Evaluation of Steel Braced Frame Structure Performance for Multiple Floors and Loading

Karan Hanamant Lawand
Post Graduate Student, Department of Civil Engineering, KJCOEMR, Pune, India

A. B. Pujari
Associate Professor, Department of Civil Engineering, KJCOEMR, Pune, India

Dr. S.K. Patil
[3]Head of Department of Civil Engineering, KJCOEMR, Pune, India

Abstract- Investigating the lateral load resisting system is the project's goal. In multistory buildings, bracings are a structural element used to withstand lateral loads (lateral loads resulting from seismic and wind stress). Bracings are currently the most often used system. It is the ideal technique for a system that resists lateral loads and will be a very practical way to increase earthquake resistance. Bracings are included to reduce the building's lateral displacement. This study examines the G+6 and G+13 storeys in relation to seismic zone III and soil type III. To determine the structural performance under ground motion during an earthquake, analysis is done. Several bracing types, including A-type, diagonal, K-, V-, and X-type bracings, are taken into consideration in this study. We took into consideration a 5x5 bay with 5m X and Z spacing for the analysis. STAAD Pro is the program used for analysis. For similar static and response spectrum analysis, results are achieved by taking into account Storey Displacement, Base Shear, Bending Moment, Structure Weight, and Time Period. Bracings are used to considerably lessen lateral movement and to improve the structure's stiffness and stability under lateral loads. To guarantee stability and safety, the design of the structural members will follow building norms and standards.

Keywords: Storey Displacement, Base Shear, Bending moment, weight of structure, Time Period, STAAD PRO

I. Introduction

The goal of the project "Analysis Of Different Type Steel Braced Frames Subjected to Seismic And Gravity Loading Using Staad" is to compare and examine how well multi-story buildings' lateral load-resisting systems work structurally. India has seen several earthquakes in the last thirty years that have seriously damaged both industrial and residential structures. Although only about 3% of the built environment is designed, over 60% of India's geographical area now falls within the higher seismic zones III, IV, and V of the Indian seismic code [IS 1893 (Part-1):2002]. India has a huge stock of sensitive buildings and the potential for strong seismic shaking. As a result, it is imperative to implement appropriate earthquake-resistant design and construction elements, and using steel in construction can have assist in creating safe constructed environments in areas like India that are vulnerable to earthquakes. A key component of designing a structure that is earthquake-resistant is giving its parts and structure enough flexibility. Steel is a ductile material; the yield plateau, strain hardening region, and strain softening part of the stress-strain curve of typical mild carbon steel are present. This does not, however, imply that the steel structure will be entirely ductile. The onus is on the designer and fabricator to make effective use of steel's ductility in order to construct ductile steel structures that can withstand earthquakes. However, unique methods and attention to detail in design and detailing are required for this. Large inertia forces that may be produced by earthquake ground motion must be resisted by a building's structural components. Large stresses, strains, deformation, and displacement are caused by these forces, especially in tall structures. Maintaining the displacement within the limit is essential.

We offer bracing in order to limit this displacement. Bracings improve the frame's lateral stability, lateral strength, and lateral stiffness. Bracing functions well as an energy dissipator under dynamic stress. Bracings are structural elements that successfully resist lateral loads in multi-story buildings. They are more economical and efficient.

Bracings made of structural steel components are employed. By absorbing the load that would otherwise be placed on the columns, the bracing system increases the structure's rigidity and stability. The strongest mechanism for supporting lateral loads is this one.

II. REASERCH METHODOLOGY

Numerical Modelling

Examining six G+6 and G+13 story structures with various bracing systems and contrasting them with bare frames is the aim of this project. As indicated in 5.1 above, four design models are currently under preparation. The main focus of the analysis is to evaluate multi-story steel buildings in seismic zones III using STAAD software. Each of the chosen designs features a unique bracing pattern. It functions as an architectural design even though it doesn't depict a real or intended building. Analysis of the structure has been conducted to evaluate its response to dynamic seismic forces and gravity.

Table. 1. Parameters for building design

Sr. No	Parameters	Values
1	No. of Storey	G+6 & G+13
2	Height from Base to Plinth	2.0 m
3	Floor Height	Ground to 5th floor: 3.0 m ,
4	Infill Wall	Interior & Exterior wall: Thickness of 150 mm
5	Materials	Using M25 grade Concrete & Fe250 Structural Steel
6	Size of the frame	25m x 25m
7	Grid spacing	For X direction grids - 5 m & For Y direction grids- 5.0 m
8	Column size	ISMB 400/450/500
9	Beam size	ISMB300/350
	Bracing size	ISA90x90x6
10	Slab depth	125 mm
11	Overall height of building	20.0 m
12	Building Plan area	Symmetric building: 625Sq.m

Table. 2. Load details for building analysis.

