Effect of Base Isolation on RCC Rectangular Building

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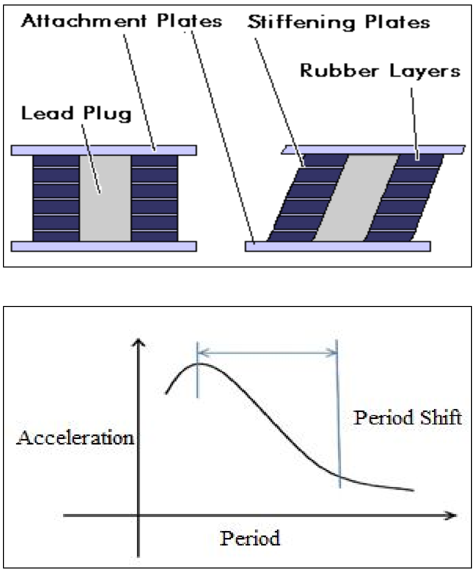
Abstract- *In passive energy dissipation systems used for earthquake resistant structures, base isolation is one of the most powerful systems. For understanding the effect of base isolation system, G+5 storey models are considered with planner asymmetry. Lead rubber isolator is used for controlling the response of building during earthquake effects and tremors. In this paper the response of building is checked for lead rubber isolator with the help of different parameters. On-linear time history analysis is done to perform the analysis. The results are checked with the help of displacement, time period and base shear. The results shows that the performance of building is become well during earthquake after using Base isolator.*

Keywords- Lead rubber isolator, Seismic Response, soil-structure interaction.

I. INTRODUCTION

Earthquake resistant building is basically to design a building which can withstand earthquake forces. As Seismic base isolation is a well-defined passive control system of earthquake for building. Earthquakes tremors are of greatest hazards; as due to these tremors there is serious damage to life as well as property also, the effect is most severe in manmade structures. To overcome these hazards caused due to earthquake waves there are so many modifications has to be done in current structural design by engineers and architects to nullify this effect. The main objective of seismic base isolation is to improve the response of building during earthquake forces i.e. during horizontal ground shaking of building. Seismic base isolation is a well-defined building protection system against earthquakes. Earthquakes are one of nature greatest hazards; throughout historic time they have caused significant loss of life and severe damage to property, especially to man-made structures. On the other hand, earthquakes provide architects and engineers with a number of important design criteria foreign to the normal design process. Seismic isolation is a structural design approach that aims to control the response of a structure to horizontal ground motion through the installation of a horizontally flexible and vertically stiff layer of structural isolation hardware between the superstructure and its substructure. The dynamics of the structure is thus changed such that the fundamental vibration period of the isolated structural system is significantly longer than that of the original, non-isolated structure, leading to a significant reduction in the accelerations and forces transmitted to the isolated structure and significant displacements in the deformable, structural base isolation, layer.

Huge amount of literature is available on the isolated structures and their earthquake performance (Ribakov and Iskhakov [1], Hossein Monfared et.al. [2], Chandak [3]).The most extensively studied base-isolation system is laminated rubber bearing (LRB) with and without a lead core (Kelly 1982, 1986; Kelly and Hodder 1982). More buildings are being built on laminated-rubber-bearing base-isolation systems all over the world [4].Fig.1 shows c/s of lead rubber isolator and period shift of building after installation of isolator.



(a) (b)

Fig.1 C/S of (a) Lead Rubber Bearing [5] (b) Period shift induced by an isolator [6]

In recent years, many studies have been done on passive energy dissipation devices. The main objective is to understand the primary concept and behavior of the base isolated structures & to compare the responses of isolated building with fixed base building with the effect of SSI. The study is based on the comparison of base shear, time period acceleration, story drift member forces and energy dissipated by isolated building.

II. MATHAMATICAL MODEL

A mathematical model of fixed base and isolated model is as shown in fig.2. The governing equation of motion for both fixed base and isolated base models are given below. The equation of motion for the MDOF fixed base model can be written as,

$$[M]\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} = -[M]\{r\}(\ddot{u}_g) \quad \text{……..(i)}$$

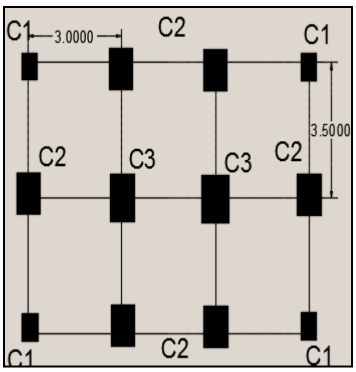
While for the MDOF isolated model can be written as

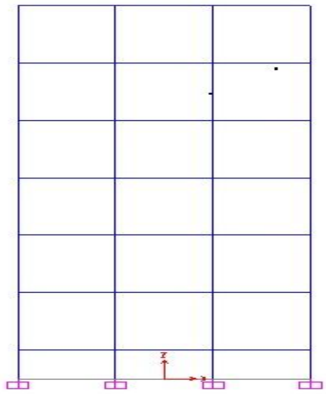
$$[M]\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} + [D]\{F_b\} = -[M]\{r\}(\ddot{u}_g) \quad \text{……...(ii)}$$

Where [M] is mass matrix, [C] is damping matrix, [K] is stiffness matrix, {u} is displacement matrix [D] is location matrix for isolator and {r} is vector of influence coefficient.

For this study, a G+6 storey building frame is considered with Rectangular planner configuration. Also, it is well known that the soil beneath the structure also affect the performance of energy dissipater during earthquake [7]. Hence, in this study three types of soil conditions are also considered. The values of soil-spring stiffness are calculated by formulae given in ASCE 41-06 [8]. The Fig.2 shows Rectangular plan while Fig. 3 shows the elevation for both planner configurations.

