Comparative study on performance of RC multi-storey structure with shear wall and steel bracing subjected to seismic load

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Abstract - *The seismic performance of multi-storey buildings is a critical consideration for structural engineers, especially in earthquake-prone regions. Shear walls and steel bracings are two common methods used to enhance the seismic resistance of reinforced concrete (RC) multi-storey buildings. In this study, we compared the seismic performance of RC multi-storey buildings with shear walls and steel bracings. Our findings showed that both shear walls and steel bracings can effectively enhance the seismic performance of RC multi-storey buildings. This study provides valuable insights into the design and construction of RC multi-storey buildings under seismic loads and can assist structural engineers in selecting the most appropriate seismic-resistant method for their specific projects*

Key Words: ETAB, Seismic analysis, Bracings, Shear wall, IS 1893(part I):2002, IS 1893(part I):2016, IS 16700:2017.

1.INTRODUCTION

Earth quake is a natural disaster that causes violent earth motions that have an impact on buildings. Due to the construction of new metropolitan populations near seismically active areas, socioeconomic disasters have spread throughout the world. Structures must have enough lateral stability, strength, and ductility to ensure the safety of the buildings. To safely withstand the significant lateral stresses that are applied to structures during frequent earthquakes, structures must have appropriate earthquake resistant features. These lateral forces have the potential to cause a structure to experience critical stresses, unpleasant vibrations, and lateral sway—all of which could create discomfort for the inhabitants. To improve the lateral stiffness, ductility, minimal lateral displacements, and safety of the structure, shear walls and bracings are placed. When designing structures for earthquakes, storey drift and lateral displacements are crucial considerations.

1.1 SHEAR WALL

One of the most widely used lateral load resisting components in high rise buildings is the shear wall. High in plane stiffness and strength, shear walls (SW) can be employed to support gravity loads and resist heavy horizontal loads at the same time. The goal of the current work is to analyze and examine the performance of RC shear walls in medium-rise buildings. In bare frame buildings, reinforced concrete shear walls are utilized to withstand lateral forces brought on by wind and earthquake.

1.2 STEEL BRACING

One of the technique that the building uses to withstand lateral forces is a bracing system. By improving the lateral stiffness and capacity of the frame, the bracing system enhances the seismic performance of the structure. By flowing through the weak columns, weight might be transmitted from the frame and into the bracing system. The bracing system's enhanced rigidity is maintained virtually to peak strength.

One or more of the following functions are performed by bracings:

- Control buckling.
- Load distribution.
- Dimensional control.

2. METHODOLOGY

It is a piece of engineering software that handles the study and design of multistory buildings. ETABS can be used to analyze simple or complex systems under static or dynamic conditions. Modal and direct-integration time history analyses may be coupled with P-Delta and large displacement effects for a sophisticated evaluation of seismic performance. ETABS is a coordinated and effective tool for designs ranging from straightforward 2D frames to intricate modern high-rises because to its interoperability with a number of design and documentation platforms.

2.2 MODEL DESCRIPTION

Number of storey = (G+8) storey
Plan dimension = 17m×17m
X and Y direction = 5 bays, 3 bays spaced 3m and other 2 spaced 4m
Bottom storey height =3.5m
Typical storey height =3m

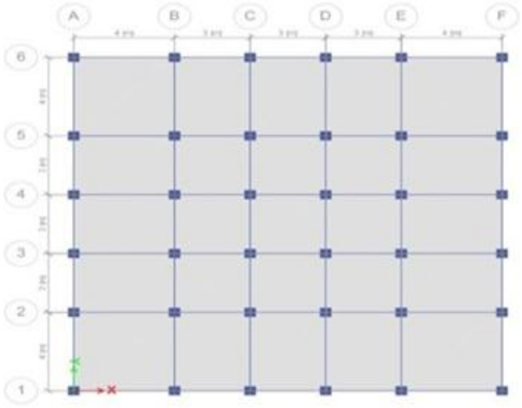


Chart: 2.2: Plan of the mode

2.3 BARE FRAME STRUCTURE

2.3.1. Material properties

Density of concrete =25 kN
Density of steel = 7850
Grade of concrete =M25
Grade of steel =Fe500

Sectional properties

Beam = 300mm×450mm
Column= 450mm×450mm
Slab = 150mm

General Loading

Live load (IS:875 1987) = 1.5kN/m2
Dead load (IS:875 1987) = 1.5 kN/m2
Earthquake load (IS:1893 2002) = 1.25 kN/m2

