frames-Influence of Aspect Ratio In this paper equivalent static method is used for analysis of wind loads on buildings with different aspect ratios. The aspect ratio can be varied by changing number of bays. Aspect ratio 1, 2, 3 were considered for present study. The analysis is carried out using ETAB

B. Dean Kumar and B.L.P. Swami Wind effects on tall building frames-influence of dynamic parameters In this paper the present work, the Gust Effectiveness Factor Method is used, which is more realistic particularly for computing the wind loads on flexible tall slender structures and tall building towers. In this paper frames of different heights are analyzed and studied.

SangtianiSuraj, Simon Modeling of spray droplets deformation and breakup In this paper an attempt was made to compare the Performance of the three Structural Systems in all four earthquake zones Base shear, time period, top story displacement, story Drift, seismic weight of structure, and results were compared to arrive the foremost economical structure in a specific Earthquake Zone for a particular plan.

Jadhav A. A., dr. Kulkarni, S. K. Galatage A. A. Comparison of effect of Earthquake and Wind loads on performance of RC framed shear wall building with its different orientation Jadhav A. A., dr. Kulkarni, S. K. Galatage A. A. [10] In this paper a studytherefore main objective 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 zone iii. The analysis is performed using etabs software.

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II. METHODOLOGY

Following is flowchart of work for Project: -

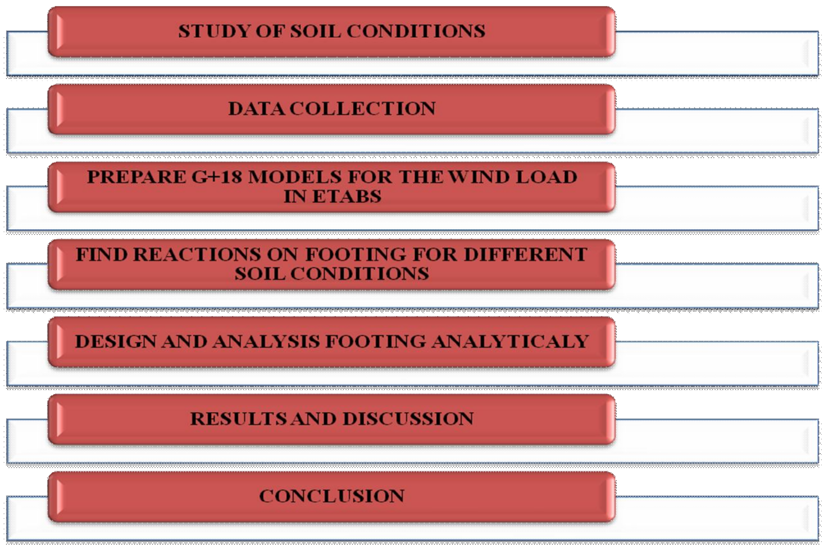

Fig 3: Flowchart

The aim is to investigate behavior of tall buildings of rectangular form and asymmetrical type for different position of shear wall subjected to wind force and seismic forces.
A study involving dynamic effect of wind load on RC buildings and study the behavior of the buildings.
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III. PROBLEM STATEMENT

In this project, a G+18-storey structure of a rectangular building and a asymmetrical 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. The building has been studied for without shear wall, shear wall at corner and shear wall at outer centre condition.

A. *Model Description For Analysis*

Preliminary data required for Analysis

Table 2: Parameters to be consider for rectangular geometry analysis

Sr.	Parameter	Values
1.	Number 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	3 m
6.	Total height of Building	58m
7.	Dead Load	1.5 Kn/m2
8.	Imposed Load	4 Kn/m2
9.	Assumed City	Pune
10.	Basic Wind Speed	39 m/s
11.	Terrain Category	Type 2
12.	Frame size	18m X 18m building size
13.	Grid spacing	6 m grids in X-direction and Y-direction.
14.	Size of column	500mm x 500 mm
15.	Size of beam	300mm x 500 mm
16.	Depth of slab	125 mm

