Effective Location of Shear Walls in G+20 Building for High Seismic Zone

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Abstract- *Lateral load resisting systems have now become a major structural element in a building to resist seismic and wind loads acting on it. The main purpose of these systems is to reduce the amplitude of a building during the action of these forces, and hence minimize the damage caused due to them. Furthermore, in high rise buildings, adequate stiffness of the structure plays a major role in inviting less effect of lateral loads (i.e. more the stiffness, less is the effect of lateral loads). Lateral load resisting systems play a major role in providing this required stiffness to the structure. The behaviour of shear wall as a lateral load resisting system has been studies in this research. Shear walls have high inplane stiffness and thus gives minimum deflection and storey drift, when subjected to lateral loads. The analysis of structure throughout the entire project is done using ETABS software. An effort has been made to calculate and analyze different parameters like storey drift, storey displacement and base shear, when the buildings are incorporated with shear walls. Based on these parameters, we have found out the most effective location of shear walls in G+20 building.*

Keywords:- R.C. frame, Seismic load, shear walls, Storey displacement, Storey drifts, Wind load , etc.

I. INTRODUCTION

RC Shear wall carry earthquake loads down to the foundation. They provide large strength and stiffness to buildings in the direction of their orientation. A large portion of the lateral load on a building, if not the whole amount, as well as the horizontal shear force resulting from the load, are often assigned to such structural elements made of RCC. These shear wall, may be added solely to resist horizontal force, or concrete walls enclosing stairways, elevated shafts, and utility cores may serve as shear walls. Shear wall not only have very large in-plane stiffness and therefore resist lateral load and control deflection very efficiently, but may also help to ensure development of all available plastic hinge locations throughout the structural prior to failure. The other way to resist such load may be to have the rigid frame augmented by the combination of masonry wall. The use of shear wall or their equivalent becomes imperative in certain high-rise buildings, if inter storey deflections caused by lateral loadings are to be controlled. A Well-designed shear walls not only provides adequate safety, but also give a great measure of protection against costly non-structural damage during moderate seismic disturbances. When the aspect ratio (height / length) of structural wall is equal to or exceed 4, the wall is considered as "Slender". If the aspect ratio of wall is equal to or less than 2, it is considered as "Squat". The slender structural wall is governed by flexure and forms a plastic flexural hinge near the base of the wall under lateral load. 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. Shear walls are usually provided along both and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

II. PROBLEM FORMULATION

As per IS 1893 (Part 1): 2002 Clause no. 6.3.1.2, the following load cases have to be considered for analysis:

1.5 (DL + IL)
1.2 (DL + IL ± EL)
1.5 (DL ± EL)
0.9 DL ± 1.5 EL

The most affecting load combination is the last one.

A. Model data

The following data has been considered for the analysis of G+20 building. The building is assumed to be located in seismic zone V. The soil beneath the proposed building is of medium type. Building is designed for residential use.

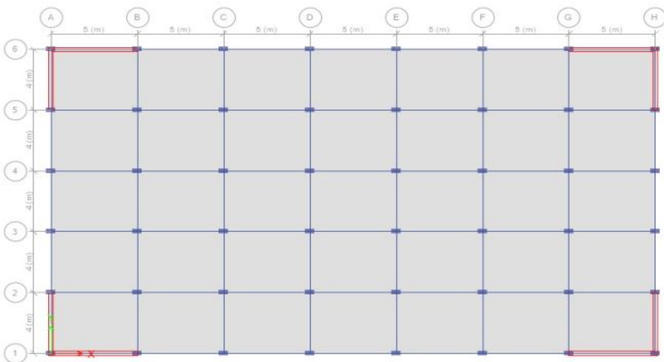
Frame specifications

- Storey : G+20
- Column size : 300x550 mm
- Beam size : 300x450 mm
- Slab thickness = 150 mm
- Grade of concrete : M25
- Density of concrete : 25kN/m³

