Alternate Arrangement of Different Base Isolation System for Seismic Protection of Building

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Abstract – *the structural and non- structural components should remain operational and safe after earthquake. So to alleviate the effect of earthquake on the structure the base isolation technique is the best alternative as an seismic protection system. The idea of base isolation system is to shrink inertia forces induce by earthquake by increasing the fundamental period of the structure. The main object of this study is the use of High Density Rubber Bearing (HDRB) and Friction Pendulum System (FPS) as isolation devices and then to compare various parameters between fixed base condition and base isolation condition by using ETABS software. In this study two model of single building with alternate arrangement of both isolator on same building. Nonlinear time history analysis is carried out for both the structure by considering different earthquakes ground motion records. The Indian Bhuj earthquake data are used for the analysis. The results obtained shows the reduction in base shear, storey drift and storey acceleration in both direction and increase in the displacement and the time period for the base isolated structure. In the second part of this study response of alternate isolation system or mixed isolation system has presented for all the test models. Many projects use of one type of base isolator, but others use more than one base isolator device (alternate system). This report intended to give an insight on the seismic performance of seismically isolated buildings using alternate arrangement of base isolation devices. The report also answer the question, that what is the performance expected from the use of more than one isolation device. If the alternate arrangement gives a good level of seismic performances, so which one is better is presented here. Finally parameters such as storey displacement, storey drift, storey acceleration and base shear are compared and obtained result where presented by both graphically and in tabular format.*

Key Words: Base isolation, HDRB, FPS, Non-linear analysis, ETABS.

INTRODUCTION

Earthquakes have the negative impact on society. It causes loss of human life and heavy economic losses due to building damages. Earthquakes cause damage to structural element as well as non structural element of building. Earthquake mainly affects structural components of lateral load resisting system. Earthquake produces huge amount of stresses and deformations on structural element of building. From last few decades structural engineers have been doing research on the characterization and evaluation of structural damage. Damage quantification is always difficult, as structural degradation processes is very complex. Different methods have been developed to evaluate damage state of structure. It includes analytical predictions and experimental measurements. Damage assessment investigates actual degradation state of a structure. Damage assessment technique is applied in different situations such as disaster planning, seismic vulnerability assessment and retrofit and repair, maintenance inspection and post earthquake evaluation. The different approaches to characterize damage such as ductility drift ratio, maximum deformation, strain softening and energy dissipation characteristics at component, element or structural level.

The purpose of the base isolation techniques to defend structures against damage from earthquake attacks has been considered as one of the most effective approaches and has gained increasing recognition during the last two decades. This is because base isolation limits the property of the earthquake attack, a flexible base principally decoupling the structure from the ground motion, and the structural response accelerations are usually less than the ground acceleration. Seismic isolation is being used worldwide to protect the structures like buildings, bridges etc., from the destructive effects of earthquakes. In base isolation the base becomes horizontally flexible, which strengthen the structure against earthquakes. There are so many factors and correctness explained for application of base isolation techniques.

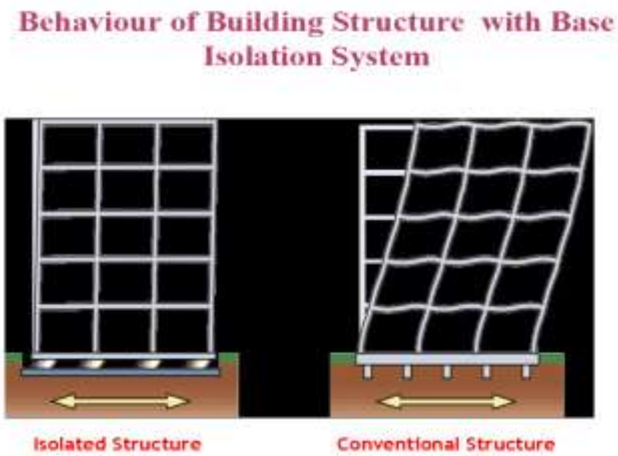


fig. Displacement of Fixed & Base Isolated Structure

The conventional technique is to strengthen the structural members in order to protect them against strong earthquakes. The special techniques to decrease inter story drifts and floor accelerations are increasingly being adopted. Base isolation is a design methodology that serves to decouple a structure from the hard-hitting ground motions caused by earthquakes. This decoupling of the structure usually occurs at the ground level, between the super-structure and the foundation. Base isolation is to avoid the superstructure of the building from gripping the earthquake energy. In seismic isolation, the fundamental intend is to diminish substantially the transmission of the earthquake forces and energy into the structure. This is achieved by rising the structure on an isolation system with substantial horizontal flexibility so that during an earthquake, when the ground vibrates strongly under the structure, only modest motions are induced within the structure itself.

