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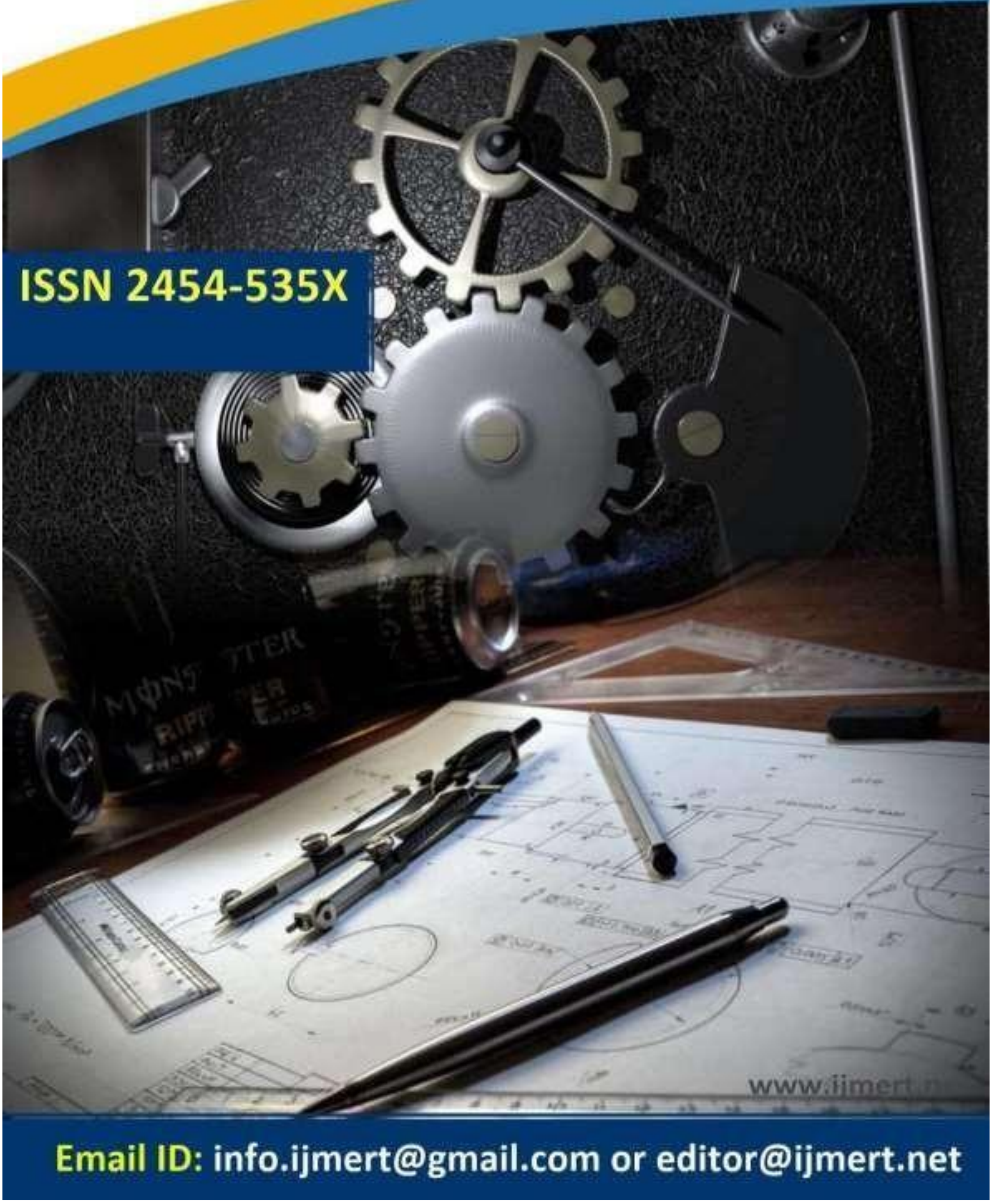

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ANALYSIS OF INDUSTRIAL STEEL STRUCTURE BY USING BRACING AND DAMPER UNDER THE WIND LOAD AND EARTHQUAKE LOAD

[1] Dr. E. Krishna Reddy, [2] Dr.K. Harish, [3] G. Nagaraju

[1] Professor, Department of CIVIL Engineering, AM Reddy Memorial College 0f Engineering and Technology, Andhra Pradesh 522601

[2] Associate Professor, Department of CIVIL Engineering, AM Reddy Memorial College 0f Engineering and Technology, Andhra Pradesh 522601

