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Dynamic Analysis of an Irregular RC Building with Different Bracing Systems

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Abstract: ***The most suitable choices in improvement of reinforcement concrete structures against lateral loading is to provide steel bracing system. The use of steel bracing has potential advantage over other scheme like higher strength and stiffness, economical, occupies less space, adds much less weight to existing structure. In this study, the analysis of a reinforced concrete (RC) irregular building (H-Shaped) with different types of bracing (Diagonal, V type, inverted V type, X type, K type) is carried outby using ETABS software. For this purpose response spectrum method is taken into consideration and results are obtained in ETABS. The buildings are located in zone III region. The main parameters considered in this paper are lateral displacement, storey drift, axial force, base shear, joint displacement.***

Keywords: Steel Bracing System, Joint Displacement, StoreyDrift, StoreyShear, Response Spectrum

1. Introduction

Most of the multistoried buildings using today are made up of reinforced concrete framed buildings. A reinforced concrete building should be designed to have a capacity to carry combined loads (dead, live and seismic loads) at certain safety level and at certain degree of reliability. Proper account of loads, material properties, structural system, and method of analysis are fundamental factors in the design of structure. Proper account of loads, material properties, structural system, and method of analysis are fundamental factors in the design of structure. When this design is finally executed in the construction process, the expected performance of the structural building should come into satisfaction. However, this ideal condition is not always realized. There are several techniques to improve the strength and lateral stability of buildings. Use of steel bracing systems is one of such method which is highly efficient and economical.

A viable solution for enhancing earthquake resistance is to use steel bracing systems for strengthening and retrofitting seismically inadequate reinforced concrete frames. The earthquake can manifest great damages due to unpredicted seismic motion. This can cause irrepairable damages to buildings. So strengthening against such seismic motion is the better option by considering economy.By the addition of bracing systems, load will be transferred out of the frame and passes on to the braces, by passing weak columns while increasing strength. The potential advantages of using steel bracing are their high strength, stiffness, economical, occupies less space and adds much less weight to the existing structure. By expanding its stiffness and stability steel bracings can enhance the resistance of structure against lateral forces. There are different types of bracings used for this purpose. They are X bracing, V bracing, Inverted V bracing, diagonal bracing and K bracing. This project is to find out which bracing is more effective in resisting lateral deformation by considering an 11 storied irregular (H-shaped) RC building. Bracing members are simple to set up and takes less space. These members can be provided in different arrangements to improve the lateral stiffness. And response spectrum analysis is carrying out. It is a linear-dynamic statistical analysis method to indicate the likely maximum seismic response of an elastic structure.

2. Objectives

1) To conduct dynamic analysis of an H- shaped reinforced concrete building located in seismic zone IV, which is modelled in ETABS.
2) To find out the bracings which are most effective to resist lateral deformation by performing Response spectrum analysis
3) To determine time period, natural frequency and mode shapes for different bracing systems

3. Methodology

The response spectrum method is employed.

3.1 Modelling of Building

Here the study is carried out for the behaviour of G+11 storied R.C frame building with H shaped plan. Floor height provided as 3.4m. And also properties are defined for the frame structure.5 models are created in ETABS software with 5 different types of bracings. They are X type, V type, inverted V type, diagonal bracing and K bracing.The general software ETABS has been used for the modelling. It is more user friendly and versatile program that offers a wide scope of features like static and dynamic analysis, non- linear dynamic analysis and non-linear static pushover analysis, etc.

3.1.1 Building Plan And Dimension Details

The Following are the specification of buildings located in seismic zone III. The complete detail of the structure including modelling concepts is given below: To model any

structure in ETABS the first step is to specify the nodal co-ordinate data followed by selection of elements from element library. For the present work beam elements are selected to model the structure. The element selected for modeling is then assigned theproperties if the element is beam the cross section of beam is assigned. For plate elements thickness is assigned. After assigning the sectional property to the member it is important to assign it with member properties.

