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Dynamic Analysis of Soft Storey Frame with Isolators

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ABSTRACT

Soft storey buildings are very common in Indian housing construction and the bottom storey is left open without walls for car parking. Past earthquakes showed that these kinds of buildings performed poor and the damages are also heavy. As the base isolation is a technique developed to prevent or minimize damage to building during an earthquake, this study focuses on the time history analysis of a soft-storey building with and without lead rubber isolator. The soft-storey building with and without isolator is analysed using Elcenrto earthquake data and the dynamic characteristics are compared.

KEYWORDS: *seismic evaluation; Time history analysis; soft storey, Base isolator*

I. Introduction

In recent years, use of base-isolation systems for protecting structures against earthquakes has attracted substantial attention. All structures are subjected to vibration. From few decades in high seismic areas base isolation has rapidly been adopted as structural design technique for buildings. The basic idea behind base isolation is separation of building from its foundation by introducing a flexible interface so that the building stays unaffected from the ground motion. Also we can say that when ground moves aggressively, building will tend to move ideally as a rigid body rather than collapsing. Generally in analytical model separation is total but practically there will be some co-relation between the ground and the super structure which provides flexibility of the structure. Mainly, laminated rubber bearing and lead rubber bearing are the most common types of base isolators used in buildings.

Kalantari and Hoseini [1] studied the behaviour of base-isolated structures with two different types of isolation systems (lead rubber and friction pendulum isolators) are compared with each other and also compared with fixed base structures considered as control model. Fabio Mazza and Vulcano [2] focused on the mechanical properties of the lead rubber bearings, they have determined the primary and secondary shape factor and design vertical pressure of the bearings to give a stable mechanical properties. Vasant and Jangid [3] investigated the seismic response of multi-storey building which is supported on various base isolation system during impact with adjacent structures. The impact response of building is studied under the variation of parameters such as stiffness of impact element, size of gap and found that effect of impact to be severe for the system with flexible superstructure and greater stiffness of storeys. Michele and Trombetti [4] focused on "shock-absorbing soft storey concept". Their purpose is to conceive a first storey isolated building capable of satisfying selected seismic performance objectives. The performance of the building under multiple earthquake design levels are finally verified through non linear time history analysis whose results confirm the effectiveness of proposed approach. Providakis. [5] observed the seismic behavior of steel-concrete composite structures and numerically investigated. Seismic analysis is performed by means of the static non linear (pushover) analysis procedure conducted on two five-storey three dimensional buildings. The result of this study allowed the verification of the adequacy of the attachment isolation system as well as the comparison of the behaviour of the seismic protecting building showing the benefits of the application of the isolation devices. In this investigation, an attempt has been made to study the effectiveness of providing lead rubber isolator in a soft-storey building under seismic excitation.

II. METHODOLOGY

For the present study a RCC framed structure with soft storey is modelled which is the base model for the study. In which the modal analysis and time history analysis are carried out, for the analysis elcentro earthquake data are given as input and as results maximum displacements of all storeys of building, maximum base shear and maximum are considered. After that a model with lead rubber isolator is created and again modal and time history analyses are performed on the structure with isolators. The results of two models are compared with each other i.e structure with fixed base and structure with base isolators.

1. Modelling of fixed base structure

RCC framed building with open storey and brick infill walls in upper storeys are modelled as shown in Figure 1. The building considered is G+ 4 storeyed building. The plan area of building is 10m x 10m with 3m as height of each typical storey. The total height of building is 15m and it consists of 2bays of 5m in each direction., hence the building is symmetrical about both the axis. The column has dimensions of 0.5m x 0.5m and the beams have dimensions of 0.3m x 0.45m and the slab thickness is 0.12m.