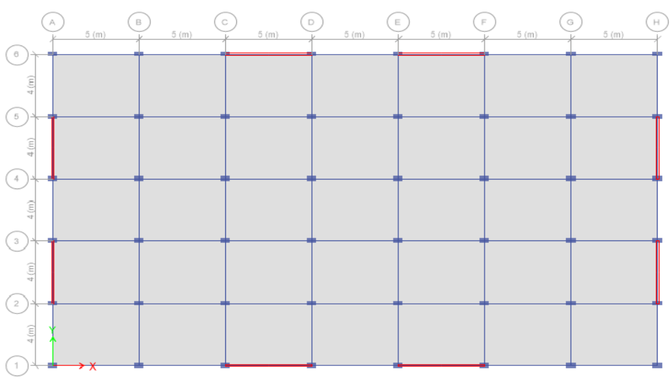
Shear walls are incorporated at different locations as follows:

- Storey height = 3m
- density of masonry = 20 kN/m³
- Thickness of external masonry wall = 150 mm
- Thickness of shear wall = 120 mm
- Zone factor(Z) : 0.36
- Importance factor(I) : 1
- Response reduction factor (R) : 5

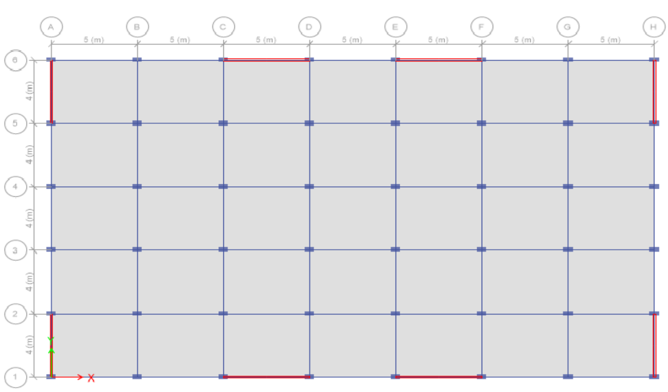
1. Shear walls at corners in X and Y direction



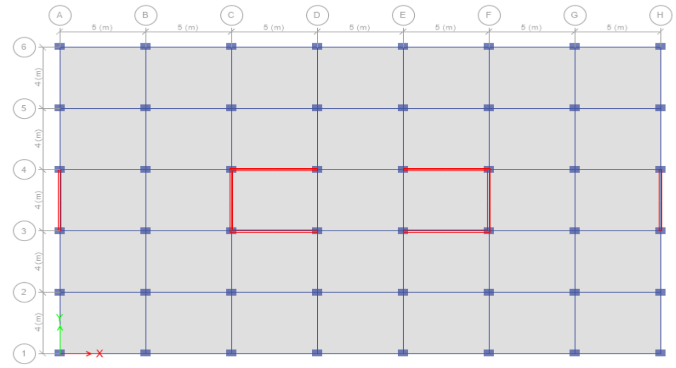
2. Shear walls at one bay away from the centre on all the phases in X and Y direction



3. Shear walls at two bays away from the centre in X direction and one bay away from the centre in Y direction.



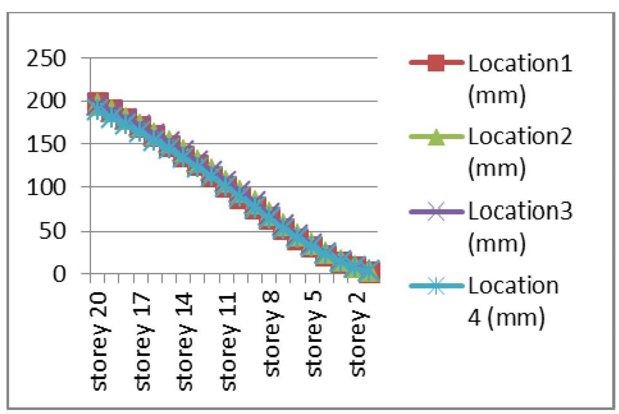
4. Shear walls around the lift and at central bay in Y direction.



III. RESULTS AND DISCUSSIONS

Displacement in X-direction due to seismic load.

