Comparison of Seismic Resistance of Moment Resisting RC Building using Shear wall and Bracing

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Abstract - *Seismic forces are the most destructive type of force and existing structures must withstand the seismic loads which can generate high stresses in existing buildings. There is a need to control the destruction caused by earthquakes to existing buildings. Nowadays, steel bracing in steel structures and concrete shear walls in RC buildings are used widely to oppose lateral forces. Both the lateral resisting systems have been used to resist the lateral loads, but their effect shows different variations and behaviour against seismic loads. In this study, G+9 storey existing buildings, along with shear walls and X - bracing are considered for the seismic analysis. Here, the seismic analysis is carried out using response spectrum analysis. The performance of the buildings is interpreted based on mode shapes, modal participating mass ratios, base shear, maximum storey displacement and inter-storey drift. For this study, the shear walls and bracings are located at three different locations in the existing building and analysis is carried out using ETABS 18.0.2 software.*

***Key Words*: Response Spectrum Method, Base Shear, Storey Displacement, Inter Story Drift**

1. INTRODUCTION

It is impossible to prevent an earthquake, but the destruction of the structures can be controlled by proper detailing and design. It is mandatory to do the seismic analysis and design for structures against collapse. Moreover, Earthquake forces are the most destructive form of force. A dynamic load varies with time quickly in comparison to the structure's frequency. If it varies slowly, the structure's response may be determined with static analysis, but if it changes quickly the response must be determined with a dynamic analysis. The response spectrum analysis is a method for dynamic analysis of a structure subjected to earthquake excitation, but it reduces to parts of static analysis. However, it is a dynamic analysis method as it used the vibration properties such as natural frequencies, natural modes and modal damping ratios of the structure and the dynamic characteristics of the ground motion through the response spectrum. RC building can adequately resist both horizontal and lateral load. However, lateral load resisting systems like a shear wall, and bracing systems should be given in a building for a multi-storey building to resist higher seismic forces. [2]

1.1 Need for the study

In the past recent years earthquakes have occurred in India and caused severe damage and suffering to humans by collapsing the structure as the previous developments in construction have not been followed by guidelines of seismic codes in the past years. Existing RC buildings were designed without considering ground motion criteria which may undergo severe damage during earthquake ground motion. [1] Moreover, the effect of lateral forces is attaining increasing importance in high-rise structures. The most suitable method is to provide a better lateral resisting system in existing structures for more resistance to ensure the safety of the structure.

1.2 Objective

- Comparative study of earthquake resisting systems on the behaviour of RC building in terms of max. storey displacement, Inter storey drift and base shear.
- To find out a better lateral resisting system and the location of the system in the existing structure located in Zone III.
- To find out the cost of the lateral resisting system which is more economical.

2. Methodology

Moment resisting RC building (G+9) is designed. For all the models, modelling and analysis of the structural system have been done in ETABS 2018 software.

Type of Structure	: G+9, RCC Frame
Typical Storey Height	: 3 m
Plan Area	: 32.95m * 19.70m
Type of Soil	: Type 2 Medium Soil
Typical Floor Slab	: 125 mm
Typical Beam (mm)	: 230*450,
Plinth Beam (mm)	: 230*500

Column (mm) :300*450, 300*500, 300*600, 300*750, 300*850, 450*950, 450*1050

2.2 Loading Data

Dead load:

- SW of slab = 3.13 kN/m^2
- SW of terrace slab = 3.75 kN/ m^2
- Weight of floor finish = 1 kN/ m^2
- Weight on water tank = 19.44 kN/ m^2
- Weight of sunk filling = 2.4 kN/ m^2
- Weight of water proofing = 1.5 kM/ m^2
- SW of Plinth Beam = 2.875 kN/m
- SW of Typical Beams = 2.59 kN/m
- SW of Landing Beam = 5.625 kN/m

Live load:

- Live loads = 2 kN/ m^2
- Live load on terrace = 1.5 kN/ m^2

Masonry wall load:

- 115mm thk wall load = 5.86 kN/m
- 230mm thk wall load = 11.72 kN/m

Earthquake load:

As per IS 1893 (Part 1): 2016, Response spectrum analysis method.

