Shear Deformation of Seismic Force Resisting System Considering Different Aspect Ratio

Akanksha Singh[1] Prof. Kamini A. Parmar[2]
[1]PG Student [2]Assistant Professor
[1,2]Department of Applied Mechanics
[1,2]L. D. College of Engineering, India

Abstract— Effectiveness and role of seismic force resisting system during earthquake is vital to be studied as most of the buildings constructed earlier and at present are having these system in them so that buildings can perform as earthquake resistant RC buildings. Shear walls commonly fail in shear and Flexure. So Shear deformation should be included in the analysis of shear wall systems. Wall aspect ratio and configuration are the factors affecting behaviour of structural walls especially their deformation capacity. As a part of research, Assessment of Shear Deformation of Shear wall building considering different Aspect ratio and Building with Bracing system under different configuration need to be explored more to know its shear deformation behaviour. In this work, G+9 & G+19 building with same geometry and configuration having shear wall under different Aspect ratio and two Bracing system X- Bracing & V- Bracing under different configuration are assessed for their shear deformation during earthquake. Response Spectrum analysis of 10 storey, and 20 storey building is done. All models are compared for Parameters Like, roof displacement, and Base shear.

Key words: Structural Elements, Shear Wall, Bracing System, Aspect Ratio, Shear Deformation

I. INTRODUCTION

Multistorey and High-rise buildings are affected by loads like gravity and earthquake loads. So, there is a need to provide seismic force resisting system so that building can perform as earthquake resistant building. The most common structural systems are Shear wall and bracing system. The provision of shear wall in building has been found effective and economical. RC shear wall has high in plane stiffness. Braces are provided in both plan directions to avoid torsion in the building. Braces help in reducing overall lateral displacement of buildings, and in reducing bending moment and shear force demands on beams and columns in buildings. The earthquake force is transferred as axial tensile and compressive force in the brace members.

In present scenario, Aspect ratio of the walls (h/L) is an important variable to consider for shear wall systems where H is the total height of the shear wall and B is the base width of the shear wall. So, assessment of Shear Deformation of Seismic force resisting system (SFRS) considering different Aspect ratio need to be explored more.

Mainly there are two types of deformation Shear and flexure. In shear deformation, the shear forces at each floor level causes the deformation of building in straight inclined shape, while in flexural deformation the forces causes a curved shape at bottom stories so its effect on top is reduced.

II. PROBLEM DESCRIPTION

Shear deformations are important to be considered for shear wall system and bracing system. Wall aspect ratio and configuration are the factors affecting behaviour of structural walls especially their deformation capacity. So, the shear deformation of multistory buildings having shear wall under different Aspect ratio and Bracing system under different configuration is needed to be studied so that one can find the best Aspect ratio of shear wall and best configuration for bracing in which building is having maximum shear strength.

A. Building Plan and 3-D View Having Shear Walls & Bracing System

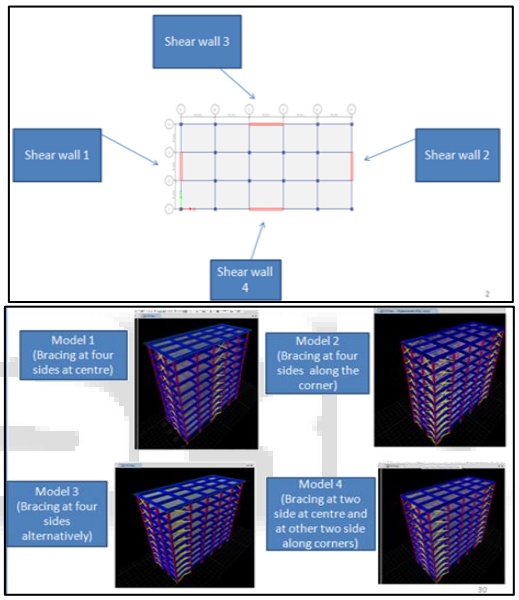

Fig. 1: Building Plan Having Shear Walls & Bracing System

The above Building model is analysed by Response spectrum analysis and Shear deformation of Building with shear wall having different Aspect ratio and Building having Bracing system (Fig 1) under four different configuration is obtained