OBJECTIVES

The main objective of the present work is to study the analysis of RCC building with Fixed Based, Base Isolation system like Rubber Isolator and Friction Isolator:

1) To study Design and Analysis software ETABS

2) To study modeling of building with fixed based, rubber isolator and friction isolator by time history analysis method

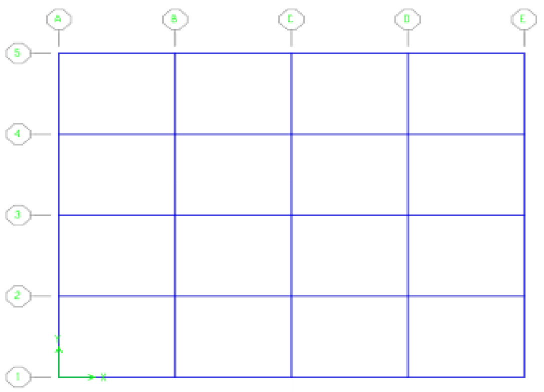
3) To find effect of axial force and moment on model with different base system introduce to the building

4) To evaluate and compared modeling with different base isolation property are introduce to the building

5) To study the their different analysis & result as compared to each modeling

6) To study correlation between seismic acceleration parameter and base of the building with alternate base isolation system.

PHYSICAL PARAMETERS



Plan of G+20 storey RCC Building

Numerical Data for Ground + 20 Storey RCC Building

Live load	3 kN/m²
Earthquake Data	Bhuj Earthquake ground motion 1.078g
Depth of foundation below GL	1.5 m (consider as fixed)
Storey height	3.5 m of ground storey & 3 m for other storey
Size of Beam	0.30m x 0.5m
Size of Column Ground to 4 th storey	1.2m x 1.2m
Size of Column 5 th to 9 th storey	1.0m x 1.0m
Size of Column 10 th to 20 th and 21st to 30 th storey	0.75m x 0.75m
Wall	230 mm thick RCC wall
Slab	130 mm thick as rigid diaphragm
Material Properties	Concrete- M25 HYSD reinforcement of grade Fe 415, Steel strut - X type bracing using IAS 150 x 150 x 6 mm

Properties of Isolators for (G+20) storey structure without strut

Types	HDRB	FPS
Vertical Stiffness (U1)	2855317.347 KN/m	29000000 KN/m
Linear Stiffness (U2 & U3)	2379.40 KN/m	1450 KN/m
Non-linear Stiffness (U2 & U3)	2005.637 KN/m	29000 KN/m
Yield Strength (Q)	193.50 KN	-
Damping (β)	0.10	0.10
Radius of dish (R)	-	3.645 m
Friction Coefficient, Fast	-	0.05
Friction Coefficient, Slow	-	0.03

Elevation of 20 - Storey building

Calculation for High Damping Rubber Bearing (HDRB)

Maximum weight on single coloumn = 8457 KN
Mass = 8.457 KN

Take T = 3.83 sec.

KH=w/g x ($2\prod/T^2$) = 8457/9.81 x ($2\prod/3.83^2$) = 2320.11 KN/M

$D_D = g/4\prod^2 \times (C_u \times T_D / B_D) = 9.81/4\prod^2 \times (0.64 \times 3.83/1.20)$ = 0.507 m

Take G = 0.4 Mpa , ϒ = 1.5

ϒ = D_D/ tϒ → 0.507/1.5 = 338 mm

Now,

KH = GA/tϒ

2320 = 0.4 x A/ 0.338

A = 1.9604 m^2

A= π/4 x $Ø^2$

Ø = 1.579 m ≈ 1.60 m

i.e. A = π/4 x $Ø^2$ = 2.0106 m^2

Avtual Stiffness = GA/tϒ = 0.4 x 2.0106/0.338 = 2379.40 KN/m

Take S = 10

Thickness of one layer of rubber, t = Ø/4S

t = 1.60/40 = 0.04m

No. of layer = 0.338/0.04 = 8.45 ≈ 9 No's

tϒ = 9 x 0.04 = 0.36m ≈ 360 mm

Now,

Ec = 240 Mpa

As = 2 x π/4 x 1600^2 = 4021238.597 mm^2

Vertical Stiffness, Kϒ = (Ec x As) / tϒ

Kϒ = 240 x 10^3 x 4021238.597/338

= 2855317.347 KN/m

Now,

$W_d = 2\pi k_e ff D^2 \times B_e ff$

Wd = 384.293 KN

Also,

Wd = 4QD

384.293 = 4Q x 0.507

Q = 189.50 KN

$K_e ff = K_2 + (Q/D)$

2379.40 = K_2 + (189.50/0.507)

