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Analysis and Design of Base Isolation for Multi Storied Building Using Lead Rubber Bearing

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Abstract **The main purpose of this study is to check the performance of the buildings in seismic zone by means of base isolation idea, and reduce the story acceleration and story drift due to earthquake ground excitation, applied to the superstructure of the building by installing base isolation devices like lead rubber bearing (LRB) at the foundation level, and then compare the performance between the fixed base building and base isolated building by using SAP 2000 software. In this present study, G+10 buildings models are analyzed in SAP 2000 software. Lead rubber bearing is used as isolation devices.**

Keywords —Base isolation, seismic design, lead rubber bearing, story drift, model period.

I. INTRODUCTION

Earthquake resistance design is based on following two basic different approaches to ensure the construction of structures, i) Conventional earthquake resistant design approach. ii) Seismic isolation earthquake resistant design approach.

Conventionally, seismic design of building structures is based on the concept of increasing the resistance capacity of the structures against earthquakes, these traditional methods often result in high floor accelerations or large inter-story drifts for buildings. Because of this, the building may suffer significant damage during a major earthquake. For buildings whose contents are more costly and valuable than the buildings themselves, such as hospitals, police and fire stations and telecommunication centers etc. Therefore, special technique to minimize inter-story drifts and floor accelerations, Seismic isolation earthquake resistant design is increasingly being adopted. Base isolation is to prevent the superstructure of the building from absorbing the earthquake energy. Therefore, the superstructure must be supported on base isolators to uncouple the ground motion..

I. BASIC PRINCIPAL OF BASE ISOLATION

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 superstructure and building move like a rigid mass without affecting the major damage to structural components. A major advantage of using seismic isolation is that, by shifting the fundamental frequency of the structure away from the dangerous for resonance range, amplification of the ground acceleration is avoided.

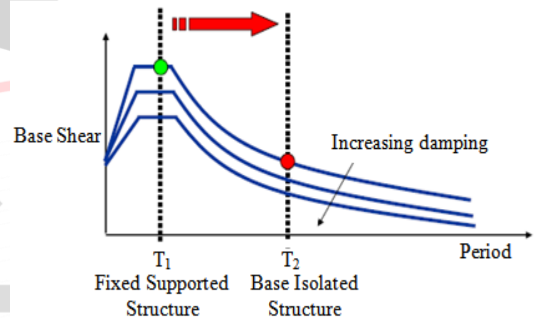


Figure 2 shows typical acceleration spectrum and Figure 3 shows typical displacement response spectrum

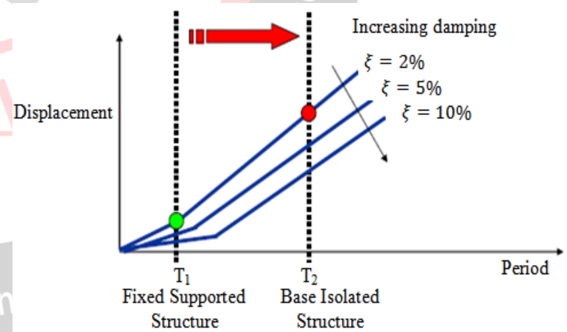


Figure 3 Typical Acceleration Spectrums (Increase period of vibration of structure to reduce base shear)

II. DIFFERENT BASE ISOLATORS

A. The most common use types of base isolators in buildings are

(a) Laminated Rubber (Elastomeric) Bearing.
(b) High Damping Rubber (HDR) Bearing.
(c) Lead Rubber Bearing (LRB).
(d) Friction Pendulum System (FPS) or Sliding Bearing

Figure 4 Elastomeric Rubber Bearing (High Damping)

