Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 10, Issue 2; April-June, 2023, pp. 118-122

http://www.krishisanskriti.org/Publication.html

Effect of Position of Steel Bracing in Irregular Building under Seismic Loading

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Abstract—*Earthquake is one of the most life threatening, environmental hazardous and destructive natural phenomenon that causes shaking of ground. In India, the construction of irregular buildings is more popular and the failure in these building due to earthquake is very common. The seismic performance of the building mainly depends upon the shape, size, and arrangement of beams, columns and lateral load resisting system in the building. Steel bracing system is one of the methods for the improvement of reinforcement concrete structures against lateral loading. Braced frames are a very common form of construction, being economic to construct and simple to analyse. In the present study, a G+10 RC irregular building with steel bracing at different locations is analysed by using Response Spectrum Analysis. The modelling and analysis of the building is done by using structural analysis software ETABS as per IS: 1893 (Part1)-2016. For this study, 5 models of the building are analysed and compared for the results such as base shear, storey drift and torsion. It is found that base shear and torsion increases with the use of steel bracing in building as the stiffness of the building increases. The storey drift in the building decreases due to the increased stiffness.*

INTRODUCTION

The primary purpose of all kinds of structural systems used in the buildings to transfer gravity loads effectively. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. The most common bracing methods for resisting lateral forces in commercial buildings include moment frames, shear walls, and braced frames. These are vertical elements that transfer lateral loads, including wind, seismic forces, and stability forces through floor or roof diaphragms to the building's foundation. A bracing system improves the seismic performance of the frame by increasing its stiffness and capacity. Steel braced frames are efficient structural systems for buildings subjected to seismic or wind lateral loadings. In braced construction, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads. The potential advantages of using steel bracing are their high strength, stiffness, economical, occupies less space and adds much less weight to the existing structure. Steel bracings can be arranged like diagonal, cross bracing X, V, inverted V or Chevron. Rolled steel sections are often used for strut bracings in buildings and single angles for ties. The applications of braced frame include structures like bridges, aircrafts, buildings, transmission towers. In this study, irregular high rise reinforced concrete buildings are analysed with different rolled steel sections of X bracing system. The main objective of this research is to determine the best positioning of steel bracing in the irregular plan building. As a result, 5 RC building models (G+10) with irregular plan of 24 meter by 12 meter side are studied with different position of bracing and the results are compared with each other.

LITERATURE REVIEW

Karthik and Vidyashree (2015) [1] analysed G+5 storey building model considering different types of vertical geometric irregularities and steel bracings using pushover analysis with the help of ETABS 9.7 software. Addition of X-type bracing, V-type Bracing and Inverted V/K-type bracing showed that the use of X-type of bracing is found more suitable to enhance the performance of the irregular buildings.

Meghana and Archana (2017) [2] analysed G+14 storeyed RC irregular building with X bracing for different IS steel sections such as rolled beam and channel sections with different depths. The building is situated in seismic zone III. Response spectrum analysis is carried out using ETABS 2015 software to investigate seismic performance of a multi storey steel frame building and to find the most effective IS section in resisting lateral loads.

Hegde *et al.* (2019) [3] analysed G+15 storeys for Zone-III by considering soil type-II. The analysis carried out to assess the structural performance under earthquake ground motions. In this study there are three different types of bracing i.e. X bracing, V bracing, Diagonal forward bracing and without bracing by using same plan in both X & Y Directions. Results were obtained by considering Storey Displacement, Storey Shear, Storey Drift and Mode Period.

Kushwaha *et al.* (2021) [4] used four different types of bracing system for zone 3 and zone 4 namely cross bracing, V bracing, modified mixed diagonal type bracing (which is a combination of forward diagonal bracing and backward diagonal bracing) and Mega cross bracing. The models analysed by the equivalent static method and response spectrum method and results were compared by using ETABS 2017 software package. In this study, structural performances are evaluated and compared in different aspects such as storey drift, storey displacement base shear, overturning moment, storey acceleration and fundamental time period of structure in different seismic zone. The use of Mega Cross-Bracing and mixed diagonal bracing showed a better performance in various seismic factors, on comparison with other bracing systems.

MODELLING AND ANALYSIS OF BUILDING

A G+10 RC irregular building with plan irregularity is modelled by using the software ETABS and dynamic analysis (Response Spectrum Analysis) is performed.

