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Seismic Performance for Fixed Base and Base Isolated Reinforced Concrete Structure

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ABSTRACT

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 study deals with structural behavior of building with and without base isolation. Lead rubber bearing is used as an isolation device then compare various parameters like Base shear, Displacement, Storey drift. 5and 15 storey buildings are test models. Nonlinear time history analysis is carried out for both fix base and base isolated structure.

Key Words: *Base isolation, Storey drift, Base shear, Nonlinear time history analysis, SAP2000*

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, which ensure the structures to withstand during frequent minor earthquakes and produce enough caution whenever subjected to major earthquake events. So that can save as many lives as possible. There are several guidelines all over the world which has been repeatedly updating on this topic. The analysis procedure quantifying the earthquake forces and its demand depending on the importance and cost, the method of analyzing the structure varies from linear to nonlinear. The behavior of a building during an earthquake depends on several factors, stiffness, adequate lateral strength, ductility, simple and regular configurations. The buildings with regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage compared to irregular configurations. But nowadays need and demand of the latest generation and growing population has made the architects or engineers inevitable towards planning of irregular configurations. Hence earthquake engineering has become an important branch of civil engineering.

The concept of protecting a building from the damaging effects of an earthquake by introducing some type of support that isolates it from the shaking ground is an attractive one, and many mechanisms to achieve this result have been proposed. It is secondary device, which is mounted on the foundation below the super structure. Isolation physically uncouples the structure from horizontal component of earthquake ground motion leading to substantial reduction in forced generated by an earthquake. Improved performance is therefore possible, causing a lower level of response than would be obtained from fix base structure. The isolation bearings are widely used in earthquake prone areas to protect the structure from seismic forces.

The present work aims at an objective demonstrating the effect of base isolation techniques like the use of lead rubber base isolator for symmetric and asymmetric buildings for low rise and high rise structures. The buildings studied in this section are 5 & 15-storey Reinforced concrete Moment Resisting Space Frames Designed for Gravity and Seismic Loads Using Linear Analysis. The structure is evaluated in accordance with seismic code IS-1893:2002 using Non-linear time history analysis with the help of the Sap 2000 version 16 software (CSI Ltd).

LITERATURE REVIEW

S.M.Wilkinson, R.A.Hiley performed non-linear time history analysis on a plane frame model that's capable of analyzing high rise buildings subjected to earthquake forces. The model introduces plastic hinges with ideal plastic properties in a regular plane frame. The displacements are described by the dynamic degrees of freedom which essentially is the translation, and moment of inertia of the diaphragm about the vertical axis.The dynamic integration adopted was the Runge-kutta method. Subsequently comparison was made with the static method. The authors concluded that the efficient simplified model for the analysis of high-rise buildings has been presented. The model accurately predicts higher modes of vibration and therefore can be used to consider the influence of these on the collapse of buildings.

*P. C. Tsopelas, S. Nagarajaiah, M. C. Constantinouand A. M. Reinhor*In this paper an analytical model and an algorithm to analyze multiple buildings on a common isolation system are presented. Verification of the accuracy of the algorithm by comparison with results obtained using a general purpose finite element program are presented. A multiple building base-isolated structure is analyzed and the results are used to demonstrate the importance of analyzing the combined system as against analyzing individual buildings with the help of Non-linear time history analysis. The authors concluded that that the response of the combined system of several buildings on a common isolation system can be significantly different than that of individual buildings with individual isolation systems. The reason for this is that the torsion characteristics of the combined system can be significantly different than that of the individual system.

*Dhawade S.M*The comparative study for seismic performance of base isolated & fixed based RC frame structure carried out in this paper. The high density rubber isolator used as a isolation device. Thework 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 reduction in the storey drift, shear, acceleration and increment in the storey displacement.

Chandak N. R. In this paper thework done on 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.

Torunbalci N. and G. Ozpalanlar.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

BASE ISOLATION

The concept of protecting a building from the damaging effects of an earthquake by introducing some type of support that isolates it from the shaking ground is an attractive one, and many mechanisms to achieve this result have been proposed. Although the earlier proposals go back hundred years, it is only in recent years that base isolation has become a practical strategy for earthquake resistant design. It is a passive control device that is installed between the foundation and the base of the building.

