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Analysis of earthquake resistant structures using base isolation

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ABSTRACT

In this project "Base Isolation", we are going to discuss what is actually base isolation and its importance. This project sheds light on various methods such as 'Time History Analysis' and Response Spectrum' to protect structures from the earthquake. Base isolation has become one of the reliable tools for earthquake resistant design of the structure. Base isolation system for buildings is introduced to decouple the building structure from potentially damaging induced by earthquake motion, and to make a comparison for the difference between the isolated bases and fixed base buildings. The response of the structure with base isolation is analyzed using Etabs.

Keywords— *Base isolation, Response spectrum, Time history, Drift, isolators, LRB (Lead Rubber Bearing), Etabs*

1. INTRODUCTION

1.1 General

The naturally occurring ground movement which eventually goes on creating disasters such as failure of structure and fatality is known as "Earthquake”. The energy that is discharged from those seismic activities makes waves, these waves are called primary waves and secondary waves. These waves transmit the ground movement to the structure via the foundation. Depending on the intensity of these vibrations, cracks and settlements are caused to the structure. Inertia force is induced in structure because of this earthquake movement as a result of damage of the structure increases with the ground motion. It is permissible to the engineers to use ductility to attain more deformation on the structure than the permitted elastic limit by increasing the small sum of forces. The maximum point at which the structure can deform and come to its original shape is called 'Elastic Limit' if building deforms more than its elastic limit, it forms cracks in the structure. However, ductility will induce some acceptable damage to the structure. But if more elasticity is introduced to the structure, it may tend to increase the overall cost and decrease the damage by increasing the strength, which in turn will be harmful to the components of the building with less strength.

Earthquakes are unanticipated phenomena if the structure is located in seismic zones. The structural engineer has to step in so as to save lives and cause minimal damage to the structures in times of earthquake. The recent development for anti-seismic designs is base isolation, which may not reduce the ground movement but would help in keeping the impact of ground movement to its minimal extent.

1.2 Necessity

- To reduce the human as well as economic loss due to the unpredictable earthquake.
- To analyze, design and execute the earthquake-resistant building in the construction industry.
- To reduce the response of building subjected to earthquake
- To create awareness of building with consideration of earthquake resistance system.
- To find the response of building by consideration of base isolation system which is one of the earthquake resistance systems.

1.3 Objective

- Study of base isolation system for tall buildings and various factors affecting this system.
- To get a basic idea about the seismic base isolation system.
- To study different material used in base isolation.
- Comparison of fixed base and isolated building.
- To study the dynamic response of building for various base isolated material.
- To know the most efficient material in base isolation system.

2. METHODOLOGY

- A G+12 storied framed structure will be considered for modelling and analysis (with or without base isolation).
- Plan area of the structure is 20 * 20 m i.e. 5 bays of 4m length in X-direction and 5 bays of 4m length in Y-direction.
- For earthquake analysis, we consider 'Time History Analysis' as well as 'Response Spectrum Method' for earthquake zone V of India (Zone Factor = 0.36).
- For Time History Analysis, Bhuj earthquake data is considered.
- All the analysis is carried out by using Etabs v 16.2.0 software which is capable to consider required IS codes like IS 1893-2016 (Part 1), IS 456-2000, and IS 800-2007.
- After analysis, the result will be compared with consideration of the following parameters; 1. Displacement; 2. Acceleration; 3. Drift.

- Finally, we suggest the importance of Base Isolation to reduce the earthquake effect on the building.

3. PERFORMANCE CRITERIA

For a normal building, there are mainly two performance criteria's: Maximum Displacement and Drift. But in case of high rise building due to the slenderness of building acceleration is also important performance criteria. If acceleration goes above comfort level, the building will be unserviceable.

3.1 Displacement

According to IS 456 lateral deflection at the top of the building should not be greater than H/500, where H is the total height of the structure.

Maximum Displacement = 0.6432m

3.2 Drift

According to IS 1893, the storey drift in any storey due to minimum specified design lateral force shall not exceed 0.004 times storey height.

Maximum Drift = 16.8mm

3.3 Acceleration

Any Indian Code does not give detailed criteria about maximum acceleration level in the building. According to research papers, human beings can sense acceleration above 0.1 m/sec^2 and 0.1 to 0.2 is noticeable. At levels 0.4 to 0.5 human faces difficulty to walk on the floor. The human can sustain acceleration up to 0.7 m/sec^2 and above this level objects in the building starts falling.

4. SCOPE

Earthquake affects our lives economically as well as ecologically. Vast destruction and damage of structure occur due to an earthquake that can be prevented by efficient planning which includes the method of base isolation that reduces the effect of the earthquake on the structure.

5. RESPONSE SPECTRUM ANALYSIS

A response spectrum is a curve plotted between the maximum response of a single degree of freedom system which is subjected to a specified seismic motion and its frequency (or time period). Response spectrum can be used only for the linear systems and not for a nonlinear system that is the same in the whole system. For soil class E and F of UBC 1997 code use of response spectrum method is restricted.

