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Dynamic analysis of RC irregular structure by providing lead rubber bearing(LRB), fluid viscous damper(FVD) and combined effect of LRB & FVDas base isolation system

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Abstract – *Earthquakes can create serious damage to structures. The structures already built are vulnerable to future earthquakes.A seismically isolated structure has a fundamental frequency that is much lower than the fundamental frequency of the corresponding fixed supported structure and the predominant frequencies of a typical earthquake. This is achieved by mounting the structures on a set of isolators that provides low horizontal stiffness and consequently, shifts the fundamental frequencies of the structures to much lower values.Themainpurposeofthisstudyistocheckthe behavioroftthebuildingsinseismiczoneby using lead rubber base isolation concept and fluid viscous dampers. and reduce the base shear, displacement and lengthen the period of oscillation due to earthquakegroundexcitation,appliedto the superstructure of the G+5, G+10 and G+15 buildings by installing lead rubber isolation (LRB) at the foundation level and fluid viscous dampers (FVD) at floor levels then compare the behavior between the fixed base condition, viscous damper condition, base isolated condition,and combined LRB & FVD conditionby using ETABSsoftware.*

Key Words: *Fixed base, Base isolation, Lead rubber bearing, Fluid viscous damper,Modal time history analysis, Response spectrum analysis, Software ETABS 2017.*

SCOPE OF STUDY

The scope of this study is limited to design of lead rubber bearing for G+5, G+10 and G+15building. Perform response spectrum analysis and linear modal time history analysis for the Bhujearthquake data. Compare the results with different seismic parameters for fixed base structures, fluid viscous damper structure, base isolated structures and combined use of LRB & FVD structure.

1. INTRODUCTION

Base isolation is one of the most widely accepted techniques to protect structures and to mitigate the risk to life and property from strong earthquakes. Structural passive control systems have been developed with a design philosophy different than that of traditional seismic design method. These control systems primarily include seismic isolation systems & energy dissipation systems. A variety of energy dissipation systems have been developed in the two decades such as friction damper, metallic damper, viscous damper. A structure installed with these dampers does not rely on plastic hinges to dissipate the seismic energy. On contrary, the dissipation of energy is concentrated on some added damper so that the damage of the main structure is reduced and functions of the structure can be possibly preserved.

The base isolation techniques and energy dissipation techniques such as a damper, reduce response of structure hence there is necessity to investigate the effect of base isolators and dampers on the response of structure. Work has been done earlier by using one type of isolator and comparative study of two or more types of isolators. Also work has been done earlier by using one type of damper and comparative study of two types of dampers for low storey to high storey structure. But very less work has been done on comparative study between one type of isolator, one type of damper and combined used of isolator & damper. Hence there is need to find out the seismic response of low storey to high storey structure by using base isolator and damper on the same type of structure.

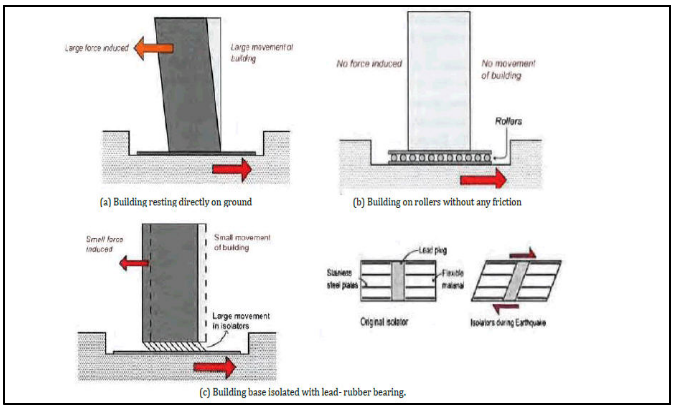


Fig.1 Effect of seismic (base) isolation on the response of a structure.

Lead rubber bearing

LeadrubberbearingswereinventedinNewZealandin1975. There are three main pieces of equipment, layers of steel plates,rubberlayersandleadcore,respectively.Thelayers of steel provide vertical stiffness and the layers of rubber supplythedevicewithhighlateralflexibility.Leadcoreisthe device that will supply extra stiffness to the isolators and appropriate damping to thesystem.

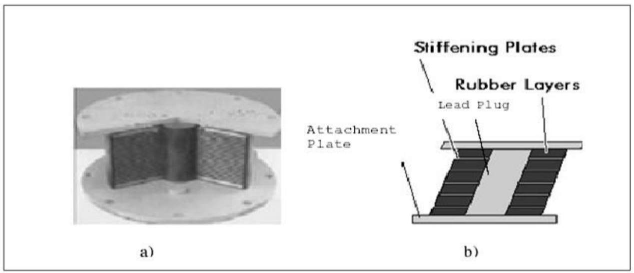


Fig.2 Lead rubber bearing

Fluid viscous damper

The dampers which utilize the viscous properties of fluids have been developed and used in structural applications. The device consists of outer steel casing attached to the lower floor and filled with highly viscous fluid. An inner moving steel plate hanging from the upper floor is contained within the steel casing. The viscous damping force is induced by relative velocity between two floors. These dampers possess linear viscous behavior and are relativelyinsensitive to temperature changes.

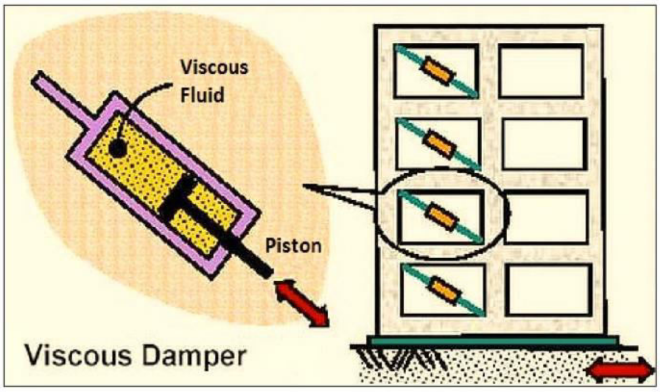


Fig.3 Mechanism of viscous damper

2. SCOPE AND OBJECTIVE OF THEPROJECT

The scope of present study aims at evaluation of seismic behavior of RC irregular frame structure using modal time history analysis and response spectrum method. The objective of present work is the comparative study on RC frame with fixed base, RC frame with viscous damper and base isolated RC frame structure & RC frame combined with base isolated & viscous damper. Modeling of (G + 5), (G + 10), (G + 15) storey RC irregular frame structures with same plan and with typical floor area 371.25 m2. The analysis is carried out with modal time history analysis and response spectrum method with ETABS Ultimate 17.0.1. Four models of each type of structure with fixed base, structure with fluid viscous damper and structure with lead rubber bearing, structure with lead rubber bearing & fluid viscous damper are considered. They are assumed to be located in Zone V. For comparative study, analysis procedure kept same for all types of structures. The parametric study of seismic behavior in terms of storey displacement, storey acceleration, modal time period, ,base shear, storey drift etc. is done.

3. METHODOLOGY

1. ThesoftwareusedforanalysisofastructureisETABS 2017.
2. The dynamic analysis is carried for structuralanalysis.
3. The codes used are IS 1893 (PART I) 2016, UBC 1997, IBC2006.
4. ProvisionspublishedbyFEMA-451(FederalEmergency Management Agency) in2003.
5. Thebuildingismodeledfirstthentheloadsareapplied as per code provisions of IS 875 (Part II) Reaffirmed in 2008 for live and dead load.
6. Response spectrum analysis and modal time history analysisiscarriedoutforthefixedbase case, fluid damper case,leadrubber isolated case and combined FVD & LRBstructures.
7. Afterthanalysisofafixedbasestructurethemaximum axial load is noted from support reactionresults.
8. Then properties of Lead core rubber bearing are calculated and these properties are used as link properties for base isolationstructure.
9. Then properties of fluid viscous damper are calculated and these properties as used as link properties for viscous damper structure.
10. Then the Base isolation structure, Fluid viscous damper structure and combined LRB & FVD are analyzedand
11. Results are tabulated anddiscussed.

4. LITERATURE STUDY

BhavanaBalachandran, Susan Abraham, 2018. In this study, (G+3) and (G+20) storey RCC building are used as test model in ETABS 2015 software. High rise, low rise, plans irregular and vertical irregular buildings are considered for this project. Lead rubber bearing is used as base isolation in this study. Linear time history analysis with El-Centro time history data is used on both fixed and base isolated buildings. The base shear and time period are compared from two time history analysis between fixed and base isolated condition. It was observed that base isolation increases the time period of the building and hence correspondingly reduces the base shear for all the cases considered.