[3] Assistant Professor, Department of CIVIL Engineering, AM Reddy Memorial College 0f Engineering and Technology, Andhra Pradesh 522601

ABSTRACT:

Following the recent trends of earthquake all over the world, it is observed that there is very high risk for earthquake, thus creating a need of earthquake resistant structure. The tall structures are prone to the seismic load and wind load. For this purpose of enhancing the stiffness and reducing lateral displacement there are various methods to resist these lateral loads like base isolation, formation of hollow foundations, tuned mass dampers, horizontal bands and bracings. Among these application, bracing is one of the best methods to resist these kinds of loads. Bracing can be applied concentrically or eccentrically. The cross bracings are one of the mostly used types of bracing. Bracings are very efficient in overcoming the elastic seismic waves. This is used for strengthening the building by increasing its stiffness and displacement capacity keeping the lateral displacement as low as possible. Various types of bracings can be used like X, V and Inverted V etc. An attempt has been made to study the reduction in responses of a structure under lateral loading due to the incorporation of different bracing systems. In this study a G+20 building structure of plan area 10.5m X 9m is analysed under earthquake load in zone IV by placing different bracing systems at different locations. The analysis is performed in ETABS by using response spectrum method. The bracing systems considered are inverted V, V and X bracings. These bracings are placed at center and outer bays of the building. From the analysis of the buildings with different bracings storey displacements, storey drifts, storey shears and overturning moments are evaluated. These results are evaluated for the load combination

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(1.2DL+1.2LL+1.2EQ X). Due to the effect of seismic loading a building normally experiences lateral as well as torsional displacement under seismic loading. Bracing system in any form increases the overall stiffness of the system and hence acts as a control mechanism for both lateral and torsional movement of the structure.

Keywords: Earth quake, Cross bracing, X bracing, vertical loading, X loads.

1. INTRODUCTION:

Earthquake is a natural phenomenon, which is generated in earth's crust and thousands of people lose their lives due to earthquakes in different parts of the world. Building collapse or damages are the major causes of these heavy no of causalities. Lateral instability has always been a major problem especially in the areas with high earthquake hazard. Bracing system effectively reduces the lateral displacements and concentric, eccentric and knee bracing systems have been used over years. When there exists an eccentric loading in building structure, Centre of mass and Centre of rigidity do not coincide. As a result, the structure experiences a response in a direction perpendicular to the excited force or torsional force. The torsional effect, being the most destructive one in a structure should be taken care of. A braced frame is a structural system commonly used in structures subject to lateral loads such as wind and seismic pressure. The members in a braced frame are generally made of structural steel, which can work effectively both in tension and compression. Bracing is a highly efficient and economical method to laterally stiffen the framed structures. Bracing system allows obtaining a great increase of stiffness with a minimal added weight, and so it is very effective for existing structure for which the poor lateral stiffness is the main problem. Bracing is efficient because the diagonal bracing works in axial stress and therefore call for minimum member sizes by providing the stiffness and strength against horizontal shear. Thus bracing system reduces lateral movement as well as torsional motion of the structures under seismic loading. Bracings are provided to increase stiffness and stability of the structure under lateral loading and also to reduce lateral displacement significantly. Concentric bracings increase the lateral stiffness of the frame and usually decrease the lateral drift. Due to increase in the stiffness it may attract a larger inertia force created due to earthquake. Here onwards, while bracings decrease, the amount of shear forces and bending

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moments in columns, increase the axial compression in the columns to which they are connected. Due to eccentric bracings there is reduction in the lateral stiffness of the system and improve the energy dissipation capacity. In eccentric connection of the braces to beams, lateral stiffness of system depends upon the flexural stiffness of the beams. The beams and columns that form the frame carry vertical loads and the bracing system carries the lateral loads. The positioning of braces, however, can be problematic as they can interfere with the design of the façade and the position of openings. Buildings adopting high-tech or post-modernist styles have responded to this by expressing bracing as an internal or external design feature.

2. LITERATURE SURVEY:

Bharat Patel (2017), They examined the base shear and lateral displacement for G+10 structures like Moment Resisting Frame (MRF), R.C.C building with V bracing (VBF) and R.C.C building with X bracing (XBF). The structures were analyzed using ETABS for Seismic Zone II. It was found that the base shear was highest in XBF and lowest in MRF. However the displacement was found for every storey for each structure, and was found that Displacement was highest in MRF and this was reduced considerably in XBF and VBF. These results concluded that XBF is the best structure in terms of safety as it has more stiffness and 61.6% reduced lateral displacement.