BUILDING DESCRIPTION

A The plan of building is a L-shaped irregular with certain percentage of plan irregularities with 24m in x direction and 20m in y direction. The building is considered as a RC moment resisting frame. The details of building are given below in Table 1.

Table 1: Details of the building

Details of Building	**Value**
Bay width in x and y direction	4 m
Grade of Concrete	M25
Grade of Rebar	Fe415
Storey Height	3.5 m bottom, 3m typical
Size of Beam	300 mm x 450 mm
Size of Column	450 mm x 450 mm
Thickness of slab	150 mm
Steel Bracing	ISMB200
Dead load	Self-Weight
Live Load	2.5 kN/m^2
Floor Finish	2 kN/m^2
Poisson's Ratio	0.2
Type of Soil	Medium
Seismic Zone (Z)	V
Response Reduction Factor (R)	5
Importance Factor (I)	1
Damping Ratio	5%

ENUMERATION OF BUILDING MODELS

- Building frame without steel bracing (M1) as shown in Figure 1
- Building frame with steel bracing at core (M2) as shown in Figure 2
- Building frame with steel bracing parallel to X-direction (M3) as shown in Figure 3
- Building frame with steel bracing parallel to Y-direction (M4) as shown in Figure 4
- Building frame with steel bracing at all exterior corners (M5) as shown in Figure 5

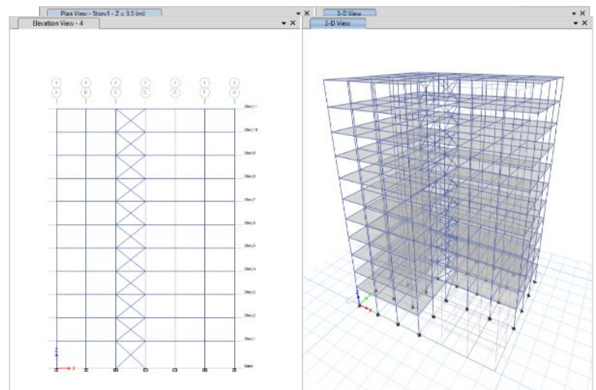


Figure 2: Steel bracing at core (M2)

Figure 0.1: Building frame without steel bracing (M1)

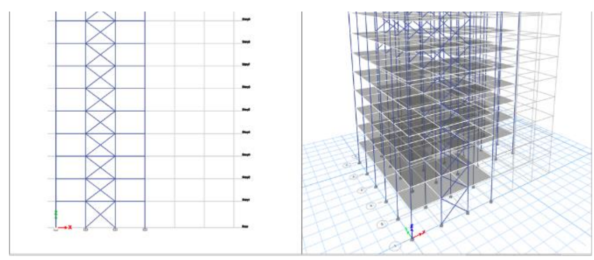
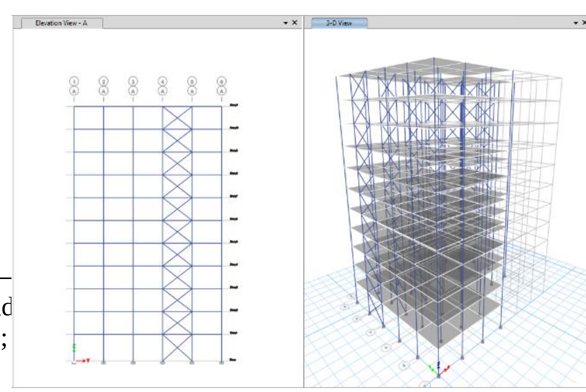


Figure 3: Steel bracing parallel to x-direction (M3)



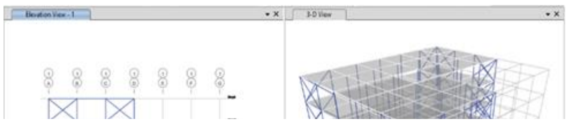


Figure 4: Steel bracing parallel to y-direction (M4)

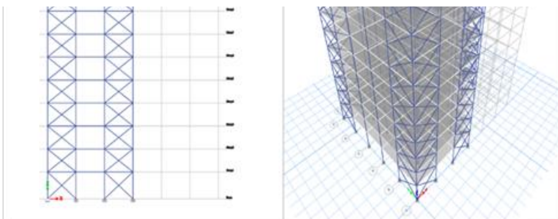


Figure 0: Steel bracing at exterior corners (M5)

