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Analysis of flat slab building with and without shear wall

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ABSTRACT
The analytical research carried out to study the behaviour flat slab building with and without shear wall reported in the present work. For analysis 15 storied flat slab building is analyzed for seismic behaviour. Response spectrum method is used for analysis considering different shear wall positions using ETABS software. Five different positions of shear wall were studied for analysis. From this analysis shear wall at core having square shape is most suitable case for construction of shear wall.
Keywords: Flat slab, Shear wall, Seismic behaviour.

I. INTRODUCTION

General practice of design and construction is to support the slabs by beams and beams by columns. This may be called as beam-slab construction [1]. The beams reduce the available net clear ceiling height. Reinforced concrete flat slabs are a structural solution widely used nowadays for office, commercial and residential buildings. They present several advantages such as the much reduced and simpler formwork, easy installation of mechanical and electrical infrastructures, the versatility and easier space partitioning and faster site operations, which makes flat slabs an economical and efficient structural system [2]. Shear walls are specially designed structural walls which are incorporated in buildings to resist lateral forces that are produced in the plane of wall due to earthquake, wind and flexural members [3, 4]. It is necessary to analyse seismic behaviour of building for different heights to see what changes are going to occur if the height of conventional RC Frame building and flat slab building changes [5].

II. ANALYTICAL WORK

Response spectrum method is used for seismic analysis of a 15 storied RCC flat slab building with RC shear wall and without shear wall. The different locations of shear walls are used to study the effect of shear wall location on behaviour of building. Shear Wall is a structural system providing stability against lateral force due to its stiffness and lateral strength. The behaviour of building is studied for different parameters like lateral displacement, story drift, story shear, time period, etc.

III. DIFFERENT CASES USED FOR ANALYSIS OF BUILDING

3.1 Different cases were considered to analyse 15 storey building to find out proper position of shear wall.

1. Performance of flat slab building without shear wall.
2. Performance of flat slab building with shear wall.
3. Performance of flat slab building with L type shear wall.
4. Performance of flat slab building with shear wall at periphery.
5. Performance of flat slab building with shear wall
6. Performance of flat slab building with shear wall at core + sign shape.
7. Performance of flat slab building with shear wall at core square sign shape.
8. Performances of flat slab building with shear wall at core C sign shape.

Following figures shows model of different cases done in ETABS software.

