# SEISMIC ANALYSIS OF STEEL FRAMES WITH AND WITHOUT BRACINGS

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**Abstract -** *This paper presents the Seismic Analysis of Steel Frames with and without Bracings by using Seismic Analysis methods. Response Spectrum Analysis and Time History Analysis are carried out with low, mid and high rise steel buildings with different patterns of bracing systems. of study was to investigate and compare different results of seismic analysis of different types of structures with bracing systems and without bracing systems. For this purpose 15 storey steel building model are used with same configuration with different bracing systems such as X brace, V brace, K brace, Knee brace and O grid brace. A commercial software ETABS2015 is used for analysis purpose. Results are obtained by considering the parameters Base Shear, Fundamental Time Period and Top Floor Displacements of steel structures.*

***Key Words***: Bracing systems, Dynamic analysis, ETABS2015, High rise steel buildings, Knee bracing, O-grid bracing, Steel Frame, Seismic load, Time history analysis

## 1. INTRODUCTION

Bracings in steel structures are commonly used because it can withstand lateral loads due to an earthquake, wind etc. It is one of the best method for lateral load resisting systems. High rise steel framed buildings are establishing more in the metro cities. Engineers have turned to braced steel framed structure as economical means for earthquake resistant loads. 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, Knee bracing and New O-grid bracing

### 1.1 Literature Review

**[1] Shih-Ho Chao, et.al. (2013)** They studied seismic performance of buildings with a hybrid bracing. A series of nonlinear time-history analyses was conducted. Investigate the seismic performance of 3- and 6-story buildings with the hybrid bracing system. The seismic performance of the HBFs was compared with conventional concentrically braced frames. Using Seismic Parameters Drift ratio, displacement response of the HSS and recommended Concentrically Brace frame.

**[2] Sutat Leelataviwat et.al. (2013)** They studied The knee braces also provide much less obstruction than the braces of conventional systems, making this structural system architecturally attractive. Two approximately half-scale KBMF specimens were tested by using Dynamic analysis. The response analysis of the example structure show that plastic hinges occurred only at the designated locations, as intended in the design. The results indicate that the proposed concept is viable and can be applied to multi-storey structures.

**[3] *Dhanaraj M, et.al. (2015)*** They studied the seismic behaviour of different bracing systems in high rise 2-D steel buildings. Nonlinear static pushover analyses were carried out. MRFs, CBFs, VBFs, XBFs and ZBFs. High rise steel buildings of 15, 20, 25, 30 and 35 storeys. The results show that the different braced frames performed well in terms of storey displacement, inter-storey drift ratio, base shear and performance point when compared with the moment resisting frame and enhances structural performances.

**[4] *H. L. Hsu, et.al. (2015)*** They studied This paper study the experimentally evaluates of seismic performance of knee braced moment resisting frame. A series of cyclic load tests were performed on the special moment resisting frame (SMRF) and KBRF systems with in-plane and out-of-plane. It was found from the test results that the strength and energy dissipation capacity of the KBRFs was significantly enhanced. It is therefore suggested that braces with in-plane buckling modes be adopted for greater earthquake resistance in KBRF frame structure designs.

**[5]** ***Maryam Boostani, et.al. (2018***) They stuided In this paper proposed a new bracing systems for earthquake resistant steel structures are introduced (O Grid-I and the O Grid-H). Experimental program and FEM (finite element method) numerical analysis. Linear and nonlinear behavior of the new O Grid bracing systems are studied and compared with X-bracing system, and MRF models. Results show that the O grid systems have more ductility and less displacement and drift compared to other frame. Absorbed or dissipate more energy.

## 2. STRUCTURAL ANALYSIS METHODS

Depending on the loading conditions and type of structure, the common elastic or inelastic analysis types are as follows:

a) Linear static analysis

b) Nonlinear-static analysis

• P-Delta analysis

• Pushover analysis

c) Linear dynamic analysis

• Linear Time History Analysis.

