

A Review on Analysis and Design of Steel Braced Framed with Different Bracing by Using Staadpro

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Abstract—Steel structures are widely adopted in high-rise construction because of their high strength, flexibility, and ease of fabrication. However, they are highly susceptible to lateral forces generated by wind and earthquakes, which may lead to excessive sway and instability. To enhance lateral stiffness and stability, bracing systems are introduced in steel frames. Bracings act as diagonal members that transfer lateral loads through axial action, thereby reducing bending moments and inter-storey drift. The present study will focus on the seismic analysis and design of a G+30 steel framed building incorporating bracing configurations such as X types, using STAAD.Pro software. Different plan geometries Square, L, C, and T-shaped buildings will be modeled to evaluate the influence of structural shape on performance. Bracings will be placed at different locations, including corners, building faces, and core, to assess their effect on the structural response. The analysis will be carried out using the Time History Method as per IS 1893 (Part 1):2016, and design will be performed according to IS 800:2007. Parameters such as storey drift, displacement, and base shear will be evaluated and compared for each configuration. It is expected that type bracings will demonstrate better lateral stiffness and reduced deflection. The study will aim to identify the most efficient bracing system for enhancing the seismic performance of high-rise steel structures.

Index Terms—Steel Structure, Bracing System, STAAD.Pro, Seismic Analysis, THA, IS 1893:2016, IS 800:2007.

I. INTRODUCTION

In modern construction, steel structures have gained wide popularity due to their high strength, durability, and ability to resist heavy loads with minimal self-

weight. They are extensively used in high-rise buildings, industrial sheds, bridges, towers, and warehouses where both strength and flexibility are essential. However, the stability of steel frames under lateral loads such as wind and earthquakes remains one of the most critical aspects of structural design. Unlike vertical loads, which act downward and are resisted primarily by gravity, lateral loads create horizontal forces that can cause swaying, torsion, and even collapse if not adequately resisted. In a steel frame, these lateral forces tend to deform the structure sideways, generating bending in beams and columns. Excessive lateral deflection can lead to non-structural damage, instability, and discomfort to occupants.

To overcome these problems, engineers use bracing systems, which are structural members arranged in specific patterns within the steel frame to provide lateral stability. Bracing forms a triangular configuration that resists horizontal movement through truss action, thereby enhancing the overall stiffness and strength of the structure.

A. Role Of Bracing In Steel Structures

Bracing systems act as an effective lateral load-resisting system in steel buildings. They connect the beams and columns to form a stable framework that transfers horizontal forces safely to the foundation. The function of a bracing system is not only to resist wind or earthquake loads but also to minimize bending moments and shear forces in vertical and horizontal members

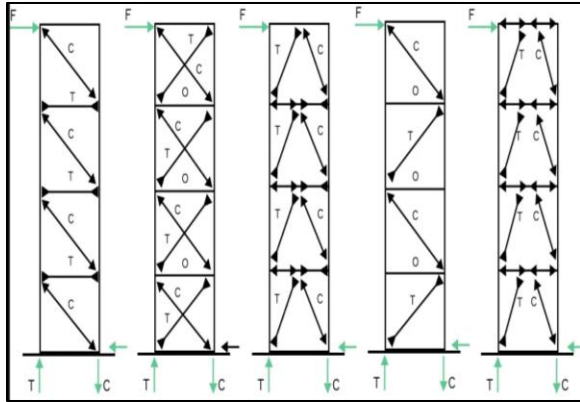


Fig 1 Lateral Load Transfer through Bracing System

1. Increases Lateral Stiffness:

By introducing diagonal members, bracing reduces the degree of lateral sway and increases the rigidity of the structure.

2. Improves Strength and Stability:

Braced frames can carry higher loads without undergoing excessive deformation, maintaining the overall stability of the building.

3. Reduces Member Forces:

Since part of the lateral load is resisted by the braces in axial tension and compression, the bending moments in columns and beams are reduced significantly.

