Study on Effectiveness of Shear Wall on Different Building Aspect Ratio

[1]Nehal A. Bhavsar, [2]Noopur A. Shah, [3]Satyen D. Ramani

[1]PG Student, Department of Civil Engineering,[2,3]Asst. Professor, Department of Civil Engineering,
SAL Institute of Technology and Engineering Research, Ahmedabad, Gujarat, India

***Abstract*—A large proportion of world's population lives under higher seismic risk region so there is a need of construction technologies which resist higher seismic forces and shear wall is such type of technology. Shear wall stabilise the whole structure against the effect of strong horizontal seismic loading. Shear wall is usually used for high rise building and excellent performance is achieved. The main goal of this research is to find out up to which base dimension the effectiveness of shear wall is maintained. The present study is an attempt to understand the effectiveness of shear wall on different aspect ratio of building (H_B/L_B). Three different aspect ratio of building (R= H_B/L_B i.e. 1,2,3) has been taken. The effectiveness has been checked up to G+30 storey building with every five incremental storey. To avoid torsional behaviour, symmetrical building with rectangular type of shear wall at the center of face of the building on both directions building was taken. The shear wall dimensions were restricted by shear wall aspect ratio (H_w/L_w).The response spectrum analysis of building without shear wall and with shear wall was carried out using ETABS® software. At the end, building response parameter Displacement was compared.**

***Keywords*—Shear Wall, Building aspect ratio, Shear wall aspect ratio, Stiffness**

I. INTRODUCTION

Earthquakes are perhaps the most unpredictable and devastating of all natural disasters. They not only cause great destruction in terms of human casualties but also have a tremendous post-occurrence impact on affected areas. The overwhelming increasing population is the requirement of high rise building. In such situation, shear wall is the best solution for resisting higher earthquake forces. A shear wall is a wall that is designed to resist shear, the lateral force that causes the bulk of damage in earthquakes. Shear walls are a type of structural system that provides lateral resistance to a building or structure. The applied load is generally transferred to the wall by a diaphragm or collector or drag member. Shear wall increases strength and stiffness of the building. Due to higher stiffness, shear wall reduces greater amount of displacement. Shear wall concept was first introduced in 1940 and seriously studied by Mr. Fazlur Khan described as vertical, cantilevered beams, which resist lateral wind and seismic loads acting on a building transmitted to them by the floor diaphragms. Shear walls are quick in construction, and in a country like India where shelter is very important in a short lapse of time, shear walls can be a proven solution. Hence the key objective of shear wall is to build a safe, tall, aesthetic building.

Based on the aspect ratio (H_w/L_w) shear wall is classified as squat and slender. Squat shear wall govern by their shear strength while slender wall govern by their flexural strength. Depending upon H_w/L_wsquat wall behave as shear beam and slender wall behave as a long cantilever beam.

Depending on the geometry shear wall classified as rectangular and flanged type (L,T,C). In additions boundary element is provided in flanged type of shear wall. Boundary element in flanged type of wall provides higher stiffness and higher shears resistance.

The various parameters that influence the response of shear wall are as follows:

- Geometry of the building
- Section shape
  Rectangular type of shear wall reduces displacement at higher rate.
- Aspect ratio of shear wall (H_w/L_w)
  If $H_w/L_w < 2$, shear deformation may govern the shear wall behaviour and deflected shape may be quarter sine. But shear failure should be avoided because of its brittle nature.
  If $H_w/L_w > 5$, flexure deformation may govern the response of shear wall and deflected shape may be parabolic.
- Types of loading
- Flexural reinforcement: The maximum shear force that can be developed depends on the actual flexural capacity which may significantly higher than the design flexural capacity due to strain hardening of the vertical reinforcement.
- Shear reinforcement: Horizontal shear reinforcement provided to prevent diagonal tension failure. It improves the inelastic response of walls subjected to high nominal shear stress by reducing shear deformation.
- Diagonal reinforcement: In the web of walls reduces shear distortion and resists sliding shear. It is particularly useful in squat walls. It also contributes in flexural strength.