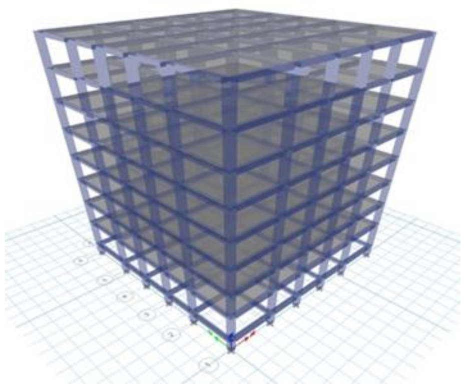


Chart: 2.3: 3d view of Bare frame

2.3.2 STRUCTURE WITH SHEAR WALL AT CORNER PERIPHERY

Section properties:

- Thickness of shear wall =230mm
- Grade of concrete = M25
- Grade of steel = Fe500

The shear wall of thickness 230mmis provided at the corner periphery of the building and the analysis is carried out to know its capacity against earthquake loading. Following Chartures represents the elevation, 3D and plan of the structure with shear wall provided at corner periphery.

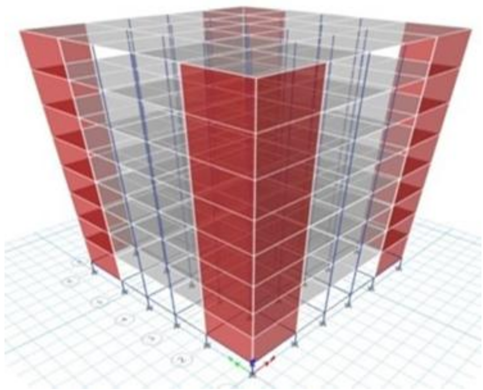


Chart: 2.3.2: 3D model of shear wall at corners

2.3.3 STRUCTURE WITH STEEL BRACING AT CORNER PERIPHERY

The cross(X) steel bracings used for the analysis is ISLB 200.
The section dimensions are as follows:
Total depth = 200mm
Total width =75mm
Thickness of flange =10.8mm
Thickness of web=5.5mm

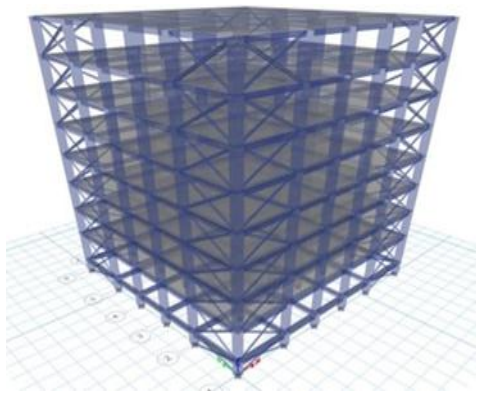


Chart: 2.3.3: 3D view of steel bracing

3. RESULTS AND DISCUSSIONS

Seismic analysis is conducted for G+8 structure i.e, bare frame structure, structure with shear wall at corner periphery and structure with steel bracings at corner periphery. The response of the structure subjected to seismic load is obtained in terms of Storey shear, Storey Displacement and Storey Drift is discussed below.

3.1 BARE FRAME STRUCTURE

3.1.1 STOREY SHEAR

The Storey Shear of the structure subjected to seismic load is shown below.

Table 3.1.1: Bare frame storey shear

Storey	Storey Shear(kN)
Story 8	66.988
Story 7	59.7532
Story 6	45.182
Story 5	32.644
Story 4	22.1392
Story 3	13.6676
Story 2	7.2293
Story 1	2.8816
GL	0.1182
Base	0

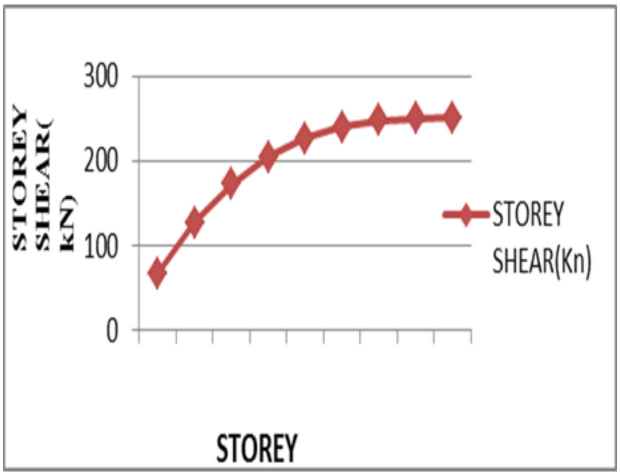


Chart 3.1.1: Bare frame storey shear

3.1.2 STOREY DISPLACEMENT

The Storey Displacement of the structure subjected to seismic load is shown below.