4. Enhances Ductility:

Properly designed bracing systems allow controlled energy dissipation during dynamic events like earthquakes, improving the structure's ability to withstand cyclic loads.

5. Economical Solution:

Compared to rigid moment-resisting frames, braced frames require smaller sections for columns and beams, making them a cost-effective option.

II. STATE OF DEVELOPMENT

The literature review presents previous studies related to the analysis and behavior of steel braced frame structures under various loading conditions. Researchers have extensively examined how different bracing configurations such as X, V, K, and diagonal systems influence the lateral stiffness, strength, and seismic performance of buildings. Recent advancements in structural software like STAAD. Pro and ETABS have enabled detailed modeling and comparative studies on braced frames. Reviewing

these works helps identify effective bracing arrangements, design parameters, and research gaps that form the basis for the present study.

[1] T. Y. Yang et. al., (2020) Eccentrically braced frame (EBF) is a robust structural system designed for seismic application. The design philosophy for EBF is to utilize the link beams to dissipate the earthquake energy. While such system has been proven to provide sufficient stiffness and strength to prevent the structure from collapse, the structural performance in terms of damage and resilience after strong earthquakes is not explicitly considered. In this paper, a novel design method, named the Equivalent Energy Design Procedure (EEDP), is adopted to design the EBF. EEDP is an alternative design procedure for fused structural systems, where engineers can design the structure to achieve the intended performance objectives at different earthquake hazard levels. To evaluate the performance of the EBF, a 5 storey EBF located in Vancouver, British Columbia, Canada is designed using both the EEDP and the Equivalent Static Force Procedure (ESFP) outlined in the 2015 National Building Code of Canada. Detailed nonlinear dynamic analyses were conducted. The results show that the EEDP designed EBF has better performance with lower initial and repair costs at different levels of earthquake shaking intensities.

[2] A. Acosta et al., (2024) Although eccentrically braced frames (EBFs) can be used with different configurations according to architectural requirements, it has not yet been indicated which configuration has a better seismic performance; therefore, this paper presents an analytical study focused on evaluating the seismic behavior of various steel buildings with EBF systems, factoring in different configurations. Furthermore, the objective is to compare the performances of EBF systems with one another, to learn more about their structural efficiency. The results obtained indicate that seismic response, in terms of peak interstory drifts, depends on the structural period and hysteretic behavior of the links, because high levels of plastic rotation increase lateral displacement. In addition, it was observed that maximum drift demands are concentrated in the lower floors where the links exhibit inelastic behavior, while the level of interstory drift decreases as height increases.

[3] C. Zhang et al., (2023) An innovative assembled self-centering buckling restrained brace (ASC-BRB) with variable post-yield stiffness is proposed in this study, aiming to better control structural responses under earthquakes of different intensity levels. The proposed ASC-BRB consists of the buckling restrained brace (BRB) system and self-centering (SC) system, where the SC system provides the variable post-yield stiffness with trilinear elastic behavior. The overall configuration and restoring force model of the brace are first described, and six independent hysteretic parameters are determined to comprehensively describe its hysteretic behavior. A simplified truss model of the ASC-BRB is established using OpenSees, and the experimental and numerical hysteretic curves coincide well with each other, indicating that the simplified model has satisfactory accuracy. The simplified model is then utilized to investigate the effect of the design parameters on the hysteretic behavior of the ASC-BRB. Nonlinear dynamic analyses are also conducted for three 6-story steel frames with different types of braces. The comparison results indicate that the proposed ASC-BRB with high post-yield stiffness can effectively limit the displacement development at the lower floors, but the structural high-mode effect will be further amplified. Finally, system level parametric analyses are performed to study the influence of brace design parameters on the structural responses, and reasonable values for these design parameters are recommended according to the parametric analysis results.

