ANALYSIS OF RC FRAMED STRUCTURE WITH STRUCTURAL STEEL BRACES USING ETABS

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Abstract - *Earthquake is the one of the major disaster known to mankind since many years, there has been a considerable contribution from earthquake engineers for the safety of the structure. One of the alternatives to reduce the damage caused due to the earthquake is adopting structural steel bracings in the structure. These members can be utilized in the building as a horizontal load resisting system to improve the stiffness of the frame for seismic forces. The present study is based on analysis of RC framed structure with structural steel braces using ETABS software. This study is conducted to know the behaviour of the different bracing system for different arrangements. G+10 building situated in zone IV is selected and analyzed with different braces. The effectiveness of braces is studied using 16 models out of which one is the bare frame model. The performance of the building is studied in terms of lateral displacement, base shear and time period. The results of the analysis are compared and it was found that the seismic behavior of braced framed building is improved as compared to unbraced framed building. It was also found that the various arrangements of bracing systems have great influence on seismic performance of the building.*

Key Words: *RC frame, Steel Braces, ETABS 2015.*

1. INTRODUCTION

In the beginning, people needed shelter to protect themselves from sun, rain and wind. They used to construct single dwelling houses with one or two storey's using mud blocks, timbers, stones etc... Gradually, the desire for better shelter increased which lead to the new invention and development in the field of civil engineering and nowadays cutting edge trend is towards more tall and slender buildings. In this way, the impacts of lateral loads on tall buildings are gaining importance consequentiality and every structural engineer is challenged with the quandaries of providing satisfactory strength and stability. Thus it is important to give satisfactory solidness and soundness in the structure with a specific end goal to discover imperviousness to horizontal loads instigated by the wind or seismic powers in tall structures. One simple solution is adopting steel braces in the RC frames. The blend of reinforced concrete frame with steel bracing enhances the behavior and performance of the structure and results in improvement of stiffness and strength of the structure.

Pravin S Kamble et al [1] carried out a study on G+4 steel moment resisting bare framed structure with & without braces. The analysis was done using SAP 2000. From this study, it was concluded that X-bracing significantly contributes to the structural stiffness and decreases the maximum interstate drift of the building compared to other types of bracing system. Shachindra Kumar Chadhar and Dr. Abhay Sharma [2] studied G+15 storey RC building with V and inverted V type bracing system. It was observed that configuration of the bracing system has a considerable effect on the seismic behavior of structure and double angle sections give better results than ISMB and ISMC section. A. Massumi and M. Absalan [6] studied the interaction between unbraced framed and braced frame using ANSYS software. It was found that frame with bracings has increased strength, stiffness, and energy absorption capacity and has an impact on upgrading the behavior of the dual system. A. Kadid and D. Yahiaoui [7] conducted Static nonlinear pushover analysis to know the capacity and behavior of braces and it was found that use of braces as lateral load resisting has improved strength and use of ZX and Zipper bracing systems has improved dynamic characteristics, ductility capacity and most effective in resisting seismic loads. Cengizhan Durucan and Murat Dicleli [8] focused on seismic retrofitting to improve the performance of building prone to earthquake. The analysis was conducted on the buildings retrofitted with the shear infill shear panel as well as on the building retrofitted with braces; it was found that building with braces has enhanced energy dissipating capacity and experienced less damage than the building with shear infill shear panels. M. A. Youssef, et.al [9] conducted an experiment using two specimens that represent RC moment frame with moderate ductility and a braced RC frame. Two cyclic load tests were conducted on the specimens. The result of the analysis showed that the ability of the building to resist earthquake forces was adequate using braces compared to the building without a bracing system.

2. EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

At the time of an earthquake, structure experiences lots of vibration due to the energy released in earth's crust. The beams and columns which are simply connected with no resistance become unstable for lateral loads. This affects the structure, which is not desirable. Therefore we have to design the structure to resist lateral loads by providing appropriate lateral load resisting system. There are many alternatives available for lateral load resisting system depending on the structure, type of lateral load, seismic zone etc., Following are some of the lateral load resisting systems that are commonly used in practice

- Moment Resisting Frames.
- Braced frames.
- Shear walls.
- Dual structural system.
- Coupled shear wall.
- Outrigger structures.
- Diagrid.