Table 3.1.2: Bare frame storey displacement

Storey	Storey displacement(mm)
Story 8	82.573
Story 7	79.548
Story 6	74.548
Story 5	67.419
Story 4	58.182
Story 3	46.901
Story 2	33.699
Story 1	18.915
GL	2.347
Base	0

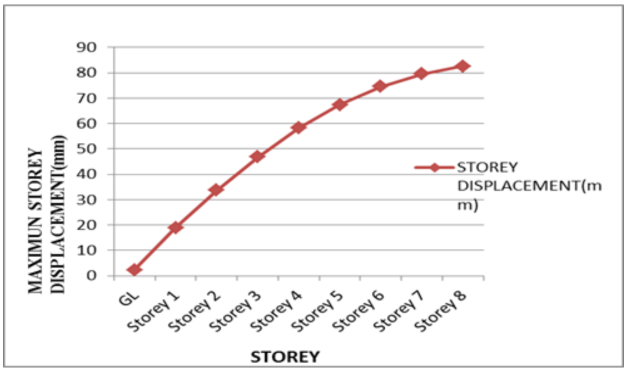


Chart 3.1.2: Bare frame storey displacement

3.1.3 STOREY DRIFT

The Storey Drift of the structure subjected to seismic load is shown below.

Table 3.1.3: Bare frame storey drift

Storey	Storey drift (in 10^{-3})
Story 8	1.009
Story 7	1.666
Story 6	2.376
Story 5	3.079
Story 4	3.76
Story 3	4.401
Story 2	4.928
Story 1	4.734
GL	1.565

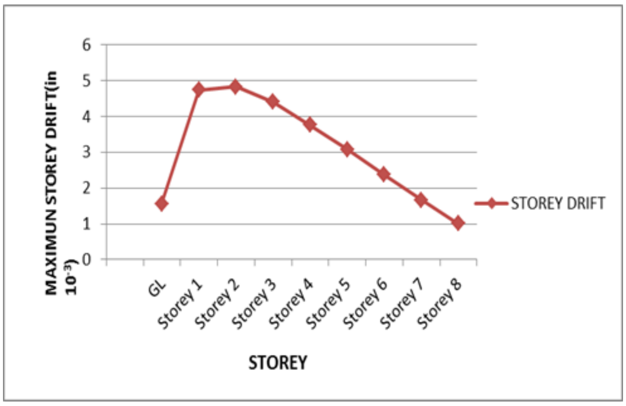


Chart 3.1.3: Bare frame storey drift

3.2 SHEAR WALL STRUCTURE

3.2.1 STOREY SHEAR

The Storey Shear of the structure subjected to seismic load is shown below.

Table 3.2.1: Shear wall storey shear

Storey	Storey shear(kN)
Story 8	146.4044
Story 7	143.7054
Story 6	108.6619
Story 5	78.5082
Story 4	53.2443
Story 3	32.8702
Story 2	17.3859
Story 1	7.0209
GL	0.2995

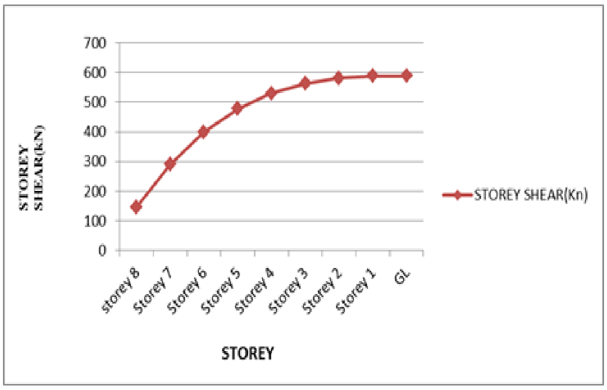


Chart 3.2.1: shear wall storey shear

3.2.2 STOREY DRIFT

The Storey Drift of the structure subjected to seismic load is shown below.

Table 3.2.2: shear wall storey drift

Storey	Storey drift (in 10^{-3})
Story 8	0.886
Story 7	0.911
Story 6	0.926
Story 5	0.925
Story 4	0.898
Story 3	0.839
Story 2	0.734
Story 1	0.565
GL	0.633

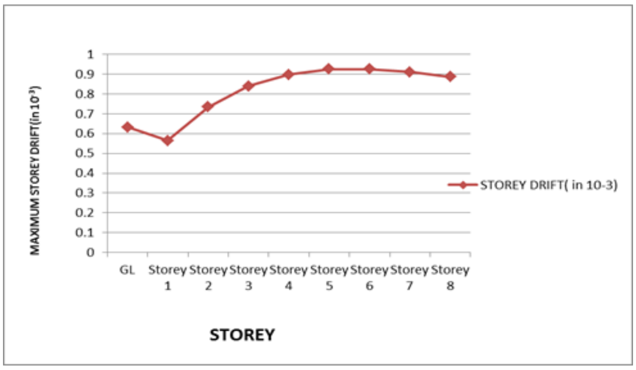


Chart 3.2.2: shear wall storey drift

3.2.3 STOREY DISPLACEMENT

The Storey Displacement of the structure subjected to seismic load is shown below.

