JOURNAL OF SCIENTIFIC RESEARCH AND TECHNOLOGY VOLUME-3 ISSUE-4 APRIL

Enhanced Seismic Analysis of Braced RC High-Rise Buildings Using STAAD Pro V8i

MD Umar[1], Daljeet Pal Singh[2]

[1] *Student, Department of Civil Engineering, Maharishi University, Lucknow, UP, India*
Email: mdumar78498@gmail.com

[2] *Assistant Professor, Department of Civil Engineering, Maharishi University, Lucknow, UP, India*
(Corresponding Author Email: daljeetpalsingh1768@gmail.com)

ABSTRACT

In this project, seismic performance study of multistory reinforced concrete (RC) structures along with the bracing systems have been done through STAAD.pro V8i, a powerful software which will significantly facilitate the task of analysis. The objective of our research is assessing seismic response of braced high-rise RC structures exposed to earthquake force. In seismic events, the buildings are considered to be braced systems to provide lateral stability and structural integrity. Using the modeling and simulation of various building configurations with different types of bracing systems, the behavior of which is being simulated under seismic loading, and set up comparison between results to determine which solution is the most efficient with regards to improving earthquake resistance.

Keywords: Seismic Analysis, Multi-Storey RC Buildings, Bracing Systems, X-Bracing, K-Bracing, Diagonal Bracing, STAAD.Pro V8i, Earthquake Resistance, Lateral Displacement, Base Shear, Structural Stability.

I. INTRODUCTION

1.1 Background

High rising structures are at risk from seismic activity. With more and more urban, it is becoming increasingly common that high-rise buildings, especially, they need to be made in seismic resilient. One of the most effective ways to enhance lateral load resisting capability in such structures is through employing bracing systems. Bracing systems absorb and redistribute the earthquake forces that cause buildings to tilt and can result in collapse.

1.2 Objectives

Seismic study of multi storey RC structures with several kinds of bracing systems is performed. The compares seismic performance of buildings with bracing depending on :

• Seismic efficacy comparisons of braced buildings as of displacement, stress distribution and structural stability.

• The structures of the building structures subject to seismic loads will be modeled and analyzed under different bracing systems using STAAD.Pro V8i. A design solution for enhanced earthquake resistance is proposed.

1.3 Scope of Work

The study includes:

- Modeling a multi-storey RC structure utilising STAAD.Pro V8i.
- Incorporating various bracing systems into design.
- Performing dynamic analysis under seismic load circumstances.
- Evaluating the results based on displacement, shear force, and stress distribution.
- Comparing the effectiveness of each bracing in enhancing seismic performance of the building.

2. LITERATURE REVIEW

Seismic analysis & utilisation of bracing methods have received wide attention. Diagonal bracing, X, K bracing etc are bracing systems which has reduce lateral displacement & enhance overall stability of structure during earthquake. Recent studies indicate that efficacy of bracing system based upon configuration, building height, the materials and seismic design codes used.
It has been found that X bracing yields better lateral stability for tall buildings by enhancing the distribution of forces and K bracing is especially appropriate to reduce torsional movement in irregular buildings. In addition, diagonal bracing is simpler and less expensive, but may not be as efficient in high seismic zones.

3. METHODOLOGY

3.1 Building Model and Assumptions

A 10 storey reinforced concrete structure is selected for this research. Typical floor plan of structure is rectangular, and each floor was modeled as 5m × 5m grid. It is assumed that the structural system in the building is uniform on all floors, and that the slab thickness and beam size are based on standard design codes.

Material Properties:

- Concrete: Compressive strength of 25 MPa
- Reinforcement: Yield strength of 500 MPa
- Density of concrete: 25 kN/m³
- Modulus of Elasticity: 25 GPa

Loading Conditions:

- Dead load and live load are applied as per IS 875.
- Seismic loads are calculated using IS 1893:2016, which accounts for the seismic zone, importance factor, and building type.

3.2 Software: STAAD.Pro V8i

The building's response is modeled and analyzed under seismic forces with STAAD.Pro V8i. The software offers a full structural platform to execute the variation of gravity loads, seismic loads, wind loads et cetera. This also makes the use of STAAD.Pro to perform dynamic analysis appropriate for assessing the effects of seismic forces on the structure of a building.