• Response Spectrum Analysis (RSA)

d) Nonlinear-Dynamic Analysis

• Nonlinear Time History Analysis

Depending on the loading conditions and type of structure, Dynamic analysis is done. ETABS2015 are used for analysis. As per IS-1893 (2002), the dynamic analysis is recommended for buildings depending upon seismic zone and height of building in the given project research work, Dynamic Response Spectrum Analysis and Time History Analysis are used for analysis of the structures.

### 2.1 Analysis

For analysis purpose 15 storey six models are considered such as without bracing, X bracing, V Bracing, K bracing, knee bracing and O grid brace. Each building is designed using IS code 1893 (part-1): 2016 and IS 800-2007. The structure considered is important Class-II and is assumed to be located in seismic zone- IV. Imposed load taken as 4 kN/m$^2$. For roof imposed load is taken as 1.5 kN/m$^2$. Design sections used are American sections. Symmetric plan building has uniform storey height of 3 m through-out. The characteristic compressive strength of concrete in slab is 25 N/mm$^2$ and yield strength of structural steel used is 450 N/mm$^2$. The sizes of beams and columns of different bracing patterns as shown in Table 1 respectively.

**Table -1:** Section Properties of 15- Storey Steel Frame

| Storey | Column | Beam | Bracing |
|---|---|---|---|
| 1-5 | W 14 X 730 | W 24 X 335 | W8 X 10 |
| 6-10 | W14 X 605 | W24 X 229 | W8 X 10 |
| 11-15 | W14 X 211 | W24 X 104 | W8 X 10 |

Minimum Time History to be selected for seismic analysis are Elcentro earthquake (1940), Koyna earthquake (1967), Bhuj earthquake (2001). Time period taken for each Time History is 0.02 sec

## 3. MODELLING

The structures studied in this research are unbraced and braced buildings with 15 storey. The overall plan dimension of configuration is 24 m × 24 m. Symmetric plan building has uniform storey height of 3 m through-out.

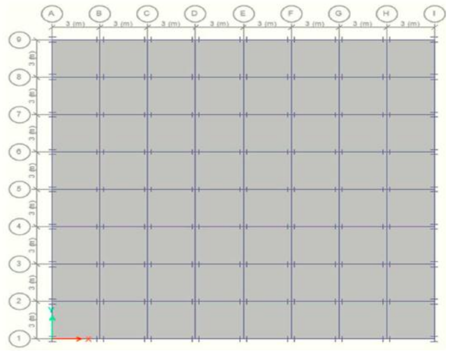

**Figure 1.** 15 Storey MR Frame

The different bracing systems are X-bracing, V bracing, K bracing, Knee bracing, O grid brace along with MRF in different storey height of steel frame are consider. The buildings consist of Eight bays in each direction and steel braces are inserted in the first two, Middle Two and last two bays as shown in Fig. 1-4.