[4] A. Kianmehr et al., (2021) Simple bracing frames can be divided into two types in terms of concentric or eccentric. Concentric bracing frames are frames that intersect with other structural members at one point in the structure along the bracing members. Otherwise, the braced frame will be eccentric. It is said empirically that due to this type of shaping, eccentric bracing frames exhibit more ductile behavior and concentric bracing frames exhibit more stiff behavior. This behavioral difference caused this study to be numerically computing for five frames, including unique concentric and eccentric bracing frames of 5 and 10 stories and an ordinary 5-story concentric bracing frame. Their tensions and drift ratios should be acceptable for the use of residential buildings. Using

the primary two steps of the new PEER probabilistic framework, namely, probabilistic seismic hazard analysis and structural analysis, which leads to the drawing of fragility curves, the probability of collapse is obtained to compare the safety capability of these frames according to their different characteristics against earthquakes. The results show that increasing the ductility or increasing the number of floors or the height of these systems can reduce collapse. Also, according to the results of the probability of collapse obtained in frames with 5-story concentric bracing frames, it can be said that some of the current regulations, which work based on previous approaches of analysis, can lead to unsafe structures with a high probability of collapse.

[5] M. Jalalvandi et al., (2022–2023) Designing steel structures with Concentric Braced Frame (CBF) lateral systems has been common in recent decades. This type of bracing has a quite unstable and complicated behavior in relatively intense earthquakes. This study tries to improve the seismic behavior of steel frames with CBF braces equipped with Shape Memory Alloy (SMA) and Buckling Restrained Braces (BRBs). In this manner, a multi-story building with inverted V chevron bracing was considered. Nonlinear time-history analyses have been performed using OpenSEES software. The dynamic responses of frames with SMA and BRB braces were compared. The results showed that the SMA and BRB braces provide energy dissipation in the nonlinear zone and can reduce maximum interstory drift. The comparison of those bracing systems revealed that implementing SMA in braces also led to a reduction in permanent displacement of the structures due to the elasticity property of the SMA bracing system. The energy dissipation of structures with the BRB system was higher than that of structures with the SMA bracing system.

[6] A. Osman et al., (2023) This study examines the feasibility of utilizing steel concentrically X-bracing rigidly connected to shear link to retrofit seismically defected reinforced concrete (RC) frames. It involves examining the lateral behavior of two hypothetical frames strengthened using this proposed system, a single story-single bay RC frame, and a five-story RC office building. For the former, both elastic and inelastic push-over analyses were performed to

examine the lateral behavior of strengthened and original RC frames, while the original and strengthened five-story frames were analyzed under the action of monotonically increasing lateral loads and nonlinear time histories. In detailing the strengthening scheme, procedure complying with the capacity design concept was adopted whereby the shear links were detailed to yield prior to RC frames structural elements to reduce the demand on them. The stiffnesses, strengths, and plastic hinging formation patterns for original and strengthened frames under the action of different loading conditions were determined and evaluated. Story shears and maximum story displacements were recorded and examined. It was concluded that this system is feasible for seismically strengthening the defected RC frames. Guidelines for detailing this scheme were provided within the context of this research study.

[7] Noor Mohammed et. al. (2016) Buildings are designed as per the code regulations meeting all specific requirements of code and assuming a linear elastic behavior for the structural members. Moreover, it is also necessary to know the behavior of a building that were designed with older codes or which may not have been designed for earthquake forces. During the seismic excitation the building responds well beyond its elastic and linear capacity and enters into non-linear stage. So, the present work is intended to provide a systematic procedure to assess the behavior of a structure during the seismic excitation. For studying the behavior, a non-linear static analysis procedure known as pushover analysis is used. The literature pertaining to pushover analysis is reviewed. A Nine story residential building located in the Hyderabad city, which was designed and constructed for gravity loads alone, was considered for analysis. The present structure is studied using the evaluation procedures provided in ATC-40 and FEMA-273 documents. Under detailed evaluation a target displacement for Immediate Occupancy, Life Safety, Collapse Prevention was given and the performance is checked in accordance with IS 1893:2002

[8] Yousuf Dinar et. al. (Jan. 2014) Structures in mega cities, are under serious threat because of faulty and unskilled design and construction of structures.

