Seismic Analysis of RC Building Frames with Different Types of Steel Bracing using Different Steel Section

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Abstract— Steel bracing system is one of the very efficient lateral load resisting system for multistory buildings. Steel bracings are generally used in steel structures to resist lateral forces, this concept is extended to RC buildings. Bracing members are subjected to compression and tension, hence they are provided to take these forces. Steel bracing system increase the stiffness and stability of the RC multistory building and decrease there deformation. Present study based on seismic analysis of RC building frames with different types of steel bracings provided externally and internally in the building using three different steel section for bracing members. For this study, a fifteen storey building assumed to be located at seismic zone IV as per IS: 1893-2002. Four types of bracings (X type, V type, inverted V type and diagonal type) are provided on two different location in the building and for these bracing members, three steel section ISA, ISMC and ISMB are used by considering same cross-sectional area. StaadproV8i computer software is used for structural modeling and analysis work. Results are in terms of following seismic parameters-bending moment, shear force, storey displacement and storey drift, which are compared with bare frame model. Results shows that steel bracings increase the stiffness and stability of the RC building as compared to bare frame model. From which X-type and inverted V type bracing shows better result than other type of bracing system. Location of these bracing members in the structure also effects the behavior of the RC building frame under seismic forces.

Key words: Steel Bracing System, RC Building Frame, Seismic Analysis, Storey Displacement, Storey Drift, Bending Moment and Shear Force Etc

I. INTRODUCTION

Steel braced frame is one of the lateral load resisting system in multistory reinforced concrete buildings**.** Bracing systems are normally used in steel structures to decrease lateral displacements and dissipate energy for the period of ground motions generate due to earthquake. This concept is extended to concrete structures. Bracing system improve the seismic performance of the structure by increasing its stiffness and stability. Bracings act as lateral load carrying members which reduces the bending moment and shear force in the columns and beams . Bracings hold the structure stable by transferring the lateral loads such as earthquake or wind loads down to the ground and resist lateral loads, in that way prevent the sway of the structure. Steel bracing in reinforced concrete multistory building is economical, easy to put up, occupy less space and provide required strength and rigidity. Bracing members can be provided either vertically or horizontally. Bracings in vertical planes (between lines of columns) provide load paths to transfer horizontal forces to ground level and provide a stiff resistance against overall sway. At every floor level, bracing in a horizontal plane, generally provided by floor plate action, provides a load path to transfer the horizontal forces (mainly from the perimeter columns, due to wind pressure & seismic force on the cladding) to the planes of vertical bracing. Bracing members can be arranged in many ways like X bracing, V bracing, inverted V bracing, diagonal bracing, K bracing, inverted K bracing etc.

II. STRUCTURAL MODELING

Following two types of structural configuration is studied.

1) RC fifteen storey building without steel bracing
2) RC fifteen storey building with different steel bracings on two locations using three steel section ISA, ISMC, ISMB by considering the same cross sectional area.

Total 9 models are analysed in this study.

- One bare frame model
- Two models of X bracing
- Two models of V bracing
- Two models of inverted V bracing
- Two models of diagonals bracing

These bracing systems are provided at two locations in the RC building frame. For bracing members three steel section ISA, ISMC and ISMB of same cross-sectional area, are used.

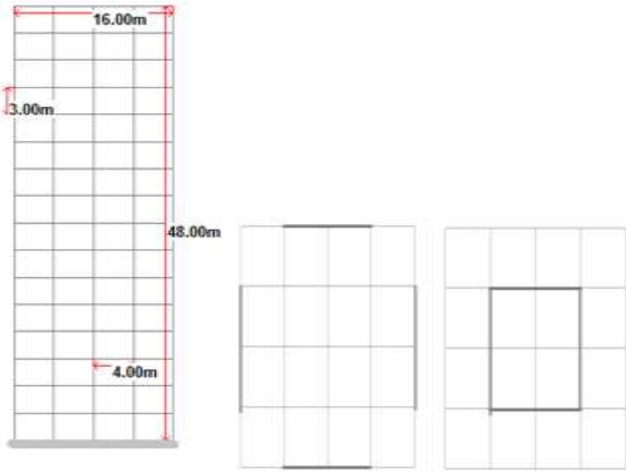


Fig. 1: Building elevation and locations of steel bracing in RC building frame

S. NO.	Description	Parameter
1.	Grade of concrete	M-30
2.	Grade of steel	Fe-415
3.	Total storey	15
4.	Floor to Floor height	3m
5.	Bay width	16m x 16m
6.	Column size	500mm x 500mm
7.	Beam size	500mm x 300mm
8.	Slab thickness	150mm

9.	Wall thickness	200mm
10.	Bracing details -1	ISA 150x150x10
11.	Bracing details-2	ISMC 350
12.	Bracing details-3	ISMB 300

Table 1: Building Details

III. METHODOLOGY

The method used in this study is Seismic coefficient method which is an equivalent static analysis considering a design seismic coefficient. Gravity (dead and imposed) load and seismic load corresponding to seismic zone IV of IS 1893:2002 are considered for the design. Ordinary moment resisting frame is considered in all the cases having response reduction factor (RF) as 3.

