International Journal of Electronics, Communication & Soft Computing Science and Engineering
ISSN: 2277-9477, Volume 2, Issue 1

# SEISMIC RESPONSE OF STEEL BUILDING WITH LINEAR BRACING SYSTEM (A Software Approach)

**Manish S. Takey** **Prof. S.S.Vidhale**

***Abstract*** **- As compare to the Reinforced cement concrete (RCC) the steel has got some important physical properties like the high strength per unit weight and ductility. The high yield and ultimate strength result in slender sections. Being ductile the steel structures give sufficient advance warning before failure by way of excessive deformations. These properties of steel are of very much vital in case of the seismic resistant design. To analysis the response of unsymmetrical building with braces subjected to seismic loading using SAP and to identify the suitability of the bracing system to resist the seismic loads efficiently and also to compare the response of braced and unbraced building which subjected to horizontal or lateral loading system. This synopsis describes the analysis of high-rise steel building frame with different bracing section. For present work equivalent static analysis is carried out for steel moment resisting building frame having (G+9) storey situated in zone III. Modelling will be done by using Response spectrum method. The steel moment resisting building frame is analyze by with and without steel bracing system. The analysis of steel bracing and the building are carried out using Software. The main parameters consider in this paper to compare the seismic performance of buildings are bending moment, shear force, story drift and axial force. The models are analyze by equivalent static analysis as per IS 1893:2002.**

***Key Word*** **- Seismic response, Steel building, Linear bracing system.**

## I. GENERAL

Seismic are one of the great damaging natural hazards. In the last three decades, the study of the variation effect on the seismic response of civil structures has been advanced significantly. For example, several response spectrum method have been developed by different researchers to calculate the seismic response of structures to multi-support excitations. Seismic it happens due to happening quickly transient motion of the ground which results into release of elastic energy in a matter of few seconds. An earthquake is caused by a sudden slip on a fault. The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in the form of waves that travel through the earth's crust and cause the shaking of the ground. The impact of the event is most traumatic because it affects large area, occurs suddenly and is unpredictable. They can cause large scale loss of life and property and disrupts essential services such as Water Supply, Sewerage systems, Communication and power, Transport etc. They not only destroy villages, towns and cities but the aftermath leads to destabilization of the economic and social structure of the nation.

In this project studied that the to analysis the response of unsymmetrical building with braces subjected to seismic loading using SAP and to identify the suitability of the bracing systems to resist the seismic loads efficiently and also to compare the response of braced and unbraced building which subjected to horizontal or lateral loading system.

## II. OBJECTIVES OF THE PROJECT

- To compare response of braced and unbraced building subjected to lateral loads.
- To identify the suitable bracing systems for resisting the seismic loads efficiently.
- To analyses the response of unsymmetrical building with braces subjected to seismic loading using SAP2000 or improve year.

