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Design of high damping rubber Isolator for RC Multistoried Structures and its Comparative Seismic Analysis

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Abstract –*Seismic base isolation is a suitable technology for earthquake resistant design of variety of buildings. 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 these results have been developed. The technique of base isolation involves the introduction of devices at the foundation of a building to increase the flexibility in the horizontal plane. The aim of the present study deals with the selection of suitable type of isolators. This study investigates structural behavior of multi storey building with or without base isolation subjected to earthquake ground motion. The performance of isolator is assessed from variation of base shear, , displacement, storey drift etc for the G+8 and G+10 building by installing high damping rubber bearing (HDRB)at the foundation level then compare the performance between the fixed base condition and base isolated condition by using SAP software.*

Key Words: *Fixed base, base isolation, high damping rubber bearing, Static pushover analysis, Nonlinear Time history analysis*, *Software (SAP2000)*

SCOPE OF STUDY

The scope of this study is limited to design of high damping rubber bearing for G+8 and G+10 buildings. Perform the static pushover analysis and nonlinear time history analysis for the selected ground motion data[11].Compare the results with different seismic parameters for fixed base building and base isolated building.

1. INTRODUCTION

Base isolators are the most effective method to reduce vibrations transmitted from ground to the structure. The role of the base isolator under seismic loading, is to isolate the structure from the horizontal components of the earthquake ground movement, whereas the vertical components are transmitted to the structure relatively unchanged. Base isolators deflect and absorb the seismic input energy transmitted horizontally to the structures. Base isolation involves mounting a building on bearings of low lateral stiffness. The principle of seismic isolation is to introduce flexibility in the basic structure in the horizontal plane, while at the same time adding damping elements to restrict the resulting motion. The basic concept of base isolation is to increase the natural period of the building to take it away from resonance with the forcing motions of earthquake. Increase in the period of vibration of the structure reduces the design base shear. A well designed seismic isolation system provides rigidity under low load levels such as wind and minor earthquake.

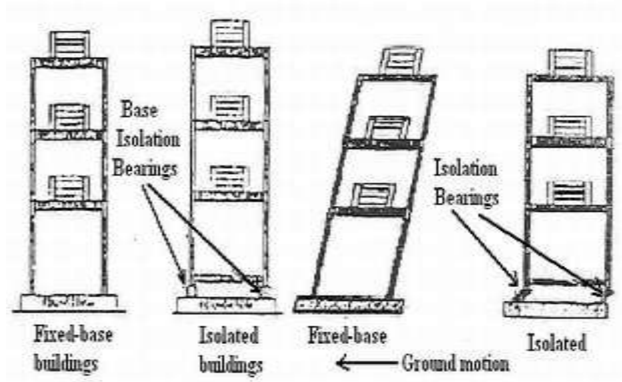


Fig1. Effect of seismic (base) isolation on the response of a structure.

High damping rubber bearing:

High damping rubber bearing[5] is composed of special rubber with excellent damping attribute, sandwiched together with layers of steel without any lead plugs. HDR adopt best rubber material of high damping ability, which enable it to absorb large energy of earthquake, taking advantage of its high elasticity, friction damping and viscosity damping characteristics as well as high durability. The bulk modulus is several orders of magnitude larger than their shear modulus, so that the material will deform only in shear. The behavior of the rubber bearing is affected by the loaded area and hence the shape factor. A linear elastic theory is the most common method to predict the compression stiffness of a thin elastomeric pad. When the vertical load is applied the height of the rubber decreases and in the mean times the rubber overflows on the lateral part of the isolator.

