International Journal of Research in Engineering, Science and Management
Volume-2, Issue-5, May-2019
www.ijresm.com | ISSN (Online): 2581-5792

Seismic Performance of Base Isolated Buildings

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***Abstract*: During past many years many of the building were collapsed due to one of the most destructive forces on earth which is earthquake. Therefore, for analysis and design some realistic method is been adopted. Base isolation systems modern approach for earthquake resistant design. Under various expected seismic events it is an attempt which predicts the performance of building. The design of base isolation in high seismic areas of world is widely used in not only building but also in residential buildings with high importance. The base isolation systems are gaining large attention as a mean to protect structure form seismic hazard. It is a suitable technology for earthquake resistant design of variety of structure like buildings, bridges, airport terminals, nuclear power plant etc. Seismic isolation consists of essentially the installation of mechanisms which decouple the structure from base by providing seismic isolators. The seismic isolation system is mounted beneath the superstructure and is referred as Base Isolation. The aim of this project deals with structural behavior of building with and without base isolation. Lead rubber bearing and friction pendulum system are used as an isolation device then compare various parameters like Base shear, Displacement, Storey drift. 6 to 18 storey buildings are test models. Nonlinear time history analysis is carried out for both fix base and base isolated structure.**

***Keywords*: Base isolation, Storey drift, Base shear, Time history analysis, LRB system.**

1. Introduction

Earthquakes are the most unpredictable and devastating of all natural disasters, which are very difficult to save over engineering properties and life, against it. Hence in order to overcome these issues we need to identify the seismic performance of the built environment through the development of various analytical procedures. Base isolation is an effective means for protection of structure during earthquake events. The concept of Base isolation is to insert a flexible layer between foundation and superstructure thus decoupling the building from damaging action of ground motion. This results in reduced frequency range and dissipates energy through damping. In this study an attempt is made to improve the performance of symmetrical and asymmetrical buildings by incorporating lead rubber base isolators at bottom level of columns. for this, symmetrical and asymmetrical buildings models with and without base isolators are considered. The 3D analysis of building is carried out for earthquake zone III. The response spectrum analysis is carried out on all the mathematical 3D models using the software SAP 2000. The results obtain from the analysis are discussed. There are total two symmetrical models under consideration, out of which first model is without isolator i.e. fixed base and in second models, lead rubber base isolator with all properties provided by manufacturer are used at base storey to improve seismic performance of such type of building. For comparison purpose, lateral displacements, storey drifts, base shear, time period are chosen.

A. Lead rubber bearing (LRB)

Lead Rubber Bearings (LRB) consists of a laminated rubber and steel bearing with steel flange plates for mounting to the structure. Ninety percent of our isolators have an energy dissipating lead core. The rubber in the isolator acts as a spring. It is very soft laterally but very stiff vertically. The high vertical stiffness is achieved by having thin layers of rubber reinforced by steel shims. These two characteristics allow the isolator to move laterally with relatively low stiffness yet carry significant axial load due to their high vertical stiffness. The lead core provides damping by deforming plastically when the isolator moves laterally in an earthquake.

2. Objectives and scope

Investigations of past and recent earthquake damage have illustrated that the building structures are vulnerable to severe damage during moderate to strong ground motion.

The objectives of the work are summarized as:

- Investigate structural behavior of multi storied buildings with or without BI subjected to ground motion
- To study the effect of various BI with varying height of the structure under motion

Scope of the study limited to the following:

- Project focused on square building, T building, C building
- To study the effect of LRB and FPS
- LRB with 0.15 damping coefficient is only considered
- Height variation is limited to 6,12,18 storeys
- Modeling is done using SAP2000 and code for design isolator is UBC 97
- Study is limited to time history analysis.

3. Methodology

Three models have been considered for the purpose of the study.

- Six storey (G+5) building.
- Twelve storey (G+11) building.
- Eighteen storey (G+17) building.

