Effect of Seismic Zone on Retrofit of RC Framed Building using Base Isolation

Ravi Kumar Reddy Chapati, Siva Kiran Kollimarla, Srinivasulu Goli, Jubeda Shaik

Abstract: Base Isolation technique is introduced to historical buildings to decouple the building super structure from potential damage caused by earthquake ground motion, arresting the building superstructures from absorbing the energy due to earthquake. A Reinforced Cement Concrete (RCC) building with lead rubber bearing is introduced in this study. Two buildings were analyzed using a three dimensional response spectrum analysis which is carried out using commercially available software called SAP 2000 V19 to study the effect of base isolation technique on building with rubber bearing isolator. The objective is to provide a retrofitting for the RCC building by comparing a fixed base model(FBM) with a base isolated model(BIM) using lead rubber bearing (LRB) isolator subjected to strong earthquakes in different seismic zones to attain an optimal design of the base isolated model. It is observed that, base isolation technique substantially increase the time period of structure and correspondingly reduce the base shear compared to FBM system. The roof displacements for an isolated base is decreased compare to the FBM system.

Index Terms: Base isolation, Retrofit, Rubber Isolator, Bearing, Response Spectrum, Seismic zones.

I. INTRODUCTION

The structures which are desired to resist lateral forces are broadly categorized into two types as rigid structures and flexible structures. The control method in case of rigid structures withstand lateral loads are, to arrest inter story displacement with the provision of diagonal bracings, the provision of shear wall in the direction of lateral load, and by using composite structural elements. Whereas in case of flexible structures, such as buildings with base-isolation models, the approach is to arrest the input excitation with the use of damper model and base isolator model. For rigid structures the control strategies are preferred to earthquake hazard resistance, long-lasting established knowledge and the maturity of advanced technologies are the alternatives to pertinent the structural stiffening. However, significant inter story drift and floor accelerations of highly stiffening structures increase risks of severe damage of the building, especially under the ground motions of large scale. The phenomenon of resonance can be avoided by the use of flexible structures and thereby effective reduction in structural response is observed. When structures are designed according to code specifications, they are presumed to be damaged during strong ground motions but to remain standing. This type of structural design is not acceptable for public buildings such as hospitals, fire stations, and telecommunications centers etc. In the floor of base isolation system the effective reduction of inter story drift can ensure the minimum damage to facilities and also human safety. In the last few decades, the concept of base isolation system had been emerged due to the enhanced knowledge and advanced available technologies. In case of high stiffness low rise buildings, seismic isolation systems are effective to alter the characteristic of the building from rigid to flexible. The increasing in number of retrofitted structures reveals the fact that, Base isolation has been proven as one of the advanced technology to reduce the damage due to earthquake hazards. One of the strategies of seismic load reduction on structure is base isolation that can reduce the effect of earthquake ground motion by decoupling the superstructure from the foundation. The structure can be isolated from the horizontal components of the ground motion by interposing super structural elements with low horizontal stiffness between the foundation and superstructure. In 1995 Kobe earthquake in japan is proven to be a massive ground motion that the structures have ever experienced before, after the investigation of such structures with retrofitted with base isolation has proven to be excellent in performance as predicted. Hence, this technique has further emerged as much as in terms of theory, design and construction phases.

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II. PARAMETRIC STUDY

A Nine story (G+8) RCC framed building for an ordinary office building has plan dimensions as shown in Fig. I. The building with live load of 350 kg/m^2 is to be considered in different seismic zones with different soil stratums. Design the building for seismic loads as per IS 1893 (Part 1):2002.

Table I. Dimensions of the structural member elements

S.No.	Structural Element	Size (mm x mm)
1	Beam	300 x 450
2	Columns (G+2)	350 x 650
3	Columns (3-8)	300 x 600
4	Slab	150

The analysis of a Reinforced Cement Concrete (RCC) structure building subjected to earthquake-induced load, with FBM. The FBM was modeled by SAP2000 (ver. V19.2.2 Advanced) for seismic analysis using Response spectrum analysis.