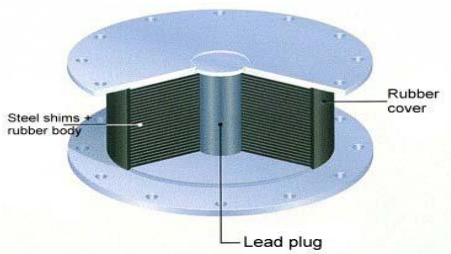


Figure 5 Lead Rubber Bearing

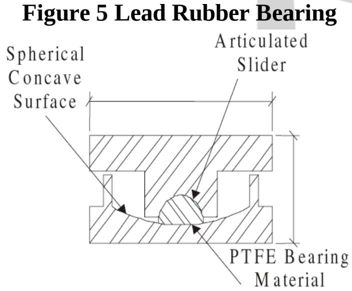
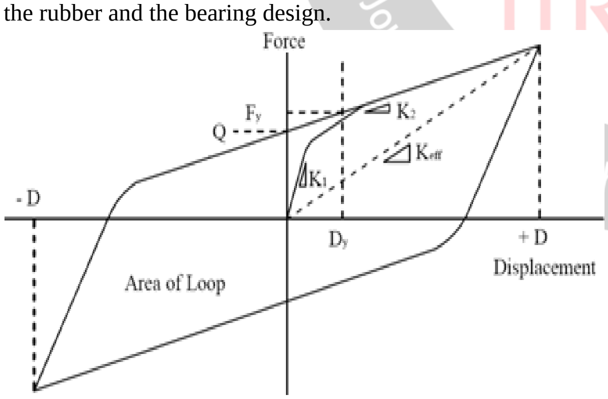


Figure 6 Friction Pendulum Bearing

B. Mechanical Characteristics of Lead Rubber Bearing

Lead rubber bearing are always modeled as bilinear elements, with their characteristics based on three parameters: K_1, K_2, and Q. As shown in figure. The elastic stiffness K_1 is difficult to measure and is usually taken to be an empirical multiple of K_2, the post-yield stiffness, which can be accurately estimated from the shear modulus of the rubber and the bearing design.



$$K_{eff} = K_2 + \frac{Q}{D} \quad ; \quad D \geq D_y$$

Where D_y = is the yield displacement. The natural frequency ω is given by

$$\omega = \sqrt{\frac{K_{eff}\, g}{W}} = \sqrt{\omega_0^2 + \mu \frac{g}{D}}$$

Where, $\mu = Q/W$, $\omega_0^2 = \sqrt{K_2\, g/W}$, and the effective period T is given by

$$T = \frac{2\pi}{\omega}$$

$$T = \frac{2\pi}{\sqrt{\omega_0^2 + \mu \frac{g}{D}}}$$

The effective damping β_{eff} for $D \geq D_y$ is defined to be

$$\beta_{eff} = \frac{area\ of\ hystersis\ loop}{2\pi K_{eff} D^2}$$

The area of the hysteresis loop is given by $4Q(D - D_y)$; to put β_{eff} in terms of these basis parameters, we note that

$$D_y = \frac{F_y}{K_1} \qquad F_y = Q + K_2 D_y \quad \text{So that} \quad D_y = \frac{Q}{K_1 - k_2}$$

Using the defination of β_{eff} and the result (Equation (1.2)), f or K_{eff}, we have

$$\beta_{eff} = \frac{4Q(D - D_y)}{2\pi(K_2 D + Q)D}$$

As a general rule of thumb, elastic stiffness K_1 is taken as 10K_2, so that $D_y = Q/9K_2$, giving

$$\beta_{eff} = \frac{4Q(D - Q/9K_2)}{2\pi(K_2 D + Q)D}$$

III. ANALYSIS AND DESIGN OF G+10 BUILDING

The shape of building is square shape. Number of story varies from 4 to 6 stories. The building dimensions are 20 m long and 20 m wide.

Material Properties and Service Load

Live load = 3.0KN/m^2

Floor finish = 1.0KN/m^2

Water proofing = 2.0KN/m^2

Earthquake load as per IS-1893 (part I) – 2002

Type of soil = Type II, medium as per IS: 1893

Story height = 3m

Walls = 0.230 m thick brick masonry wall

Material Properties-

Concrete- M30

E_C = 5000$\sqrt{f_{ck}}$ N/mm^2 = 5000 x $\sqrt{30}$ = 27386.12 N/mm^2

Analysis – Equivalent lateral force procedure for base isolation from excel sheet

Items	Values	Units
Design Period	2.5	sec
MCE period	3.5	sec

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T_X	0.9	sec
KDMin	46232.197	KN/m
KMMin	23587.8556	KN/m
KDMax	56506.0185	KN/m
KMMax	28829.6013	KN/m
DDX	0.25	m
DMX	0.52	m
DTDX	0.66	m
DTMX	1.38	m
D'DX	0.23	m
D'MX	0.50	m
V_{bx}	14025.5907	KN
V_S	7012.79534	KN

. Modal Period (G + 10) –

Mode Shape	FB	BI-Bottom
1	1.15	2.74
2	1.02	2.69
3	0.95	2.47
4	0.38	0.60
5	0.34	0.55
6	0.32	0.51
7	0.23	0.30
8	0.20	0.27
9	0.19	0.25
10	0.16	0.20
11	0.14	0.18
12	0.13	0.17

