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Earthquake Performance of RCC Frame Structure using different Types of Bracings with LRB Isolation Technique

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Abstract – *Acceleration due to regular disaster is inescapable in tall structures. The taller of the building catch a higher rate of the acceleration than the ground floor because of gravity and bringing about basic harm. Different sorts of studies are in advance to advance a fruitful model that withstands the common disaster that impact the condition of the building structure. Auxiliary designing assumes a crucial part in giving an answer that safeguards the structure all things considered. Bracings are utilized to give steadiness and opposes horizontal loads (lateral Loads) were the base disengagement innovation gives latent auxiliary vibration control. X, V and Inverted V (Chevron) bracings given in various sides of building and the impact of base shear in building segments is retained for steel supporting with and without utilizing lead Rubber bearing as base isolators. The forces effect on the structure with X, V and Inverted V (Chevron) Bracings is measured for the reenacted display for various cases utilizing E-Tabs v2015 software.*

Key Words: **Base isolation, Bracings, Response spectrum, Time period, Base shear, Story Drift, Acceleration, E-Tabs v2015**

1. INTRODUCTION

The basic role of a wide range of basic frameworks utilized as a part of the building kind of structures is to exchange gravity stacks successfully. The most widely recognized loads coming about because of the impact of gravity are dead load, live load. Other than these vertical loads, structures are likewise subjected to horizontal burdens caused by wind, impacting or quake. Lateral loads can grow high anxieties, deliver influence development or cause vibration. It is vital for the structure to have adequate quality against vertical loads together with satisfactory solidness to oppose lateral (seismic) loads. Reinforcing of structures turns out to be a superior choice taking into economic considerations and immediate shelter issues as opposed to substitution of structures. Seismic retrofitting or reinforcing of building is one of the most important aspects for mitigating seismic dangers particularly in quake prone areas.

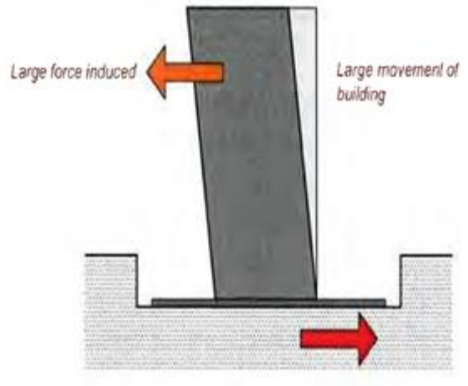
Steel bracing and concrete bracing system is an exceptionally productive, highly effective and economical technique for opposing lateral (horizontal) forces in an RCC frame structure. Bracing system has been utilized to balance out horizontally most of the world tallest building structures and additionally one of the major retrofit measures. Supporting is proficient on the grounds that the diagonals work in hub stretch and in this manner call for least part sizes in giving firmness and quality against even shear. Various scientists have researched different technique , for example, infilling walls, adding walls to existing column segments, encasing column segments, and including solid concrete bracing system or steel bracing system to enhance the quality and flexibility of existing structures.

A bracing system enhances the seismic execution of the frame by increasing its firmness and capability. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, bypassing the frail column segments while increasing the strength. Steel braced frames are capable structural system for structures subjected to seismic or wind lateral loadings. The utilization of steel bracing system for retrofitting RC frames with inadequate Lateral resistance is alluring. The structural system comprises of moment frames with specific bays provided with brace through the height of the structure. Braces help in decreasing overall lateral displacement of structures, and in decreasing Bending moment and shear force requests on beams and column segments in structures.

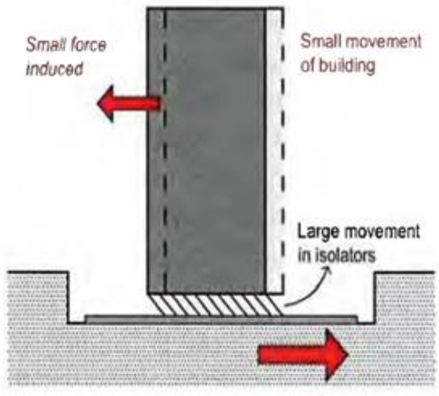
The seismic quake force is transferred as axial tensile and compressive force in the brace members. Different sorts of bracings can be utilized including global bracing along the building stature. X and Chevron brace successfully reduce bending moment, shear force and axial force demands on the beams and column of the original frame and are generally utilized. Tremor by itself, is not a disaster, it is regular wonder result from ground movement, some of the time violent. These deliver surface waves, which cause vibration of the ground and structures remaining on top.

