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Stability Analysis of Rigid Steel Frames With and Without Bracing Systems under the Effect of Seismic and Wind Loads

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Abstract: **As compared to reinforced concrete structures, steel has got some important properties like high strength and ductility. We know that steel is ductile so it gives warning before failures. All these properties of steel will play very important role in case of seismic and wind resistant design, there are many types of frame such as rigid frame, semi rigid frames and simple frames among these we have taken rigid frames for this case study. The rigid frames are the frames in which the angle between the members doesn't changes even after the loading and the beam-column connections are moment resisting connections which means do not allow any relative rotations at the joints of the members. Bracing is required to provide lateral stability of the frame. In this project five models are created in which one is without bracing structure and four models with different bracing structures and an attempt is made to analyze the response buildings with and without bracings systems subjected to seismic load and wind load using ETABS and to identify the suitability of the bracing systems to resist the lateral loads efficiently, here the steel considerations like sectional properties, loads and load combinations as per IS 800:2002. The main parameters consider in the present study is to compare the seismic and wind performance of buildings are base shear, roof displacement. The models are analyze by equivalent static analysis as per IS 1893:2002. Effect of Wind Loads on the Structural Systems are analyzed and compared as per IS 875 (part 3). Based on the results and discussions we can conclude that for highly affected earthquake zone-IV and for different wind speed 50m/s, therefore the structure having X- type Bracings are highly effective type of bracing style.**

Keywords**: Rigid frames, Bracings, seismic and Base shear**

I. INTRODUCTION

As we know in western countries steel structures are widely using because of its high strength, ductility property reduces the construction and erection time. The steel is having less weight as compared to reinforced concrete structures so which reduces load on footings. The size of frame members are less as compared to RC structures which gives more space inside the building. In steel structures we know much type of frames such as rigid and simple frames. In rigid frames, beams and columns are joined together with moment resisting connections. Here the bracings are provided to resist lateral stability of the frame. The rigid frames are the frames in which the angle between the members doesn't changes even after the loading and the beam-column connections are moment resisting connections which means do not allow any relative rotations at the joints of the members. The most fearsome and critical experienced fact nature is Earthquake and its frightful results. Simply we can say an earthquake is unexpected movement earth. When a structure subjected to natural wind from a few minutes to hour then a wind speed would produce a static force on a structure.

1.1 Concentrically Braced Frames

Concentrically Braced Frames (CBFs) are a class of structures resisting lateral loads through a vertical concentric truss system, the axes of the members aligning concentrically at the joints as shown in figure 1. CBFs tend to be efficient in resisting lateral forces because they can provide high strength and stiffness. These characteristics can also result in less favourable seismic response, such as low drift capacity and higher accelerations. CBFs are a common structural steel or composite system in areas of any seismicity. Steel Concentrically Braced Frames (CBFs) have been used for years in steel construction and therefore have been studied extensively for seismic performance. These guidelines, however are generally too conservative and actually produce CBFs that are ineffective in seismic events. CBFs are strong, stiff and ductile, making them ideal for seismic framing systems. The inelastic behavior of the brace provides most of the ductility, but in order to fully utilize the frame, the connections and framing members must also be taken into account. Therefore, it is important to consider not only the performance of the brace when designing, but also the ability for the connections and the framing members to withstand the strength and deformation Steel concentric braced frames (CBFs) are one of the lateral load resisting systems, especially for structures constructed in high seismic regions. The work lines of CBFs essentially intersect in some points. In CBFs, steel braces improve the lateral strength and stiffness of the structural system and participate in seismic energy dissipation by yielding in tension and buckling in elastically in compression. Consequently, the cyclic axial response of the bracing members, which are expected to undergo tension deformations beyond yield and compression deformations into the post-buckling range, represent the most crucial aspect of the seismic response of a Braced frame system.