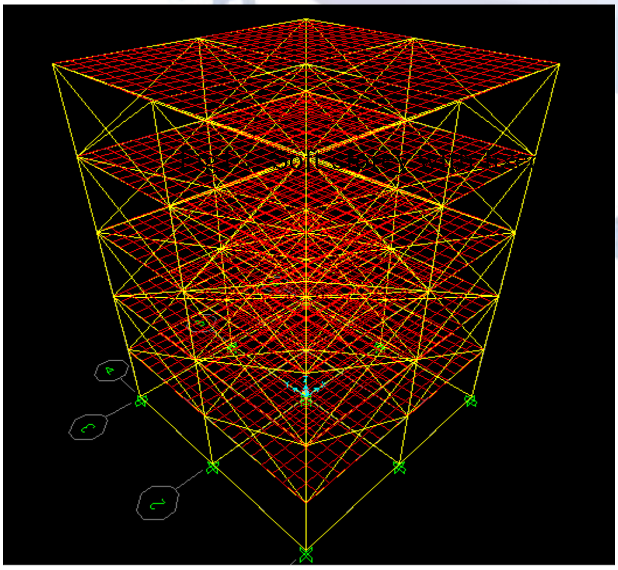

Fig1 :- Fixed base model with soft storey

2. Modelling of base isolated structure

The purpose is to improve the stiffness of the soft storey structure. Therefore the bearings are used in the same model (Figure 2) to analyse the efficiency of the structure. It can be seen that the failure mode is the shear mode which is predominant in the case of soft storey frame. The model is modified using the lead rubber isolators and the properties of isolators are obtained after design the isolators which is designed by taking the maximum axial force acting on the fixed base model. Table 1 shows the properties of isolators.

Table-1 Properties of isolators

Required Stiffness (K_{eff})	18661.44 kN/m
Bearing Horizontal Stiffness (K_b)	151.33 kN/m
Vertical Stiffness (K_v)	2540.76 kN/m
Yield Force (F)	14.72 kN
Stiffness Ratio	0.1
Damping	0.05

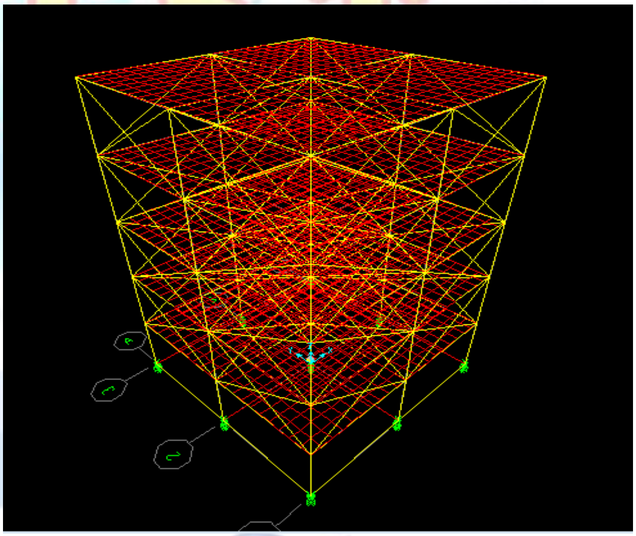

Fig 2:- Model with base isolator

3. Modal Analysis of models

After modelling of fixed base structure modal analysis is done on the structure and deformed shape (Figure 3) is obtained with corresponding time period (Table 2) and after that considering elcentro earthquake data as input time history analysis is done and from that the maximum response displacement at each floor of the fixed base storey is obtained and also the maximum base shear and maximum base moment are obtained.

Table 2:- Time period for the fixed base model

Modes	Mode-1	Mode-2	Mode-3
Time Period (s)	0.278	0.0902	0.0612

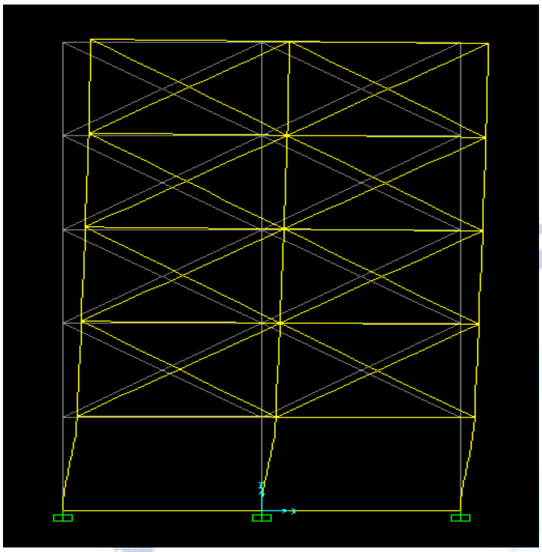

Fig3 :- Deformed shape of fixed base model

Table 3 shows the time period of model with isolators for the first three modes. Figure 4 shows the deformed shape of the model with isolators.