D E Nassani (2017), He studied the seismic behavior of steel structures without bracing system and with a various bracing systems. They also provide the comparative assessment of steel frames with different bracing systems under seismic load. The study include diagonal bracing, X bracing, Chevron bracing and V bracing composition. In their research, they analyze a total of 30 high rise 2-D steel building frames in terms of capacity curves, base shear and plasticization using pushover analysis. They use time history analysis to evaluate drift ratio, global damage index, storey displacement and roof displacement time history. The research describes the improvement in seismic resistance, effective reduction in drift and the results of time history analysis and pushover analysis were similar.

Soundarya N Gandhi (2017), They developed a model of G+14 R.C structure and analyzed it using ETABS software for seismic zone V. They found the various aspects of the lateral displacement for different conditions of structure like braced frame using cross bracing, V bracing for the different

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heights in a structure at Seismic Zone V. The result was concluded as the Base Shear for X bracing was much higher than without bracing. However the Storey Displacement was lowest for the X bracing. And the Storey Drift was lowest for Inverted V bracing than X, V or without bracings. Thus from these results it was concluded that X bracing is the most suitable bracing for the G+14 R.C building.

G Hymavathi (2015), A G+20 48m x 44m steel building was supposed to be located at Visakhapatnam and analyzed on Staad. Pro with outer panels were provided with X bracings and internal panels were without bracings. This structure was analyzed for the Earthquake Zone II and V. In this the loads were based on IS 875:1984, IS 1893:2002 and IS 800:2007, the axial force and the nodal displacement were found out on the load combination (Dead Load + Live Load + Wind Load) and (Dead Load + Live Load + Earthquake Load). It was found that Axial Force in braced columns were comparatively low than the unbraced columns for both the Zone II and V. The Nodal displacement for wind load and earthquake load were very low in the braced structure than the unbraced structure.

Prof. Bhosle (2015), He examined the G+12 R.C building under seismic conditions using the ETABS software. The structure was supposed to be lye in the seismic zone III and analyzed as per IS 1893:2002 using various type of steel and concrete bracing like Diagonal bracing, V bracing, Combine V bracing, K bracing and X bracing. The bracings were providing in the two fashions: all sides of the building and other as at only two parallel sides of the building. Results were recorded and it was concluded that the X bracing is most efficient in reducing the lateral drift and strengthening the structure by increasing the stiffness of the structure and base shear.

3. MATERIALS AND METHODOLOGY

All the structures are designed for the combined effects of gravity loads and seismic loads to verify that adequate vertical and lateral strength and stiffness are achieved to satisfy the structural performance and acceptance deformation levels prescribed in the governing building code. Because of the inherent factor of safety used in the design specification, most structures tend to adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans, those in which stability for design, or for overall stability analysis of structures.

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In general, most earthquake code provisions implicitly require the structures be able to resist:-

- Minor earthquake without any damage.
- Moderate earthquake with negligible structural damage and some non-structural damage.
- Major earthquake with some structural damage and non-structural damage without collapse.
- The structure is expected to undergo fairly large deformation by yielding in some structural members.

Seismic codes are unique to a particular region or country. In India, IS 1893:2002 (part-1) is the main code that provided outline for calculation of seismic design force. This force depends on the mass and seismic coefficient of the structure and later in turn depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil on which it rests and ductility. IS 1893:2002 (part-1) deals with assessment of seismic loads on various structures and buildings. The whole centers on the calculation of base shear and its distribution over height. The analysis can be performed on the basis of external action, the behaviour of the structure or structural materials and the type of structural mode selected. In all that treated as discrete system having concentrated mass at floor levels, which include half the column and walls above and below the floor. In addition, appropriate of live load at this floor is also lumped with it.

