

Analysis and Design of g+12 storey building with shear wall effect with two basements

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ABSTRACT - Now a day's most of the earth quake resistant buildings are provided with shear walls hence I included shear wall in my model. The main objects of this study were to investigate the behavior of multi storey building with and without basement walls with shear wall effect. For the study two models of G+12 storey buildings with two basements along with shear wall are considered. The building has six bays in X1 direction and six bays in X3 direction with the plan dimension of 26m × 26m. The constructing is kept symmetric in both orthogonal instructions in plan to avoid torsional reaction. Underneath pure lateral forces the orientation and length of columns is kept same throughout the height of the structure.

Key Words: earth quake resistant buildings, multi storey building, multi storey building with basement walls with shear wall effect, multi storey building without basement walls with shear wall effect

1. INTRODUCTION:

When a structure is subjected to ground motions in Associate in nursing earthquake, it responds by moving. The random motions of the bottom caused by Associate in nursing earthquake are often resolved in any 3 reciprocally Perpendicular directions: the 2 horizontal directions (x and z) and also the vertical direction (y). This motion causes the structure to vibrate or shake all told 3 directions; the predominant direction of shaking is horizontal. All the structures square measure primarily designed for gravity hundreds force adequate to mass time's gravity within the vertical direction. Thanks to the inherent issue of safety employed in the look specifications, most structures tend to be adequately protected against vertical shaking. Generally, however, the inertia forces generated by the horizontal parts of ground motion need bigger thought in seismic style. Earthquake generated vertical inertia force should be thought-about within the style unless checked and proved to be insignificant, In general, buildings aren't notably liable to vertical ground motion, however its result ought to be borne in mind within the style of RCC columns, steel column connections, and pre-stressed beams. Vertical acceleration ought to even be thought-about in structures with massive spans, those within which stability may be a criterion for style, or for overall stability analysis of structures with massive spans. Structures designed just for vertical shaking, in general, might not be able to safely sustain the result of

horizontal shaking. Hence, it's necessary to confirm that the structure is sufficiently immune to horizontal earthquake shaking too.

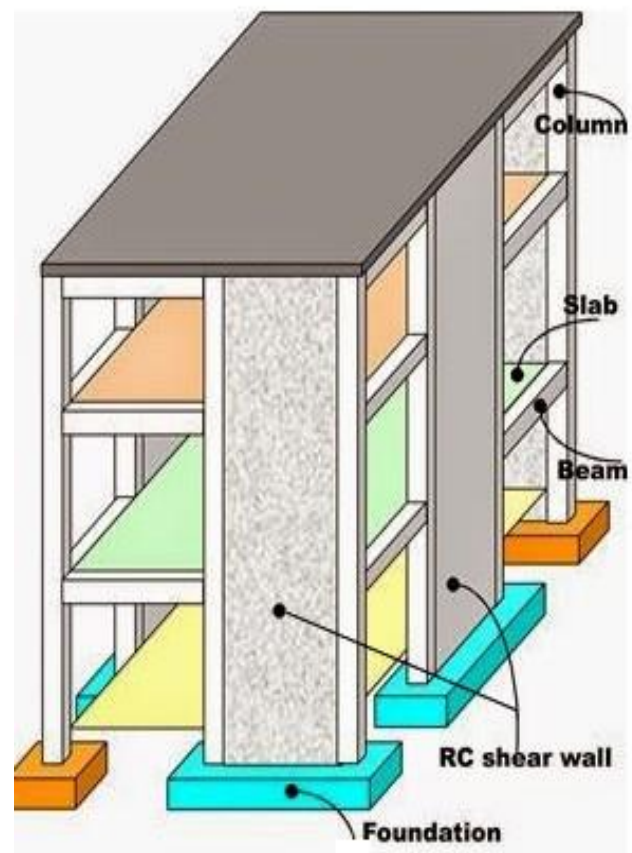


Fig -1: Reinforced shear walls in buildings

Table -1: Important features of building

1	Type of structure	Multi storey special moment resisting frame
2	Zone	3
3	Layout	As shown in fig 6.1
4	Number of stories	G+12 storey building with shear wall
5	Number of basements	2
6	Floor to floor height	3 m
7	External walls	230 mm
8	Internal walls	150 mm

9	Live load	3 kN/m ²
10	Material	M 25 and Fe415
11	Seismic analysis	Response Spectrum Method (IS 1893 (Part 1): 2002
12	Design philosophy	Limit state method conforming to IS 456 : 2000
13	Size of column	0.45 × 0.6 m
14	Size of beams in longitudinal and transverse direction	0.3 × 0.45 m
15	Thickness of slab	0.15 m
16	Thickness of basement wall	0.2 m
	Thickness of shear wall	0.2 m
17	Response reduction factor	5
18	Importance factor	1

2. MODELS CONSIDERED FOR ANALYSIS

Following two models are analysed as special moment resisting frame using response spectrum analysis. Model 1: G+12 storey building with two basements without basement walls along the effect of shear wall. Model 2: G+12 storey building with two basements with basement walls along the effect of shear wall.

