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Seismic Response of Multi-Storey Building with Elastomeric Lead Rubber Bearing

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ABSTRACT: Earthquake is a major disaster in many regions of the world. One of the most effective means for the protection of building structure during seismic hazard is base isolation. Base isolation is a method of inserting a flexible layer between superstructure and foundation, thus protecting the structure from damaging action of ground motion. According to different types of base isolation devices, elastomeric bearing is one of the most popular devices used to reduce the effects of an earthquake. Non-linear Time history analysis is carried out to find seismic responses of structures using well known SAP 2000 software. For time history analysis, one known earthquake El-Centro is used. Effect of LRB on a regular building by varying its thickness is compared. Results such as base shear, storey displacement, storey drift and Energy dissipation were compared.

KEYWORDS: Base isolation, Time History Analysis, Lear Rubber Bearing (LRB)

I. INTRODUCTION

One of the worst natural hazards is earthquake, which may cause widespread destructions and loss of life. The effects of earthquake vary upon the intensity and magnitude. An earthquake is the result of a sudden release of energy in the earth's crust that creates seismic waves in all directions. In recent times, many new systems have been developed to reduce the effect of earthquake on structures and thus reducing the loss of life and property. One of the most widely implemented and accepted seismic protection systems is base isolation. Base isolation is a designed strategy which uncouples the structure from the damaging effects of the ground motion. The term isolation refers to reduce the interaction between structure and ground. And also isolation system is used to provide an additional means of energy dissipation, and thus reducing the transmitted acceleration into the super structure. The fundamental principle of base isolation is to modify the response of the building so that the ground can move below the building without transmitting these motions into the building. Two types of isolators: elastomeric isolators and sliding isolators.

II. SEISMIC ANALYSIS

Seismic analysis is a subset of structural analysis and is the calculation of the seismic response of a structure subjected to earthquakes. It is part of the process of structural design, structural assessment or earthquake engineering, retrofit in regions where earthquakes are prevalent and vulnerable to structures. FEMA 356(ASCE 2000) provides four different analysis procedures for a performance-based evaluation of a structure: 1. Linear static procedure 2. Linear dynamic procedure 3. Non-linear static procedure (Push-over analysis) and 4. Non-linear dynamic procedure (Time history analysis). In this study, linear and non-linear dynamic analyses were conducted to estimate the nonlinear response characteristics of the case study structure.

2-1. Time History Analysis

The nonlinear dynamic procedure provides an estimate of the dynamic response of the structure when subjected to certain ground motion demands. Nonlinear dynamic analysis utilizes the combination of ground motion records with a detailed structural model, thus it is capable of producing results with relatively low uncertainty. FEMA 356 ensures guidelines regarding the required number of ground motions that should be used in case of nonlinear dynamic analysis.

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III. GEOMETRY AND MATERIAL PROPERTY

The 3 Dimensional image of a 11 storey reinforced concrete structure building, which is used as the subject structure in this study as shown in figure respectively. All columns are 450x450 mm and beams are 300 x 500 mm with floor heights are 3 m. There are 4 bays of 5m in X-direction, 4 bays of 3m in Y-direction, i.e. plan dimensions are 20 m x 12 m. All structural members are of concrete with Fck=40N/mm2 and FY= 415 N/mm2. In superstructure, the base period in each direction is 0.75 seconds and the superstructure modal damping ratios are assumed to be constant as 5% for each mode. The three-dimensional model of the base-isolated building and the non-linear time-history analyses are made using a well-known software program SAP2000 version. Material and Geometric property is obtained from journal and are mentioned in table 1.

Table 1. Material and Geometry Property

Grade of concrete	M40
Grade of steel	Fe 415
Floor to floor height	3m
Slab thickness	150mm
Wall	230mm
Column	450 x 450 mm
Beam	300 x 500 mm
Live load on all floors & roof	3 kN/m^2
Floor Finish	1 kN/m^2

