



SEISMIC EVALUATION OF HIGH RISE STEEL STRUCTURES WITH AND WITHOUT BRACING

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ABSTRACT

Major concern of steel frame structure is to have good lateral resistance High rise steel frame building is well establishing in metro cities. Study of brace frame response is widely studied in many branches of structural engineering. Many researchers studying these types of structures mainly to study their capacities for external loads. Engineers have turned to braced steel frame as economical means for earthquake resistant loads. In this paper dynamic analysis by response spectrum method is carried out with high rise steel building with different pattern of bracing system. Aim of study was to investigate and compare different results of seismic analysis of different types of bracing system and without bracing. For this purpose 25 stories steel building model is used with same configuration and different bracing system such as X brace, V brace , inverted V brace and K brace. A commercial package Etabs2013 is used for analysis purpose.

Keyword: Bracing , Dynamic analysis ,Etabs, Steel frame, lateral loads, Structural engineering

I INTRODUCTION

Steel structure must have adequate strength and stiffness so that interstory drift is controlled in order to prevent damage to structural and non structural elements. A steel frame can be strengthened in various types to resist lateral forces. Bracing is one of structural system used to resist lateral loads. These systems are moment resisting beam-column connections; braced frames with moment-resisting connections, braced frames with pin jointed connections and braced frames with both pin-jointed and moment-resisting connections. Most widely used lateral load resisting system is bracing. Diagonal structural element is inserted in structural system so that triangulation is formed. It is strong in compression. Bracing system is economical and Selection of appropriate lateral load resisting system has significant effect on performance of steel frame structure. Steel bracing is economical, easy to erect and occupies less space. [1]



Bracing systems are mainly categorized into two systems

i) Concentric Brace system

Concentrically brace frames CBF consisting of columns, beams, trusses joined with pin connection. Lateral load in this system is resisted by truss action and columns. CBF have high stiffness as braces are in compression and may buckle which is brittle failure.

ii) Eccentric Brace system

In this system lateral load are resisted by both frame and truss action. It is simply define as braced member is attached to isolated member

Because of lateral loading on building is reversible, bracing members are both subjected in turn to both tension and compression, consequently they are designed for more severe case of compression. Bracing element will have very important effect on structural behavior under earthquake effect. Suitability of bracing type varies from structure to structure depending upon geometry The diagonal brace-B shows highly effective and economical design of bracing style. [2]Bracings are good to reduce the displacement and in case of K and V-bracing, the displacement is higher than without bracing because of irregularity in shape of the structure. The braced buildings of the storey drift either increases or decreases, as compared to unbaced building with the same configuration for the different bracing system. [3]

The displacement of the building decreases depending upon the different bracing system employed and the bracing sizes [4].It is found from test that stiffens slit walls are capable of developing ductile hysteresis behavior. It is also observed from experiment that knee braced frames has more strength and stiffness. Knee braced frames has more earthquake resisting capacity than Moment resisting frames. [5]

In the Knee Braced frame system diagonal brace provide elastic stiffness where beams and columns are hinge-connected. Knee element prevents collapse of structure under extreme seismic excitation by dissipating energy through flexural yielding. And cost of repairing of structure is limited to changing element only.[6].For story displacement with all types of bracing X bracing is effective. Chevron and diagonal braced are less effective as compare to X bracing, displacement of building decreases with bracing structure as compare to unbrace system. Bending moment and story drift also decreases with braced model. [7] Concentrically braced frames are generally considered as less ductile seismic resistant structures than other system due to brace buckling or fracture when subjected to large cyclic displacement. This lead to simpler design of concentrically braces frame compared to other system such as moment frames.[8]

In this paper, response spectrum analysis is carried out for 5 different models. Different parameters such as base shear, displacement and modal time period is compared for these models. The main objectives of study are:

- 1) To study seismic performance of building with and without bracing



- 2) To study effectiveness of various bracing systems on seismic performance of steel frame building such as X brace, V brace, K brace, inverted V brace.
- 3) To suggest efficient bracing system for steel frame structure for better seismic performance.