All building frames are assumed to be located on medium soil. All buildings are important type structure. Damping ratio is taken as 5%.The various seismic parameters are summarized below in the table.

Seismic parameter	**Value**
Zone factor	0.24
Response reduction factor(RF)	3
Importance factor(I)	1.5
Rock & soil site factor	2
Damping ratio	.05
Type of structure	1

Table 2: Seismic Parameters

The slab thickness is taken as 150 mm for all the buildings. All Infill walls are considered to be the external with thickness of 200 mm. The parapet wall is assumed to be of 200 mm thickness and of 1m height for all the building frames. The unit weight of brick is taken as 20Kn/$m^3$and concrete as 25kN/m^3. All supports are taken as fixed. The structures are modeled by using computer software StaadProV8i. The floor load is taken as 4.75kN/m^2 including floor finish load as 1 kN/m^2. The live load of 3kN/m^2 is assumed in all the cases. Total 15 load cases are taken according to the IS: 1839-2002. The various load case details including 1893 load X1,1893 load Z1,dead load(member load, self-weight,& floor load) , live load and other 11 load cases are generated based on Indian codes.

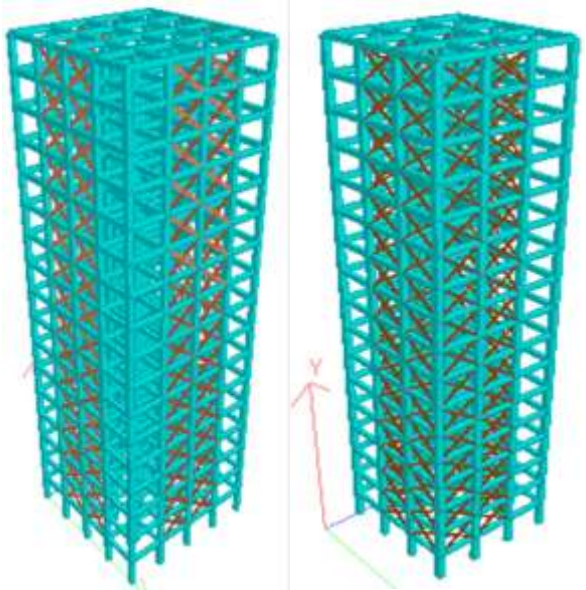


Fig. 15(a): X bracing at location1 Fig. 15(b): X bracing at Location 2

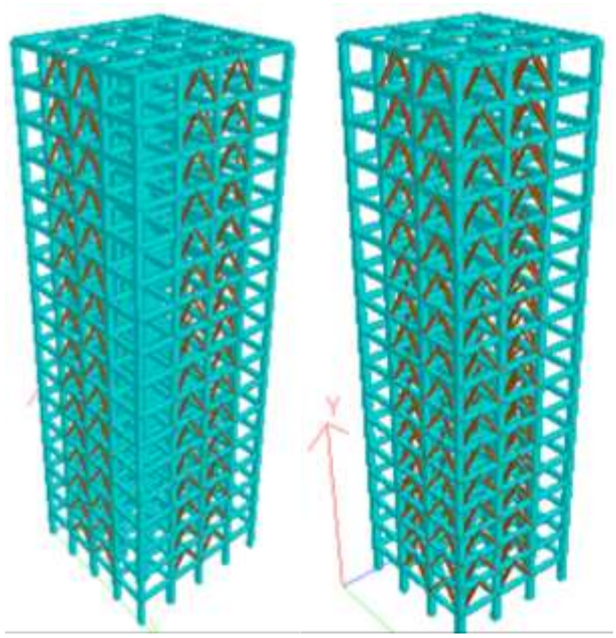


Fig. 15(c): Inverted V bracing at Location 1 Fig. 15(d): Inverted V bracing at Location 2

Fig. 15: storey building frames with steel bracings

Similarly V bracing and diagonal bracing are provided at these locations. For bracing members three steel section ISA, ISMC and ISMB are used.

IV. RESULTS

Results of analysis are present in terms of various graphs and their discussion.

