International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

A Review of detailed investigation on Retrofitting of Reinforced Concrete frames using Steel Bracings.

D. Banerjee [1], S. Pandey [2]

[1] Department of Civil Engineering, M. Tech Student, Techno India University, WB, India
[2] Department of Civil Engineering, Assistant Professor, Techno India University, WB, India

---

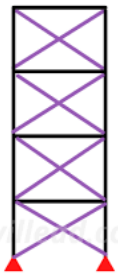
Abstract

Reinforced concrete buildings are generally designed to resist lateral loads and gravity loads which are acting on the structure. So, while designing such kinds of frames earthquake load should be considered which can cause collapse of the building. Bracing element also improves the seismic behaviour of the structure. Steel bracing takes less space, can adopt required stiffness as well as strength. Bracings are also very cost effective and easy to install. Retrofitting of building can be done by using steel bracings. In this paper different types of steel bracings are observed. Bracings under different loading condition are studied. Effects of Combined bracings with respect to unbraced frames are also studied. Different types of bracing patterns are also discussed. It is also observed that how steel bracings are used as the active part of the building. Main object of this paper is to determine the best bracing pattern for different loading conditions and effect of internal and external bracings also analyse bracings having eccentricity.

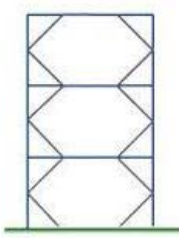
Keywords – Bracing pattern, Internal and External bracings, Eccentricity, Displacement, Lateral loads, Stiffness etc.

1. Introduction

Generally for resisting the earthquake and different load, bracings can be implemented. Tall structures are generally prone to wind load and seismic load. For reducing the displacement, improving strength and stiffness, there are different methods. Bracing is one of the best method among them which provides structural stability and resist different loads. Bracings are also efficient to overcome the elastic seismic waves. Horizontal and vertical bracings should be applied. There are different types of bracing patterns like X, V, inverted V, K, Diagonal bracing etc. It also increase lateral resistance and reduce the internal forces by appropriate bracing pattern. The Crossed bracing or X bracing is one of the most used bracing.



(X bracing)



(K bracing)

(V bracing)

(Inverted V bracing)

(Diagonal bracing)

1.1 Advantages

- Steel Bracings are lateral load resisting system
- Provides more free space and allowable opening
- Easy to modify
- Easy to analyse
- Capable to resist accidental loads, twisting etc.
- Provides extra strength to the structure

1.2 Disadvantages

- Connections are difficult to fabricate
- Increases the total self-weight of the structure
- More number of members
- Heavy Bracings are required for long spans
- Skilled labour required
- Design load for bracing design is always debatable

2. Literature Reviews

Study on this topic for last 10-15 years has been discussed below: -

A. Massumi et. al. (2008) revealed that adding X bracings to rc frames or structures, which depends on the connection details, will significantly increase the stiffness of the frames and change its behaviour, but adding steel X bracings, which are not connected to each other for strengthening the concrete frames, does not change failure mechanism of the frame.

Mehmet Agar et. al. (2008) Investigated the use of steel bracing for the strengthening of low, medium, and high rise reinforced concrete buildings. The ultimate lateral load capacities of the strengthened frames are determined by a load-controlled push-over analysis. The post-tensioning effect of preloading is also investigated. After his experiment he concluded that a) Depending on the original design and its height to width ratio, it is possible to increase the lateral load capacities of existing R/C frame structures by up to 20 times using a bracing system composed of steel X-bracing and an enclosing steel frame around it in the frame bays and without even anchoring them into the existing R/C frame structure. b) The lateral load capacities of existing R/C frame structures could increase by using a bracing system composed of steel X-bracing and an enclosing steel frame around it by up to 2.5 times by transferring some of the existing axial loads in the R/C columns to steel bracing system through a preloading applied to the vertical steel members of the bracing system.

S. I. Khan et. al (2013) Analyzed a nonlinear static pushover using the displacement coefficient method, as described in FEMA 356 on an existing hostel building in Babasaheb Naik College of Engineering, Pusad. Built in 1987, the subject hostel building is a four-story, rectangular structure. In this paper he concluded that the joints of the structure have displayed rapid degradation and the inter storey deflections have increased rapidly in non- linear zone in structure without bracings. Also (a) The floor displacement is maximum for without braced building frame as compared to braced building frame. In the braced building frame, floor displacement is minimum for X-bracing, and nearly same for inclined bracing and inverted V bracing. (b) in inclined bracing system deflection is nearly same as that of X-bracing and inverted V bracing and base shear is also nearly same, so from economic point of view we can provide inclined bracing system to the structure to resist the seismic forces without compromising with strength and stiffness of the structure.