Fig. 1 Building without shear wall

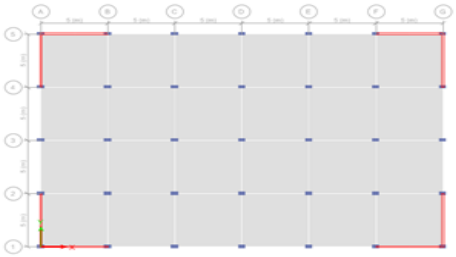


Fig. 2 Building with L type shear wall

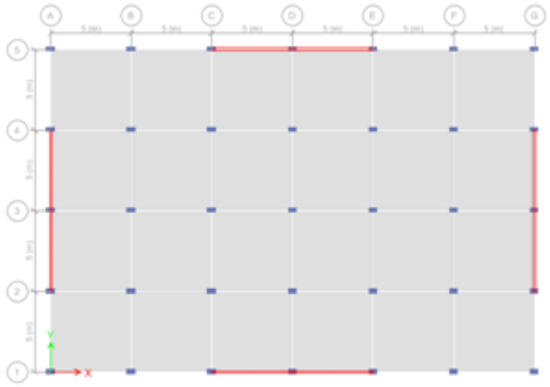


Fig. 3 Building with shear wall at periphery

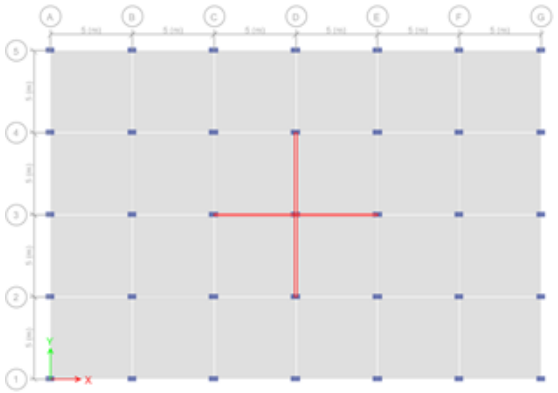


Fig. 4 Building with shear wall at core + sign type

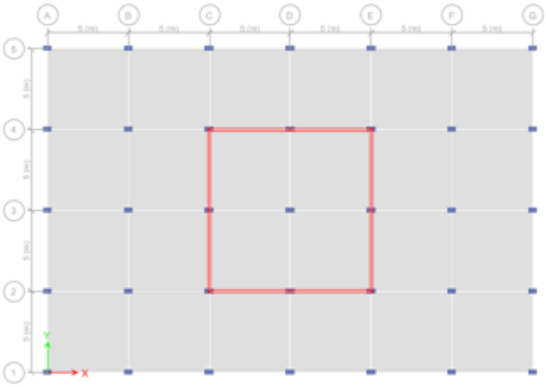


Fig. 5 Building with shear wall at core square type

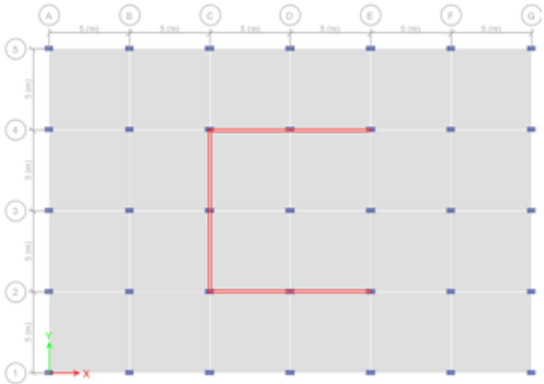


Fig. 6 Building with C type shear wall

3.2 Structural data

Table 1. Details of structural data

Type of structure	RCC 15 story
Zone	V
Floor to floor height	3 m
Thickness of slab	200mm
Shear wall thickness	150 mm
Live load	3 kN/m^2
Floor finish	1 kN/m^2
Column size	550mm x 1350mm

IV. ANALYTICAL RESULTS AND DISCUSSION

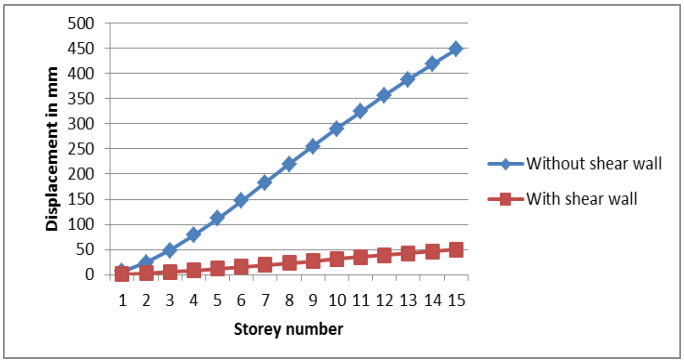
4.1 EFFECT OF SHEAR WALL ON FLAT SLAB BUILDING

a. Story displacement for flat slab building with and without shear wall

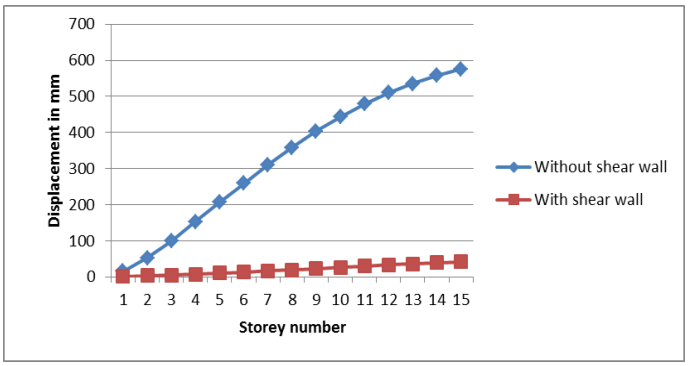
Table 2. Story displacement for flat slab building with and without shear wall

Story	Elevation	Without shear wall (mm)		With shear wall at core square shape (mm)	
	m	X Direction	Y Direction	X Direction	Y Direction
Storey15	45	448.1	575.7	50.2	41.9
Storey14	42	418.5	557.2	46.6	39
Storey13	39	388.2	535.4	42.9	35.9
Storey12	36	356.7	509.4	39	32.8
Storey11	33	324	478.8	35.1	29.5
Storey10	30	290.2	443.3	31.1	26.2
Storey9	27	255.2	403.2	27.1	22.9
Storey8	24	219.5	358.8	23.1	19.6

