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# A Review on the Analysis of Building with Different Types of Bracings

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***Abstract:*** ***Bracing is one of the most extensively used lateral load resisting systems in multi-storied frame structure. It helps in reducing structure damage or collapse during an earthquake. To know the responses of providing bracings in high rise buildings is the aim of this study. Hence, it is necessary to demonstrate work on the analysis, design and post effects of bracings when seismic forces act in a building. In this paper, a review is taken out over the analysis and design of buildings with and without bracings to study more detail analytical results and conclusions to find its effectiveness in reducing the impact of lateral loads on high rise buildings in case of an earthquake.***

***Keywords: earthquake, bracings, ETABS, SAP2000, StaadPro***

## I. INTRODUCTION

Earthquakes cause great damage to buildings which can result in collapse of a high rise building if it is of high intensity. Hence it is of utmost importance to take proper actions to save the buildings from collapse or failure. One such measure is to use bracings in buildings. Bracing provides stability and resists lateral loads caused due to earthquakes. In braced system, beams and columns are designed under vertical load only, assuming the bracing system carries all lateral loads. The members in a braced system are made of structural steel, which can work capably both in tension and compression. Braced systems exhibit high lateral stiffness and strength under high magnitude earthquakes. Steel bracing is economical, occupy less space and reduces lateral displacement as well as bending moment of frame structure. It is also easy to erect and has the flexibility to design for meeting the required strength and stiffness. Hence it is widely used in buildings in earthquake prone areas to reduce the effects of seismic loads on buildings.

Based on the arrangement of bracing, there are concentric and eccentric bracings. Concentric bracing system consists of diagonal braces located in the plane of the frame. Both ends of the brace join at the end points of other framing members to form a truss, creating a stiff frame. Concentric bracing may be arranged in several different configurations like X bracing or K bracing. On the other hand, eccentrically braced frames consist of diagonal braces located in the plane of the frame where one or both ends of the brace do not join at the end points of other framing members. The system essentially combines the features of a moment frame and a concentrically braced frame and provides a unique combination of stiffness, strength and ductility.

The different types of structural arrangements of bracings are as follows:

*1)* X-Bracing
*2)* K-Bracing
*3)* V-Bracing
*4)* Inverted V-Bracing
*5)* Diagonal Bracing

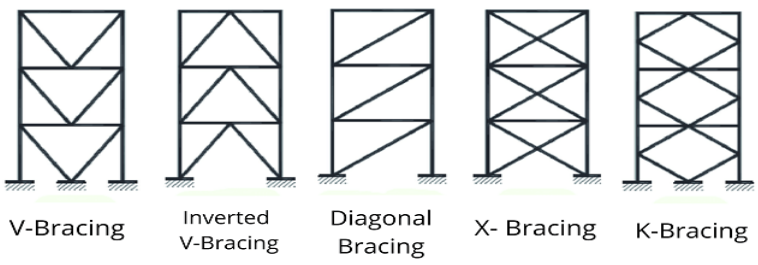


Fig. 1: Different types of bracings

 

## II. REVIEW OF LITERATURE

*1)* Harsha et al carried out the seismic analysis of buildings with floating column strengthened using buckling restrained braces. Pushover analysis was used to evaluate the performance of the building. The buildings were modelled using different configurations of bracings. The different types of bracings studied were inclined bracing, inverted V bracing and X bracing. Analyses of buildings were carried out using ETABS 17 software. The building performance was compared with corresponding moment resisting frames. From the results, it is found that the X bracing configuration is the most effective method of bracing in improving the base shear capacity and in minimising the displacement of the building. The maximum improvement in the base shear capacity was observed while using the X bracing. It was found that the seismic strengthening of small buildings will be more than multi-storeyed building by using buckling restrained braces. The maximum percentage improvement in the base shear capacity in a three storeyed building was found to be 51.34% while using an X bracing whereas it was only 20.68% in a six storeyed building. The percentage improvement in the base shear capacity was more for external floating column provided along the X direction compared to the internal floating column provided along the Y direction in all configurations of bracings. So the bracings are more effective when the floating column comes in the X direction. The maximum percentage improvement in the base shear capacity in a three storied L shaped building with external floating column along X direction was found to be 65.52% whereas it was only 26.55% in a three storied L shaped building with internal floating column provided along the Y direction.