- Zone factor (Z) = 0.16
- Importance Factor (I) = 1
- Reduction factor (R) = 5

2.3 Load Combinations

- Load combinations are carried out to find out critical load cases and their combinations which is multiplied by safety factors.

Table -1: Load combinations

1.5DL	0.9DL±1.5EQy
1.5(DL+LL)	1.5(DL+RSx)
1.5(DL±EQx)	1.5(DL+RSy)
1.5(DL±EQy)	1.2(DL+LL+RSx)
1.2(DL+LL±EQx)	1.2(DL+LL+RSy)
1.2(DL+LL±EQy)	0.9DL+1.5RSx
0.9DL±1.5EQx	0.9DL+1.5RSy

2.4 Modelling

- SW thickness and Steel bracing members:

Table -1: Member details

SW thk.	Model 1,2,3	200 mm
X-bracing	Model 4	SHS 220*220*8, SHS 250*250*10
	Model 5	SHS 220*220*10, SHS 250*250*10
	Model 6	SHS 220*220*6

- Location and number of models:

Table -2: Model details

Bare Frame	Model 0	Bare Frame
Shear Wall System	Model 1	SW around lift
	Model 2	SW at foyer
	Model 3	SW at corner
Bracing System	Model 4	X - Bracing around lift
	Model 5	X - Bracing at foyer
	Model 6	X - Bracing at corner

Bare frame

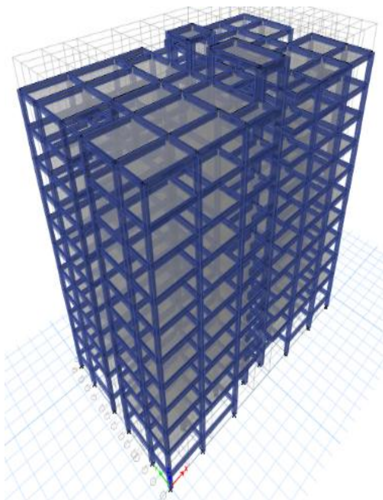

Fig. -1: Model 0 - Bare frame

Shear wall modelling

Model 1:

- Length of SW in X = 3.42 m and Tx = 2.69 s

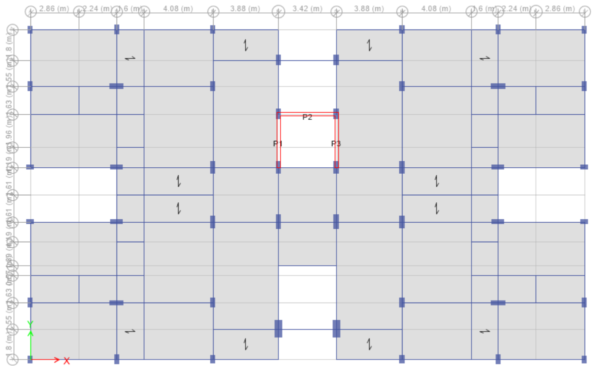

Fig. -2: Model 1

- Length of SW in Y = 3.15 m and Ty = 1.99 s

Model 2:

- Length of SW in X = 2.84 m and Tx = 2.11 s

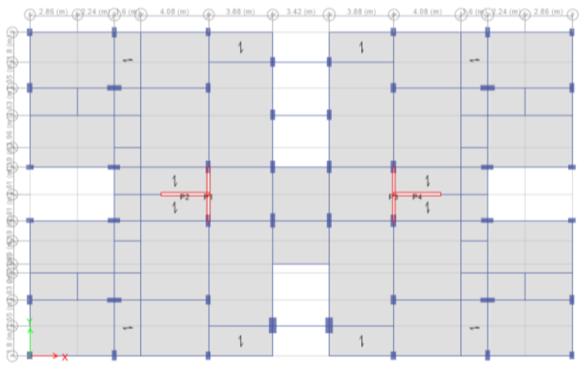

Fig. -3: Model 2

- Leng th of SW in Y = 3.22 m and Ty = 1.97 s

Model 3:

- Length of SW = 1.68 m and Tx = 1.96 s

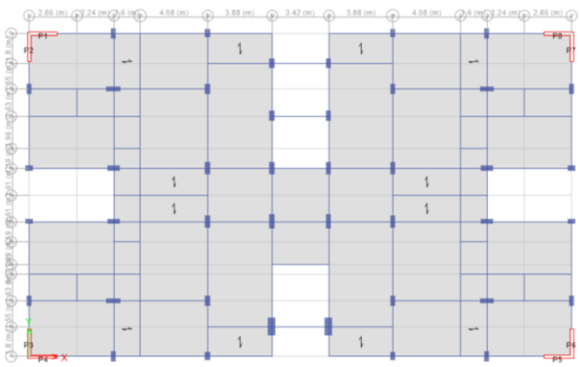

Fig. -4: Model 3

Bracing modelling

Bracing members are designed for compression and tension forces. Slenderness ratio KL/r_{min} = 250.

Model 4:

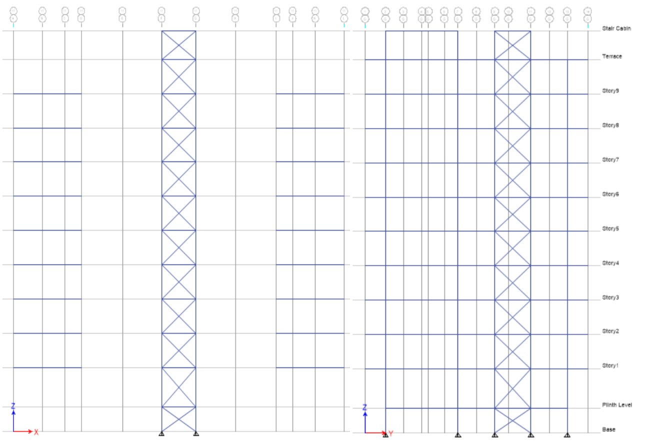

Fig. -5: Model 4

Model 5:

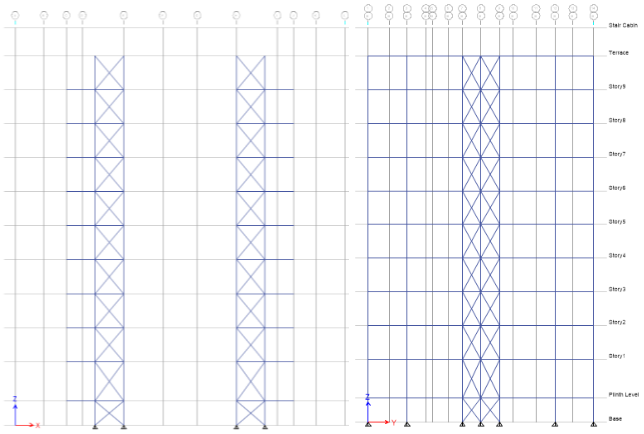

Fig. -6: Model 5

Model 6:

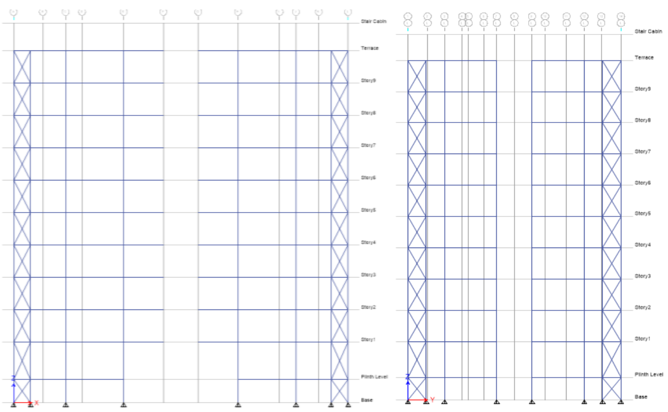

Fig. -7: Model 6

3. Results and Discussions

3.1 Dead load

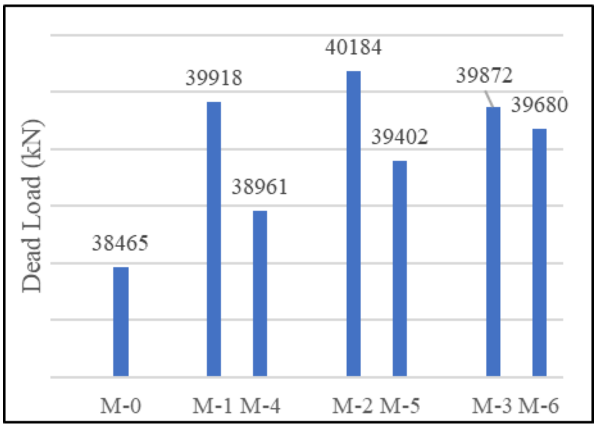

Chart -1: Dead Load Comparison

- Bare frame has the lowest dead load among all the models, and it is 38465.8 kN, which can resist only gravity loads.
- Model 1,2 and 3 which consist of shear wall has more dead load than model 4,5 and 6 which has X – bracing.
- There is 957 kN difference in dead load when shear wall and bracing is located around lift area and the difference decreases to 781 kN and 192 kN when shear wall and bracing is located at foyer and the corner of the building respectively.

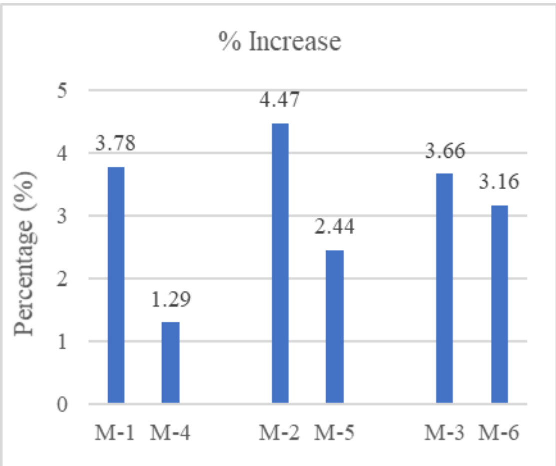

Chart -2: Percentage increase in Dead Load

- As the location of bracing members moves away from the centre the DL weight is increasing.
- When the lateral resisting system is located at the corner of the building, the % increase in DL is almost the same for both the system

3.2 Base Shear

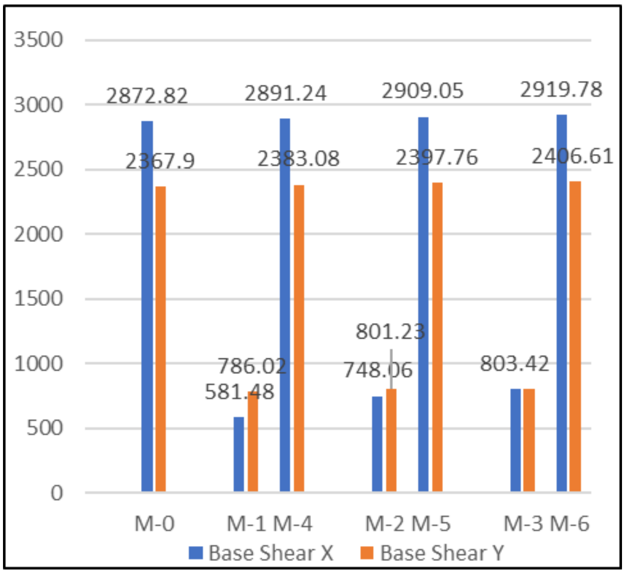

Chart -3: Base shear comparison

- As per the above graph, it is shown that there is almost similar base shear for the bare frame and all the bracing models.
- Base shear reduces significantly after introducing the SW in the existing structure at different locations.