Storey7	21	183.2	310.7	19.2	16.4
Storey6	18	147.1	259.5	15.5	13.3
Storey5	15	111.9	206.2	12	10.4
Storey4	12	78.5	152.2	8.7	7.6
Storey3	9	48.5	99.5	5.7	5.2
Storey2	6	23.7	51.9	3.1	3
Storey1	3	6.6	15.4	1.1	1.2



Graph1. Comparison of displacement with and without shear wall in X direction



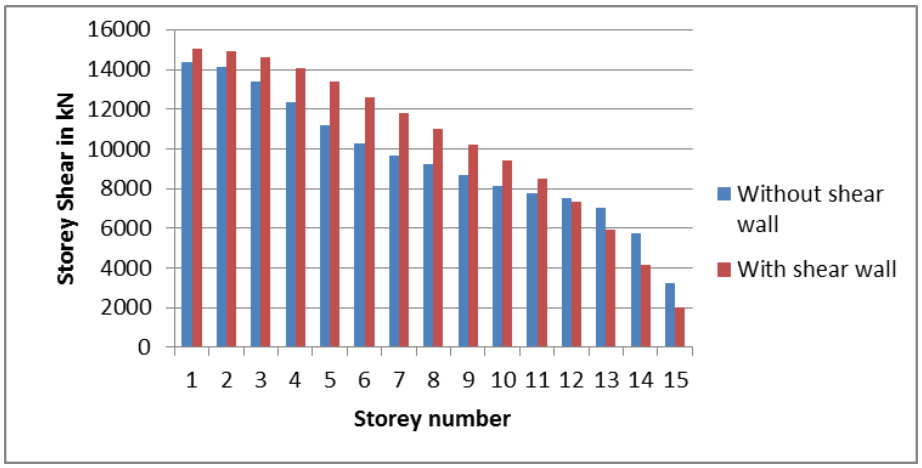
Graph2. Comparison of displacement with and without shear wall in Y direction

From the graph 1 and 2 it is observed that the values of displacement in X direction for building without shear wall is 8.92 times greater than building with shear wall and top storey displacement in Y direction for building without shear wall is 13.73 times greater than building with shear wall.

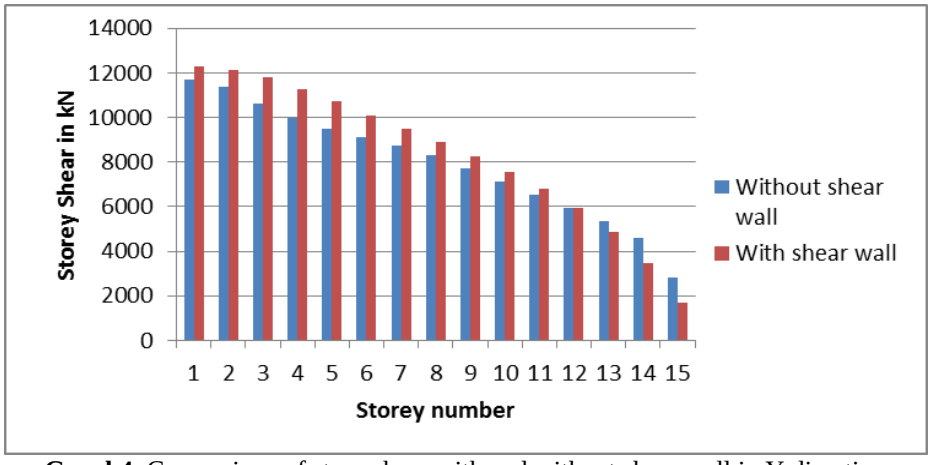
b. Story shear for flat slab building with and without shear wall

Table 3. Story shear of building with and without shear wall

Story	Elevation	Without shear wall (kN)		With shear wall at core square shape (kN)	
	m	X Direction	Y Direction	X Direction	Y Direction
Storey15	45	3259.04	2807.05	2043.672	1701.13
Storey14	42	5733.4	4567.21	4172.92	3442.66
Storey13	39	7003.5	5364.71	5939.182	4844.82
Storey12	36	7494.19	5957.37	7362.964	5946.51
Storey11	33	7751.17	6552.03	8497.364	6824.82
Storey10	30	8154.47	7122.9	9422.925	7565.82
Storey9	27	8705.75	7736.81	10232.27	8236.32
Storey8	24	9220	8303.87	11007.04	8873.68
Storey7	21	9664.84	8734.48	11794.84	9494.97
Storey6	18	10243.9	9122.77	12597.16	10108.7
Storey5	15	11160.5	9509.95	13374.08	10713.9
Storey4	12	12331.5	9952.57	14062.2	11288.6
Storey3	9	13420.3	10633.8	14596.85	11784.5
Storey2	6	14113.3	11378.8	14932.13	12140.1
Storey1	3	14340	11716	15060	12304



