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Study of the effect of base isolation on flat slab building for multi-storey building in seismic prone areas

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Abstract - *The main aim of using seismic base isolation tool is to reduce the inertial forces introduced in the structure by shifting the fundamental period of the structure out of dangerous resonance range and concentration of the deformation demand at the isolation system. In the paper a parametric study on Reinforced Concrete building and flat plate building with fixed base and isolated base with rubber bearing are carried out using response spectrum method. Here, the design spectra recommended by Indian Standard Code IS 1893-2002 (part-1) is considered for comparison. The main objective of this study is to investigate the differences in the dynamic analysis of G+4, G+8 and G+10 RC building and Flat plate building with fixed and isolated base condition. To evaluate the seismic response of the buildings, elastic analysis is performed using the computer finite element program SAP2000. From the analysis, it is found that the time period and top displacement are more in flat plate building with base isolator compared to other models. The base shear is reduced in flat plate building compared to other models.*

***Key Words*:** Reinforced Concrete Frame, Flat Plate Frame, SAP 2000, and Response Spectrum Analysis.

1.INTRODUCTION

The traditional method, i.e., strengthening the stiffness, strength, and ductility of the structures, has been in common use for a long time. Therefore, the dimensions of structural members and the consumption of material are expected to be increased, which leads to higher cost of the buildings as well as larger seismic responses due to larger stiffness of the structures. Thus, the efficiency of the traditional method is constrained. To overcome these, many vibration-control measures called structural control, have been studied and remarkable advances in this respect have been made over recent years. Structural Control is the one of the areas of current research aims to reduce structural vibrations during loading such as earthquakes and strong winds. In terms of different vibration absorption methods, structural control can be classified into active control, passive control, hybrid control, semi-active control and so.

Base isolation is a passive vibration control system that does not require any external power source for its operation and utilizes the motion of the structure. Performance of base isolated buildings in different parts of the world during earthquakes in the recent past established that the base isolation technology is a viable alternative to conventional earthquake-resistant design of medium-rise buildings.

The application of this technology may keep the building to remain essentially elastic and thus ensure safety during large earthquakes as they decouples the structure from the horizontal components of the ground motion and reduces the possibility of resonance. This decoupling is achieved by increasing the flexibility of the system, together with appropriate damping by providing isolator at the basement level of the structure.

2. OBJECTIVE OF WORK

The main objective of this study is to investigate the differences in the dynamic analysis of G+4, G+8 and G+10 RC building and Flat plate building with fixed and isolated base condition by comparing the responses such as time period, base shear and top displacement by using response spectrum analysis.

3. DESCRIPTION OF BUILDING

In the present work G+4, G+8 and G+10 storey regular plan buildings situated in zone V, are considered. For the study RC frame and flat plate frame are taken with fixed base and with base isolator. This study includes modelling and analysis of the models by using standard FEA package Software SAP 2000. Material properties and section properties are defined and assigned. Reinforced concrete frame elements are modelled as beam and column elements. Slab is modelled as an area element. Response spectrums are performed on models. For this study, 12 building models are considered for the comparison.

The characteristics of the isolators used are selected from the available or producible products in the light of the information obtained from the manufacturers. While deciding about the isolator characteristics; the characteristics of the device, which subject the structure to minimal effects, while themselves are displacing within reasonable scales, with the criteria such as the base shear forces, storey shear forces, relative story drifts, are selected.

