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Effect of Base Isolation In High Seismic Zone With Different Aspect Ratio of High Rise-Buildings

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Abstract – *Base isolation technique is most commonly used method to protect the structure from damaging effect of earthquake. The concept behind this technology is to use flexible isolators between the foundation and the superstructure to separate the superstructure from the foundation. In present study, performance of G+10 storey RC framed structures with different aspect ratios is investigated using ETABS 2018 software and response spectrum method is used for analysis. Aspect ratios varying from 0.25 to 2.0 are considered for the analysis. Aspect ratios of the models are chosen in such a way that Y-direction plan dimension is kept constant whereas X-direction plan dimension values are increased. 10 cases have taken in this study, First five for fixed base and other five for base isolated base (LRB). Structural parameter such as time period, storey displacement, Base shear and storey drift are studied and made comparisons with or without base isolator under different aspect ratio.*

***Key Words*: Base Isolation, Lead Rubber Bearing, Response Spectrum Analysis, Aspect ratio.**

1. INTRODUCTION

Earthquakes are one of the most devastating natural disasters, having a negative effect on towns and communities all over the world. The destruction caused by earthquakes is associated to man-made structures. Because earthquakes strike with little or no notice thus earthquake engineering is essential. High overturning moments in high-rise buildings and torsion from ground motion due to eccentricity are two of the most serious structural challenges caused by earthquake forces.

Fig -1 Damages to the building during earthquake

Recent earthquakes have provided enough evidence on the performance of various types of structures under various earthquake conditions and at various foundation conditions to provide engineers and scientists food for thought. As a result, several strategies to protect structures from earthquakes have emerged. Base isolation is also one of the strategy to protect structure from earthquake. The method of base isolation was developed in an attempt to reduce the effects of earthquakes on buildings during earthquakes, and it has been proven to be one of the most effective methods in recent decades.

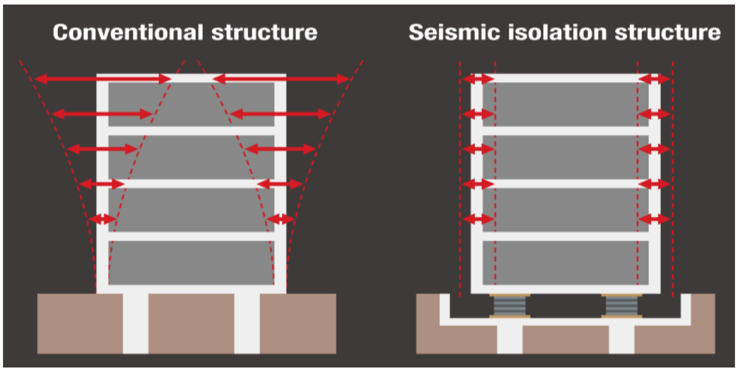

Fig -2 Performance of conventional building Vs seismic isolated building

Base isolation of structures is one of the most preferred means to protect it against seismic force. The term base isolation is made up of two words: the first is "base," which refers to a section that supports or acts as a foundation for a building, and the second is "isolation," which refers to the state of being separate. The effective reduction of inter-storey drift in the base isolation system's floor can guarantee the least amount of damage to facilities while also ensuring human safety. The basic idea behind the base isolation system is to prevent the transmission of potentially damaging earthquake ground motions into a structure, which can be accomplished by introducing horizontal flexibility at the structure's base and presenting some damping elements to counteract earthquake ground motions.

1.1 Lead Rubber Bearing

The LRB was developed in New Zealand and is widely utilised in earthquake-prone locations such as Japan and New Zealand. To obtain optimum superstructure response, LRB is made up of multiple layers of thin low damping rubbers and steel plates formed in alternate layers with a lead core cylinder at its centre. The damp ratio can be achieved in the range of 2 to 4% by using LRB.