The methodology followed out to achieve the abovementioned objectives is as follows.

i. Review of the existing literature by different researchers.
ii. Design and optimization of building members for G+5, G+12, G+17 as per Indian codes.
iii. Study on seismic effect on floor to floor by analyzing the parameters such as lateral displacement, storey drift, time period, base shear.
iv. Study on Time History Analysis for both fixed support and LRB base isolator.
v. Comparison of results.

A. *Structural specifications*

Table 1
Building design data

Storey No.	G+5	G+11	G+17
Height	18m	36m	54m
Beam size	230x450mm	300x450mm	300x500mm
Column size	300x450mm	300x900mm	500x1000mm
Slab size	110mm	110mm	120mm
Grade of concrete	M20, M25	M20, M25	M20, M25
Grade of rebar	Fe415	Fe415	Fe415

Live load on floor is taken as 3kN/m^2 and on roof is 1.5kN/m^2. Floor finish on the floor is 1kN/m^2 and weathering course on roof is 1kN/m^2.

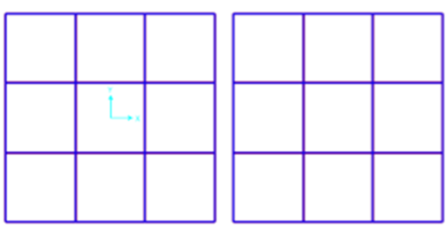

Fig.1. Plan of (G+5) and (G+11) Building

B. *Analytical investigations*

1) *Time history analysis*

Time History analysis has been carried out using the Imperial Valley Earthquake record of May 18, 1940 also known as the Elcentro earthquake for obtaining the various floor responses. The record has a sampling period of 0.02 seconds. Nonlinear Dynamic analysis (Time History) can be done by direct integration of the equations of motion by step by step procedures. Direct integration provides the most powerful and informative analysis for any given earthquake motion. A time dependent forcing function (earthquake accelerogram) is applied and the corresponding response – history of the structure during the earthquake is computed.

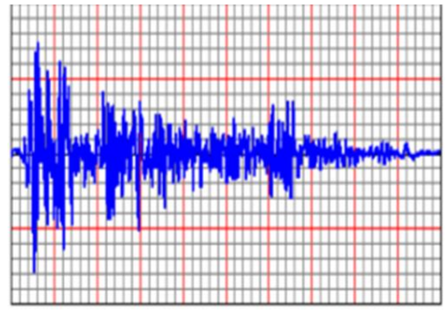

Fig. 2. Acceleration Time History of El Centro Imperial Valley 1940 Ground Motion Records

4. Results and discussion

A. *Displacement*

The storey displacement at each level for various building model are obtained from the time history analysis methods is shown below.

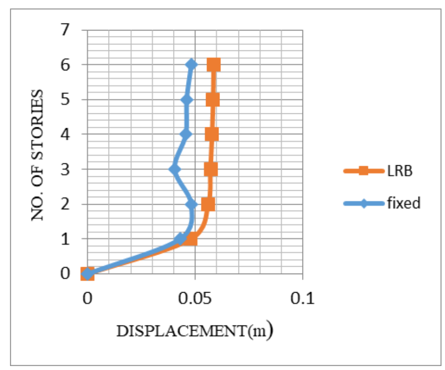

Fig. 3. Storey v/s. Displacement for G+5 & G+5 Building Combination

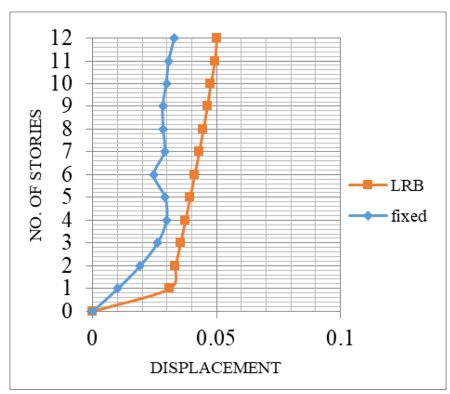

Fig. 4. Storey v/s Displacement for G+11 & G+11 Building Combination

In case of fixed base building, displacement is zero at the base and increases as storey height increases. But in case of base isolated building, at the base there is a considerable amount of displacement and increase in the displacement is less as height increases compared to fixed base building.