## III. MODELING AND ANALYSIS OF BUILDING

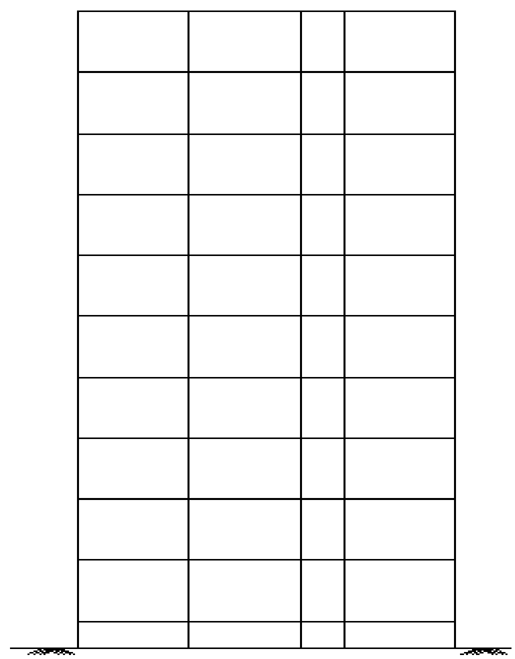

Fig 3.1 Elevation of Building

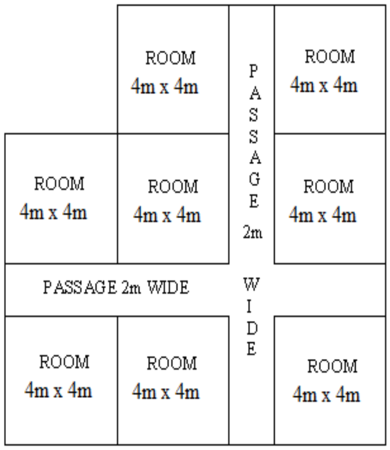


Fig 3.2 Plan of building

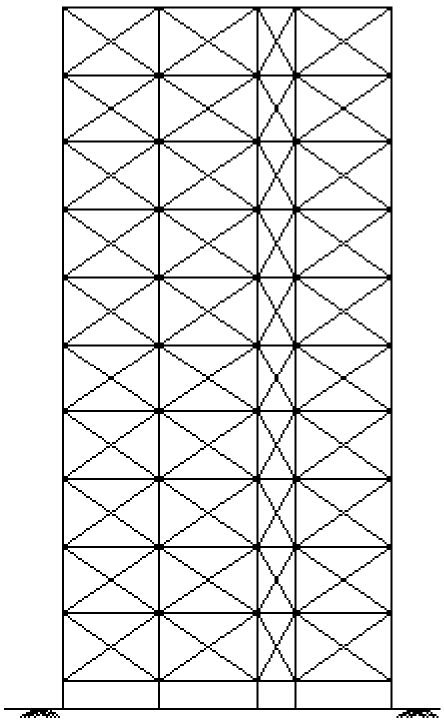

Fig 3.3 Elevation of X braced building

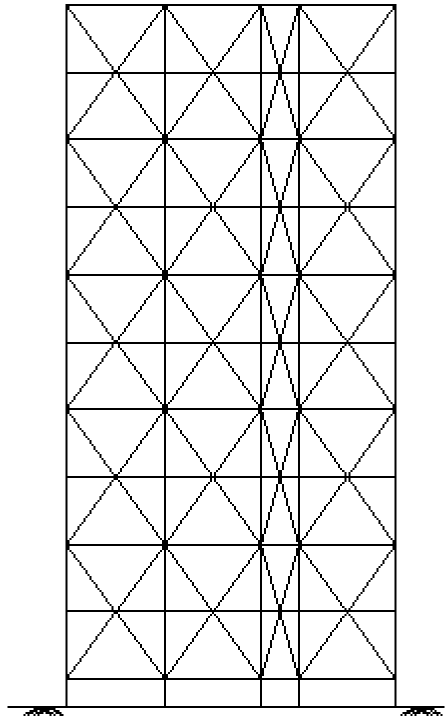

Fig 3.4 Elevation of Diagonal braced building

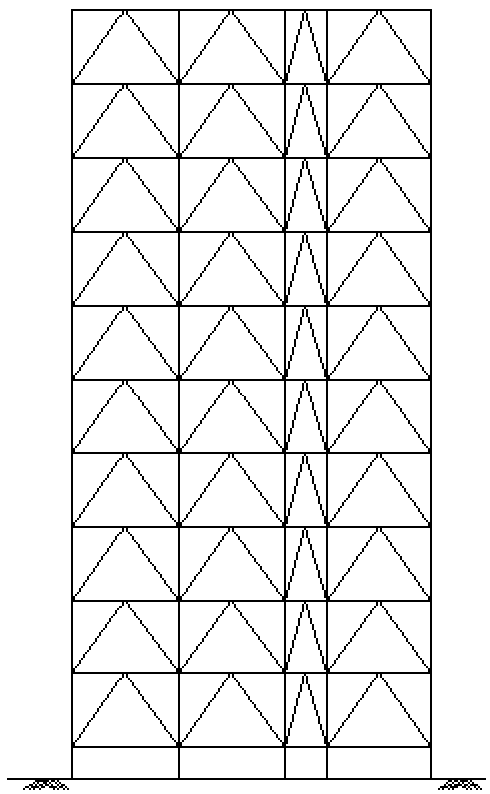

Fig 3.5 Elevation of Inverted V braced building

## IV. INTRODUCTION TO SAP 2000 ANALYSIS

The steel building is how it works using the software SAP 2000. It gets better the seismic performance of high rise buildings, different bracing systems with different braced sections are proposed and the analysis is carried out for unsymmetric building. Response spectrum analysis is carried out on these models. The analysis results are demonstrated with the help of figures and charts. Finally, the comparative study is carried out based on different parameters such as bending moment, lateral displacement, axial forces, storey drifts and base shear.

SAP2000 is anything that has a fixed form inputs, meaning that material properties, equilibrium and compatibility equation, energy and work principals, incompatible elements, boundary conditions, analysis methods, design principals and philosophy. Also, the information about building and site condition, meaning that the number of frames with spacing of columns longitudinal direction and transverse direction. The number of stories and types of diaphragm, usage of building, soil condition, wind and seismicity condition.

## V. Introduction To Result And Discussion

Earthquakes are one of the greater damaging natural hazards. They are not only towns destroy villages, and cities but the aftermath leads to destabilization of the economic and social structure of the nation. The major cities affected by the earthquake are Bhuj, Anjar, Gandhidham, Khandala Port, Ahemdabad, Rajkot, Sundernagar etc. where major damage occurred. In this work, analysis of symmetrical braced and unbraced building is carried out for earthquake zone III. Comparison of different performance characteristics are made to check the performance of unbraced and braced building having different bracing systems. Bracing is done with different IS channel sections and different bracing systems are used to improve the seismic performance of building. Response Spectrum analysis is carried out on building models using the software SAP 2000.

*Storey Drift*

The graphs of storey drift versus storey level are plotted for different bracing sections and systems.

*For ISMC 200*

The graphs for ISMC 200 are plotted in X direction and Y direction as shown in fig. 5.1 and fig. 5.2.