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Table 3: Models

MODEL 1	G+18 Rectangular building without shear wall
MODEL 2	G+18 Rectangular building with shear wall at corner
MODEL 3	G+18 Rectangular building with shear wall at outer centre
MODEL 4	G+18 Unsymmetrical building without shear wall
MODEL 5	G+18 Unsymmetrical building with shear wall at outer centre
MODEL 6	G+18 Unsymmetical building with shear wall at corner

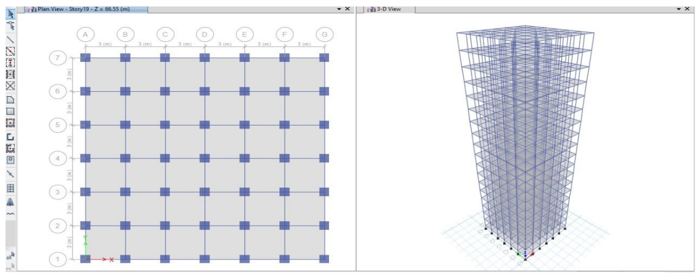

Fig 1.Rectangular building without shear wall

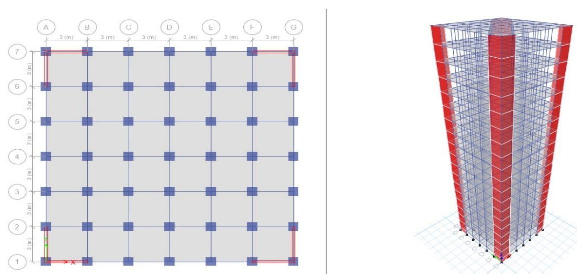

Fig 2. Rectangular building with shear wall at corner

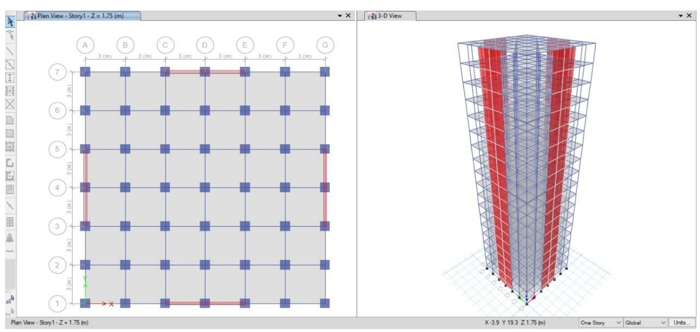

Fig 3. Rectangular building with shear wall at outer centre

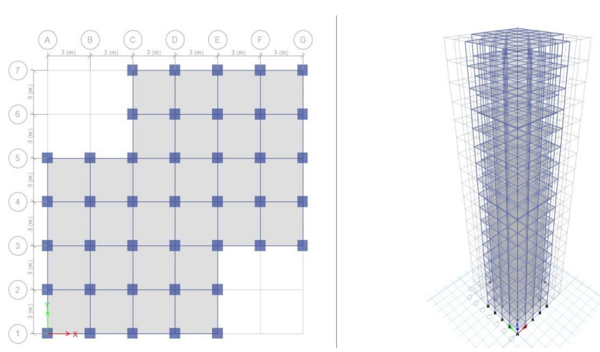

Fig 4. Unsymmetrical building without shear wall

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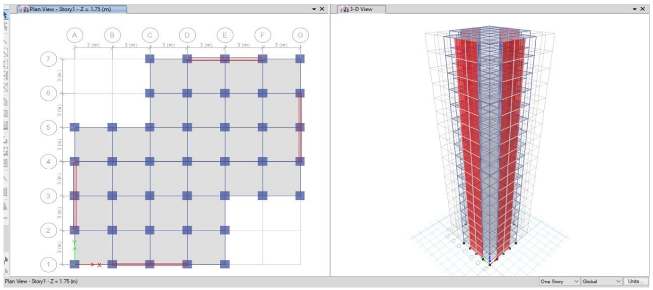