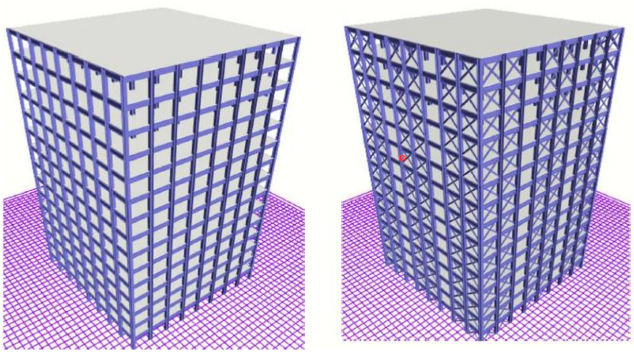

**Figure 2.** 15 Storey MR Frame and X bracing Frames

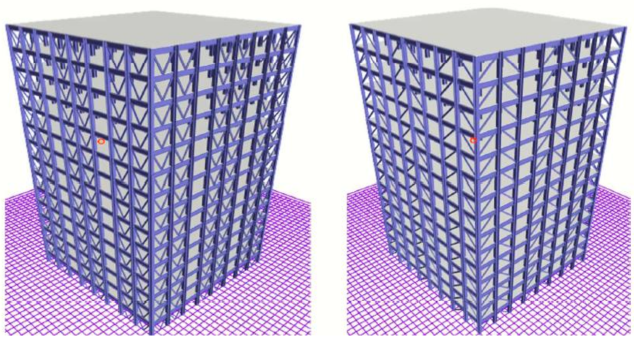

**Figure 3.** 15 Storey V bracing and K bracing Frames

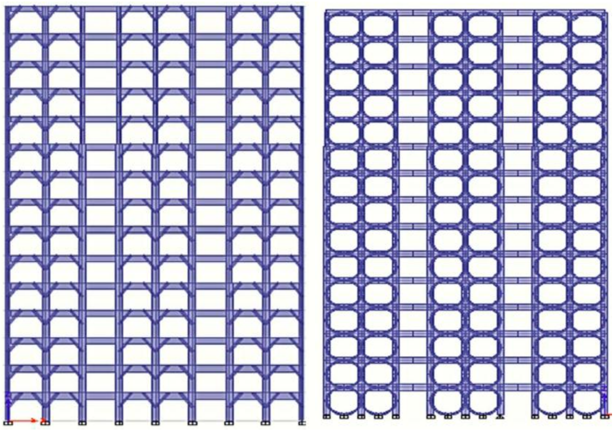

**Figure 4.** 15 Storey Knee bracing and O grid bracing Frames

## 4. RESULTS AND DISCUSSION

3D analysis is carried out by using Response Spectrum Analysis and Time History Analysis six models. Dynamic response of these buildings is carried out in terms of Base Shear, Fundamental Time Period and Top Floor Displacement of frame.