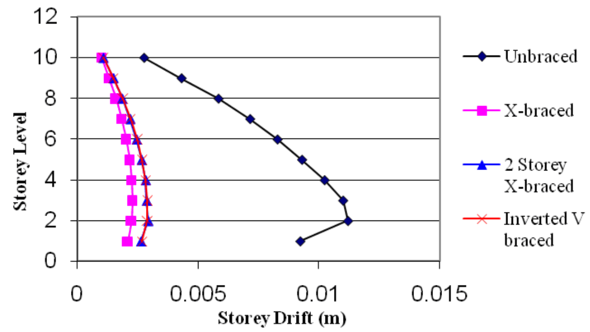


**Fig.5.1..Storey Drift In X- Direction**

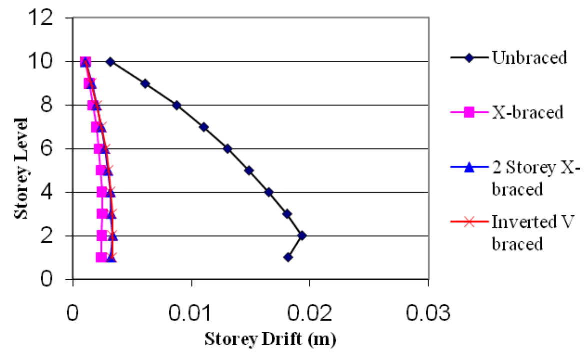


**Fig.5.2. Storey Drift In Y - Direction**

From fig. 5.1 and fig. 5.2 it can be seen that storey drift in braced building in both X and Y direction are reduced in comparison with the unbraced building. The maximum drift at the second storey in X direction reduces by 63.35%, 61.12%, and 60.73% and in Y direction by 66.81%, 66.53%, 66.5% for X bracing, 2-storey X bracing and inverted V bracing respectively.

*For ISMC 250*

The graphs for ISMC 250 are plotted in X direction and Y direction as shown in fig. 5.3 and fig. 5.4.

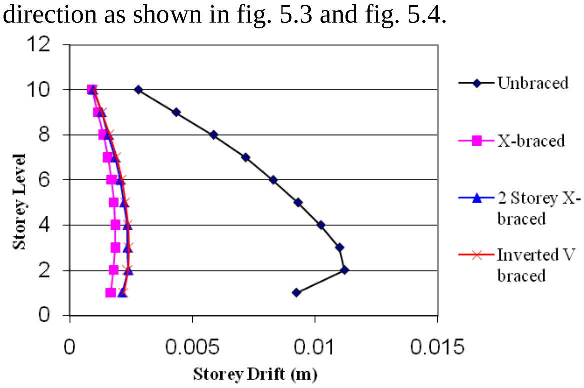


**Fig.5.3. Storey Drift In X - Direction**

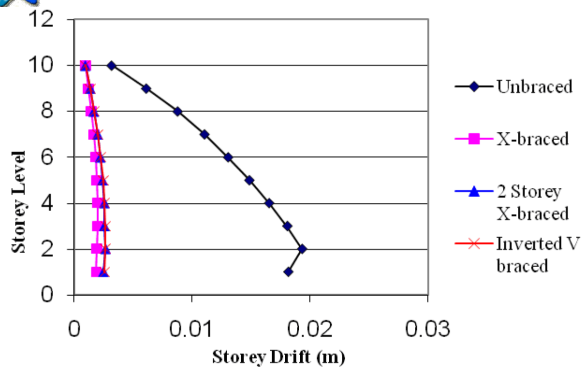


Fig.5.4. Storey Drift In Y - Direction

From fig. 5.3 and fig. 5.4 it can be seen that storey drift in braced building in both X and Y direction are reduced in comparison with the unbraced building. The maximum drift at the second storey in X direction reduces by 66.8%, 65.5%, and 64.43% and in Y direction by 69.5%, 70.1%, 69.22% for X bracing, 2-storey X bracing and inverted V bracing respectively.

*For ISMC 300*

The graphs for ISMC 300 are plotted in X direction and Y direction as shown in fig. 5.5 and fig. 5.6.

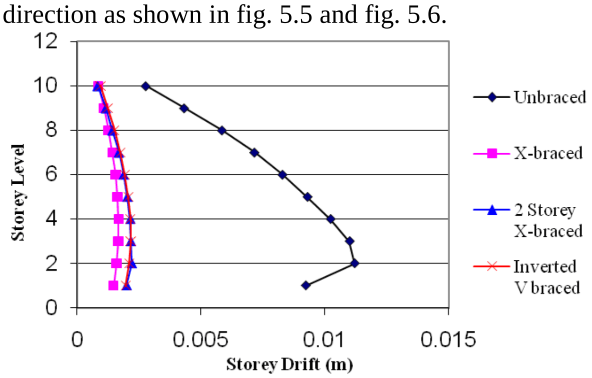


Fig.5.5. Storey Drift In Y - Direction

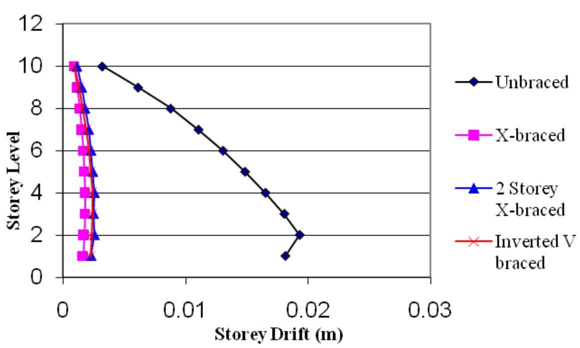


Fig.5.6. Storey Drift In Y - Direction

From fig. 5.5 and fig. 5.6 it can be seen that storey drift in braced building in both X and Y direction are reduced in comparison with the unbraced building. The maximum drift at the second storey in X direction reduces by 68.6%, 69.6%, and 66.26% and in Y direction by 70.7%, 64.6%, 70.5% for X bracing, 2-storey X bracing and inverted V bracing respectively.

*For X Bracing System*

The graphs for X Bracing System are plotted in X direction and Y direction as shown in fig. 5.7 and fig. 5.8.