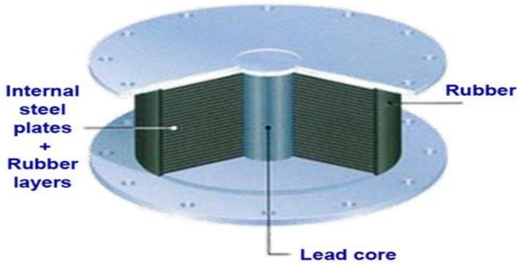

Fig -3 Lead rubber bearing

Lead rubber bearings are constructed composed of low-damping elastomers and lead cores with sizes ranging from 15% to 33% of the bearing's bonded diameter. For seismic isolation, laminated-rubber bearings provide the appropriate displacements. The maximum shear strain range for lead-plug bearings varies by manufacturer, although it is typically between 125 and 200 percent. The cylindrical rubber bearings in LRB isolators are strengthened with steel shims. Shims and rubber are layered on top of each other. Steel plates are also installed at the isolator's two ends. The steel shims increase the structure's load carrying capability, making it strong under vertical loads and flexible under horizontal loads.

1.2 OBJECTIVES

The primary goal of the study is to compare the responses of RCC buildings with different aspect ratios of fixed bases and base isolation. For the purpose of analysis, a lead rubber bearing is used. The current study's objectives are as follows:-

1. Seismic analysis of R.C.C. building with base isolation and without base isolation using ETABS software.

2. To study the suitability of different base isolation systems for different length to width ratios of building.

3. To know which base isolation is most effective for different aspect ratios.

2. METHODOLOGY

A building model of G+10 storey building has been modeled in ETABS 2018 software and considered for present project. Modal analysis and Response spectrum analysis are performed on models. In present work, 3D RC G+10 storied buildings of 5 different dimensions of aspect ratio varying from 0.25 to 2.0 has been considered, one with fixed base and second with base isolation using Lead rubber bearing. Zone V with medium soil condition has considered in this study. Details of models are shown in table 1.

Table -1: Description of models

Model	Plan Dimension (M)		Aspect Ratio
	X-Direction	Y-Direction	
M1	5	20	0.25
M2	10	20	0.5
M3	20	20	1.0
M4	30	20	1.5
M5	40	20	2.0

Table -2: Parameters of the developed RC framed structure models

Structure Type	G+10
Total No. of storey	12
Total height of building from GL to terrace	33 m
Total height of building from base to terrace	36 m
Spacing of bays in X-Direction	5 m
Spacing of bays in Y-Direction	5 m
Storey Height	3 m
Bottom Storey Height	3 m
Grade Of Concrete	M30
Grade Of Steel	FE500
Size Of Column	450x450 mm
Size Of Beam	230x450 mm
Thickness of slab	150 mm
Live load on floor	3 KN/m^2
Live load on terrace	1 KN/m^2
Floor Finish	1 KN/m^2
Wall Load	11.73 KN/m^3
Soil type	Medium (II)
Zone	V
Density of brick masonry	20 KN/m^3
Seismic Load	IS 1893:2016