### 4.1 Response Spectrum Analysis of 15 storey Building

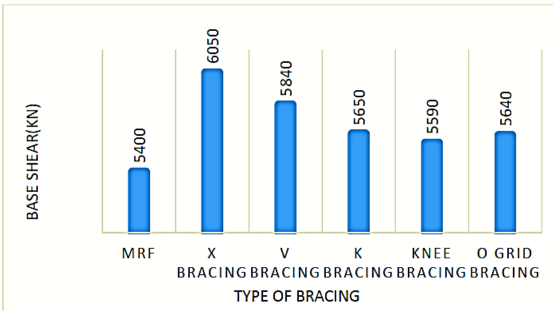


**Chart-1:** Variation of Base Shear

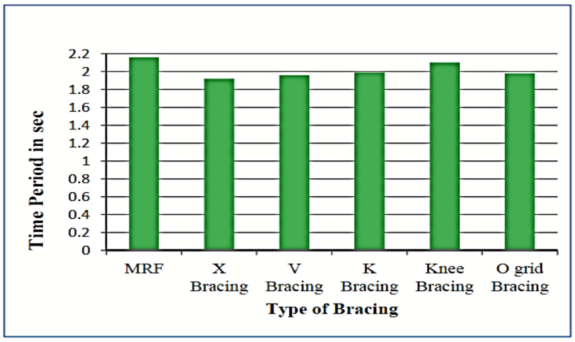


**Chart-2:** Variation of Fundamental Time Period

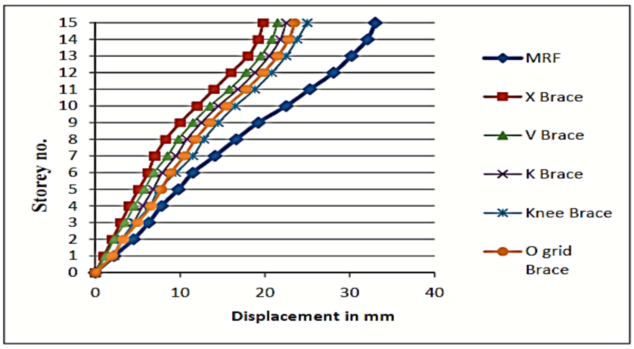


**Chart-3:** Variation of Top Floor Displacement

Base shear of building with bracing system increased as seismic weight of building is increased. Base shear of building as compared to without bracing model increases by 12.91%, 9.42%, 7.74%, 9.86% for X bracing, K bracing, O grid bracing and V bracing respectively. Top floor displacement of building is decreased by 31.97%, 24.51%, 20.35%, 28.91% for X bracing, K bracing, O grid bracing and V bracing as compare to without bracing model. Fundamental time period of building is decreased by 11.36%, 8.72%, 7.37%, 9.23% for X bracing, K bracing, O grid bracing and V bracing respectively.

### 4.2 Time History Analysis of 15 storey Building

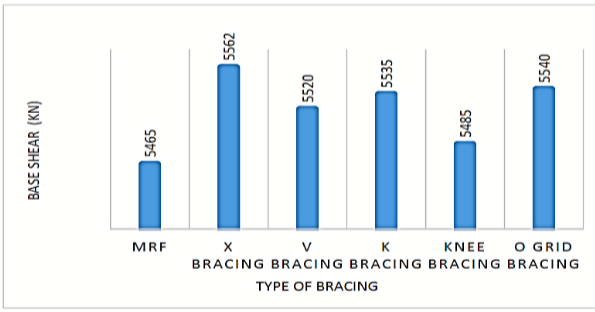


**Chart-4:** Variation of Base Shear by Elcentro Earthquake

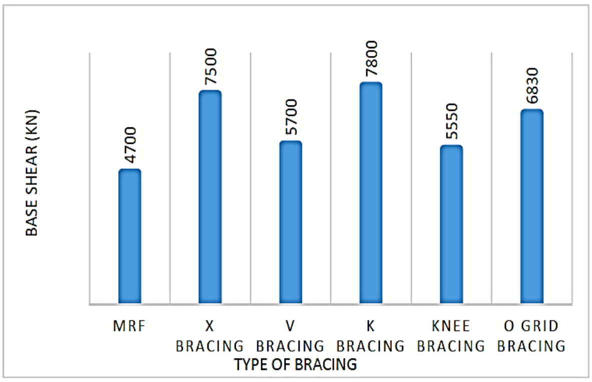


**Chart-5:** Variation of Base Shear by Koyna earthquake

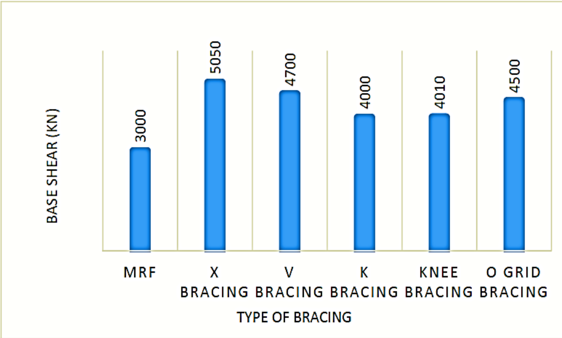


**Chart-6:** Variation of Base Shear by Bhuj earthquake

In this we can also observe that base shear of building as compared to without bracing model increases by 21.1%, 15.47%, 25.42%, 9.98% for V bracing, K bracing, X bracing and O grid bracing respectively.

## 5. CONCLUSIONS

Conclusions of present study are as follows,

1. The type of bracing, weight of frame, number of floors and site condition affect the base shear values.
2. Base shear of building with bracing system increased as seismic weight of building is increased.
3. It could be concluded that bracings are a good solution to decrease the roof displacements of frames.
4. X-bracing system has high elastic stiffness and low displacement and MRF has low elastic stiffness and high displacement.
5. Knee bracing system has showed high displacement.
6. For high rise steel structure X bracing system is more efficient as compared to V brace, K brace and O grid brace system.
7. The new O Grid bracing systems in comparison with MRF was led to more based shear absorption.
8. The results of this study showed that the new O Grid bracing systems have appropriate vibration period, appropriate elastic stiffness and appropriate displacement.

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