Graph3. Comparison of story shear with and without shear wall in X direction



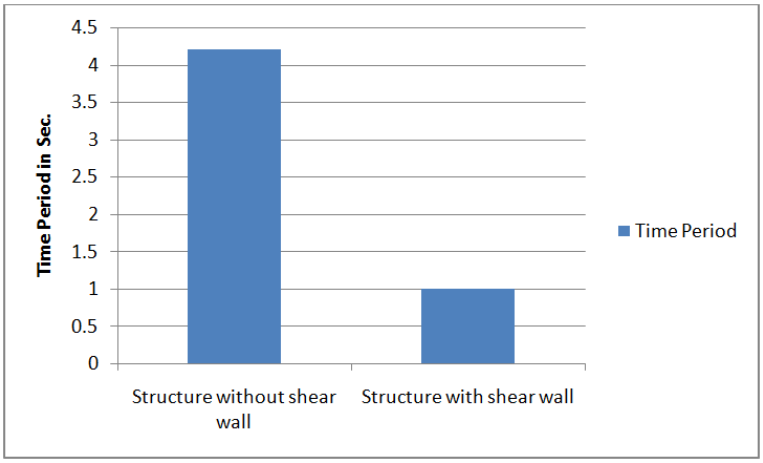
Graph4. Comparison of story shear with and without shear wall in Y direction

From the graph 3 and 4 it is observed that the values of base shear in building provided with shear wall are found near about 5.021% and 4.778% more in X and Y direction respectively.

c. Time period for flat slab building with and without shear wall

Table 4.Time period with and without shear wall

Parameter	Structure without shear wall	Structure With shear wall at core square shape
Time	4.209 Sec.	1.006 Sec.



Graph5 Variation of time period of building

From the graph 5 it is observed that Time period is more for model without shear wall. Model with shear wall have 76.09% less time period than model without shear wall.

d. Story drift for flat slab building with and without shear wall

Table 5. Story drift with and without shear wall

Story	Elevation	Without shear wall		With shear wall at core square shape	
	m	X Direction	Y Direction	X Direction	Y Direction
Storey15	45	0.01085	0.00829	0.001212	0.00099
Storey14	42	0.01123	0.00957	0.001261	0.00104
Storey13	39	0.01164	0.01092	0.001307	0.00108
Storey12	36	0.01201	0.01223	0.001341	0.00111
Storey11	33	0.01229	0.01354	0.001359	0.00113
Storey10	30	0.01249	0.01483	0.001361	0.00113
Storey9	27	0.01259	0.01605	0.001346	0.00112
Storey8	24	0.01257	0.0171	0.001313	0.00109
Storey7	21	0.01238	0.0179	0.001263	0.00105
Storey6	18	0.01196	0.01837	0.001194	0.00099
Storey5	15	0.01123	0.01839	0.001107	0.00092
Storey4	12	0.01005	0.01773	0.000997	0.00084
Storey3	9	0.00827	0.01594	0.000861	0.00073
Storey2	6	0.00572	0.01218	0.000681	0.00061
Storey1	3	0.00219	0.00513	0.000352	0.00039