Sr.N	Parameters	Values

o		
a.	Dead load	Weight of slab = 0.125 X 25 = 3.125 KN/m^2 Weight of floor finish = 1.5 KN/m^2 Total Dead load = 4.625 KN/m^2
b.	For the Roof and Floors the Live load is as follows	According to IS:875 (part -2) For Roof-2 KN/m^2 and For Floor -2 KN/m^2
c.	For the Roof and Floors the Floor Finish is as follows	According to IS:875 (part -2) floor finish is 1 KN/m^2
d.	For all the levels , Wall Load is	o.15 x (3-0.3) x 7 = 2.835 KN/m
f.	Wall load of Parapet	0.15 x 1.2 x 7 = 1.26 KN/m

Table. 3. Seismic data required analysis

Sr. No	**Parameters**	**Values according to IS 1893:2016 (Part 1)**	**References**
1	Type of Structure	Special RC moment resisting frame	Table No. 9, Clause 7.2.6
2	Seismic Zone	II	Table No. 3, Clause 6.4.2
3	Location	Pune	Annex E
4	Zone Factor(Z)	0.16	Table No. 2, Clause 6.4.2
5.	Type of soil	Rock or Hard Soil	Clause 6.4.2.1
6	Damping	5 %	Clause 7.2.4
7	Response spectra	According to IS	Clause 6.4.6
8	Load combinations	1.5(DL + LL) 1.2(DL+LL+EL) 1.5(DL+EL) 0.9DL+1.5EL	Clause 6.3.1
9	Response reduction factor for Inelastic deformation (R)	5	Table No. 9, Clause 7.2.6
10	Occupancy Importance factor (IF)	1	Table No. 8, Clause 7.2.3