VijithaVijayan, Suji P. 2018. In this study, a six storey building which is situated in Bhuj city is considered. X bracings provided in different sides of structures with and without using lead rubber bearing and friction pendulum bearing as base isolators. Response spectrum analysis carried out for frames with and without bracing using base isolation techniques using the software ETABS2015. Analysis results show a reduction in base shear for base isolated buildings. The storey displacement and time period of base isolated building is increased as compared to that of fixed base structure

Sushil P. Lipte, Dr. V. R. Rathi, Dr. P. K. Kolase, 2018.. In this study, a comparison is made of the seismic response of a G+7 & G+14 story base-isolated building by idealizing the superstructure as rigid and flexible. In this work the Lead Rubber Bearing (LRB) isolation system is considered. Two different heights of buildings low and medium rise in zone V is considered. For such analysis ETAB software was used. 3 bay G+7 & G+14 story structure was analysed for dynamic earthquake using response spectrum method. The results obtained are Story drift, Story acceleration, Base shear, Lateral displacement, Reaction at base. This paper intends to demonstrate how an isolation system can be efficient, evaluating its effectiveness for the building in terms of story acceleration, base shear, story drift and story displacement reductions.

Mayuri D. Bhagwat, Dr.P.S.Patil, July 2014 In the present work, dynamic analysis of G + 12 multi-storeyed practiced RCC building considering for Koyna and Bhuj earthquake is carried out by time history analysis and response spectrum analysis and seismic responses of such building are comparatively studied and modelled with the help of ETABS software. Two time histories (i.e. Koyna and Bhuj) have been used to develop different acceptable criteria (base shear, storey displacement, storey drifts).

5. LOADING

Live Load = 2 KN/m2
Floor Finish = 1.5 KN/m2
Terrace Live Load = 1.5 KN/m2
Terrace Floor Finish = 1.5 KN/m2
Terrace Water Proofing = 2.75 KN/m2

Table.1 Seismic details as per IS 1893 Part 1:2016

Sr. No.	Particulars	Description
1	Seismic Zone	V
2	Zone Factor	0.36
3	Soil Type	Type-II (Medium)
4	Importance Factors	1
5	Response Reduction Factor	5
6	Damping of the structure	5%
7	IS Code	IS 1893:2016 PART-I

6. MODELLING

Table.2 Model Details of G+8 Building

Sr. No.	Particulars	Description
1	Type Of Frame	SMRF
2	Area	371.25 m^2
3	Height of storey	3m
4	Flexural members per floor	40
5	Compression members per floor	25
6	No.of slabs per floor	16
7	Slab thickness	150 mm
8	Size of column (in mm)	(600x600) (500 x 500) (400 x 400)
9	Size of Beam (in mm)	(250 x 600) (250 x 450)
10	Wall thickness (in mm)	150mm 100mm

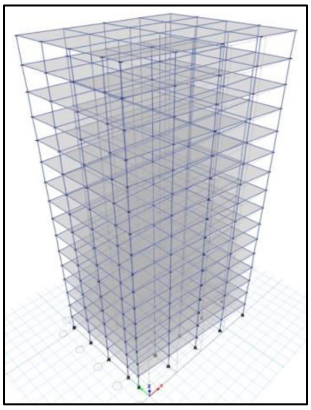


Fig.4 3D-View G+15 Model

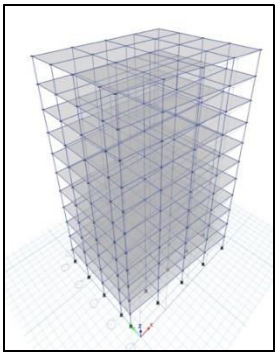
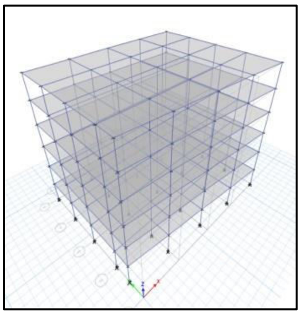


Fig.5 3D-View G+10 Model



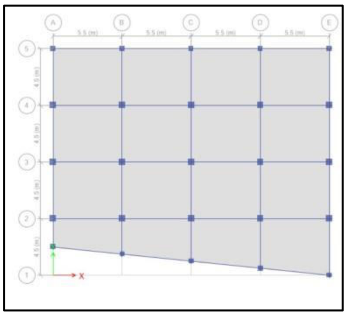


Fig.6 3D-View G+5 ModelFig.7 Plan View of Model

7. ANALYSIS OF MODEL

Time History Analysis

Time history analysis is a step by step analysis of the dynamical response of a structure to a specified loading that may vary with time. The analysis may be linear or nonlinear. Time history analysis is used to determine the dynamic response of a structure to arbitrary loading.

Response Spectrum Analysis

The response spectrum is a plot of the maximum response (usually the acceleration Sa) of single degree of freedom (SDOF) systems as a function of their natural period T. A variety of ways are available to combine the individual responses considering the fact that these maximum responses occur at different instants of time. When the natural periods are sufficiently apart, the most common way of combining the maximum responses is by taking the square root of the sum of the squares (SRSS) method.

8. DESIGN OF LEAD RUBBER BEARING

Bilinear model can be used for all isolation systems used in practice. To model the nonlinear force-displacement behavior of the isolation system through the bilinear hysteresis loop, three parameters are important namely (i) elastic stiffness, K1 (ii) post-yield stiffness, K2 (iii) characteristic strength, Q. The elastic stiffness K1 is estimated as a multiple of post-yield stiffness K2 for high damping rubber bearings. The effective stiffness defined as the secant slope of peakto-peak values in a hysteresis loop, is given by,

Keff = K2 + (Q / D)D >Dy

Where, Dy is the yield displacement.

Dy = Q / (K1 – K2)

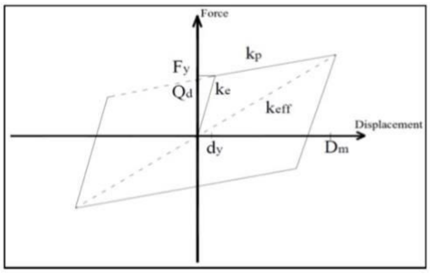


Fig.8Force-displacement relationship of bilinear model

The area of the hysteresis loop, i.e. the energy dissipated per cycle, Wd is given as

Wd = 4Q (D – Dy)

The effective damping is defined by,

βeff = 4Q (D – Dy) / (2π Keff D2)

To make a bilinear model of the isolator the time period T, the damping β, the displacement D, and sustained gravity load to be carried by the isolator W has to be specified. With the time period T specified, the effective stiffness Keff is given by,

Keff = W (2π) 2 / gT2

After that, global energy dissipated per cycle, Wd is calculated by,

Wd = 2π Keff D2 βeff

At this point Dy is neglected and Q is estimated from the above equation. It is then possible to estimate K2 from the above equation. Then Dy is calculated from the equation. Assuming a relationship between elastic stiffness K1 and post-yield stiffness K2. For LRB, K1 = 10 K2 has been assumed. Then again Q has been estimated from above equation with new Dy. Iteration process has been continued until the solution converged within acceptable error limit for Q, K2 and Dy.After above calculation properties required for ETABS is calculated are listed belowtable.3.

Table.3Properties for analysis in ETABS 2017

Particulars	G+5	G+10	G+15
ROTATIONAL INERTIA 1 **in ton-m2**	0.0379687	0.1301	0.2649
FOR U1 & EFFECTIVE STIFFNESS **in kN/m**	1737211.3	3130586.5	4411924.4
FOR U2 & U3 LINEAR EFFECTIVE STIFFNESS **in kN/m**	1737.21	3130.58	4411.92
FOR U2 & U3 EFFECTIVE DAMPING **in kN-s/m**	0.05	0.05	0.05
FOR U2 & U3 DISTANCE FROM END-J **in m**	0.0031752	0.003175	0.003175
FOR U2 & U3 NON-LINEAR STIFFNESS **in kN/m**	16008.403	28848.25	44655.88
FOR U2 & U3 YIELD STRENGTH **in kN**	50.83	91.60	129.09

In ETABS 2017 an isolator link assigned to each column at the foundation level as a single joint element to connect the superstructure to the ground. Lead rubber Bearing links were applied as link of rubber isolator. The behavior of link elements in ETABS 2017 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 torsional deformation (R) about U1 is linear only. Rotations above U2 and U3 are (R2 & R3) are linear only.