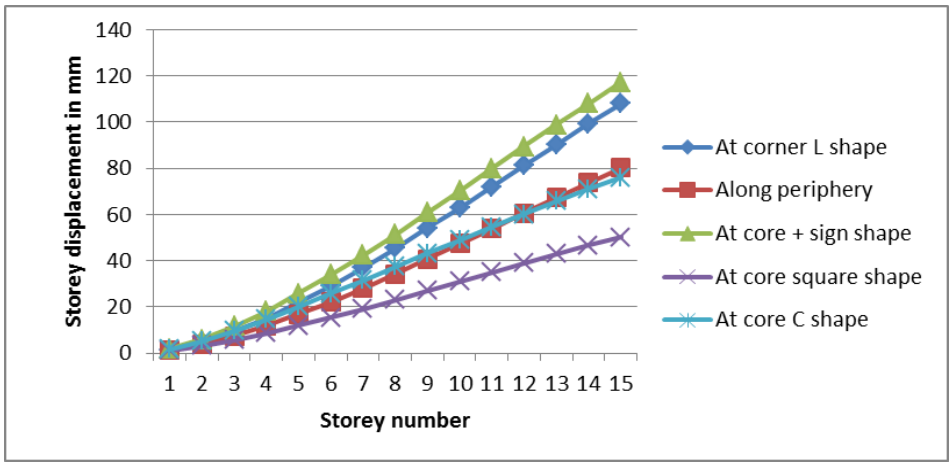
As per IS 1893:2002 maximum storey drift should not be more than 0.004 times to storey height of the structure. Here value of limiting storey drift is 0.012 where height of storey is 3m. Drift values for building without shear wall exceeds the limiting value. Model with shear wall at core square shape gives minimum storey drift as compared with model without shear wall.

4.2 EFFECT OF LOCATION OF SHEAR WALL ON FLAT SLAB BUILDING

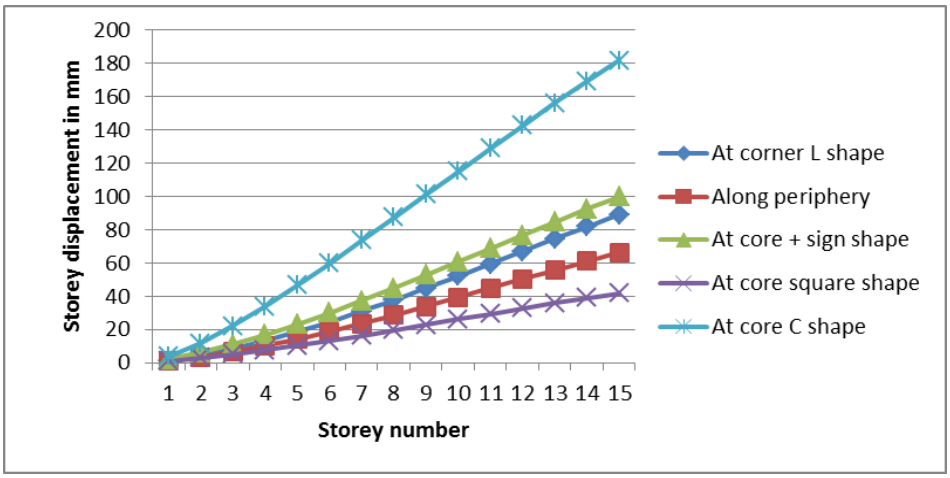
a. Story displacement

Table 6. Variation of story displacement

Story	Elevation	At corner L shape		Along periphery		At core + sign shape		At core square shape		At core C shape	
	m	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.
Storey15	45	108.1	89.1	80.2	66.3	117.2	100	50.2	41.9	76	181.9
Storey14	42	99.2	81.9	73.8	61.1	108.1	92.5	46.6	39	71	169.3
Storey13	39	90.2	74.5	67.3	55.7	98.9	84.7	42.9	35.9	65.7	156.2
Storey12	36	81.1	67.1	60.6	50.3	89.4	76.8	39	32.8	60.2	142.7
Storey11	33	72	59.6	53.9	44.8	79.9	68.7	35.1	29.5	54.6	129
Storey10	30	62.9	52.2	47.3	39.4	70.3	60.7	31.1	26.2	48.9	115.2
Storey9	27	54	44.9	40.7	34	60.8	52.7	27.1	22.9	43.2	101.3
Storey8	24	45.4	37.8	34.3	28.7	51.5	44.9	23.1	19.6	37.4	87.4
Storey7	21	37	31	28.1	23.6	42.5	37.3	19.2	16.4	31.6	73.5
Storey6	18	29.1	24.5	22.2	18.8	33.9	30	15.5	13.3	25.8	59.9
Storey5	15	21.8	18.5	16.8	14.3	25.7	23.1	12	10.4	20.2	46.6
Storey4	12	15.2	13.1	11.8	10.2	18.2	16.8	8.7	7.6	14.7	33.8
Storey3	9	9.5	8.3	7.5	6.6	11.6	11	5.7	5.2	9.6	22
Storey2	6	4.8	4.4	3.9	3.6	6	6.1	3.1	3	5.1	11.7
Storey1	3	1.5	1.5	1.3	1.3	1.9	2.2	1.1	1.2	1.6	3.7



Graph 6. Variation of story displacement in X direction for different position of shear wall



Graph 7. Variation of story displacement in Y direction for different position of shear wall.