Fig 5. Unsymmetical building with shear wall at outer centre

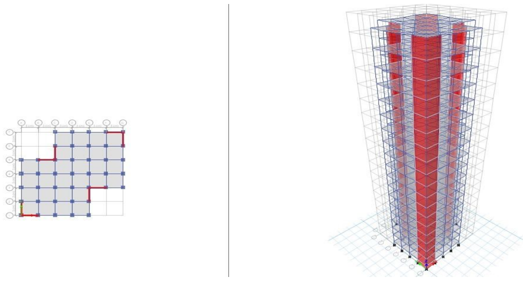


Fig 6. Unsymmetrical building with shear wall at corner

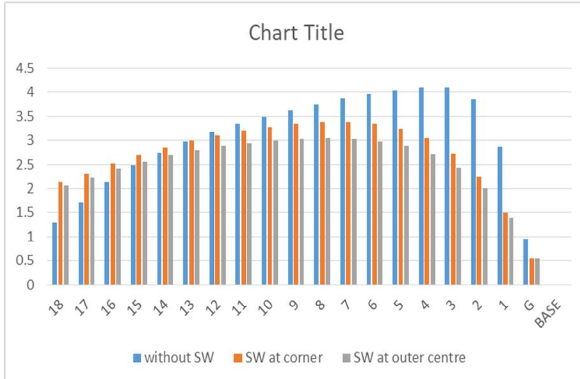
IV. RESULT AND DISCUSSION

In this project, a G+18-storey structure of a rectangular building and a asymmetrical 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:

A. Results For Rectangular Building

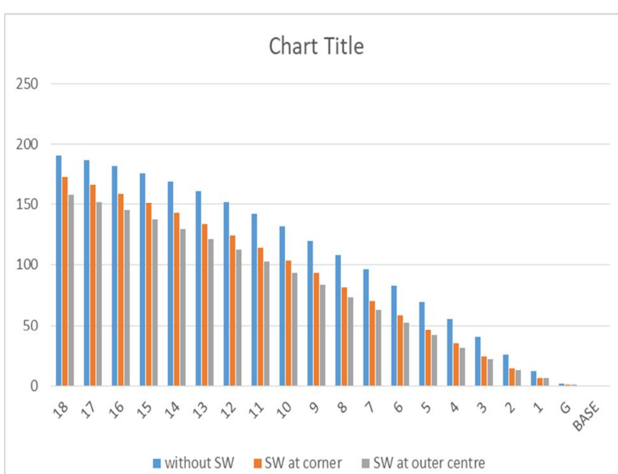
1) Storey Drift

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
BASE	0	0	0



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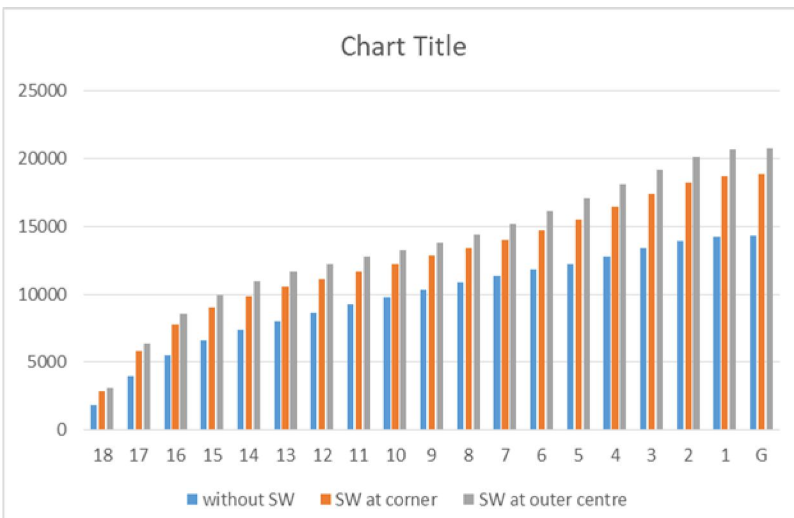
3) Base Shear