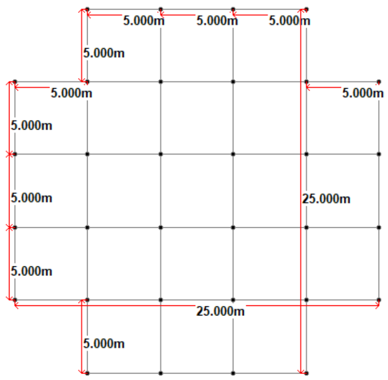


Fig.1. Plan view

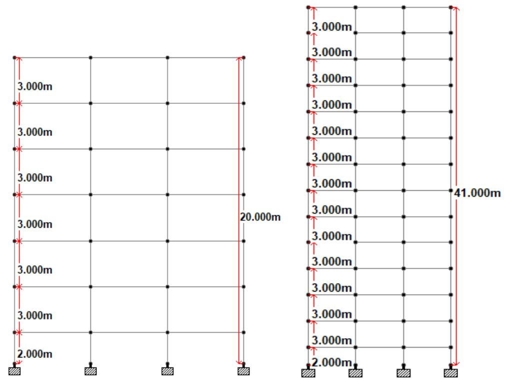


Fig.2. Elevation View

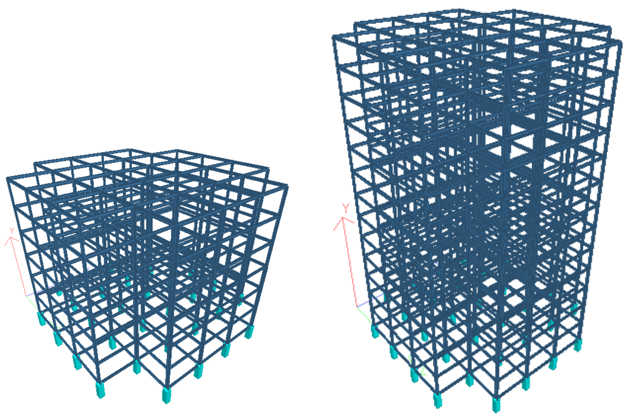


Fig.3. View for Bare Frame

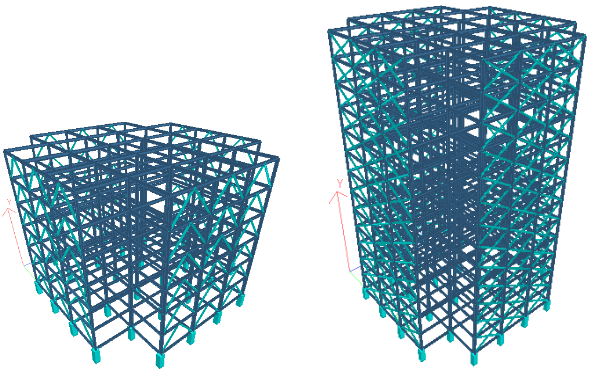


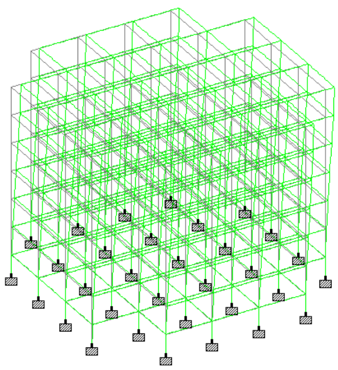
Fig.4. 3D View for Braced Frame

Methodology

1. Examine the responses to gravity loads of six different types of braced frames and one unbraced frame.
2. Examine the reactions to seismic loads of six different types of braced and unbraced frames.
3. Examine the reactions to wind loads of six different types of braced and unbraced frames.
4. From the perspective of the design force, choose the best bracing type and placement.
5. Examine different kinds of multistory frames with the same kind of bracing and make a critical comparison with the examples above.
6. Examine multistory frames that have soft ground (stilted floor) storeys and that have soft storeys at intermediate floor levels, using various bracing kinds.
7. Optimizing the frames using the most appropriate kind of bracing system.
8. To look into how a multi-story steel frame construction responds to earthquakes.
9. Under the same bracing arrangement, but with different building heights or story counts.

III. Experiment and Result

Shear Force Displacement visualization due to earthquake load:



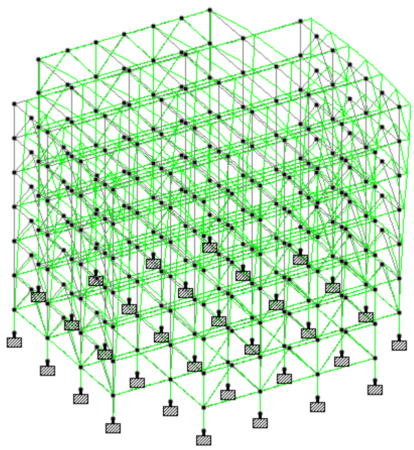
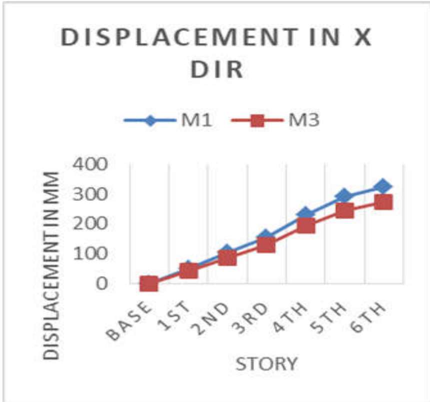


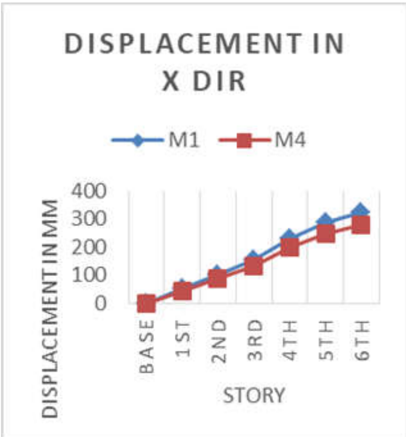
Fig.5. Bare frame deflection view. **Fig.6.** Braced frame deflection view.