Table 3.2.3: shear wall storey displacement

Storey	Storey displacement(mm)
Story 8	21.281
Story 7	18.624
Story 6	15.89
Story 5	13.113
Story 4	10.339
Story 3	7.644
Story 2	5.128
Story 1	2.927
GL	0.949

Chart 3.2.3: shear wall storey displacement

3.3 STEEL BRACING STRUCTURE

3.3.1 STOREY SHEAR

The Storey Shear of the structure subjected to seismic load is shown below.

Table 3.3.1: Steel bracing storey shear

Storey	Storey shear(kN)
Story 8	95.5956
Story 7	85.5338
Story 6	64.6758
Story 5	46.7283
Story 4	31.6911
Story 3	19.5644
Story 2	10.3481
Story 1	4.1252
GL	0.1704

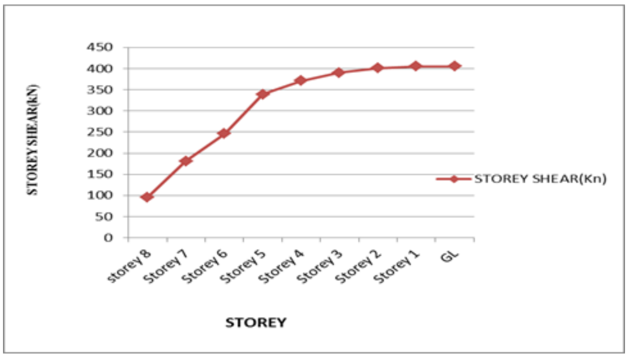


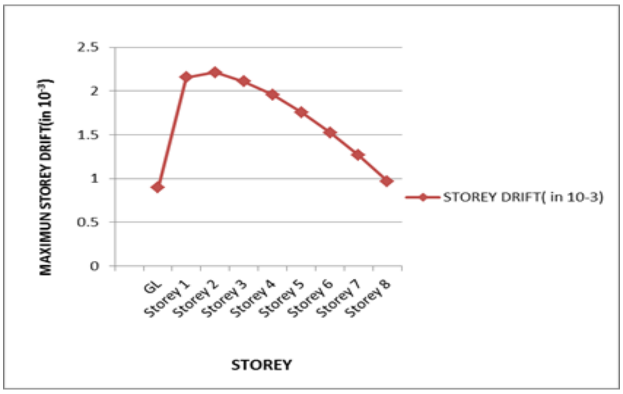
Chart 3.3.1: Steel bracing storey shear

3.3.2 STOREY DRIFT

The Storey Drift of the structure subjected to seismic load is shown below.

Table 3.3.2: Steel bracing storey drift

Storey	Storey drift (in 10^{-3})
Story 8	0.969
Story 7	1.266
Story 6	1.526
Story 5	1.759
Story 4	1.958
Story 3	2.11
Story 2	2.212
Story 1	2.155
GL	0.894



Charture 3.3.2: Steel Bracing storey drift

3.3.3 STOREY DISPLACEMENT

The Storey Displacement of the structure subjected to seismic load is shown below.

Table 3.3.3: Steel bracing storey displacement

Storey	Storey displacement(mm)
Story 8	44.282
Story 7	41.376
Story 6	37.577
Story 5	33
Story 4	27.722
Story 3	21.848
Story 2	15.52
Story 1	8883
GL	1.342

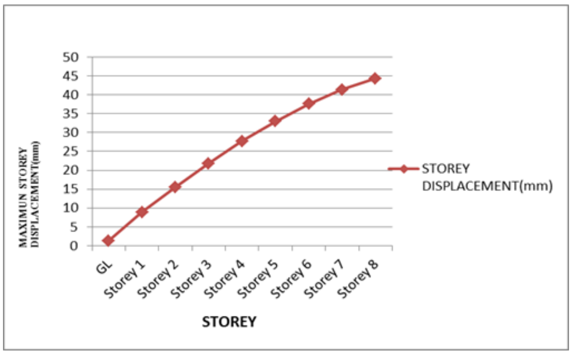


Chart 3.3.3: Steel bracing storey displacement

4. Comparison of response parameter structure

The comparison of the response of the building with bare frame and with structural systems such as shear wall and steel bracings in terms of parameters such as storey shear, storey drift and storey displacement is explained below. From the comparison of the response, it is seen that bare frame structure is very weak to seismic actions while the structure with shear wall and steel bracings at the corner periphery performs well against seismic load when compared to bare frame structure.

