

Comparative Study on Seismic Response of Irregular Structure with Lead Rubber Bearing and Friction Pendulum Bearing Base Isolation System

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ABSTRACT: Base isolation is one of the most modern technique and widely accepted seismic protection system used in the building in Earthquake prone areas. The base isolation system separates the structures from its foundation and primarily moves it relative to that of the super structure. The main objective of this project is to understand the seismic performance of a G+10 irregular building made of three different materials such as RCC, Steel and Composite with Lead Rubber Bearing (LRB) and Friction Pendulum Bearing (FPB) base isolation system and to compare the seismic response with and without base isolation using Response spectrum method in ETABS-2015 software. The response of the structure such as time period, base shear, story drifts and story displacements are studied and comparison is made. From this study it can also be concluded that it is better to provide isolation systems in seismic prone areas rather than providing fixed base and among two isolators used here FPB performs better than LRB for all the structures.

KEYWORDS: - RCC, steel, Composite structures, Irregular, Response spectrum, Fixed, LRB, FPB base isolation, ETABS 2015.

I. INTRODUCTION

Earthquakes are the natural calamity that occurs due to the shifting of plates or plate tectonics in earth's crust and has taken the lives of millions of people throughout the ages. These forces are very strong and remain for a short duration of time. In the earthquake design of small and medium storey structures, the earthquake force is much greater than the fundamental frequency of vibration which means building acts as an amplifier and the acceleration experienced at each floor increases to the top. So the stresses and interstory drifts increases in the member and the column gets damaged between the floors. Sometimes the acceleration causes more damage to the contents and occupants of the floors without making more damage to the structure. The accelerations can be decreased by making the building more flexible. But flexibility creates some problems in the structure such as it creates cracks in the partition walls, windows may fall due to high wind force. Thus in low to medium rise buildings the best way to achieve flexibility is by using base-isolation method. Hence the usage of flexible devices in the horizontal direction in the base of the structure reduces transmission of severe earthquake ground motions into the superstructure. Thus to achieve the safety of structure against earthquake, there is a need to increase the seismic capacity (resistance) of the structure and to decrease the seismic demand (forces) on the structure. The lateral strength and the lateral stiffness are the main requirement of the seismic resistance. Engineers are required to select an appropriate structural system to resist the lateral forces together with the gravity force, within the functional and architectural constraints. It is very much essential that all the lateral load resisting structural components need to be rigidly connected. The seismic demand on the structure can be reduced by seismic

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modification isolation. The fundamental principal of seismic isolation is to modify the response of the building to permit the dissipations of vibration energy or by base isolation. The basic principle of base isolation is to reduce and control vibrations induced from earthquake on any structures. The isolation system deflects through the dynamics of the system but it does not absorb the energy. In this project “plus” shaped plan irregular structure is considered and here two types of base isolation systems are considered, one is Lead Rubber Bearing (LRB) and the other one is Friction Pendulum Bearing (FPB) base isolation system.

1.1 Objectives of the work

- To study the behaviour of structure with and without base isolation.
- To study the response of the RCC, Steel and Composite structure with and without base isolation.
- To know the good base isolation system for various structures.

II. METHODOLOGY

The experimental model is analysed using the software ETABS-2015. The methodology mainly discusses the method of analysis of structure and seismic analysis of fixed and base isolated structures.

2.1 Geometrical modelling

The below table shows the details of the model used for the analysis and also seismic evaluation is carried out as per IS 456:2000 and IS 1893 (part 1):2002 using ETABS 2015 software.