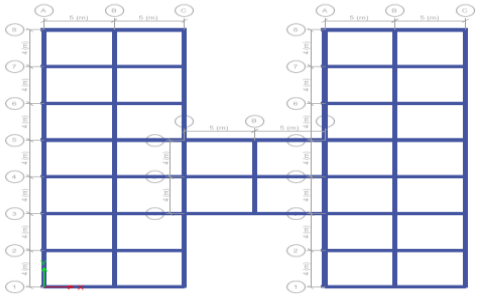

Figure 4.1: Plan of H Shaped Building

Table 4.1: Details and Dimension of the Building Models

Earthquake zone	III
Damping ratio	5%
Importance factor	1
Type of soil	Medium soil
Type of structure	All general RC frame
Response reduction factor	5(SMRF)
Poisson's ratio	0.15
Density of RCC	25kN/m3
Thickness of slab	160mm
Depth of beam	380mm
Width of beam	300mm
Dimension of column	300mm X 450mm
Height of each floor	3.4m
Bracing used	ISA 110 x 110 x 10

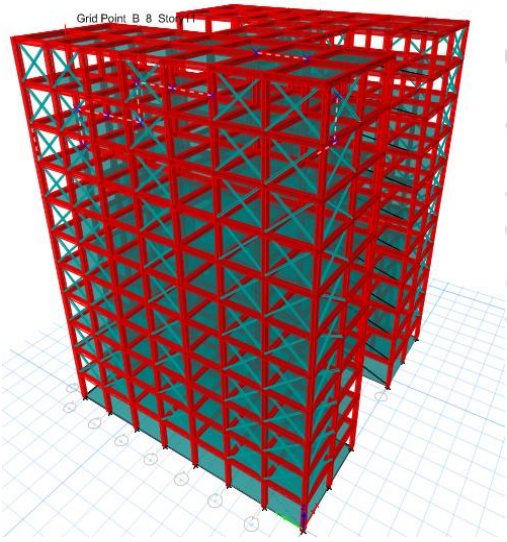

Figure 4.3: X Braced Building Model

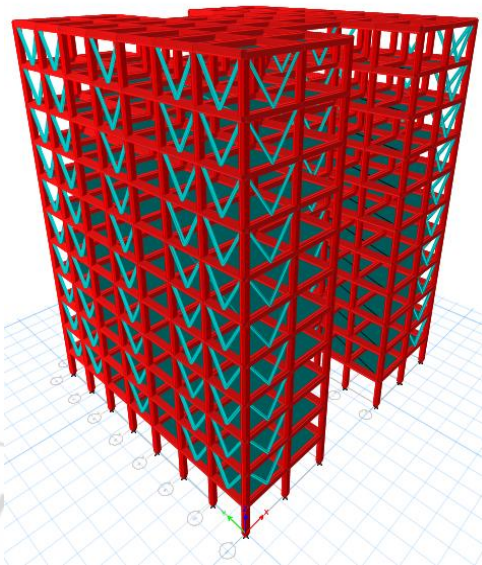

Figure 4.4: V Braced Building Model

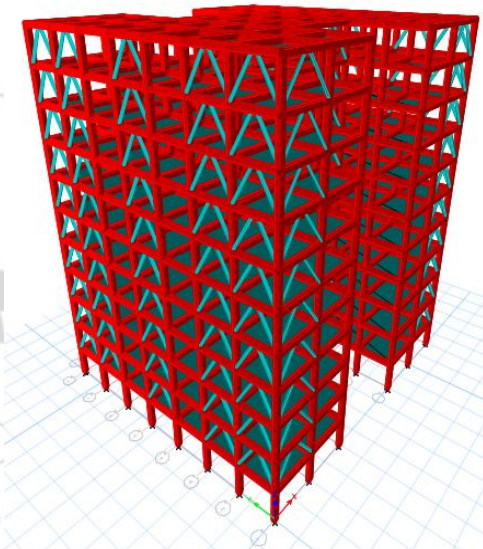

Figure 4.5: Inverted V Braced Building Model

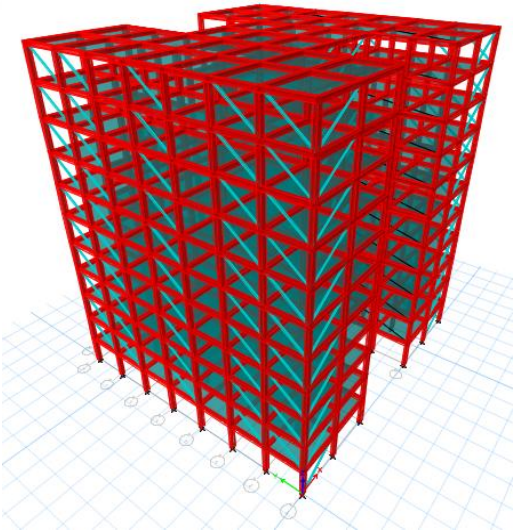

Figure 4.6: Diagonal Braced Building Model

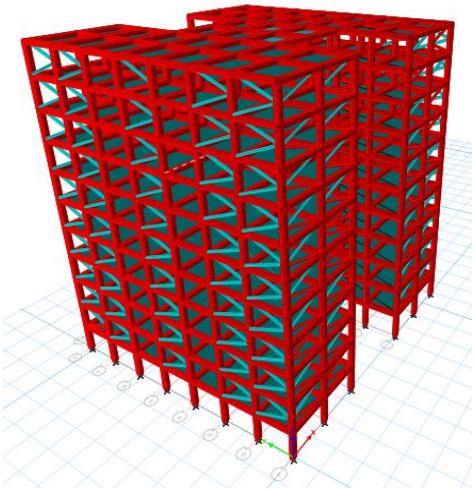

Figure 4.7: K Braced Building Model

3.2 Load Formulation

In the present project workfollowing loads are considered for analysis. Dead Loads (IS- 875 PART 1) and Live Loads (IS 875 PART 2). In addition to the above mentioned loads, dynamic loads in form of Response Spectrum method are also be assigned.