B. Building Details

- Type of frame: Concrete moment resisting frame fixed at the base
- Concrete Grade: M25
- Steel Grade: Fe250
- Number of storey:(G+10), (G+20)
- Spacing between frames: 6m along x and 4m along y-directions
- Story height: 3.0 m
- Depth of Slab: 120 mm
- Size of beam in all Direction: (300 × 500) mm
- Size of column: 600*600mm
- Thickness of Shear Wall: 250 mm

C. Earthquake Parameter and Loading Definition

- Earthquake Resistant design of structure as per IS 1893:2002
- Zone: IV

- Soil type: Medium soil
- Importance factor: 1
- Response Reduction factor:5
- Time period: As per Clause No. 7.6.2 of IS 1893:2002
- Seismic zone factor: 0.24 for zone IV
- Earthquake load in X and Y direction
- Live load on floor: 2 KN/m^2
- Live load on terrace: 1.5 KN/m^2
- Floor Finish: 1.5KN/m^2
- Wall load: 14KN/m
- Codes used for analysis : IS 1893:2000 and IS 456:2000

III. TYPE OF BUILDING MODELS WITH SHEAR WALL BASED ON ASPECT RATIO

A. Type of Building Models with shear wall based on Aspect ratio

- Aspect ratio for Shear wall 1 and 2(Fig.1) is fixed i.e., (30/4)=7.5
- Aspect ratio for Shear wall 3 & 4 is varied as shown in below table. The height of shear wall is kept constant and only width of shear wall is varied.

Model	10 storey building (h/L for walls 3 and 4)	20 storey building (h/L for walls 3 and 4)
1	30/4 = 7.5	60/4=15
2	30/4 .5=6.67	60/4.5= 13.33
3	30/5 =6	60/5=12
4	30/5.5= 5.45	60/5.5=10.9
5	30/6 =5	60/6=10
6	30/6.5= 4.62	60/6.5=9.24
7	30/7= 4.28	60/7=8.56