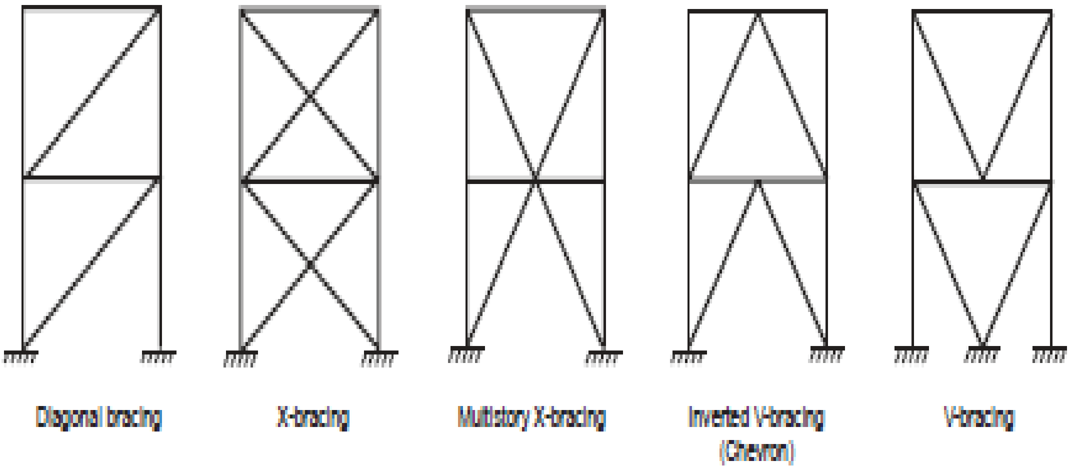


Figure-1: Types of concentrically braced frames

II. MAIN OBJECTIVES

Basically for this study five models are created which includes rigid frame and rigid frame with concentric bracing systems, with constant bay width of 6m, the structure is G+40 stories high rise structure for different configurations of bracing systems. All these models are analyzed using ETABS software and results are extracted and to determine the stability of the frame and a comparative study among the frames for earthquake zone III at basic wind speed 44m/s will be done. The main parameters consider in the present study is to compare the seismic performance of buildings are base shear an for wind speed the parameter considered is roof displacement. The models are analyze by equivalent static analysis as per IS 1893:2002**.** To identify the suitability of the bracing systems to resist the seismic and wind loads efficiently and also to compare the response of braced and un-braced building, which subjected to horizontal or lateral loading system.

III. STRUCTURAL MODELING

The structural modelling and analysis is done using ETABS software package by employing to resist seismic and wind loads. Investigation is carried out to assess the performance of the idealized (G+40) storied typical rigid steel frame structure with and without bracing system containing five different model of similar plan are subjected to seismic load according to zone-III at wind speed 44m/s a typical plan is shown in figure 2. Located on a hard soil strata are chosen for the study. It essentially consists of deck slab (150 mm thick) of size 6 m X 6 m resting on steel beams. This slab and beam structural system is supported on Steel columns. Bracings are provided at the peripheral edges of the building. The five models of with and without bracing systems shown in figure 3.

TABLE -1: size of columns, beams and bracings

Storey level	Column schedule	Beam schedule	Bracing schedule
G+40	CI 1200	ISMB 550	BR 230X230X40
11 to 20	CI 1000	ISMB 550	BR 230X230X40
21 to 30	CI 900	ISMB 550	BR 230X230X40
31 to 40	CI 800	ISMB 550	BR 230X230X40