Table-3:- Time period for model with isolator

Modes	Mode-1	Mode-2	Mode-3
Time Period (s)	1.230	0.6374	0.0387

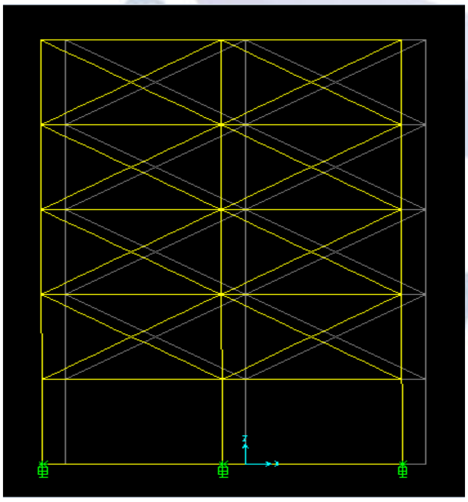

Fig 4:- Deformed shape of structure with isolator

4. Time History Analysis of models

After the modal analysis, time history analysis is done using Elcentro earthquake data (Figure 5). This data has chosen because its data are very close to Indian earthquake data.

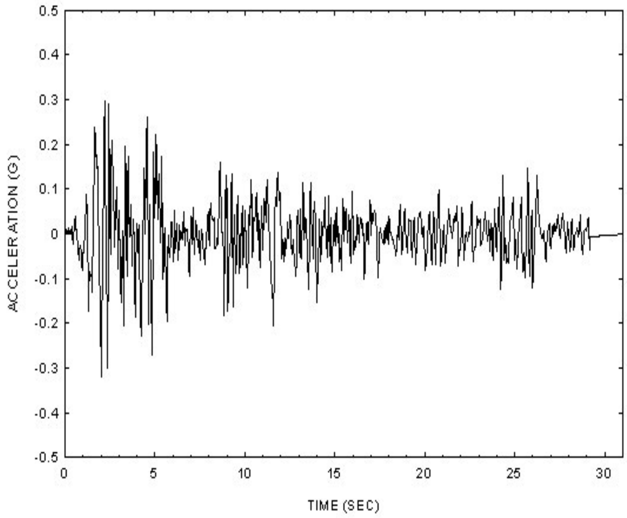

Fig:-5 Elcentro earthquake data

III. Results and Discussion

After analysis we get the results of both models which are compared with each other with respect to stiffness, response displacement, maximum base shear and maximum base moment.
The time period of the fixed base model is nearly 4.4 times reduced after incorporation of isolator in the model. It can be seen from the seismic spectrum as shown in Figure 6 that the severity of damage of the fixed base model is altered by using isolators.

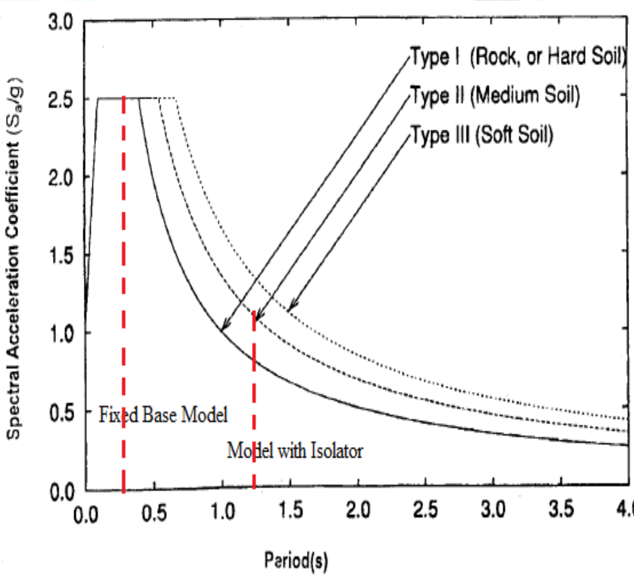

Fig:-6 Comparison of damage level in the models

Figure-7 shows the maximum displacement of both models and it is observed that the displacement in the model with isolator is much higher than the fixed base model; however the maximum drift is within the limit as specified in the seismic code IS 1893:2002.

