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# Seismic Evaluation of High-rise Structure by Using Steel Bracing System

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**Abstract**

The use of steel bracing systems for strengthening seismically inadequate reinforced concrete frames is a viable solution for enhancing earthquake resistance.

In this paper, the seismic analysis of reinforced concrete (RC) buildings with different types of bracing is studied. A G+9 building is analyzed for seismic zone III as per IS 1893: 2002 using STAAD Pro software. The main parameters consider in this paper to compare the seismic analysis of buildings are lateral displacement, story drift, axial force, base shear. It is found that the X type of steel bracing significantly contributes to the structural stiffness and reduces the maximum interstorey drift of the frames. The bracing system improves not only the lateral stiffness and strength capacity but also the displacement capacity of the structure.

***Keywords:*** *Lateral Displacement, Base Shear, Storey Drift.*

## 1. Introduction

The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

Strengthening of structures proves to be a better option catering to the economic considerations and immediate shelter problems rather than replacement of buildings. Moreover it has been often seen that retrofitting of buildings is generally more economical as compared to demolition and reconstruction. Therefore, seismic retrofitting or strengthening of building structures is one of the most important aspects for mitigating seismic hazards especially in earthquake prone areas.

### 1.1 Types of Bracing

There are two types of bracing systems

1) Concentric Bracing System

The steel braces are usually placed in vertically aligned spans. This system allows to obtaining a great increase of stiffness with a minimal added weight. Concentric bracings increase the lateral stiffness of the frame thus increases the natural frequency and also usually decreases the lateral storey drift. However, increase in the stiffness may attract a larger inertia force due to earthquake. Further, while the bracings decrease the bending moments and shear forces in columns and they increase the axial compression in the columns to which they are connected.

2) Eccentric Bracings

Reduce the lateral stiffness of the system and improve the energy dissipation capacity. The lateral stiffness of the system depends upon the flexural stiffness property of the beams and columns, thus reducing the lateral stiffness of the frame. The vertical component of the bracing forces due to earthquake causes lateral concentrated load on the beams at the point of connection of the eccentric bracings.

## 2. Structural Details

The RC building used in this study is ten storied (G+9). building have same floor plan with 4 bays having 4m distance along longitudinal direction and 3 bays having 4m distance along transverse direction as shown in figure. 2.1.

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- The floor to floor height is 3m for all the stories.
- The live load = 3 KN/m$^2$ for all floors.
- Floor finish load is 1 KN/m$^2$.
- Thickness of brick wall over all floor be 0.230 m.
- Thickness of slab = 0.125 m.
- The unit weight of concrete = 25KN/m$^3$
- Unit weight of brick masonry = 20 KN/m$^3$.
- The compressive strength of concrete = 25 N/mm$^2$
- Yield strength of steel = 415 N/mm$^2$.
- The modulus of elasticity of concrete 25000 N/mm$^2$
- The modulus of elasticity of steel = $2\times105$ N/mm$^2$
- The steel bracing used is ISA 110X110X10.
- Located in seismic region III sub-soil type 2 (medium).
- Importance factor 1
- Seismic analysis is carried out on building models using the software Staad pro V8i.
- The load cases considered in the seismic analysis are as per IS 1893 – 2002 and IS 456.