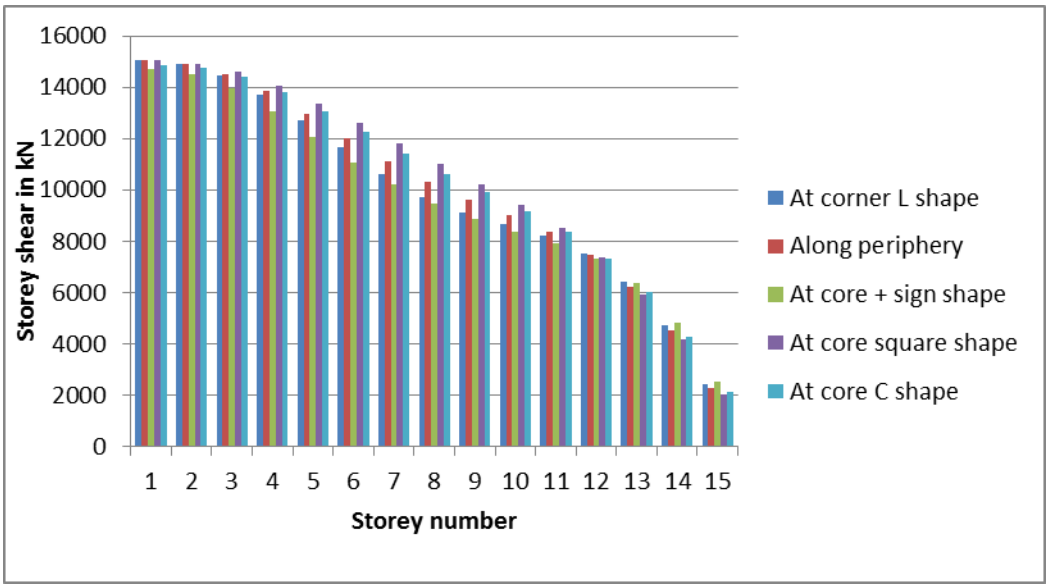
From the graph 6 and 7 it is observed that for structure with shear wall at core square shape have minimum storey displacement and it is maximum for structure with C type shear wall. It is 72.40%, 57.16%, 53.56%, 37.40% less by structure with C type shear wall, + sign type shear wall, L type shear wall and along periphery type shear wall respectively.

b. Storey Shear

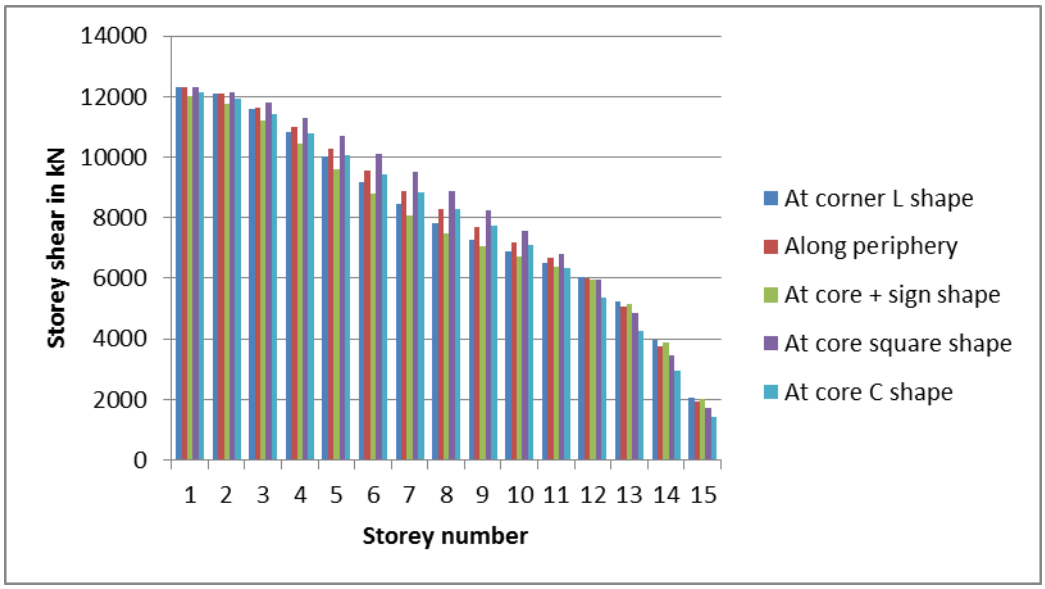
Table 7. Variation of Storey shear for different position of shear wall