Table -1 Details of the structure

Type of frame	Special moment resisting frame
No of storey's	G+10
Storey height	3m
Height of the building	33m
No. Of flexural members (per floor)	148
No. Of Compression members (per floor)	75
No. Of Slabs (Per floor)	64
Slab thickness	150 mm
Wall thickness	230 mm
Wall masonry	Brick
Steel grade	Fe345
Rebar grade	HYSD 415
Concrete grade	M25 Beam, M30 Column
Support conditions	Fixed, Base isolated

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Table -2 Section Details

Structure	Column	Beam
RCC	600X600 mm	300X450 mm
Steel	(Built up I section)	
	Total depth	900 mm
	Flange width	500 mm
	Flange thickness	60 mm
	Web thickness	50 mm
Composite	600X600 mm (ISMB400)	ISMB350

Table -3 Seismic Data

Seismic zone	III
Zone factor	0.16
Soil type	Type II (Medium)
Importance factor	1.0
Response reduction factor	5.0
Damping of the structure	5%

2.2 Description of models

Totally 9 models is been considered for this study below describes the details of it,

Model 1: Response spectrum analysis of RCC structure with fixed base.

Model 2: Response spectrum analysis of RCC structure with LRB Isolator.

Model 3: Response spectrum analysis of RCC structure with FPB Isolator.

Model 4: Response spectrum analysis of Steel structure with fixed base.

Model 5: Response spectrum analysis of Steel structure with LRB Isolator.

Model 6: Response spectrum analysis of Steel structure with FPB Isolator.

Model 7: Response spectrum analysis of Composite structure with fixed base.

Model 8: Response spectrum analysis of Composite structure with LRB Isolator.

Model 9: Response spectrum analysis of Composite structure with FPB Isolator.

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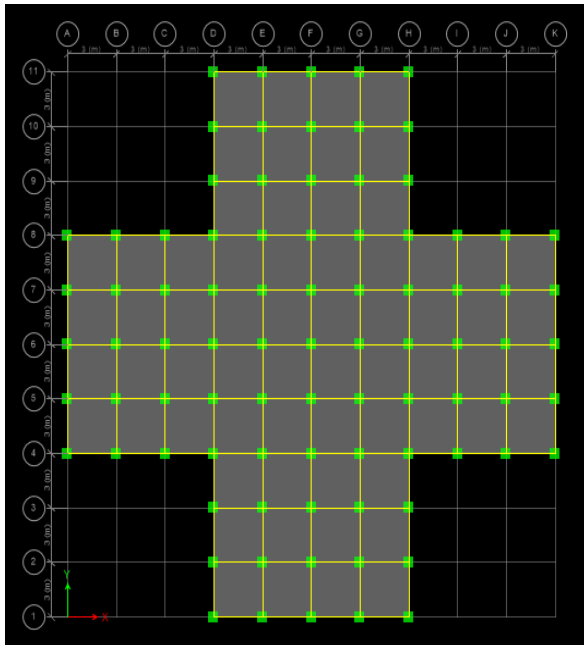