The base isolation system introduces a layer of low lateral stiffness between the structure and the foundation. With this isolation layer the structure has a natural period which is much longer than its fixed base natural period. This lengthening of the period can reduce the pseudo-acceleration and hence the earthquake induced forces in the structure. In buildings, the base isolator protects the structure from earthquake forces in two ways. By deflecting the seismic energy andby absorbing the seismic energy. The seismic energy is deflected by making the base of the building flexible (instead of fixed) in lateral directions, thereby increasing the fundamental time period of the structure.

As buildings with longer time periods attract less seismic force the isolation system deflects the seismic energy. In particular, high energy in the ground motions at highermode frequencies are deflected. The seismic energy is absorbed by the isolator because of its non-linear response to earthquake excitation. The (internal) force–displacement curve of isolators under sinusoidal excitation exhibits hysteretic behavior and, therefore, much of the input energy to the isolators is lost in the hysteresis loop. Because of these two properties of the isolators, they have become very attractive passive control devices to be used in the control of seismic response of structures, especially the building structures. Extensive research, both theoretical and experimental, has been carried out in the area of base isolation of structures. The major effect of seismic isolation is to increase the natural period which reduces the acceleration and thus force demand on the structure.

In terms of energy, an isolation system shifts the fundamental period of a structure away from the strongest components in the earthquake ground motion, thus reducing the amount of energy transferred into the structure (i.e., an isolation system “reflects” the input energy away from the structure). The energy that is transmitted to the structure is largely dissipated by efficient energy dissipation mechanisms within the isolation system.

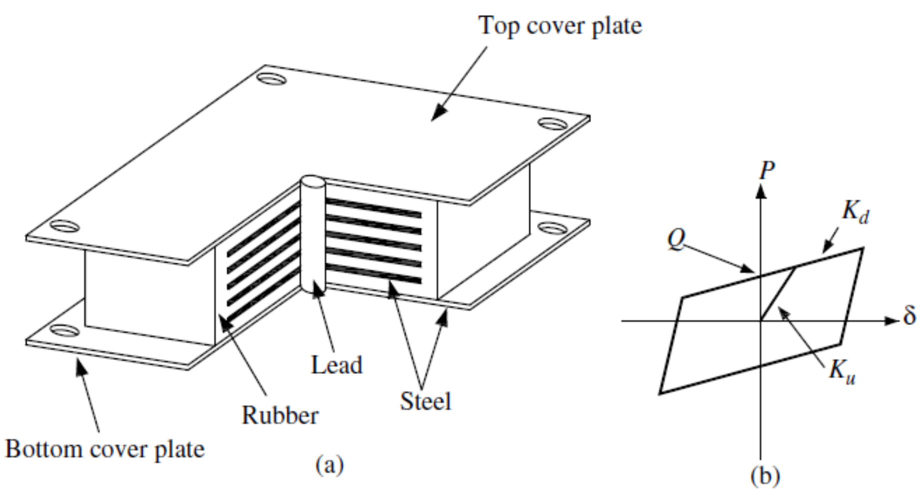


Figure.1: illustrates the Lead Rubber Bearing and the corresponding force-deformation graph.