Sometimes structure designers are more concerned in constructing different load resistant members without knowing its necessity and its performance in the structure. Different configuration of construction may also lead to significant variation in capacity of the same structure. Nonlinear static pushover analysis provides a better view on the performance of the structures during seismic events. This comprehensive research evaluates as well as compares the performances of bare, different infill percentage level, different configuration of soft storey and Shear wall consisting building structures with each other and later depending upon the findings, suggests from which level of performance shear wall should be preferred over the infill structure and will eventually help engineers to decide where generally the soft storey could be constructed in the structures. Above all a better of effects of pushover analysis could be summarized from the findings. Masonry walls are represented by equivalent strut according to pushover concerned codes. For different loading conditions, the performances of structures are evaluated with the help of performance point, base shear, top displacement, storey drift and stages of number of hinges form

[9] A. Kadid et. al. (2008) The recent earthquakes including the last Algerian earthquake in which many concrete structures have been severely damaged or collapsed, have indicated the need for evaluating the seismic adequacy of existing buildings. In particular, the seismic rehabilitation of older concrete structures in high seismicity areas is a matter of growing concern, since structures venerable to damage must be identified and an acceptable level of safety must be determined. To make such assessment, simplified linear-elastic methods are not adequate. Thus, the structural engineering community has developed a new generation of design and seismic procedures that incorporate performance based structures and is moving away from simplified linear elastic methods and towards a more nonlinear technique. Recent interests in the development of performance-based codes for the design or rehabilitation of buildings in seismic active areas show that an inelastic procedure commonly referred to as the pushover analysis is a viable method to assess damage vulnerability of buildings. The Boomers 2003 earthquake which has devastated a large part of the north of Algeria has

raised questions about the adequacy of framed structures to resist strong motions, since many buildings suffered great damage or collapsed. To evaluate the performance of framed buildings under future expected earthquakes, a nonlinear static pushover analysis has been conducted. To achieve this objective, three framed buildings with 5, 8 and 12 stories respectively were analyzed. The results obtained from this study show that properly designed frames will perform well under seismic loads.

[10] Shubham P. Dhoke et. al. (2017) Due to development in construction technology and structural systems growth of high rise building increases. Now-a-days in modern tall buildings, lateral loads induced by earthquake or wind are often resisted by various lateral load resisting system (viz., Beam Column System, Frame Tube System, Shear Wall & Frame System and Diagram System, etc.). This paper contains comparative analysis of various lateral load resisting system (i.e., Beam Column System, Frame Tube System and Diagram System). Modelling and analysis of different lateral load resisting system done in ETABS-2015 software. This paper gives information about various lateral load resisting system and which of them is more beneficial. Lateral load plays an important role while designing any multi-storey building, so study & analyse the lateral load resisting system. The comparison of lateral load resisting systems is done by using Response Spectrum Method on the basis of various parameters such as storey displacement, storey drift, storey forces and modal time period.

[11] Tej Parkar et. al. As the population is increasing tremendously with every passing year and the land available for use of habitation is the same as it was a decade ago. Due to this, metro cities are getting densely populated day by day. So, the only solution to the problem is vertical growth. Now this need for the increase in the vertical height of the buildings has made the buildings tall and slender. Since buildings are getting taller and slender the primary concern of design engineers is shifting from gravity loads to lateral loads. The effect of lateral forces becomes more and more dominant as the building becomes taller and taller. Hence, traditional simple framed structures have now been replaced by complex but yet more effective structural systems that perform

better in case of lateral load. The lateral load resisting system effectively controls the excessive drift due to either winder earthquake and thus minimizes the risk of damage to building. The objective of this papers to study, performance of lateral load resisting system in high-rise building subjected to seismic and wind load. Study of the literature is reviewed in this paper on various aspects of lateral load resisting system as; Behaviour of lateral load resisting system in High-Riser building, Behaviour of lateral load resisting system in High-Rise steel and composite structure, Effect of seismic and wind load on High-Rise structures