II BUILDING DESCRIPTION

2.1 Structure and analytical model

For analysis work, 6 models of high rise steel frame structure are selected for analysis. The length of building is 30 m and width is 16 m. Width of bay in X direction 5 m and 4 m in Y direction. Height of 1st story is 3.5 m and height of remaining stories is 3 m. Total height of building is 75.5 m. Material concrete grade is M25 is used, while steel Fe 250 (mild steel) is used. Modal damping 5% is considered. Slab thickness is taken as 120 mm. For rebar grade of steel is Fe 415 is used. Loads as per IS 875:1984 and Load combinations as per IS 1893:2002 are given. Steel structure design is done as per IS 800:2007

2.2 Loads

1) Dead Loads

Self weight is calculated by the software based on section properties and material constants provided. In addition to this superimposed dead load due to floor finishes is applied on all floors.

2) Live Loads:

Live load is taken as 4 kN/m² as per IS 875 part II

III MODELING AND ANALYSIS

3.1 Modeling

The building is modeled using finite element software Etab 2013. Beams and columns are modeled as frame element and joined node to nodes. Slabs are modeled as rigid membrane elements and diaphragm constraint is assigned. Columns are considered rigid at base and soil structure interaction is ignored. Various types of bracing systems are modeled such as X brace, V brace, K brace, inverted V brace.

3.2 Method Of Analysis

As per IS 1893 (Part 1): 2002 dynamic analysis is carried out by Response spectrum method. Dynamic response of braced frames such as base shear, maximum story displacement, modal time period are presented and compared with bare frame.

For each such frame, design base shear (V_B) obtained from response spectrum analysis is compared with base shear (V_B) calculated using fundamental time period T_a given in clause 7.6 in IS 1893:2002 for corresponding building modeled and values of base shear obtained by response spectrum are corrected by modified scale factor with the help of correction factor $V = V_B/V_B$. Damping considered for all modes of vibration was five percent. For

determining the seismic response of the frame in different direction of ground motion response spectrum analysis is carried out in longitudinal and transverse direction (X and Y). Other parameters considered were, severe seismic zone (IV), zone factor 0.24, importance factor 1. Default number of modes (i.e. 12) in software is used and modal responses were combined using CQC method. The response spectrum for medium soil sites with 5% damping as per IS 1893 (Part 1):2002 is utilized for response spectrum analysis.