- Special transverse reinforcement: This required in potential hinging region of the wall where large inelastic rotations are occur.
- Location of shear wall
  Shear wall should be laid symmetrically to avoid torsional stresses.

.

II. PRESENT STUDY

Usually Shear wall is used for slender structures. Slender structures are those in which the ratio of height to base dimension (width or length) of building is higher. The ratio of height to base dimension of building is called aspect ratio (R= H_B/L_B). For checking the effectiveness of shear wall on different building aspect ratio, the three aspect ratio of building (R= H_B/L_B) R=1, R=2 and R=3 was taken. For each of the aspect ratios, building of G+5,G+10,G+15, G+20,G+25,G+30 storey without shear wall and with shear wall was modelled. Symmetrical plan of the building was taken hence $H_B=L_B$. Rectangular type of shear wall was provided at the centre of the faces in both directions symmetrically.

Building Data

Grade of concrete	=	M 25
Col. Size (m×m)	=	0.5×0.5
Beam size (m×m)	=	0.4×0.5
Thickness of slab	=	0.2 m
Thickness of shear wall	=	0.25m
Storey Height	=	3.5 m each
Bottom storey height	=	2 m
Live load	=	3kN/m^2
Dead load on slab	=	1 kN/m^2
External wall load	=	16.10 kN/m
Internal wall load	=	8.05 kN/m
Parapet wall load	=	2.3 kN/m

No of storey	Height of building (H_B) (m)	R=1 (H_B/L_B =1)		R=2 (H_B/L_B =2)		R=3 (H_B/L_B =3)	
		Length of building L_B (m)	Plan area of building (provided) (m^2)	Length of building L_B (m)	Plan area of building (provided) (m^2)	Length of building L_B (m^2)	Plan area of building (provided) (m^2)
G+5	23	23	20×20	11.5	10×10	7.67	8×8
G+10	40.5	40.5	40×40	20.25	20×20	13.3	12×12
G+15	58	58	55×55	29	30×30	19.33	20×20
G+20	75.5	75.5	75×75	37.75	35×35	25.16	24×24
G+25	93	93	90×90	46.5	45×45	31	32×32
G+30	110.5	110.5	110×110	55.25	55×55	36.83	36×36

Table 1 Geometrical data of Buildings

Shear wall was modelled as shell element and thickness of it for all the building was kept 250 mm. The length of shear wall was restricted by shear wall aspect ratio H_w/L_w . In Case 1 H_w/L_w=10 and in Case 2 H_w/L_w=10 was taken for a study purpose.For Case 1H_w/L_w= 10 and Case 2 H_w/L_w= 20 the length of the shear wall is shown in Table 2 for different storey building. For a particular storey as height and aspect ratio of wall are constrain the length of shear wall remain same for three different aspect ratio of building ex. in Case 1 for G+5 storey building the length of shear wall is 2.3 m for R=1,R=2 and R=3.

No of storey	Height of wall H_w (m)	Case1 (H_w/L_w= 10) L_w (m)	Case2 (H_w/L_w=20) L_w (m)
G+5	23	2.3	1.2
G+10	40.5	4	2
G+15	58	5.5	3
G+20	75.5	7.5	3.5
G+25	93	9	4.5
G+30	110.5	11	5.5

Table 2 Shear wall dimensions

The purpose of incorporation of shear wall is to increase the resistance capacity of building by means of stiffness incorporation. Hence for the study purpose, the stiffness of the building with shear wall was kept two times the stiffness of building without shear wall. Further for the models having shear walls, the dimensions of the column was decided by the stiffness factor. Nominal size of it was taken 0.5×0.5 for a first time. Further iteration was carried out by changing the size of column for achieving the stiffness two times of building without shear wall. First of all, iteration was done in G+10 storey building in Case 1 (H_w/L_w= 10) and the same process was carried out to other buildings for every aspect ratio of building R(H_B/L_B).For particular Case 1, Fig. 1,Fig 2 and Fig.3 shows the plan and 3-D view of the G+10 storey building of R=1,R=2,R=3 respectively.

