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Effect of Shear Wall on RC Building of Varying Heights

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Abstract: ***Earthquake is an unexpected and expensive disaster for both livelihood and economy. In the modern day construction, there has been a lot of importance to make the structure resistant against lateral loads for multi storied building. Shear walls are an option of lateral load resisting system. The Concept of designing shear wall is to provide building structure with sufficient strength and deformation capacity to sustain the demands imposed by lateral loads with adequate margin of safety. The study focuses on effect of shear wall on R.C. building at different heights. For this purpose five models of different heights 15m, 30m, 45m, 60m and 75m and with different aspect ratios of 1.33, 0.66, 0.44, 0.33 and 0.26 respectively have been considered. All the models were designed for seismic zone V. For analysis purpose response spectrum method of analysis is considered as per IS: 1893-2002. The comparative study has been done for base shear, storey displacement, storey drift and storey stiffness. Utilization of shear walls when placed at corners of the building of low aspect ratio in high rise buildings is more effective compared to the low rise buildings of higher aspect ratio, as it gives the larger base shear and lesser displacement. The storey stiffness and storey drift is greatly improved when shear wall is placed at corners of the building.***

Keyword**:** ***Aspect Ratio, Base Shear, Different Heights, Shear wall, Displacement.***

I. INTRODUCTION

1.1 General:

Due to the rapid growth of the world's population and decrease of land to accommodate new trend of construction has been developed. In this trend or strategy the buildings which are constructed are not expanding on the ground but they are expanding towards sky or increasing in height. As the time is passing the architects are designing the structures or buildings which want to talk to the sky. Thus this buildings needs to be designed with most priority so that it can withstand the major natural hazard since this buildings gives shelter to many and are used for various purposes. As the height of the structure increases it becomes more intense to lateral loads. Thus buildings are designed to resist the lateral load such as earthquake forces, wind forces etc.

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To resist this lateral force the functional planning of a building affects the way in which it can accommodate its structural skeleton.

The lateral load is resisted by using bearing wall or shear wall, moment resisting frames, dual system, and tube system. Two main types of structural systems, which are concrete frame systems and concrete frame-wall systems, which are used by civil engineers are the external vertical and horizontal loads for concrete structures. Experimental and analytical research demonstrated that the concrete frame wall buildings have display better seismic performance and resistance compared to concrete frame system. In order to design a structure to resist earthquake loads, the forces on the structure must be specified. The exact forces that will occur during the life of the structure cannot be anticipated. Most National Building Codes identify some factors according to the boundary conditions of each building considered in the analysis to provide for life safety. A realistic estimate for these factors is important. However the cost of construction and therefore the economic viability of the projects are essential.

II. OBJECTIVE OF THE STUDY

1. To analyse and compare the behaviour of structure of RC buildings of different heights, which can withstand the effect of earthquake loads by using shear wall.
2. Considering 5, 10, 15, 20 and 25-storey high rise structures to study and compare the various parameters like- Base shear, Displacement, Storey Drift and Storey stiffness.
3. For earthquake analysis Response spectrum method has been used.

III. ANALYTICAL STUDY

A. Modeling and material properties

In this work, five models of different heights are considered to understand the seismic behavior of RC shear wall. The building frames are assumed to be located in Indian seismic zone V with type II soil conditions. Modelling consists of building details, load combinations, application of Response spectrum in ETABS and building models. The characteristic strength of concrete M30 and steel were taken as Fe500

Table- I: Details of structural Elements and material data

No. Of storeys	5, 10, 15, 20, 25
Story height	3.00 m
Grade of concrete	M30
Grade of steel	HYSD Fe 500
Thickness of slab	0.150m
Shear wall thickness	150

Seismic zone	V
Exterior wall	12 kN/m
Parapet wall	4 kN/m
Live load on slab	3 kN/m^2

Table- I shows the structural element's dimensions and materials used, dimensions of the plan 4 x 4, no. of storeys taken for the modeling, storey height, grade of concrete and steel, thickness of slab and shear wall considered, seismic zone of the place considered as per IS: 1893- 2016(part-I), super dead loads of exterior and parapet walls and live load on the slab considered.

Table- II and III Shows the beam and column sizes considered for the different heights of the building, to make the structure as per the IS: 456-2000.