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

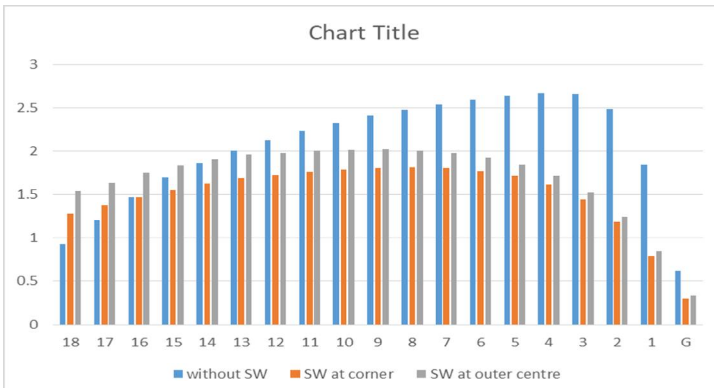


B. Results For Unsymmetrical

1) Storey Drift

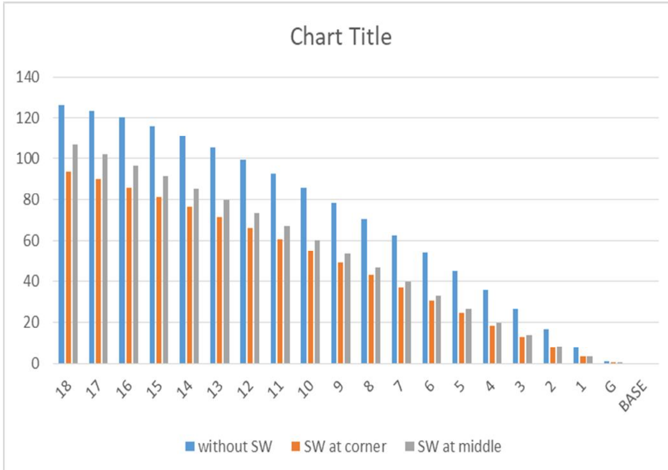
STOREY	without SW	SW at corner	SW at outer centre
18	0.927	1.283	1.541
17	1.198	1.372	1.635
16	1.473	1.467	1.751
15	1.696	1.553	1.84
14	1.867	1.626	1.91
13	2.006	1.685	1.962
12	2.126	1.726	1.978

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



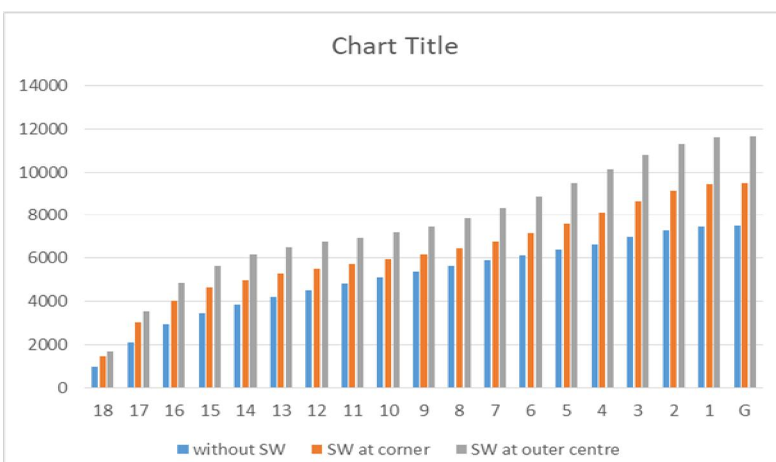
2) *Joint Displacement*

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



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