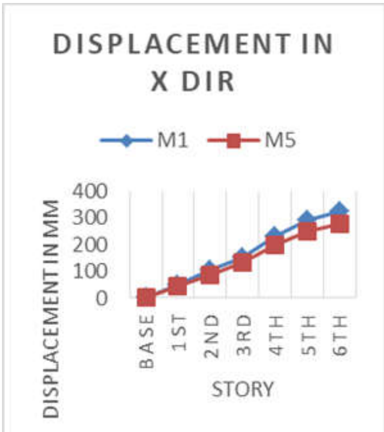
Storey Displacement:

Comparison for Storey Dispacement in X-Direction of frame between Bare frame VS braced frame multistorey building model :

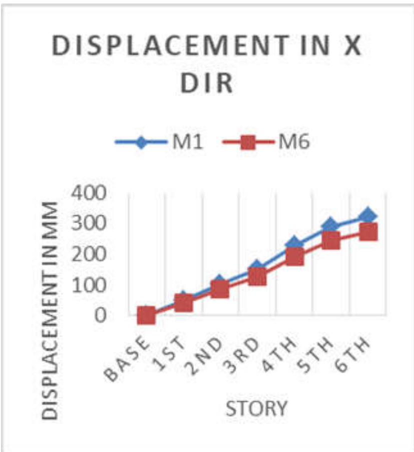


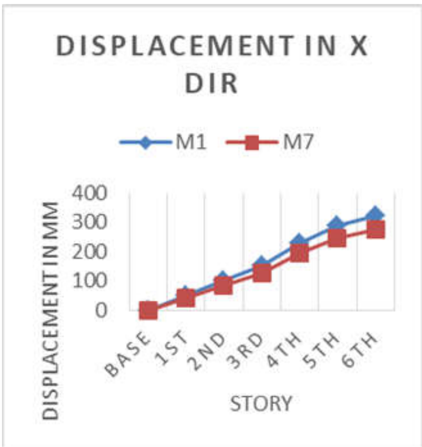
Graph 1. Storey Displacement for **Graph 2.** Storey Displacement for M1&M2 M1&M3



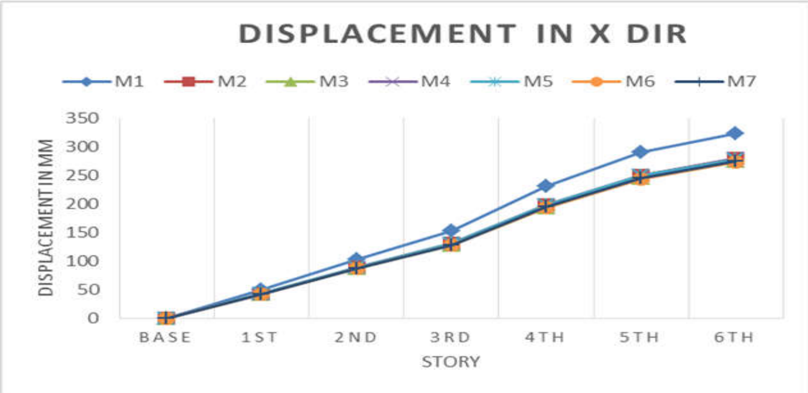


Graph 3. Storey Displacement for **Graph.4.** Storey Displacement for M1&M4 M1&M5

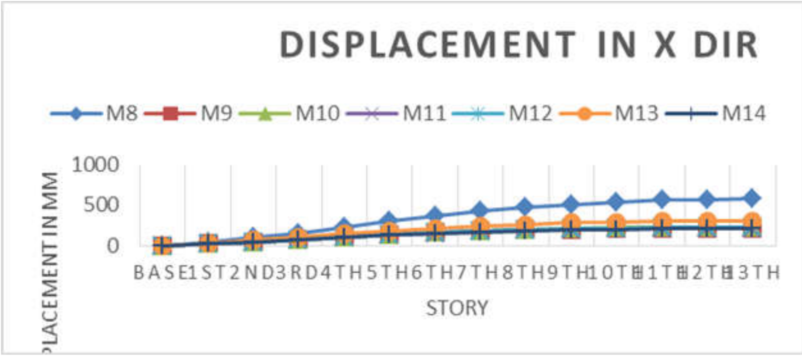




Graph 5. Storey Displacement for **Graph 6.** Storey Displacement for M1&M6 M1&M7