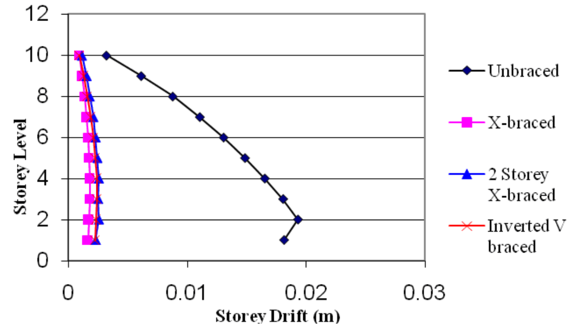


Fig.5.7. Storey Drift In X - Direction

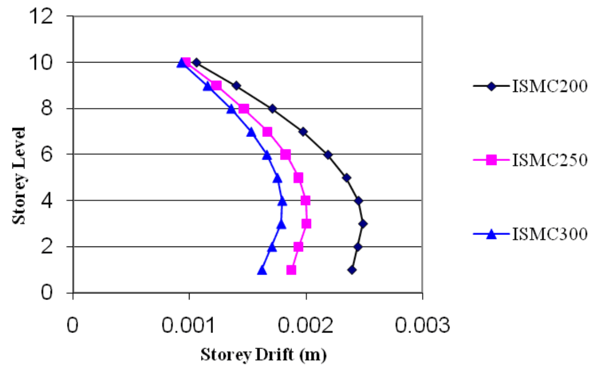


Fig.5.8. Storey Drift In Y - Direction

Fig. 5.7 and fig. 5.8 illustrated that the storey drift for building with ISMC 300 is less as compared to building with ISMC 200 and ISMC 250. The storey drift in X braced building with ISMC 300 in X direction reduces by 5.3% and 14.38% and in Y direction by 4.11%, 11.9% as that of building with ISMC 200 and ISMC 250 respectively.

*For Diagonal Bracing System*

The graphs for diagonal Bracing System are plotted in X direction and Y direction as shown in fig. 5.9 and fig. 5.10.

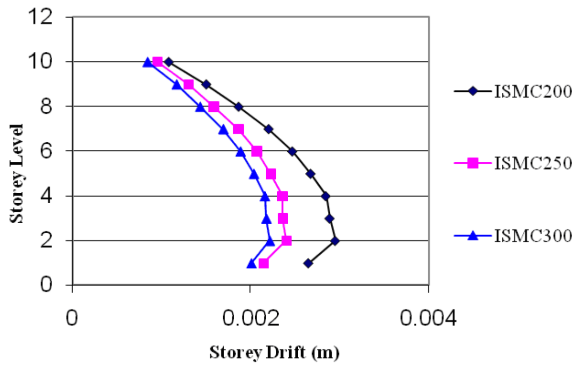


**Fig.5.9. Storey Drift In X - Direction**

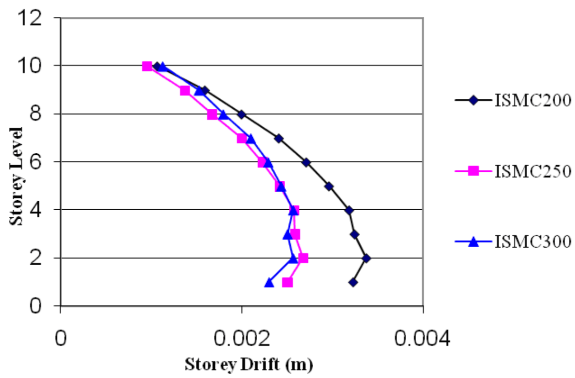


**Fig.5.10. Storey Drift In Y - Direction**

Fig. 5.9 and fig. 5.10 illustrated that the storey drift for building with ISMC 300 is less as compared to building with ISMC 200 and ISMC 250. The storey drift in Diagonal braced building with ISMC 300 in X direction reduces by 11.34% and 21.17% and in Y direction by 10.77%, 5.32% as that of building with ISMC 200 and ISMC 250 respectively.

*For Inverted V Bracing System*

The graphs for Inverted V Bracing System are plotted in X direction and Y direction as shown in fig. 5.11 and fig. 5.12.

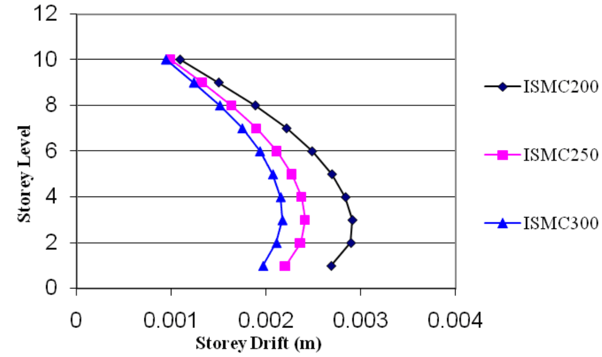


**Fig.5.11. Storey Drift In X - Direction**

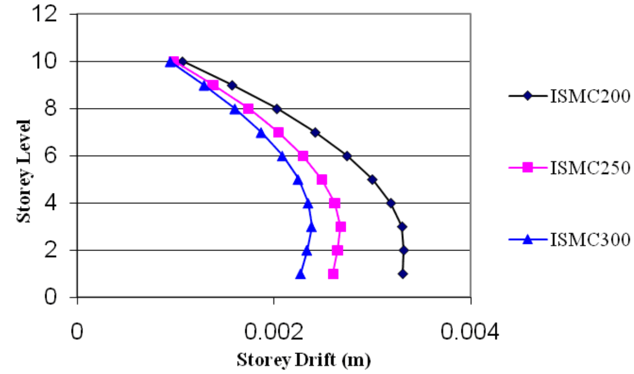


**Fig.5.12. Storey Drift In Y - Direction**

Fig. 5.11 and fig. 5.12 illustrated that the storey drift for building with ISMC 300 is less as compared to building with ISMC 200 and ISMC 250. The storey drift inverted V braced building with ISMC 300 in X direction reduces by 9.4% and 14.06% and in Y direction by 8.23%, 12.06% as that of building with ISMC 200 and ISMC 250 respectively.