K_2 = 2005 .637 KN/m

dy = $Q/9K_2$

dy= 189.50/9 x 2005.637

dy = 0.01049

Wd = 4Q (D_D-dy)

384.293 = 4Q (0.507 - 0.01049)

Q = 193.50 KN

And

β = 4 x 193.50 x 0.49651/π^2 x 2379.40 x 0.507^2

β = 0.10

Input Data for Rubber Isolation in ETABS Programming

U1 = 2855317.347 KN/m

U2 & U3 (Linear) = 2379.40 KN/m

U2 & U3 (Non Linear) = 2005.637 KN/m

Q = 193.50 KN

β = 0.10

Calculation for Friction Pendulum Sliding Bearing (FPSB)

Maximum weight on single column = 8457 KN
Mass = 8.457 KN

Take T = 3.83 sec.

$T = 2\pi \times (\sqrt{R/g})$

$3.83 = 2\pi \times (\sqrt{R/9.81})$

$R = 3.645$

$D_D = g/4\Pi^2 \times (C_u \times T_D / B_D) = 9.81/4\Pi^2 \times (0.64 \times 3.83/1.20) = 0.507$ m

$B_eff = 2/\pi \times (0.05/0.05 + 0.507 \div 3.645)$

$B_eff = 0.168$

Vertical Stiffness Kv is 10 tmes more than vertical stiffness of Rubber Isolator

Vertical Stiffness of Friction Isolator Kv = 10Kv of Rubber Isolator

Kv = 29000000

Input Data for Friction Isolation in ETABS Programming

U1 = 29000000 KN/m

U2 & U3 (Linear) = 1450 KN/m

U2 & U3 (Non Linear) = 29000 KN/m

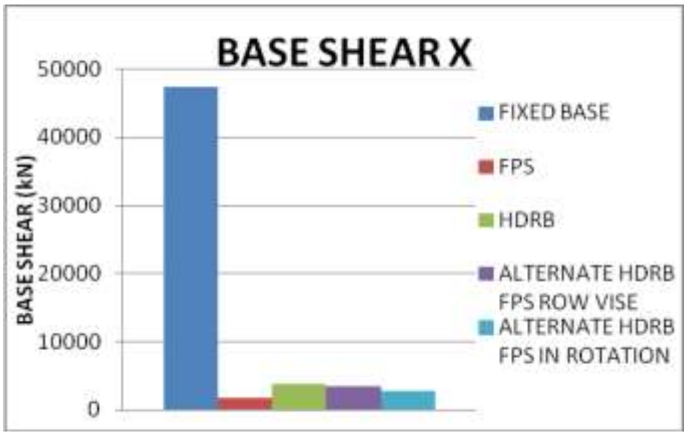
Friction Coefficient, Slow = 0.03

Friction Coefficient, Fast = 0.03

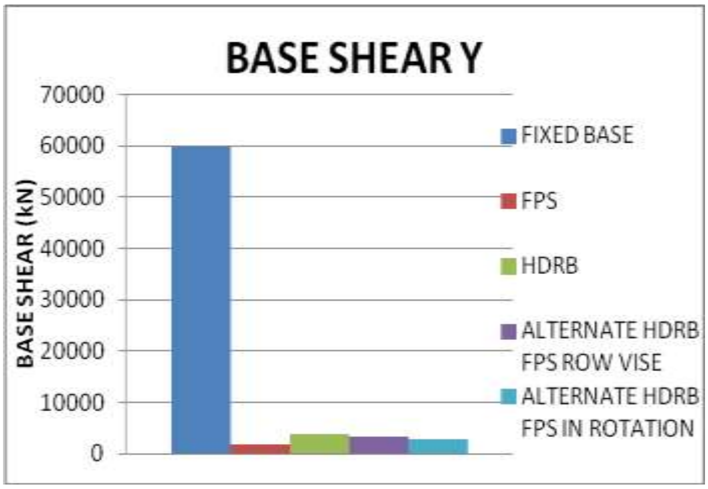
Radius of Sliding Surface, R = 3.645 m

$\beta = 0.10$

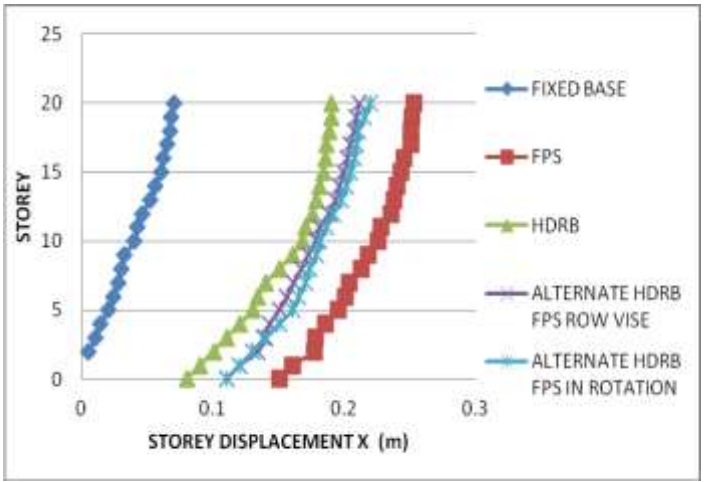
Results for (G+20) Storey Building



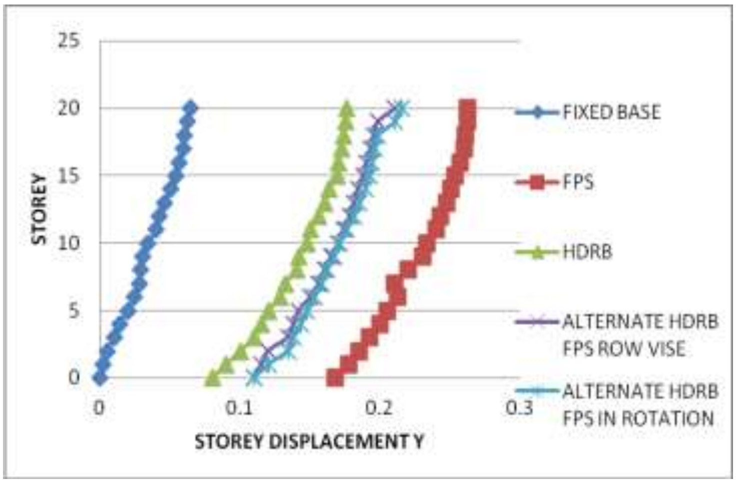
Base Shear in X-Direction



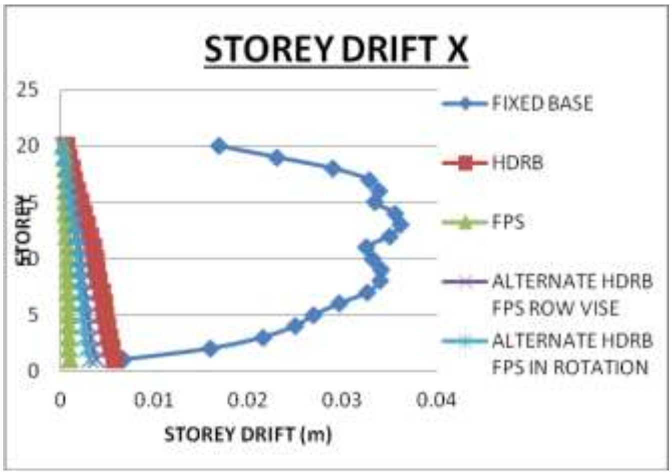