1.1 Base Isolation

The idea of separating the superstructure from the substructure has dependably been an elegant thought in principle, yet just as of late has it turn into a viable solution. The objective is to have flexible material in the even plane that is equipped for anticipating vitality stream into the superstructure. This adaptability expands the superstructure's period, which, thus, lessens the induced acceleration.



Building resisting Directly on the Ground



Building on Flexible rubber pads connected to building and foundation

The introduction of isolators can decrease the acceleration significantly and huge numbers of the stiffening routines require not to be utilized as a part of the superstructure. Without isolators the building itself would need to experience extensive scale development or maintain expanded inner deformation to withstand the huge inertial strengths. Along these lines, by giving isolators at the base of the structure that has high adaptability, it is conceivable to extraordinarily decrease auxiliary harm.

1.2 Priciples of Base Isolation

A building that is superbly rigid will have a zero period. At the point when the ground moves the acceleration actuated in the structure will be equivalent to the ground acceleration and there will be zero relative displacement between the structure and the ground. The structure and ground move the same sum.

A building that is superbly flexible will have an infinite period. For this sort of structure, when the ground underneath the structure moves there will be zero increasing speed incited in the structure and the relative displacement between the structure and ground will be equivalent to the ground displacement. The structure won't move the ground will.

An isolated system does not ingest the vibrating vitality, yet rather redirects it through the motion of the system. It extends the regular time of vibration of the structure so that the responses are extraordinarily decreased. Sometimes a passive damper may additionally use to control inordinate displacement. Figure 1 speaks to the moving of period by the isolator and the subsequent decrease in the acceleration response and displacement response.

1.3 Types of Base Isolators

It is also necessary to provide an adequate seismic gap (between the structure and the surrounding foundations) which can accommodate the isolator displacements.

Many different forms of practical base isolation systems have been developed to provide seismic protection for buildings.

1. Elastomeric Bearing.
2. High Damped Rubber Bearing.
3. Lead Rubber Bearing.
4. Friction Pendulum system.

1. Laminated Rubber (Elastomeric) Bearing

Laminated rubber bearings are constructed of alternating rubber layers bonded to intermediate reinforcing plates that are typically steel as illustrated by the schematic of a deformed bearing shown in Fig. The total thickness of rubber provides the low horizontal stiffness need to achieve the period shift whereas the spacing of the steel shim plates controls the vertical stiffness of the bearing for a given shear modulus and bonded rubber area .

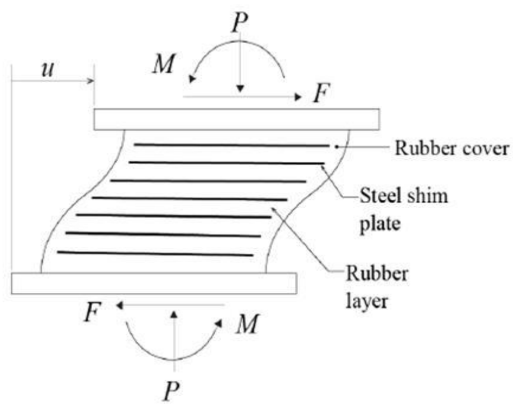


Fig. 1.3.1 Laminated Rubber (Elastomeric) Bearing

2. High Damping Rubber (HDR) Bearing

The energy dissipation in high-damping rubber bearings is achieved by special compounding of the elastomeric. Damping ratios will generally range between 8% and 20% of critical. The shear modulus of high-damping elastomeric generally ranges between 0.34 MPa and 1.40 MPa. The material is nonlinear at shear strains less than 20% and characterized by higher stiffness and damping, which minimizes the response under wind load and low-level seismic load. Over the range of 20-120% shear strain, the modulus is low and constant. At large shear strains, the modulus and energy dissipation increase. This increase in stiffness and damping at large strains can be exploited to produce a system that is stiff for small input, is fairly linear and flexible at design level input, and can limit displacements under unanticipated input levels that exceed design levels . HDR bearing is shown in Fig.

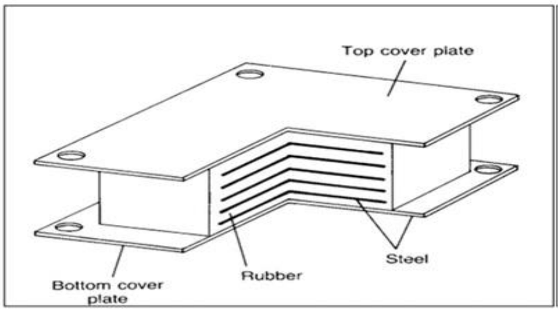


Fig 1.3.2 High Damping Rubber (HDR) Bearing

3. Lead Rubber Bearing (LRB)

Lead-plug bearings are generally constructed with low-damping elastomers and lead cores with diameters ranging 15% to 33% of the bonded diameter of the bearing as shown in Fig. Laminated-rubber bearings are able to supply the required displacements for seismic isolation. By combining them with a lead-plug insert which provides hysteretic energy dissipation, the damping required for a successful seismic isolation system can be incorporated in a single compact component.