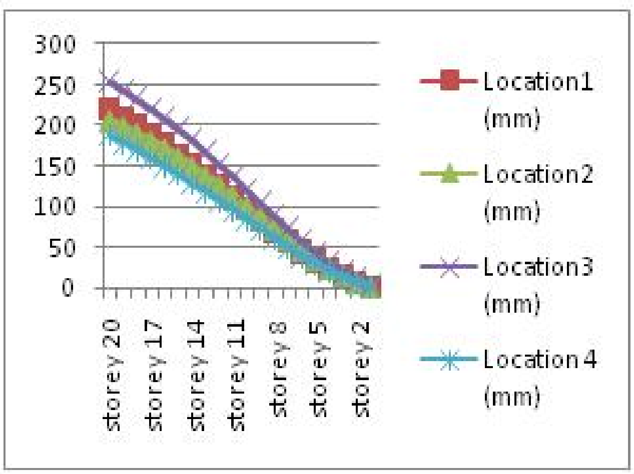
storey	Location1 (mm)	Location2 (mm)	Location3 (mm)	location4 (mm)
20	198.4	194.9	194.6	188.7
19	189.2	187.4	187.1	180.8
18	179.5	179.4	179.1	172.4
17	169.4	170.8	170.6	163.6
16	158.8	161.6	161.4	154.2
15	147.8	151.7	151.5	144.2
14	136.3	141.2	141	133.7
13	124.6	130.1	129.9	122.8
12	112.5	118.5	118.3	111.4
11	100.2	106.4	106.3	99.8
10	87.9	94.1	94.1	87.9
9	75.7	81.7	81.6	76.1
8	63.7	69.3	69.3	64.3
7	52.1	57.1	57.1	52.8
6	41	45.3	45.3	41.8
5	30.8	34.2	34.2	31.5
4	21.5	24	24	22
3	13.4	15.1	15.1	13.8
2	6.9	7.7	7.7	7.1
1	2.3	2.5	2.5	2.4



Displacement in X-direction due to seismic load.

Displacement in Y-direction due to seismic load.

storey	Location1 (mm)	Location2 (mm)	Location3 (mm)	location 4 (mm)
20	219.1	205.6	253.3	186.8
19	208.9	197.7	242.9	178.1
18	198.3	189.3	231.9	169
17	187.3	180.3	220.3	159.6
16	175.7	170.6	208	149.7
15	163.6	160.2	194.8	139.3
14	151	149.1	180.9	128.6
13	138	137.5	166.4	117.6
12	124.7	125.3	151.2	106.3
11	111.2	112.7	135.6	94.8
10	97.7	99.8	119.7	83.3
9	84.1	86.7	103.6	71.9
8	70.8	73.7	87.7	60.7
7	57.9	60.9	72.1	49.8
6	45.7	48.4	57	39.4
5	34.2	36.6	42.8	29.7
4	23.9	25.8	29.9	20.9
3	14.9	16.2	18.6	13.2
2	7.6	8.3	9.4	6.9
1	2.5	2.7	2.9	2.3

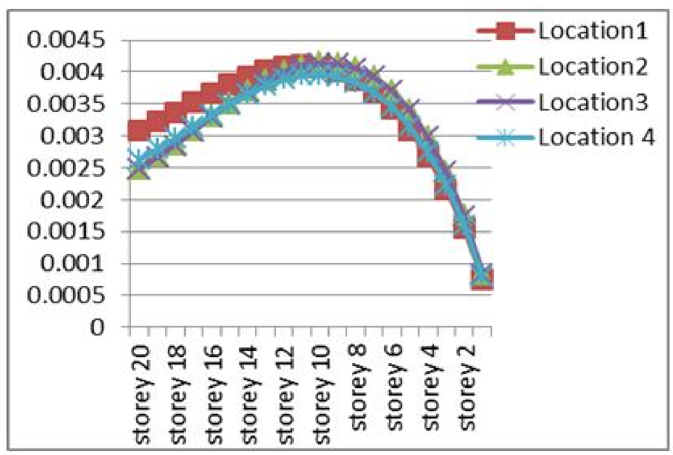


Displacement in Y-direction due to seismic load.

Note: The amount of shear walls is kept same in all the models to get more generalized and practical results.