Hendramawat et. Al. (2013) did an experiment and the main aim of the experiment was to improve the seismic behaviour of an existing RC building. Analysis was done by ETABS. X bracings were used here. results showed that the seismic stability of an existing RC frame can be improved by applying steel bracings, also the displacements can be reduced by 16 to 55 percent by applying steel X bracings.

Prof. Bhosle et. al. (2015) analyzed a 13 storied building by different bracing patterns like X, V, inverted V, diagonal, K, combined V using ETABS software. The analysis was done with respect to additional gravity load and lateral load. The main aim of this paper was to find out the changes occurred in displacement, stiffness, story drift of the structure. From the paper it is concluded that i) displacement of structure is reduced. ii) Storey drift was reduced by X bracing and also X bracing have provided the maximum structural strength. iii) Structures displacement capacity also improved by applying bracing system with respect to unbraced structure. iv) it was also found out by this experiment that, X bracing is most efficient with respect to storey overturning moment.

Mohammed Hyderuddin et. al. (2016) retrofitted various models with various steel bracing systems on periphery columns storey wise and analyzed for seismic forces. One building is analyzed for models with Diagonal bracing, 'V' type bracing, Inverted 'V' type bracing, Combined 'V' type bracing, 'X' type bracing, 'K' type bracing and compared with an unbraced frame. The effectiveness of various types of steel bracing in rehabilitating a ten-storey building is examined. The main parameters in this study to compare the seismic analysis of buildings are lateral displacement, storey drift, axial forces in the columns, Base shear. The percentage reduction in lateral displacement is found out. It is found that the 'X' type of steel bracing significantly contributes to the structural stiffness and reduces the maximum storey drifts of the frames. The bracing systems improve not only the lateral stiffness but also the displacement capacity of the structure.

Chamarthi Manikumar. et. al. (2018) analyzed A ten storey construction for seismic zone III as per IS 1893-2002 the using of ETABS software program. The models

are retrofitted with different bracings on periphery columns storey wise and analyzed for seismic forces. The building is analyzed for models with Diagonal bracing, 'V' type bracing, inverted 'V' type bracing, blended 'V' kind bracing, 'X' kind bracing, 'K' type bracing and in comparison, with an un braced frame. The effectiveness of numerous forms of metallic bracing of a 10-storey constructing is tested. The percentage reduction in lateral displacement is observed out. It's far found that the 'X' sort of metal bracing extensively contributes to the structural stiffness and reduces the maximum storey drifts of the frames. The bracing systems enhance not only the lateral stiffness however also the displacement capacity of the shape.

Jenna Maria Jaleen et. al.(2019) Studied various X bracing configurations formed by bracing at the middle, corner as well as alternate frames of a building (B+G+4). A comparative study is conducted to identify the ideal X type bracing configuration for retrofitting the building by studying various parameters such as lateral displacement, storey drift, axial forces, bending moment, shear force and story stiffness. After the analysis of structure with different types of X bracing configurations, it is concluded that the overall displacement of the structure decreases. However, the maximum reduction in the lateral displacement is due to the application of middle braces.

M. Hisamuzzaman et. al. (2019) studied the performance assessment of different bracing systems and compared in a seismically vulnerable RC building to find out the efficient bracing. Nonlinear static pushover analysis is carried out to assess the structural performance on different bracing systems in RC buildings. Different steel bracing pattern is used such as inverted V-braced frames, X-braced frames, ZX braced frames and Zipper braced frames. The effects of another parameter influencing the performance which is the lateral load patterns are also investigated. The performances are compared based on the capacity curve and maximum storey displacement of the building. This experiment is done with an existing RC building which is already retrofitted with X pattern braced system. The results obtained indicate that, ZX and the Zipper bracing systems are found to be the most efficient.

Peter Kirruti et. al. (2020) modelled a 20 storied building and tested with different bracings that is X, V and inverted V (combined) using ETABS software. The main objective of this paper was to observe the displacement, stiffness, story drifts and base reactions of the structure under applying external load. X bracings are used in 1st to 10th floor and inverted V bracings are used in 11th to 20th floor. The better performance observed in X bracings for the lower storey and inverted V for the upper storey. Stiffness increased from top to bottom storey wise. The most improved performance was seen when combined bracing systems are used.

S. Pandey et. al. (2020) studied A G+20 storied building and analysed for lateral load using design software STAAD Pro. Performance of different types of bracing systems (X, V, inverted V, Diagonal, K, two storied K) are checked under gravity load and wind load. Various results such as bending moment, shear force, lateral deflections, storey drift, axial load on columns are extracted from this analysis and studied meticulously. In few cases of brace pattern effect of providing eccentricity are also studied to suggest optimum positioning of these bracing systems. After the study it is concluded that 1) Steel brace patterns help to reduce lateral displacement, storey drift, bending moment, shear force and axial load on columns. 2) Among the various existing brace patterns overall performance of X brace is better followed by K brace. 3) Lateral displacement, storey drift, bending moment, shear force and axial load can be reduced by introducing eccentricity in many types of brace pattern. 4) Among all the bracing patterns with eccentricity overall performance of diagonal brace pattern with eccentricity of 1 m is best.