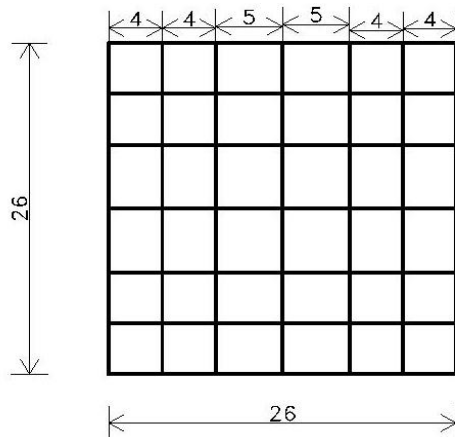


Fig -2: layout of building (all dimensions in meters)

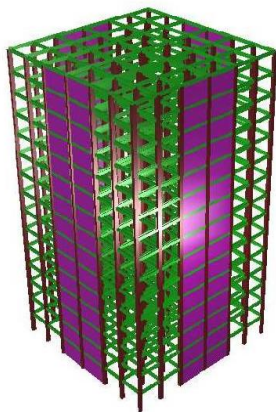


Fig -3: Isometric view of G+12 storey building with shear wall without basement walls.

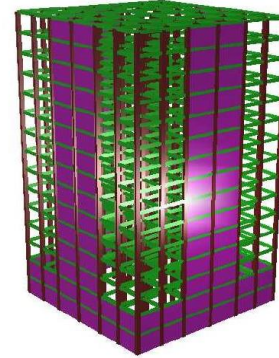


Fig -4: Isometric view of G+12 storey building with shear wall along with basement walls.

3. LOAD COMBINATIONS

The load combinations used for the seismic analysis are

- 1) 1.5(DL+LL)
- 2) 1.2(DL+LL+EQX1)
- 3) 1.2(DL+LL-EQX1)
- 4) 1.2(DL+LL+EQX3)
- 5) 1.2(DL+LL-EQX3)
- 6) DL+1.5EQX1
- 7) DL-1.5EQX1
- 8) DL+1.5EQX3
- 9) DL-1.5EQX3

Response spectrum analysis has been performed as per IS 1893 (part- 1) 2002 for each model using STRAP software. Lateral load calculation and its distribution along the height is done. The seismic weight is calculated using full dead load plus 25% of live load. The results obtained are tabulated as following parameters.

4. COMPARISON OF RESULTS

4.1 Comparison of modal results

Table -2: Modal results of G+12 storey building with two basements without basement walls along with shear wall effect

Mode	Mass participation	Time period	Frequency
1	0.726	1.6306	0.7515
2	0.071	0.6366	1.5709
3	0.044	0.5040	1.9842
4	0.020	0.4148	2.4107
5	0.010	0.3470	2.8821
6	0.007	0.3106	3.220
7	0.015	0.2994	3.3399
8	0.001	0.2846	3.5140
9	0.003	0.2362	4.2337

Mode	Mass participation	Time period	Frequency
10	0.003	0.2312	4.3244
11	0.008	0.2291	4.3652
	0.908		

Table -3: Modal results of 15 storey building with shear wall including 2 basements with basement walls

Mode	Mass participation	Time period	Frequency
1	0.782	1.2545	0.7971
2	0.058	0.6264	1.5963
3	0.056	0.4861	2.0572
4	0.011	0.4012	2.4923
	0.907		

It is observed that building without basement walls gives higher time period compared to building with basement walls. Due to inclusion of basement walls, time period is reduced. It is also shows that time period are reduced by shear wall when compared with first case buildings without shear wall.