*VI. Lateral Displacement*

The different graphs are plotted taking floor level as the abscissa and displacement as ordinate for different bracing sections and systems.

*For ISMC 200*

The graphs for ISMC 200 are plotted in X direction and Y direction as shown in fig. 5.13 and fig. 5.14.

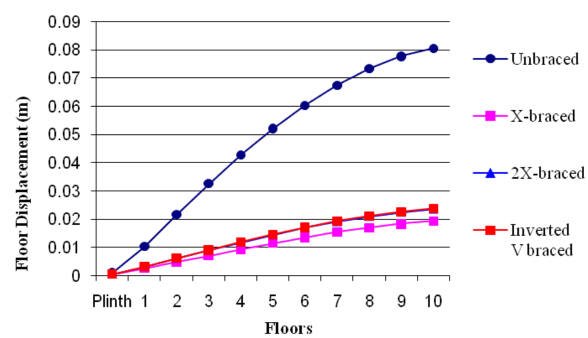


**Fig.5.13. Displacement Of Floors In X - Direction**

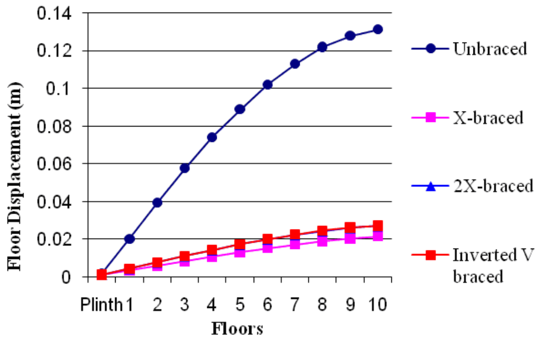


Fig.5.14. Displacement Of Floors In Y – Direction

From fig. 5.13 and fig. 5.14 it can be seen that lateral displacements in braced building in both X and Y direction are reduced in comparison with the unbraced building. The displacement at the top storey in X direction reduces by 75.9%, 70.51%, and 70% and in Y direction by 83.43%, 79.39%, 79% for X bracing, 2-storey X bracing and inverted V bracing respectively.

*For ISMC 250*

The graphs for ISMC 250 are plotted in X direction and Y direction as shown in fig. 5.15 and fig. 5.16.

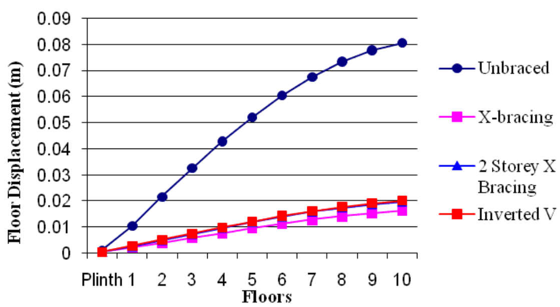


Fig.5.15. Displacement Of Floors In X – Direction

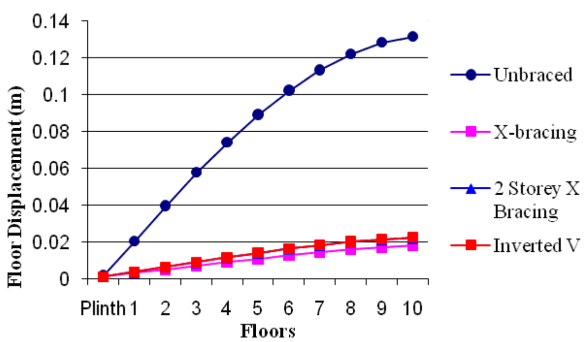


Fig.5.16. Displacement Of Floors In Y – Direction

From fig. 5.15 and fig. 5.16 it can be seen that lateral displacements in braced building in both X and Y direction are reduced in comparison with the unbraced building. The displacement at the top storey in X direction reduces by 79.8%, 75.34%, and 74.97% and in Y direction by 86.14%, 83%, 82.67% for X bracing, 2-storey X bracing and inverted V bracing respectively.

*For ISMC 300*

The graphs for ISMC 300 are plotted in X direction and Y direction as shown in fig. 5.17 and fig. 5.18.