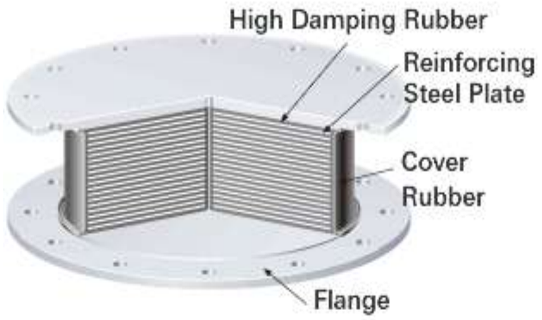


Fig 2 .High damping rubber bearing

2. OBJECTIVE OF THE PROJECT

The main objective of project was to comparative study [12] of fixed base and base isolated structure by dynamic analysis. The results were compared for Base shear, displacements and storey drift. The objective of the project is as explained below:-

1. The G+8 and G+ 10 storeys RC frame is isolated using high damping rubber bearing, to reduce the base shear when compared with conventional building.
2. To design the high damping rubber bearing by using the data from SAP2000
3. To increase the mode period[7] of the base isolated structure when compared to conventional building.
4. To decrease the displacement and storey drift of the base isolated when compared to conventional.
5. To decrease the story drift of a base isolated structure when compared with fixed base structure.
6. To study the effectiveness of providing high damping rubber bearing for Kobe ground motion data.

3. METHODOLOGY

1. The software used for analysis of a structure is SAP2000.

2. The dynamic analysis is carried for structure.

3. The codes used are IS 1893 (PART I) 2016, UBC 1997, IBC 2006.

Provisions Published by FEMA-451 (Federal Emergency Management Agency) in 2003

4. The building is modelled first then the loads are applied as per code provisions of IS 875 (PART II).

5. After analysis of a fixed base structure the maximum axial load is noted from support reaction results.

6. Then once axial load is noted the high damping rubber bearing is designed and properties are calculated.

7. Then these properties are used as link properties for base isolation structure in SAP2000[11].

8. Then the Base Isolation Structure is analyzed[4] and then results are tabulated and discussed

4. LITERATURE STUDY

Syed Ahmed Kabeer K. I. and Sanjeev Kumar K.S. (2014) in this paper studied how to prevent loss during earthquake by using Base- isolation. The mechanism of the base isolator increases the natural period of the overall structure, and decreases its acceleration response to earthquake/seismic motion. The study is based on to check for the adequacy of the base isolation against earthquake damage when compared to the conventional earthquake resistant design. A building was analyzed using the equivalent lateral force method and response spectrum analysis as fixed base and as isolated base with lead rubber bearing. In this paper they did study for reinforced concrete structures to show the ultimate capacity of the selected bearing system, and to make a comparison for the difference between the isolated base and the fixed base buildings. Finally they concluded lead rubber bearing reduces significantly the displacement, moment and shear generated for the same. {Ref.7}

Sameer S. Shaikh and P.B. Murnal.(2015) In this paper A three story building is modeled to compare the response of the structure by using SAP2000. Time history analysis is conducted for the 1994 Northridge and 1940 El-Centro earthquakes. The analysis result shows that when isolator position is shifting it significantly affects the response quantities. It is possible to arrive at optimum location of the isolator so as to get the maximum benefit of base isolation. {Ref.11}

Ajai Kumar Rai and Brajesh Mishra.(2017) In this paper studied base isolation techniques, reviews of the current practices and past researches but also need of these techniques by analyzing the earthquake data of the seven prominent cities/districts of the eastern Uttar Pradesh. This has been achieved by evaluating the each city/district by existing civil engineering structures of cultural / historical / archaeological importance, existing & pace of growth of high rise buildings, depth of alluvial soil over the soil/rock, geological, geographical and topographical features and earthquake magnitude. {Ref.4}

Kishan Bhojani, et.al. (2017) In this paper studied base isolation system which can be used in multi-storey building to reduce seismic response of the structure. This study represents the initialize study of dynamic parameter like effective damping for four earthquake time history. The optimum effective damping has been found out under the effect of Loma Prieta earthquake time history. Study has been conducted to evaluate the effect on maximum displacement, maximum acceleration, maximum base shear in bare frame and frame with isolator. In this study laminated rubber bearing are used as base isolator. After studding they concluded that. thickness of the isolator decreases with increase in damping. Ii. In linear analysis the displacement is increased while in non-linear analysis displacement is decreased. {Ref.5