Table 1: Type of Building Models with shear wall based on Aspect ratio

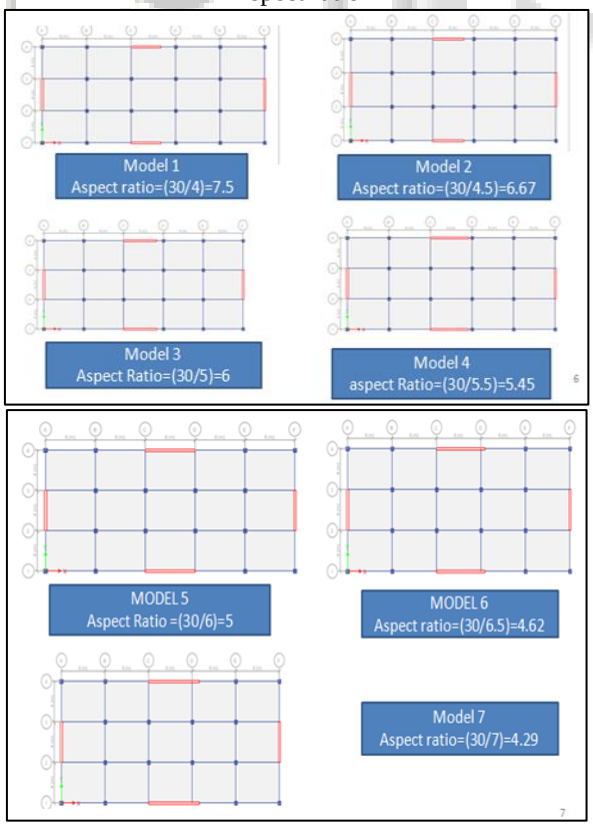

Fig. 2: Plan of Building Models with shear wall based on Aspect ratio

B. Comparison of behaviour of shear deformation of 10 storey and 20 storey shear wall building

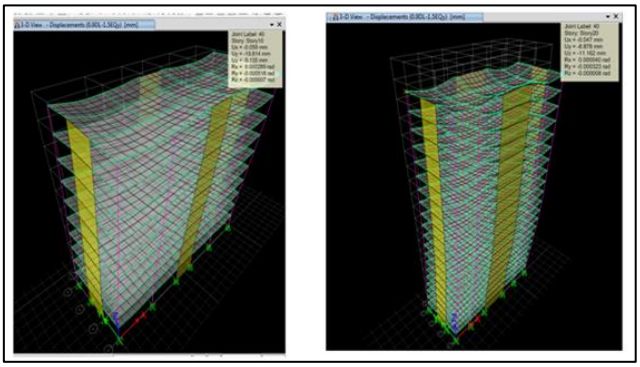

Fig. 3: Deformation of Shear wall building

- From the shape of deformation behaviour, it can be observed that Shear deformation occurs in 10 storey shear wall building while in 20 storey building, flexural deformation takes place.
- In shear deformation, the shear forces at each floor level causes the deformation of building in straight inclined shape, while in flexural deformation the forces causes a curved shape at bottom stories so its effect on top is reduced.

C. Comparison of Shear deformation of 10 storey and 20 storey Shear wall building

- Shear deformation is measured in terms of roof displacement.

	10 Storey Building		
Model	Aspect ratio	Roof displacement (mm)	
		Ux	Uy
1	No shear wall	30.22	29.4
2	30/4 = 7.5	24.012	20.5735
3	30/4 .5=6.67	23.4186	20.5505
4	30/5 =6	23.3358	20.5275
5	30/5.5= 5.45	23.5014	20.5045
6	30/6 =5	22.7148	20.7115
7	30/6.5= 4.62	21.1278	20.6885
8	30/7= 4.28	20.2446	20.6655

Table 2: Comparison of shear deformation of G+9 Building

	20 Storey Building		
Model	Aspect ratio	Roof displacement (mm)	
		Ux	Uy
1	No shear wall	19.112	18.2308
2	60/4=15	14.0256	11.284
3	60/4.5= 13.33	13.2336	11.8172
4	60/5=12	14.7024	11.1972
5	60/5.5=10.9	15.7248	11.1476
6	60/6=10	10.4976	11.222
7	60/6.5=9.24	12.024	11.1848
8	60/7=8.56	12.0816	11.16744

Table 3: Comparison of shear deformation of G+19 Building

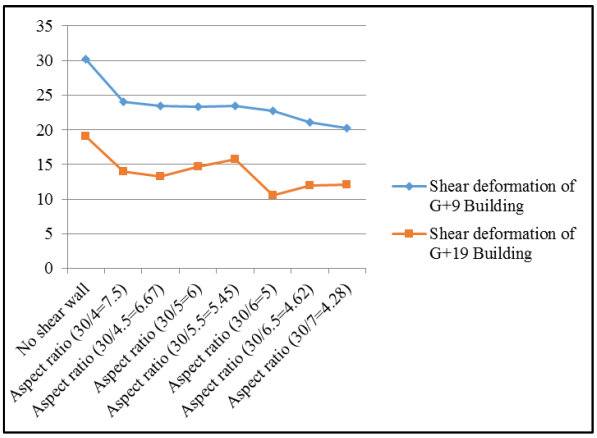

Fig. 4: Comparison of Shear deformation of G+9 & G+19 Building

- From the shape of deformation behaviour (Fig.3), it can be observed that Shear deformation occurs in 10 storey shear wall building while in 20 storey building, flexural deformation takes place.
- The shear deformation is governing in 10 storey as aspect ratio of the shear wall is varied. (Fig. 4)
- The value of shear deformation in G+9 building is more i.e., 30.22 mm and less in G+19 building i.e., 19.11 mm (Fig.5 & 6)
- So, Shear strength governs the design of medium buildings i.e., up to 10 storey.
- After 10 storey, flexural deformation occurs.