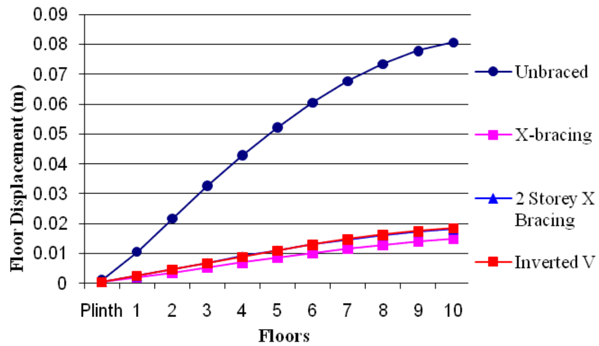


Fig5.17. Displacement Of Floors In X – Direction

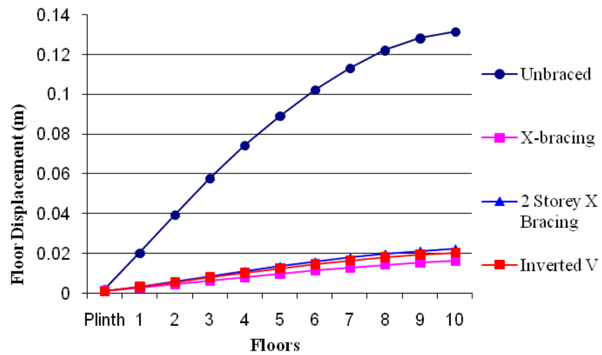


Fig.5.18. Displacement Of Floors In Y – Direction

From fig. 5.17 and fig. 5.18 it can be seen that lateral displacements in braced building in both X and Y direction are reduced in comparison with the unbraced building. The displacement at the top storey in X direction reduces by 81.62%, 77.45%, and 77.16% and in Y direction by 87.37%, 82.83%, 84.26% for X bracing, 2-storey X bracing and inverted V bracing respectively.

*For X Bracing System*

The graphs for X Bracing System are plotted in X direction and Y direction as shown in fig. 5.19 and fig. 5.20.

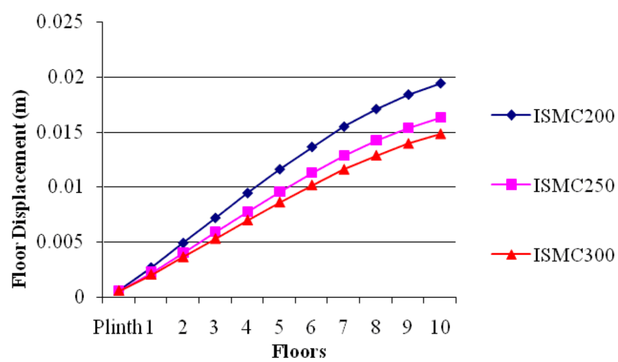


Fig.5.19. Displacement Of Floors In X – Direction

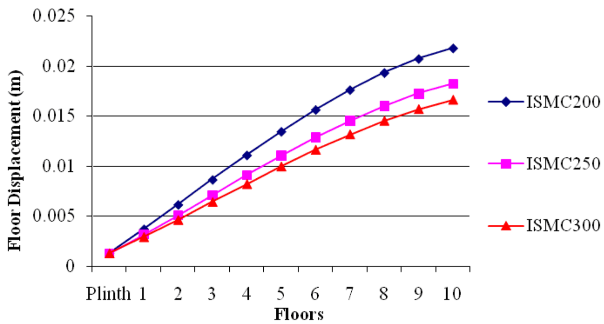


**Fig.5.20. Displacement Of Floors Y – Direction**

Fig. 5.19 and fig. 5.20 illustrated that the lateral displacement of floors in X braced building with ISMC 300 is lower than that of with ISMC 200 and ISMC 250. The top storey displacement in X braced building with ISMC 300 in X direction reduces by 9.06% and 23.77% and in Y direction by 8.86%, 23.79% as that of building with ISMC 200 and ISMC 250 respectively.

*For Diagonal Bracing System*

The graphs for diagonal Bracing System are plotted in X direction and Y direction as shown in fig. 5.21 and fig. 5.22.

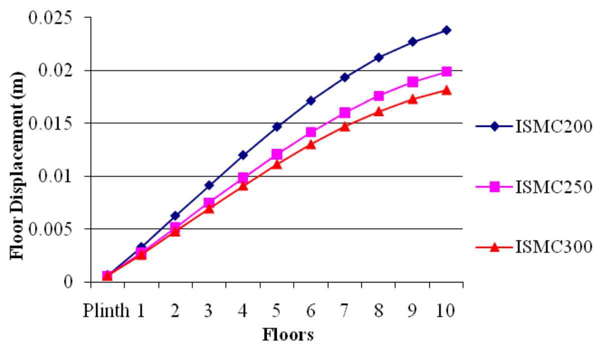


**Fig.5.21. Displacement Of Floors X – Direction**

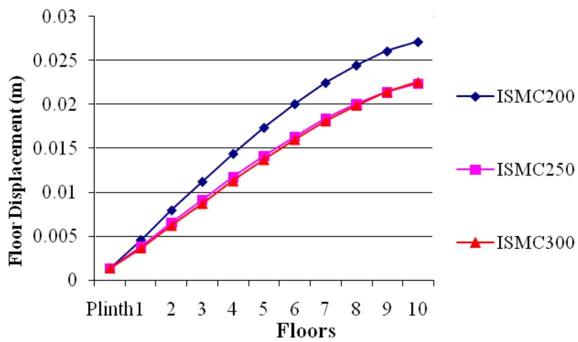


**Fig.5.22. Displacement Of Floors Y – Direction**

Fig. 5.21 and fig. 5.22 illustrated that the lateral displacement of floors in diagonal braced building with ISMC 300 is lower than that of with ISMC 200 and ISMC 250. The top storey displacement in diagonal braced building with ISMC 300 in X direction reduces by 7.2% and 23.38% and in Y direction by 7.2%, 16.81% as that of building with ISMC 200 and ISMC 250 respectively.