Procedure for using the response spectrum method of analysis in Etabs

- Define response spectrum function
- Choose function type
- For UBC spectra assign seismic coefficients C_a and C_v.
- Assign the damping ratio
- This completes defining response spectra function
- Now define response spectra cases
- In response to spectra cases, assign damping ratio
- Select the type of model combination
- Next select type of directional combination
- To input response spectra is the next step in which we have to calculate scale factor from the following formula

$$Scale\ factor = Ig/2R$$

Where, I = Importance factor of a building
g = Acceleration due to gravity
R = Response reduction factor

- Next, run the analysis and get the result.

6. DESCRIPTION OF THE STRUCTURE

Plan Dimensions = 20m * 20m (X*Y)
Floor to Floor height = 3m (Z)
The total height of the building = 39m
Type of the structure = OMRF
Soil type (as per IS 1893 (part 1) 2002) = Medium
Response reduction factor = 3
Importance factor = 1
Seismic zone factor = 0.36 (zone v)
Grade of concrete and steel = M30 and Fe500
Beam size = 0.23m * 0.48m
Column size = 0.30m * 0.70m
Slab thickness = 0.150m

Load combinations = 1.2[DL+IL+(EL_X+0.3EL_y)]
1.2[DL+IL-(EL_x-0.3ELy)]
1.2[DL+IL+(EL_y+0.3EL_x)]
1.2[DL+IL-(EL_y-0.3EL_x)]
1.5[DL+(EL_x+0.3EL_y)]
1.5[DL-(EL_x-0.3EL_y)]
1.5[DL+(EL_y-0.3EL_x)]
1.5[DL+(EL_y+0.3EL_x)]
0.9DL+1.5(EL_x+0.3EL_y)
0.9DL-1.5(EL_x-0.3EL_y)
0.9DL+1.5(EL_y+0.3EL_X)
0.9DL-1.5(EL_y-0.3EL_X)

Load Applied
Dead Load = Calculated as per self-weight
Floor Finish = 1KN/m^2
Live Load = 3KN/m^2
Seismic Load = Calculated as per IS 1893:20

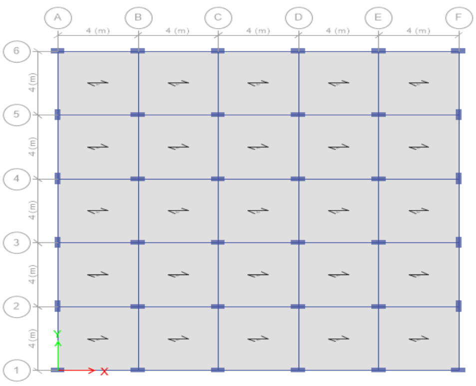

Fig. 1: Plane dimensions

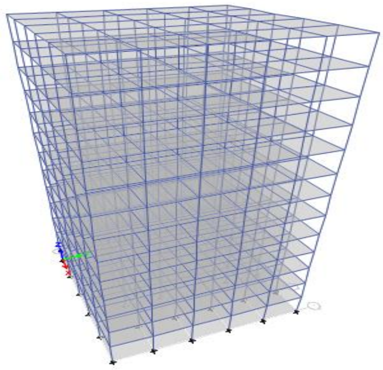

Fig. 2: 3D dimension

6.1 Material Properties

Grade of concrete = M30 (column) and M30 (Beams and Slab)
Grade of steel = Fe500
Density of concrete = 25KN/m^3
Density of brick infill wall = 20KN/m^3

6.2 Section Properties

Beam size = 230mm * 480mm

Column size = 300mm * 700mm
Slab thickness = 150mm
Wall thickness = 250mm
Link element = 0.5m

6.3 Load Consideration
6.3.1 Gravity Load:
Dead Load = Column, Beam, Slab
Live Load = 3KN/m^2
Floor Finish = 1.5KN/m^2
Wall Load = 12.5KN/m^2

7. PLACING OF LEAD RUBBER BEARING

- Isolator is provided above every footing
- Base isolators are placed at 0.5m above the base level

The following properties are calculated:
(a) Effective stiffness
(b) Vertical stiffness
(c) Horizontal stiffness

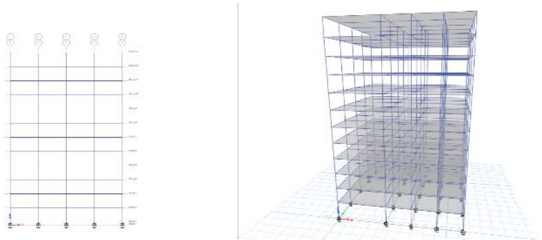

Fig. 3: Placing of lead rubber bearing

8. CONCLUSION

In the present work, the response of multistoreyed building due to earthquake excitations has been carried out using finite element analysis on G+12 storey i.e. RC bared structure with a fixed base which is model 1 and model 2 is with lead rubber bearing. Based on the studies carried out, the following conclusions are drawn:

8.1 Mode Period
It clearly shows that the mode period of model 2 is higher than model 1 due to its flexibility.

8.2 Storey Displacement
It increased with the period at different storey level for the base isolated building.

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