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Seismic Performance of RC Structure Using Different Base Isolator

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Abstract

Hospital buildings are of great importance after any natural calamity such as earthquake. The structural and non-structural components should remain operational and safe after earthquake. So to mitigate the effect of earthquake on the structure the base isolation technique is the best alternative as a seismic protective system. The basic idea of base isolation system is to reduce the earthquake induced inertia forces by increasing the fundamental period of the structure. The aim of this study is the use of High density rubber bearing (HDRB) and friction pendulum system (FPS) as an isolation device and then to compare various parameters between fixed base condition and base isolated condition by using SAP2000v14 software. In this study the (G+12) storey hospital building is used as a test model. Nonlinear time history analysis is carried out for both fixed base and base isolated structure. The result obtained shows the reduction in base shear in both direction and increase in the displacement and time period for the base isolated structure.

Keywords: Base isolation, HDRB, Non-linear time history analysis, SAP2000..

Introduction

Hospital facilities must remain safe after the earthquake, for providing routine medical services and to save the life of human beings. Hence to mitigate the response of earthquake on the structure many engineers and architects trying to find out the best applicable method to reduce the response given to ground motion by the structures. Base isolation is one of the best alternatives for this issue. During earthquake the conventional structure without seismic isolation is subjected to substantial storey drifts, which may lead to damage or even collapse of the building. Whereas the isolated structure vibrates almost like a rigid body with large displacement due to the presence of isolators at the base of structures. In the base isolation technique the flexible interface is introduced between the foundation and the base of the superstructure from earthquake ground motion there by increasing the fundamental time period of the structure. A source of damping is also provided to reduce the deflection of the structure. Fig. 1 illustrates the behaviour change of structure without base isolator and with base isolator incorporation.

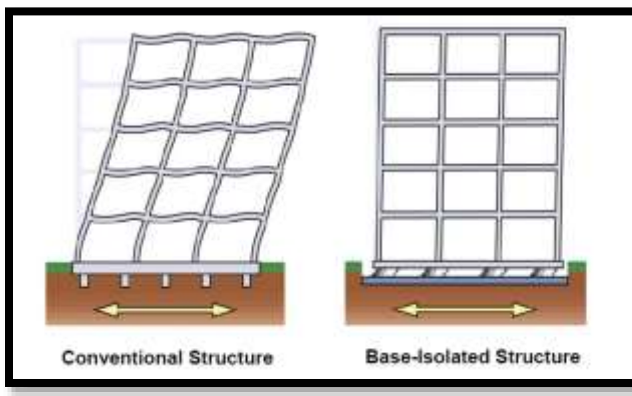

Fig.1 Effect of Base Isolation

Literature Review

Dhawade S.M. [1] presented the comparative study for seismic performance of base isolated & fixed based RC frame structure. The high density rubber isolator used as a isolation device. The work presented by author was done on (G+14) structures using ETABS software. A linear static analysis was carried out on the given structure. The comparative study was presented hear between fixed base and base isolated structure. A result shows

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reduction in the storey drift, shear, acceleration and increment in the storey displacement.

Chandak N. R. [2] was presented the work reelected to Effect of Base Isolation on the Response of Reinforced Concrete Building. The six storey building is analyzed with rubber isolating device and by providing friction pendulum isolation device at its base. The analysis was done by using response spectrum analysis. Results obtained from the presented work shows that there is reduction of base shear, storey drift, storey shear, torque and increment in the storey displacement.

Santosh H.P. *et al.* [3] presented the work on seismic analysis of low to medium rise building for base isolation. The lead rubber isolator was used as an isolating device. The analysis was done by using STAAD Pro software. The six storey building were analyzed both by considering the base as fixed base structure and then by considering it as a base isolated by means of lead rubber bearings. The analytical results obtained shows the reduction in storey acceleration and the storey shear in case of base isolated structure compared to non isolated structure

Torunbalci N. *et al.* [4] presented the analytical study on mid-storey building by considering various seismic isolation techniques. For a case study, a six storey building was analyzed by using three dimensional nonlinear time history analysis. The analysis was done on the basis of various seismic isolation and energy dissipating alternatives. Alternatives which included rubber bearings, friction pendulum bearings, additional isolated storey and viscous dampers.