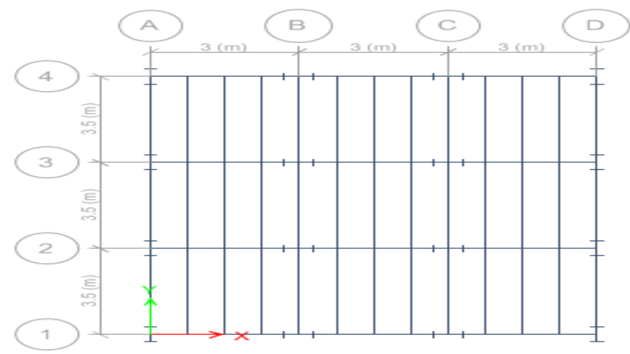

Figure 3.1 Plan of the building

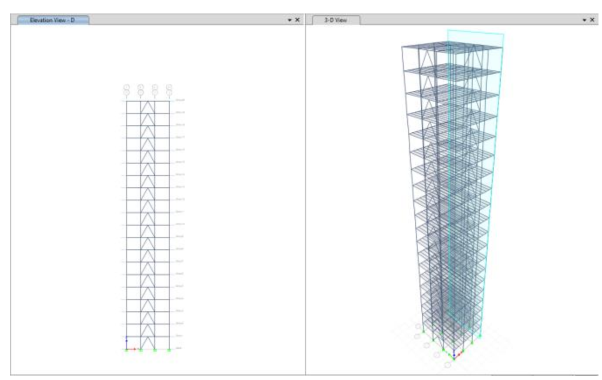

Figure 3.2 Elevation and 3D view of the building with inverted V bracings at center bay.

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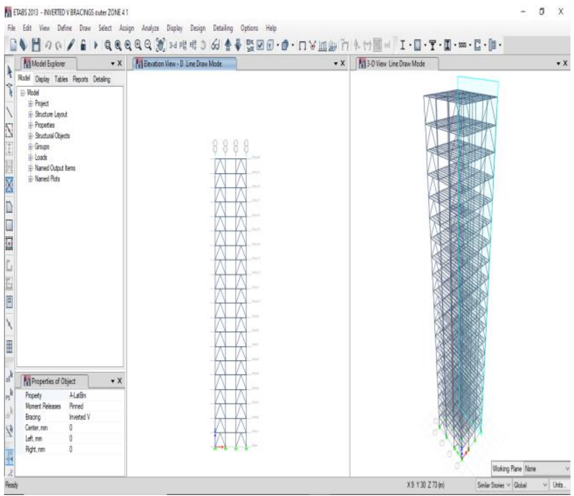

Figure 3.3 Elevation and 3D view of the building with inverted V bracings at outer bays