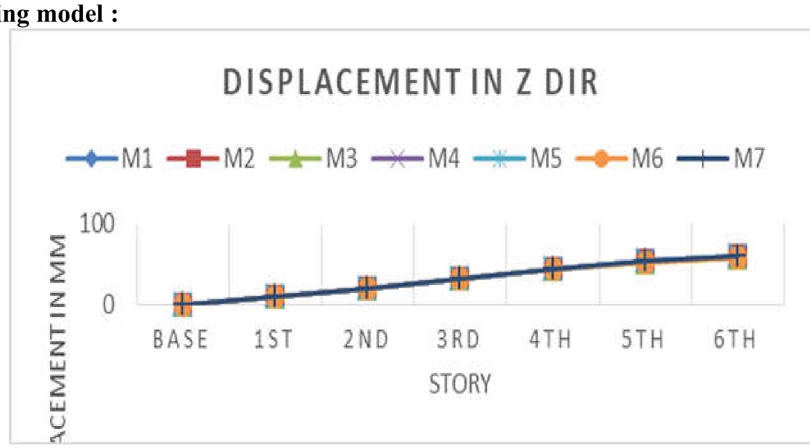
Graph 7. Storey Displacement in X-Direction for M1 to M7



Graph 8. Storey Displacement in X-Direction for M8 to M14

We conclude from the graphical representations that the Storey Displacement in X-Direction with braced frame is less than that of bare frame in terms of percentage change. The variation comes out to be roughly 13–15% (or roughly 13.6% for M2 and 15.16% for M3). The introduction of bracing in the frame reduces deflection and improves structural performance.

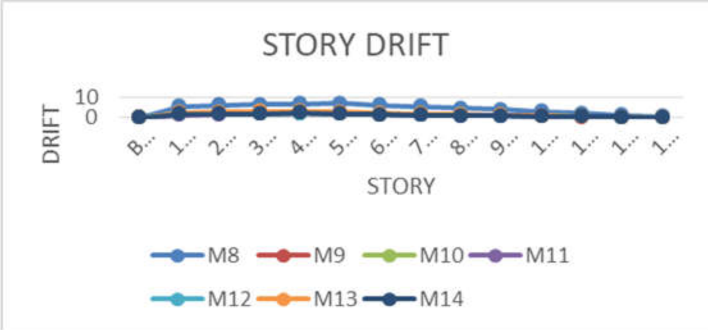
Comparison for Storey Dispacement in Z-Direction of frame between Bare frame VS braced frame multistorey building model :



Graph 9. Storey Displacement in Z-Direction for M1 to M7

Based on the graphical representations, we may conclude that the Storey Displacement in Z-direction is slightly less with a braced frame than a naked frame. The variance is about between one and two percent (or, for M2, roughly 1.16%). There is less deflection in the Z-Direction since the column orientation is in that direction.

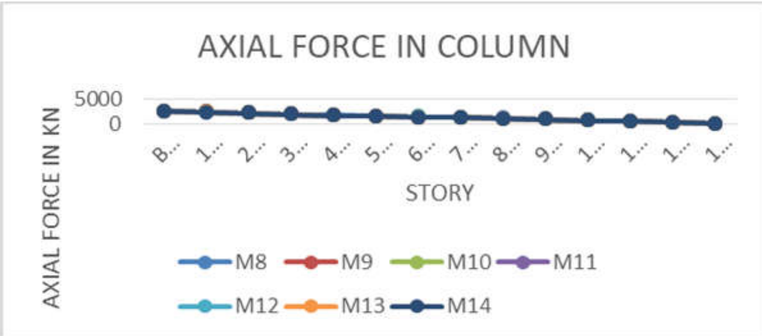
Comparison for Storey Drift in X-Direction of frame between Bare frame VS braced frame multistorey building model :



Graph 10. Storey Drift in X-Direction for M8 to M14

We conclude from the graphical representations that Storey Drift in X-Direction is lessened by a smaller percentage change when using a braced frame instead of a bare frame. The variation is roughly 12.4% (about 12.4% for M13) and 11.5% (about 11.5% for M10). Structural performance increases when bracing introduced in the frame drifts less.

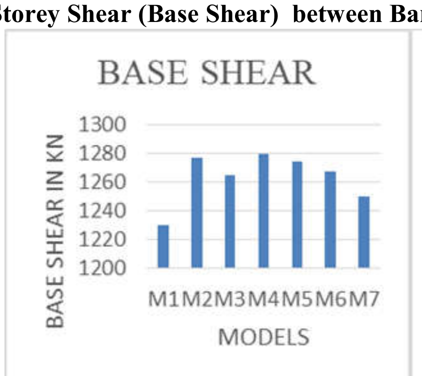
Comparison for Axial force in column of frame between Bare frame VS braced frame multistorey building model :



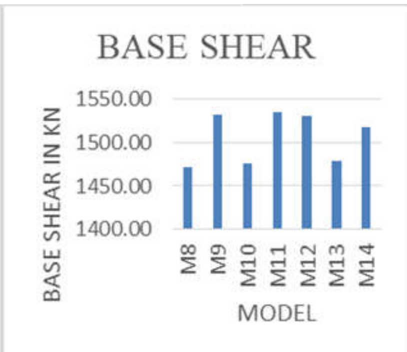
Graph 11. Axial force in column for M8 to M14

We conclude from the graphical representations that the percentage change in axial force in a column with a braced frame is lower than that of a column with a bare frame. The variation is roughly 1.14 percent.