9. DESING OF FLUID VISCOUS DAMPER

The damping in the viscous damper can be computed using the following formula for given values of force F, velocity V and α.

F= CVα

F = Force in the member
i.e. damper capacity = Assume 25T = 250KN
V = Avg. velocity between two ends of damper = 0.33 m/s
α = Damping exponent = 0.3
C = Damping coefficient = 350 KN-s/m
Parameters considered for Taylor fluid viscous damper:
The single diagonal tension/compression brace with viscous damper can be modeled as a damped brace using the following link properties:

1. Name = VISCOUS
2. Type = Damper
3. M = Mass of damped brace
4. W = Weight of damped brace
5. Rotational inertia 1 = Rotational inertia 2 = Rotational inertia 3 = 0
6. Direction = U1
(nonlinear -- put check mark in nonlinear box next to U1)
7. K = Effective Stiffness = AE/L (properties of brace)
8. C = Effective Damping = As per calculations
9. Damping Exponent (α) = 0.15 – 0.5 = consider 0.3

10. RESULT OBTAINED FROM SOFTWARE ETABS 2017

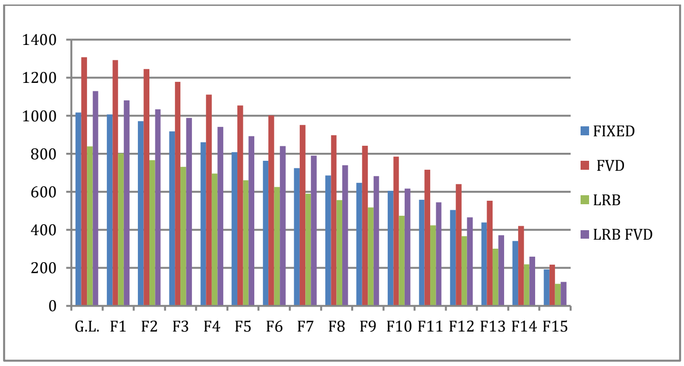
All results are computed after analysis of model in software ETABS 2017.

1. **Observations of G+15 Storey Structure :**

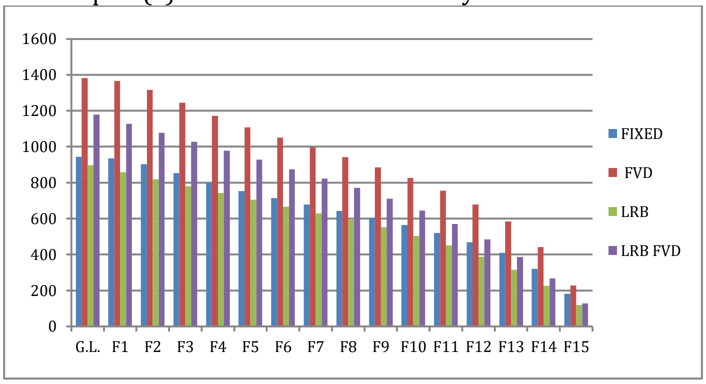
Table 4.Time period in Sec.

Mode	FIXED	FVD	LRB	LRB FVD
1	2.871	2.973	3.495	3.791
2	2.693	2.843	3.321	3.666

Results obtained from response spectrum analysis :

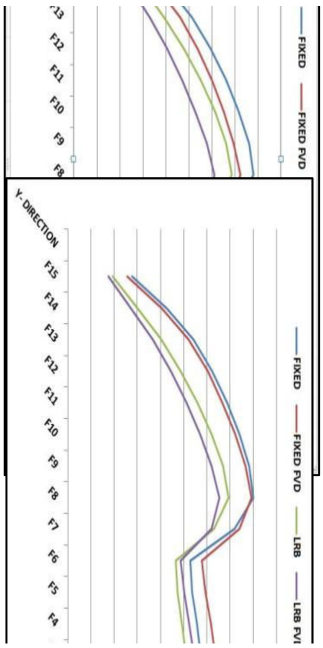


Graph 1(a): Base shear at each storey in X-direction.



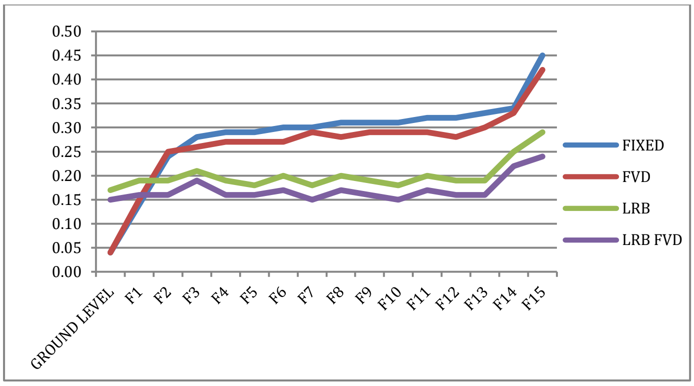
Graph 1(b): Base shear at each storey in Y-direction .

From graph-1(a) & graph-1(b) it is seen that as compared to the fixed base structure, Base Shear of base isolated structure is reduced by 17.51 % to 39.45 % and 4.38 % to 34.32 % in X and Y direction respectively. There is very little difference in case of structure with viscous damper. Whereas the combined used of LRB & FVD gives variation in base shear for top five stories. It is reduced by 2.37% to 34.93% and 5.80% to 29.53% in X and Y direction respectively.Lead rubber bearing isolator separates the superstructure from substructure. This results into transmission of very less forces or acceleration in the superstructure. This decreases base force in the base isolated structure& combined use of LRB & FVD structure.

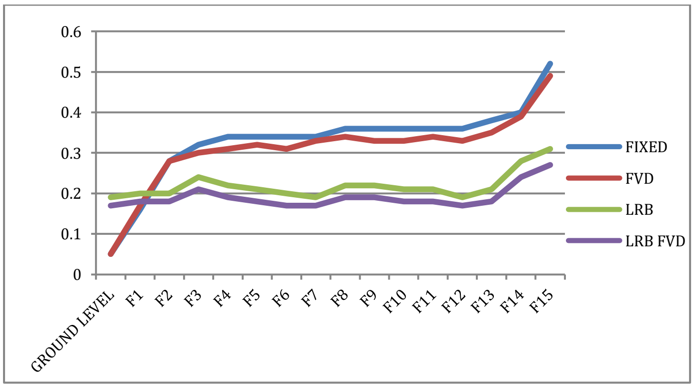


Graph 2: Storey Drift in X-direction & Y- direction for response spectrum analysis.

From graph-2 it is seen that as compared to fixed base structure, Storey drift of base isolated structure in response spectrum analysis is decreased by 1.26 % to 29.46 % &4.73 % to 29.67 % in X & Y direction respectively. Storey drift of structure with fixed base and structure with viscous damper are almost same. Whereas the combined used of LRB & FVD gives majorreduction in storey drift by 5.96% to 42.78% & 5.13% to 37.05% in X and Y direction.Storey drift is reduced by combined used of LRB & FVD compared withlead rubber bearing isolator, viscous damper.

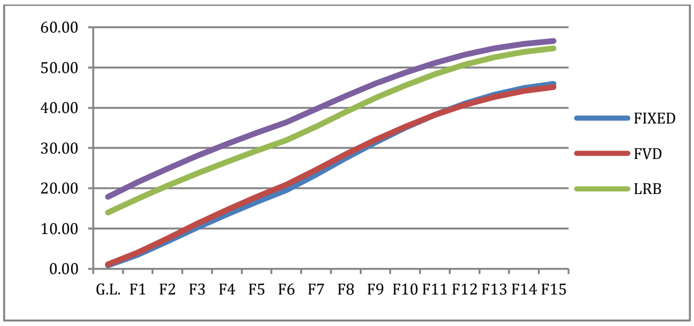


Graph 3 (a): Storey acceleration in X-direction for response spectrum analysis

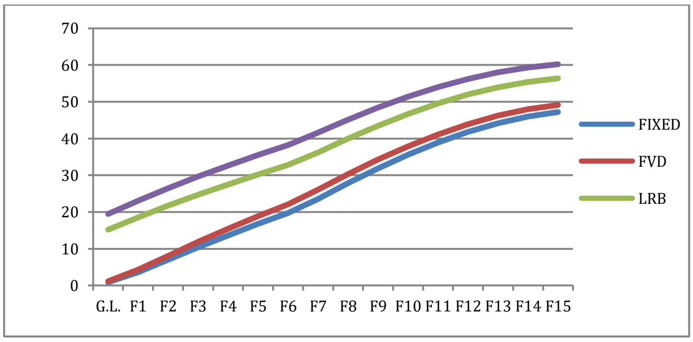


Graph 3 (b): Storey acceleration in Y-direction for response spectrum analysis

From graph 3(a) and graph 3(b) it is seen that as compared to fixed base structure, Maximum storey acceleration in response spectrum analysis of base isolated structure is reduced by 20.43 % to 42.42 % & 25 % to 47.24 % in X & Y direction respectively. And in structure with viscous damper, it is reduced by 10 % & 8.82 % in X & Y direction respectively. Whereas combined used of LRB & FVD results gives much reduction in storey acceleration is around 32.14% & 51.52% in X and Y direction respectively.