Base Isolation

In seismic isolation, the fundamental purpose is to reduce substantially the ground motion forces and energy transmission. Installing isolating layers with a considerable horizontal flexibility is a good way to achieve that aim. Base isolation is classified under two categories. They are elastomeric bearings and sliding type bearings.

Types of Base Isolators

1. Laminated Rubber Bearing
2. Lead Rubber Bearings (LRB)
3. High Damping Rubber Bearings (HDRB)
4. Friction Pendulum System (FPS)

Lead Rubber Bearings

Lead rubber bearing (LRB) are the laminated rubber bearing containing one or more lead plugs to deform in shear. The lead in the bearing deforms physically at a flow stress of 10 MPa, providing the bearing with bilinear response. For that reason the lead must fit tightly in the elastomeric bearing, and this is achieved by making the lead plug slightly larger than the hole and applying force at the time of inserting it in the hole. The cross-sectional view of LRB is shown in Fig. 2

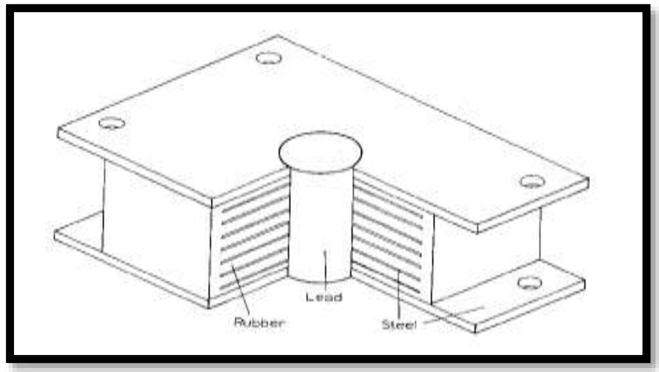

Fig. 2 Lead rubber bearing [6]

High Density Rubber Bearings

High density rubber bearing (HDRB) is another type of elastomeric bearing which consist of thin layers of high damping rubber and steel plates in alternate layers. Like LRB this type of bearing does not contain lead at the center of bearing. The rubber used is either natural rubber or synthetic rubber which provide a sufficient amount of damping. The cross-sectional view of HDRB is shown in Fig. 3

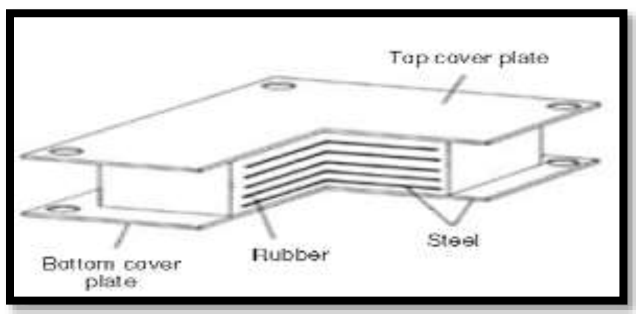

Fig. 3 High Density Rubber Bearings [6]

Friction Pendulum System

The friction pendulum system (FPS) is a sliding type isolation system and consists of a spherical stainless steel surface and an articulated slider, covered by Teflon based composite material. It works on the principal of simple pendulum. Friction Pendulum bearings are seismic isolators that are installed between a structure and its foundation to protect the supported structure from earthquake ground shaking. The cross-sectional view of FPS is as shown in Fig. 4