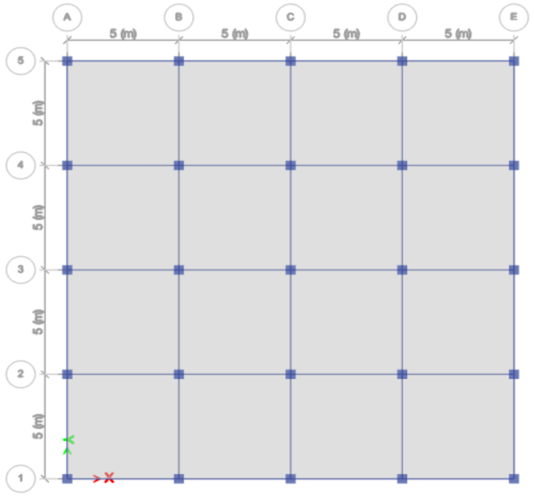

Fig -4 Plan of model 3

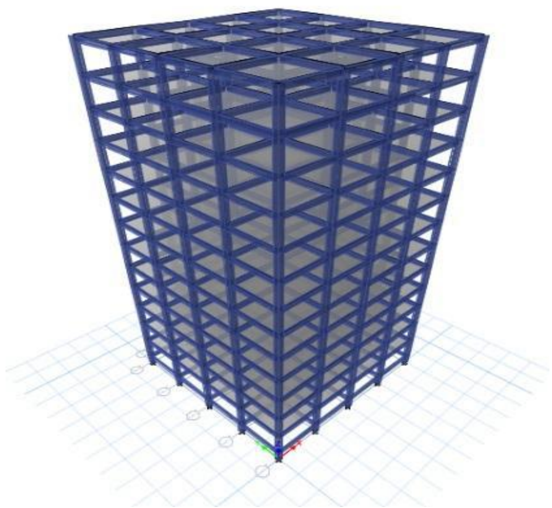

Fig -5 3D Rendered view of model 3

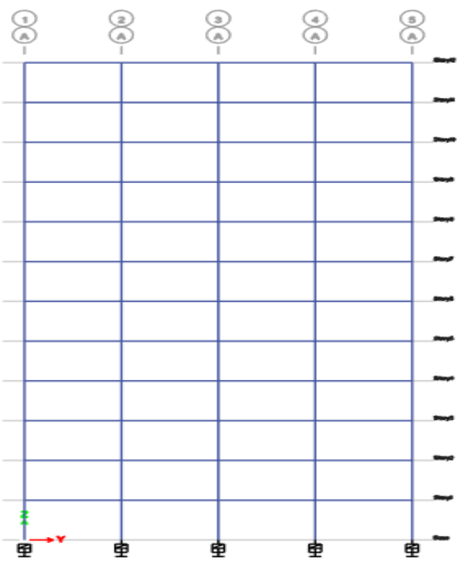

Fig -6 Elevation of model 4 with isolated base (LRB)

3. RESULTS AND DISCUSSIONS

After performing Analysis on 10 building models, it is observed that values of lateral displacement (mm) with floor level in X direction increased around 35-45 % with base isolation as compared to fixed base. Values of lateral displacement (mm) with floor level in Y direction increased slightly around 34-46 % with base isolation as compared to fixed base. Values of Story over-turning moment of building decreased in X direction around 25-28 % with isolation as compared to fixed base. Values of Story over-turning moment of building decreased in Y direction around 25-30 % with base isolation as compared to fixed base case. Value of Base shear in X direction decreased by around 21-27 % with base isolation as compared to fixed base, Value of Base shear in Y direction decreased by around 23-29 % with base isolation as compared to fixed base, Value of Time period increased by around 47-56% with base isolation as compared to fixed base. Maximum Story drift in X direction of model 1 is increased by 50% with base isolation as compared to fixed base, but on higher stories drift decreases considerably. Maximum Story drift in X direction of model 2 increased by 66% with base isolation as compared to fixed base, but on higher stories drift decreases considerably. Maximum Story drift in X direction of model 3 increased by 75% with base isolation as compared to fixed base, but on higher stories drift decreases considerably. Maximum Story drift in X direction of model 4 increased by 60 % with base isolation as compared to fixed base, but on higher stories drift decreases considerably. Maximum Story drift in X direction of model 5 increased by 55% with base isolation as compared to fixed base, but on higher stories drift decreases considerably. Maximum Story drift in Y direction of model 1 increased by 45% with base isolation as compared to fixed base. Maximum Story drift in Y direction of model 2 for increased by 60% with base isolation as compared to fixed base. Maximum Story drift in Y direction of model 3 for increased by 62% with base isolation as compared to fixed base. Maximum Story drift in Y direction of model 4 increased by 75% with base isolation as compared to fixed base. Maximum Story drift in Y direction of model 5 increased by 70% with base isolation as compared to fixed base.

