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Performance of Base Isolated Building Structures with Asymmetry in Plan

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***Abstract*- A natural disaster like an Earthquake can cause heavy damage to life and property, particularly in the case of high rise buildings that have increased substantially in the past two to three decades. Also due to the growing demand and interest in creativity, architects are designing structures with irregularities such as asymmetry in plan of the structure**.

A building with asymmetric plan is considered and a base isolation technique using lead rubber isolators and friction pendulum isolators is attempted on the said building. Performance of the base isolated building is evaluated using the Response Spectrum Method. Also a comparative study on fixed base and base isolated structures with lead rubber isolators and friction pendulum isolators for different parameters is done.

Keywords—Base Isolation; Plan asymmetry; Lead Rubber Bearings; Friction Pendulum Bearings; Response spectrum Analysis.

I. INTRODUCTION

A natural disaster like an earthquake has damaged the life and property of humans mercilessly over the years. Earthquake occurs as a result of the disturbance that is triggered underneath the ground surface either due to release of strain energy stored or due to convergence or divergence of tectonic plates. The resulting ground movement induces large forces onto the structure for a short instance of time. Ground acceleration gives rise to inertia forces whose magnitude equals the product of mass of the structure and ground acceleration (resulting from ground motion). Inertia forces act as lateral loads on the structures and make huge demand on the structure to withstand it, as generally it is not designed to cater for such high level of lateral loads.

Early design strategies for resisting earthquake loads include strengthening the structural elements, by making use of Moment resisting frames and braces etc. But as the members become heavier due to increase in strength, it attracts larger seismic forces which turns up as a serious limitation in the above design approach. Consequently the ductile design method came into practice, in which the members are designed in such a way that they undergo deformation in the post elastic stage without collapsing. In this approach the ductile elements are made weak compared to the brittle ones. There were problems experienced with this method because of the difficulty in concreting at the beam column junctions, due to complexity of the reinforcements at the junction. Hence the recent trend is to go for Vibration control methods such as Base Isolation.

Base isolation concept advocates on decreasing the demand rather than increasing the capacity of the structure [1]. As the Earthquake forces cannot be controlled, designers try to bring about modification on the demand the quake makes on the structure, by reducing the transmissibility of the ground motion acceleration to the superstructure. The strategies involved in base isolation technique are period shifting of the structures and rigid superstructure type behaviour in the fundamental mode.

II. LITERATURE REVIEW

Khante S.N et al [2], in their research work, have implemented Base isolation using lead rubber bearing for 13 storied symmetrical and asymmetrical buildings with various levels of mass eccentricity varying from 0 to 20 %. The evaluation of the performance of Base isolator's is done by performing Time History Analysis using records of Bhuj Earthquake. They have concluded that the technique of base isolation using lead rubber bearings is very effective even for huge levels of mass eccentricity.

A.B.M Saiful Islam et al [3] in their research have studied '' The effect of base isolation on a building with soft storey". The two types of Isolation systems used in the research of the authors were Lead Rubber Bearings and High Damping Rubber bearings. Time history analysis was done in order the gauge the performance of the selected system. The authors have also studied the effect of varying percentage of infill masonry on the performance of base isolated buildings.

Radmila B. Salic et al [4], in their work have considered an existing G+7 building in Skopje. The study of the authors involve ambient vibration testing of existing building, Processing of the signals and obtaining natural frequency and Mode shapes using ARTeMIS (Ambient Response Testing and Modal Identification Software), Tuning or Updating the Fixed base analytical model to the Existing structure and using the updated model to evaluate the performance of Lead Rubber Bearings suitable for existing structure.

III. MODELLING AND ANALYSIS

The modelling and analysis was performed in ETABS (version 15) [5]. The details of the model used for the study is described below. The plan and three dimensional

view of the building used for the study are shown in the figures below.