Base Shear in Y-Direction



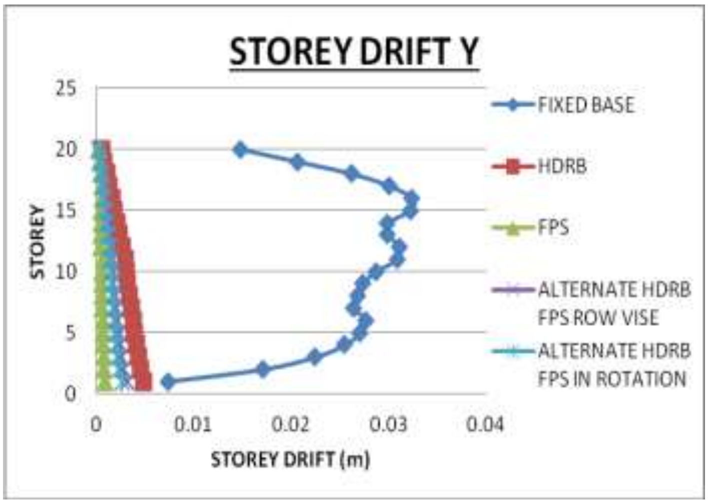
Storey Displacement in X-Direction



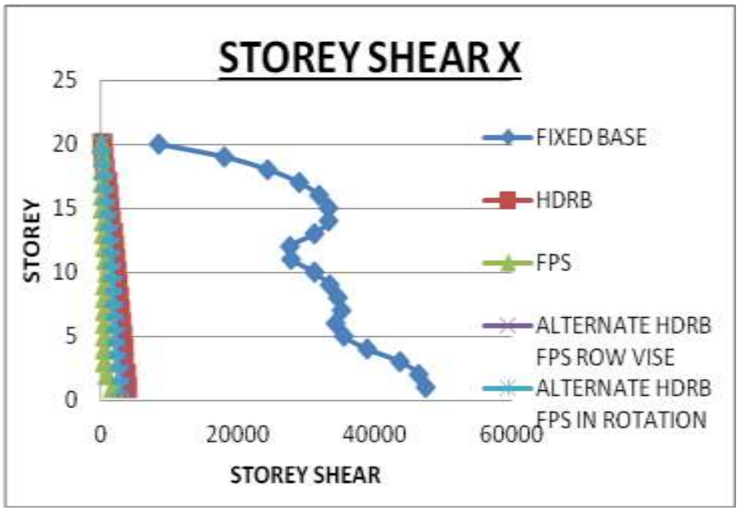
Storey Displacement in Y-Direction



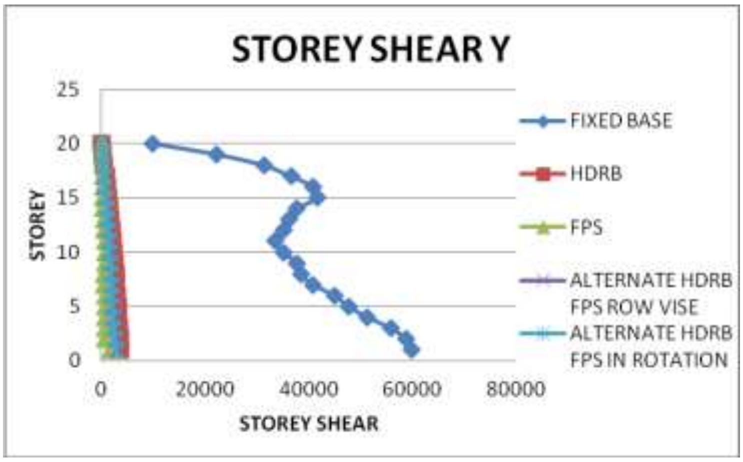
Storey Drift in X-Direction



Storey Drift in Y-Direction



Storey Shear in X-Direction



Storey Shear in Y-Direction

CONCLUSIONS

- It is concluded that time period of the structure in case of FPS, HDRB & Alternate Arrangement of both. it is increased over conventional fixed base structure.
- It is concluded that base shear of structure reduces by the use of base isolator. But it is greatly reduces by use of FPS over HDRB & Alternate Arrangement of both.
- It is also concluded that FPS gives maximum base displacement compared to HDRB.
- Storey drift is reduce by both HDRB and FPS. But it is greatly reduces by the use of FPS.
- It is seen that base isolation technique lengthens the time period of structure at greater extent for mid rise structure. But, as the number of stories goes on increasing the proportion of increment in time period of base isolated structure goes on decreasing.
- It is concluded that as the number of storey's increase, the friction pendulum system give minimum value for top displacement. Hence, it is concluded that this type of system helps to minimize top displacement for multi storey structure.
- It is concluded that Friction Pendulum system helps in reducing storey drift & storey acceleration at greater extent than High Density Rubber Bearing for both mid-Storey and multi-storey structure.
- Friction pendulum system is beneficial than lead rubber bearing isolator & slightly higher than high density rubber isolator in terms of cost.

Future Scope

Within limited scope of present study the broad conclusion are drawn. However present study may also be extended in following areas:

- The present study carried out by using HDRB & FPS type isolator, this can also extended by use of all three basic isolation system such as Lead rubber bearing (LRB), HDRB & FPS and their comparisons with each other.

- The present study also extended by taking various combinations using all three base isolation systems in single structure and to find the response of such structure.

- In this dissertation work, the study is carried out without considering the irregularity of building, study may also extended by considering this important factor.

- The present work also extended by considering pushover analysis for base isolated structure as present work is carried out by nonlinear time history analysis.

Applications

A base isolation technique has a number of applications all around world. Base isolation techniques used in many structural buildings which is located in strong earthquake zones. It is also used in constructing bridges to save these structures from earthquake. Now days, in many projects base isolation technique is used in constructing water tanks.

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