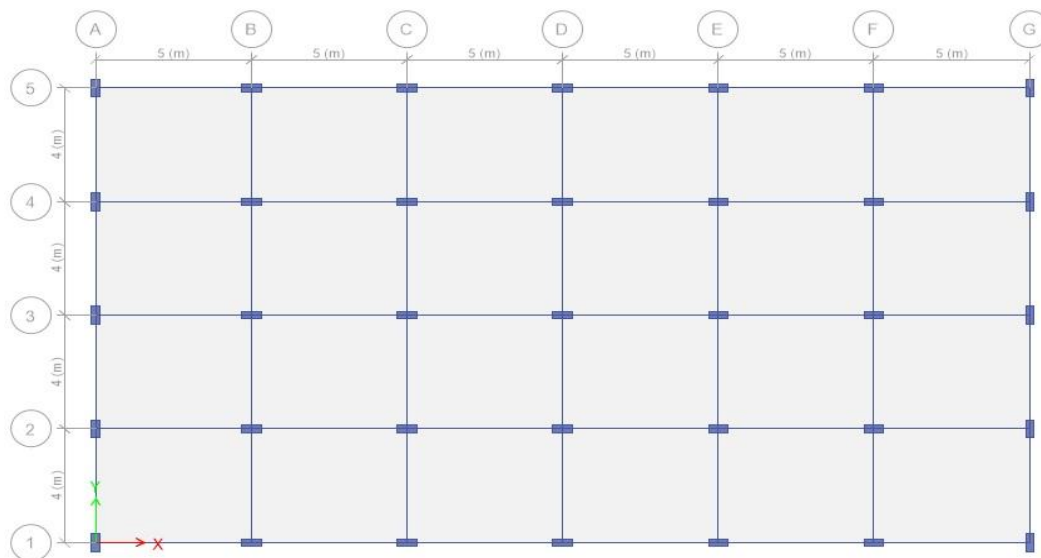


Fig 1: Plan of Building

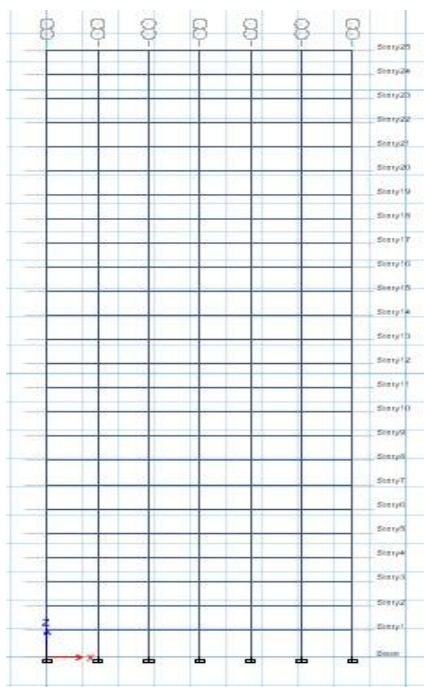


Fig 2 : Elevation of Steel frame Without Bracing

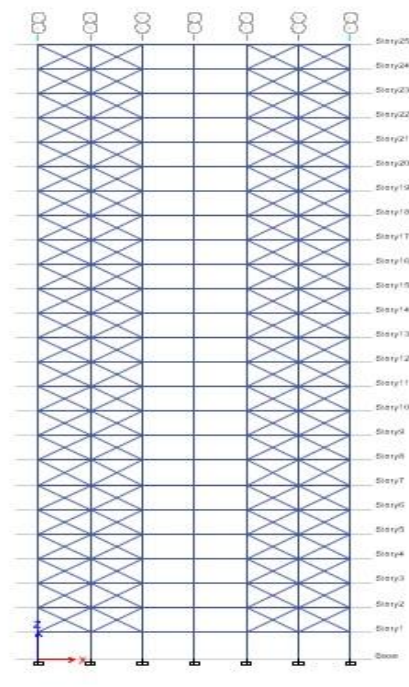


Fig 3 : Elevation of Steel frame With X Bracing

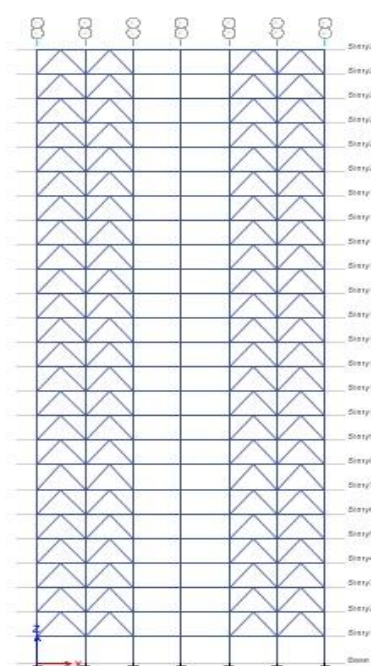


Fig 4: Elevation of Steel frame With Inverted V Bracing

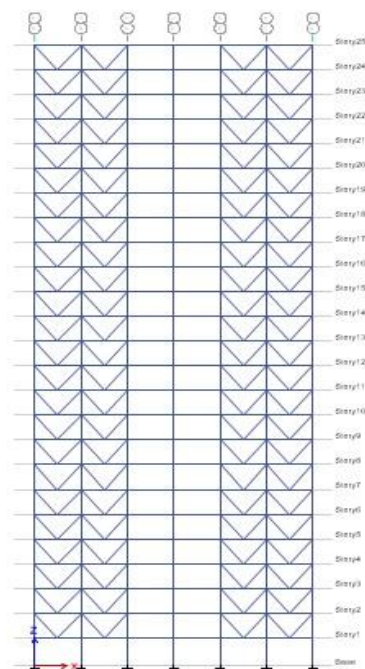


Fig 5 : Elevation of Steel frame With V Bracing

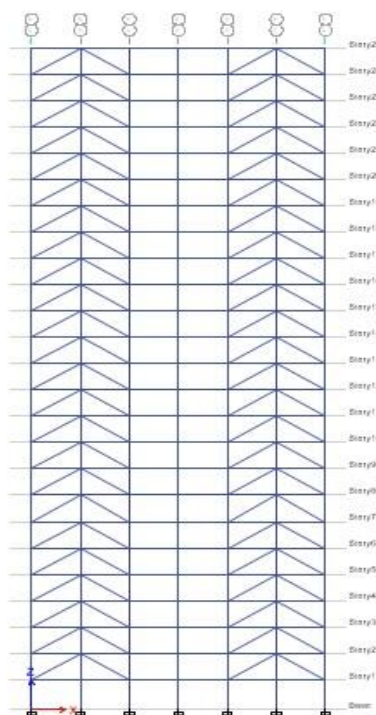


Fig 4: Elevation of Steel frame With K Bracing

III RESULTS AND DISCUSSION

Structural behavior of all these structures is studied with reference to displacement, base shear, and modal time period. From results obtained from this study it can be observed that use of bracing system can increase base shear due to increase in lateral stiffness. Base Shear Comparison between without brace model and X bracing, V bracing, K bracing and inverted V bracing is carried out. As building is asymmetrical base shear in X and Y axis base shear is different. In this model base shear in X direction is more than base shear in Y direction. For different bracing systems base shear varies in both directions depending upon geometry of bracing. For different bracing systems displacement varies for each bracing system depending upon geometry of bracing. Base shear in X direction is shown in figure 6. Similarly base shear in Y direction is shown in figure 7. It is observed that displacement is decreased with help of bracing system as compared to bare frames. Displacement in X direction is shown in figure 8. Similarly displacement in Y direction is shown in figure 9. It is noted that displacement decreased with use of bracing system as compared to bare frames. Modal time period of building varies with bracing system. Modal time period is shown in table 1. Modal time period decreased with use bracing system as compared to bare frame. This happens because stiffness of building increases with use of bracing system.