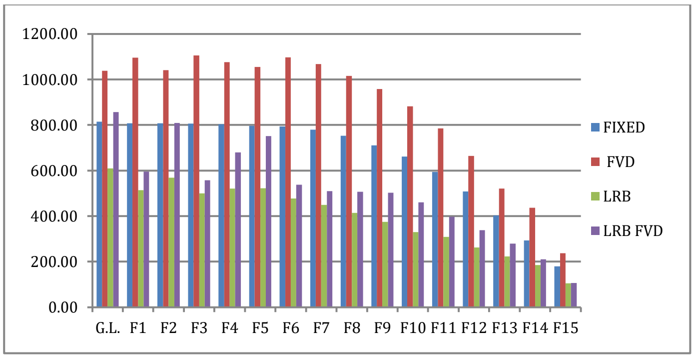
Graph 4 (a): Storey displacement in X-direction for response spectrum analysis



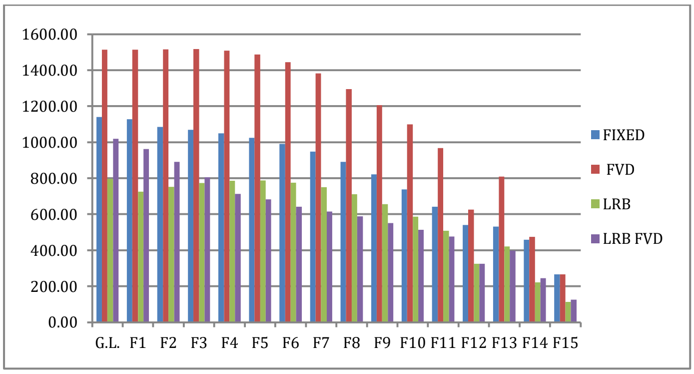
Graph 4 (b): Storeydisplacement in Y-direction for response spectrum analysis

From graph 4(a) and graph 4(b) it is seen that as compared to fixed base structure, Maximum storey displacement in response spectrum analysis of base isolated structure is increased by5.27 % & 10.45 % in X and Y direction respectively. And in structure with viscous damper, it is decreased by 7.91 % & 13.14 % in X & Y direction respectively. Storey displacement is reduced by viscous damper. But it is increased by lead rubber bearing isolator and combined use of LRB & FVD.

Results obtained from modal time history analysis :

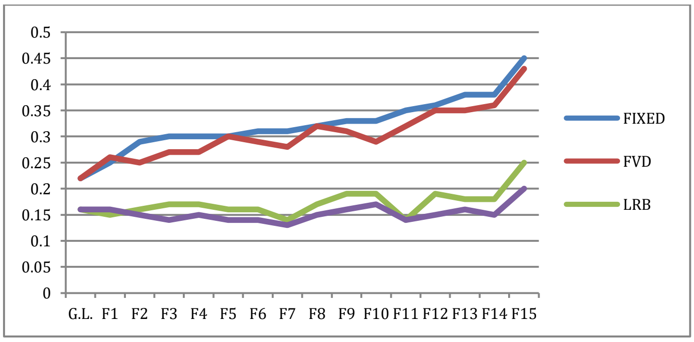


Graph 5(a):Base shear at each storey in X-direction.

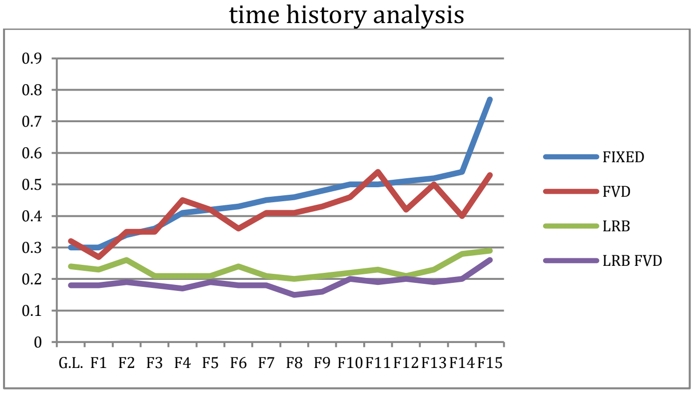


Graph 5(b): Base shear at each storey in Y-direction

From graph-5(a)& graph-5(b) it is seen that as compared to the fixed base structure, Base Shear of base isolated structure is reduced by 25.20 % to 50.13 % and 20.16 % to 39.85 % in X and Y direction respectively. There is very little difference in case of structure with viscous damper. Whereas the combined used of LRB & FVD gives variation in base shear. It is reduced by 5.63% to 41.71% and 10.58% to 52.82% in X and Y direction respectively. Lead rubber bearing isolator separates the superstructure from substructure. This results into transmission of very less forces or acceleration in the superstructure. This decreases base force in the base isolated structure& combined use of LRB & FVD structure.

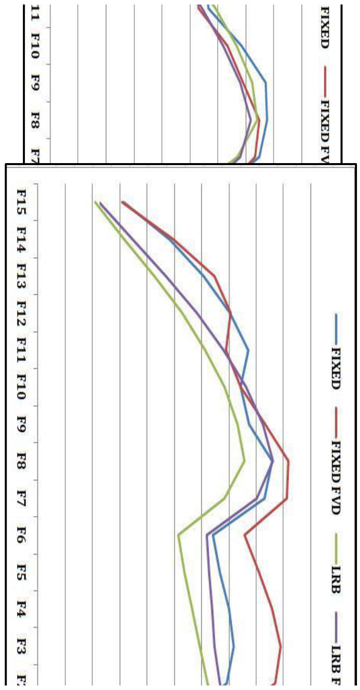


Graph 6 (a): Storey acceleration in X-direction for modal time history analysis



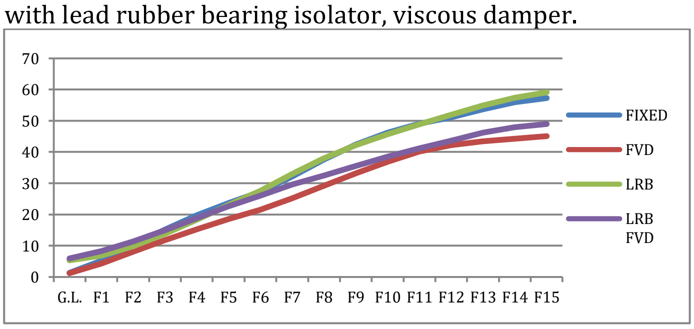
Graph 6 (b): Storey acceleration in Y-direction for modal time history analysis

From graph 6(a) and graph 6(b) it is seen that as compared to fixed base structure, Maximum storey acceleration in modal time history analysis of base isolated structure is reduced by 27.27 % to 60 % & 20 % to 58.82 % in X & Y direction respectively. And in structure with viscous damper, it is reduced by 6.2 % & 8.83 % in X & Y direction respectively. Whereas combined used of LRB & FVD results gives much reduction in storey acceleration is around 51.65% & 57.19% in X and Y direction respectively.

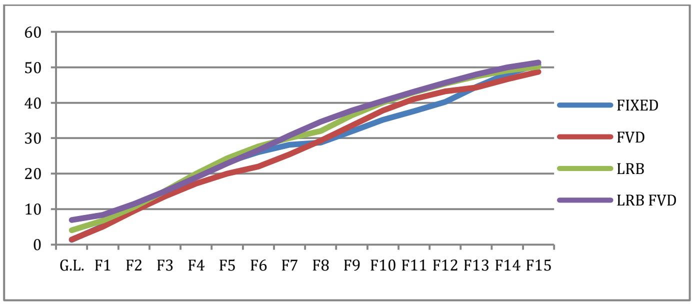


Graph 7: Storey Drift in X-direction & Y- direction for modal time historyanalysis

From graph-7 it is seen that as compared to fixed base structure, Storey drift of base isolated structure in modal time history analysis is decreased by 2.76 % to 34.18 % &5.29 % to 33.33 % in X & Y direction respectively. Storey drift of structure with fixed base and structure with viscous damper are almost same. Whereas the combined used of LRB & FVD gives major reduction in storey drift by 3.88% to 43.41% &3.24% to 28.52% in X and Y direction. Storey drift is reduced by combined used of LRB & FVD compared with lead rubber bearing isolator, viscous damper.