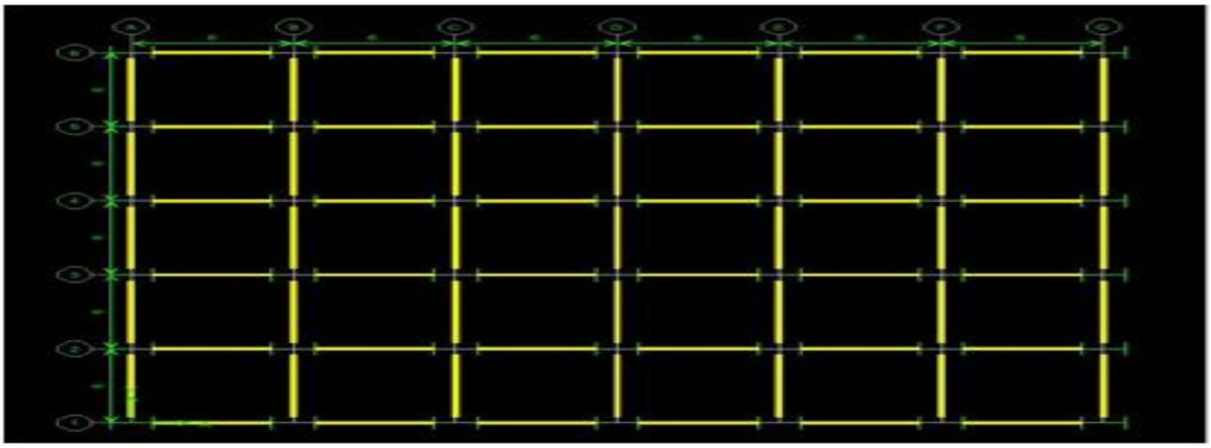


Figure-2: Typical plan of structure

TABLE -2: Sectional properties of steel members.

All dimensions in mm	Height	Flange width	Flange thickness	Web thickness
ISMB 550	550	190	19.3	11.2
CI 1200	1200	850	40	40
CI 1000	1000	600	35	35
CI 900	900	500	35	35
CI 800	800	450	30	30
Bracings	Outside horizontal leg	Outside vertical leg	Horizontal and vertical leg thickness	
BR 230X230X40	230	230	40	

3.1 Assumptions made in the analysis

The following are the assumptions made during analysis of the structure:

- The building floors are assumed to be infinitely rigid in their own planes.
- The bottom supports at base level are assigned as fixed.
- The entire mass of the structure is assumed to be uniformly distributed at the floor levels.
- The storey height and floor mass are assumed to be uniform across the height of the building.
- The lateral force resisting planes in the models being studied are selected to be regular and simple.
- The source of the mass of a structure is defined from Loads, which specifies a load combination that defines the mass of the structure. The mass is equal to the weight defined by the load combination divided by the gravitational multiplier, g. This mass is applied to each joint in the structure on a tributary area basis in all three translational directions.