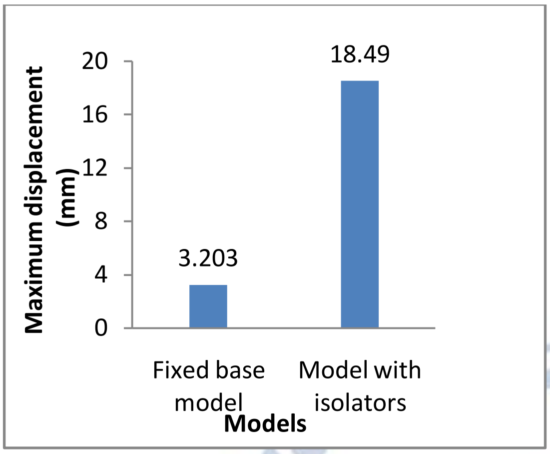

Fig 7:- Maximum Displacement for both models

Figures 8 to 11 show the base shear and base moment for fixed base model and model with isolator, respectively. It is observed that the base shear and base moment of the fixed base model is considerably reduced by adopting the isolation technique.

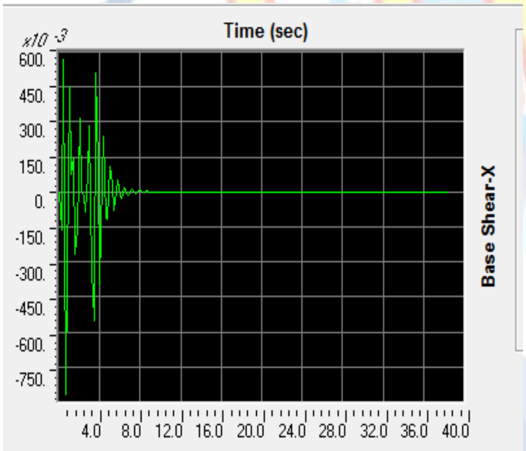

Fig 8:- Base Shear-Time history of fixed base model

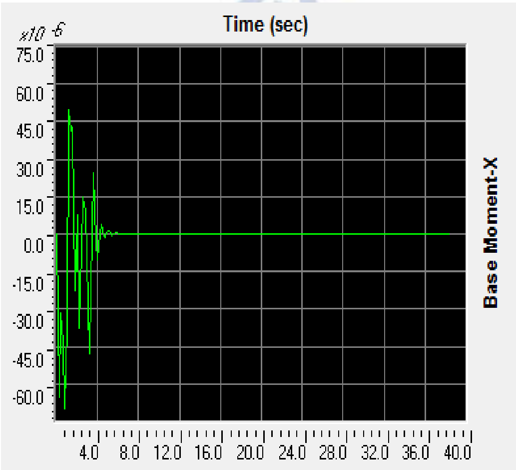

Fig 9:-Base Moment-Time history of fixed base model

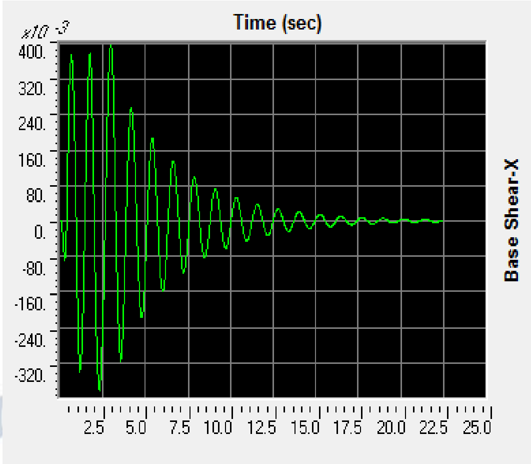

Fig 10:- Base Shear-Time history of building with isolator

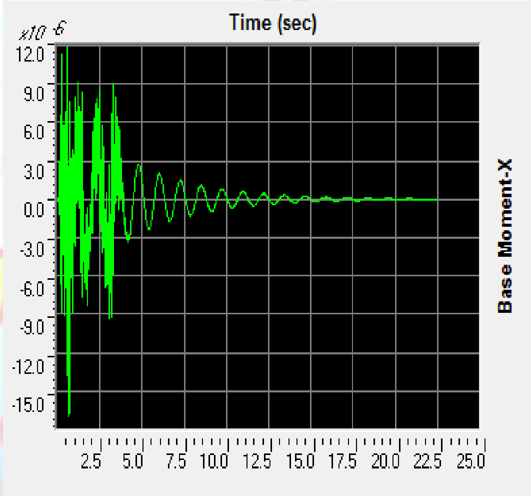

Fig 11:-Base Moment-Time history of building with isolator

IV. CONCLUSION

The investigation on soft-storey frame with modifications using lead rubber isolator yielded significant results. By using lead rubber isolator under the base of building the damage in the building due to earthquake can be reduced which is evident from the reduction in the fundamental time period, base shear and base moment.

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