Results and Discussion

The analysis is done by using the Response Spectrum Analysis Method in x and y directions i.e. RS_x and RS_y respectively. The obtained results i.e. base shear, storey drift and torsion of various building models in seismic zone V in x and y directions are given in Figure 6, Figure 7, Figure 8, Figure 9,

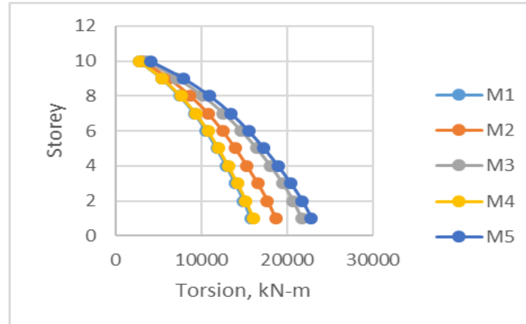


Figure 10: Torsion for RS_x

Figure 10 and Figure 11.

From the Figure 6 and Figure 7, it is observed that base shear increases with steel bracing as compare to bare frame building. It is observed that For RS_x analysis, the building with steel bracing parallel to x-direction (M3) has greater base shear as compared to steel bracing at other locations (M2, M4 and M5) and for RS_y analysis building with steel bracing parallel to y-direction (M4) has greater base shear as compared to steel bracing at other locations (M2, M3, M5).

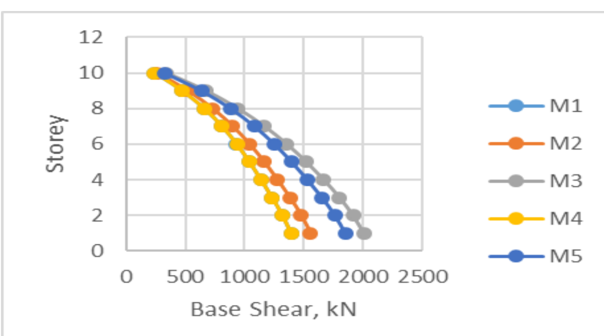


Figure 0: Base shear for RS_x

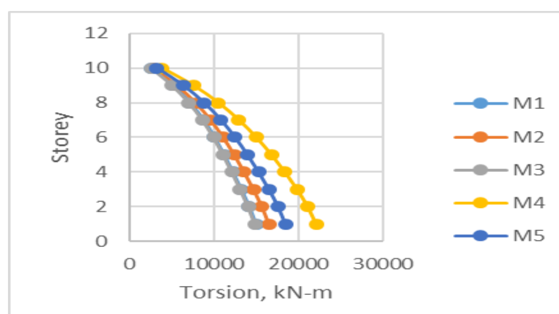
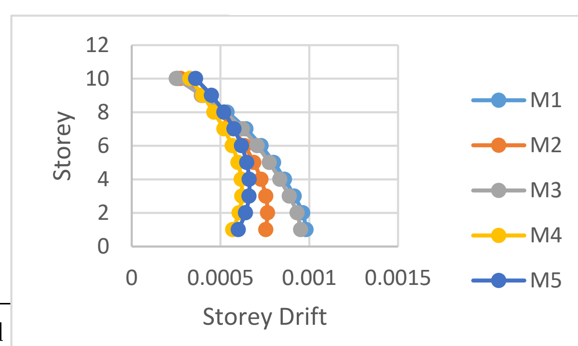