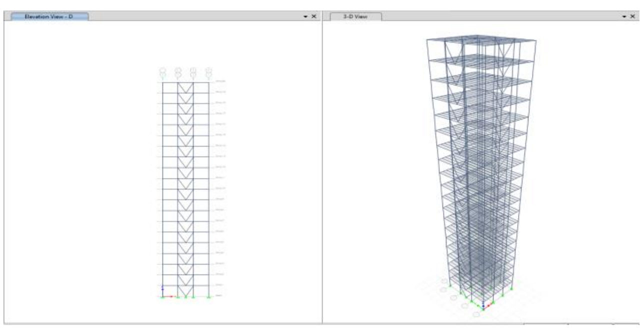

Figure 3.4 Elevation and 3D view of the building with V bracings at center bay

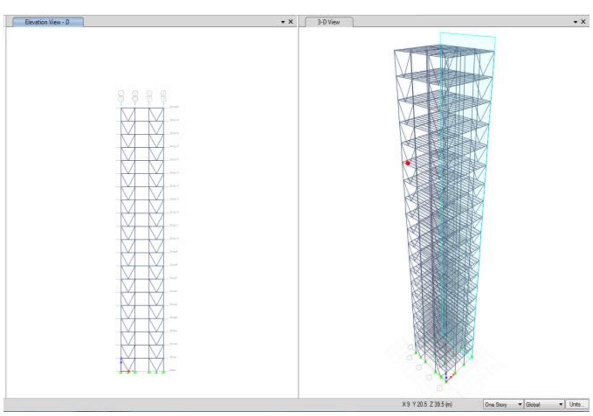

Figure 3.5 Elevation and 3D view of the building with V bracings at outer bays

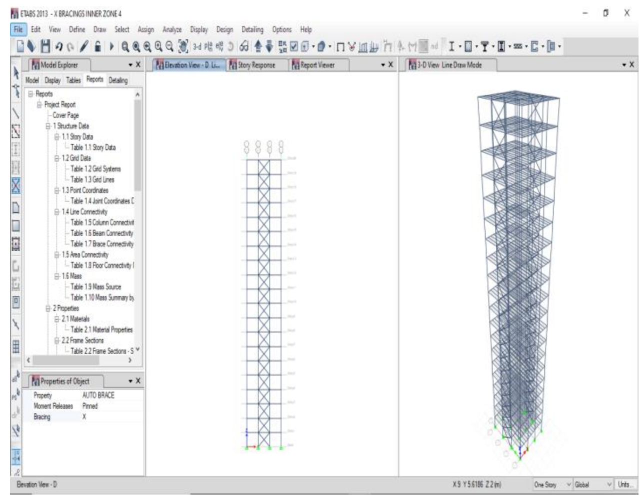

Figure 3.6 Elevation and 3D view of the building with X bracings at center bay

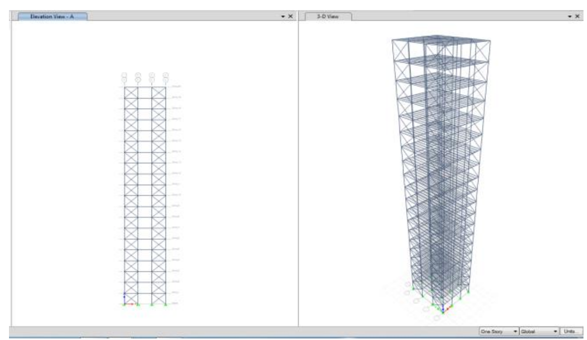

Figure 3.7 Elevation and 3D view of the building with X bracings at outer bays

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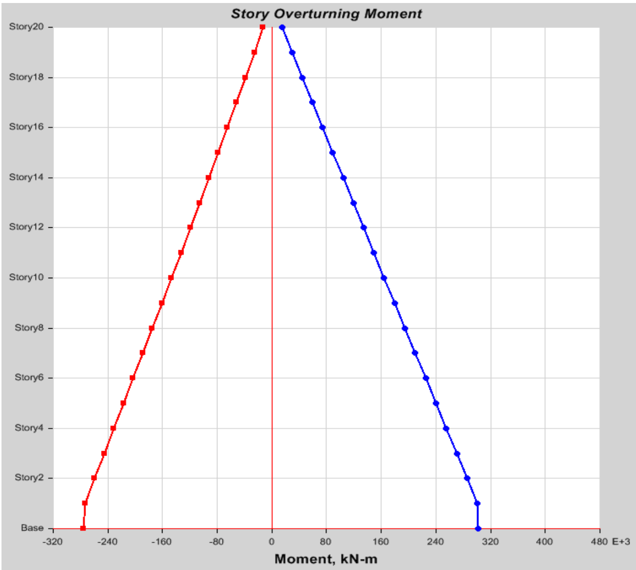

Fig.3.8. Maximum storey overturning moments of a building with X bracings at outer bays.

CONCLUSION

- The maximum storey displacement in X-direction is higher when X bracings provided at outer bays for the building. Storey displacementsof inverted V and V bracings at outer and center bays of the building are 10% lesser than the building with X bracings at outer bays.
- The maximum storey displacement in Y-direction is higher when X bracings provided at center bays for the building. Storey displacements of inverted V and V bracings at center bays of the building are 5% and 12% lesser than the building with X bracings at center bays respectively.
- The storey drifts of the buildings in X-direction with inverted V, V and X bracings are almost similar. The maximum storey drift is 0.002474 occurred in inverted V bracings placed at center bays.
- The storey drifts in Y-direction are higher in the building with X-bracings placed at outer bays and the value is 0.000463.Storey drifts of buildings with inverted V and V bracings placed at center bays are 46% and 28% lesser than building with X-bracings placed at outer bays respectively.
- The storey shears of the buildings in X-direction with inverted V, V and X bracings are almost similar. The maximum storey shear is 362.6566 KN occurred in X bracings placed at outer bays.
- The overturning moments of the buildings in X-direction with inverted V, V and X bracings are almost similar. The maximum overturning moment is 301729.6234 KN-m occurred in X bracings placed at outer bays.
- The overturning moments of the buildings in Y-direction with inverted V, V and X bracings are almost similar. The maximum overturning moment is 275265.9902 KN-m occurred in X bracings placed at outer bays.
- From the analysis results we can conclude that the building with inverted V bracings placed at outer bays is more efficient to seismic effect than other bracings placed at different locations.

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- The braced structural frames are more resistant to lateral loads as compared to structural frames without bracings.
- Bracing system in any form increases the overall stiffness of the system and hence acts as a control mechanism for both lateral and torsional movement of the structure.

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