3.3 Maximum Storey Displacement

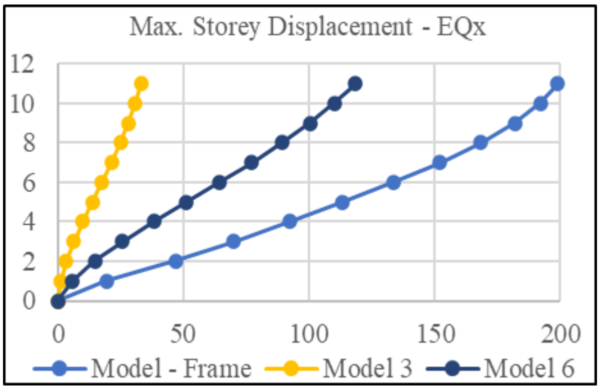

Chart -4: Max. storey displacement - X direction

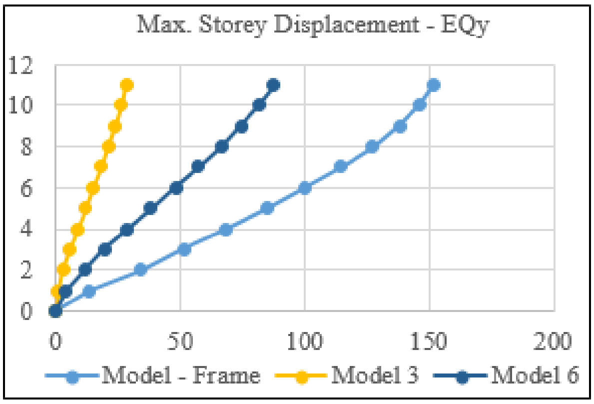

Chart -5: Max. storey displacement - Y direction

- The maximum storey displacement for the bare frame is more than the permissible limit which is 130mm. For Eqx and Eqy, the displacement value at the terrace level is 198.94mm and 151.78mm respectively.

3.4 Interstorey Drift

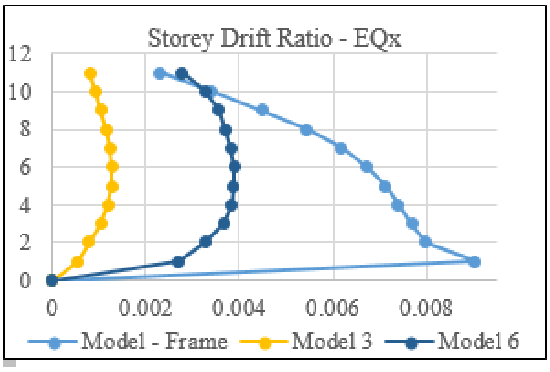

Chart -6: Interstorey drift ratio - X direction

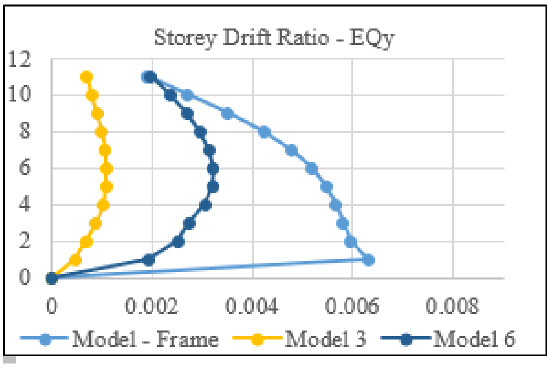

Chart -7: Interstorey drift ratio - Y direction

- The graphs indicate that after adding shear wall and X - bracing, the stiffness is increased significantly in the existing building and the storey drift ratio for all the storeys are less than 0.004 for both the models.

3.5 Cost Comparison

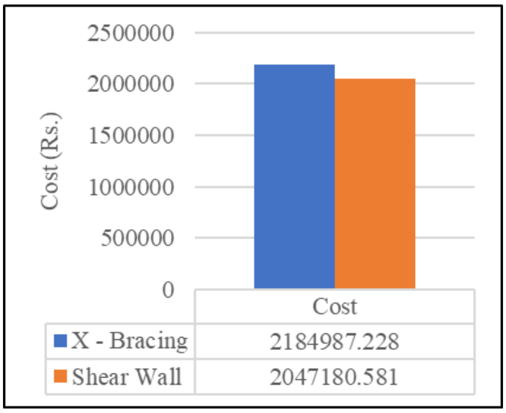

Chart -8: Cost comparison

4. Conclusion

1. Seismic behavior is affected to a great level and the stiffness, and the strength of the building is increased significantly when shear walls and the bracing system is provided to the high-rise building.