Storey drift in X-direction due to earthquake

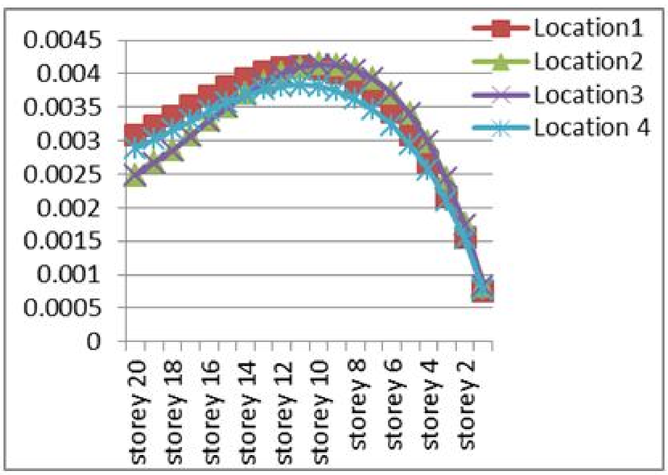
storey	Location1	Location2	Location3	location 4
20	0.003078	0.002491	0.002483	0.002628
19	0.003234	0.002673	0.002664	0.002794
18	0.003371	0.002862	0.002853	0.002954
17	0.003523	0.003077	0.003069	0.003136
16	0.003673	0.003297	0.003289	0.00332
15	0.003812	0.00351	0.003502	0.003495
14	0.003931	0.003704	0.003697	0.003653
13	0.004023	0.003872	0.003865	0.003784
12	0.004082	0.004005	0.003998	0.003883
11	**0.004101**	0.004097	0.004091	0.003942
10	0.004076	**0.004142**	**0.004136**	**0.003957**
9	0.004002	0.004133	0.004128	0.003922
8	0.003873	0.004064	0.00406	0.00383
7	0.003683	0.003926	0.003922	0.003674
6	0.003426	0.00371	0.003706	0.003447
5	0.003094	0.003401	0.003398	0.003138
4	0.002679	0.002985	0.002983	0.002737
3	0.002169	0.002441	0.002439	0.002227
2	0.001551	0.001747	0.001746	0.001597
1	0.00076	0.000834	0.000833	0.000784



Storey drift in X-direction due to earthquake

Storey drift in Y-direction due to earthquake

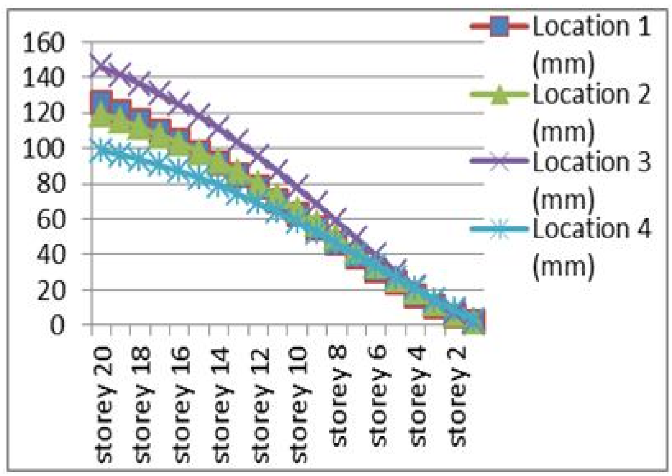
storey	Location1	Location2	Location3	location 4
20	0.003522	0.00249	0.0036	0.002886
19	0.003664	0.00267	0.003782	0.003016
18	0.003825	0.00286	0.004009	0.003155
17	0.004002	0.00308	0.00427	0.003302
16	0.004179	0.0033	0.004541	0.003445
15	0.004344	0.00351	0.004803	0.003575
14	0.004488	0.0037	0.005042	0.003684
13	0.004601	0.00387	0.005246	0.003767
12	0.004675	0.00401	0.005405	0.003818
11	**0.004705**	0.0041	0.00551	**0.003834**
10	0.004685	**0.00414**	**0.005553**	0.003809
9	0.004607	0.00413	0.005525	0.003741
8	0.004466	0.00406	0.005417	0.003626
7	0.004255	0.00393	0.005218	0.003457
6	0.003965	0.00371	0.004914	0.00323
5	0.003588	0.0034	0.004489	0.002937
4	0.00311	0.00299	0.00392	0.002568
3	0.002516	0.00244	0.003179	0.002105
2	0.001784	0.00175	0.002234	0.001526
1	0.00086	0.00083	0.001023	0.00077