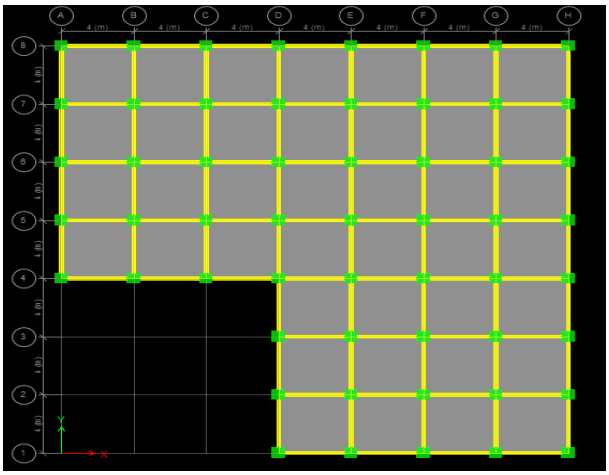

Figure 1: plan of the building

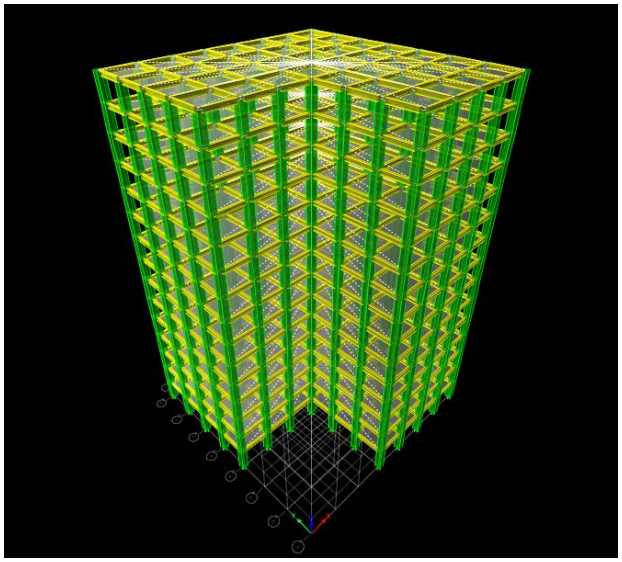

Figure 2: Three dimensional view of the building

The model used for the study is assumed to be a 15 storey public building in an area classified under the earthquake zone V. The sizes of beams and columns used in modelling are 230 mm X 450 mm and 700 mm X 700 mm respectively. The isolators were modelled as non-linear link properties in ETABS, the input being the effective stiffness in the three mutually perpendicular directions. For a lead rubber and friction pendulum isolator, the effective stiffness in vertical direction is taken as 4000000 KN/m and 2000 KN/m in the other two horizontal directions.

The Response Spectrum method is used for evaluating the performance of fixed base and base isolated building models. The response spectrum function is taken from IS 1893:2002 [6] with 5% in structure damping.

IV. RESULTS

The building model under consideration is analysed in ETABS (Version 15) using Response Spectrum Analysis. The comparison of various parameters like Fundamental time period, Maximum acceleration, Maximum displacement, Inter storey drift and storey shear is done for different bearing types like Fixed base bearing (FBB), Lead rubber bearing (LRB), friction Pendulum bearing (FPB). The results of the analysis are presented graphically.