*For Inverted V Bracing System*

The graphs for Inverted V Bracing System are plotted in X direction and Y direction as shown in fig. 5.23 and fig. 5.24.

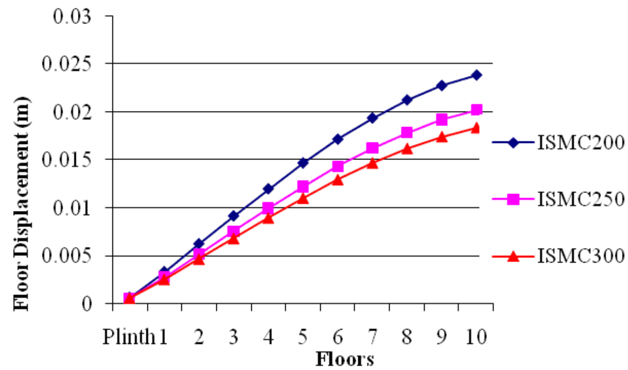


**Fig.5.23. Displacement Of Floors X – Direction**

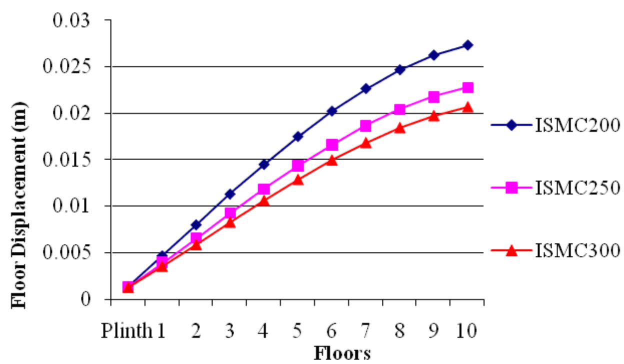


**Fig.5.24. Displacement Of Floors Y – Direction**

Fig. 5.23 and fig. 5.24 illustrated that the lateral displacement of floors in inverted V braced building with ISMC 300 is lower than that of with ISMC 200 and ISMC 250. The top storey displacement in inverted V braced building with ISMC 300 in X direction reduces by 8.89% and 22.87% and in Y direction by 9.19%, 16.66% as that of building with ISMC 200 and ISMC 250 respectively.

## VI. BASE SHEAR

The maximum base shears at the base for unbraced and different braced building are shown in fig. 5.25 and fig. 5.26.

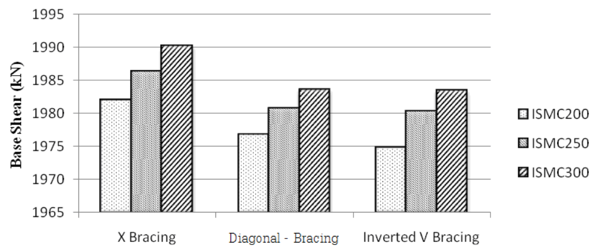


**Fig.5.25.** Base Shear in X - Direction

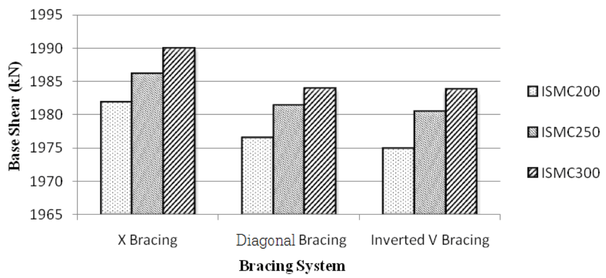


Fig.5.26. Base Shear in Y- Direction

Fig. 5.25 and fig. 5.26 shows that the base shear in X bracing system is more as compared to 2 storey X bracing system and inverted V bracing system. The base shear produce in X and Y direction is same because stiffness of building is same in both direction. As the stiffness of bracing sections increases, the base shear in building also increases in both directions.

## VII. BENDING MOMENT

The maximum bending moment for unbraced and different braced building are shown in fig. 5.22 and fig. 5.28.

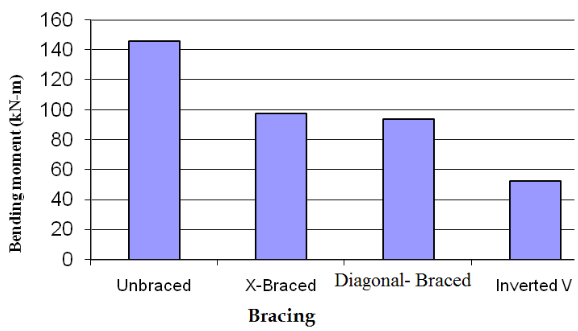


**Fig.5.27. Bending Moment Of Building With ISMC200**

From fig 5.27 it can be seen that bending moment in braced building reduces in comparison of unbraced building. Bending moment in building with X bracing system is less among three bracing system.

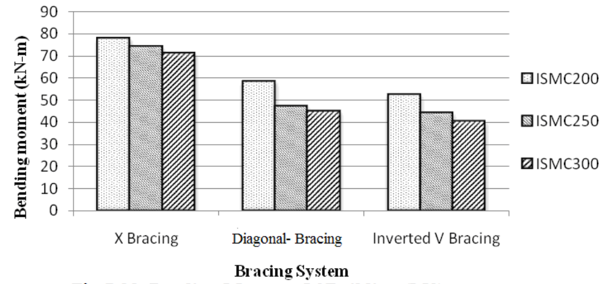


**Fig.5.28. Bending Moment Of Building (M3)**

Fig 5.28 illustrated that axial force in the braced building reduce as the stiffness of brace increases.