4.2 Comparison of storey forces and storey shears

Table -4: Storey shears and storey forces (kN) in X1 Direction

Storey	Without basement walls		With basement walls	
	Storey shears	Storey forces	Storey shears	Storey forces
2 Basement	2034.21	38.86	1869.89	0
1 Basement	2019.17	97.01	1869.89	2.6
Ground	1980.34	136.82	1869.89	87.31
1	1921.94	153.05	1821.45	115.56
2	1848.21	160.14	1754.90	133.01
3	1759.74	170.90	1672.88	143.07
4	1656.66	181.38	1576.35	151.10
5	1540.20	185.80	1464.78	160.45
6	1410.05	189.82	1337.28	170.96
Storey	Without basement walls		With basement walls	
	Storey shears	Storey forces	Storey shears	Storey forces
7	1263.20	200.00	1193.02	181.72
8	1096.81	213.04	1030.75	193.93
9	909.43	226.22	848.35	209.78
10	698.31	244.93	643.58	228.92
11	458.31	270.18	416.06	247.42
12	189.33	189.33	168.84	168.84

It is observed that due to the effect of shear wall the base shear is increased because the shear wall attracts the most of the lateral forces and reduces time period. Due to inclusion of basement walls the structure is assumed to be fixed at ground level and no storey shear is observed at basement storeys.

4.3 Comparison of Lateral deflection

Table -5: Maximum Lateral deflection (mm) in X1 direction

Storey	Without basement walls	With basement walls
2 Basement	0.8	0
1 Basement	2.2	0
Ground floor	3.7	0.6
1	5.1	1.7
2	6.5	3.0
3	7.7	4.3
4	8.9	5.6
5	10.0	6.7
6	11.0	7.8
7	12.0	8.8
8	12.8	9.8
9	13.5	10.6
10	14.1	11.4
11	14.5	12.1
12	14.8	12.6

Table -6: Maximum Lateral deflection (mm) in X3 direction

Storey	Without basement walls	With basement walls
2 Basement	1	0
1 Basement	2.5	0
Ground floor	4.1	0.7
1	5.5	1.9
2	6.9	3.3
3	8.1	4.6
4	9.3	5.8
5	10.4	7.0
6	11.5	8.1
7	12.4	9.1
Storey	Without basement walls	With basement walls
8	13.3	10.1
9	14.1	11.0
10	14.7	11.8
11	15.1	12.5
12	15.3	13.1

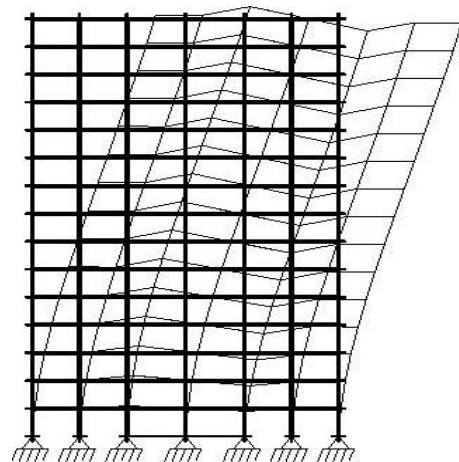


Fig -5: Mode shape of building with shear wall without basement walls

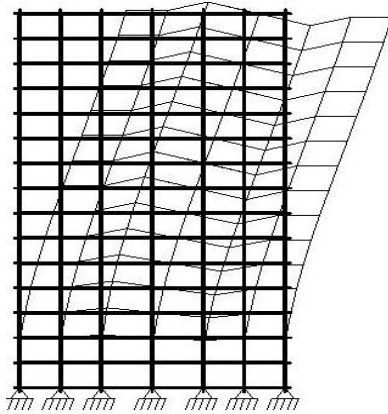


Fig -6: Mode shape of building with shear wall and basement walls

Table -8: Storey Drift (mm) in X3 direction

Storey	Without basement walls	With basement walls
2 Basement	1	0
1 Basement	1.5	0
Ground floor	1.6	0.7
1	1.5	1.2
2	1.5	1.4
3	1.4	1.3
4	1.4	1.2
5	1.4	1.2
6	1.4	1.2
7	1.4	1.2
8	1.3	1.1
9	1.1	1.0
10	1.0	0.8
11	0.8	0.7
12	0.7	0.6

Table -9: Storey Drift (mm) in X3 direction

Storey	Without basement walls	With basement walls
2 Basement	1	0
1 Basement	1.5	0
Ground floor	1.6	0.7
1	1.5	1.2
2	1.5	1.4
3	1.4	1.3
4	1.4	1.2
5	1.4	1.2
6	1.4	1.2
7	1.4	1.2
8	1.3	1.1
9	1.1	1.0
10	1.0	0.8
11	0.8	0.7
12	0.7	0.6