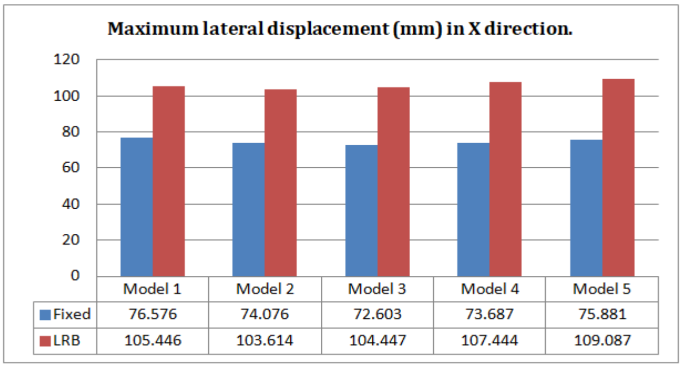

Chart-1:Maximum lateral displacement (mm) in X direction

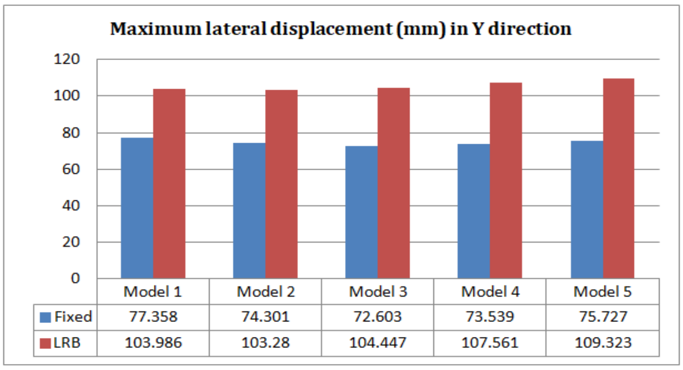

Chart-2: Maximum lateral displacement (mm) in Y direction

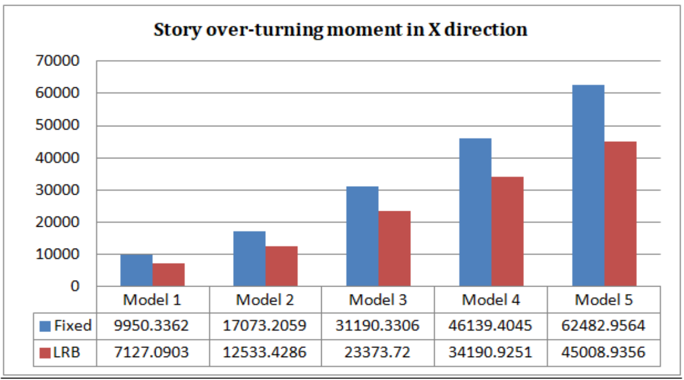

Chart-3: Story over-turning moment in X direction

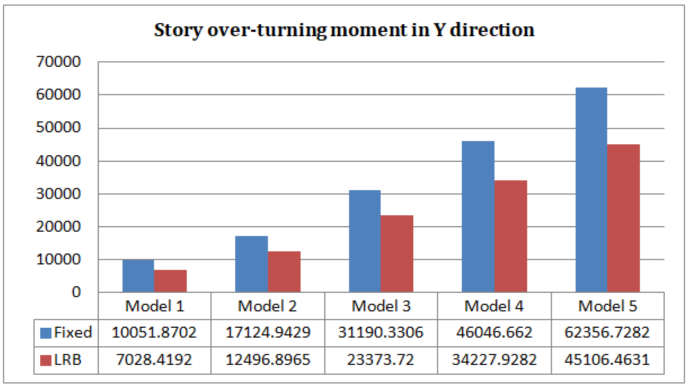

Chart-4: Story over-turning moment in Y direction

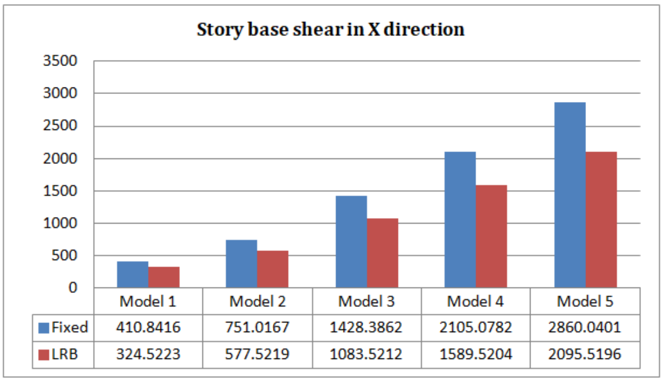

Chart-5: Story base shear in X direction

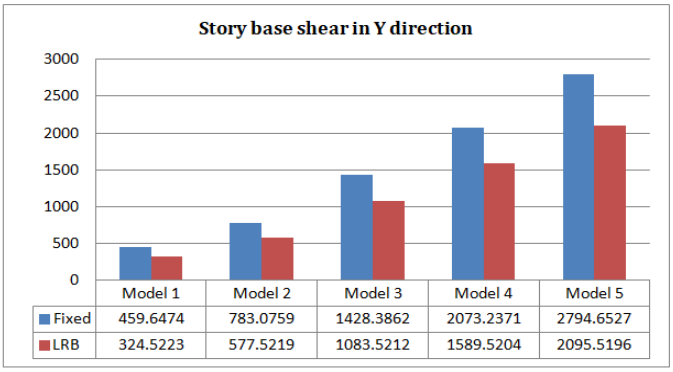

Chart-6: Story base shear in Y direction

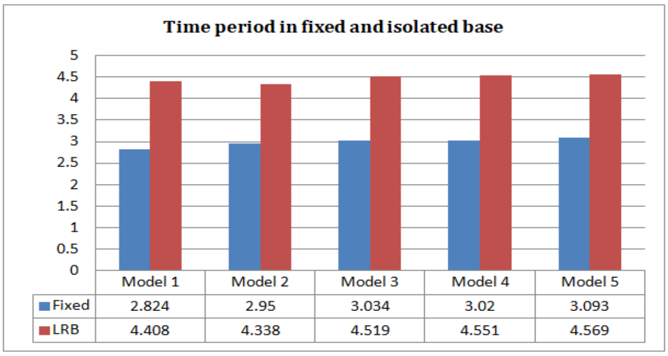

Chart -7: Time period in fixed and isolated base

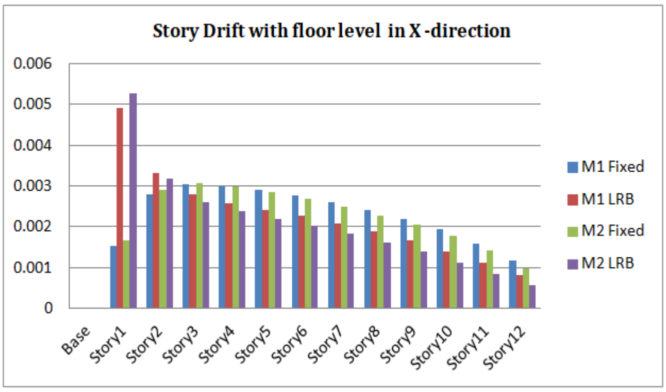

Chart -8: Story Drift with floor level in X direction for model 1 & model 2

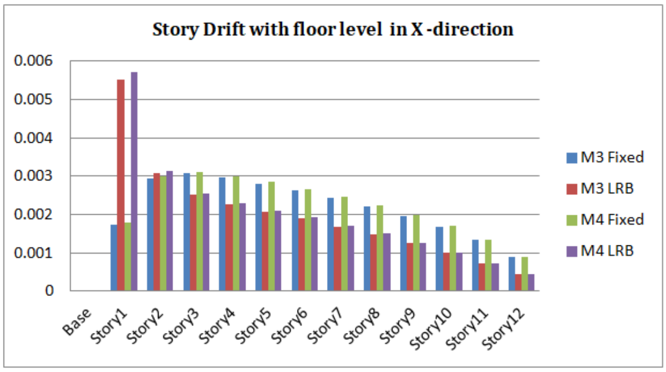

Chart -9: Story Drift with floor level in X direction for model 3& model 4

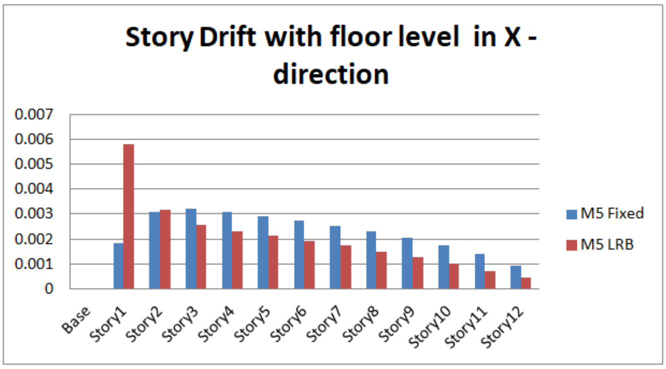

Chart -10: Story Drift with floor level in X direction for model 5