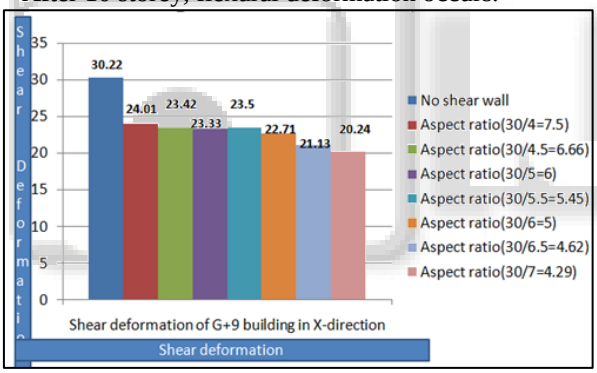

Fig. 5: Shear deformation of 10 storey shear wall building with different Aspect ratio

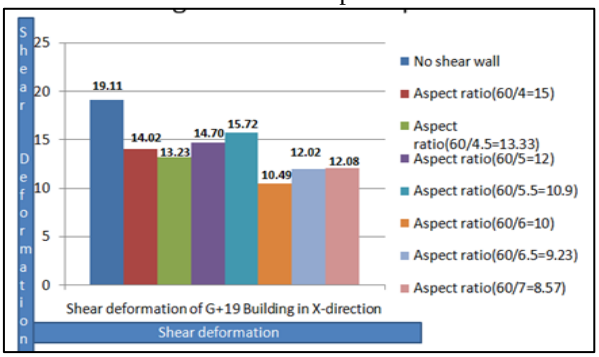

Fig. 6: Shear deformation of 20 storey shear wall building with different Aspect ratio

Model	Aspect ratio	Roof displacement (mm)		Base reaction (KN)	
		Ux	Uy	RSx	RSy
1	No shear wall	30.22	29.4	784.17	783.28
2	30/4 = 7.5	24.01	20.57	956.49	976.02
3	30/4.5=6.6	23.41	20.55	982.37	980.32
4	30/5 =6	23.33	20.52	998.57	983.90
5	30/5.5=5.4	23.50	20.50	1012.9	988.20
6	30/6 =5	22.71	20.71	990.40	977.12
7	30/6.5=4.6	21.12	20.68	1018.5	980.85
8	30/7= 4.28	20.24	20.66	1021.2	984.2

Table 4: Comparison of shear deformation and Base reaction of G+19 Building

Model	Aspect Ratio	Roof Displacement (mm)		Base Reaction (KN)	
		Ux	Uy	RSx	RSy
1	No shear wall	19.11	18.23	697.19	737.7
2	60/4=15	14.02	11.28	830.04	781.58
3	60/4.5=13.3	13.23	11.81	847.07	785.57
4	60/5=12	14.70	11.19	860.68	789.17
5	60/5.5=10.9	15.72	11.14	873.19	792.48
6	60/6=10	10.49	11.22	855.64	783.46
7	60/6.5=9.24	12.0	11.18	882.60	786.95
8	60/7=8.56	12.08	11.16	909.49	790.21

Table 5: Comparison of shear deformation and Base reaction of G+9 Building

From the above numerical investigation, following conclusions are drawn:

- Shear deformation is governing in 10 storey building as aspect ratio of shear wall is varied.
- The value of shear deformation in G+9 building is more i.e, 30.22 mm and less in G+19 building i.e., 19.11 mm (Fig.5 & 6).