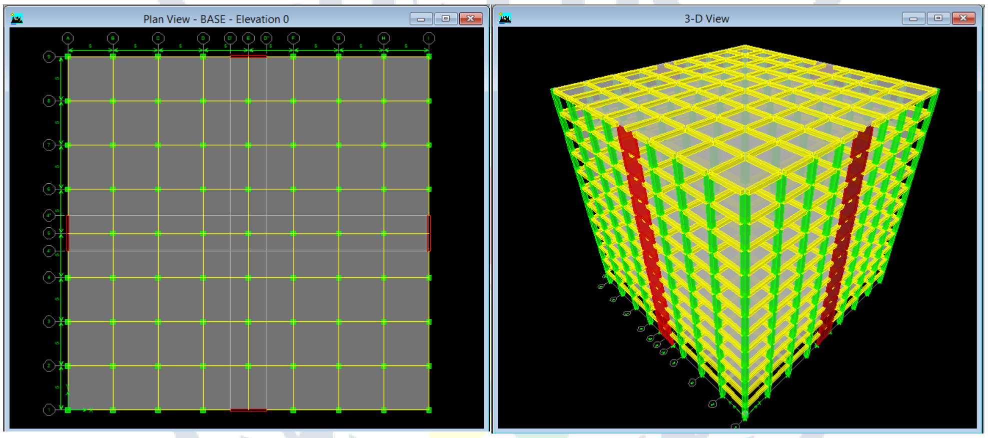

Fig. 1 Plan and 3D view of building for R=1 (40m×40m)

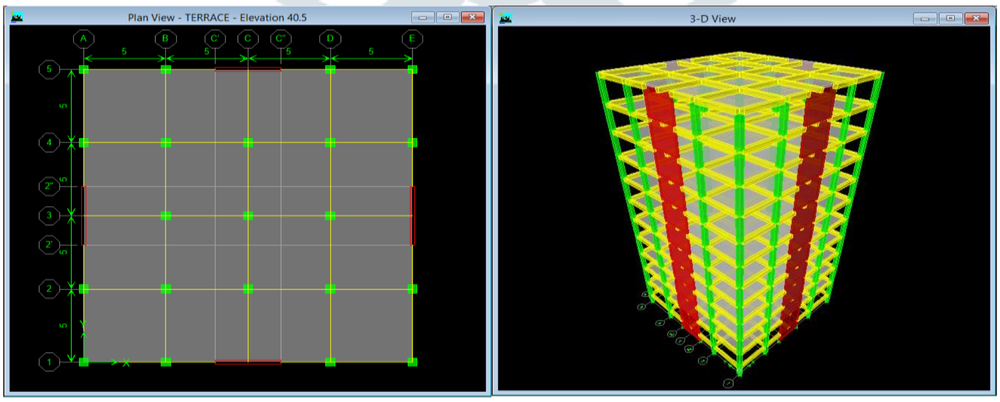

Fig. 2 Plan and 3D view of building for R=2 (20m×20m)

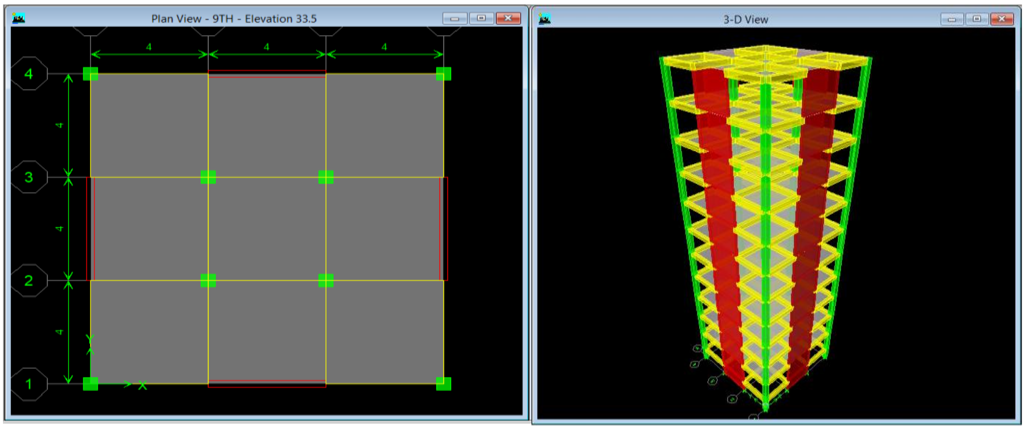

Fig. 3 Plan and 3D view of building for R=3 (12m×12m)