Comparison for Storey Shear (Base Shear) between Bare frame and braced fram multistorey building model



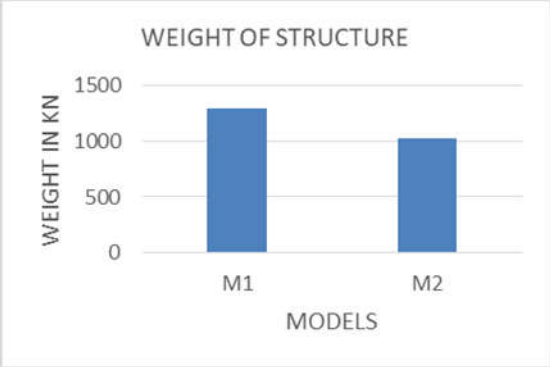
Graph 12. Storey (Base Shear) for M1 to M7



Graph 13. Storey (Base Shear) for M8 toM14

Since base shear depends on the weight of the structure, the graphical representations lead us to the conclusion that there is no major change in base shear.

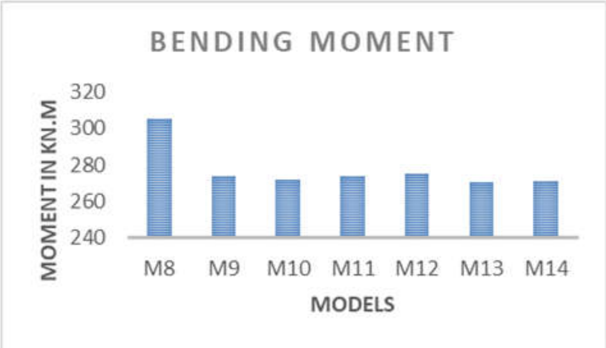
Comparison for weight of structure between Bare frame and braced fram multistorey building model :



Graph 14 . Weight of the structure for M1 to M2

We conclude from the graphical representations that the weight of a braced frame is 15–20% less than that of a bare frame.

Comparison for Bending moment between Bare frame and braced fram multistorey building model :

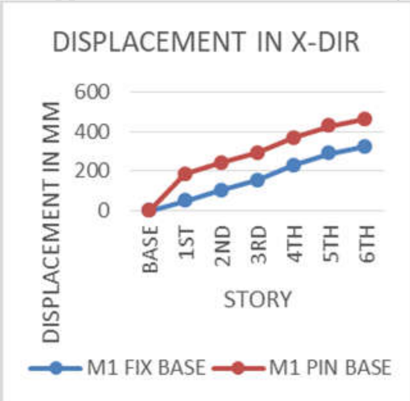


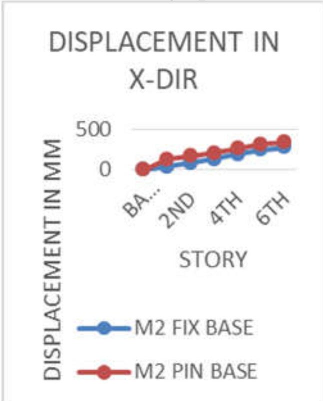
Graph 15. Bending moment for M8 to M14

We conclude from the graphical representations that the braced frame has a 10–11% lower bending moment than the bare frame. The moment of the frame decreases as bracings are added because they enhance the stiffness of the frame.