3. BRACED FRAMES

Bracing is an effective and economical method of resisting horizontal forces in a framed structure. Braced frame systems are utilized both in RC as well as in steel buildings. Normally, the structure comprises of column and beams whose basic purpose is to transfer gravity load. When bracings are fixed to it, the total set of members forms a vertical cantilever truss like structure to resist the horizontal forces.

Bracing members are utilized in the building as a horizontal load resisting system to improve the stiffness of the frame for seismic forces. Braces can be connected with fixed-ended or pin ended connection. In the case of pin ended connection, it will be subjected to axial forces and it normally fails under compressive load by global buckling. Once the buckling occurs, its strength gets reduced in the succeeding cycles. But there will not be many changes in maximum tensile strength in subsequent cycles. The main advantage of using braces is that they dissipate the energy without damaging the building and also it can be replaced without any difficulty when it gets damaged.

4. TYPES OF BRACING

- **Horizontal bracing:** Bracing in every floor level gives a load path to transfer the horizontal forces to the planes of vertical bracing. The floor systems that are provided may themselves act as braces to provide resistance.
- **Vertical bracing:** Bracing in vertical planes (between lines of the column) provides load paths for transferring horizontal forces to ground level and provide a stiff resistance against overall sway.

This thesis work mainly deals with vertical bracing systems and therefore emphasis is given more to the vertical bracing system.

5. METHODOLOGY

In the present study, G+10 storey buildings are analyzed with and without braces. The plan consists of 5 bays of 5m center to center each in both X & Y directions and height of each storey being 3m. The plan of the building remains same for all the floors. The study is carried out for different types of bracing systems with different configurations using Response Spectrum method of analysis in ETABS 2015.

Different types of models considered for analysis

1. Building without bracings
2. Building with X-Bracing
3. Building with V-Bracing
4. Building with Inverted V-Bracing
5. Building with Diagonal Bracing
6. Building with K-Bracing

Table -1: Description of the model

Plan dimension	25m x 25m
No of grids	5 along both X & Y direction
Width of each bay	5.0 m
Height of each storey	3.0 m
Material Properties	Concrete ● Columns: M-30 ● Beams: M-25 ● Slabs: M-25 Steel ● Main bars: Fe-500 ● Confinement bars: Fe-415
Section Properties	Column section ● 0.50m x 0.50m Beam section ● 0.23m x 0.550m Slab thickness ● 150 mm Braces section (I section) ● ISMB 600
Loads	● Live load: 3kN/m^2 ● Floor finishes: 1.5kN/m^2

Table -2: Load combinations

Load Combination	Limit State of Collapse		
	DL	LL	EQ
TDL + TLL	1.5	1.5	-
TDL + WL	1.5 or 0.9*	-	1.5
TDL + TLL + WL	1.2	1.2	1.2
TDL + EQ	1.5 or 0.9*	-	1.5
TDL + TLL + EQ	1.2	1.2	1.2

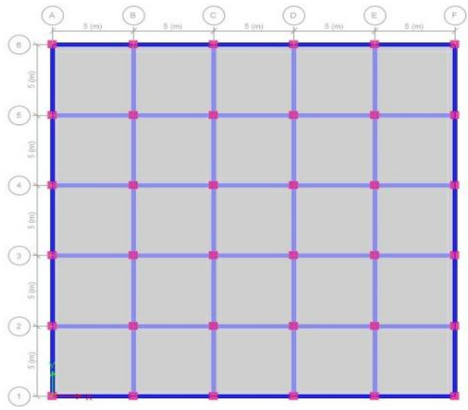

Fig. 1: Plan of the building.

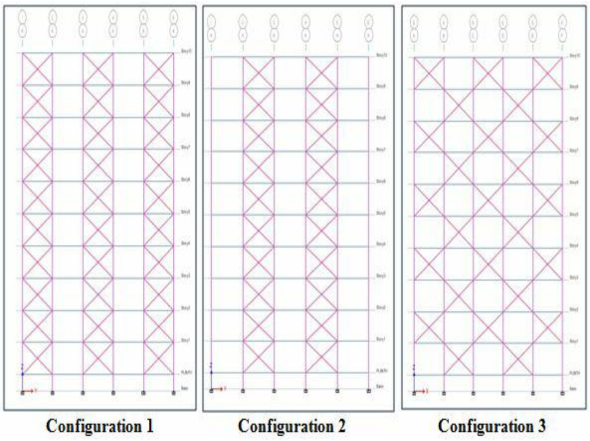

Fig. 2: G+10 RC framed building with X-bracings for different configurations.