A. Graphs for Location 1:

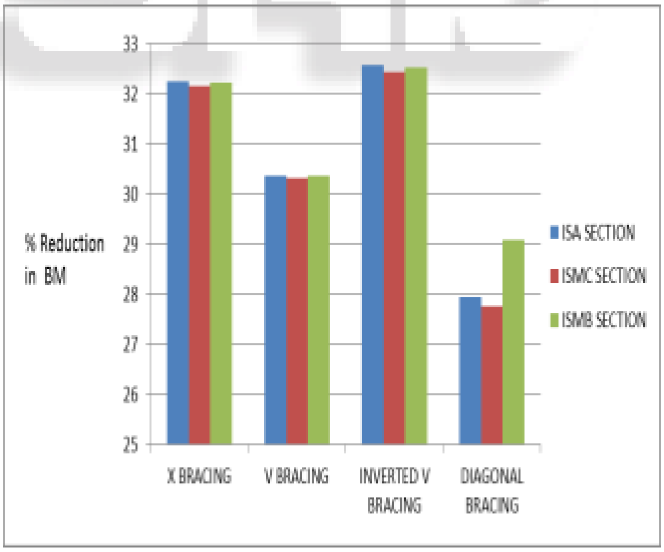


Fig. 16: % Reduction in Bending Moment

Above graph shows the % reduction in bending moment as compared to bare frame. Three section as ISA, ISMC and ISMB are used for steel bracing members. Diagonal type , X type , V type and inverted V type bracings are considered. From the above graph it is clear that , X type and inverted V type bracings have maximum % reduction in BM as compared to V type and Diagonal type bracings. For diagonal bracing ISMB section show better result as compared to other section.

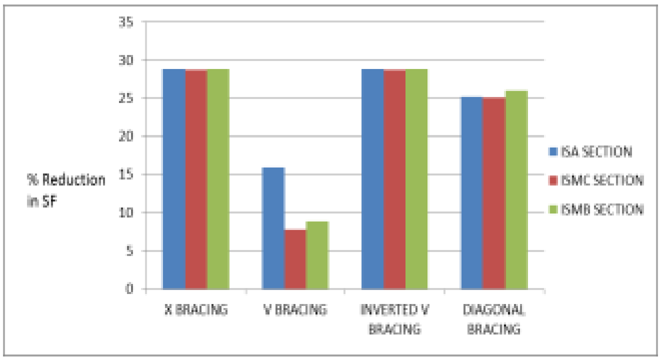


Fig. 17: % Reduction in Shear Force

Above graph shows % reduction in shear force, when steel bracings placed at location 1 as compared to shear force of bare frame. X type and inverted V type bracing show the maximum % reduction in shear force about 28 %, than other type of bracings. Diagonal bracing give approx 25 % reduction in shear force while V type bracing show lowest value. All three steel section show the approx equal results but for V type bracing ISA section give better result.

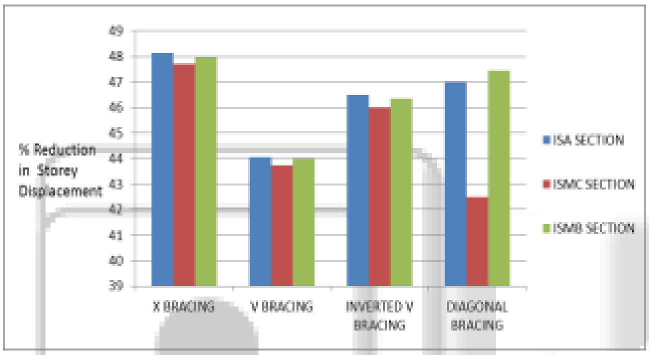
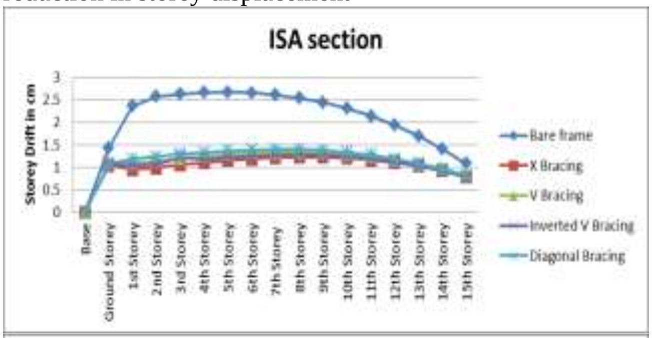
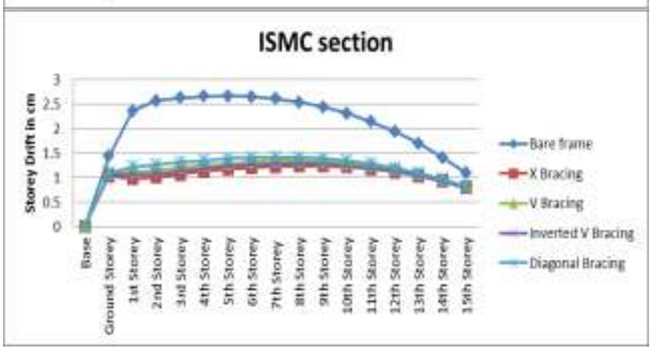