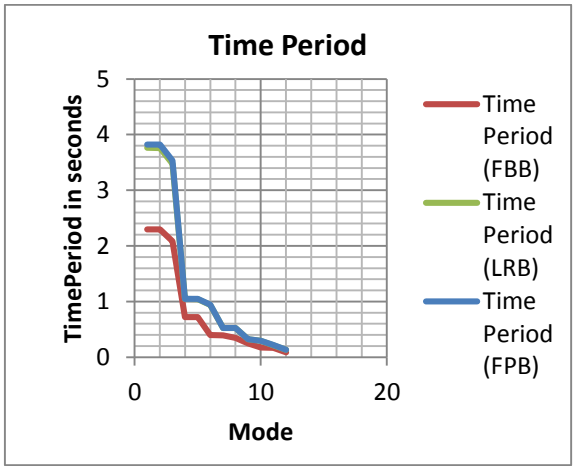

Figure 3: Comparison of Time Periods for FBB, LRB and FPB models

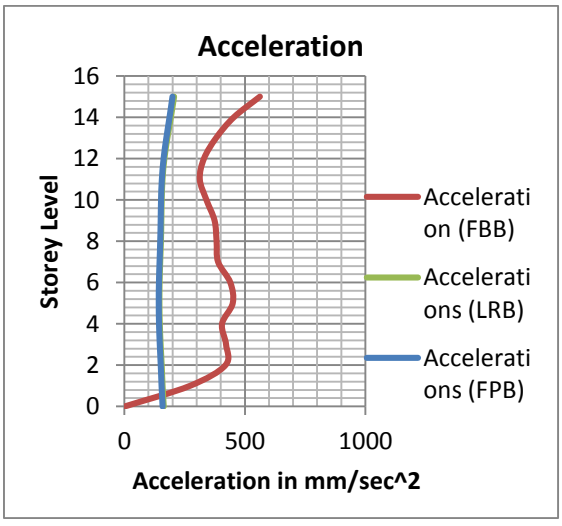

Figure 4: Comparison of Accelerations for FBB, LRB and FPB models

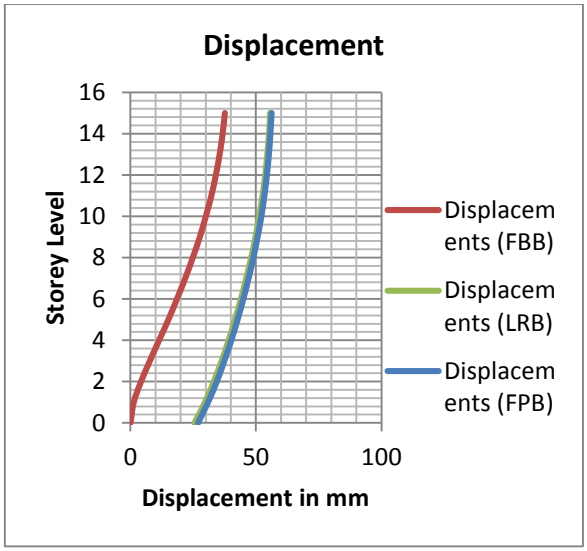

Figure 5: Comparison of Displacements for FBB, LRB and FPB models

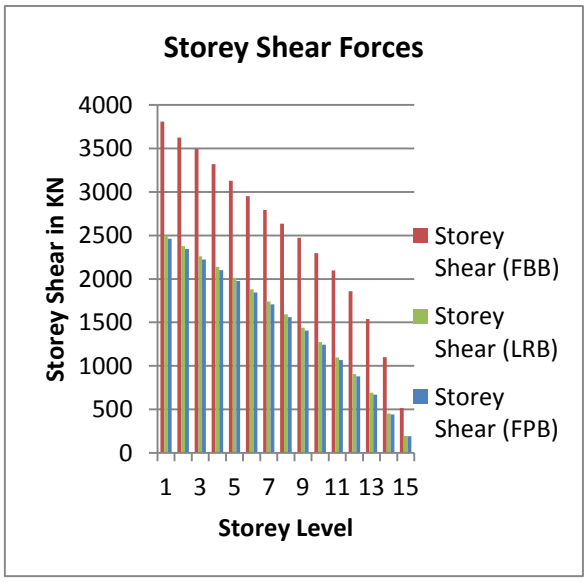

Figure 6: Comparison of Storey Shear Forces for FBB, LRB and FPB models

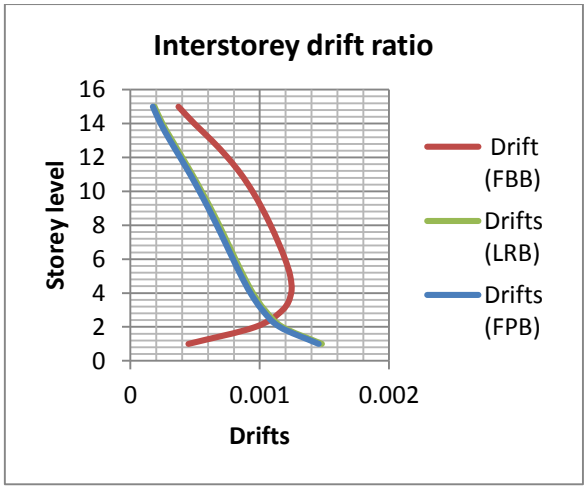

Figure 7: Comparison of Storey Shear Forces for FBB, LRB and FPB models

V. CONCLUSIONS

From the results presented graphically, it can be observed that the parametric variation for both Lead rubber bearing and Friction Pendulum bearing for all the parameters is nearly the same. It can also be seen that the fundamental time period for Base isolated models is roughly twice that of building model with fixed base. The acceleration values decrease from 563 mm/sec^2 for fixed base models to 200 mm/sec^2 for base isolated models. The displacement of the base isolated models has increased by 1.5 times compared to that of fixed base models due to increase in flexibility of the base isolated models.. it can also be observed that the maximum storey shear force has reduced from 3810 KN for fixed base models to 2460 KN for base isolated models. The inter storey drift ratio for all storey levels in base isolated models is less compared to that of fixed base models except at first floor level.

VI. FUTURE SCOPE

Base isolation of buildings on plain ground perform well as seen from the above observations, base isolation may be attempted for buildings on slopes.

Also various alternatives for isolators should be found using experimental study, so that the performance of isolators becomes more efficient.

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