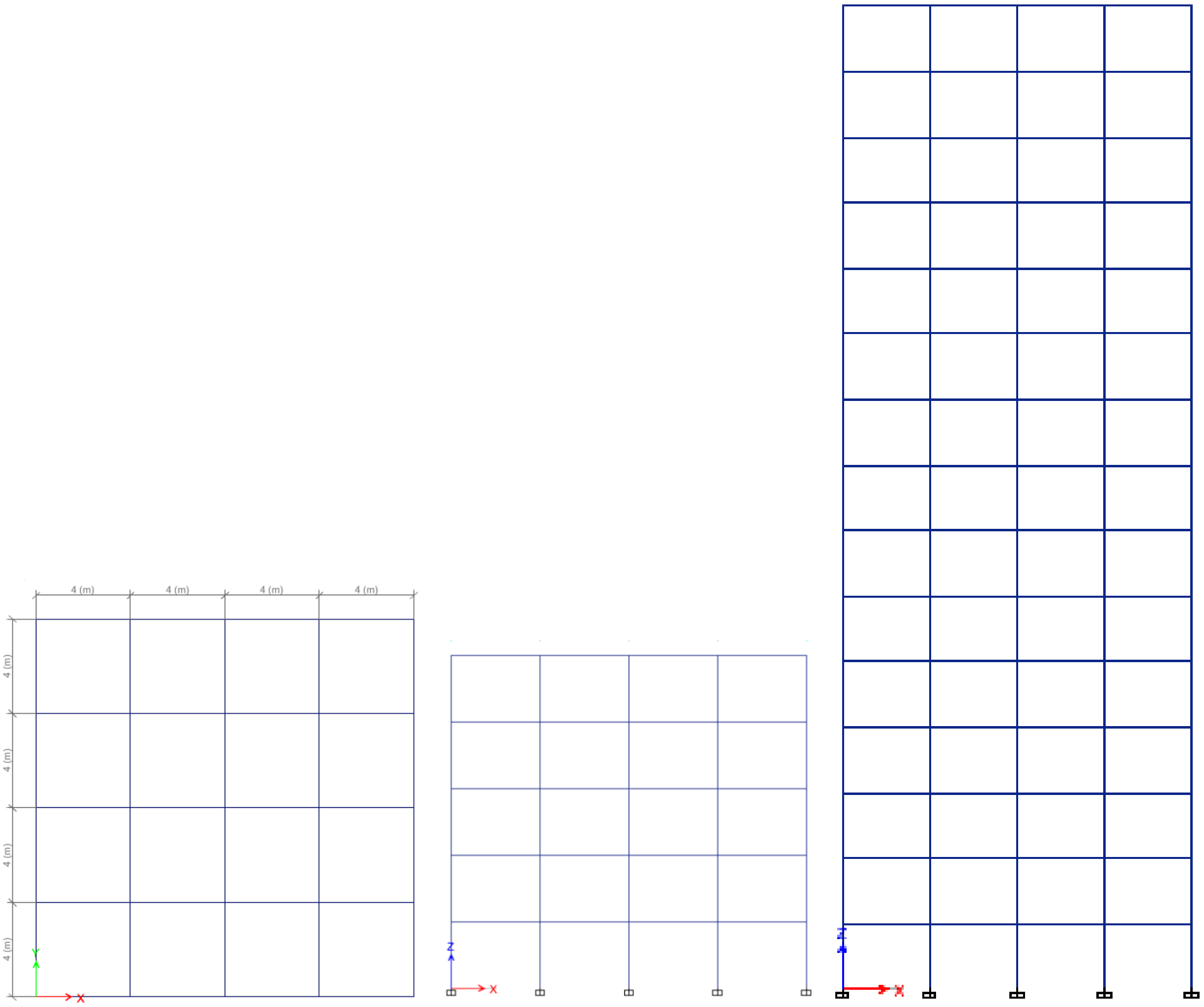


Fig.2 illustrates Plan of buildings(x-y) plane and Elevation(x-z)plane of both five and fifteen storey

The Layout of plan having 4X4 bays of equal length of 4m. The buildings considered are Reinforced concrete special moment resisting space frames of 5 and 15 storey symmetric. Stiffness of the infill is neglected in order to account the Nonlinear Behavior of Seismic demands. All these buildings has been analyzed by NLTHA method. The storey height is kept uniform of 3m for all kind of building models which are as below. The analysis illustrates the step-by-step procedure for determination of forces.

The Plan configuration consists of

Model 1 – Building in rectangular shape symmetry, Five storey-Number of bays in x-direction=4 , Number of bays in y-direction=4.