IV. TYPE OF BUILDING MODELS WITH BRACING SYSTEM UNDER FOUR DIFFERENT CONFIGURATION

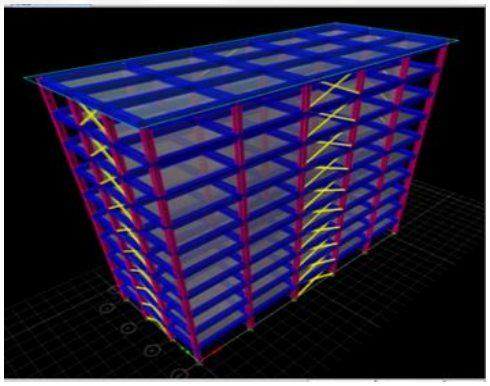

Fig. 7: Building with X- Bracing

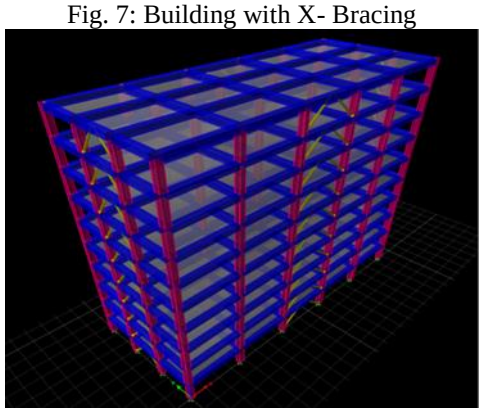

Fig. 8: Building with V- Bracing

A. Type of Building Models with four different configuration are

- Model 1(Bracing at four sides at centre)
- Model 2(Bracing at four sides along the two corner)
- Model 3(Bracing at four sides alternatively)
- Model 4(Bracing at two side at centre and at other two side along corners)

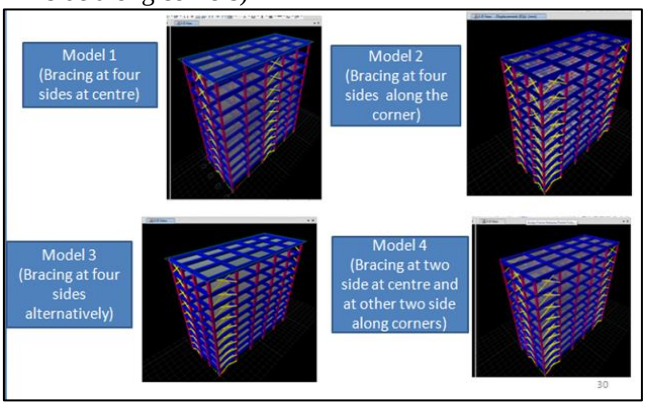

Fig. 9: Four configuration of Building having Bracing system

B. Comparison of Shear deformation of 10 storey building with X & V Bracing system

Shear deformation is measured in terms of roof displacement

Bracing system	Roof Displacement (mm)		Base reaction (KN)		Steel quantity (kg)
Model	Ux	Uy	RSx	RSy	
Without Shear wall	30.2	29.4	724.2	700.5	
1	21	21.2	936	930	827240
2	19.3	20	1048	1170	1654480
3	23.4	26	904.7	1063	827240
4	19.6	21.1	1030	1107	1301240

Table 6: Shear deformation of G+9 Building Models having X-Bracing under different configuration

Bracing system	Roof Displacement (mm)		Base reaction (KN)		Steel quantity (kg)
Model	Ux	Uy	RSx	RSy	
Without Shear wall	30.2	29.4	724.2	700.5	
1	25.25	26.8	790	751	553740
2	23.59	25.3	879.8	807.1	1107480
3	28.62	32.9	759.5	733.8	553740
4	23.97	26.6	864.5	764.1	853140

Table 7: Shear deformation of G+9 Building Models having V-Bracing under different configuration

Out of four models, Model 1 (Bracing at all four sides at centre) is efficient for both Building with X- Bracing and V Bracing because

- It is having optimum value of shear deformation, and base reaction compared to other models and material used is also less, so it is economical.
- Building with X-Bracing is better than V-Bracing as shear deformation is less.