2. There is an increase in dead load. Model 1: 3.78% and Model 4: 1.29%, Model 2: 4.47% and Model 5: 2.44%, Model 3: 3.66% and Model 6: 3.16%

3. Base shear in X direction is reduced by 79.75%, 73.96% and 72.03% for model 1, 2 and 3 respectively and in Y direction it is reduced by 66.81%, 66.16% and 66.07% for model 1, 2 and 3 respectively. Base shear is increased by 0.64%, 1.26% and 1.63% for model 4, 5 and 6 respectively in both X and Y directions.

4. Torsional irregularity is observed when the lateral resisting system is provided at the lift and foyer area in the first two primary modes. Model 1, 2, 4 and 5 undergoes rotation in Z direction in the first mode. Translation in X direction is observed in the first mode and translation in Y direction is observed in the second mode for model 3 and 6.

5. A significant decrease in storey displacements and storey drifts is observed in the case of shear wall and bracing models due to increased stiffness of the building. Shear wall building significantly reduces the lateral displacement and lateral drift when compared with X-braced building.

6. Lateral displacement is decreased by 83.33 % in the shear wall and 40.49% in the bracing system located at corners when compared to bare frame in X direction. Lateral displacement is decreased by 81.28 % in shear wall and 42.39% in bracing system located at corners when compared to bare frame in Y direction.

7. Interstorey drift is maximum on 1st storey in the bare frame (27.53 mm and 20.55 mm) because of less stiffness and it is more than the permissible limit, which is 12 mm, but after providing lateral resisting systems it is maximum on 5th storey in both X and Y direction. (3.84 mm and 3.26 mm for shear wall system and 11.68 mm and 9.67 mm for X - braced system)

8. The steel bracing system's cost is 6.31% more than the shear wall building.

REFERENCES

[1] N. S. ,. I. M. A. Alashkar Y., "A Comparative Study of Seismic Strengthening of RC Buildings by Steel Bracings and Concrete Shear Walls," *International Journal of Civil and Structural Engineering Research,* vol. 2, no. 2, October 2014.

[2] R. P. S. S. S. B. S. K. K.V.G.M. Sreeram, "Effective location of Shear Walls and Bracings for Multistoried Buildings," *International Research Journal of Engineering and Technology,* vol. 04, no. 01, Jan 2017.

[3] D. C. K. P. D. B. K. B. K. Anes Babu, "Effect of Steel Bracings on RC Framed Structure," *International Journal of Mechanics and Solids.,* vol. 12, 2017.

[4] IS 13920 (1993) : Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces - Code of Practice., New Delhi: Burea of Indian Standards, 1993.

[5] IS 1893 (Part 1) : 2016 - Criteria for Earthquake Resistant Design of Structures, New Delhi: Bureau of Indian Standards, 2016.

[6] IS 456 : 2000 - Plain and Reinforced Concrete - Code of Practice, New Delhi: : Bureau of Indian Standards., 2006.

[7] G. A. M. P. S. Praveen kumar, "Analysis and Evaluation of Structural Systems with Bracing and Shear Wall," *International Research Journal of Engineering and Technology,* vol. 03, no. 04, Apr 2016.

[8] IS 800 (2007) : General Construction in Steel - Code of Practice, New Delhi: : Bureau of Indian Standards, 2007.

[9] IS 875 - 1 (1987) : Code of Practice for Design Loads (Other than Earthquake) For Buildings and Structures, Part 1 : Dead Loads, New Delhi: Bureau of Indian Standards, 1987.

[10] P. A. a. M. Shrikhande, Earthquake Resistant Design of Structures, ISBN, 2007.