Table- II: Beam Sizes for Different storeys

Beam Size	5 STOREY	230X300
	10 STOREY	300X320
	15 STOREY	300X340
	20 STOREY	300X360
	25 STOREY	300X350

Table- III: Column Sizes for Different storeys

Column Size	5 STOREY	300X300
	10 STOREY	350X350
	15 STOREY	500X500
	20 STOREY	500X500
	25 STOREY	550X550

B. Load Combinations:

Following load combinations with the appropriate partial safety factor satisfying IS code provision i.e.IS 456:2000, table 18, clause 18.2.3.1 and IS 1893:2002, clauses 6.3.2.1 are shown in table –IV

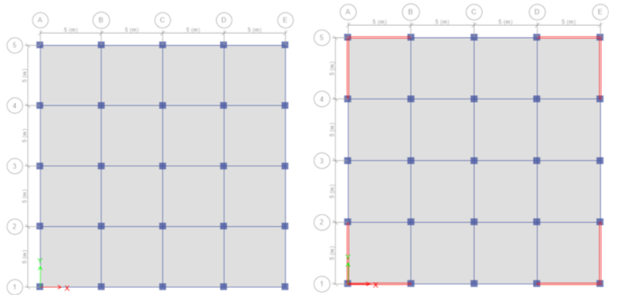
Table- IV: Load combinations considered

S. No.	Load combinations
1	1.5(DL + LL)
2	1.2(DL + LL + EQX)
3	1.2(DL + LL - EQX)
4	1.2(DL + LL + EQY)
5	1.2(DL + LL - EQY)
6	1.5(DL + EQX)
7	1.5(DL - EQX)
8	1.5(DL + EQY)
9	1.5(DL - EQY)
10	0.9DL + 1.5EQX
11	0.9DL - 1.5EQX
12	0.9DL + 1.5EQY
13	0.9DL - 1.5EQY

C. Application of response spectrum in ETABS:

1) File - new model.
2) Define –materials- add new material.
3) Define-section properties- frame sections(Beam & column)
4) Define –section properties- area sections(Slab)
5) Select nodes at first story-assign- joint –restraints-fixed-ok
6) Assign beams, columns and slab to the structure as desired.
7) Select floor plan and assign the diaphragm for every floor.
8) Define-load patterns (Live, Dead, Super Dead)
9) Add the mass source to structure to be followed by the software
10) Run Analysis to check for design is done as per the IS: 456- 2000
11) Check all the members are passed.
12) If all members are passes the design check, unlock the modal to define the response spectrum function.
13) Define- functions- Response Spectrum- choose the IS: 1893-2002 to be followed and add the function for desired seismic zone and type of soil.
14) Again go to define- load case- add new case as Response in X-direction, ensure that "Response spectrum" has been selected for the load case type.
15) Now run the analysis for Response Spectrum analysis.

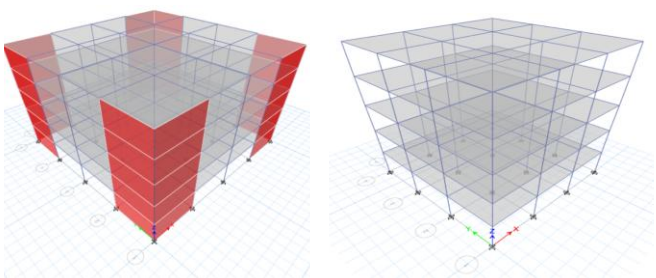
D. Building Models:



(a) (b)

Fig- 3.1 Plan of all the models with and without shear wall

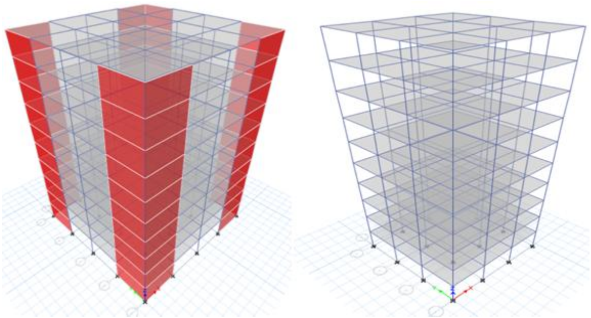
Fig- 3.1 shows the plan and plan dimensions of the building (a) without and (b) with shear wall respectively. The plan of the building is considered to be square plan 4 x 4 bays, each bay width is considered to be 5mtrs. And shear walls are taken at the corners of the building.