Graph 8 (a): Storey displacement in X-direction for modal time history analysis.



Graph 8 (b): Storey displacement in X-direction for modal time history analysis.

From graph 8(a) and graph 8(b) it is seen that as compared

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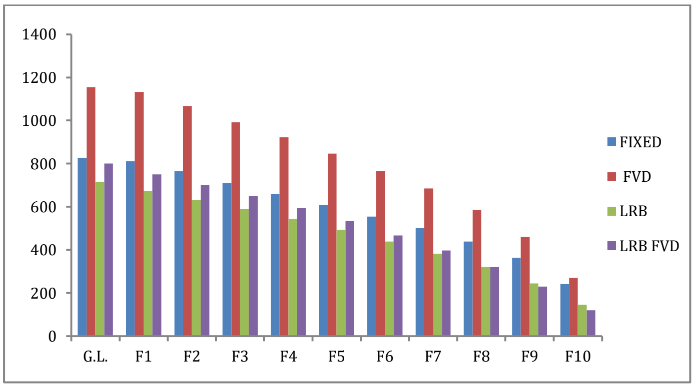
to fixed base structure, Maximum storey displacement in non-linear time history analysis of base isolated structure is increased by19.94 % &20.02 % in X and Y direction respectively. And in structure with viscous damper, it is decreased by 20.24&2.94 % in X & Y direction respectively. Storey displacement is reduced by viscous damper. But it is increased by lead rubber bearing isolator and combined use of LRB & FVD. Viscous damper provides damping in the structure. Vertical load is increase on isolator results in reduction in vertical and horizontal stiffness of isolator. Hence storey displacement of base isolated structure& combined used of LRB & FVD structure is increased.

2. Observations of G+10Storey Structure :

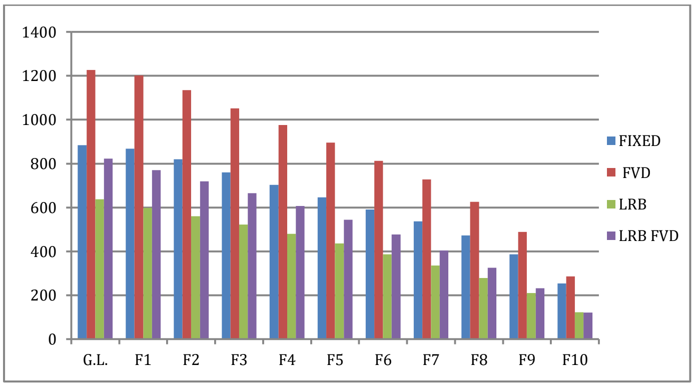
Table 5.Time period in Sec.

Mode	FIXED	FVD	LRB	LRB FVD
1	2.220	2.219	3.003	3.240
2	2.077	2.121	2.866	3.155

Results obtained from response spectrum analysis :

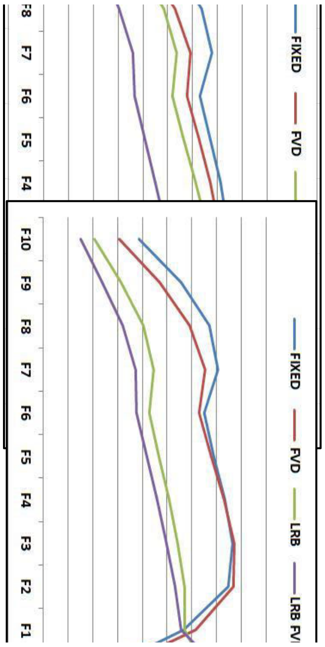


Graph 9(a): Base shear at each storey in X-direction.



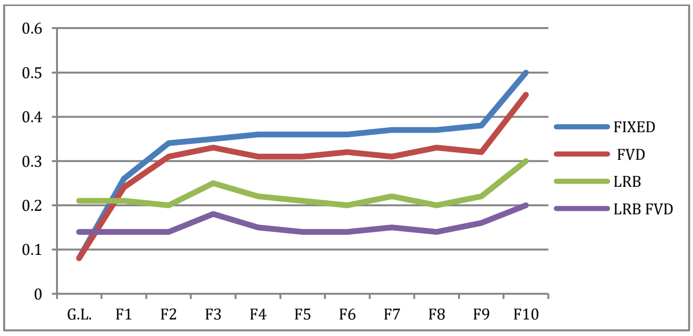
Graph 9(b): Base shear at each storey in Y-direction

From graph-9(a) & graph-9(b) it is seen that as compared to the fixed base structure, Base Shear of base isolated structure is reduced by 13.39 % to 39.81 % and 27.83 % to 51.46 % in X and Y direction respectively. There is very little difference in case of structure with viscous damper. Whereas the combined used of LRB & FVD base shear is reduced by 3.19% to 50.23% and 7.01% to 52.30% in X and Y direction respectively. This results into transmission of very less forces or acceleration in the superstructure. This decreases base force in the base isolated structure& major decreases base force in the combination of LRB & FVD structure.

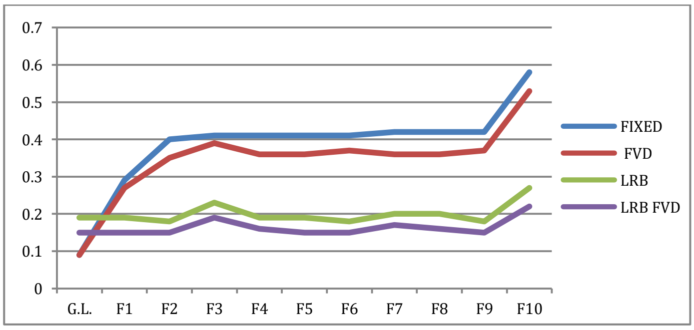


Graph 10: Storey Drift in X-direction & Y- direction for response spectrum analysis

From graph-10 it is seen that as compared to fixed base structure, Storey drift of base isolated structure in response spectrum analysis is decreased by 3.28 % to 34.46 % &23.56 % to 46.26 % in X & Y direction respectively. Storey drift of structure with fixed base and structure with viscous damper are almost same. Whereas the combined used of LRB & FVD givesmajor reduction in storey drift by 26.05% to 62.10% & 28.45% to 60.95% in X and Y direction. Storey drift is reduced by combined used of LRB & FVD compared with lead rubber bearing isolator, viscous damper.

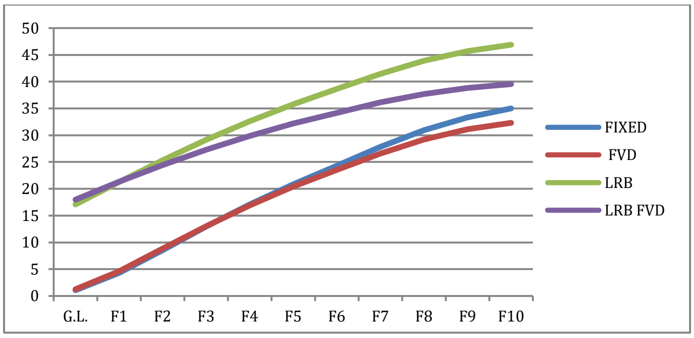


Graph 11 (a): Storey acceleration in X-direction for response spectrum analysis

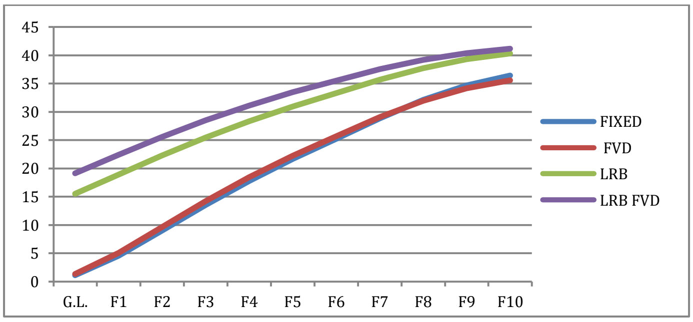


Graph 11 (b): Storey acceleration in Y-direction for response spectrum analysis

From graph 11(a) and graph 11(b) it is seen that as compared to fixed base structure, Maximum storey acceleration in response spectrum analysis of base isolated structure is reduced by 19.23 % to 45.95 % & 34.48 % to 56.10 % in X & Y direction respectively. And in structure with viscous damper, it is reduced by 7.69 % to 16.22 % & 6.90% to 14.29% in X & Y direction respectively. Whereas combined used of LRB & FVD results gives much reduction in storey acceleration is around 46.15% to 62.16% & 48.28% to 64.29% in X and Y direction respectively.