- **Live Load**

Floor load:

Live Load Intensity specified (Commercial building) = 4kN/m^2

Live Load at roof level =1.5 kN/m

3.3 Analysis

The three dimensional reinforced concrete structures were analyzed by Response Spectrum Analysis using ETABS software. It is a linear dynamic statistical analysis method to indicate the likely maximum seismic response of an elastic structure. A plot of the peak acceleration for the mixed vertical oscillators. A response spectrum is simply a plot of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency that are forced into motion by the same base vibration or shock.The analysis results will show the performance levels, behaviour of the structures.

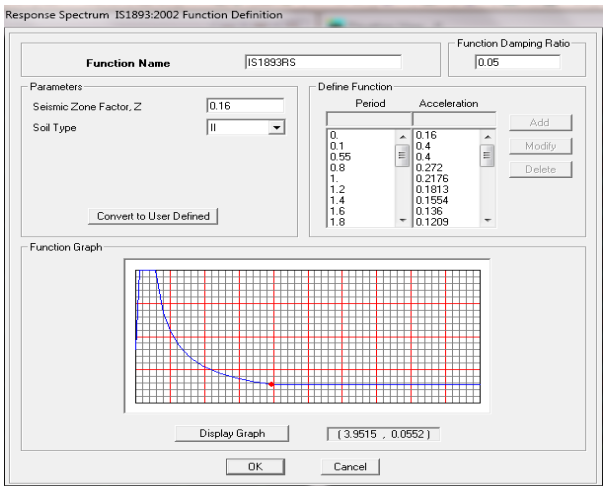

Figure 5.1: Response Spectrum Curve

4. Comparison of Results

From the output of ETABS, various results are obtained. And these results are evaluated by preparing various graphs. It is to compare and find which bracing is more effective against lateral loads.