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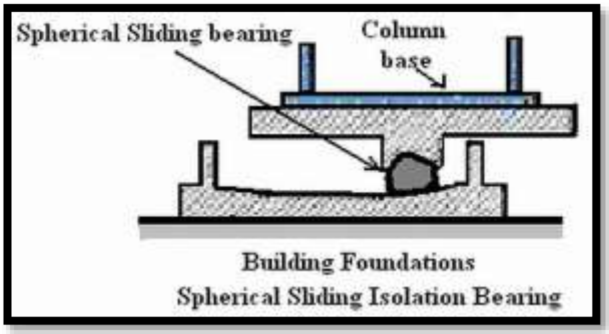

Fig. 4 Friction Pendulum System [6]

Case study of hospital building

The (G+12) RCC hospital building is taken for the case study & it is assumed to be located in zone IV as per IS:1893-2002.It is modelled in SAP2000 [7] software and analyzed for fixed base and then analysed by providing High Density Rubber Bearing (HDRB) and Friction Pendulum System (FPS) isolator at the base. The non-linear time history analysis is carried out by considering El-Centro time history data. Comparison between the fixed base and the base isolated structure is carried out and the parameters such as base shear, mode period, storey displacement, storey drift and storey acceleration are compared using SAP2000 [7].

Building Details and Plan

The (G+12) RCC Hospital building is taken for the case study and its structural details such as grade of concrete, grade of steel, beam sizes, column sizes and all the other parameters are assumed as per Table 1.

Table 1. Building Details

Grade of concrete	M 40
Grade of steel	Fe 415
Floor to floor height	3 m
Plinth height above GL	1 m
Parapet height	1.2 m
Slab thickness	150 mm
External wall	230 mm
Internal wall	150 mm
Column	450 × 450 mm
Beam	300 × 500 mm
Live load on all floors	3 kN/m^2

Properties of Base Isolators Used For Analysis

The design properties of both High Density Rubber Bearing (HDRB) & Friction Pendulum System (FPS) isolators for the 13 storey RCC hospital symmetric building are as shown in Table 2.

Table 2. Properties of isolators

Type	HDRB	FPS
Vertical Stiffness (U1)	2812845.46 kN/m	29000000 kN/m
Linear Stiffness (U2 & U3)	2454 kN/m	1450 kN/m
Non-linear Stiffness (U2 & U3)	2069.24 kN/m	29000 kN/m
Yield Strength (Q)	130.14 kN	-
Damping (β)	0.10	0.10
Radius of dish (R)	-	1.01 m

The (G+12) RCC Hospital building is taken for the case study. The plan and 3D view of the 13 storey hospital building are as shown in Fig.5 and Fig.6 respectively.