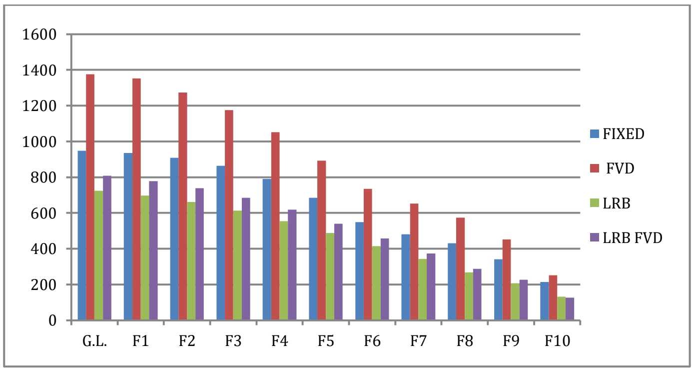
Graph 12(a): Storey displacement in X-direction for response spectrum analysis



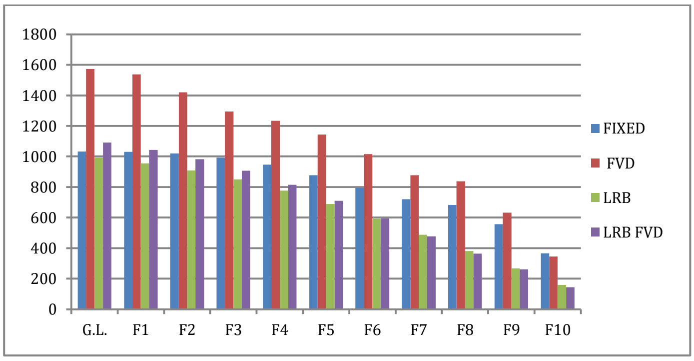
Graph 12(b): Storey displacement in Y-direction for response spectrum analysis

From graph 12(a) and graph 12(b) it is seen that as compared to fixed base structure, Maximum storey displacement in response spectrum analysis of base isolated structure is increased by54.76 % &35.82 % in X and Y direction respectively. And in structure with viscous damper, it is decreased by 4.40 % &1.47 % in X & Y direction respectively. Storey displacement is reduced by viscous damper. But it is increased by lead rubber bearing isolator and combined use of LRB & FVD.

Results obtained from modal time history analysis :

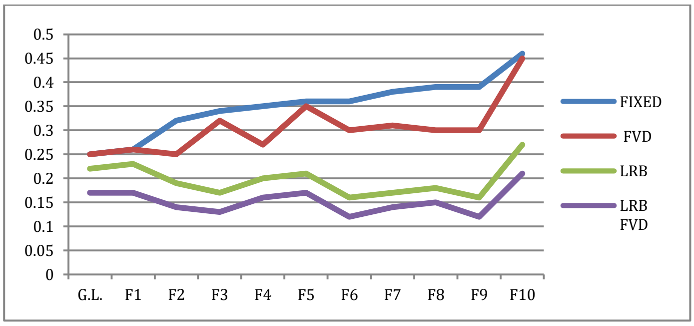


Graph 13(a):Base shear at each storey in X-direction.

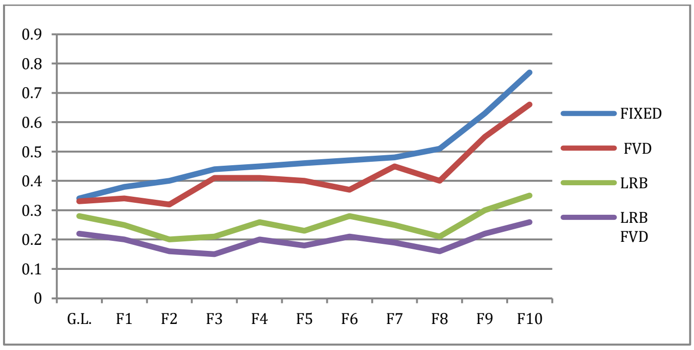


Graph 13(a):Base shear at each storey in Y-direction

From graph-13(a) & graph-13(b) it is seen that as compared to the fixed base structure, Base Shear of base isolated structure is reduced by 23.55 % to 39.35 % and 4.07% to 56.32 % in X and Y direction respectively. There is very little difference in case of structure with viscous damper. Whereas the combined used of LRB & FVD gives variation in base shear. It is reduced by 14.69% to 41.14% and 3.64% to 60.94% in X and Y direction respectively. Lead rubber bearing isolator separates the superstructure from substructure. This results into transmission of very less forces or acceleration in the superstructure. This decreases base force in the base isolated structure& combined use of LRB & FVD structure.

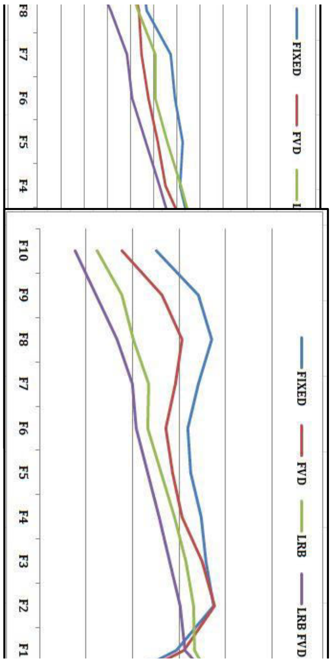


Graph 14 (a): Storey acceleration in X-direction for modal time history analysis



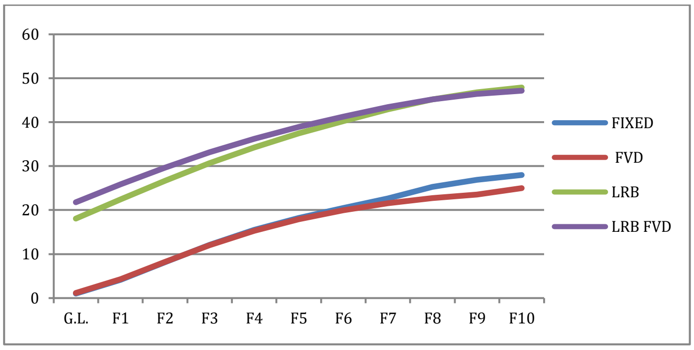
Graph 14 (b): Storey acceleration in Y-direction for modal time history analysis

From graph 14(a) and graph 14(b) it is seen that as compared to fixed base structure, Maximum storey acceleration in modal time history analysis of base isolated structure is reduced by 14.54% to 58.97 % &17.62 % to 58.82 % in X & Y direction respectively. And in structure with viscous damper, it is reduced by 12.44 % &12.57 % in X & Y direction respectively. Whereas combined used of LRB & FVD results gives much reduction in storey acceleration is around 55.15% &58.24% in X and Y direction respectively.

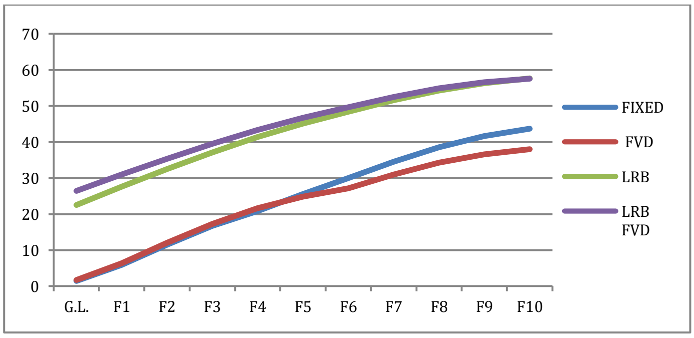


Graph 15: Storey Drift in X-direction & Y- direction for modal time history analysis

From graph-15 it is seen that as compared to fixed base structure, Storey drift of base isolated structure in modal time history analysis is decreased by 7.76 % to 20.12 % &11.50 % to 50.52 % in X & Y direction respectively. Storey drift of structure with fixed base and structure with viscous damper are almost same.Whereas the combined used of LRB & FVD gives major reduction in storey drift by 5.42% to 55.44% &19.25% to 69.43% in X and Y direction.Storey drift is much reduced by combined used of LRB & FVD compared with lead rubber bearing isolator, viscous damper.