Fig.1. Plan view of the model

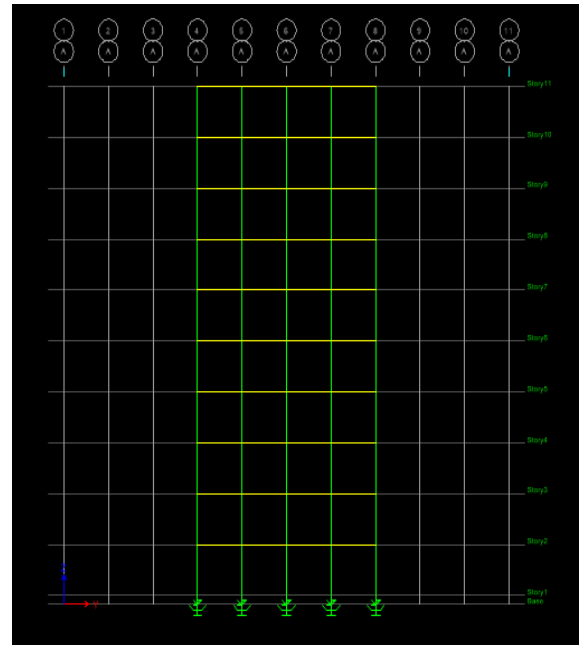


Fig.2. Elevation view of the models

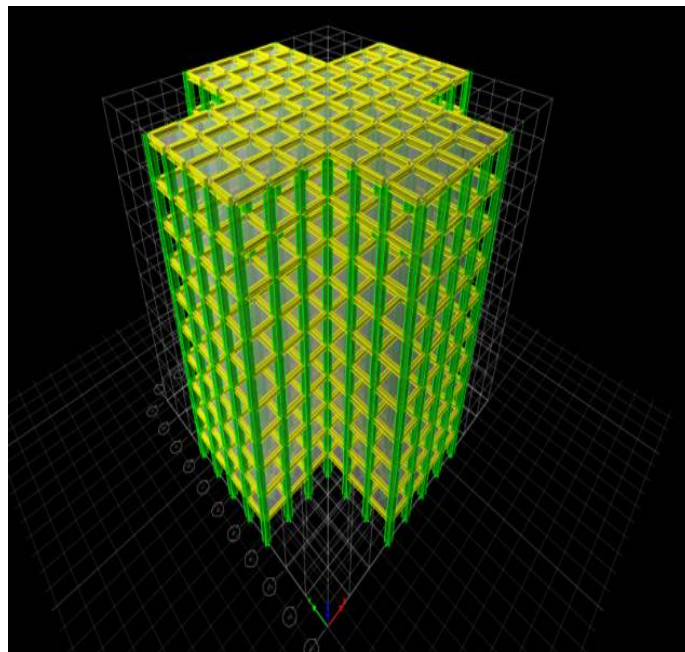


Fig.3 3D View of the model

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2.3 Modelling of LRB and FPB in ETABS 2015

Properties of FPS and LRB Isolators are modelled as spring elements (point springs) in ETABS 2015 and their properties are given as Link Properties. The properties of the friction pendulum bearing system isolator and lead rubber bearing isolator are referred from Torunbalci1 and G. Ozpalkanlar octo.12-17(2008)^[10] pp: 3-4, based on which they are enlisted below in table,

Table-4 Properties of Lead Rubber Bearing Isolator

U1 Linear Effective Stiffness	15000000 kN/m
U2 and U3 Linear Effective Stiffness	800 kN/m
U2 and U3 Nonlinear Stiffness	250 kN/m
U2 and U3 Yield strength	80 kN
U2 and U3 Post Yield stiffness ratio	0.1
PYSR	0.1

Table-5 Properties of Friction pendulum system isolator

U1 Linear Effective Stiffness	15000000 kN/m
U1 Nonlinear Effective Stiffness	15000000 kN/m
U2 and U3 Linear Effective Stiffness	750 kN/m
U2 and U3 Nonlinear Stiffness	15000 kN/m
U2 and U3 Friction Coefficient, Slow	0.03
U2 and U3 Friction Coefficient, Fast	0.05
U2 and U3 Rate Parameter	40
U2 Radius of Sliding Surface	2.23

2.4 Loads considered

Dead Load: The dead load is considered as per IS: 875 (Part-1)-1987.

Imposed Load: The Imposed load is considered as per IS: 875 (Part-2)-1987, Live Load for Floors: 3.0 kN/m², Floor Finish: 1.25 kN/m, Wall Load: 11.14 kN/m.

Seismic Load: The seismic load is considered as per IS: 1893 (Part-1)-2002

III. RESULTS AND DISCUSSIONS

The comparison of different parameters like displacement, Storey shear, storey drift and time period is done and tabulated from the results obtained from response spectrum analysis of RCC, Steel and Composite structures in fixed base and LRB and FPB base isolated base isolated conditions.