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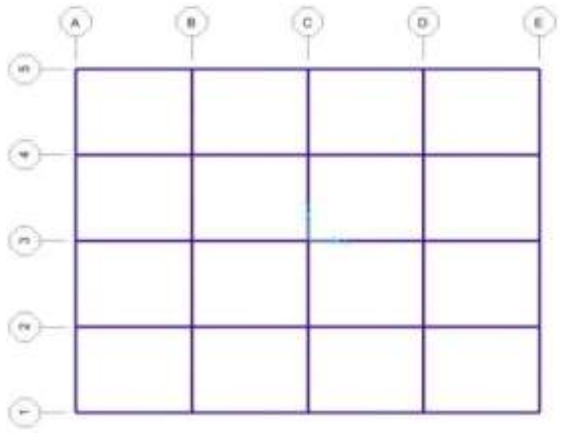

Fig. 1. Plan view of the Model

A. Fixed Base Model

A FBM was set as per the preliminary design of the building. Response-spectrum function is simply a list of period versus spectral acceleration values. In SAP2000, the acceleration values in the function are assumed to be normalized; that is, the functions themselves are not assumed to have units. Instead, the units are associated with a scale factor that multiplies the function and that is specified when the response-spectrum analysis case is defined. Deformed shapes and bending moments are listed at different levels below for the Table IV.

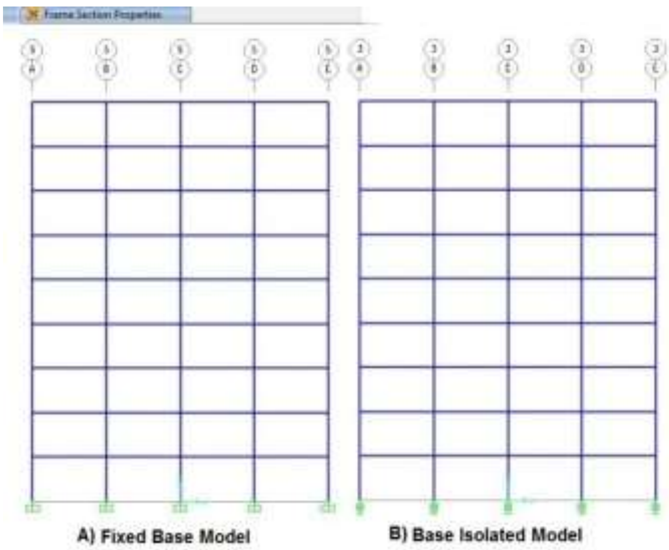

Fig. 2. Fixed base and Base isolated models

B. Base Isolated Model

The preliminary design of fixed base model is carried out in the initial stage. A design methodology for bilinear elastomeric isolation systems, with lead rubber isolator is presented here. Preliminary characteristics of model such as time period, mode shape, and base shear of FBM system are obtained. Then, for the BIM system a target value of time period or peak lateral roof displacement is set. From the obtained results, the properties of rubber isolator such as stiffness and damping are evaluated. Using this rubber base isolation system, the building is analyzed and the responses such as seismic force and lateral roof displacement are obtained.

Table II. High Damping bearing properties

Bearing property	Value (kN/m)
Vertical Stiffness	1500000
Initial shear stiffness	2500
Shear yield force	80
Post yield shear to initial shear stiffness ratio	0.1

III. RESULTS

A. FIXED BASE MODEL

Table IV. Base Shear and Roof Displacement for Fixed base Building in various soils in different Seismic zones

Soil Type	Seismic Zone	Base Shear (RSx) kN	Roof Displacement (mm)
I	II	407.97	12.35
I	III	652.76	1976
I	IV	979.14	29.65
I	V	1478.68	44.5
II	II	545.62	16.8
II	III	872.997	26.87
II	IV	1309.5	40.31
II	V	1964.24	60.46
III	II	662.701	20.62
III	III	1060.32	32.99
III	IV	1590.48	49.48
III	V	2385.72	74.22

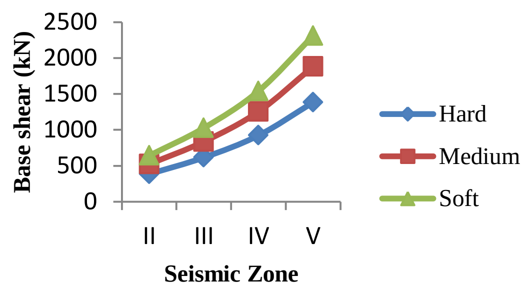

Fig. 3. Base shear variation for different soils in various seismic zones

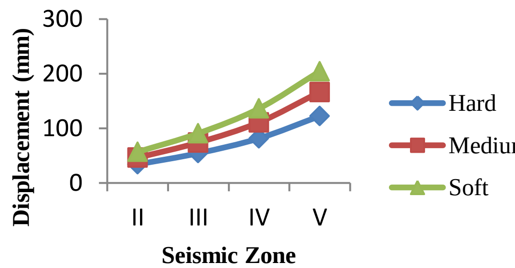

Fig. 4. Roof Displacement variation for different soils in various seismic zones

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B. BASE ISOLATED MODEL

Table V. Base Shear and Roof Displacement for Base Isolated Building in various soils in different seismic zones