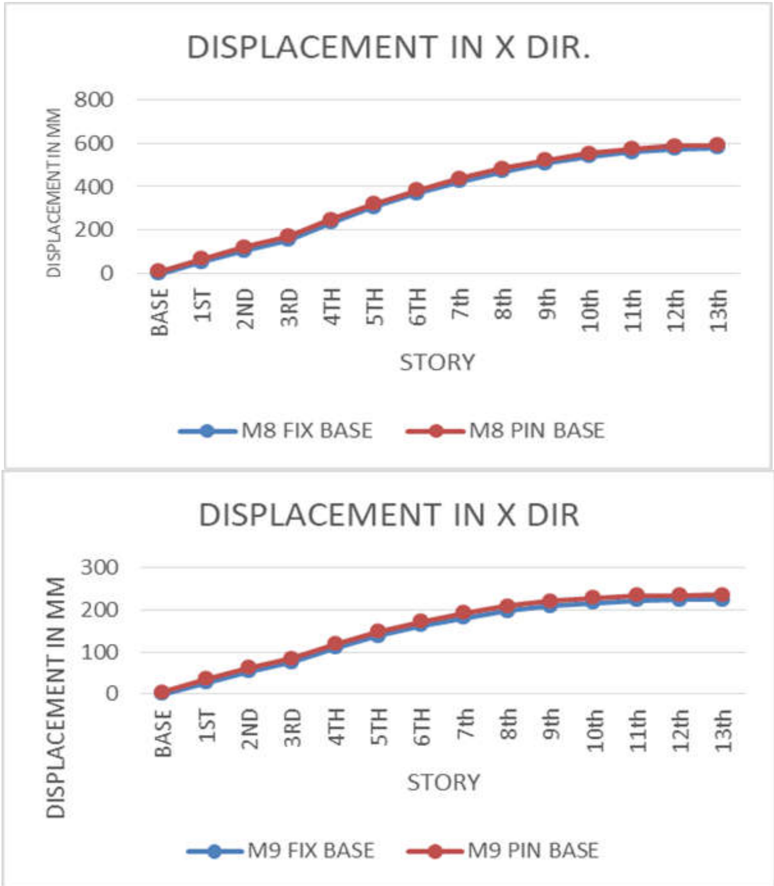
Results for the support condition Pin base and Fix base :

In the second part of the study, the support condition was changed, and a comparison analysis between fix base support and pin base support was conducted. The findings are shown in a table and graph.





Graph 16. Storey Displacement in X-Direction for M1 & M2 in case of Fix base & Pin base.



Graph 17. Storey Displacement in X-Direction for M8 & M9 in case of Fix base & Pin base.

The aforementioned graph shows that when using a fixed base support frame instead of a pin base support frame, the storey displacement in the X-Direction changes by a less proportion. The difference is roughly 25–30% (roughly 30% for M1) and 19.1% (nearly 19.1% for M2). As bracing is added to the frame, the pin base support system's deflection decreases.

IV.CONCLUSION

This research examines various braced buildings and compares their seismic properties, including base shear and storey displacement. Based on analysis, the following results are summarized:

- Storey Displacement-

-Strength and rigidity are increasingly crucial elements in high-rise structures. Therefore, bracing systems are used to improve both of these properties for this reason. When compared to other braced buildings, MRF buildings displayed a greater storey displacement, indicating their weakness and increased susceptibility to seismic damage.

- Compared to bare frames, braced frames have a lower % change in storey displacement in the X-direction. The variation comes out to be roughly 13–15% (or roughly 13.6% for M2 and 15.16% for M3). The introduction of bracing in the frame reduces deflection and improves structural performance.

- Storey Drift-

- Compared to bare frames, braced frames have a lower % change in storey drift in the X-Direction. The variation is roughly 12.4% (about 12.4% for M13) and 11.5% (about 11.5% for M10). Structural performance increases when bracing introduced in the frame drifts less.

- Axial force-

- The axial force in the column of a braced frame is 1.14 percent less than that of a bare frame.

- Bending moment-

- The bending moment of a braced frame is reduced by 10% to 11% as compared to a bare frame.

- Storey Shear-

- Since base shear is reliant on the weight of the structure, there has been no discernible change in base shear.

- The base shear of braced structures rose relative to brace-free buildings, indicating an increase in the stiffness of the structure.

- Structure weight-

-When compared to a bare frame, the weight of a braced frame is reduced by 15 to 20%. The stability of the frame increases as bracings are added because they improve the rigidity of the frame.

- Storey Displacement for pin base and fix base-

- Compared to pin base support frames, there is a smaller % change in storey displacement in the X-direction with fixed base support. The difference is roughly 25–30% (roughly 30% for M1) and 19.1% (nearly 19.1% for M2). As bracing is added to the frame, the pin base support system's deflection decreases.

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