Storey drift in Y-direction due to earthquake

Displacement in X-direction due to wind load

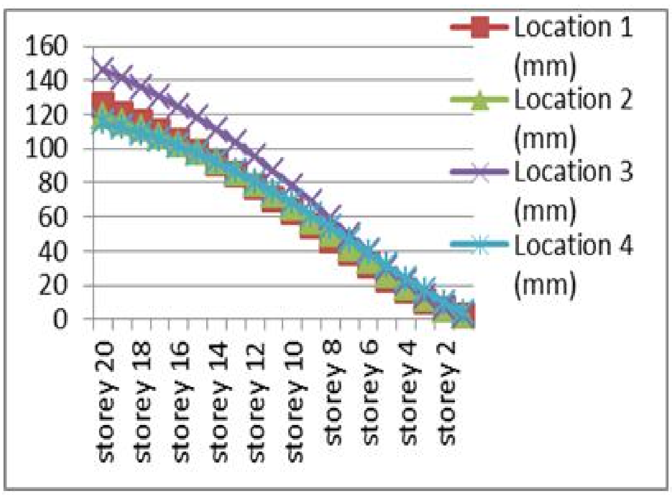
storey	Location1 (mm)	Location2 (mm)	Location3 (mm)	location 4 (mm)
20	125.5	119.3	146.2	98.6
19	120.5	115.6	141.3	96.3
18	115.3	111.7	136.1	93.5
17	109.8	107.4	130.6	90.5
16	104.1	102.8	124.6	87
15	98	97.7	118.1	83.2
14	91.5	92.2	111.1	79
13	84.7	86.1	103.5	74.4
12	77.6	79.7	95.4	69.4
11	70.2	72.8	86.8	64
10	62.5	65.5	77.8	58.3
9	54.7	57.8	68.5	52.4
8	46.8	50	58.9	46.2
7	38.9	42	49.2	39.8
6	31.2	34	39.5	33.3
5	23.8	26.2	30.2	26.8
4	16.9	18.8	21.5	20.4
3	10.8	12	13.6	14.2
2	5.7	6.3	7	8.5
1	1.9	2.1	2.3	3.3



Displacement in X-direction due to wind load

Displacement in Y-direction due to wind load

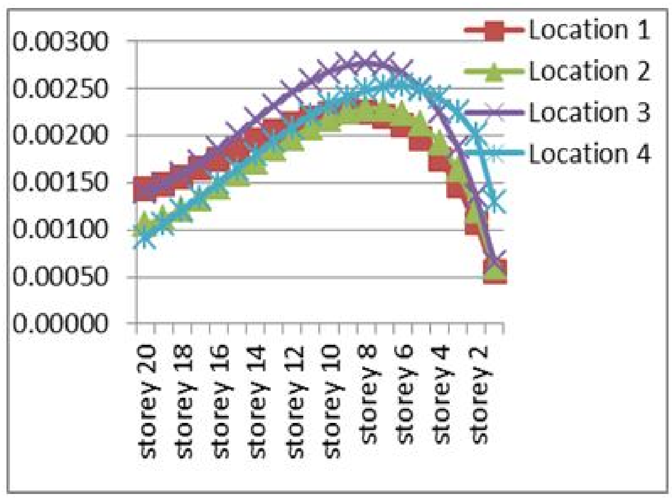
storey	Location1 (mm)	location2 (mm)	location3 (mm)	location4 (mm)
20	125.5	119.3	146.2	115.1
19	120.5	115.6	141.3	112.3
18	115.3	111.7	136.1	109.1
17	109.8	107.4	130.6	105.5
16	104.1	102.8	124.6	101.5
15	98	97.7	118.1	97.1
14	91.5	92.2	111.1	92.1
13	84.7	86.1	103.5	86.7
12	77.6	79.7	95.4	80.9
11	70.2	72.8	86.8	74.7
10	62.5	65.5	77.8	68.1
9	54.7	57.8	68.5	61.1
8	46.8	50	58.9	53.9
7	38.9	42	49.2	46.4
6	31.2	34	39.5	38.8
5	23.8	26.2	30.2	31.3
4	16.9	18.8	21.5	23.8
3	10.8	12	13.6	16.6
2	5.7	6.3	7	9.9
1	1.9	2.1	2.3	3.9