4. MODELLING IN SAP2000

Hysteretic isolator links were used to simulate rubber bearings in SAP2000. An isolator link assigned to each column at the foundation level as a single joint element to connect the superstructure to the ground. High damping rubber Bearing links were applied as link of rubber isolator. The behavior of link elements in SAP2000 is defined in the Link/Support Property. Directional properties U1, U2, U3, R1, R2, and R3 are mechanical behavior in six directions. The properties for axial deformation (U1) is linear only, shear deformations (U2, U3) are linear and nonlinear. And tensional deformation (R) about U1 is linear only. Rotations above U2 and U3 are (R2 & R3) are linear only. All internal deformations of the isolator links are assumed to be independent of each other.

Table 1: Model Details of G+8 Building.

SR.NO.	Particulars	Description
1	Type Of Frame	SMRF.
2	Area	22.5 x 27 sq.m
3	No.of Storey's	G+8
4	Height of storey	4 m
5	Height of building	36 m (class B)
6	flexural members per floor	71
7	Compression members per floor	42
8	No.of slabs per floor	30
9	slab thickness	200 mm
10	Size of column	300 x 900 mm
11	Size of Beam	300 x 600 mm
12	Wall thickness	230 mm
13	Concrete grade	M30
14	Steel grade	Fe 500, Fe 415

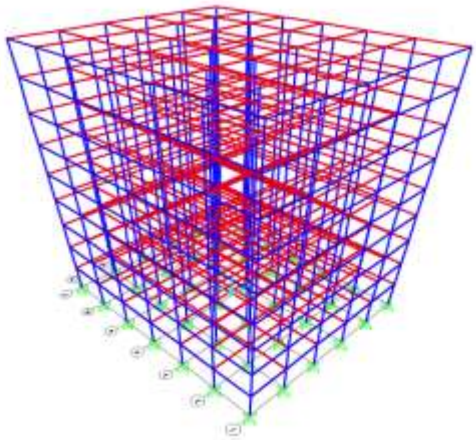


Fig.3 G+8 building 3D Model

Properties of G+8 building for analysis in SAP 2000

U1 Linear Effective Stiffness = 11300000000 N/m

U2 and U3 Linear Effective Stiffness =1338366.667 N/m

U2 and U3 Nonlinear Stiffness = 10229264.52 N/m

U2 and U3 Yield strength = 63421.44 N

U2 and U3 Post Yield stiffness ratio 0.0998

Damping = 20%

Table 2: Model Details of G+10 Building.

SR.NO.	Particulars	Description
1	Type Of Frame	SMRF
2	Area	27 x 31.5 sq.m
3	No. Of Storey's	G+10
4	Height of storey	4 m
5	Height of building	44 m (class B)
6	flexural members per floor	97
7	Compression members per floor	56
8	No.of slabs per floor	42
9	slab thickness	200 mm
10	Size of column	300 x 1000 mm
11	Size of Beam	300 x 600 mm
12	Wall thickness	230 mm
13	Concrete grade	M30
14	Steel grade	Fe 500, Fe 415

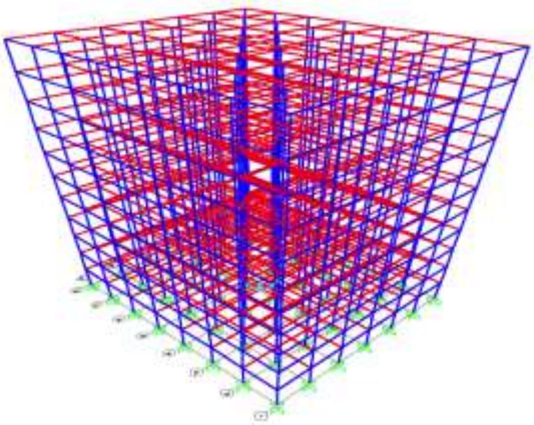


Fig.4 G+10 building 3D Model

Properties of G+10 building for analysis in SAP 2000

U1 Linear Effective Stiffness = 12900000000 N/m

U2 and U3 Linear Effective Stiffness = 1927744.44 N/m

U2 and U3 Nonlinear Stiffness = 14694272.67 N/m

U2 and U3 Yield strength = 91398.376 N

U2 and U3 Post Yield stiffness ratio 0.149

Damping = 20%

Table 3: Bearing Details of G+8 & G+10 Building.