*Axial Force*

The maximum axial forces in column for unbraced and different braced building are shown in fig. 5.29 and fig. 5.30

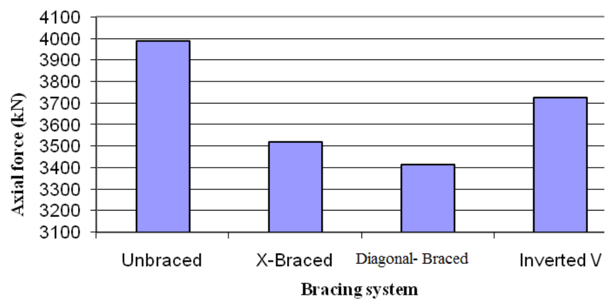


**Fig.5.29. Axial Force For Building With ISMC200**

From fig 5.29 it can be seen that maximum axial force in braced building reduces in comparison of unbraced building. Axial force in building with 2 storey X bracing system is less among three bracing system.

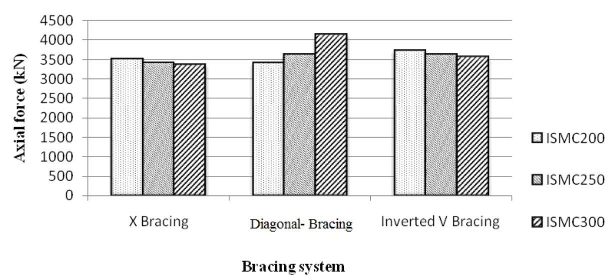


**Fig.5.30. Axial Force For Building**

Fig 5.30 illustrated that axial force in the braced building reduce as the stiffness of brace increases.

## CONCLUSION

Do most of your work on analysis results following conclusion are their face looks as below :-

1. The braced building of the storey drift decreases as compared to the unbraced building which indicates that the overall response of the building decreases.

2. The displacement of the building decreases depending upon the different bracing system employed and the bracing sizes.
3. About the whole of performance of X braced building better than other two types of braced building.
4. It seems that watch them carefully also observed that as the size bracing section increases the displacements and storey drifts decreases for the braced buildings.

## REFERENCES


1) Egor Popov, *Seismic Steel Framing Systems for Tall Buildings*, Sino-American Symposium on Bridge and Structural Engineering, Vol. 17 (3), Sept. 1982.
2) Federico M. Mazzolani, Gaetano Della Corte, Mario D'Aniello, *Experimental Analysis of Steel Dissipative Bracing System For Seismic Upgrading*, Journal of Civil Engineering And Management Vol. 15(1) Pages 7–19, 2009.
3) Ghobarah, *Rehabilitation of a Reinforced Concrete Frame Using Eccentric Steel Bracing*, Engineering Structures Vol. 23 Pages745–755, 2001.
4) Hakan Yalciner and Amir A. Hedayat, *Repairing and Strengthening of an Existing Reinforced Concrete Building: A North Cyprus Perspective*, American Journal of Engineering and Applied Sciences Vol. 3 (1): Pages 109-116, 2010.
5) Kyoung Sun Moon, *Structural Developments in Tall Buildings: Currents Trends and Future Prospects*. Architectural Science Review, Vol. 50.3, Pages 205-223, 2007.
6) M. A. Youssef, H. Ghaffarzadeh, *Seismic Performance of RC Frames With Concentric Internal Steel Bracing*, Engineering Structures Vol. 29 1561–1568, 2007.
7) M. R. Maheri, A. Sahebi, *Use of Steel Bracing In Reinforced Concrete Frames*. Engineering Structures, Vol. 19, No. 12, Pages 1018-1024, 1997.
8) M. R. Maheri, *Recent Advances in Seismic Retrofit of RC Frames*, Asian Journal of Civil Engineering (Building and Housing) Vol. 6, No.5 Pages 373-391, 2005.
9) Mina Naeemi, Majid Bozorg, *Seismic Performance of Knee Braced Frame*, Engineering Structures, Vol. 17, No. 5, Pages 334-343, 1999.
10) Nateghi F, *Seismic Strengthening of Eight-Storey RC Apartment Building Using Steel Braces*. Engineering Structures, Vol. 17(6) Pages 455-61, 1995.
11) N. K. Rai, G. R. Reddy, S. Ramanujam, V. Venkatraj , P. Agrawal, *Seismic Response Control Systems for Structures,* Defence Science Journal, Vol. 59, No. 3, Pages 239-251, May 2009.
12) T. D. Bush, E. A. Jones, and J. O. Jirsa, *Behavior of RC Frame Strengthened Using Structural Steel Bracing.* Journal of Structural Engineering, Vol. 117, No. 4, Paper No. 25709, ©ASCE, April 1991.
13) Chapter Bracing System.
14) Seismic Demands In Steel Braced Frame Buildings With Buckling Restrained Braces.
15) Asymmetric And Kind Of Bracing Effects In Steel Frames Under Earthquake Loads.
16) IS 1893 : 2002 .


## AUTHOR'S PROFILE


**Manish S. Takey**
(M.E Pursuing from Prof. Rammeghe Institute Technology & Research Badnera)

**Prof. S.S.Vidhale**
(Department of civil engineering
PRMIT & R Badnera)