3.3 Analysis Types

- **Linear Static Analysis**: It is used to calculate basic load distribution.
- **Dynamic Response Spectrum Analysis**: The building response to earthquake motion is evaluated by this method using a response spectrum obtained from the seismic zone of the region.
- **Time History Analysis**: This advanced technique is utilised for simulating real time seismic response over a period, enhancing our understanding about how the structure behaves during a period of time.

3.4 Bracing Systems

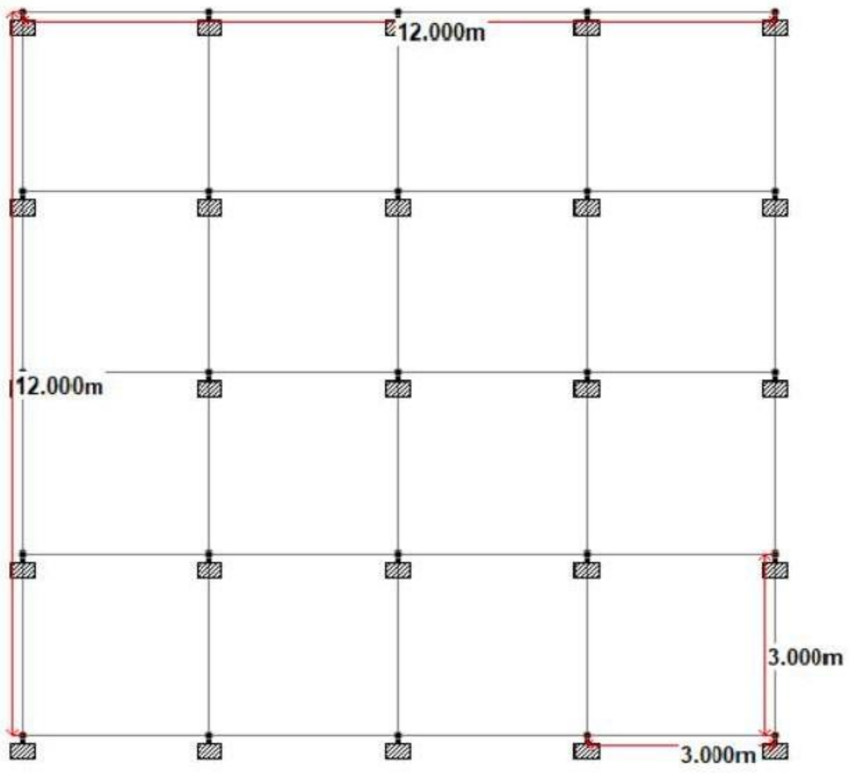
Three types of bracing systems are modeled:

- **X-Bracing**: Two diagonal braces crossing at the center, forming X shape.
- **K-Bracing**: Two diagonal braces connected to central vertical member, making K pattern.
- **Diagonal Bracing**: Single diagonal braces placed at strategic locations along the building's facade.

Table-1 RC Frame Data Details Considered for the Analysis

The geometry of the structure	Detail/ value
Grids in the direction-X	5
Grids in the direction-Z	5
Grid line space of line in X-direction	3meter
Spacing of Grid line in Z-direction	3meter
Number of Storey	G+14
Height of each storey	3m
Height of the ground-floor	3m
Beam dimension	450mm x 450mm
Column size	600mm x 600mm
Steel bracing	ISMB 200
Soil Type	Medium
Response Reduction Factor	5
Seismic Zone	IV
Dead Load	3kN/m^2
Importance Factor(I)	1
Combination Method	CQC
Support type	Fixed
Live Load	4kN/m^2
Damping Ratio	5%