Fig. 18: % Reduction in Storey Displacement

Above graph shows the % reduction in storey displacement for location 1. X type bracing show good result about 48 % reduction in storey displacement than other type of bracings. In case of diagonal bracing ISMB and ISA steel section give better result about 47 % than ISMC section. V type bracing show lowest values of % reduction in storey displacement





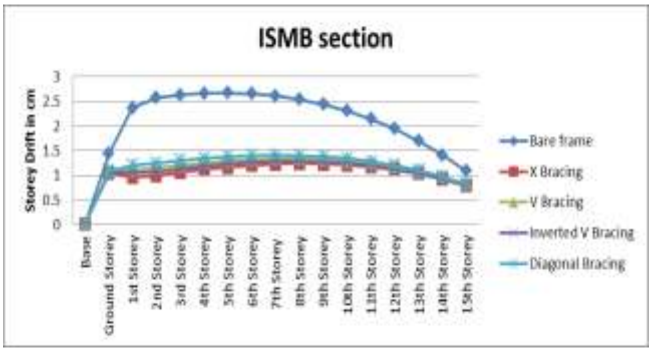


Fig. 19: Storey Drifts for location 1

Above graph show the storey drift for ISA, ISMC and ISMB section for location 1. Bare frame show the maximum storey drift as compared to steel braced frame. X type bracing show better result as compared to other type of bracing. All steel section gives approx. same results of storey drift. Diagonal bracing have maximum storey drift.

B. Graphs for Location 2:

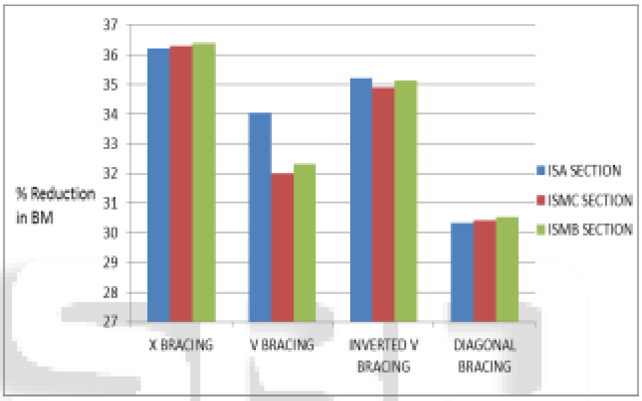


Fig. 20: % Reduction in Bending Moment

This graph represents % reduction in bending moment for location 4. In this case X type of bracing shows maximum reduction in BM about 36 % , while diagonal bracing give lowest value. Inverted V type bracing shows about 35 % reduction in BM. In case of V bracing , ISA section shows good result as compared to ISMC and ISMB section.

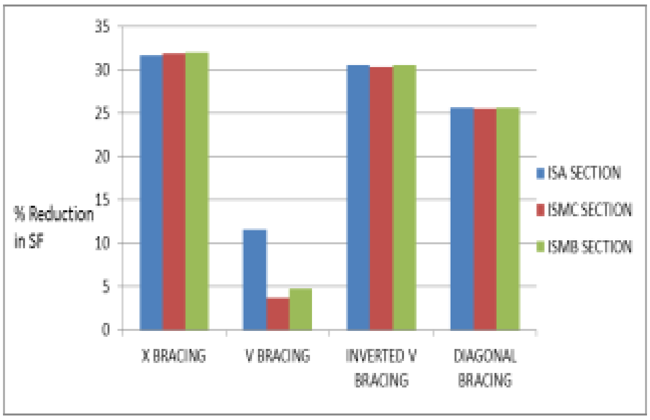


Fig. 21: % Reduction in Shear Force

Above graph shows % reduction in shear force for location 4. X type and inverted V type bracing shows better result than other bracings. X type and inverted V type bracing shows about 32% and 30 % reduction in shear force. V bracing have lowest values. All three steel section shows approx same result but for V bracing ISA section give better result.