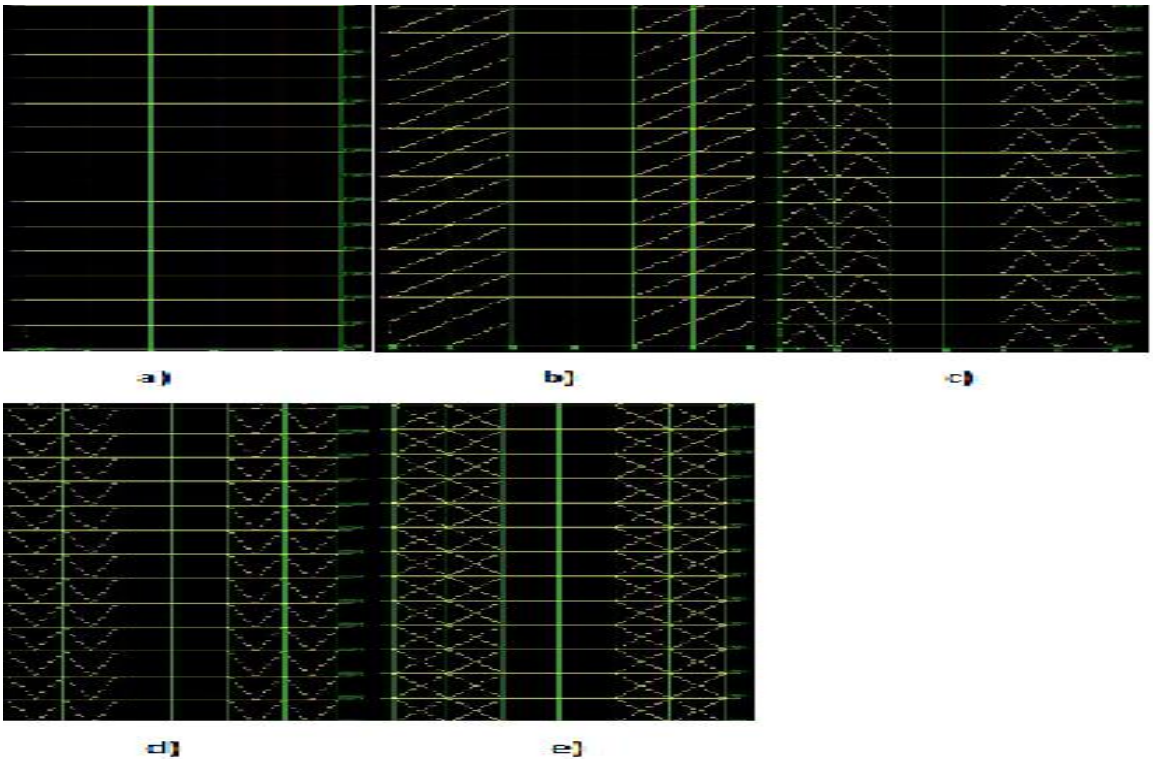
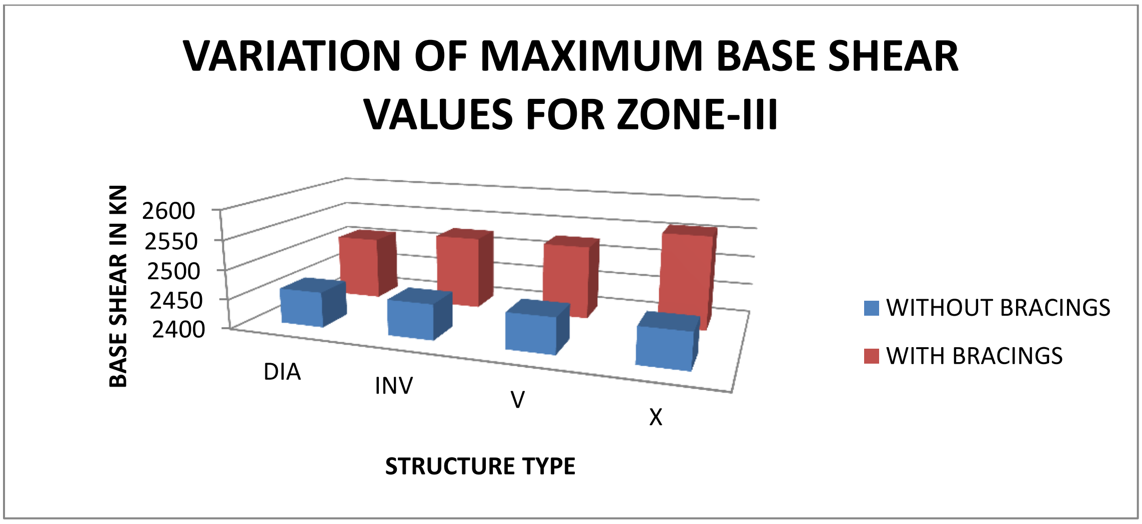


Figure-3: steel framed model of building a) Without bracing b) Diagonal Bracing c) Inverted-V Bracing d) V-Bracing e) X-Bracing

IV. ANALYSIS OF RESULTS AND DISCUSSION

4.1 Seismic Base Shear

Seismic forces accumulate downward in a building. Seismic forces are always more at the base of the building. Simply we can say the seismic force at base of the building is called the base shear. In a multi-storey building all vibration modes of the building contribute to the base shear. Graph-1 shows the variation of base shear. Base shear is an approximation of the highest probable lateral force that will occur due to seismic ground motion at the base of a structure.