4.1. Storey shear

The comparison of Storey Shear with bare frame, shear wall and steel bracing the structure subjected to seismic load is shown below.

Table 4.1: Comparison of storey shear with bare frame, shear wall and bracing

Storey	Storey shear(kN)		
	Bare frame	Shear wall	Bracing
Story 8	66.988	146.4044	95.5956
Story 7	59.7532	143.7054	85.5338
Story 6	45.182	108.6619	64.6758
Story 5	32.644	78.5082	46.7283
Story 4	22.1392	53.2443	31.6911
Story 3	13.6676	32.8702	19.5644
Story 2	7.2293	17.3859	10.3481
Story 1	2.8816	7.0209	4.1252
GL	0.1182	0.2995	0.1704

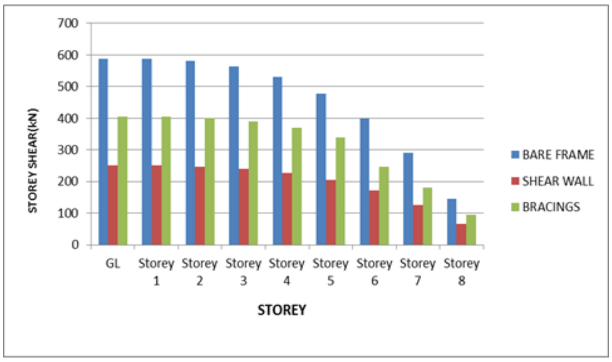


Chart 4.1: comparison of storey shear with bare frame, shear wall and steel bracing

4.2 STOREY DRIFT

The comparison of Storey Drift with bare frame, shear wall and steel bracing the structure subjected to seismic load is shown below.

Table 4.2: Comparison of storey drift with bare frame, shear wall and bracing

Storey	Storey drift (in 10^{-3})		
	Bare frame	Shear wall	Bracing
Story 8	1.009	0.886	0.969
Story 7	1.666	0.911	1.266
Story 6	2.376	0.926	1.526
Story 5	3.079	0.925	1.759
Story 4	3.76	0.898	1.958
Story 3	4.401	0.839	2.11
Story 2	4.928	0.734	2.212
Story 1	4.734	0.565	2.155
GL	1.565	0.633	0.894

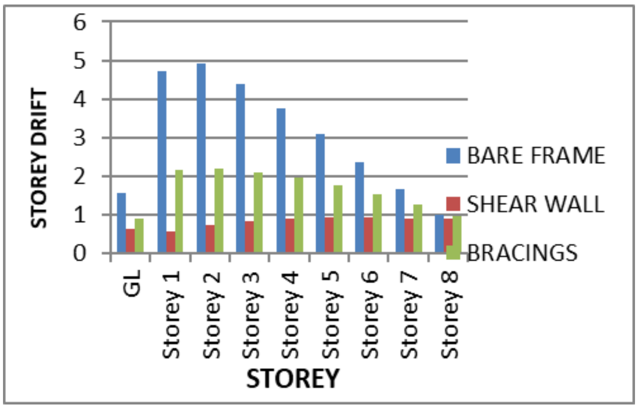


Chart 4.3: Comparison of storey drift with bare frame, shear wall and bracing

According to the obtained above graph, the structure with a shear wall and steel bracings experiences less storey shear, displacement, and drift than a typical bare frame building. Buildings with corner shear walls experience 4%, 36%, 26% less story shear, displacement, and drift, correspondingly. Storey shear, displacement, and drift are reduced by 10%, 23.%, and 11% respectively as compared to bare frame structure and structure with corner X steel bracings. As a result, it may be said that shear walls and steel bracings are more effective at protecting structures from earthquake load

5. CONCLUSION

Based on analysis and design of multistory structure the following conclusions are made:

Providing shear walls in suitable sites significantly reduces the earthquake related displacements. The seismic reaction is more significantly impacted by the placement of shear walls at corner and bracings at corner than bare frame.

When compared to a normal structure, the above designed structures natural lifespan is drastically reduced the following the installation of steel bracings and shear wall.

By using X Type steel bracing system, the building's lateral displacement is decreased by 35% to 45%, and the X bracing ty pe also reduces maximum displacement. By using X type steel bracing system the structure frame will have minimum possible bending moments compared to other two steel bracing types.

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