Fig.3.1 Structural Layout of RC Frame Prototype



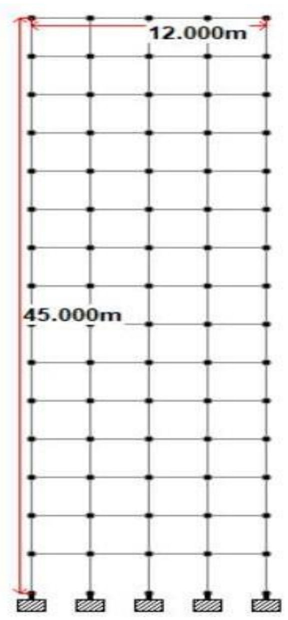


Fig.3.2(a) Structural Elevation of RC Frame Model

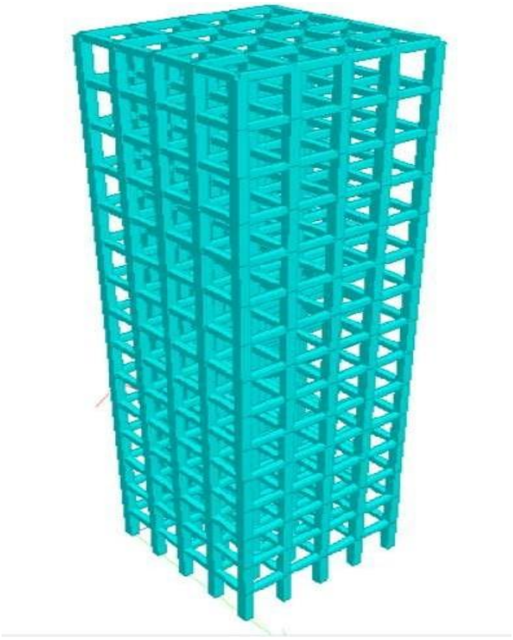


Fig.3.2(b) Rendered view of unbraced RC Frame(Model-1)

Fig.3.3(a) Structural Plan for X- braced RC Frame (Model-2)

Fig.3.3(b) Rendered view for X-braced RC Frame (Model-2)

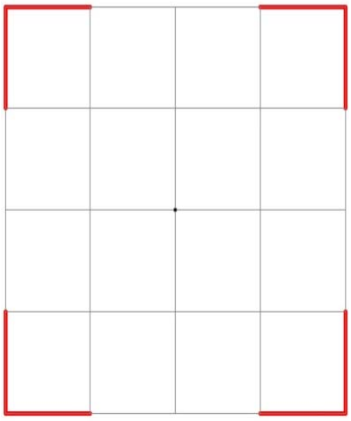


Fig.3.4(a) Structural Plan for X-braced RC Frame (Model-3)

Fig.3.4(b) Rendered view for X-braced RC Frame (Model-3)

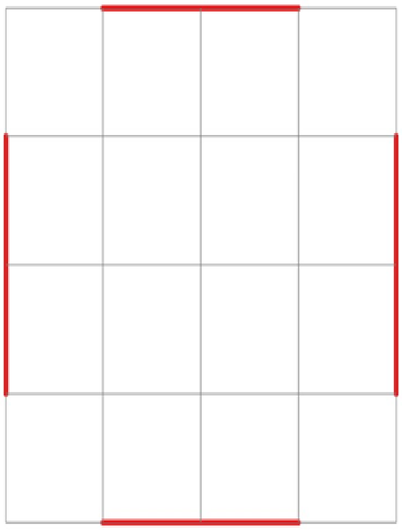


Fig.3.5(a) Structural Plan for Inverted V-braced RC Frame (Model-4)

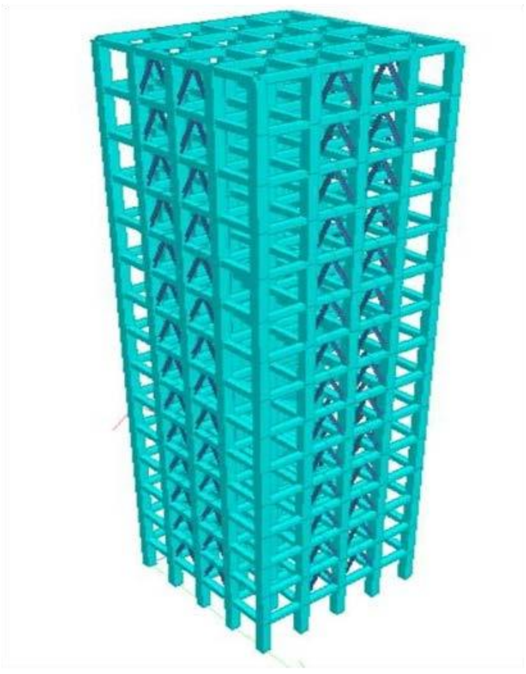


Fig.3.5(b) Rendered view for Inverted V-braced RC Frame (Model-4)

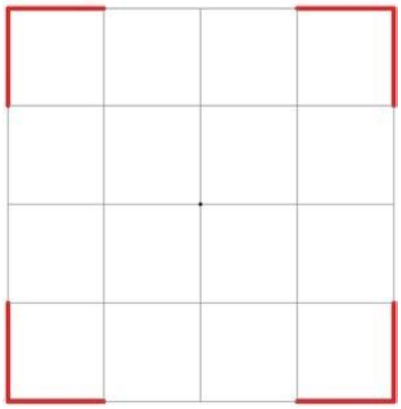


Fig.3.6(a) Structural Plan for Inverted V-braced RC Frame (Model-5)