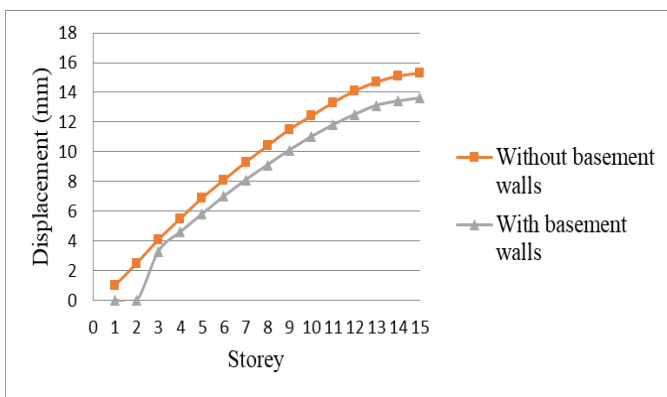


Chart -1: Graph plotted for Lateral displacement vs storey

4.4 Comparison of storey drift

Table -7: Storey Drift (mm) in X1 direction

Storey	Without basement walls	With basement walls
2 Basement	0.8	0
1 Basement	1.4	0
Ground floor	1.5	0.6
1	1.5	1.1
2	1.4	1.3
3	1.4	1.2
4	1.4	1.2
5	1.3	1.2
6	1.3	1.1
7	1.3	1.1
8	1.2	1.0
9	1.1	0.9
10	0.9	0.7
11	0.7	0.6
12	0.7	0.6

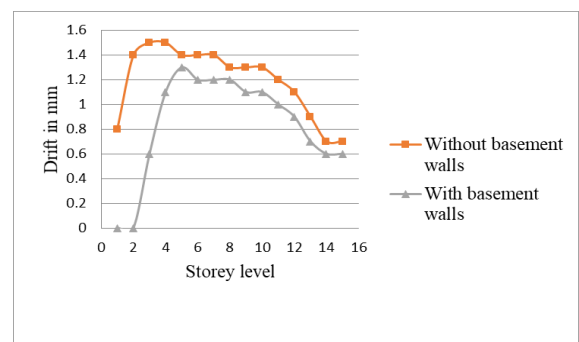


Chart -2: Graph plotted for Storey drift vs Storey

A graph is plotted taking Storey drift on ordinate and the floor level on abscissa for both with and without basement walls. An abrupt change in drift profile indicates the stiffness irregularity. There is sudden change in the slope at first storey. The graph shows the storey drift is maximum for building without basement walls which are having soft storey's, this indicates ductility demand in first storey column for this model is largest. However the storey drift

profile becomes smoother right for building with basement walls indicating large stiffness and less ductility demand. By comparing the graphs we also observed that basement walls are much effective in reducing storey drift and lateral deflection.

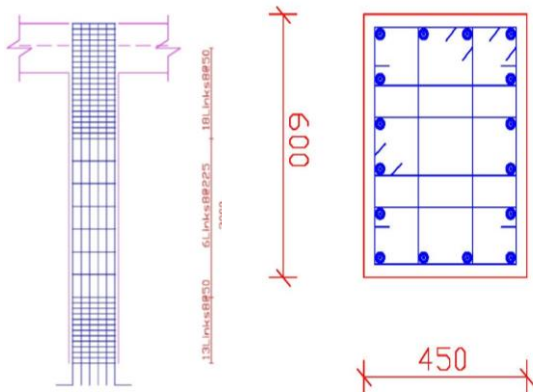


Fig -7: Typical reinforcement arrangement of column without basement walls

Table -10: Storey Drift (mm) in X3 direction

Storey	Member	Axial force		Moments		% of Reinforcement	Capacity
		Design	Actual	M2	M3		
Basement 2	122	4085	4019	44.6	18.4	1.86	1.01
Basement 1	255	3769	3714	58.9	8.5	1.40	1.01
Ground	288	3537	3411	64.1	3.9	1.16	1.03
1	521	3330	3134	65.3	4.12	0.93	1.06
2	654	3354	2882	65.4	5.79	0.93	1.16
3	787	3319	2607	64.9	6.3	0.93	1.27
4	920	3278	2334	64	6.7	0.93	1.40
5	1053	3224	2062.2	63	9	0.93	1.56
6	1186	3204.8	1791.1	62.1	11.1	0.93	1.78
7	1319	3119	1520	61	13.2	0.93	2.04
8	1452	2938	1227	59.3	15.2	0.93	2.38
9	1585	2721	957	53.8	41.8	0.93	2.83
10	1718	2430	690	49.6	40.7	0.93	3.50
11	1851	1873	422	45	40.2	0.93	4.41
12	1984	654	154	38.4	52.5	0.93	4.28