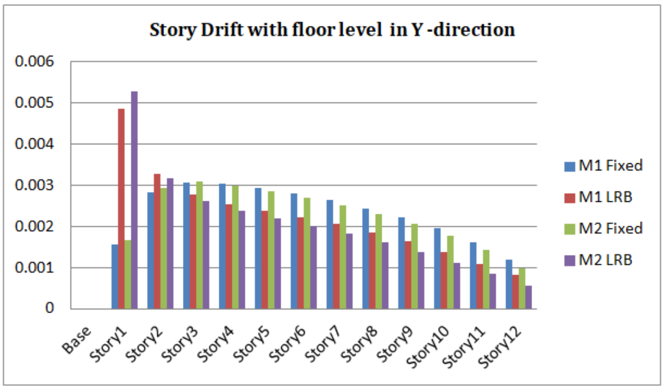

Chart -11: Story Drift with floor level in Y direction for model 1 & model 2

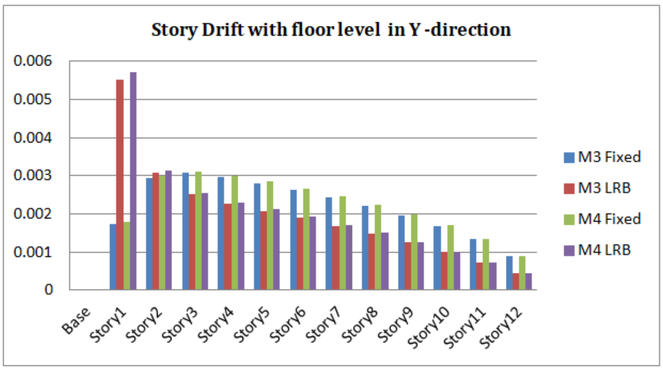

Chart -12: Values of Story Drift with floor level in Y direction for model 3& model 4

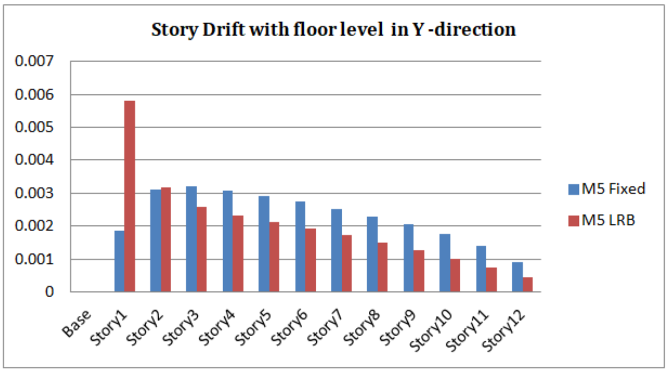

Chart -13: Values of Story Drift with floor level in Y direction for model 5

4. CONCLUSIONS

From the analysis it is found that the lateral displacement in both X and Y direction increases around 40% with LBR base isolation building as compared to fixed base building which makes building more ductile. Also lateral displacement in both directions is minimum for the aspect ratio 1.0 and from analysis, it has been concluded that there is decrease of around 27% in over-turning moment of isolated base as compared to fixed base. Percentage of over-turning moment is least for model 5 i.e. with aspect ratio 2.0 in X direction and it is least for model 1 i.e. with aspect ratio 0.25 in Y direction. From analysis, it has been concluded that there is decrease of around 25% in base shear of isolated base as compared to fixed in both X and Y directions. Model 5 i.e. is aspect ratio 2 in X direction and model1 i.e. aspect ratio 0.25 has reduced maximum percentage of base shear. It has been concluded that there increase in time period of isolated base as compared to fixed base of around 50% which makes structures falls out of earthquake resonance range. From above analysis results it has been concluded that maximum story drift increases for all models with base isolation as compared to fixed base case, but drift decreases considerably in upper stories which makes structures safer during earthquakes. Overall LBR bas isolation system increases structure response during earthquakes and with aspect ratio point of view model 5 is suitable configuration with aspect ratio 2.

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