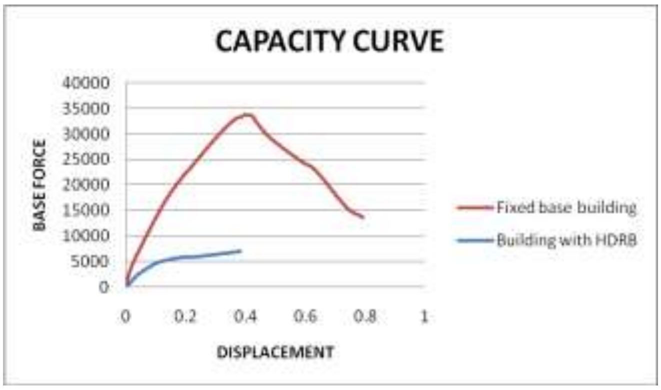
SR.NO	Parameters	G+8	G+10
1	Diameter of Bearing	505 mm	620 mm
2	Thickness of individual rubber layer	20mm	22mm
3	Numbers of rubber layer	10	10
4	Thickness of individual steel plates	2.8mm	2.8mm
5	Numbers of steel plates	9	9
6	Thickness of top and bottom steel plates	25mm	25mm
7	Total height of bearing	276mm	296mm

Above Table 3. Shows, dimensions of bearing which are calculated on the basis of required stiffness. Time period is assumed to be 2 sec.

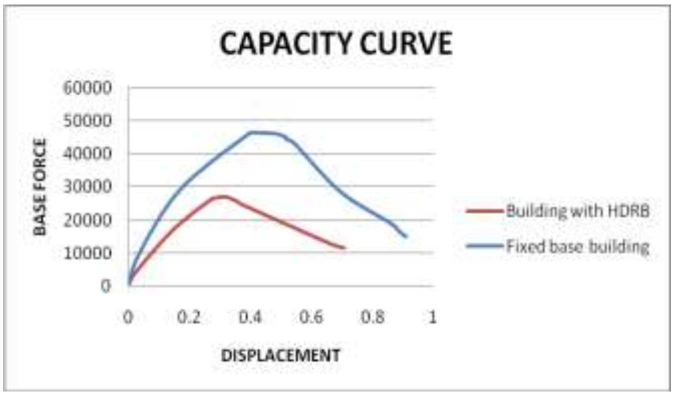
6. RESULT OBTAINED FROM SOFTWARE SAP 2000

All results are computed after analysis of model in software SAP2000.