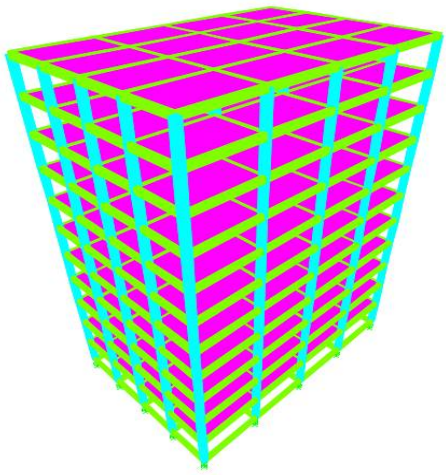

Fig 1. 3-D model of case study building

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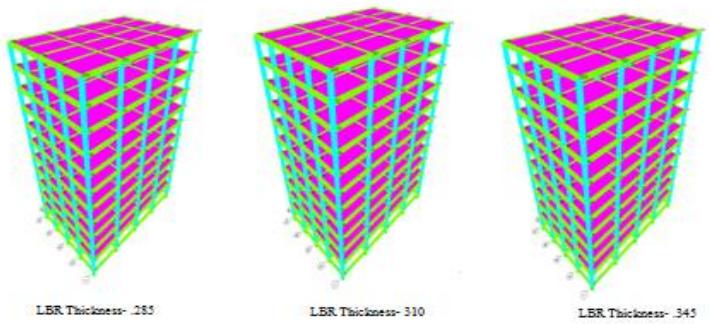

Fig 2. Building with varying LRB Thickness

Based on details mentioned in table 1, case study building is designed and analysed using well known software SAP 2000. 3D model of case study building is shown in fig 1. The same building has been redesigned by using LRB as base isolator instead of fixed building. Studies have been conducted by varying the thickness of LRB that is LRB of various thickness. Results were compared between fixed building and building with LRB of various thicknesses.

3-1 Properties of LRB in three different thickness

Table 2. Properties of LRB for Thickness - 0.285m

K eff	3544.23	Linear
K H	2976.11	Non linear
K V	1496740.13	
Yield strength QR	161.94	
Post yield stiffness ratio	0.1	
Damping	0.1	

Table 3.Properties of LRB for Thickness - 0.310 m

K eff	2461.27	Linear
K H	2066.68	Non linear
K V	1301764.57	
Yield strength QR	122.66	
Post yield stiffness ratio	0.1	
Damping	0.1	

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Table 4. Properties of LRB for Thickness - 0.345 m

K eff	1808.28	Linear
K H	1518.41	Non linear
K V	1072118.89	
Yield strength QR	100.94	
Post yield stiffness ratio	0.1	
Damping	0.1	

IV. RESULTS AND DICSUSSION

4-1. Storey Displacement

It's the total displacement of one storey with respect to ground and the maximum permissible limit is prescribed in IS codes for buildings. Figure shows storey versus displacement graph. Building with LRB Thickness of 0.345m show the maximum displacement of 0.24m in top storey, but it's taken by elastomeric bearing. Thus causes only small displacement in building. Whereas in case of fixed building, maximum displacement of top story is 0.15m, which is taken by building itself and causes severe damage.

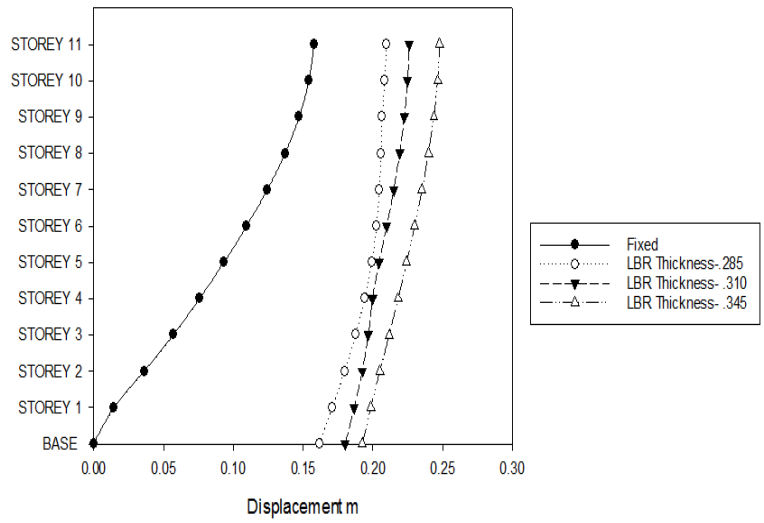

Fig 3. Combined Storey V/S Displacement graph

Figure shows that increasing the thickness of elastomeric bearing beyond a particular limit, it doesn't cause a considerable difference in displacements. Overall building displacement is same in case of LBR Thickness of .285 and LBR Thickness of .310m.

4-2. Base shear

It's the estimate of maximum expected lateral force that will occur due to seismic ground motion which acts on a building structure. Figure 4 show that maximum base shear occurs in fixed building. LRB Thickness of .385m shows least base shear. As thickness increases, base shear decreases and shows a drastic change.