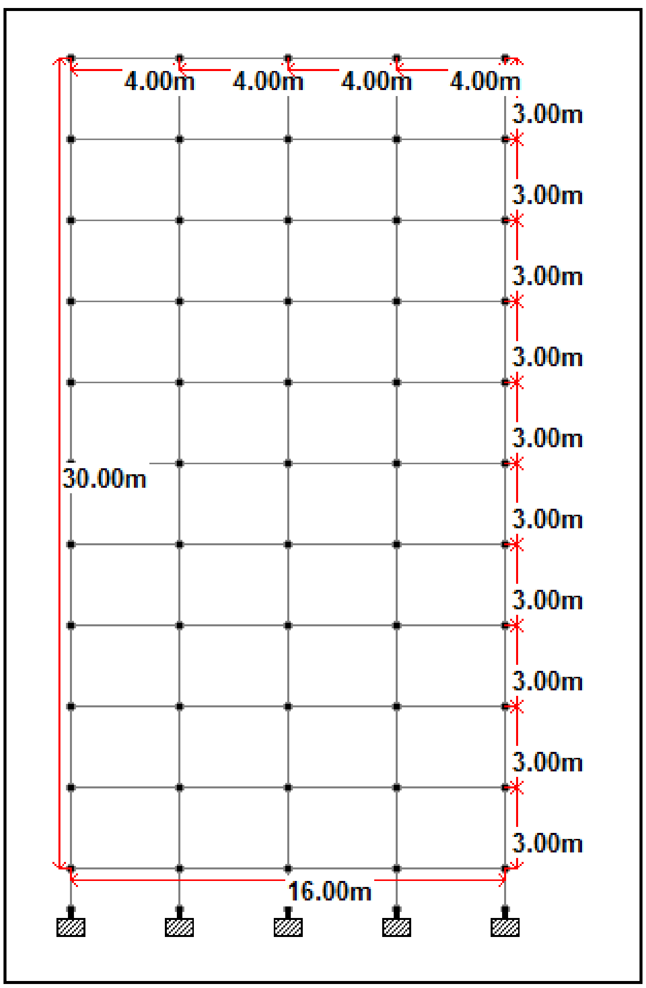


Fig:2.1 Elevation of Building

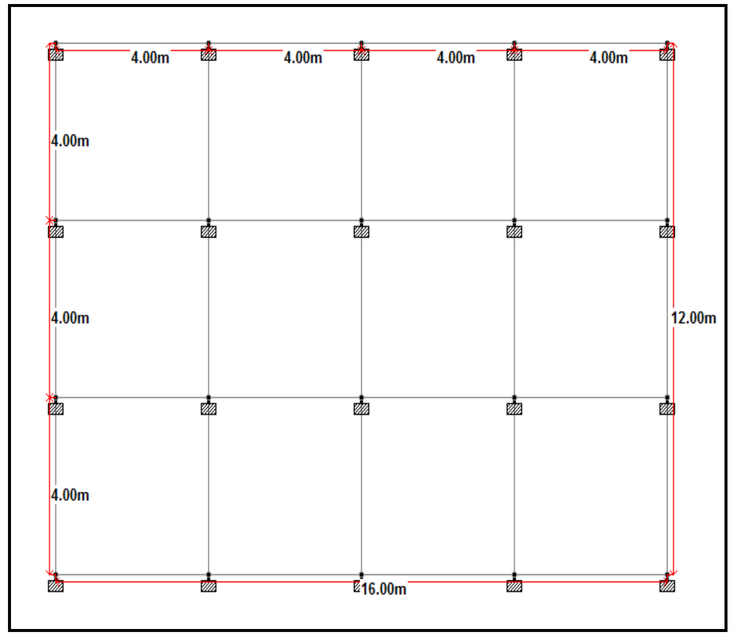


Fig:2.2 Building Plan

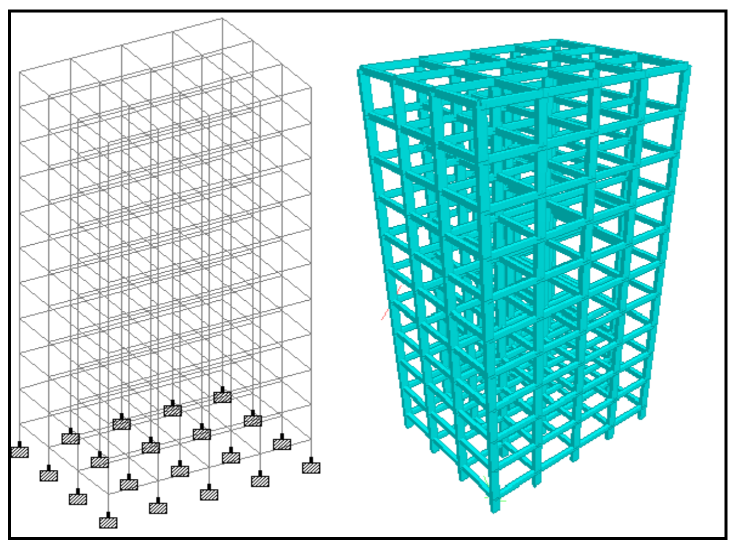

Fig:2.3 Building Without Bracing

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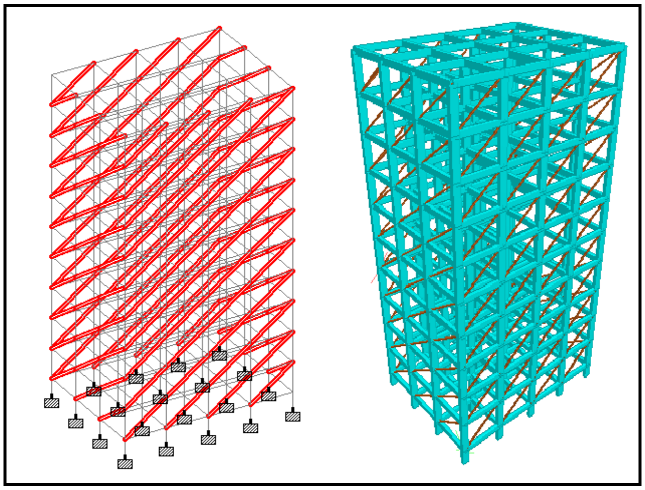