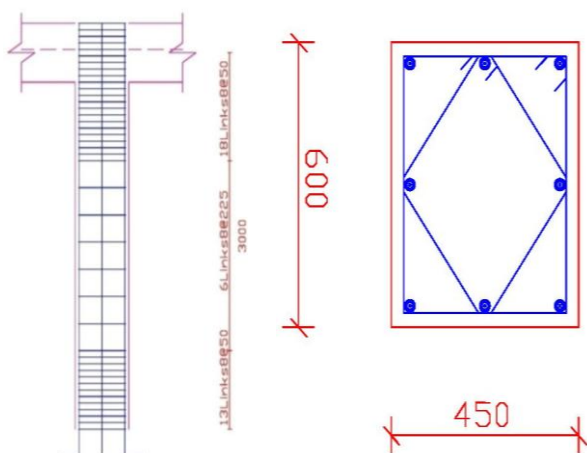


Fig -8: Typical reinforcement arrangement of column with basement walls

Table -11: Design of typical column of G+12 storey building with effect of shear wall and basements

Storey	Mem ber	Axial force		Moments		% of Reinforcement	Capac ity
		Desig n	Actual	M2	M3		
Basement 2	122	4085	4019	44.6	18.4	1.86	1.01
Basement 1	255	3769	3714	58.9	8.5	1.40	1.01
Ground	288	3537	3411	64.1	3.9	1.16	1.03
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11	1851	1873	422	45	40.2	0.93	4.41
12	1984	654	154	38.4	52.5	0.93	4.28

5. Conclusion

From the above the results it is observed that due inclusion of shear walls along with basement walls time periods, roof displacements, axial forces are reduced due to stiffness induced by the shear walls and basement walls. Base shears are increased due to shear walls because most of the lateral forces are attracted by the shear walls. Percentage of reinforcement required in columns without basement walls is more than columns with basement walls. When basement walls are provided no seismic forces are acting on the basement walls only member forces transferred from the super structure are acting on the basement columns.

REFERENCES

- [1] Krishna raju N, "Advanced Reinforced Concrete Design", new age international publications, New Delhi.
- [2] Varghese P.C, "Limit state design of reinforced concrete, 2nd edition", Phi learning publications, New Delhi.
- [3] Ramamrutham.S, "Design of Reinforced Concrete Structures" Dhanpat Rai Publishing Company.
- [4] Chopra A.K. 1995, "Dynamics of Structures", PrenticeHallpublications.
- [5] Irfanulla, Patil, V.B., "Seismic Evaluation of RC Framed Buildings with Influence of Masonry Infill Panel", International Journal of Recent Technology and Engineering (IJRTE), PP 117-118.
- [6] Wakchaure and Ped., "Earthquake Analysis of High Rise Building with and without In filled Walls", International

Journal of Engineering and Innovative Technology (IJEIT), pp 91- 92.

- [7] Lee and Kim, "Efficient seismic analysis of high-rise buildings considering the basements", Journal of the Engineering Mechanics division, ASCE, pp 4.11.01
- [8] Ernesto F. Cruz, and Anil K. Chopra, "Simplified Procedures for Earthquake Analysis of Buildings" Journal of Structural Engineering, Vol. 112, PP- 3.
- [9] Murty C V R and Sudhir K Jain, "Beneficial Influence Of Masonry Infill Walls on Seismic Performance of Rc Frame Buildings" Proceedings of 12th World Conference on Earthquake Engineering 2000.
- [11] Aaroon Rasheed Tamboli and Umesh Karadi. N, "Seismic Analysis of RC Frame Structure with and without Masonry Infill Walls" Indian Journal of Natural Sciences Vol.3 pp -14.
- [13] Shah. H. J, and Jain S.K, "Seismic Analysis of six Storey Building", Document no: IITK-GSDMA-EQ-V-3 final report.
- [14] Balendra T., Tan Y.P. & Lee S.L. 1982. "Simplified dynamic analysis of buildings with basements", Journal of the Engineering Mechanics Division. ASCE, Vol. 108. Pp-895-914.
- [15] IS 456-2000," Plain and Reinforced concrete", Bureau of Indian standards, New Delhi.
- [16] IS-1893 (Part1)-2002, "Criteria for Earthquake Resistant Design of Structures", Bureau of Indian standards, New Delhi.
- [17] IS 875 (PART 1): 1987, "Code of practice for Design loads (other than earthquake) for buildings and structures", Bureau of Indian standards, New Delhi.
- [18] IS 875 (PART 2): 1987, "Code of practice for Design loads (other than earthquake) for buildings and structures", Bureau of Indian standards, New Delhi.
- [19] IS 875 (PART 5): 1987, "Code of practice for Design loads (other than earthquake) for buildings and structures", Bureau of Indian standards, New Delhi.