III. RESULTS AND DISCUSSION

The shear wall reduces the lateral sway of the building. The displacement of building with shear wall and building without shear wall was calculated by analysing the model using ETABS software. The percentage difference of building with shear wall and without shear wall is find out.

For Case 1 (H_w/L_w= 10)

No of storey	R=1			R=2			R=3		
	W/out SW	With SW	%Diff Dis	W/out SW	With SW	%Diff Dis	W/out SW	With SW	%Diff Dis
G+5	27.9	15.2	45.51	22.6	10.8	52.21	13.4	5.6	58.20
G+10	22.9	18	20.70	23	17.6	23.47	19.7	14.9	24.36
G+15	157.3	103	34.26	63.6	35.10	44.81	68.9	36.8	46.58
G+20	244	160	34.18	115	64.30	44.28	107	57.6	46.16
G+25	334	214	35.65	248	134	46.16	163.9	86.3	47.34
G+30	442.8	305.8	30.93	331.5	186.1	43.86	195	107	44.98

Table 3Roof Displacement (mm) of without shear wall, with shear wall, percentage difference of Displacement

For Case 2H_w/L_w= 20

No of storey	R=1			R=2			R=3		
	W/out SW	With SW	%Diff Dis	W/outS W	With SW	%Diff Dis	W/outS W	With SW	%Diff Dis
G+5	27.9	16.8	39.78	22.6	12.3	45.57	13.4	7.10	47.01
G+10	22.9	19.3	14.97	23	18.3	20.43	19.7	14.8	24.87
G+15	157.3	102	35.09	63.6	42.7	32.86	68.9	37.8	45.13
G+20	244	170.7	30.04	115.4	70.4	38.99	107	63.3	40.84
G+25	334	242	27.39	248	175.4	29.52	163.9	94.8	42.15
G+30	442.8	312.4	29.44	331.5	224.9	32.15	195	116.6	40.32

Table 4 Roof Displacement (mm) of without shear wall, with shear wall, percentage difference of Displacement

IV. CONCLUSION

In both case of shear wall aspect ratio (H_w/L_w=10,20)

- The percentage displacement difference of each storey increasing with building aspect ratio R=1 to R=3 but the increasing rate is not higher (remain almost constant). So that it can be concluded that the effectiveness of shear wall does not depend on building aspect ratio.
- As the aspect ratio of shear wall increases (length of shear wall decreases), the displacement of the building increases. In case 1 (H_w/L_w=10) the displacement of the building reducing at higher rate than case 2 (H_w/L_w=20).
- The effectiveness of shear wall is maintained up to G+20 storey for shear wall at the centre of faces.
- To achieve effectiveness beyond twenty storey the core shear wall or couple shear wall mechanism is required which increase the capacity of the building.

REFERENCES

[1] Manoj S.Medhekar and SudhirK.Jain, "Seismic behaviour, design and detailing of RC shear walls, Part I: Behaviour and Strength",1993

[2] Manoj S.Medhekar and SudhirK.Jain, "Seismic behaviour, design and detailing of RC shear walls, Part II: Design and detailing", 1993

[3] VarshaAgarwal, "Seidmic Response Of Gravity Cloumns In Buildings With Shear Walls", Master of Technology - Department of Civil Engineering ,Indian Institute Of Technology -Kanpur ,May 1996

[4] Mir M. Ali, "Evolution of Concrete Skyscrapers: from Ingalls to Jin mao" , Electronic Journal of Structural Engineering, Vol. 1, No.1 (2001) 214

[5] C.V.R. Murty, RupenGoswami, A.R.Vijyanarayanan, Vipul V. Mehta, "Earthquake Behaviour of Buildings".