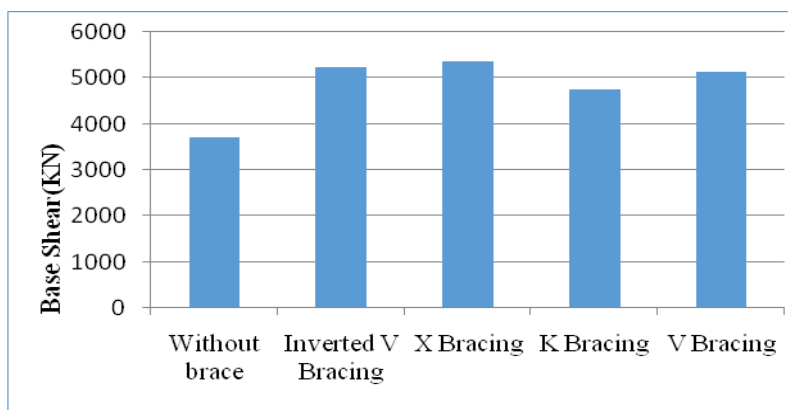


Fig 6: Base Shear in X direction

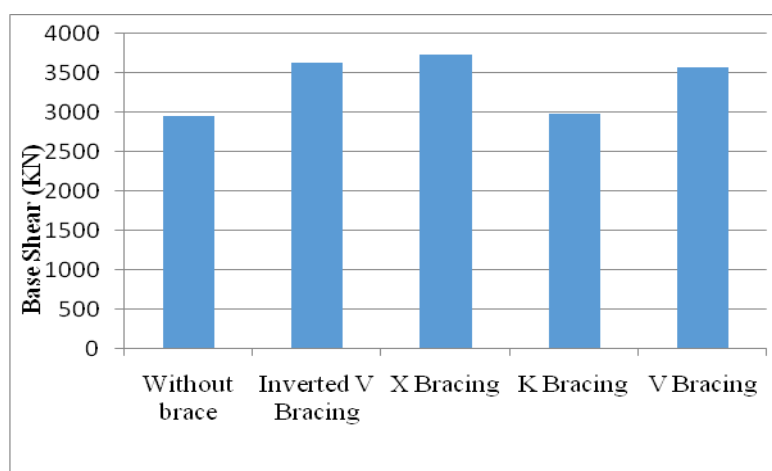


Fig 7: Base Shear in Y direction

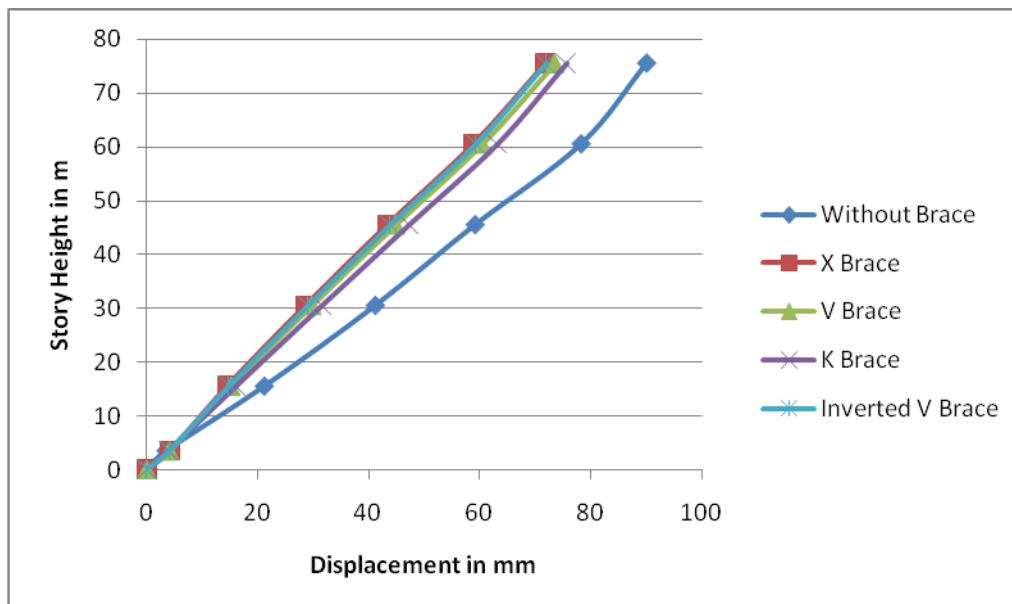


Fig 8 : Displacement in X direction

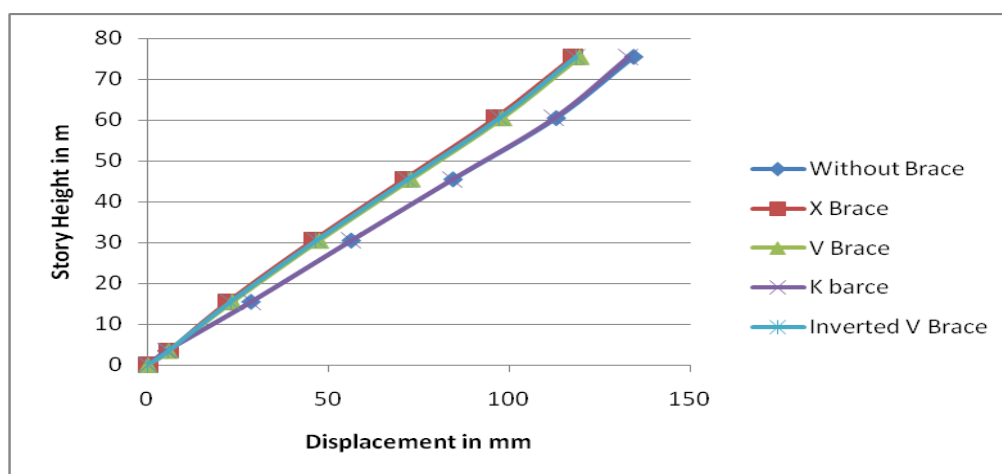


Fig 9 : Displacement in Y direction

Table 1: Modal Time Period comparison

Types of Bracing	Without Brace	With Brace	% Difference
X Brace	3.979	3.401	14.52
V Brace	3.979	3.95	0.72
K Brace	3.979	3.478	12.59
Inverted v brace	3.979	3.473	12.71



IV CONCLUSION

The result of present study shows that bracing element will have very important effect on structural behavior of structure. From figure it is seen that due to bracing in both direction base shear of structure increases up to 30.63%.Modal time period reduced up to 14.52 %.The displacement of roof level of building decreases up to 20.2 % due to bracing system. It is suggested that X bracing is highly effective bracing system.

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