Fig:2.4 Diagonal Bracing

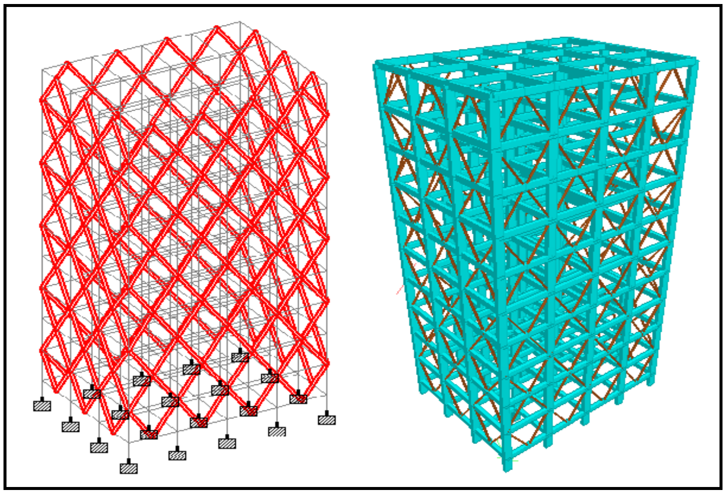

Fig:2.7 Combine V Type Bracing

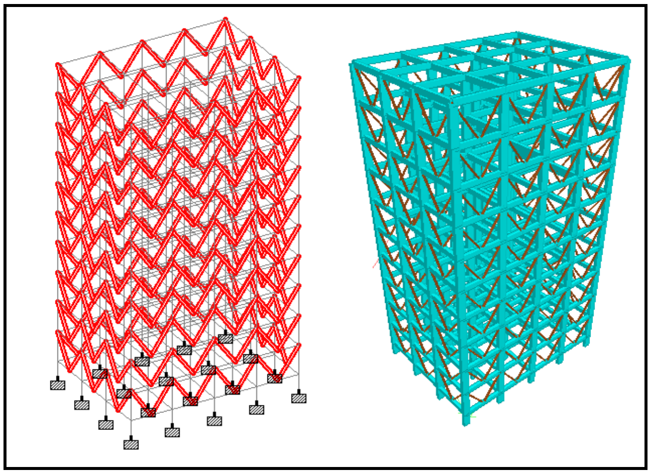

Fig:2.5 V Type Bracing

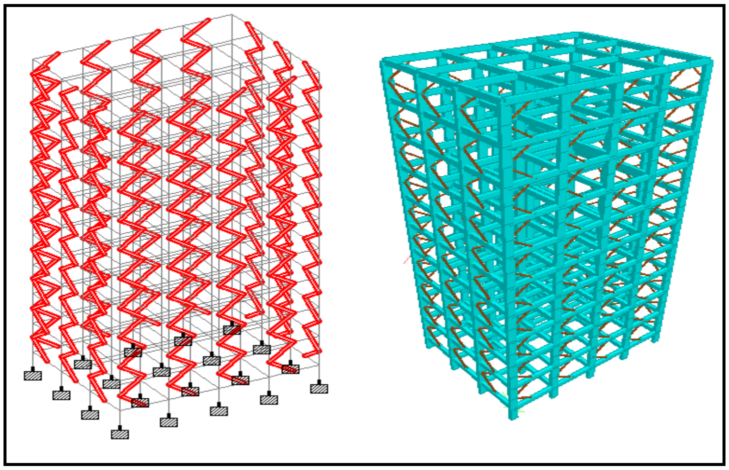

Fig:2.8 K Type Bracing

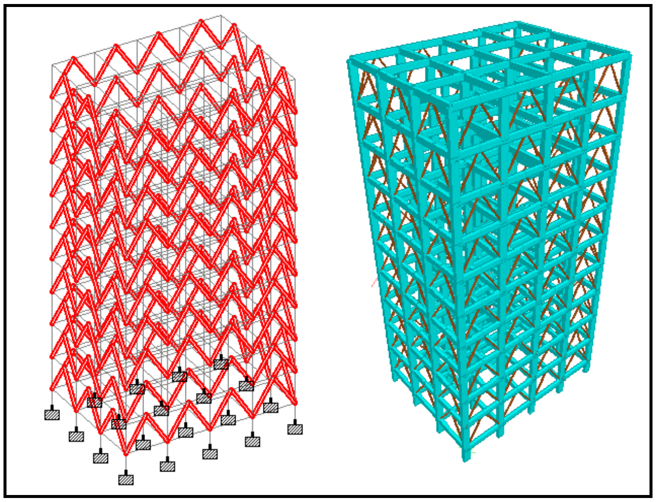

Fig:2.6 Inverted V Type Bracing

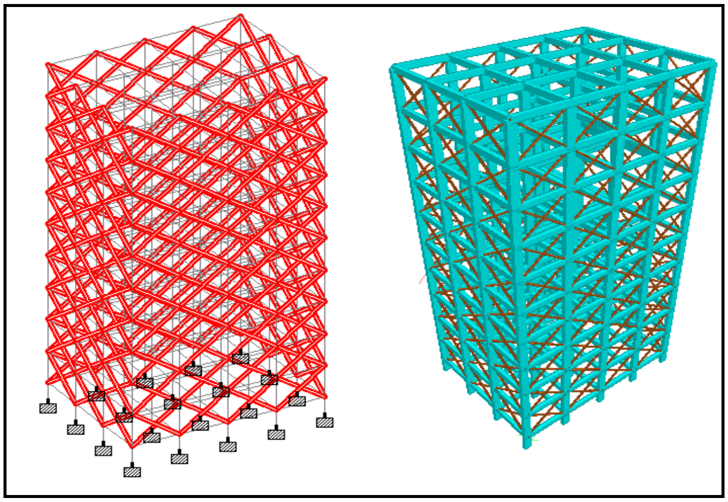

Fig:2.8 X Type Bracing

# 3. Results

## 3.1 Lateral Displacement

It is observed that the lateral displacement are reduced to largest extent for X type of bacing systems, while the displacement is maximum for the system without bracing. The displacement are reduced sequentially for bracing type K, diagonal, V and Invered V, combined V. These patterns are observed due to increased stiffness provided by the respective bracings. Top roof displacement for the system with X bracing is reduced by 64.55% in X direction and 65.04 % in Z direction as compared to that of without bracing system.