*2)* Islam et al conducted a study to check the structural performance of metallic constructing with different bracing systems. A 10 storied frame structure was analysed and designed due to lateral loading. The different bracing systems studied were X bracing, inverted V-type bracing, K bracing and single diagonal bracing. A comparative analysis was performed on lateral displacement, moments on beam between braced, story drift and un-braced structures at dissimilar floor stage. From the analysis, it was found that the deflection and bending moment in bracing system was very less as compared to RC-frame structure. Among all the types of bracing system, X-type bracing is most effective and economical because it reduced 35.69% deflection in Zone-3 and 35.29% deflection in Zone-5 as compared to RC-frame structure. Among all models, braced structure has shown better resistance and stiffness than RC-frame structure. It was concluded that X-bracing structure was the best suitable from the structural point of view.

*3)* Jagadish et al conducted an experiment to study the effect of different types of bracing systems in multi storied steel buildings. For the study, G+15 storied steel building models are used with same configuration and different bracing systems such as Single-Diagonal, X bracing, Double X bracing, K bracing, V bracing are used. The analysis was performed using STAAD.Pro V8i software. From the results obtained, it was found that bracings are good to reduce the displacement and in case of K and V-bracing, the displacement is higher than without bracing because of irregularity in shape of the structure.

*4)* Kanthariya et al carried out a comparative study of RC structure with different arrangement of RCC bracing system. A RCC high rise building of G+ 10 storeys was used for bracing system to improve seismic resistance using various type of RCC bracing system such as single diagonal bracing, double diagonal bracing in seismic zone III using IS-1893:2002 for RC structure. Analysis was done for parameters like base shear, bending moment, deflection using the software Staad Pro V8i. From the results, it was found that the deflection in single diagonal system was more as compared to double diagonal bracing system and jerk was produced in single diagonal system. The base shear was high in top in single diagonal bracing system and average decrease to floor to floor. In case of double diagonal bracing, shear force increased with respect to floor height and became nearly equal to single diagonal bracing. The bending moment in case of single diagonal bracing was high compared to double diagonal bracing system.

*5)* Ketan et al studied the effect of bracing and unbracing in steel structures using the software ETABS. Different bracing systems like X-bracing, Diagonal bracing are used for the analysis. Various parameters like lateral displacement, base shear, time period and story drift were compared among all the models to find the most suitable model. From the results, it was found that the maximum reduction in storey displacement was observed in X-braced frame i.e. 85.40% and minimum reduction is for K-braces i.e. 47.28%. It is found that base shear increased after application of bracings. The increase in base shear was more for X-braces as compared to other bracing systems, as base shear mainly depends on the weight of the structure. It has been observed that after incorporation of braces there was a reduction of the time period of the structure. This reduction is due to the fact that there is an increase in stiffness of the structure after application of braces.

*6)* Kumar et al carried out a comparative study of the steel bracing on reinforced concrete frame structure using the software SAP2000. In the study, building modelling is performed with and without a bracing system. Static Analysis was performed for each different types of reinforcement used such as inverted V braces, X braces model with different types of reinforcement. The

results were compared in terms of displacement, drift of the floors, base shear and moment of the RC building. From the analysis, it was found that there is 51.25% reduction in maximum storey displacement in X direction and 47.25% reduction in Y direction in case of X braced frame as compared to unbraced RCC frame. Comparative to unbraced RCC frame there is 43.375% reduction in maximum story displacement in X direction and 41.06% reduction in Y direction when V braced frame arrangement was used. Compared to unbraced RCC frame there is 14.86% reduction in base shear in X direction and 22.27% reduction in Y direction when X braced frame was used. Compared to unbraced RCC frame there is 9.0% reduction in base shear in X direction and 8.7% reduction in Y direction when V braced frame arrangement was used. It has also been observed that the maximum reduction of axial force and bending moment occurred after the application of the crossed bracings and V bracings.

