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# Seismic Analysis of the RC Structure with Different Bracing System: A Review

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**Abstract -** *In this review paper, we studied about the research work related to Reinforced cement concrete structure or frame in which different bracing system was provided. After completing these study we will write some conclusions. In the previous research work, the RC structure is attached to the X, V, K, etc steel bracing system. The main purpose of providing the steel bracing system to reduce the effect of the seismic and wind activity in the structure so the building can remain safe. The analysis of this structure is done by using wind and seismic analysis.*

***Key Words***: RC Structure, Steel bracing, seismic analysis, ETABS, SAP2000, Wind analysis.

## 1.INTRODUCTION

In the present time, Steel structure plays an important role in the construction industry. Previous earthquakes in India show that not only non-engineered structures but engineered structures need to be designed in such a way that they perform well under seismic loading. The structural response can be increased in Steel moment-resisting frames by introducing steel bracings in the structural system. Bracing can be applied as concentric bracing or eccentric bracing. There are 'n' number of possibilities to arrange steel bracings, such as cross bracing 'X', diagonal bracing 'D', and 'V' type bracing.

Steel moment-resisting frames without bracing, inelastic response failure generally occur at beam and column connections. They resist lateral forces by flexure and shear in beams and columns i.e. by frame action. Under severe earthquake loading, ductile fracture at beams and columns connections is common.

Brace hysteretic behavior is also quite complex; exhibiting unsymmetrical properties in tension and compression, and typically showing substantial strength deterioration when loaded monotonically in compression or cyclically into the inelastic range. This complex behavior results in substantial differences between the distributions of internal forces and deformations predicted using conventional design methods based on elastic behavioral models and more realistic nonlinear analysis procedures. The consequences of such differences in behavior are two-fold, the braces selected for some stories are often far stronger than required, while braces in other stories have capacities very close to design targets, and the distribution of design forces in beams and columns are often far different than those expected in an actual earthquake. These discrepancies tend to concentrate earthquake damage on a few "weak" stories. Such damage concentrations place even greater burdens on the limited ductility capacities of conventional braces and their connections. It has also been noted that lateral buckling of conventional braces may cause substantial damage to adjacent nonstructural elements.

**Fig -1**: Steel bracing in RC Structure

### 1.1 Type of the bracing System

There are six types of the bracing system provided in the structure:

A. X bracing system
B. K bracing System
C. V bracing system
D. Diagonal Bracing system
E. Eccentrically Bracing System
F. Inverted V Bracing system

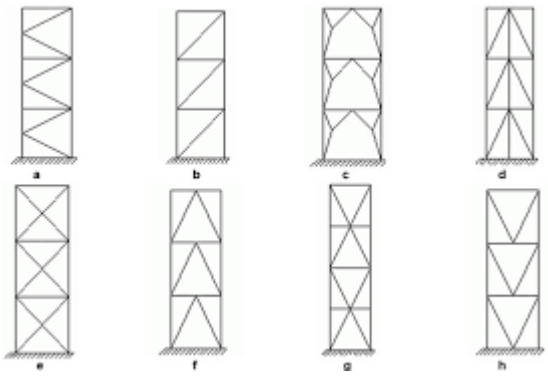

**Fig -2**: Type of Bracing System

## 2. LITERATURE REVIEW

The summary of the research paper are given below:

**[1]Mahmoud R. Maher, R. Akbari (2003)** carried out the study for the earthquake behavior factor (*R*) for steel Xbraced and knee-braced RC buildings. The *R* factor components including ductility reduction factor and over strength factor are extracted from inelastic pushover analyses of brace-frame systems of different heights and configurations. The effects of some parameters influencing the value of the *R* factor, including the height of the frame, the share of the bracing system from the applied load, and the type of bracing system are investigated. The height of this type of lateral load-resisting system has a profound effect on the *R* factor, as it directly affects the ductility capacity of the dual system. Finally, based on the findings presented, tentative *R* values are proposed for steel-braced moment-resisting RC frame dual systems for different ductility demands.

**[2]P. Jayachandran (2009)** carried out the study to enables optimization of initial structural systems for drift and stresses, based on gravity and lateral loads. The design issues are the efficiency of systems, rigidity, member depths, the balance between sizes of beam and column, bracings, as well as spacing of columns, and girders, and areas and inertias of members. Drift and accelerations should be kept within limits. Good preliminary design and optimization lead to better fabrication and erection costs, and better construction. The cost of systems depends on their structure weight. This depends on the efficient initial design. The structural steel weight is shown to be an important parameter for the architects, construction engineers, and fabrication and assembly optimization.