Graph 16 (a): Storey displacement in X-direction for modal time history analysis.



Graph 16 (b): Storey displacement in Y-direction for modal time history analysis

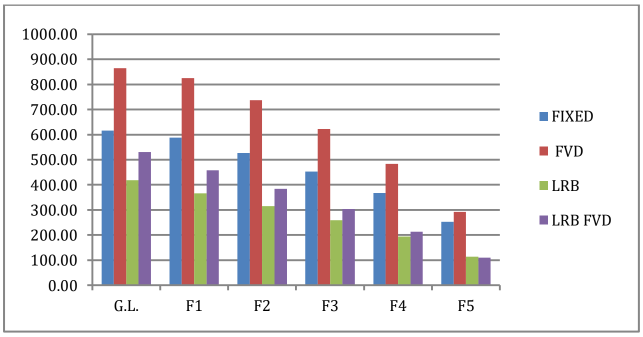
From graph 16(a) and graph 16(b) it is seen that as compared to fixed base structure, Maximum storey displacement in modal time history analysis of base isolated structure is increased by24.54 % &26.59 % in X and Y direction respectively. And in structure with viscous damper, it is decreased by 5.54&9.79 % in X & Y direction respectively. Storey displacement is reduced by viscous damper. But it is increased by lead rubber bearing isolator and combined use of LRB & FVD. Viscous damper provides damping in the structure. Vertical load is increase on isolator results in reduction in vertical and horizontal stiffness of isolator. Hence storey displacement of base isolated structure& combined used of LRB & FVD structure is increased.

3. Observations of G+5Storey Structure :

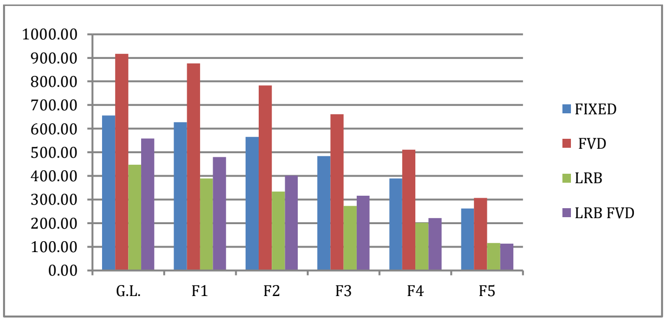
Table 5.Time period in Sec.

Mode	FIXED	FVD	LRB	LRB FVD
1	1.293	1.245	2.333	2.623
2	1.213	1.196	2.266	2.587

Results obtained from response spectrum analysis :

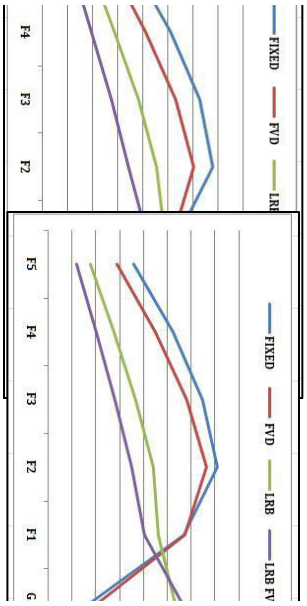


Graph 17(a): Base shear at each storey in X-direction



Graph 17(b): Base shear at each storey in Y-direction

From graph-17(a) & graph-17(b) it is seen that as compared to the fixed base structure, Base Shear of base isolated structure is reduced by 32.01 % to 55.11 % and 31.74 % to 55.74 % in X and Y direction respectively. There is very little difference in case of structure with viscous damper. Whereas the combined used of LRB & FVD base shear is reduced by 13.78% to 56.48% and 14.78% to 56.74% in X and Y direction respectively. This results into transmission of very less forces or acceleration in the superstructure. This decreases base force in the base isolated structure& major decreases base force in the combination of LRB & FVD structure.



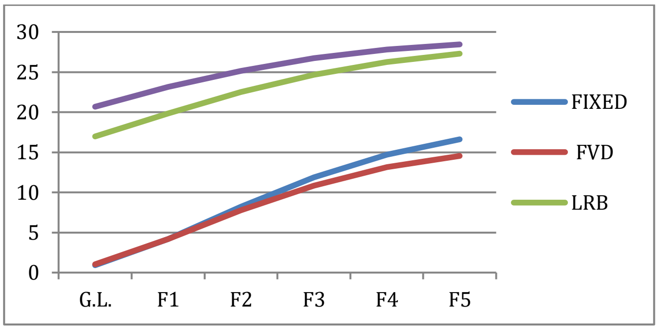
Graph 18: Storey Drift in X-direction & Y- direction for response spectrum analysis

From graph-18 it is seen that as compared to fixed base structure, Storey drift of base isolated structure in response spectrum analysis is decreased by 10.28 % to 47.78 % &18.63 % to 50.97 % in X & Y direction respectively. Storey drift of structure with fixed base and structure with viscous damper are slightly varies. Whereas the combined used of LRB & FVD gives major reduction in storey drift by 23.14% to 67.08% & 29.09% to 66.34% in X and Y direction. Storey drift is reduced by combined used of LRB & FVD compared with lead rubber bearing isolator, viscous damper.

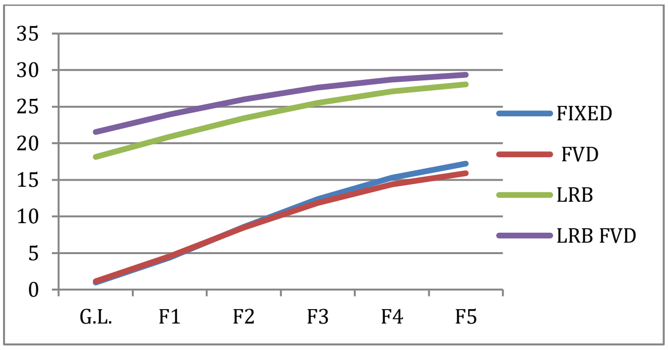
Graph 19(a): Storey acceleration in X-direction for response spectrum analysis.

Graph 19(b): Storey acceleration in Y-direction for response spectrum analysis.

From graph 19(a) and graph 19(b) it is seen that as compared to fixed base structure, Maximum storey acceleration in response spectrum analysis of base isolated structure is reduced by 53.49 % to 59.09 % & 54.17 % to 61.22 % in X & Y direction respectively. And in structure with viscous damper, it is reduced by 7.55 % to 15.91 %& 6.78% to 16.33% in X & Y direction respectively. Whereas combined used of LRB & FVD results gives much reduction in storey acceleration is around 60.47% to 66.04% & 62.50% to 67.35% in X and Y direction respectively.



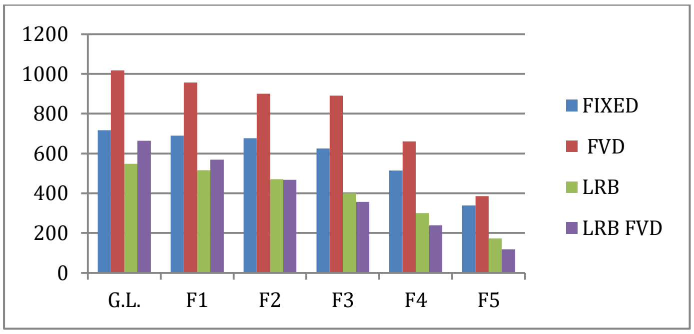
Graph 20(a): Storey displacement in X-direction for response spectrum analysis



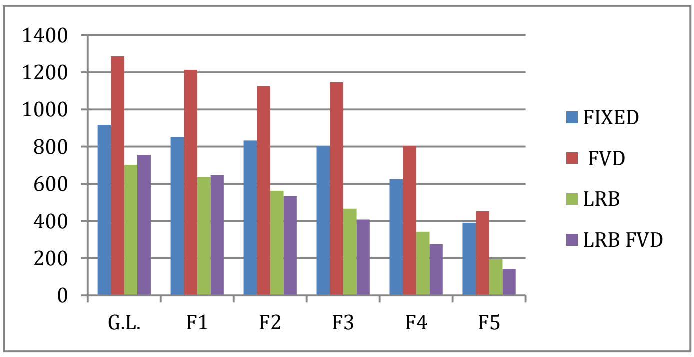
Graph 20(b): Storey displacement in Y-direction for response spectrum analysis

From graph 20(a) and graph 20(b) it is seen that as compared to fixed base structure, Maximum storey displacement in response spectrum analysis of base isolated structure is increased by78.63 % &76.89 % in X and Y direction respectively but it is within the limiting value i.e. less than 0.004 x (height of structure above G.L.). And in structure with viscous damper, it is decreased by 9.25 % &4.76 % in X & Y direction respectively. Storey displacement is reduced by viscous damper. But it is increased by lead rubber bearing isolator and combined use of LRB & FVD.