A. Modelled considered for analysis

1- RC frame

2- Flat plate frame

3- RC frame with base isolator

4- Flat plate with base isolator

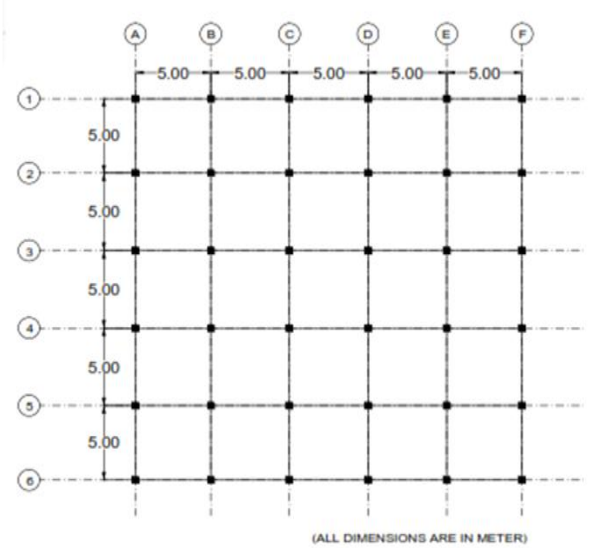

FIG. 1: Plan view of building for all models

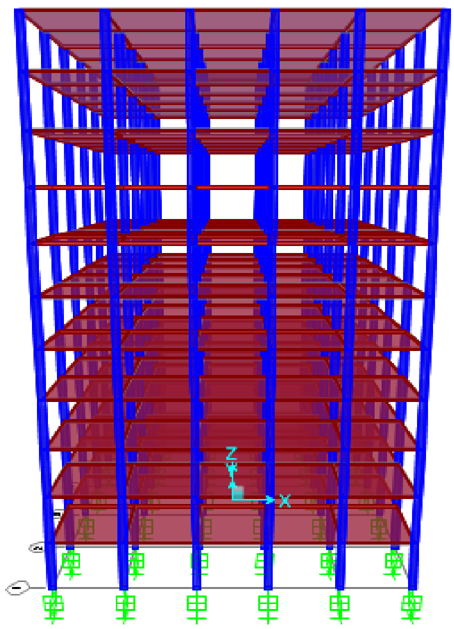

FIG 2: 3D view of plan regular BI building

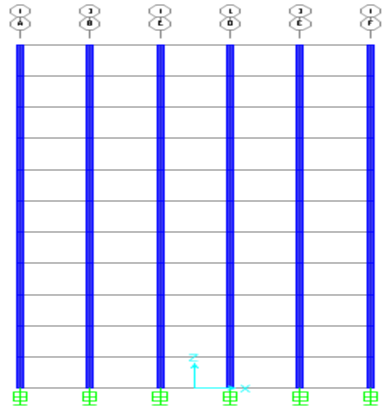

FIG 3: Elevation of vertical regular BI building

B. Building Data

For all 12 Building models, the following data is used for the analysis.

C. Details of Building

Type of structure: Multi-storey RC frame and flat plate frame structure

Type of building: Commercial Building

Number of stories: (G+4), (G+8) and (G+10)

Floor to floor height: 3.6 m

Type of Soil: medium type soil

D. Materials

M20- grade concrete

Fe-415 steel

E. Member Dimensions

Column size: 300mmX450mm for all buildings.

Slab thickness: 150 mm for RC frame and 170mm for flat plate frame

Beam Size: 300 mm x 450 mm

F. Loading data

Dead load:

Floor finish = 1 kN/m^2

Terrace water proofing = 1.5 kN/m^2

Live load:

Roof = 1.5 kN/m^2

Live load on floor = 3.5 kN/m²

G. Earthquakes Data

Zone (Z) = V

Response reduction factor (R) = 3

Importance factor (I) =1

Rock and soil site factor (SS) = 2

Zone factor = 0.36

Damping ratio (DM) = 0.05

H. Link properties

Nonlinear Link Type: Rubber Isolator

U1 Linear Effective Stiffness: 1500000 kN/m

U2 and U3 Linear Effective Stiffness: 800 kN/m

U2 and U3 Nonlinear Stiffness : 2500 kN/m

U2 and U3 Yield Strength : 80 kN

U2 and U3 Post Yield Stiffness Ratio: 0.1

4. RESULTS AND DISCUSSION

The forces, time periods and displacements developed in all the member of the structure are obtained from the analysis and discussed in this section. Further, these results have been used for understanding the behaviour of the structure for RC frame and flat plate frame with and without base isolator.

A. Time Period

Figure 4 shows the variation of natural time period with number of storeys for different models. The graph shows the comparisons of time period V/s No. of story for RC frame and flat plate frame structure.