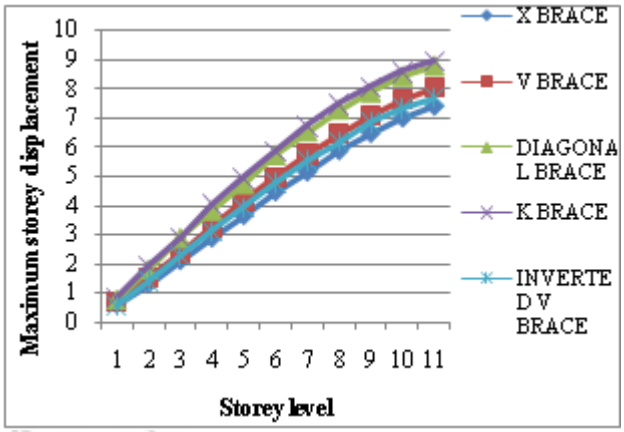

Figure 4.1: Maximum lateral displacement (mm) in X direction

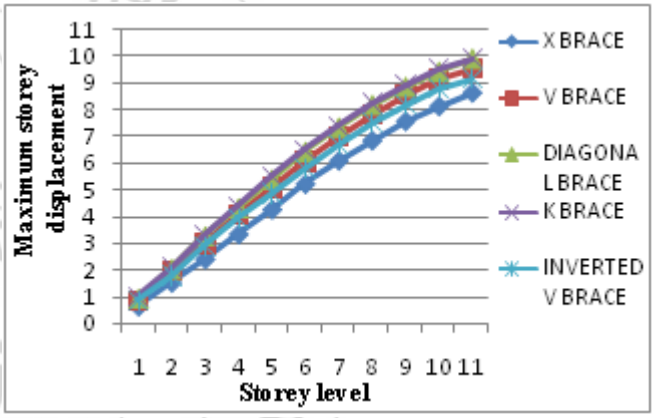

Figure 4.2: Maximum lateral displacement (mm) in Y direction

From the above graphs, it is observed that the lateral displacement are reduced to largest extent for X type of bracing system, while the displacement is maximum for the inverted V braces. The displacement are reduced sequentially for Inverted V, K bracing, diagonal, V and X braces. These patterns are observed due to increased stiffness provided by the respective bracings.

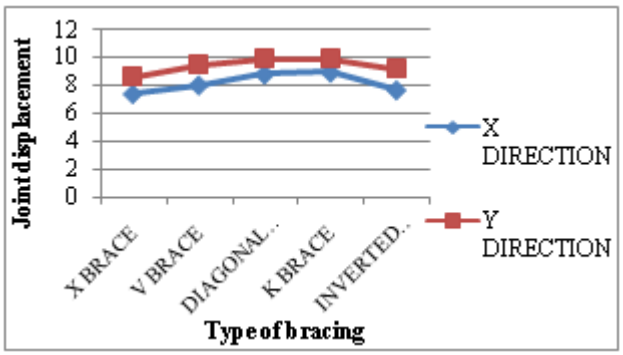

Figure 4.3: Joint displacement (mm) in X & Y directions

From the graph it is clear that joint displacement is minimum for X braced buildings compared to others. The maximum joint displacement occurs for K braces.