Story	Elevation	At corner L shape		Along periphery		At core + sign shape		At core square shape		At core C shape	
	m	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.
Storey15	45	2425.59	2066.36	2272.063	1911.79	2527.639	2017.25	2043.672	1701.13	2123.159	1437.62
Storey14	42	4735.4	3957.45	4512.273	3744.36	4810.734	3876.23	4172.92	3442.66	4272.882	2953.91
Storey13	39	6418.52	5242.67	6234.624	5085.71	6368.364	5155.55	5939.182	4844.82	6002.096	4256.3
Storey12	36	7539.89	6032.23	7486.977	6014.11	7331.341	5938.47	7362.964	5946.51	7343.278	5372.48
Storey11	33	8229.22	6510.61	8368.53	6666.54	7917.166	6390.05	8497.364	6824.82	8367.967	6320.04
Storey10	30	8679.59	6879.55	9024.062	7193.38	8363.142	6706.27	9422.925	7565.82	9180.676	7105.69
Storey9	27	9116.65	7288.77	9618.235	7708.5	8845.273	7046.68	10232.27	8236.32	9899.331	7750.83
Storey8	24	9729.17	7805.5	10289.49	8268.45	9447.031	7495.69	11007.04	8873.68	10624.58	8308.07

Storey7	21	10591.2	8441.18	11102.4	8889.24	10192.74	8078.55	11794.84	9494.97	11409.36	8848.04
Storey6	18	11641.6	9187.13	12030.55	9570.11	11082.53	8793.95	12597.16	10108.7	12245.51	9431.15
Storey5	15	12735.3	10013.4	12980.82	10294.4	12080.04	9614.9	13374.08	10713.9	13074.69	10084.2
Storey4	12	13714.3	10847.2	13837.32	11014.1	13083.61	10467.5	14062.2	11288.6	13814.88	10782.7
Storey3	9	14456.8	11575.4	14499.74	11646.4	13937.56	11230.8	14596.85	11784.5	14388.73	11440.9
Storey2	6	14901.1	12083.2	14908.06	12098.8	14494.25	11774.6	14932.13	12140.1	14745.57	11934.7
Storey1	3	15060	12304	15060	12304	14700	12010	15060	12304	14880	12157



Graph 8. Variation of story shear in X direction for different position of shear wall.



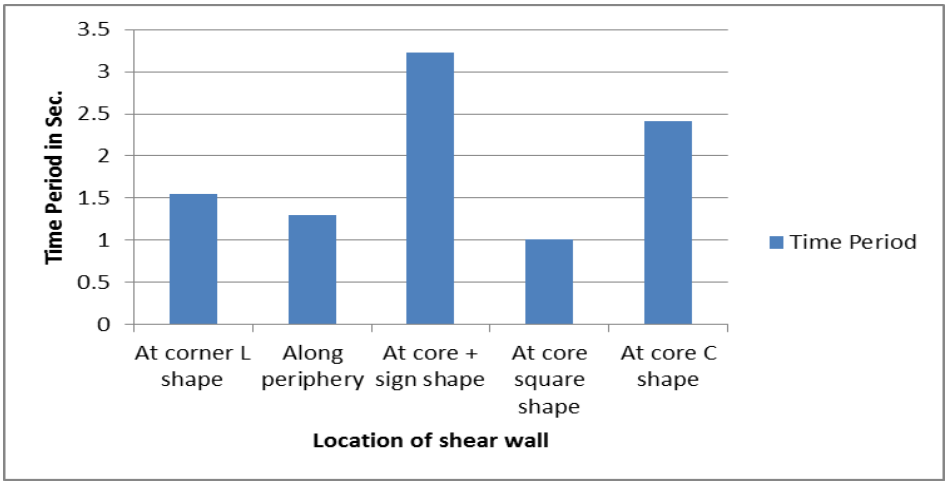
Graph 9. Variation of story shear in Y direction for different position of shear wall.

From the graph it is observed that structure with shear wall at core (square shape), along periphery and at corner have maximum storey shear.

c. Time period

Table 8. Variation of time period for different position of shear wall

At corner L shape	Along periphery	At core + sign shape	At core square shape	At core C shape
1.546 Sec.	1.295 Sec.	3.225 Sec.	1.006 Sec.	2.411 Sec.