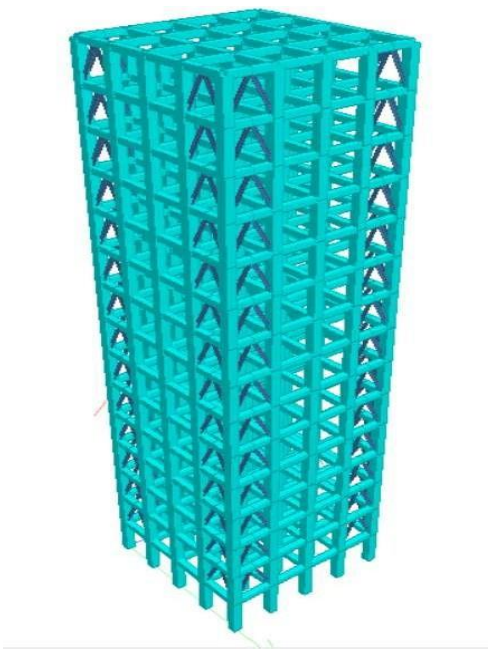


Fig.3.6(b) Rendered view for Inverted V-braced RC Frame (Model-5)

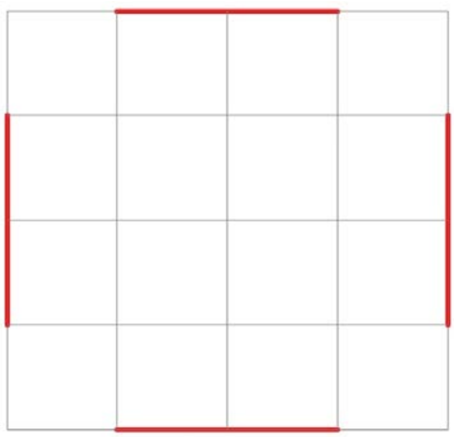


Fig.3.7(a) Structural Plan for V-braced RC Frame (Model-6)

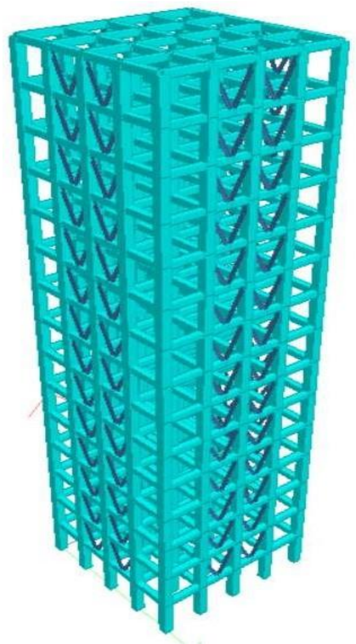


Fig.3.7(b) Rendered view for V-braced RC Frame (Model-6)

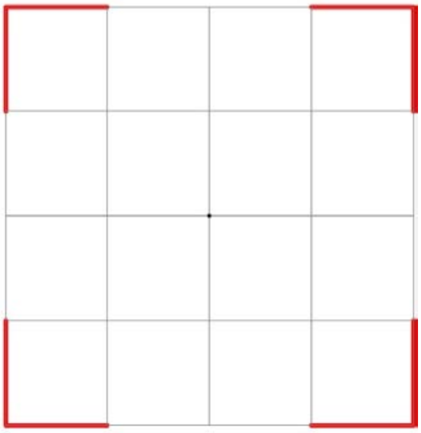


Fig.3.8(a) Structural Plan for V- braced RC Frame (Model-7)

Fig.3.8(b) Rendered view for V-braced RC Frame (Model-7)

4. RESULTS AND DISCUSSION

4.1 Seismic Response Comparison

Seismic response of structure with different bracing systems is equated based on the following parameters:

4.1.1 Lateral Displacement

- **X-Bracing**: Lateral displacements are significantly reduced in the braced model relative to the unbraced. Approximately 35% reduction to displacement at the top floor is observed.
- **K-Bracing:** Lateral resistance is somewhat better than diagonal bracing and displacement is reduced 25%.
- **Diagonal Bracing:** Reduction of only 10% least effective to reduce lateral displacement

4.1.2 Base Shear

- **X-Bracing**: Because lateral forces are transferred more efficiently and thus represent a higher base shear, this system is a more effective resistance to seismic forces.
- **K-Bracing**: The base shear is moderate which provides an efficient and cost balance.
- **Diagonal Bracing**: It is less effective in distributing seismic forces, according to offers the lowest base shear.