Results obtained from modal time history analysis :

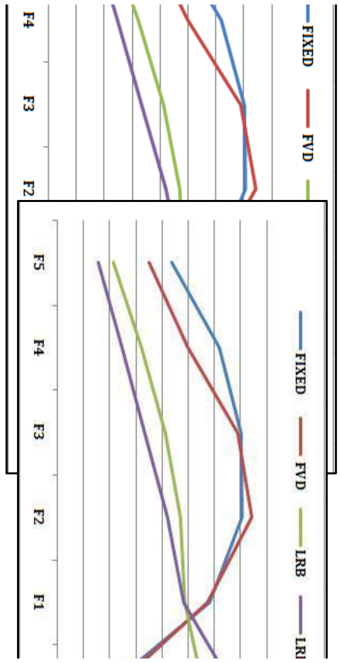


Graph 21(a): Base shear at each storey in X-direction



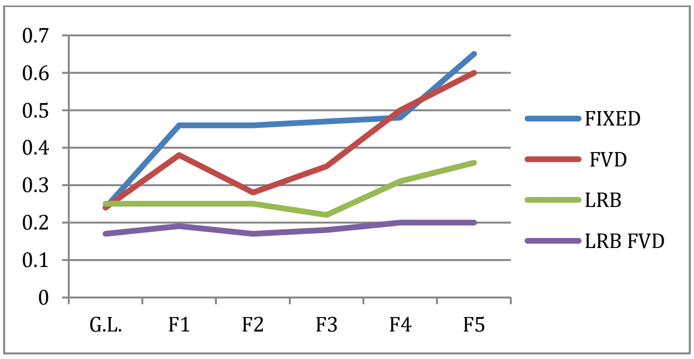
Graph 21(b): Base shear at each storey in Y-direction

From graph-21(a) & graph-21(b) it is seen that as compared to the fixed base structure, Base Shear of base isolated structure is reduced by 23.46 % to 48.95 % and 23.49% to 50.29% in X and Y direction respectively. There is very little difference in case of structure with viscous damper. Whereas the combined used of LRB & FVD gives variation in base shear. It is reduced by 7.46% to 64.92% and 17.71% to 63.42% in X and Y direction respectively. Lead rubber bearing isolator separates the superstructure from substructure. This results into transmission of very less forces or acceleration in the superstructure. This decreases base force in the base isolated structure& combined use of LRB & FVD structure.

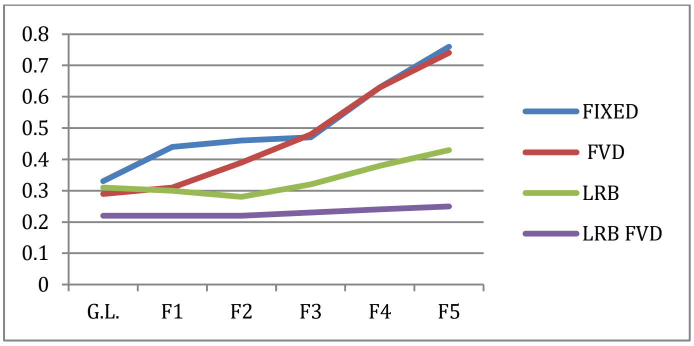


Graph 22: Storey Drift in X-direction & Y- direction for modal time history analysis

From graph-22 it is seen that as compared to fixed base structure, Storey drift of base isolated structure in modal time history analysis is decreased by 22.22 % to 43.22 % &33.12 % to 51.03 % in X & Y direction respectively. Storey drift of structure with fixed base and structure with viscous damper are almost same. Whereas the combined used of LRB & FVD gives major reduction in storey drift by 14.50% to 63.50% &16.98% to 64.58% in X and Y direction. Storey drift is much reduced by combined used of LRB & FVD compared with lead rubber bearing isolator, viscous damper.

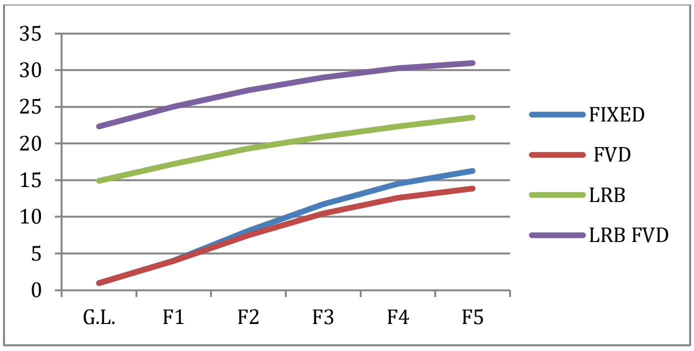


Graph 23 (a): Storey acceleration in X-direction for modal time history analysis

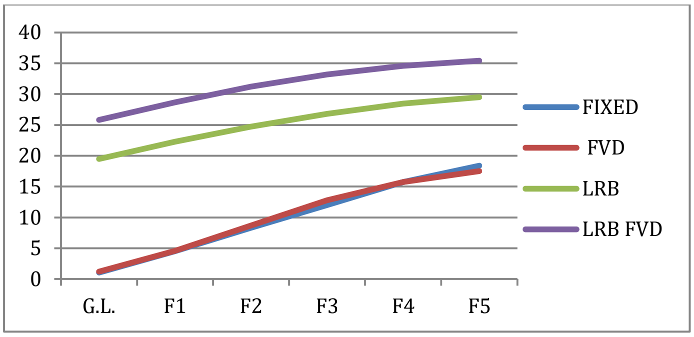


Graph 23 (b): Storey acceleration in y-direction for modal time history analysis

From graph 23(a) and graph 23(b) it is seen that as compared to fixed base structure, Maximum storey acceleration in modal time history analysis of base isolated structure is reduced by 35.42% to 53.19 % &31.82 % to 43.42 % in X & Y direction respectively. And in structure with viscous damper, it is reduced by 17.12 % &9.57 % in X & Y direction respectively. Whereas combined used of LRB & FVD results gives much reduction in storey acceleration is around 56.70% &52.60% in X and Y direction respectively.



Graph 24(a): Storey displacement in X-direction for modal time history analysis



Graph 24(b): Storey displacement in Y-direction for modal time history analysis

From graph 24(a) and graph 24(b) it is seen that as compared to fixed base structure, Maximum storey displacement in modal time history analysis of base isolated structure is increased by30.25 % &32.69 % in X and Y direction respectively. And in structure with viscous damper, it is decreased by 9.46&4.86 % in X & Y direction respectively. Storey displacement is reduced by viscous damper. But it is increased by lead rubber bearing isolator and combined use of LRB & FVD. Viscous damper provides damping in the structure. Vertical load is increase on isolator results in reduction in vertical and horizontal stiffness of isolator. Hence storey displacement of base isolated structure& combined used of LRB & FVD structure is increased.

11.CONCLUSION

From the comparative study of fixed base, viscous damper, base isolation and base isolation& viscous damper by using lead rubber bearing& fluid viscous damper the following conclusions are made :

1. Time periods are increased which increases reaction time of a structure during earthquake.
2. Combined used of lead rubber bearing& fluid viscous damper lengthens the time period of base isolated structure at greater extent. And fixed base with viscous damper reduces the time period of structure at certain extent.
3. In base isolated structure with lead rubber bearing& fluid viscous damper, storey drift and storeydisplacement are reduced at greater extent for low and multi-storey base isolated structures..
4. In structure with viscous damper, storey drift and storey displacement are reduced at greater extent for high storey structure. Viscous dampers have better control effect on displacement.
5. Base shear reduced after the lead rubber bearing (LRB) is provided as base isolation system which reduces the seismic effect on building.
6. Base isolation technique is found to be most effective for low and multi-storey RC structure. Viscous damper is found to be most effective for high storey structure.
7. From the results it is recommended that time history analysis should be performed as it predicts the structural response more accurately than the response spectrum analysis.
8. It can be concluded that the used of combination of base isolator and viscous damper for better efficient,low to multi-storey RC structurein seismic prone areas.

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