(a) (b)

Fig- 3.2: 3D view of 5storey model (a) with and (b) without shear wall

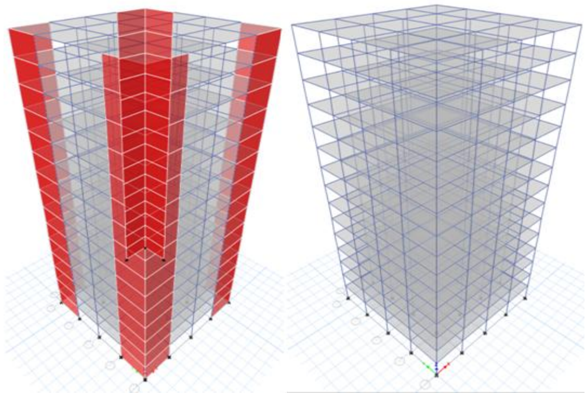
Fig- 3.2 shows a 5 storey building (a) with shear wall of thickness 150mm (b) conventional building without shear wall, resting the beams of size 230 x 300 mm and columns, of size 300 x 300 mm considering both buildings as fixed at the bottom. In this study dead load is taken up by the software ETABS itself and dead load should be included of the weight of the permanent construction. Live load is assigned as per the IS 875-1987 (part-II) and is considered as 3 kN/M^2.



(a) (b)

Fig- 3.3: 3D view of 10storey model (a) with and (b) without shear wall

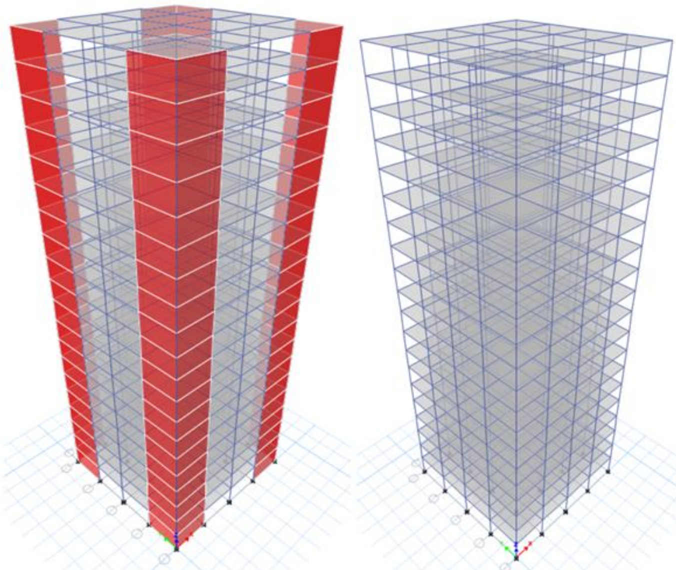
Fig- 3.3 shows a 10 storey building (a) with shear wall of thickness 150mm (b) conventional building without shear wall, resting the beams of size 300 x 320 mm and columns of size 350 x 350 mm, considering both buildings as fixed at the bottom. In this study dead load is taken up by the software ETABS itself and dead load should be included of the weight of the permanent construction. Live load is assigned as per the IS 875-1987 (part-II) and is considered as 3 kN/M^2.



(a) (b)

Fig- 3.4: 3D view of 15 storey model (a) with and (b) without shear wall

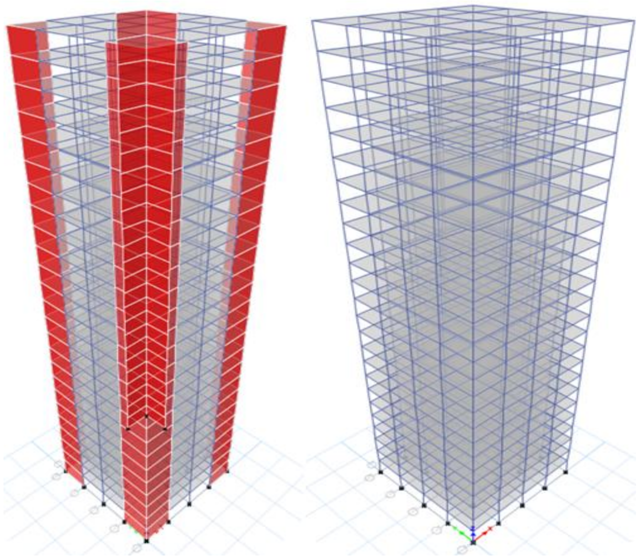
Fig- 3.4 shows a 15 storey building (a) with shear wall of thickness 150mm (b) conventional building without shear wall, resting the beams of size 300 x 340 mm and columns of size 500 x 500 mm, considering both buildings as fixed at the bottom. In this study dead load is taken up by the software ETABS itself and dead load should be included of the weight of the permanent construction. Live load is assigned as per the IS 875-1987 (part-II) and is considered as 3 kN/M^2.