Soil Type	Seismic Zone	Base Shear (RSx)kN	Roof Displacement (mm)
I	II	383.93	33.98
I	III	614.29	54.37
I	IV	921.43	81.55
I	V	1382.15	122.32
II	II	522.14	46.21
II	III	835.43	73.94
II	IV	1253.15	110.91
II	V	1879.72	166.36
III	II	641.15	56.74
III	III	1025.85	90.79
III	IV	1538.77	136.19
III	V	2308.16	204.28

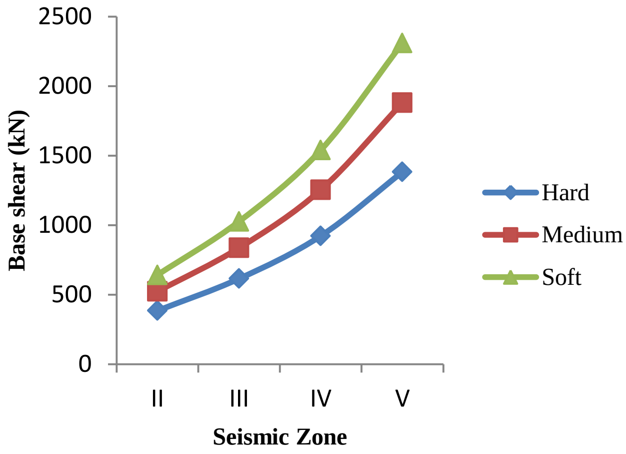

Fig. 5. Base shear variation for different soils in various seismic zones

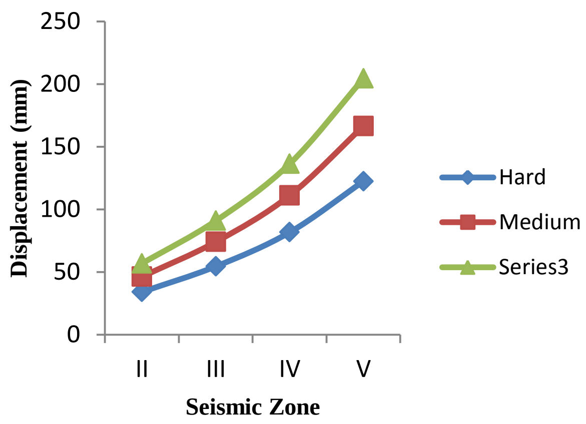

Fig. 6. Roof displacement variation for different soils in various seismic zones

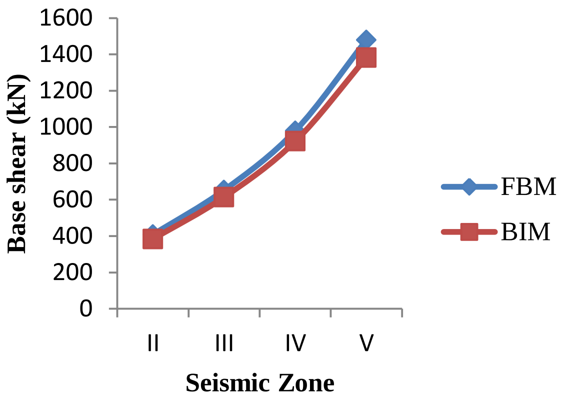

Fig. 7. Base shear variation for Hard Soil

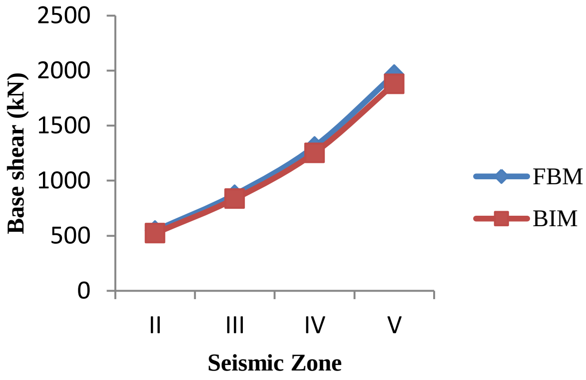

Fig. 8. Base shear variation for Medium Soil

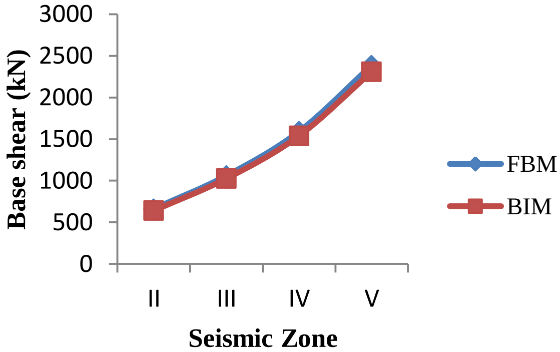

Fig. 9. Base shear variation for Soft Soil

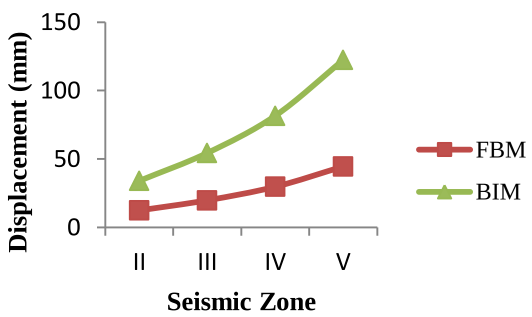

Fig. 10. Roof Displacement variation for Hard Soil

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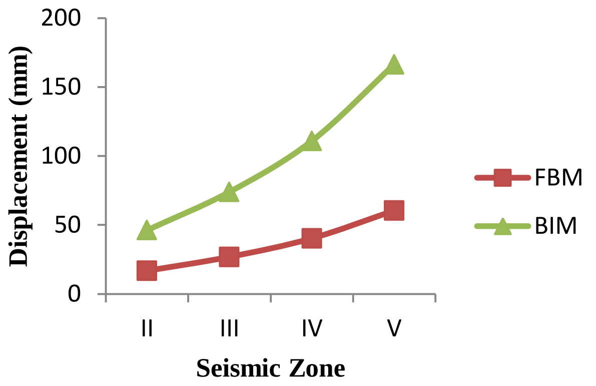

Fig. 11.Variation of Roof Displacement for Medium Soil

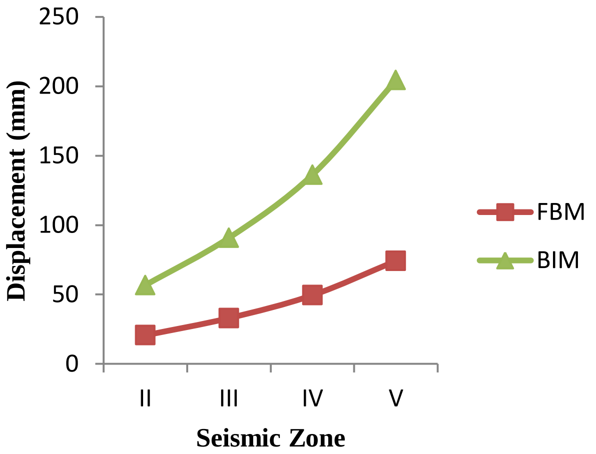

Fig. 12.Variation of Roof Displacement for Soft Soil

IV. CONCLUSIONS

The following conclusions are been drawn from the modeling and analysis results

1. From the modeling study, the main observation on the accuracy of seismic effect and lateral load patterns utilized in the Multi-Modal Response Spectrum analysis (MRA) in assessing the seismic effect in different seismic zones showed that the accuracy of the results depends mainly on the characteristics of ground motion, properties of the structure and its load path.
2. Time period of FBM from MRA is observed to be 2.32 sec, and that of BIM is 4.49 sec. It shows that the isolation of the structure from the base under lateral load analysis amplifies its natural period of vibration.
3. From Fig. 7,8, and 9it is observed that, the design base shear of BIM is reduced by about 6.8% compared to FBM irrespective of soil characteristics.
4. From Fig. 10, 11, 12 it is observed that, the peak Roof Displacement of BIM is increased by about 175% compared to FBM irrespective of soil characteristics.
5. Fig 3 and 5 show that, the design base shear from MRA increases with increasing seismicity of site and also decrease with increasing rigidity of the soil.
6. Fig 4 and 6 show that, the peak roof displacement from MRA increases with increasing seismicity of site and also decrease with increasing rigidity of the soil.
7. From above conclusions it is obvious that, though natural period and amplitude of a structure increase with Base Isolation, the design lateral force on the structure get reduced and there by the structure will be safe under lateral loads compare to fixed base system.

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