**[3]R.K. Gajjar, Dhaval P. Advani (2011)** investigated, the design of a multi-storeyed steel building is to have a good lateral load resisting system along with a gravity load system because it also governs the design. They presented to show the effect of different types of bracing systems in multi-storied steel buildings. For this purpose, the 20 stories steel buildings model is used with the same configuration, and different bracings systems such as knee brace, X brace, and V brace is used. A commercial package STADD Pro is used for the analysis and design and different parameters are compared.

**[4]Guillermo Coeto (2011)** The title of the research paper is "Stiffness-Based Sizing of Bracing System for Tall and Slender Building". In this research, the work author applied a new methodology for analysis to determine the dynamic response of the building which influenced the flexural drifts and higher mode of vibration. From the evaluation of the dynamic characteristics of the different versions of the bracing system, it is concluded that the proposed methodology results in adequate stiffness-based sizing during the performance-based preliminary design of tall braced buildings. The application of the methodology to the sizing of the braces and their support columns for four versions of a twenty four-Storey bracing system has yielded adequate design in terms of lateral stiffness.

**[5]A. Kadid & D.Yahiaoui (2011)** The title of this research paper is" Seismic Assessment of Braced RC Frames". This study work is based on the earthquake which came in Turkey (1999), Taiwan (1999), and Algeria (2003) during when most of the existing structures were designed without seismic design criteria. In this paper, the researcher concluded a numerical study to assess the behavior of braced RC frames using pushover design. The author concluded that among existing seismic rehabilitation techniques the use of braced RC frames as the main lateral load resistance system is the most appropriate technique. The addition of steel braces in the RC frames enhances the strength of the structure and improves the seismic performance of the RC Frame.

**[6]Kevadkar, Kodag, et al (2013)** concluded that the structure in heavy susceptible to lateral forces may be a concern to severe damage. In this, they said along with gravity load (dead load, live load) the frames able to withstand lateral load (loads due to the earthquake, wind, blast, fire hazards, etc) which can develop high stresses for that purpose they used shear wall and steel bracing system to resist such type of loading like an earthquake, wind, blast, etc. In the study according to author R.C.C. building is modeled and analyzed in STADD & results are compared in terms of Lateral Displacement, Story Shear and Story Drifts, Base shear, and Demand Capacity (Performance point).

**[7]Nauman Mohammed (2013)** The title of this research paper is "Behavior of Multistoried RCC Structure with Different Type of Bracing System". The researcher concluded that braced frames are an efficient structural system for building under high lateral loads such as seismic loads or wind loads. In this research work, the author analyzes different-different structural systems with various braced frames. In the end, the author found that the cross-bracing system is the most appropriate structural system in comparison to others. The flexural and shear deformation is

reduced by the bracing system and lateral loads are transferred to the foundation through axial action.

**[8]Rishi Mishra (2014)** The title of this research paper is "Analysis of RC Building Frames for Seismic Forces Using Different Types of Bracing Systems". The author concluded that the concept of using steel bracing is advantageous to resist seismic forces. The bracing system effectively reduces the lateral displacement (up to 80%) of the structure compared to a Braced frame. Steel bracings the amount of forces in members significantly reduces. The bracing system proves as an effective member to control the Storey drift (up to 56%) in structures as compare to Braced frames. After using bracing members as resistive members margin of safety against collapse increased.

**[9]Keyvan Ramin (2014)** The title of the research paper is "Seismic Behavior of Steel Off-Diagonal Bracing System Utilized in Reinforced Concrete Frame". In this research work, the author utilizes the off-diagonal bracing system (ODBF) and compares it with other bracing systems. In the end, the researcher found that the dynamic performance and energy absorption capacity of the structure has been increased. The ODBS bracing system increases the basic shear endured by the structure as well as the structure's drift, causing the increase of the hysteresis curve's surface area which, in turn, leads to the enhancement of modified ductility or system flexibility.

**[10]P. Sairaj (2014)** In this paper, it was concluded that the economical aspects of the G+4 multi-storey building designed by using braced frame composite construction. For the ductile performance, overall displacement and inter-storey drift can be effectively controlled by adopting a braced frame model. This concept was very useful for retrofitting and seismic up-gradation of an existing multi-storied building.