Displacement in Y-direction due to wind load

Storey drift in X-direction due to wind load

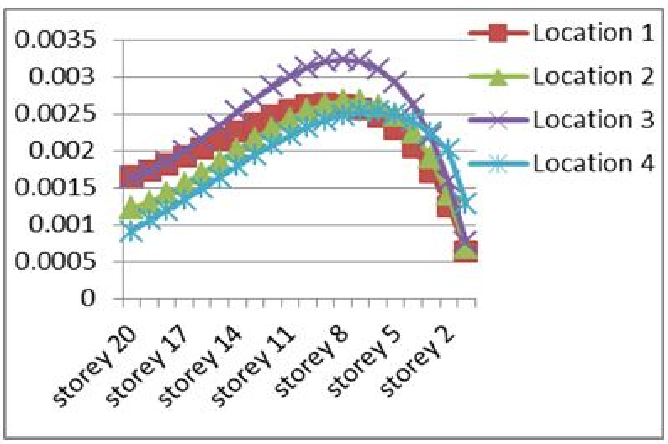
	location1	location2	location 3	location 4
20	0.001426	0.00105	0.001404	0.00091
19	0.001484	0.00112	0.001479	0.00106
18	0.001557	0.001213	0.001582	0.00120
17	0.001645	0.001327	0.00171	0.00134
16	0.001742	0.001453	0.001854	0.00149
15	0.001843	0.001585	0.002007	0.00164
14	0.001943	0.001719	0.002162	0.00179
13	0.002038	0.00185	0.002312	0.00194
12	0.002121	0.001973	0.002452	0.00208
11	0.00219	0.002083	0.002575	0.00221
10	0.002238	0.002176	0.002674	0.00232
9	**0.002261**	0.002246	0.002742	0.00241
8	0.002252	**0.002284**	**0.002771**	0.00248
7	0.002205	0.002284	0.002749	0.00252
6	0.002112	0.002233	0.002665	**0.00253**
5	0.001964	0.00212	0.002503	0.00249
4	0.00175	0.001926	0.002247	0.00240
3	0.001459	0.00163	0.001874	0.00224
2	0.001071	0.001205	0.001358	0.00201
1	0.000548	0.0006	0.000653	0.00129



Storey drift in X-direction due to wind load

Storey drift in Y-direction due to wind load

	location1	location2	location3	location 4
20	0.001663	0.001225	0.001638	0.00091
19	0.001731	0.001307	0.001726	0.00106
18	0.001816	0.001415	0.001846	0.00120
17	0.001919	0.001548	0.001995	0.00134
16	0.002033	0.001695	0.002163	0.00149
15	0.002151	0.001849	0.002341	0.00164
14	0.002267	0.002006	0.002522	0.00179
13	0.002377	0.002158	0.002697	0.00194
12	0.002475	0.002302	0.00286	0.00208
11	0.002555	0.002431	0.003004	0.00221
10	0.002612	0.002539	0.00312	0.00232
9	0.002638	0.00262	0.0032	0.00241
8	0.002627	0.002665	0.003232	0.00248
7	0.002572	0.002664	0.003207	0.00252
6	0.002464	0.002606	0.003109	0.00253
5	0.002291	0.002473	0.00292	0.00249
4	0.002042	0.002247	0.002621	0.00240
3	0.001702	0.001901	0.002186	0.00224
2	0.00125	0.001405	0.001584	0.00201
1	0.00064	0.0007	0.000762	0.00129



Storey drift in Y-direction due to wind load

IV. CONCLUSIONS

- Lateral displacements in X-direction is less than that in Y-direction, because the total number of bays resisting the lateral load is more in X-direction compared to that in Y-direction.
- Amongst all the four locations considered, the displacement is minimum in case of location 4 when subjected to seismic force in both the directions.
- Similarly, in case of wind load also location 4 shows the best behaviour in terms of displacement in both the directions.
- Peak storey drift is minimum for location 1 in X-direction, but in Y-direction, location 4 shows the minimum peak storey drift, when subjected to seismic force and wind load.
- From above all observations, location 4 can be considered as most effective location for shear walls in G+20 building.

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