C. Comparison of Shear deformation of 20 storey building with X & V Bracing system

Bracing system	Roof Displacement (mm)		Base reaction (KN)		Steel quantity (kg)
Model	Ux	Uy	RSx	RSy	
Without Shear wall	19.11	18.23	697.1	737.7	
1	10.69	11.05	925.1	893.4	1654480
2	9.7	10.4	1038	1123	3308960
3	12	13.52	895.7	1020	1654480
4	9.8	10.97	1020	1062	2602480

Table 8: Shear deformation of G+19 Building Models having X-Bracing under different configuration

Bracing system	Roof Displacement (mm)		Base reaction (KN)		Steel quantity (kg)
Model	Ux	Uy	RSx	RSy	
Without Shear wall	19.11	18.23	697.1	737.7	
1	10.57	11.16	924.0	879.8	1107480
2	9.671	10	1021	944	2214960
3	11.73	13	881	859	1107480
4	9.827	11	1003	894	1706280

Table 9: Shear deformation of G+19 Building Models having X-Bracing under different configuration

Out of four models, Model 1(Bracing at all four sides at centre) is efficient because.

It is having optimum value of shear deformation, and base reaction compared to other models and material used is also less, so it is economical.

It is efficient to provide V- Bracing in 20 storey building as both building with X- Bracing & V-Bracing are giving nearly same result of shear deformation and also less material is used in V-Bracing.

D. Comparison of Shear deformation of 10 storey & 20 storey building having structural element: shear wall and Bracing system

	10 Storey Building				20 Storey Building			
	Without Structural element	Shear wall	Bracing		Without Structural element	Shear wall	Bracing	
			X	V			X	V
Shear deformation (mm)	30.22	20.2446	21	25.25	19.112	14.0256	10.69	10.573

Table 10: Comparison of Shear deformation of 10 storey & 20 storey building having structural element: shear wall and Bracing system

V. CONCLUSION

From the above numerical investigation, following conclusions are drawn:

- Shear deformation is governing in 10 storey building. For 10 storey building, provision of shear wall is efficient as less shear deformation is there while for 20 storey building, bracing system is efficient as less shear deformation is there.
- Shear deformation is governing in 10 storey building as aspect ratio of shear wall is varied.
- The value of shear deformation in G+9 building is more i.e, 30.22 mm and less in G+19 building i.e., 19.11 mm.

A. Part-1 (Building with Shear wall with different Aspect ratio)

1) For 10 Storey Building

- Base reaction increases as aspect ratio of Shear wall is decreased.
- Shear deformation decreases as aspect ratio of wall is decreased up to Aspect ratio (30/5), after that it increases for Aspect ratio (30/5.5) and again it decreases as Aspect ratio of shear wall is decreased.
- The variation in Shear deformation is observed due to change in stiffness as Aspect ratio of shear wall is varied.
- As per the results, for G+9 Shear wall building with Aspect ratio (30/7=4.29) is giving better result for Shear deformation, Base reaction and storey shear force than other models.
- So, it is efficient to provide a shear wall of length 7m in G+9 building.

2) For 20 Storey Building

- Base reaction increases as aspect ratio of Shear wall is decreased.
- Shear deformation decreases as aspect ratio of wall is decreased up to Aspect ratio (30/4.5), then it increases for Aspect ratio (30/5) & (30/5.5) and then again it decreases as Aspect ratio of wall is decreased.
- The variation in Shear deformation is observed due to change in stiffness as Aspect ratio of shear wall is varied.
- As per the results, for G+19 Shear wall building with Aspect ratio (60/6=10) is giving better result for Shear deformation, Base reaction and storey shear force than other models.
- So, it is efficient to provide a shear wall of length 6m in G+19 building.

B. Part-2 (Building with Bracing system with different configuration)

- Out of four models, Model 1(Building with Bracing at all four sides at centre) is efficient for both Building with X-Bracing and V- Bracing because it is having optimum value of shear deformation, and base reaction compared to other models and material used is also less, so it is economical.
- For G+9 storey, Building with X -Bracing is having less shear deformation (21mm) than V-Bracing in which shear deformation is 25.25mm. So, it is good to provide X- Bracing in G+9 Building.
- For 20 storey building, it is efficient to provide V-Bracing as both building with X- Bracing & V-Bracing are giving nearly same result of shear deformation (for X-Bracing 10.69 mm & for V-Bracing 10.57mm) and also less material is used in V-Bracing.

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