(a) (b)

Fig- 3.5: 3D view of 20 storey model (a) with and (b) without shear wall

Fig- 3.5 shows a 20 storey building (a) with shear wall of thickness 150mm (b) conventional building without shear wall, resting the beams of size 300 x 360 mm and columns of size 500 x 500 mm, considering both buildings as fixed at the bottom. In this study dead load is taken up by the software ETABS itself and dead load should be included of the weight of the permanent construction. Live load is assigned as per the IS 875-1987 (part-II) and is considered as 3 kN/M^2.



(a) (b)

Fig- 3.6: 3D view of 25storey model (a) with and (b) without shear wall

Fig- 3.6 shows a 25 storey building (a) with shear wall of thickness 150mm (b) conventional building without shear wall, resting the beams of size 300 x 350 mm and columns of size 550 x 550 mm, considering both buildings as fixed at the bottom.. In this study dead load is taken up by the software ETABS itself and dead load should be included of the weight of the permanent construction. Live load is assigned as per the IS 875-1987 (part-II) and is considered as 3 kN/M^2

IV. RESULTS AND DISCCUSIONS

This chapter consists of results and discussion of comparison of building with and without shear wall of different heights and with different aspect ratios. Comparisons have done between base shear, displacement, storey drift and storey stiffness as shown in fig- 4.1, 4.2, 4.3 and 4.4 respectively.

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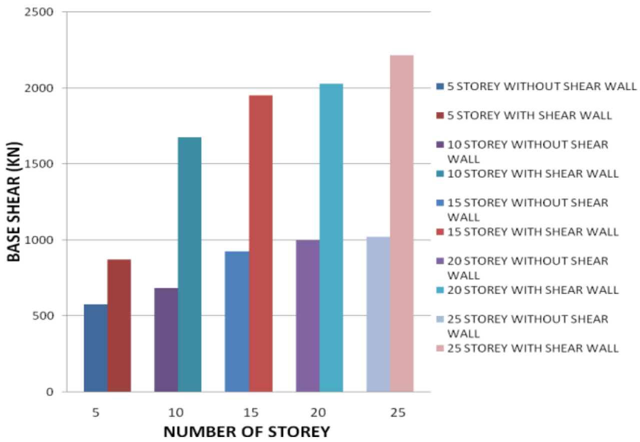

Fig- 4.1: Comparison of Base Shear of Different storeys

Fig- 4.1 shows the graphical representation of the comparison of base shear of

different storey buildings of 5, 10, 15, 20 and 25 - storeys with and without shear wall having different aspect ratios 1.33, 0.66, 0.44, 0.33 and 0.26 respectively. As the height of the structure increases from 5 storeys to 25 storeys structure, base shear also increases but with the shear wall, the base shear increases more than 50% than compared to the structure without shear wall

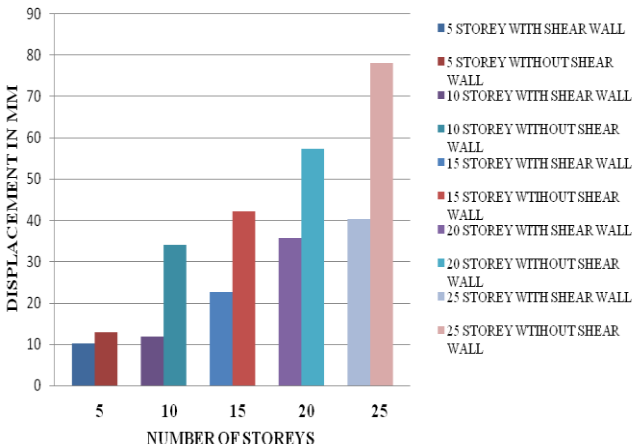

Fig- 4.2: Comparison of Max. Displacements of Different storeys

Fig- 4.2 shows the graphical representation of the comparison of Max. Displacements of different storey buildings of 5, 10, 15, 20, and 25 - storeys with and without shear wall having different aspect ratios 1.33, 0.66, 0.44, 0.33 and 0.26 respectively. The structure with shear wall has the decreasing displacement of more than 50% than the structure without shear wall in all the models presented