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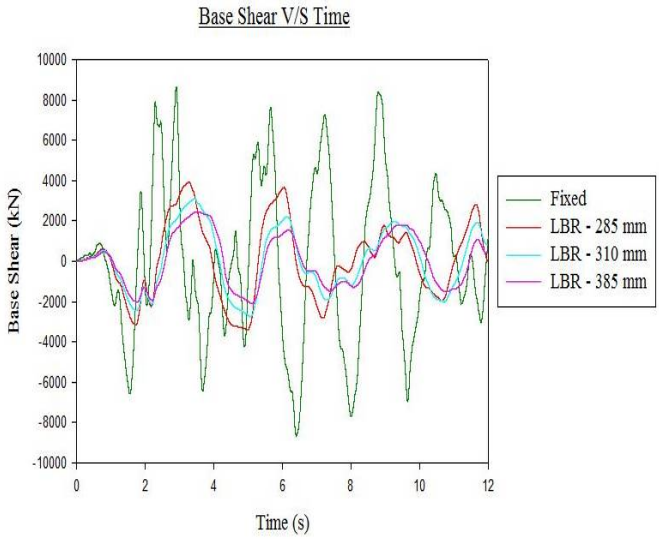

Fig 4. Combined Base Shear V/S Time

Table 6. Base Shear in four different cases

Sl. No	Fixed	LRB Thickness - .285	LRB Thickness- .310	LRB Thickness- .345
Base Shear(KN)	8637	5356	3105	2468

Base Shear is maximum in fixed building of 8637 KN. Thus building causes severe damage. Base shear of building with LRB Thickness of 0.285m is 5356 KN. Thus, base shear get decreased upto 38%. Second, base shear of building with LRB Thickness of 0.310m is 3105 KN. There is a decrease of 42% in Base Shear. By increasing the thickness of LRB to 0.345m, base shear obtained is 2468 KN. This shows a decrease of 20 % in base shear. As thickness of LRB increases, base shear decreases. Building with LRB thickness of 0.345 shows a decrease in base shear of 71% when compared with fixed building.

4-3. Energy graph for El-Centro Earthquake

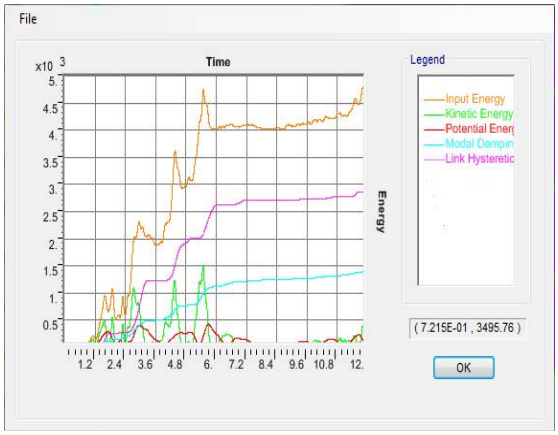

Fig 6. Building with LRB of Thickness .285m

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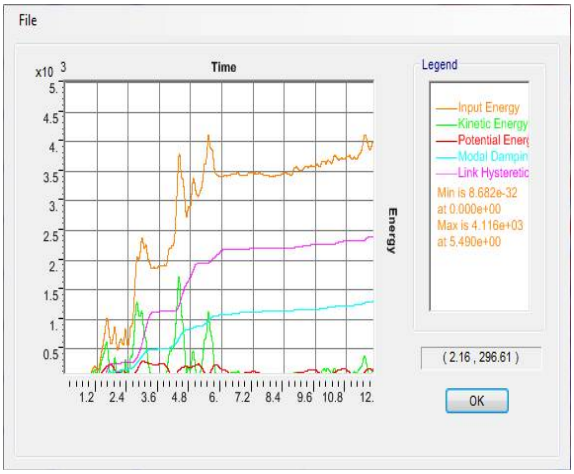

Fig 7.Building with LRB of Thickness .310m

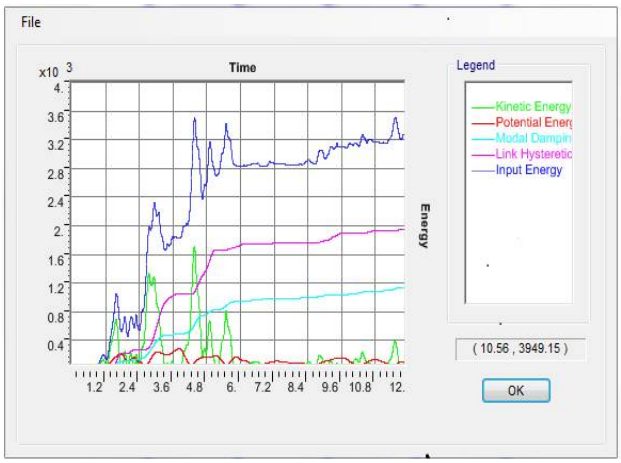

Fig 8. Building with LRB of Thickness .345m

Table 7. Energy dissipation in four different cases

Sl. No	Fixed	LRB Thickness- .285	LRB Thickness- .310	LRB Thickness- .345
Input Energy	3244	4790	4116	3508
Link Hysteresis	0	2970	2490	1980
Energy taken by building	3244	2820	1636	1560