*7)* Neela et al performed an earthquake resistant building design by considering bracings and shear wall system in ETABS software. In this study, a G+10 story building was analysed by pushover analysis method and comparison was made between the general building, steel building and shear wall buildings to design the earthquake resistant structures design. Parameters like story drift, story shear, story moment, building torsion, time period and model stiffness were compared. From the analysis, it was observed that steel bracings can be used as an alternative to the other strengthen or retrofitting techniques available as the total weight on the existing building will not change significantly. The maximum value of shear in X direction was observed for steel bracings building than remaining cases.

*8)* Prasad et al performed seismic analysis of steel structures with and without bracings in different seismic zones. In this study, four G+5 steel structures were modelled without bracings and having X, V bracings and diagonal bracings. The structures were modelled in STAAD.Pro structural analysis and design software by considering various load and load combinations as per IS: 1893-2002. Analysis was done for buildings in seismic zones 2, 3, 4 and 5. From the analysis, it was found that the lateral displacement, shear force and bending moment decreased in X type bracing when compared to X and V type bracings. Support reactions and axial force decreased in diagonal bracing system when compared to X and V type bracings. X bracing gave lesser values as compared to no bracing, V bracing and diagonal bracing structures. Hence it was concluded that X type steel bracing is preferable in high seismic zones.

*9)* Ravali et al proposed the suitability of type of bracing for controlling the seismic activity on industrial structures in respective seismic zones III and IV of India. Natural time period, frequency, roof displacements are the major parameters considered for observing response of structures. Response spectrum analysis of 3D industrial structure with concentric bracings using SAP2000 and ETABS software was carried out in this study. From the analysis, it was found that as stiffness of structure increases, the time period decreases. X-Bracing system greatly influences the base shear of structure and reduces it. Using of X-bracing greatly reduces the lateral displacement of the structure when compared to other bracings.

*10)* Sambhaji et al carried out a comparative analysis between various types of bracings for RC building in different seismic zones. A G+25 tall structure was analysed for seismic loading corresponding to various seismic zones. Effectiveness of bracings in reducing lateral displacements and their efficiencies during the earthquake was investigated. Results show that X bracing is the best structure when it comes to reducing lateral displacements. As much as 26% decrease in lateral displacements in Z-direction and up to 53% reduction in lateral displacements along X-direction was observed. But X-bracing arrangement showed most increase in value of maximum bending moment (24.86%) and support reactions (30%). Diagonal bracings showed the overall good performance considering lateral displacement (45.58%), support reactions (26.77%) and maximum bending moment (14.16%).

*11)* Shinde et al carried out a study to evaluate the efficiency of combination of bracing for steel building. In this study, modelling of the steel braced structures was done with a different combination of bracing and analysed using the software SAP2000. Four types of bracing such as X bracing, V bracing, inverted V bracing and knee bracing were used for the study. Response spectrum analysis was performed and comparison between the seismic parameters like base shear, roof displacement, storey drift was studied. It was found that the K bracing was 2 to 4 % efficient in different seismic prone area and also had good ductility and stiffness than other type of bracings.

*12)* Vasugi et al carried out seismic performance of 4different knee braced frames. A static nonlinear analysis was done using Ansys software. Results showed that steel frame with X knee bracing were having less displacement and high load carrying capacity compared to other bracing system. As the storey height increases, the load carrying capacity of frame decreases. So, it was suggested that in a high seismic zone area, construction of high storey buildings should be avoided.

## III.CONCLUSIONS

From the study of literature presented in this paper, conclusions are drawn out on the responses of buildings without bracing and with different types of bracings as,

*1)* The seismic strengthening of small buildings will be more than multi-storied buildings by using buckling restrained braces.
*2)* Inclusion of bracing systems in a structure is more resilient in the event of an earthquake.
*3)* Bracing system increase base shear in building and provide more stiffness as compared to unbraced system structure.
*4)* Braced system is effective and provides more resistance during an earthquake.
*5)* Bracing system is less costly as compared to other earthquake resistant techniques.
*6)* After introducing bracing system into a bare frame, the lateral displacement of the building reduces to a great extent.
*7)* Increase in base shear occurs after the application of bracing in a structure.
*8)* Among all the types of bracings, X bracing system greatly influences the base shear of structure and also reduces the lateral displacement of the structure the most.