Model 2 – Building in rectangular shape symmetry, Fifteen storey—Number of bays in X-direction-4 , number of bays in Y-direction=4

Table 1: Assumed Preliminary data required for the Analysis of the frame

Sr.no	**Variable**	**Data**
1	Type of structure	Moment Resisting Frame
2	Number of Stories	5 & 15
3	Floor height	3m

4	Live Load	3.0 kN/m^2
5	Dead load	1.0 kN/m^2 and wallload of 15KN/m
6	Materials	Concrete (M30) and Reinforced with HYSD bars (Fe415)
7	Size of Column	500X500 mm
8	Size of Beams	300x450 mm in all direction
9	Depth of slab	150mm thick
10	Specific weight of RCC	25 kN/m^3
11	Zone	V
12	Importance Factor	1
13	Response Reduction Factor	5
14	Type of soil	Medium

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 reduces due to the use of base Isolators as compared to the fixed base structure storey displacement increases in the base isolated structure. The results presented in the tabular format for five as well as fifteen storey are as follows.

A.BASE SHEAR

The graph illustrates base shear in five storey andin fifteen storey building.

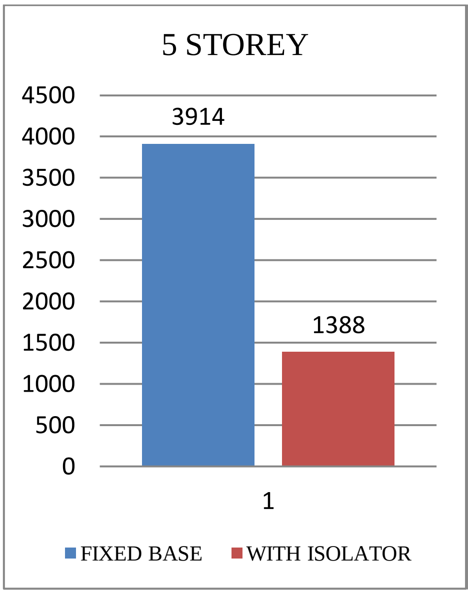


Fig.3 Base shear in five storey building

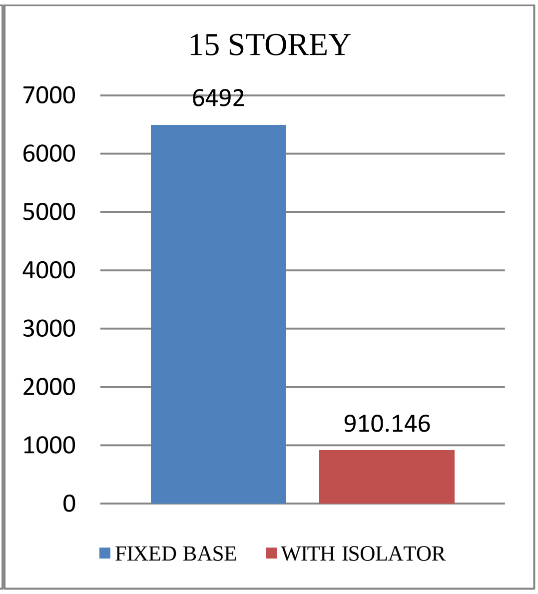
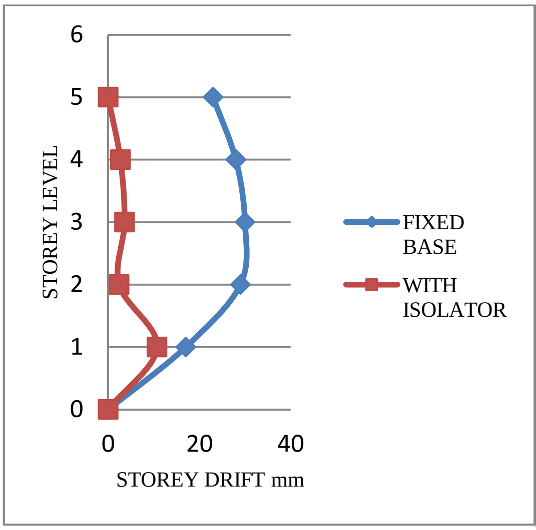


Fig.4 Base shear in fifteen storey building

B.STOREY DRIFT

The graph illustrates storey drift in five storey and in fifteen storey building.