Table 7 shows the energy on four different cases. First, in fixed building when El Centro earthquake occurs, input energy is 3244. This energy should be taken by building itself and causes severe damage. Second, building with LRB Thickness .285, input energy obtained is 4790. Of these 2970 energy is dissipated by link hysteresis and thus only 2820 energy is taken by building. Third, in case of building with LRB Thickness .310, input energy obtained is 4116. Of these, 2490 energy is dissipated by link hysteresis. Area of link hysteresis curve gives the energy dissipated. So only an

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amount of 1636 energy is taken by building. In fourth case, building with LRB Thickness .345, input energy on building is 3508. Of these, 1980 is dissipated by link hysteresis and thus only small value of 1560 energy is taken by building and thus causes very less damage

IV. CONCLUSION

Table 5.10 Displacement, Base Shear, Link Deformation and Energy of different building

Sl. No	Fixed	LRB Thickness: .285	LRB Thickness-.310	LRB Thickness-.345
Displacement of top storey	.15	.20	.22	.24
Base Shear (KN)	8637	5356	3105	2468
Link Deformation	0	.0977	.1381	.1306
Energy taken by building	3244	2820	1636	1560

- Displacement is increased by increasing the thickness of LRB on building. But this displacement is taken by the Lead Rubber Bearing.
- Base Shear is maximum in case of fixed building. Base shear get reduced by increasing the thickness of LRB Thickness. Almost 71% of base shear is reduced in building with LRB Thickness of 0.345m.
- Link deformation is increased by increasing the thickness of LRB up to a limit.
- Energy taken by building with LRB of thickness 0.345m is less when compared with fixed building.

REFERENCES

1] **B. M. Saiful Islam, Mohammed Jameel** (2011), Seismic isolation in buildings to be a practical reality: Behavior of structure and installation technique, *Journal of Engineering and Technology Research*, Vol. 3(4), pp. 99-117.
[2] **Gomase O.P, Bakre S.V**(2011), Performance of Non-Linear Elastomeric Base Isolated building structure, *International Journal Of Civil And Structural Engineering* , Vol 2.
[3] **Mehmet KOMUR, Turan KARABORK, Ibrahim DENEME** (2011), Nonlinear Dynamic Analysis of Isolated and Fixed-Base Reinforced Concrete Structures, *Gazi University Journal of Science*. Vol. 463-475.
[4] **A.B.M. Saiful Islam , Raja Rizwan Hussain , Mohammed Jameel** (2012), Non-linear time domain analysis of base isolated multi-storey building. under site specific bi-directional seismic loading, *Automation in Construction*. pp. 554-566.
[5] **K S Sable, J S Khose, V P Kulkarn**i (April 2012), Comparison of Different Bearing Types Performance in Multistoried Building, *International Journal of Engineering and Innovative Technology (IJEIT)*, Vol 1, Issue 4,.
[6] **Shirule Pravin Ashok , Niraj Mehta , Rahulwagh(**Sep 2012), Response Spectrum Analysis Of Multi Storeyedbase-Isolated Building, *International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)* Vol.2, Issue 3, pp 66-75,.
[7] **E.Niranjani and K.Aravinthan(2014)**, Design of Base Isolated School Building with Elastomeric Bearing, *The Asian Review of Civil Engineering*, Vol. 3 No. 2, pp.19-26.
[8**] M. Jabbareh Asl1, M. M. Rahman1, A. Karbakhsh**(2014), Numerical Analysis of Seismic Elastomeric Isolation Bearing in the Base-Isolated Buildings, Open *Journal of Earthquake Research.*
[9**] S.K. Sabu, 2H.S.Chore, 3 S.B.Pati**(2014), Effectiveness of Lead Rubber Base Isolators, for seismic resistance of Buildings, supported on different soil stratas, *International Journal of Electrical, Electronics and Computer Systems (IJEECS)* Volume -2, Issue-4.
[10] **Jong Wan Hu**(2014), Response of Seismically Isolated Steel Frame Buildings with Sustainable Lead-Rubber Bearing (LRB) Isolator Devices Subjected to Near-Fault (NF) Ground Motions, *Sustainability* .