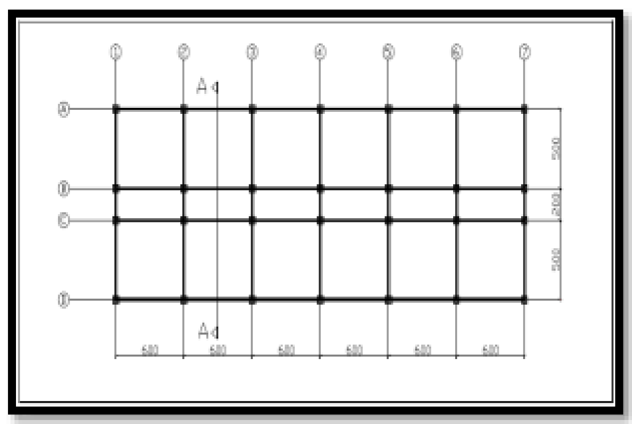

Fig.5 Plan view of symmetrical building

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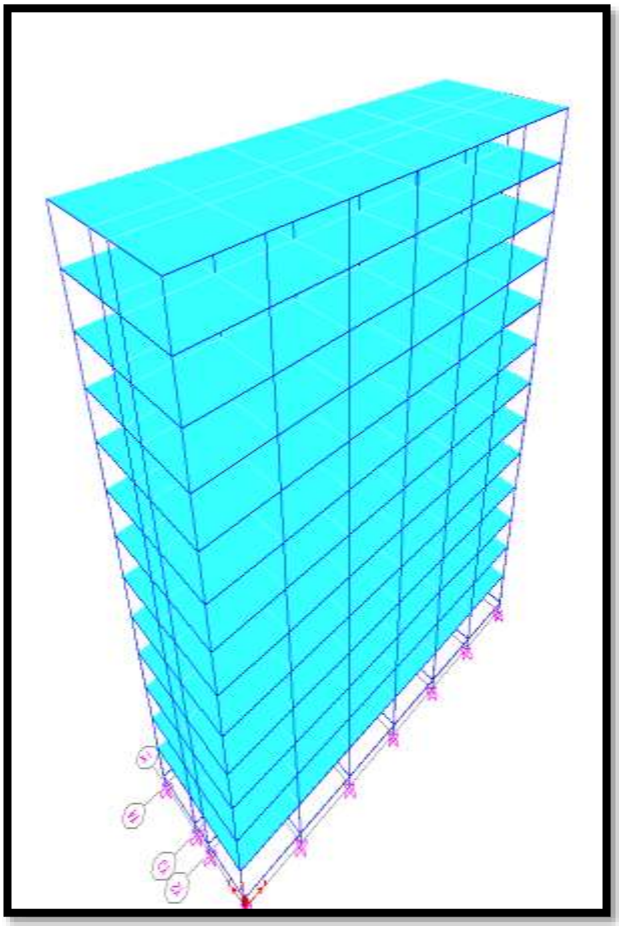

Fig.6 3-D Model of fixed base structure

Results and discussion

In this study, the comparison between the fixed base structure and the base isolated structure is done. The aspects such as base shear, storey drift and storey acceleration reduces due to the use of base isolators as compared to the fixed base structure. Also parameters such as time period and storey displacement increases in the base isolated structure. The above results are presented in the tabular format in both X and Y direction as follows.

Time period

Modal period of fixed base structure and base isolated structure using High Density Rubber Bearing (HDRB) & Friction Pendulum System (FPS) isolators are compared. Mode period both in X & Y direction for all three cases was compared and shown in Table 3.

Table 3: Time period in X & Y Direction

Cases	Fixed Base (Seconds)	HDRB (Seconds)	FPS (Seconds)
X-direction	2	2.94	3.44
Y-direction	1.98	2.92	3.41

Base Shear

The graph shows the maximum base shear both in X & Y directions.

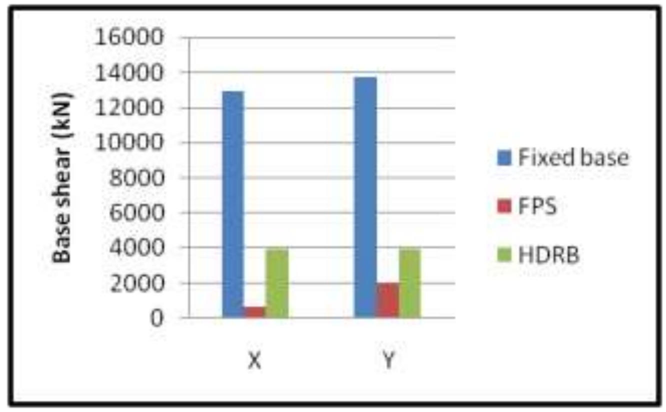

Fig.7 Base Shear in X & Y Direction

Storey Displacement

The graph (Fig.8 & Fig.9) shows the storey displacement for the structure, both in X and Y direction respectively.