6. RESULTS AND DISCUSSION

The displacement of the structure is reduced after application of braces compared to the bare frame. The maximum reduction in storey displacement is observed in X-braced frame i.e. 85.40% for Configuration 3 and minimum reduction is for K-braces i.e. 47.28 for Configuration 2.

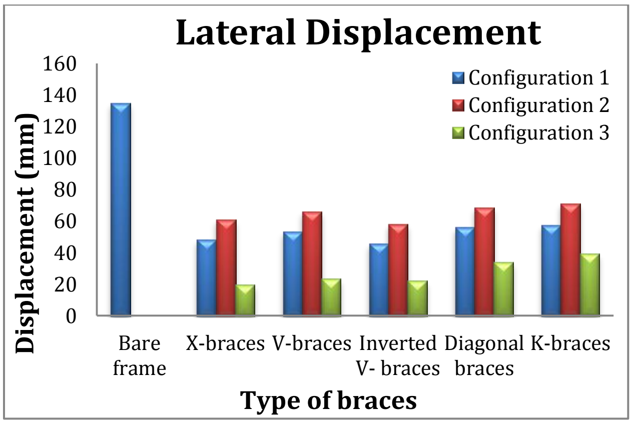

Fig. 3: Lateral displacements (mm) for G+10 storey building

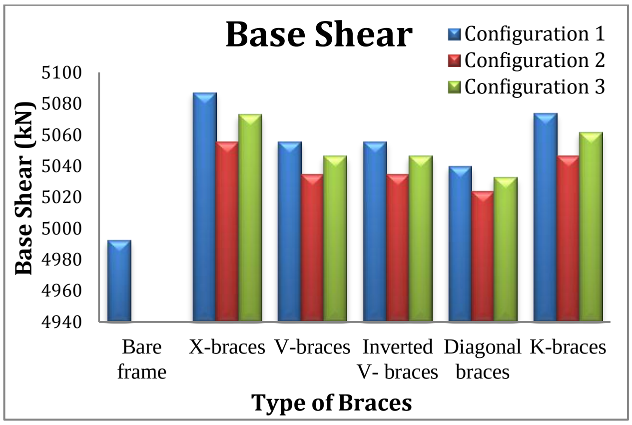

Fig. 4: Base shear (kN) of bracing system for different configuration

The Base shear for the bare frame is 4992.441kN in X and Y- direction respectively. It is found that base shear increases after application of bracings. The increase in base shear is more for X-braces compared to other bracing systems, as base shear mainly depends on the weight of the structure.

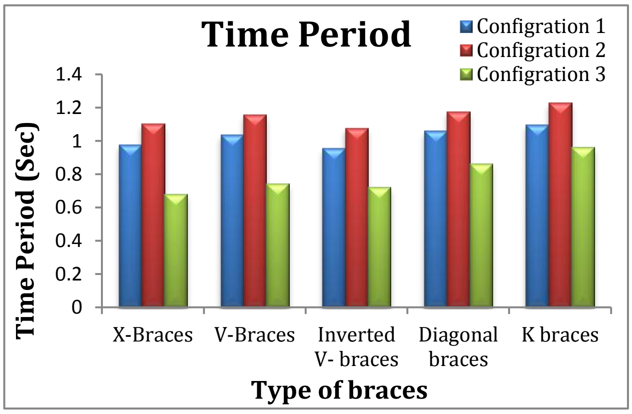

Fig. 5: Time Period (Sec) values for different bracing system

The time period for a bare frame is 1.745sec. The maximum reduction is 60.92% in X braces for configuration 3. After incorporation of braces, there is a reduction of the time period of the structure. This reduction is due to the fact that there is an increase in stiffness of the structure after application of braces. Therefore, braces influence the overall performance the structure.

7. CONCLUSION

- After introducing bracing to bare frame lateral displacement is found to reduce.
- Maximum reduction in lateral displacement is observed in inverted V braced frame and X braced frames.

- Inverted V-braces and X-braces shows better resistance to storey displacement. Hence, it can be recommended.

- Increase in base shear is observed after application of bracing. The minimum increase in the base shear is observed in the frame with X-bracing for all the configurations.

- The time period of the structure decreases with incorporation of braces as the stiffness of the building will be increased.

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