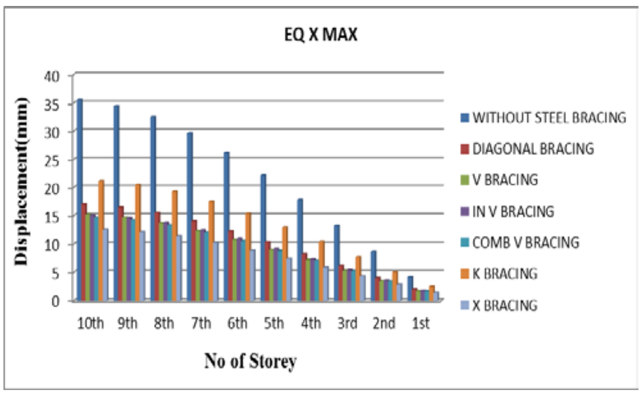


Fig:3.1 Graph of Maximum Lateral Displacements (mm) in X Direction for G+9 Buildings

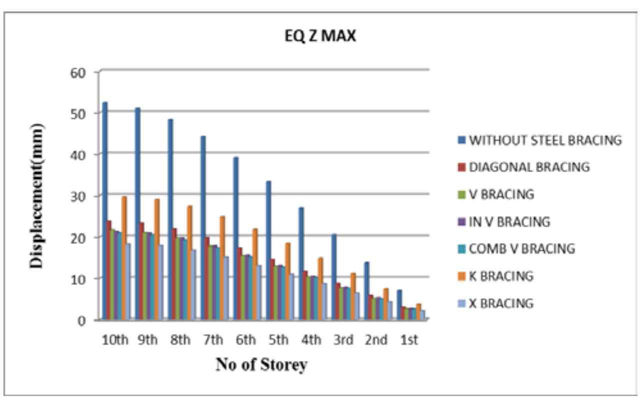


Fig:3.2 Graph of Maximum Lateral Displacements (mm) in Z Direction for G+9 Buildings

## 3.2 Story Drift

It can be observed from the graph that the story drifts are reduced to largest extent for X type of bacing systems, while these are maximum for the system without bracing.