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3.1 Storey Displacement

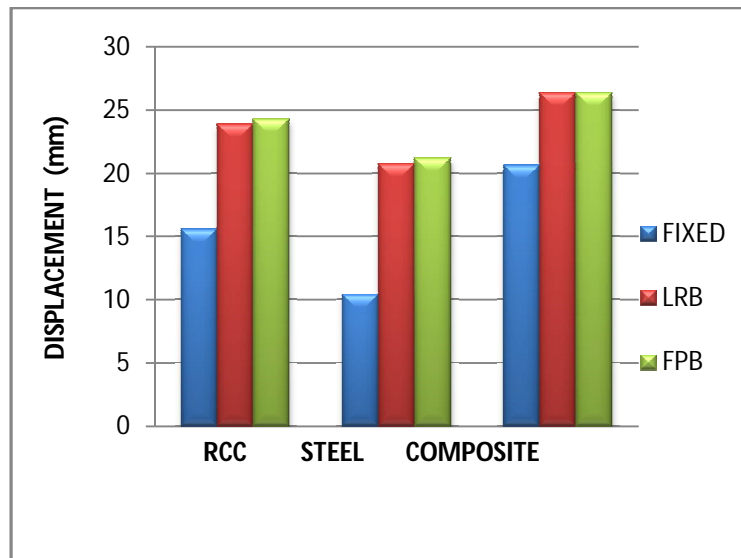


Fig.4 Displacement v/s different models

The fig.4 shows that the displacement of both the base isolated structures increases compared to that of fixed base structures. In RCC (LRB= +35%, FPB= +36%), In Steel (LRB=+50%, FPB=+51%), In Composite (LRB & FPB= +22%) increase is obtained.

3.2 Storey Drift

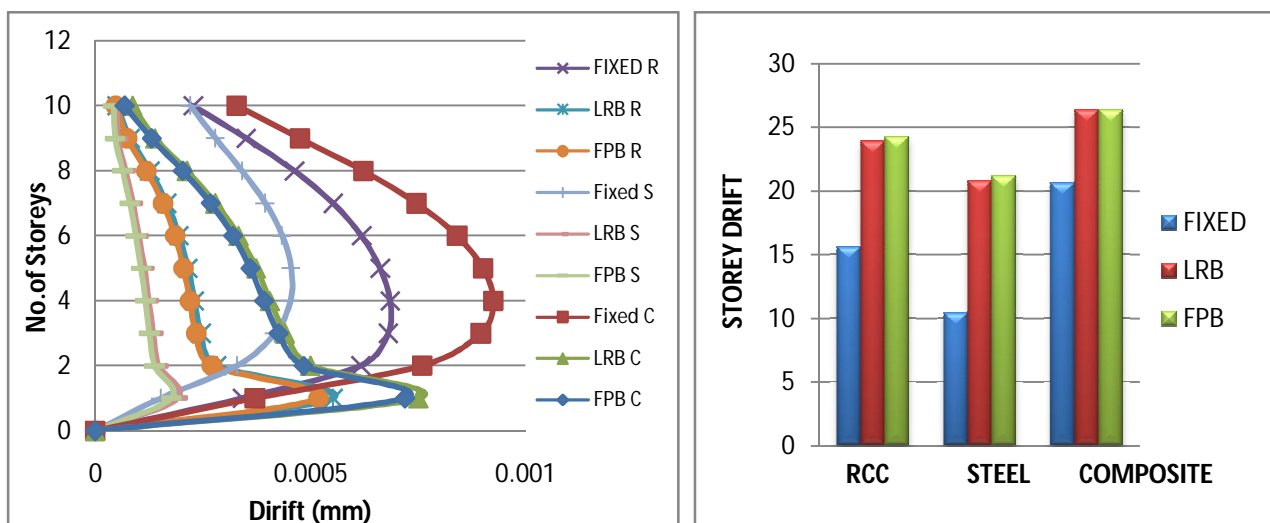


Fig.5 Storey drifts v/s different models

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The fig.5 shows that the storey drifts in both the base isolated structures decreases (except initial floor levels) with the increase in storey heights compared to that of fixed base structures. The base isolated structure produces larger drifts only in the first floor as shown in the figure. The reduction in RCC (LRB= -20%, FPB= -25%), In Steel (LRB=-58%, FPB=-62%), In Composite (LRB =-19%, FPB= -23%) is obtained.