[12] Khuzaim J. Sheikh et. al. (2017) In the early structures at the beginning of the 20th century, structural members were assumed to carry primarily the gravity loads. Today, however, by the advances in structural design and high-strength materials, building weight is reduced, and slenderness is increased, which necessitates taking into consideration mainly the lateral loads such as wind and earthquake. Understandably, especially for the tall buildings, as the slenderness, and so the flexibility increases, buildings suffer from the lateral loads resulting from wind and earthquake more and more. As a general rule, when other things being equal, the taller the building, the more necessary it is to identify the proper structural system for resisting the lateral loads. The objective of this papers to study, the performance of structural system in high-rise building subjected to seismic and wind load. Study of the literature is reviewed in this paper on various aspects of structural system as; behaviour of high- rise structure was assessed by overall building drift, story drift, displacement, base shear.

[13] Arafa Elhelloty et. al. (2017) Structures can be subjected to dynamic loads that it are due to wind, waves, traffic, earthquake, and blasts and dynamic analysis is used to find dynamic displacements, time history, natural frequencies and mode shapes. Lateral forces on buildings such as wind, earthquake and blast forces can be produced critical stresses in the buildings that it cause excessive lateral sway of the buildings and undesirable stresses and vibrations in the buildings. Design and structural evaluation of the building systems subjected to lateral loads form the important task of the present generation and the

designers are faced with problems of providing adequate strength and stability of buildings against lateral loads. Different lateral loads resisting systems are used in high-rise building as the lateral loads due to earthquakes are a matter of concern. Steel plate shear walls system and steel bracings system are used in steel structures buildings and their effect shows unequal variations and behavior against seismic loads. Recently, laminated composite plate shear walls are used as a lateral load resisting system where the laminated composite plates are used as infill plate in shear walls. The laminated composite plates are created by constructing plates of two or more thin bonded layers of materials and it can be either cross-ply laminates or angle-ply laminates. In this paper, the modal and transient analysis are carried out to study the effect of lateral loads resisting systems on response of buildings subjected to dynamic loads. Three and five stories steel frame buildings without and with three lateral loads resisting systems which are steel plate shear walls, steel bracings and laminated composite plate shear walls subjected to dynamic loads are investigated with respect to natural frequencies, mode shapes and time history graphs for total displacement and equivalent stresses. Comparative study is conducted to evaluate the effect of lateral loads resisting systems on the performance of buildings subjected to dynamic loads using the finite element system ANSYS16.

III. CONCLUSION

- Based on the review of existing literature, it has been observed that although numerous studies have investigated the seismic and structural performance of steel braced frames, significant research gaps still exist. Most previous studies have primarily focused on individual bracing configurations or specific structural conditions, without conducting a comprehensive comparative evaluation of different bracing systems such as diagonal, X, K, and V-type bracings under identical loading, geometry, and boundary conditions. Moreover, limited attention has been given to identifying the most efficient bracing system in terms of stiffness, strength, lateral displacement control, and overall structural performance.

- Among the available bracing systems, X-bracing (cross bracing) has shown superior performance in several studies due to its higher stiffness, better load distribution, and enhanced lateral load resistance. However, a systematic and consistent comparison under uniform design parameters is still lacking. Therefore, there is a need to critically evaluate and validate the effectiveness of X-bracing over other bracing configurations. This gap forms the basis of the present study, where a detailed analysis is carried out to justify the selection of X-bracing as the most efficient bracing system for improving structural performance under lateral loads.
- Furthermore, the influence of building plan shapes such as Square, L, C, and T-shaped configurations on the overall performance of steel braced frames has not been sufficiently addressed. Similarly, limited studies have evaluated how the location of bracing (at corners, faces, or the core of the building) affects lateral stiffness, displacement control, and base shear resistance. Therefore, there is a clear need to conduct a comparative analytical study to evaluate the performance of different bracing types, plan shapes, and bracing positions in steel frames, thereby identifying the most efficient configuration for enhanced lateral load resistance and overall structural stability.

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