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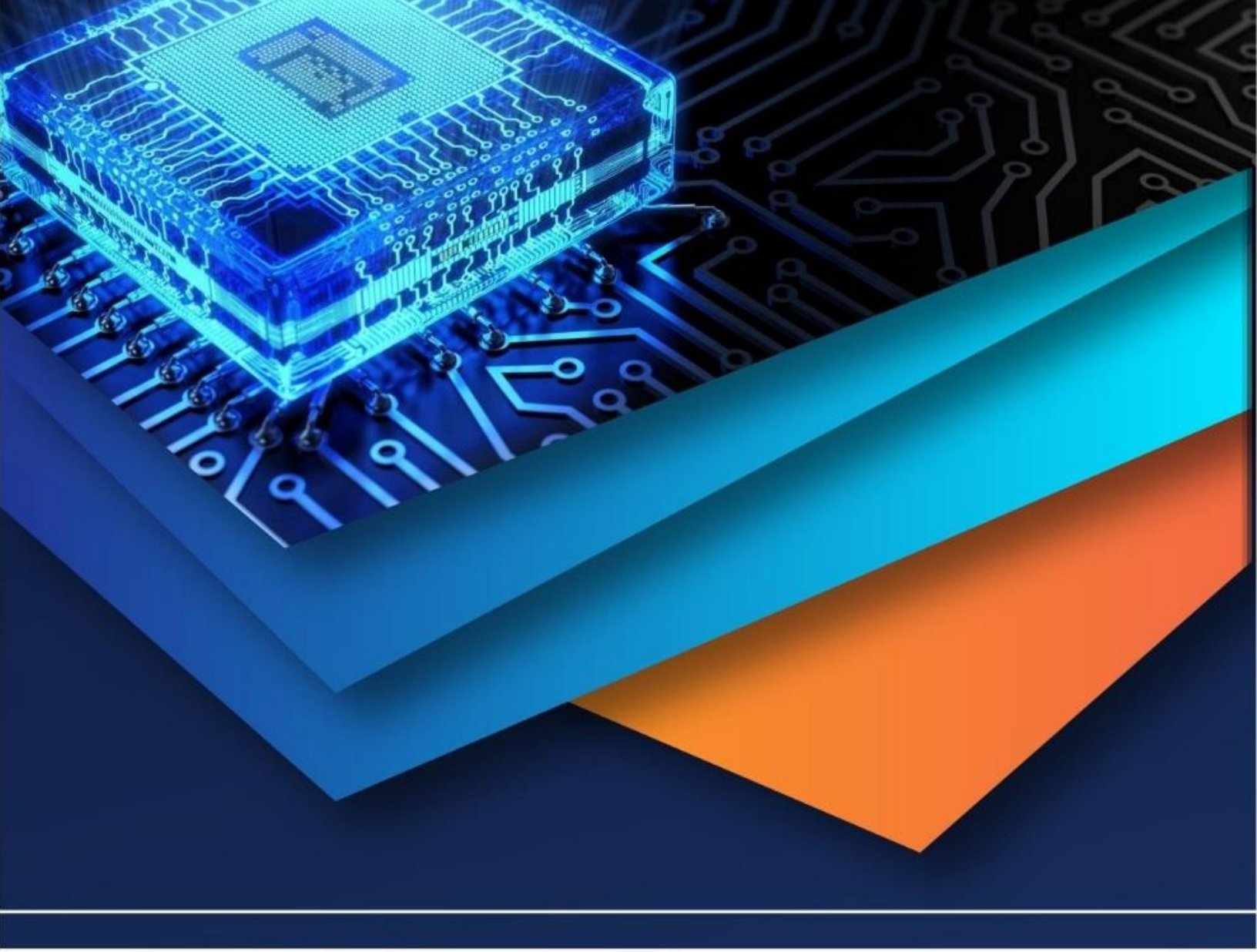

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