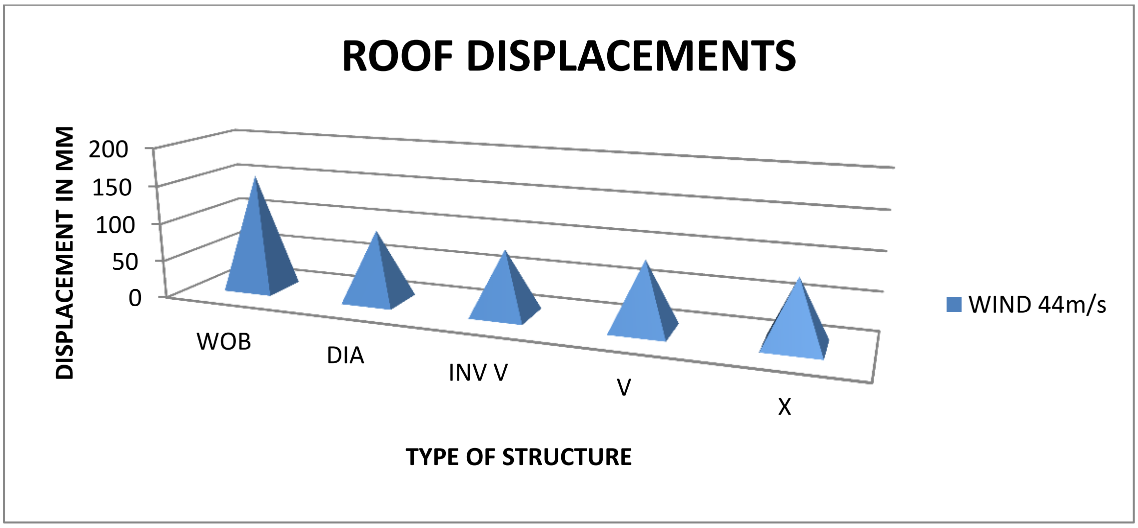


Graph -1: Variation of Maximum Base Shear Values for Zone-III

From chart 1 it is clear that, when the structure subjected to seismic force at zone III, the maximum base shear value variation between without bracing and bracing system for zone-III is 49KN to 98KN.

4.2 Roof Displacements

Wind-induced motions, even when they are more violent than those induced by earthquake Displacements, the extent to which a structural element moves or bends under pressure is the main serviceability concern in the structures. Lateral displacements that occur during lateral loads should be limited to prevent distress in structural members and architectural components. The value of maximum displacement is a direct and efficient measure used to quantify the overall displacement response of a building. Graph-2 shows the variation of roof displacement values for with and without bracings systems.



Graph -2: Story V/S Displacement for Wind Speed 44 m/s

The displacement varies from about 84mm to 94mm.Roof displacement has been reduced by 40% to 45% in case of braced system as compared to without bracing system.

V. CONCLUSIONS

A brief introduction on earthquakes and the philosophy of structural design are explained. In addition to the above, wind loads on steel structures is carried out by the basic structural typologies, Analysis of earthquake response of non-linear time history analysis is carried out. The result of the present study shows that bracing element will have very important effect on structural behaviour under lateral loads. From results and discussions it shows that due to bracings at peripheral of structure, the base shear increases up to 40% for zone-III. The roof displacement values decreases up to 45%. Based on the results and discussions we can conclude that for highly affected earthquake zones and for different wind speeds the X-type Bracings are highly effective design of bracing style. From the conclusion it is clear that steel structure is highly effective against lateral loads particularly with braced structures and the main disadvantage is corrosion and maintenance of steel structure.

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