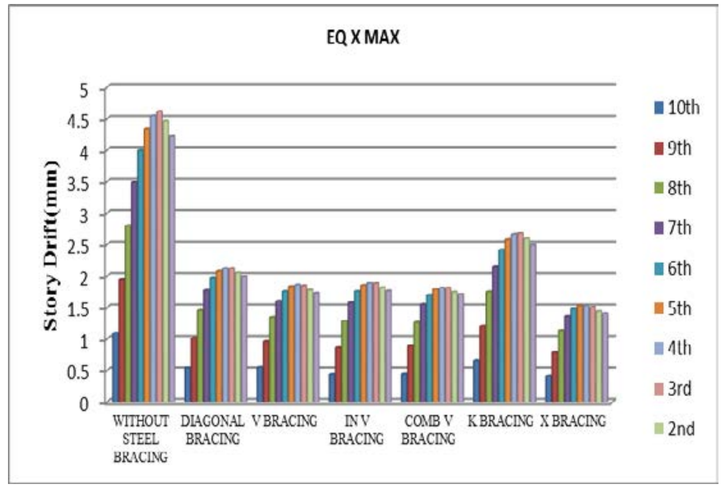


Fig:3.3 Graph of Storey Drift Displacement (mm) in X Direction for G+9 Building

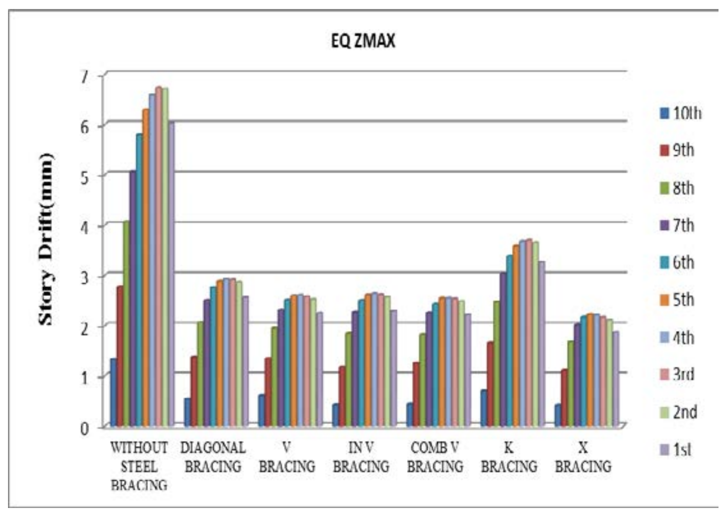


Fig:3.4 Graph of Storey Drift Displacement (mm) in Z Direction for G+9 Building

## 3.3 Axial Force

It can be observed from the graph that the axial forces are maximum for X type of bacing systems, while these are minimum for the system without bracing. Axial force at the ground floor level column for the system with x bracing is increased by 21.18% as compared to that of without bracing system.

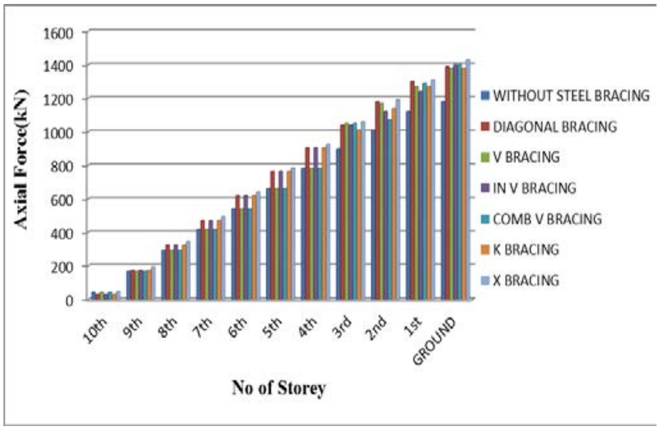


Fig:3.5 Graph of Axial Force (kN) in Column for G+9 Buildings

### 3.4 Base Shear

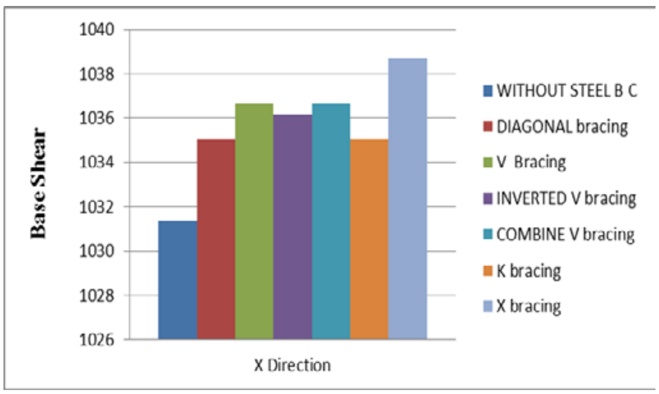


Fig:3.6 Graph of Base shear in X Direction (kN)

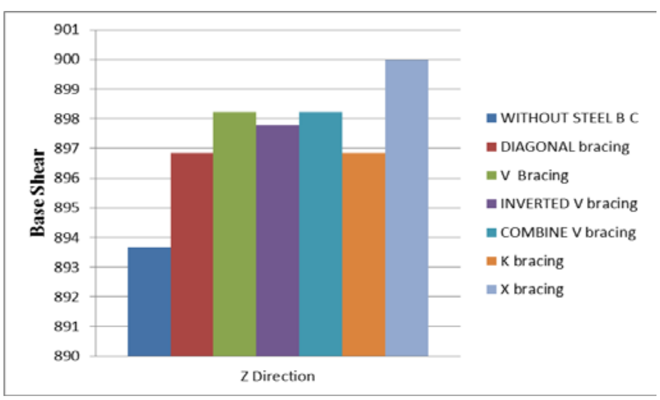


Fig:3.7 Graph of Base shear in Z Direction (kN)

## 4. Conclusions

The following conclusions are drawn based on analysis.

- Steel bracings used as alternative techniques.
- Using Steel Bracing the total weight on the existing building will not change significantly.
- The lateral displacement of the building is reduced up to 65% by using X type of bracing system.
- Stiffness of the building is increases.
- Story drifts are reduces using X type of bacing systems.
- The axial force is maximum for X bracing system is up to 22%.

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