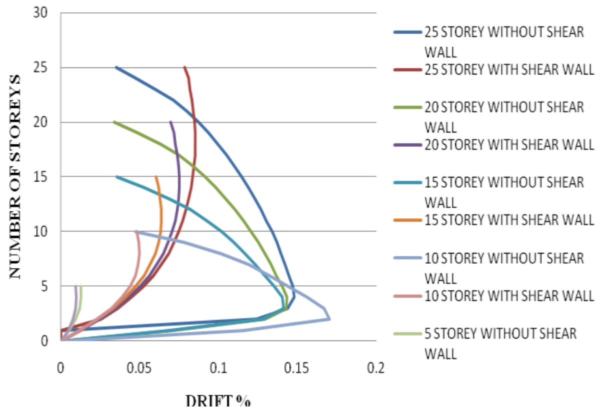

Fig- 4.3: Comparison of Storey Drift of Different storeys

Fig- 4.3 shows the graphical representation of comparison of storey drift of different storeys building of 5, 10, 15, 20 and 25 - storeys with and without shear wall having different aspect ratios 1.33, 0.66, 0.44, 0.33 and 0.26 respectively with and without shear wall. As the height of the structure increases from 5-storey to 25-storey the structure with shear wall, has the inter storey drift increasing at the top storeys while it's decreasing in the lower storeys when compared with the structure without shear wall with varying percentage

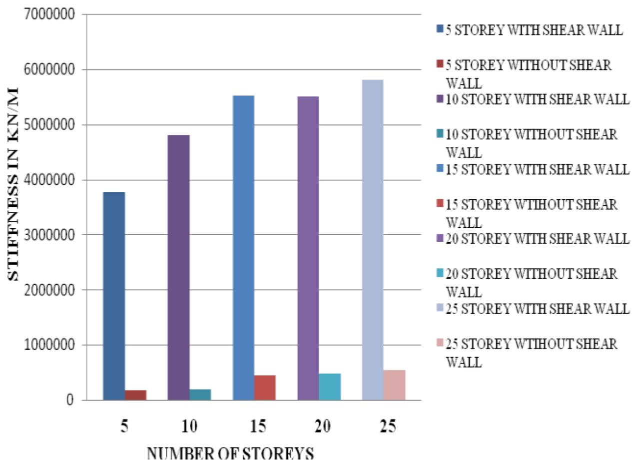

Fig- 4.4: Comparison of Storey stiffness of Different storeys

Fig- 4.4 shows the graphical representation of comparison of storey stiffness of different storeys building of 5, 10, 15, 20 and 25 - storeys with and without shear wall having different aspect ratios 1.33, 0.66, 0.44, 0.33 and 0.26 respectively with and without shear wall. By using structural wall as the lateral loads resisting system (LLRS), stiffness is increased by 90% compared to structure without structural wall.

V. CONCLUSION

Response Spectrum analysis is performed on 5, 10, 15, 20 and 25 – storey buildings with and without shear wall and with different aspect ratios of 0.26, 0.33, 0.44, 0.66 and 1.33 respectively. The comparison of base shear, maximum displacement, storey drift and storey stiffness between different heights of the storeys has been carried out.

The following are the conclusions drawn:

1. The high rise structures with shear wall of height above 30 meters (i.e., 10, 15, 20 and 25 storeys) of aspect ratio of 0.66, 0.44, 0.33 and 0.26 respectively is performing better than the low rise structure of height 15m (i.e., 5 storey) of aspect ratio 1.33, as the high rise structures gives more than 50% of base shear while low rise structure increases the base shear just by 33% as per the figure no. 4.1.
2. In high rise structures the displacement is reduced by 50% while in low rise structure the displacement is reduced by just 20%, as per the figure no. 4.2. So, utilization of shear wall in high rise buildings is more effective than in low rise buildings.
3. As the height of the structure increases, the structure with shear wall has the storey drift percentage increasing at the top storeys while it's decreasing in the lower storeys when compared with the structure without shear wall with varying percentage which is in permissible limits as per the figure no. 4.3.
4. By using shear wall as the lateral loads resisting system, stiffness is greatly improved compared to the building without shear wall as per the figure no. 4.4.

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