3. Conclusion from Literature Review

- From the literature reviews it is concluded that the use of different bracing increases strength and stiffness thereby enhances the seismic performance of Reinforced Concrete structures. Bracing systems also results in reduction of structural displacement, storey drift, base shear etc.
- The concept of different Bracing patterns are simple and well understood however, there are many configurations and methods by which bracings can be constructed. The reliability and the performance of the Bracing system and its superior seismic response compared to unbraced frame and many bracing systems have been confirmed by many tests using softwares like STAAD pro, ETABS etc. The primary elements of the Bracing system have been kept the same, while recent tests focused on the improving the performance of Reinforced Concrete structure by determining the best bracing system.

4. Future Scope of Work

- The present study was conducted to find out comparison between the seismic parameters such as Base Shear, Displacement, Storey Drift, Stiffness etc. for Reinforced Concrete frame

structure with different bracing systems at various locations.

Additional research can be done in the following areas-

- Model of a high rise or multi-storied building could be developed and analysed with different bracing patterns at different floors for obtaining the best result for improving the overall building strength like displacement, storey drift, stiffness with respect to externally applied gravity and lateral loads. This study can be done by using STAAD pro software.
- Further a detailed investigation can be done keeping Eccentricity as the main parameter.
- In maximum experiment External Bracings are tested, so testing with Internal Bracings can also be done with modelled multi storied building using STAAD pro.

5. References

[1] A. Massumi et. al. (2008) "Strengthening of low ductile reinforced concrete frames using steel X bracings with different details".

[2] Mehmet Agar et. al. (2008) "Strengthening of reinforced concrete frames by using steel bracings".

[3] S. I. Khan et. al (2013) "Seismic Retrofitting of RC Building by Using Different Bracing Systems".

[4] Hendramawat et. Al. (2013) "Evaluation of the Use of Steel Bracing to Improve Seismic Performance of Reinforced Concrete Building".

[5] Prof. Bhosle et. al. (2015) "Analysis of Reinforced Concrete Building with Different Arrangement of Concrete and Steel Bracing system".

[6] Mohammed Hyderuddin et. al. (2016) "Retrofitting of Reinforced Concrete Frames using Steel Bracing".

[7]Chamarthi Manikumar et. al. (2018) "Design And Construction Of Reinforced Concrete Frames Using Steel Bracings".

[8]Jenna Maria Jaleen et. al.(2019) "Retrofitting Of Reinforced Concrete Frames Using Different X Bracing Configurations".

[9]M. Hisamuzzaman et. al. (2019) "Performance Assessment of Retrofitted RC Frames with Different Patterns of Steel Bracing".

[10]Peter Kirruti et. al. (2020) "Seismic performance assessment of steel bracing systems in high-rise reinforced concrete structures".

[11] S. Pandey et. al. (2020) "Performance of Different Bracing Patterns for Moderately Tall Steel Buildings Subjected to Lateral Load".

[12] Pasha Javadi (2013) "Retrofitting of RC Frames by Steel Braced Frames Utilizing a Hybrid Connection Technique".

[13] Badoux et. al. (2022) "Retrofitting of reinforced concrete structures with steel bracing systems".

[14] Bikram Shah et. al. (2019) " Effects of Steel Bracings in the Progressive Collapse Resistance of Reinforced Concrete Building".

[15] Siavash Sadeghinezha et. al. (2021) " Strengthening of Vulnerable RC Moment Resisting Frames Using Direct Internal Connection of X-Steel Bracing".

[16] Somil Khattar et. al. (2019) " Seismic Performance of Reinforced Concrete Frame with Steel Bracing System".

[17] T. S. Mustafa et. al. (2019) " Seismic Retrofit of Reinforced Concrete Frame Structures".

[18] Vani Prasad et. al. (2014) " Effectiveness of inclusion of steel bracing in existing RC framed structure".

[19] Amol Patil et. al. (2022) " To Investigate Efficient Concentric Bracing system in high rise steel building".

[20] Pratik K. Zaveri et. al. (2020) "Effectiveness of Steel Bracing System".

[21] Samruddhi Sawarkar (2022) To Study and Analyze Effects of Bracing in Design of Building".

[22] Ayaanle Ali (2020) The Performance Analysis of the Difference Types of Steel Bracing for the Reinforced Concrete Building".