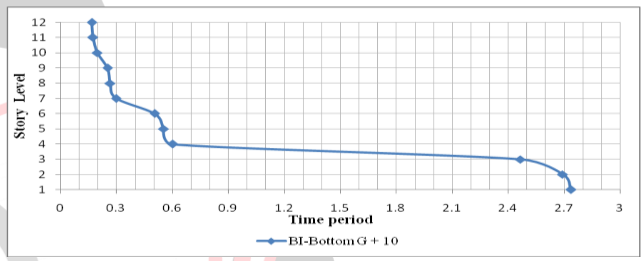
Displacement (G + 10) –

Story Level	Fixed Based	Bottom BI
	U1, in cm	U1, in cm
1	1.05	19.86
2	2.73	20.53
3	4.52	21.22
4	6.32	21.92
5	8.39	22.72
6	10.38	23.49
7	12.24	24.20
8	13.89	24.84
9	15.28	25.37
10	16.32	25.76
11	17.01	26.05

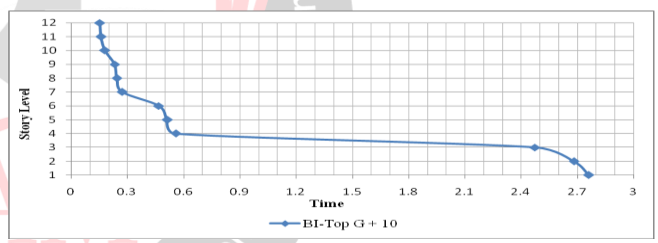
Story Drift (G + 10) –

Story No.	Fixed		Bottom	
	Drift X	Drift Y	Drift X	Drift Y
	cm	cm	cm	cm
1	1.68	2.01	0.67	0.87
2	1.78	2.06	0.69	0.89
3	1.81	2.06	0.70	0.89
4	2.07	2.18	0.79	0.93
5	2.00	2.09	0.77	0.90
6	1.86	1.94	0.71	0.83
7	1.66	1.73	0.64	0.74
8	1.39	1.44	0.53	0.62
9	1.04	1.07	0.39	0.45
10	0.70	0.69	0.29	0.31

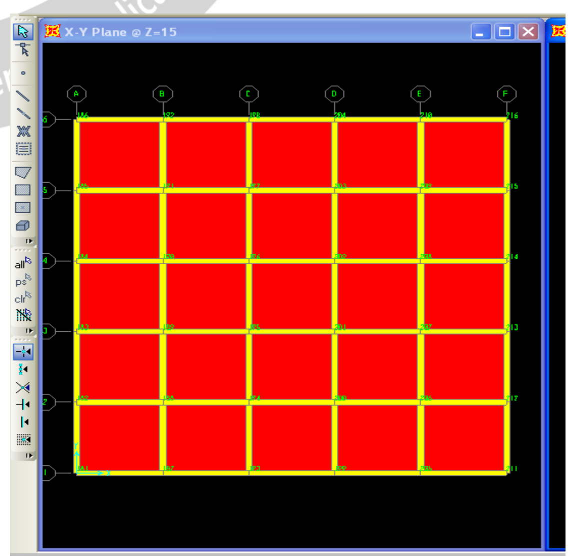
Model Period –



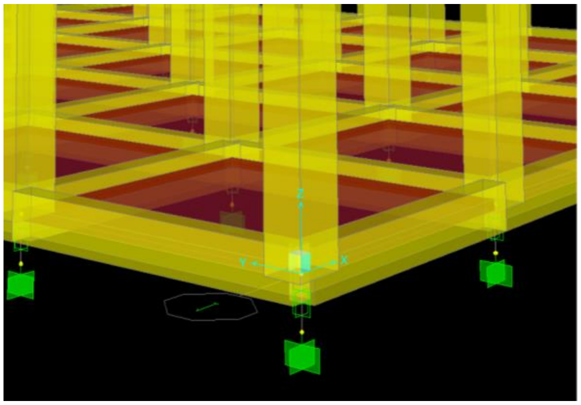
Graph 1 - Model Period (Fixed based Building)



Graph 2 - Model Period (Base Isolated Building)



Snap -1 Modelling in SAP



Snap -2 Assign of Base Isolators in SAP

IV. CONCLUSION

From the present study, a comparison is made between base isolated and fixed supported building models. From this study it is found that, by using seismic base isolation technology to building models, the story accelerations are reduced significantly in the base-isolated building compared to the fixed base buildings. Story drift can be reduced in base isolated buildings. The more the period is lengthened, the lesser the story accelerations and story drifts of the superstructure above the base isolators. The displacements are increased with period in the base isolated building for all cases. The base shears in each direction are decreased.

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