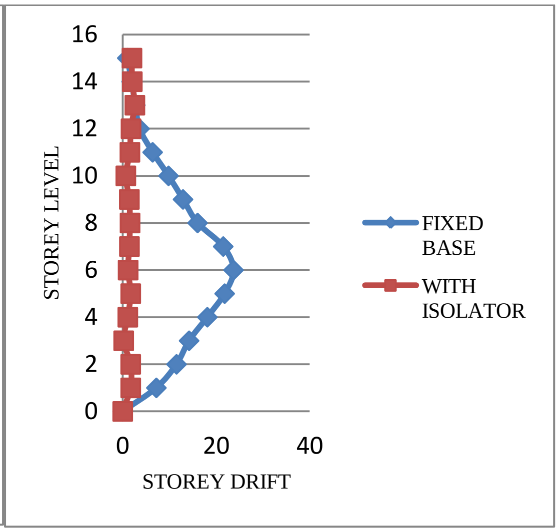
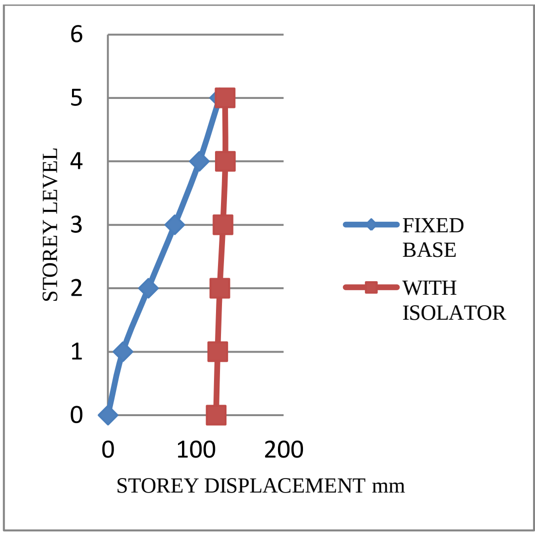


Fig.5 Storey Drift in five storey building

Fig.6 Store Drift in fifteen storey building

C.STOREY DISPLACEMENT

Thee graph illustrates storey displacement in five andfifteen storey buildings.



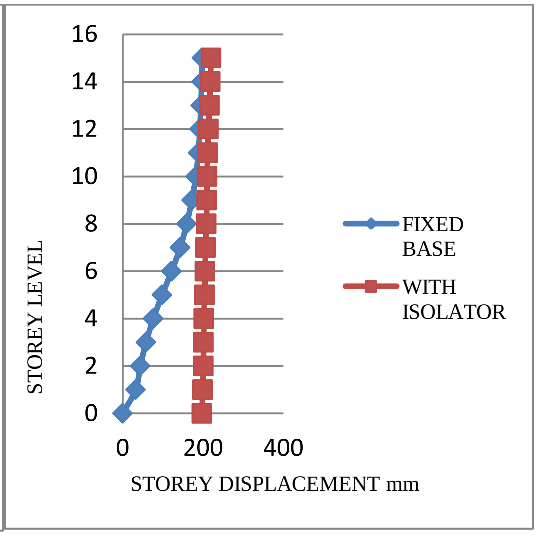


Fig.7 Storey Displacement in five storey building

Fig.8 Storey Displacement in fifteen storey building

CONCLUSION

1) The storey drifts were decreased by 81.42% for five storey building and decreased by 61.79% for fifteen storey building.
2) The Base Isolators were found to be excellent seismic control devices for five storey buildings in controlling forced Responses such as base shear for symmetric buildings because of the reduction in Base shear by 64.53% for five storey and 85.98% in fifteen storey Buildings.
3) All fixed base building have zero displacement at base of the building whereas in case of base isolated model appreciable amount of lateral displacement was observed at the base. Also it has been observed that as floor height increases, lateral displacements increases drastically in case of fixed base building. But for base

isolated buildings the lateral displacement variation is smaller as the height increases

4) The overall results suggested that base isolators were excellent seismic control devices only for low-rise symmetric Buildings but were inefficient for high-rise buildings.
5) In conclusion by performing Non Linear Time-History Analysis, it can be demonstrated that base isolators are effective for low-rise symmetric Buildings only.

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