The building is of RCC with special moment resisting frame located in seismic zone V.





Rectangular Plan
Fig.2 Planner configuration of models
Fig.3 Elevation of building models

The design properties of building are given in Table 1

Table 1: Properties of building models

	Rectangular Building
Mass of individual storey (N.sec^2/m)	532300
Stiffness of each storey (N/m)	29839.73 *10^{3}N/m
damping of structure (C)	5% for RCC structure

For the building models considered for this study Lead Rubber Isolators are designed as per design approach discussed by Kelly & James [1993]. For the modeling of this isolator in SAP2000, the link element 'Rubber Isolator' having same behavior as isolator is used. The properties of rubber isolator [9] are shown in Table 2.

Table 2: Properties of Lead rubber isolator

Effective stiffness K_{eff} (kN/m)	1029.15
Yield force F(kN)	16.89
Post elastic stiffness K_2 (kN/m)	895.43
Pre elastic stiffness K_1 (kN/m)	8954.3
Yield displacement Dy	0.002256

For performing Non-linear time history analysis step by step procedure is followed as per IS 1893:2002.For study purpose two past recorded earthquakes are taken shown in Table 3

Table 3: Earthquakes used for study

EQ	PGA	Moment Magnitude	Year of Occurrence
Imperial Valley	0.248g	6.9	1940
San Fernando	0.181g	6.5-6.6	1971

The peak ground acceleration is given in the terms of acceleration due to gravity. Two earthquakes named as Imperial Valley and San Fernando are taken for analysis.

III. RESULTS AND DISCUSSION:

Using SAP2000 the analysis is carried out for rectangular shape building model for fixed base and isolated base model. The natural time period for fixed based and isolated base for rectangular building model is shown in Table IV.

Table 4: Natural time period of building models

		Without SSI
Rectangular shaped building (Sec)	Fixed base	1.2
	Rubber Isolator	2.444

C

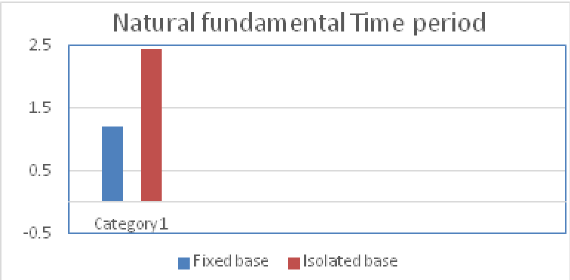


Fig.4 Natural fundamental time period in X-direction for Rectangular shaped building

From the table 4, it is clear that for rectangular model the time period increases compared with fixed base building after introducing isolator. The time period increases relatively higher after introducing the base isolator. As it provides flexible base for the building.

Table V: Base shear of models

		Without SSI
Rectangular shaped building (kN)	Fixed base	1267.559
	Rubber Isolator	251.409

From the Table V it is clear that the lateral seismic force that is the value of base shear is increases after installation of isolator. As the acceleration of building is reduces and time period is increases the value of base shear is reduces. Fig.4 shows the base shear value for two given earthquakes with different combination of loads.

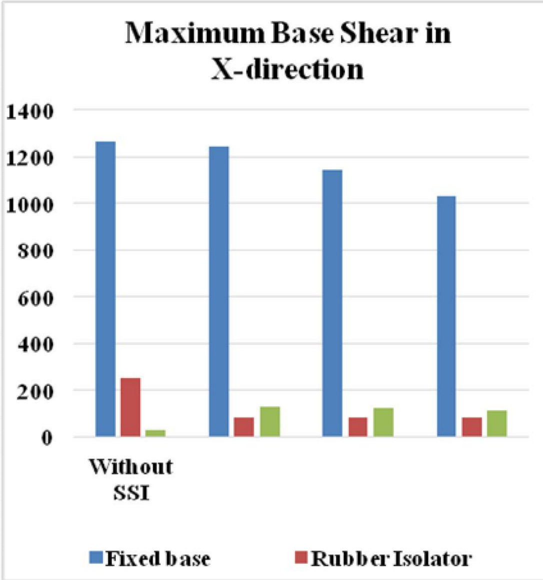


Fig.4 Maximum Base Shear in X-direction for Rectangular shaped building

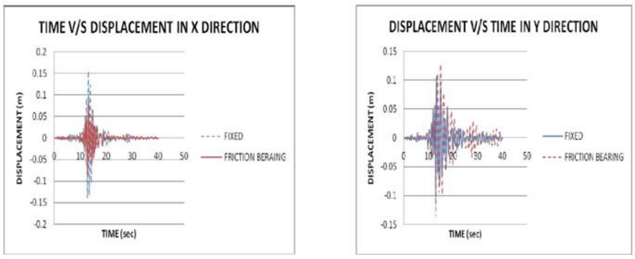


Fig.5 Maximum Displacement in X-direction for Rectangular shaped building

IV. CONCLUSIONS

From analytical results, it is observed that base isolation reduces the overall seismic response of building in comparison to fixed base building for given rectangular model. The comparison of models show that the natural time period of vibration increases more than double for isolated building. Time period affects the earthquake response of the structure, as the time period increases the base shear and acceleration values found to be reducing. Introduction of seismic base isolation system at base level of building shows low base shear values and makes the building to behave like a rigid body structure. The results shows that the base isolator is reducing the overall effect of earthquake forces on given RCC building.

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