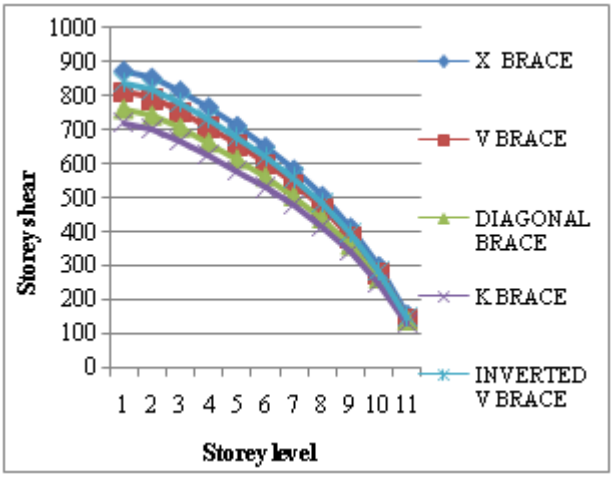

Figure 4.4: Storey shear (kN) in X direction

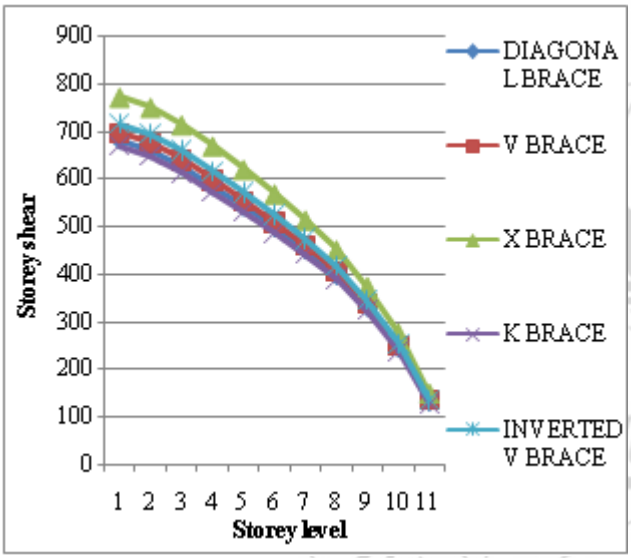

Figure 4.5: Storey shear (kN) in Y direction

From the graph it is clear that storey shear is minimum for X braced buildings compared to others. The maximum storeyshear occurs for inverted V braces. Also the value of shear decreases from bottom storey to top storeyie, the maximum storey shear occurs at the base.

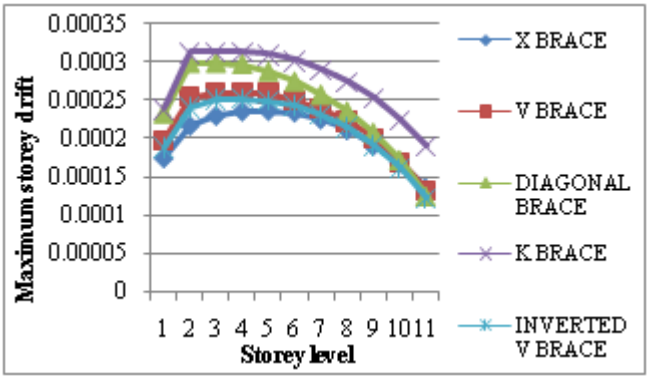

Figure 4.6: Maximum Storey drift (mm) in X direction

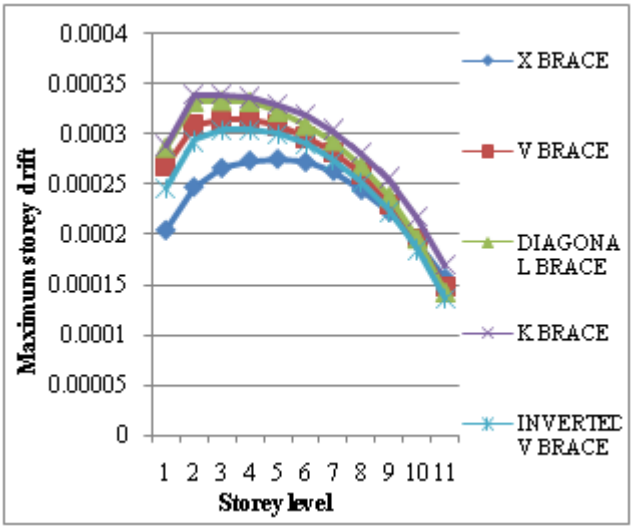

Figure 4.7: Maximum Storeydrift (mm) in Y direction

From the graph it is clear that storey drift is minimum for X braced buildings compared to others. The maximum storey drift occurs for InvetedV braces. Also the value of drift first increases upto 5thstorey after that drift is decreasing, ie maximum drift occurs in middle storeys.

5. Conclusions

In the present study, an attempt is made to find which type of bracing is effective to resist lateral deformation in a multistoried RC framed building by Response Spectrum Analysis. The seismic analysis is carried out taking into consideration that all the buildings are located in zone III i.e. Thiruvananthapuram region as per code. The Storey shears, storey displacement at each storey along with the storey drift are plotted and compared for each model. The mode shapes corresponding to each time period are obtained. The following conclusions are drawn based on the analysis:

- The maximum storey displacement of the building is reduced by the use of X type bracing system. Displacement value decreases from top storey to base. The minimum value for X brace at the base is 0.63mm in X direction and 0.65mm in Y direction.
- Joint displacement is minimum for X braced building and minimum value is 7.4413mm.
- Storey shear is higher for building with X brace. Maximum shear acting at the base and the value is 875.46kN in X direction and 772.03kN .
- Storey drift is maximum at intermediate storey levels and minimum the top storey. The minimum value for X braced building is 0.0001349mm in X direction and 0.0001571mm.
- Building with X type of bracing is found to be most effective.

6. Future Scope

Further studies can be carried out using different sections and arrangements of bracings.

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