B. *Storey drift*

Inter storey drift of (G+5)(G+5) building combination and (G+11)(G+11) building combination with and without base isolator are given below.

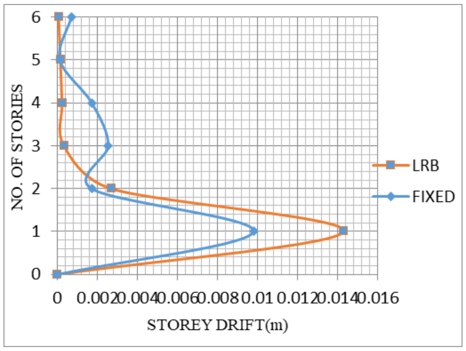

Fig. 5. Storey v/s Storey Drift for G+5 & G+5 Building Combination

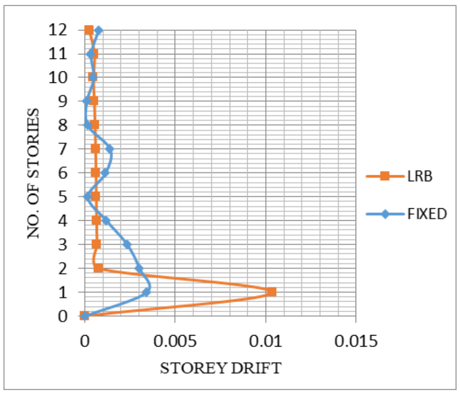

Fig. 6. Storey v/s Storey Drift for G+11 & G+11 Building Combination

In case of fixed base building, storey drift is higher at the lower floors and it decreases as we move to the top floors. But for base isolated buildings, storey drift is comparatively lower than fixed base buildings at the lower floors and decreases as we move to the top floors. At top floor, storey drift is nearly equal to zero.

C. Base shear

The base shear for both building models with and without isolator are tabulated in table 2.

Table 2
Base shear for both with and without isolator building

Storey No.	Fixed	LRB	Percentage of Variation (%)
G+5	2539.13	1166.22	45.93
G+11	1441.29	275.60	19.12
G+17	4296.21	472.04	10.98

Table 2 Base Shear for Both with and Without Isolator Building. Base shear of the building considerably decreases after incorporation of base isolator which is due to flexible behavior of building. The base shear is decreased by 45% for building with isolator.

D. Time period

The time period for both building models with and without isolator are tabulated in table 3.

It is observed that the time period of vibration is more for building with isolator. The increment is of 41.8%.

Table 3
Time period

Storey No.	Fixed	LRB	Percentage of Variation (%)
G+5	1.14009	2.72262	41.87
G+11	1.89568	3.68397	51.45
G+17	2.31132	4.58932	50.36

5. Conclusions

In this study, the comparison between the fixed base structure and the base isolated structure is done.

- Storey displacements are more for fixed base buildings as compared to isolator base buildings.
- As floor height increases, a lateral displacement varies drastically in case of fixed base building for base isolated buildings the lateral displacement variation is smaller as the height increases
- For base isolated buildings the lateral displacement variation is smaller as the height increases
- The addition of isolators decreases the value of storey drift and compared to the fixed base buildings
- Storey drift shows a higher value at the base of isolated base buildings when compared to fixed base buildings.
- The time period of the building increased by the addition of the isolators, this may be due to the flexibility of the isolator.
- The base isolated buildings shows lower value for base shear when compared to fixed base buildings.
- Base isolation method has proved to be a better method of earthquake resistant design.

Hence, usage of LRB is an effective base isolation technique which reduces the impact of the earthquake on the structure.

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