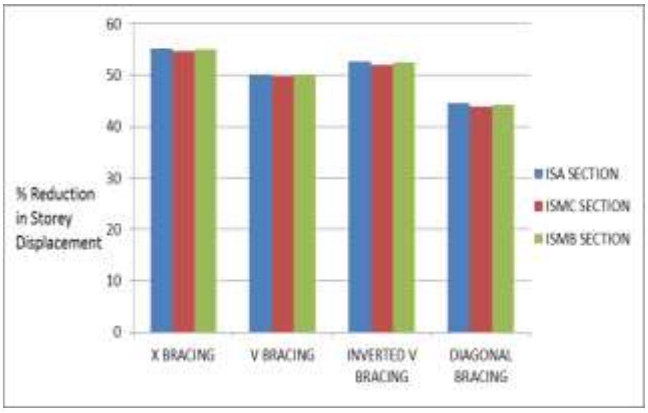


Fig. 22: % Reduction in Storey Displacement

Above graph shows % reduction in storey displacement with respect to different bracing patterns. X bracing have maximum reduction about 55 % while diagonal bracing shows lowest value. Inverted V type and V bracing shows about 52 % and 50 % reduction in storey displacement respectively. All steel section shows approx same results.

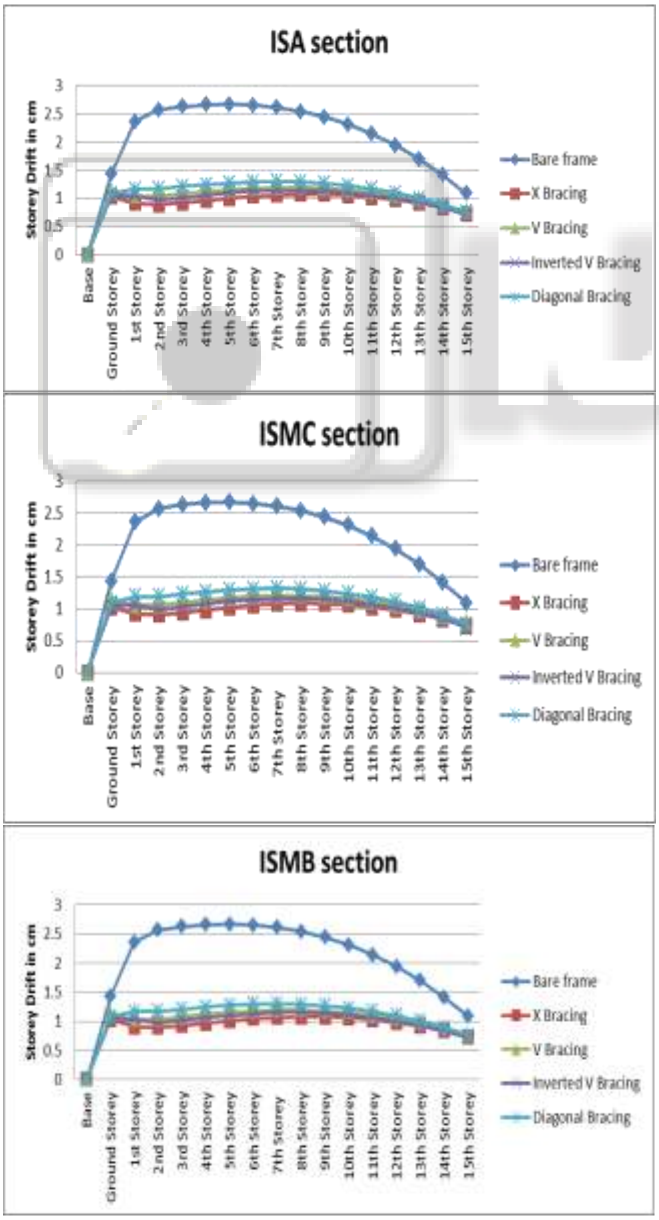


Fig. 23: Storey Drift for location 2

These graphs represent storey wise storey drift for various types of steel bracings. Bare frame have maximum storey drift than steel braced frame. X bracing shows lower values of storey drift while diagonal bracing shows higher values of storey drift.

V. Conclusion

Following are the conclusions of the study –

– The provision of steel bracing members in the RC building frame increase the resistance of the RC building against earthquake forces.
– Steel braced frame shows better performance than bare frame.
– X bracing and inverted V bracing reduce the bending moment and shear force effectively than other type of bracing.
– Storey displacement and storey drifts are minimum for X bracing as compared to other bracings.
– ISA and ISMB section shows better result as compared to ISMC section.
– Internally braced frame (location 2) give better performance than externally braced frame (location 1).

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