3.3 Base Shear

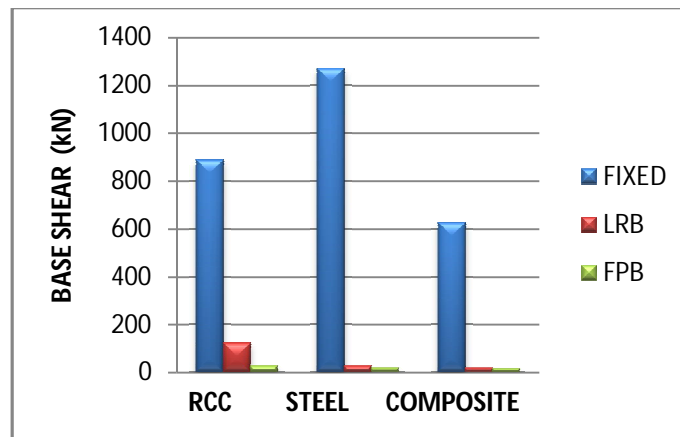


Fig.6 Storey shear v/s different models

The fig.6 shows that the base shear reduces completely in both the base isolated structures compared to that of fixed base structure. The reduction in RCC (LRB= -69%, FPB= -68%), In Steel (LRB=-77%, FPB=-78%), In Composite (LRB =-58%, FPB=-59%) is obtained. Among two isolators FPB isolated structures shows lesser base shear than that of LRB isolated structures.

3.4 Time Period

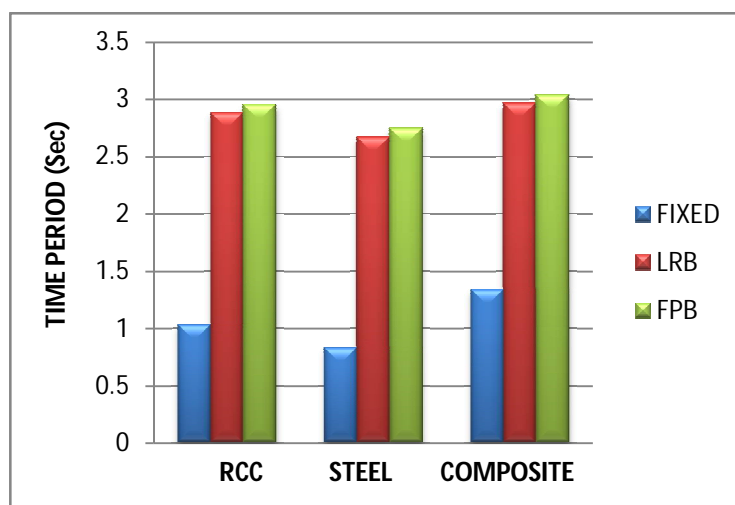


Fig.7 Time period v/s different models

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The fig.7 shows that the time period of base isolated structures increases compared to that of fixed base structures in all the three material properties. In RCC (LRB= +64%, FPB= +65%), In Steel (LRB=+69%, FPB=+70%), In Composite (LRB =+55% & in FPB= +56%) increase is obtained.

IV .CONCLUSION

In this project an attempt is made to understand the effectiveness of base isolating system for earthquake. On the basis of the analysis the following conclusions are drawn.

- There is an increase in time period value for base isolated structure compared to that of fixed base structure.
- Both the isolation system increases the time period compared to fixed base. But FPB isolation system provides more time period than LRB isolation system.
- Results also shows that the time period in the Composite structure is maximum compared to RCC and steel structure in both base isolated and fixed base structures.
- There is a large reduction in the base shear for the structure with base isolation as compared to fixed base structures.
- Both the base isolation system gives almost same amount of reduction in the base shear for different structures such as RCC, Steel and Composite.
- More reduction in base shear can be achieved for steel structure as compared to RCC & Composite structure.
- The displacement of the isolated structure increases due to a large increase in the flexibility of the structure.
- Out of two base isolation systems, it is found that the displacement in FPB isolation is more compared to that of LRB isolation system. The analysis result also shows that the maximum displacement is occurred in Composite structure as compared to RCC and Steel structure.
- From the analysis result, it is observed that only the first storey of the base isolated structure gets more storey drift value compared to fixed base structure. But in the remaining storeys the drift values goes on decreasing in the base isolated structure and the drift value goes on increasing in the fixed base structure.
- Based on the results, it was also found that among the two isolators, FPB isolator gives better performance compared to LRB isolator for irregular medium storey structures.

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BIOGRAPHY



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