Figure 11: Torsion for RS_y



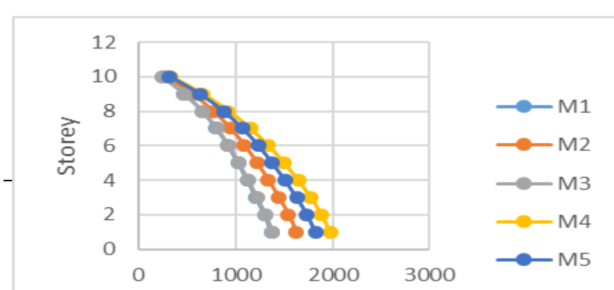


Figure 7: Base shear for RS_y

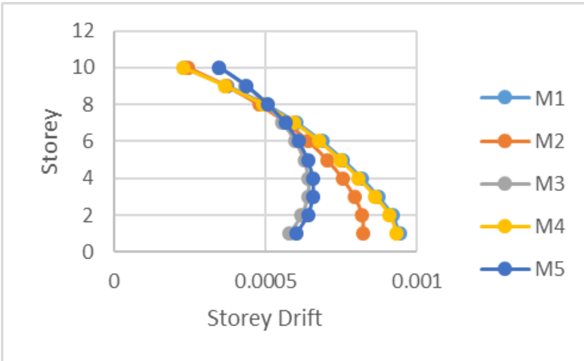


Figure 8: Storey Drift for RS_x

From the above Figure 8 and Figure 9, it is observed that maximum storey drift of the building decreases with the use of steel bracing. It is observed that the building with steel bracing parallel to x-direction (M3) has least maximum storey drift as compared to steel bracing at other locations (M2, M4 and M5) for RS_x analysis. Whereas for RS_y analysis, building with steel bracing parallel to y-direction (M4) has least maximum storey drift as compared to steel bracing at other locations (M2, M3 and M5).

From the figure 10 and figure 11, it is observed that torsion of the building increases with the use of steel bracing. It is observed that the building with steel bracing parallel to y-direction (M4) has least torsion as compared to steel bracing at other locations (M2, M3 and M5) for RS_x analysis. Whereas for RS_y analysis, building with steel bracing parallel to x-direction (M3) has least torsion as compared to steel bracing at other locations (M2, M4 and M5).

Conclusions

Figure 9: Storey Drift for RS_y

The following conclusions are:

1. Base shear of the building increases with the use of steel bracing in the building as expected.
2. For RS_x analysis, the building with steel bracing parallel to x-direction (M3) has greater base shear as compared to steel bracing at other locations (M2, M4 and M5) and for RS_y analysis building with steel bracing parallel to y-direction (M4) has greater base shear as compared to steel bracing at other locations (M2, M3, M5).
3. Storey drift in the building decreases with the use of steel bracing in the building.
4. The building with steel bracing parallel to x-direction (M3) has least maximum storey drift as compared to steel bracing at other locations (M2, M4 and M5) for RS_x analysis. Whereas for RS_y analysis, building with steel bracing parallel to y-direction (M4) has least maximum storey drift as compared to steel bracing at other locations (M2, M3 and M5).
5. Torsion in the building changes with the use of steel bracing as the eccentricity (distance between centre of mass and centre of rigidity) as well as stiffness of the building changes.
6. The building with steel bracing parallel to y-direction (M4) has least torsion as compared to steel bracing at other locations (M2, M3 and M5) for RS_x analysis. Whereas for RS_y analysis, building with steel bracing parallel to x-direction (M3) has least torsion as compared to steel bracing at other locations (M2, M4 and M5).
7. All considered lateral load resisting arrangements in the irregular building plan for stipulated dimensions with steel bracing are suitable to resist the lateral force in zone V with medium soil condition. Because all obtained results are within the limits given in the IS code.

References

[1] Karthik, K. M., and Vidyashree, D., "Effect of steel bracing on vertically irregular r.c.c building frames under seismic loads", *International Journal of Research in Engineering and Technology*, 2015, vol. IV, no. 06, pp. 90-96.

[2] Meghana, B. M., and Archana, S., "Linear Analysis of Multistorey Irregular RCC Buildings with Different Sections of X-Bracing", *International Journal of Engineering Research & Technology (IJERT)*,2017, vol. VI, no. 06, pp. 651-655.

[3] Hegde, R., Kiran, R., and Supriya., "Comparative study of different types of Bracing and Regular RCC Structure", *International Research Journal of Engineering and Technology (IRJET)*, vol. VI, no. 05, pp. 1118-1123, 2019.

[4] Kushwaha, N., Azhar, S., Binnani, N., and Rode, V. R., "Comparative Study of Different Bracing System in Seismic Zone 3 and 4", *Journal of Civil and Construction Engineering*, vol. VII, no. 01, pp. 27-46, 2021.

[5] IS-875, Part 1. 1987. Indian Standard Code of Practice for Dead Loads for buildings and Structures. Bureau of Indian Standards, New Delhi, India.

[6] IS-875, Part 2. 1987. Indian Standard Code of Practice for Imposed Loads for buildings and Structures. Bureau of Indian Standards, New Delhi, India.

[7] IS-1893, Part 1. 2016. Criteria for Earthquake Resistant Design of Structures Part 1 General provisions and Buildings. Bureau of Indian Standards, New Delhi, India.

[8] IS-456. 2000. Indian Standard Plain and Reinforced Concrete - Code of Practice. Bureau of Indian Standard, New Delhi, India.

[9] IS-800. 2007. Indian Standard General Construction in Steel - Code of Practice. Bureau of Indian Standards, New Delhi, India.