**[11]R. Snehaneela (2015)** In this paper it was concluded that Outrigger braced structures had efficient structural form consist of a central core, comprising braced frames with horizontal cantilever "outrigger" trusses or girders connecting the core to the outer column. When the structure was loaded horizontally, vertical plane rotation of the core was restrained by the outriggers through tension in the windward column and compression in the leeward column. The effective structural depth of the building was greatly increased, thus augmenting the lateral stiffness of the building and reducing the lateral deflections and moments in the core. In effect, the outriggers join the columns to the core to make the structure behave as a partly composite cantilever. By providing an eccentrically braced system in outrigger frame by varying the size of links and analyzing it. Push-over analysis was carried out by varying the link size using computer programs, SAP2000 to understand their seismic performance.

**[12]Adithya M. (2015)** The title of the research paper is "Study on Effective Bracing System for High Rise Steel Structures". In this paper, the researcher introduced various types of bracing systems such as X bracing, V bracing, and Inverted V bracing Systems in the steel structures and analyze them by time history analysis using ETAB software and compared the results to determine the most efficient bracing system. The author analyzed a 20 storied steel structure with various bracing systems. In the end, the researcher compared various seismic parameters and found that regarding displacement criteria, a maximum reduction of 68.43% is obtained in a single braced frame. The lateral storey displacements are greatly reduced by the use of single diagonal bracings arranged as a diamond shape in the 3rd and 4th bay in comparison to concentric (X) bracing and eccentric (V) bracing systems.

**[13]Sachindra Kumar Chadhar (2015)** The title of this research paper is "Seismic Behavior of Building Frame with Steel Bracing System Using Various Arrangements". In this research paper, the author adopted a G+15 storey reinforced concrete building with various arrangements of bracing systems. MultiStorey reinforced concrete buildings are vulnerable to excessive deformation, which necessitates the introduction of special measures to decrease this deformation. The steel braced frame is one of the lateral load opposing frameworks in multiStorey structures. The steel bracing system enhances the resistance of the structure against horizontal forces by expanding its stiffness and stability. Bracings hold the structure stable by exchanging the horizontal loads, for example, quake or wind burdens down to the ground and oppose sidelong loads, in that way keep the influence of the structure.

**[14]Muhammed Tahir Khaleel (2016)** The title of this research paper is "Seismic Analysis of Steel Frames with Different Bracing using ETABS Software". In this paper, the author implies various types of bracing systems in an RC frame building and analyze it with a various analytical approach such as equivalent static analysis, response spectrum analysis and time history analysis under the seismic zone V as per IS 1893:2002.

**[15]Gunjali Butani (2017)** The title of the paper, written by this author is "Comparative Study of Different Bracing Systems On G+29 Steel frame building". The main concept behind this research paper is as the concept of using a steel bracing system is one of the advantageous concepts which may use to strengthen the existing structures. Through the analysis, it is clear that diagonal bracing is more effective in most cases comparatively. Displacement produced by the lateral loads can be reduced up to 93% by using single diagonal bracing.

**[16] Jonty Choudhary (2018)** The title of the Research paper written by this author "Comparative Study and Analysis of Un-braced RCC Framed Structures With Steel

Braced RCC Framed Structures Using Response Spectrum Method" and the conclusion is given below

1. 64.40% reduction in maximum Storey displacement in X-direction and 83.18% reduction in Y-direction comparatively when X-braced frames are used.
2. 78.27% reduction in maximum Storey drift in X-direction and 105.99% reduction in Y-direction comparatively when X-braced frames are used.
3. 17.5% reduction in base shear in X-direction and 29.54% reduction in Y-direction comparatively when X-braced frames are used.

**[17]Farhat Aziz Sheen (2019)** The title of the research paper is "Comparative Study for Different Bracing Systems of an Irregular Steel Structure". In this research paper, the author concluded that bracing systems are highly effective in rigid frame structures when subjected to lateral loadings. Bracing systems have less nodal displacement in both static analysis and time history analysis. In the nonlinear static analysis, the author had determined the structure with deliberates good results for X and chevron bracing.

## 3. CONCLUSIONS

After study the above research paper, we found some conclusion regarding providing the bracing system in the RC structure:

1. The maximum lateral displacement due to seismic activity in the RC structure is resisted by the X-bracing system as compared to the other type of steel bracing system.
2. The value of the axial force and shear force in the column start increasing and decreasing respectively after providing the bracing system in the RC Structure, which means that we can provide less number of the transverse reinforcement in the column.
3. The effect of the bending moment in the column starts decreasing after providing the steel bracing system in the RC structure.
4. The fundamental natural period of the RC structure due to the seismic activity on the RC structure get decreasing after proving the different types of the steel bracing system.

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