Graph 10. Variation of time period of building for different position of shear wall.

From the graph 10 it is observed that time period is maximum for model of shear wall at core (+ sign shape) and minimum for model of shear wall at core square shape and it is about 68.80% lesser than that of building with shear wall at core (+ sign).

d. Story drifts

Table 9. Variation of story drift for different positions of shear wall

Storey	Elevation	At corner L shape		Along periphery		At core + sign shape		At core square shape		At core C shape	
	m	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.	X Dir.	Y Dir.
Storey15	45	0.00301	0.00245	0.002164	0.00176	0.003102	0.00258	0.001212	0.00099	0.001836	0.00453
Storey14	42	0.00306	0.00251	0.002214	0.00182	0.003186	0.00269	0.001261	0.00104	0.001942	0.00478
Storey13	39	0.0031	0.00254	0.002252	0.00185	0.003259	0.00276	0.001307	0.00108	0.002036	0.00498
Storey12	36	0.00311	0.00256	0.002271	0.00187	0.003301	0.0028	0.001341	0.00111	0.002096	0.00511
Storey11	33	0.00309	0.00254	0.002266	0.00187	0.003306	0.00281	0.001359	0.00113	0.00212	0.00515
Storey10	30	0.00304	0.0025	0.002235	0.00184	0.003272	0.00278	0.001361	0.00113	0.002115	0.00512
Storey9	27	0.00295	0.00243	0.002178	0.00179	0.0032	0.00272	0.001346	0.00112	0.002089	0.00504
Storey8	24	0.00282	0.00233	0.002093	0.00173	0.003091	0.00263	0.001313	0.00109	0.002051	0.00492
Storey7	21	0.00266	0.0022	0.001979	0.00163	0.002944	0.00251	0.001263	0.00105	0.002002	0.00477
Storey6	18	0.00246	0.00203	0.001836	0.00152	0.002756	0.00235	0.001194	0.00099	0.001938	0.00459
Storey5	15	0.00222	0.00183	0.001661	0.00138	0.002521	0.00216	0.001107	0.00092	0.001846	0.00434
Storey4	12	0.00192	0.0016	0.001445	0.00121	0.002231	0.00193	0.000997	0.00084	0.001711	0.00398
Storey3	9	0.00156	0.00131	0.001197	0.00101	0.001867	0.00165	0.000861	0.00073	0.001504	0.00347
Storey2	6	0.00112	0.00097	0.000887	0.00078	0.001382	0.00132	0.000681	0.00061	0.001169	0.00267
Storey1	3	0.0005	0.00051	0.000421	0.00044	0.000623	0.00073	0.000352	0.00039	0.000543	0.00123

From the table no. 9 it is observed that the values of the storey drift for all the stories are found to be within the limits i.e. 0.004 times to storey height according to IS 1893:2002 (Part I) [11].

V. CONCLUSIONS

From analysis of 15 storied RCC flat slabs building with provision of shear wall at different location, following conclusions are drawn.

1. The seismic responses in X and Y direction namely base shear for structure with shear wall are found more by 5.021% and 4.778 % than structure without shear wall, storey displacements without shear wall is 88.79% and 92.72% more than with shear wall respectively.
2. For structure with shear wall at core square shape have minimum storey displacement. Storey displacement is uniformly increasing and it is maximum at top floor of the structure. It is 72.40%, 57.16%, 53.56%, 37.40% less by structure with C type shear wall, + sign type shear wall, L type shear wall and along periphery type shear wall respectively.
3. For structure with shear wall at core (square shape), along periphery and at corner have maximum storey shear. It is 1.19%, 2.39% more by structure with C type shear wall, + sign type shear wall respectively.
4. For structure with shear wall at core square shape have minimum storey drift compared to structure with C type shear wall, + sign type shear wall, L type shear wall and along periphery type shear wall respectively. The values of storey drift for all the stories are found to be within the limits i.e. 0.004 times to storey height according to IS 1893:2002 (Part I).
5. For structure with shear wall at core square shape have minimum time period. It is 58.27%, 68.80%, 34.92%, 22.31% less by structure with C type shear wall, + sign type shear wall, L type shear wall and along periphery type shear wall respectively.
6. Structure with shear wall at core square shape is suitable for the effect of earthquake load on the seismic performance.

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