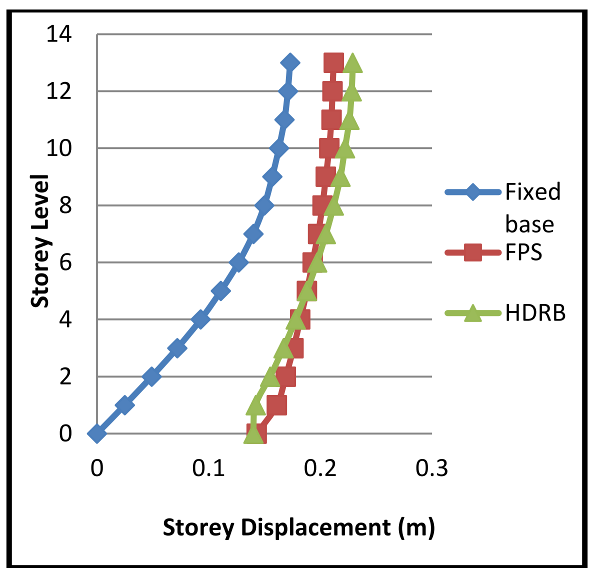

Fig.8 Storey Displacement in X-Direction

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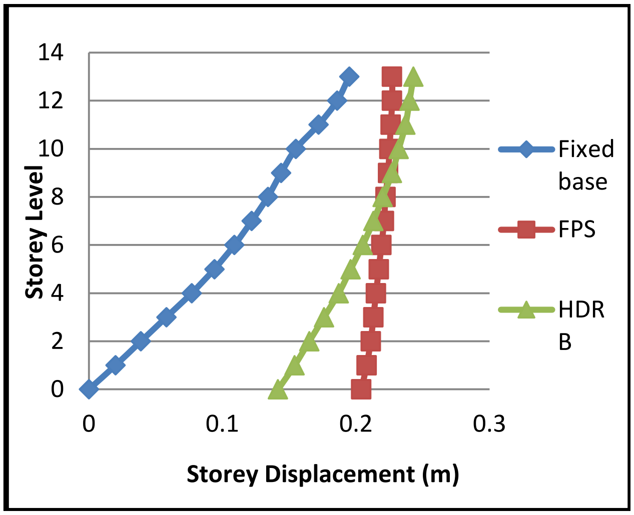

Fig.9 Storey Displacement in Y-Direction

Storey Drift

The graph (Fig.10 & Fig.11) shows the storey drift for the structure, both in X and Y direction respectively.

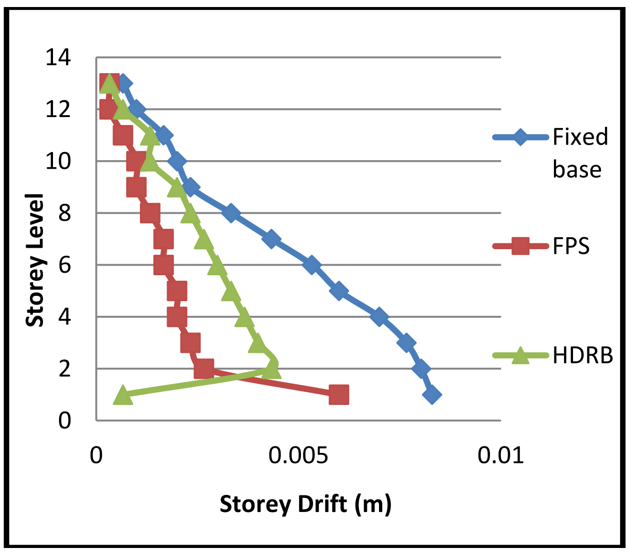

Fig.10 Storey Drift in X-Direction

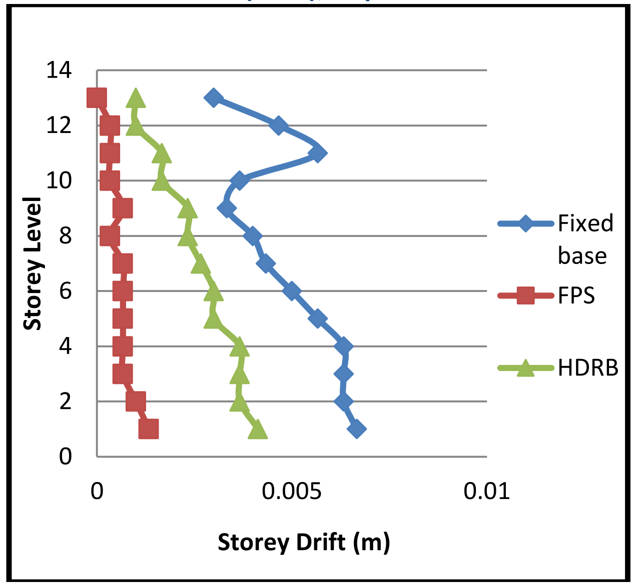

Fig.11 Storey Drift in Y-Direction

Storey Acceleration

The graph (Fig.12 & Fig.13) shows the storey acceleration for the structure, both in X and Y direction respectively.