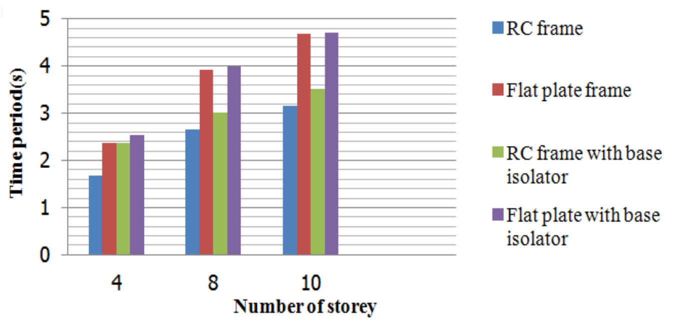

FIG.4: Variation of No. of storeys V/s time period

From the graph it is observed that the natural time period increases as the number of story increases. In flat plate frame with base isolator, the time period increases by 15.5% as compared to RC frame.

B. Base Shear

The total horizontal force on the structure is calculated on the basis of structural mass and fundamental period of vibration and corresponding mode shape. The base shear is distributed along the height of the structure in terms of lateral force. The results are plotted in figure 5.

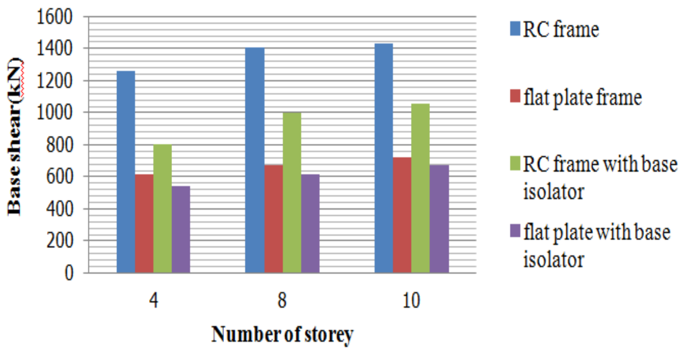

FIG 5.: Variation of No.of storeys V/s base shear

From the graph, it can be observed that, on increasing the number of storey the base shear increases. The base shear is maximum in RC frame and is minimum in flat plate with base isolator. In flat plate frame with base isolator, base shear decreases by 50.2% as compared to RC frame.

C. Lateral Displacement

The lateral displacement obtained by response spectrum analysis for zone V are shown in the below figure 6.

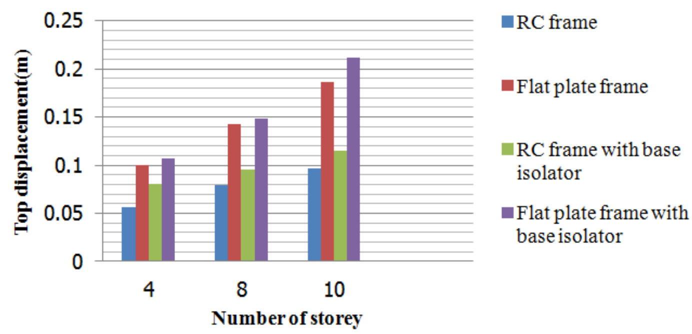

FIG.6: Variation of No. of storeys V/s top displacement

From the graph, it can be seen that, lateral displacement increases as the storey level increases. From the figure, it can be observed that, in flat plate building the lateral displacement increases drastically as the number of storey increased. Top displacement in flat plate with base isolator increases by 48% as compared to RC frame.

5. CONCLUSIONS

1) Amongst all the models, flat plate building with base isolator has higher time period due to its high flexibility. Time period of the structure increases by 15.5% with the use of lead rubber bearing which helps in less transfer of lateral forces at the time of earthquake.

2) In comparison with RC building, the base shear is reduced by 50.2% in flat plate building with base isolator. The base isolation has high efficiency in decreasing the base shear compared to fixed base building.

3) There is much variation in displacement and drastically increased by 48% in flat plate building with base isolator when compared with all models.

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