Results obtained from pushover analysis

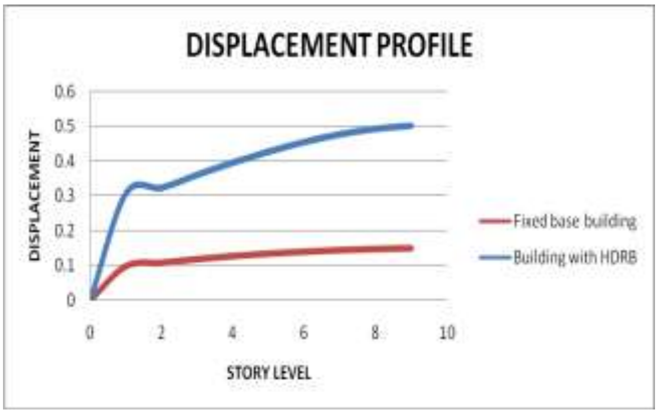


Graph 1: Capacity curve of G+8 storey building with & without HDRB

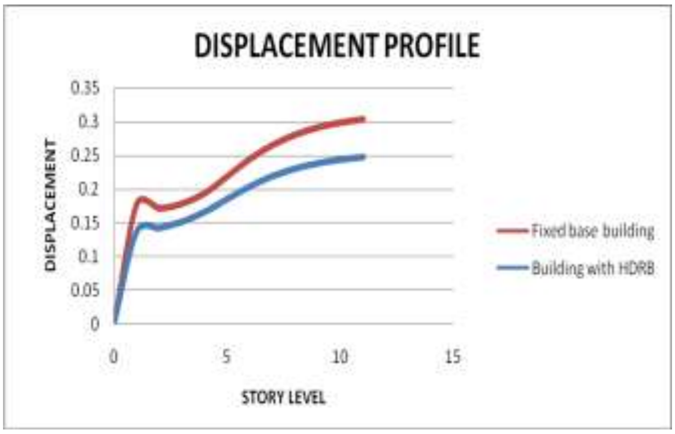


Graph 2: Capacity curve of G+10 storey building with & without HDRB

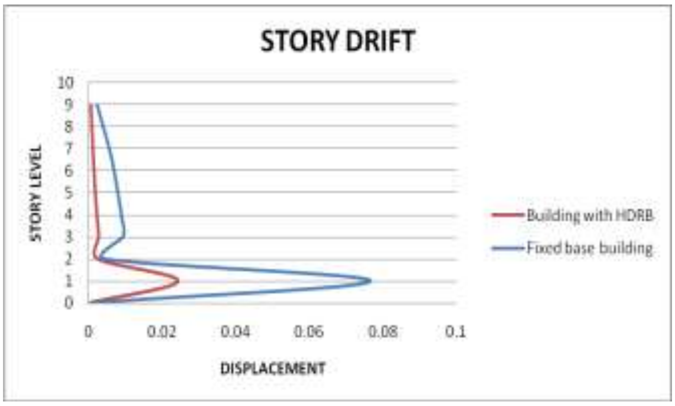
Results obtained from time history analysis



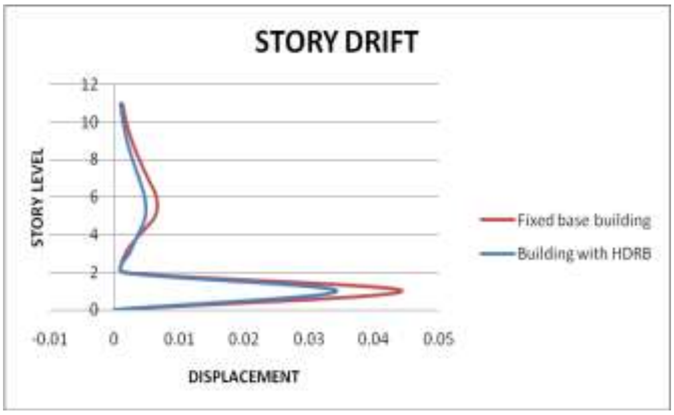
Graph 3: Displacement profile of G+8 storey building for Kobe ground motion data



Graph 5: Displacement profile of G+10 storey building for Kobe ground motion data



Graph 7: inter storey drift of G+8storey building for Kobe ground motion data



Graph 9: inter storey drift of G+10 storey building for Kobe ground motion data

7. CONCLUSION

From the comparative study of fixed base and base isolation methods by using high damping rubber bearing the following conclusions are made:

1. Time periods are increased which increases, reaction time of a structure during earthquake.
2. Base shear get reduced after using the high damping rubber bearing (HDRB) as base isolation system, which reduces the seismic effect on building.
3. It is observed that when increasing the number of a story, maximum storey displacement becomes considerable.
4. From nonlinear analysis displacement of base isolated building reduced to 25% - 40% over the fixed base building. Base shear get reduces 55% - 80% and storey drift is get reduces up to 60 -76%.
5. It can be concluded that the performance of base isolated structure is efficient in seismic prone areas.

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