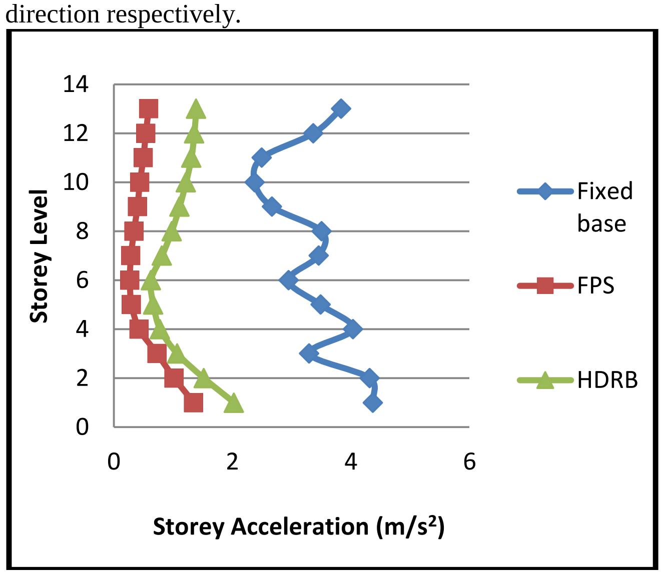

Fig.12 Storey Acceleration in X-Direction

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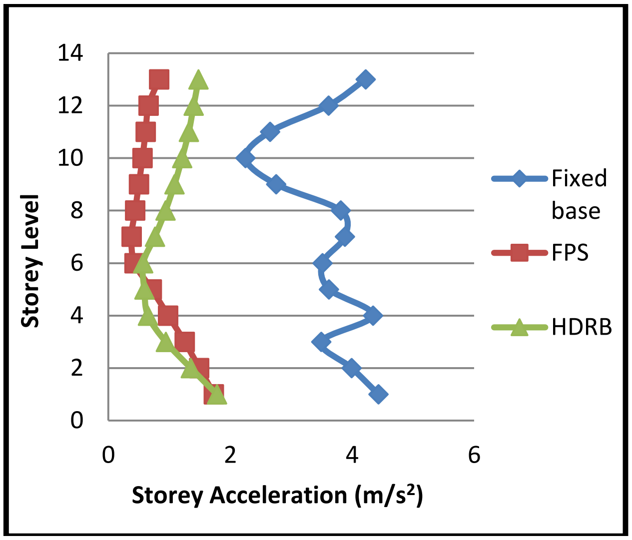

Fig.13 Storey Acceleration in Y-Direction

Conclusions

- Base isolation method has proved to be a reliable method of earthquake resistant design.
- The results of the research shows that the response of the structure can be reduced by the use of High Density Rubber Bearing (HDRB) and Friction Pendulum System (FPS) isolators.
- The base shear in X-direction is reduced by 70% in HDRB & it is reduced by 94% by the use of FPS. Also in Y-direction it is reduced by 71% in HDRB & in FPS it is reduced by 85%.
- Time period of both the base isolated structures i.e. HDRB and FPS increases as compared to the fixed base structure.
- The storey displacement is more in both directions, in both the cases of base isolated structure using HDRB & FPS.
- Results shows that storey drift both in X & Y directions considerably reduced by using base isolation devices over the conventional structure.
- Results shows that storey acceleration both in X & Y directions considerably reduced by using base isolation devices over the conventional structure.

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