4.1.3 Stress Distribution

Results of the stress distribution analysis indicate not only that X-bracing reduces displacement, but also that it provides a more uniform stress distribution across the structure such that it minimizes the risk of localized failure. Strain distribution is slightly different in case of K braking, while it shows higher stress concentrations for diagonal braking.

4.2 Cost-Effectiveness

X bracing is the best seismically, but is the most complex and most expensive to design and install. Conversely, K-braced structures offer a good compromise between performance and cost, and hence are a viable solution for tall buildings. While simpler, diagonal bracing is the most cost effective solution but may not be optimal for high seismic zones.

Table 2 Mass participation factor in z-direction for Model-2

Mode	Mass Participation Factor (%)						
	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
1	55.45	70.65	1.94	39.73	70.17	74.93	20.76
2	22.70	6.76	74.53	38.34	7.03	3.07	56.47
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	3.51	5.96	3.05	1.68	0.38	6.36	8.60
5	8.07	7.70	10.94	10.96	12.74	6.31	4.42
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5. CONCLUSIONS

The study demonstrates that bracing systems significantly improve the seismic response of multi-storey RC structures. Among the three bracing systems analyzed:

- **X-Bracing:** In general, X-Bracing offers the best lateral displacement and base shear reduction performance at the highest cost..
- **K-Bracing** : Good seismic resistance and moderate construction complexity are provided by K-Bracing
- **Diagonal Bracing**: Despite being relatively complex to construct and relatively noisy, Diagonal Bracing is the most cost effective option, but it provides very little seismic resistance, and, so, not suited for high seismic zones.

STAAD.Pro V8i has shown to be a useful tool and has been used for the detailed seismic analysis of multi-storey buildings for better earthquake resilience for engineers and architects.

6. Recommendations

- X bracing was recommended for high seismic regions because it performs better than X bracing in displacements and shear forces.
- Considering the entire mass as K-braced, it can therefore be designed using a balanced design which is cost-effective at the same time as being safe in moderate seismic zones.
- In low seismic zones or in low height building with low seismic force, Diagonal bracing can be taken as bracing.

Future studies could involve looking at impacts of numerous kinds of foundation systems, or the use more complex dynamic analysis techniques such as non-linear time history analysis.

REFERENCES

1. Katte, Aniket, and D. B. Kulkarni. "Seismic Analysis of Multi-Storey Steel Structure with Steel Bracing at Different Location." International Research Journal of Engineering and Technology (IRJET), ISSN (2019):2395-0056.
2. Anes Babu, Dr, et al. "Effect of steel bracings on RC framed structure."International Journal of Mechanics and Solids 9.1 (2017):97-112.
3. Bajoria et.al. (2012) examined the steel structure with or without bracing for the seismic analysis.
4. Tupe, Rashmi, ital. "Zinc in him its glycation induced structural, functional modifications in albumin and protects erythrocytes from glycated albumin toxicity." International journal of biological macromolecules 79 (2015):601-610.
5. Chadhar and Sharma (2015) studied that for resisting the horizontal forces in RCC building.
6. Yadav, Purnima, Diptendu Roy, and Megha Kalra. "Model-based analysis of base isolation systems for multistory buildings subject to various Seismic Events." (2018):209-221.
7. Saxena, Aakash, and S.S. Kushwaha. "Seismic Evaluation of G+2 Institutional Building in Bhopal"
8. Cao, Xu-Yang, et al. "Seismic retrofitting of existing frame buildings through externally attached sub-structures: State of the art review and future perspectives." Journal of Building Engineering 57 (2022):104904.
9. Ahmad, Naveed, et al. "Haunch retrofitting technique for seismic upgrading deficient RC frames." Bulletin of Earthquake Engineering 17.7 (2019):3895- 3932.
10. Moretti, Marina L. "Seismic design of masonry and reinforced concrete infilled frames: a comprehensive overview." American Journal of Engineering and Applied Sciences 8.4 (2015):748.
11. Shendkar, Mangesh Kumar R et al. "Investigation of Seismic Design Parameters in Irregular Reinforced Concrete Buildings with Masonry Infills." International Conference on Advances in Structural Mechanics and Applications. Springer, Cham, 2022.