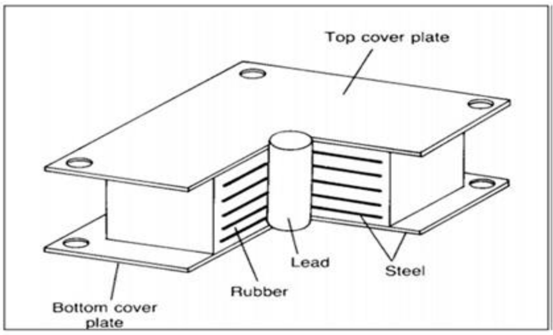


Fig 1.3.3 Lead Rubber Bearing (LRB)

4. Friction Pendulum Sliding (FPS) Bearing

The concept of sliding bearings is also combined with the concept of a pendulum type response, obtaining a conceptually interesting seismic isolation system known as a friction pendulum system (FPS) as shown in Fig. In FPS, the isolation is achieved by means of an articulated slider on spherical, concave chrome surface.

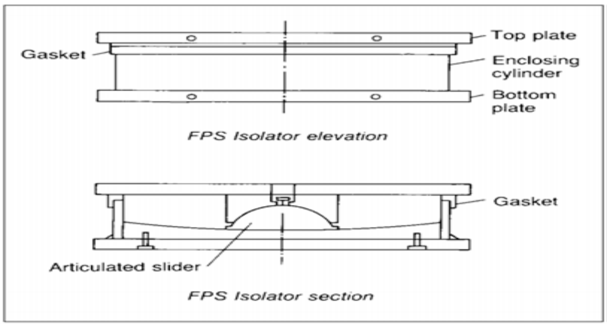


Fig 1.3.4 Friction pendulum sliding (FPS) Bearing

2. Literature review

S.M. Kalantari1, H. Naderpour and S.R. Hoseini Vaez (Oct, 2008)[1] has done the work on the effect on using two different types of seismic isolators in reducing the base shear and storey shear of 2,5,8 and 12 storey building. The analysis made under earthquake characteristics of Manjil, Naghan, Tabas and Elcentro using non linear method. The results defines that by using LRB isolators, maximum displacements of stories in low rise structures has been increased in comparison with fixed base structure model.

Ashish R. Akhare, Tejas R.Wankhade (May, 2014)[2] has done the work on Hospital buildings are of great importance after any natural calamity such as earthquake. The structural and non-structural components should remain operational and safe after earthquake. So to mitigate the effect of earthquake on the structure the base isolation technique is the best alternative as a seismic protective system. The basic idea of base isolation system is to reduce the earthquake induced inertia forces by increasing the fundamental period of the structure. The aim of this study is the use of High density rubber bearing (HDRB) and friction pendulum system (FPS) as an isolation device and then to compare various parameters between fixed base condition and base isolated condition by using SAP2000v14 software. In this study the (G+12) storey hospital building is used as a test model. Nonlinear time history analysis is carried out for both fixed base and base isolated structure.

The result obtained shows the reduction in base shear in both direction and increase in the displacement and time period for the base isolated structure.

K. Sugantha Priya, RM. Jennifer Priyanka, S.Karthick, K.Dhivakaran (February 2015)[3] has done the work on an emerging demand for earthquake resistant structure provokes new trends in seismic analysis. In present days a new challenge of constructing asymmetrical building has higher thirst compared with symmetrical buildings. It has been proved for these buildings were able to sustain stiffness and flexibility. Bracings a vital finding enhances the resistances to lateral loads. This paper deals with a study on literatures assembling the need of steel braces over asymmetrical buildings. The author's suggestions were discussed and possible ways to persuade the types of bracing over asymmetric building were framed in this paper. It has been concluded from findings of literatures that initiating the usage of bracings on asymmetric building can effectively reduce the deflection due to lateral loads.

Shachindra Kumar Chadhar, Dr. Abhay Sharma (Aug-2015)[4] has done the work on Steel bracing system is one of the effective measures for resisting the horizontal forces like seismic and wind forces in reinforced concrete multi-storey buildings. Bracing members are subjected to tension and compression; subsequently they are provided to take these forces. Steel bracing framework expands the stiffness and strength of the RC multi-storey building and reduces their deformation. Present study is based on seismic analysis of RC building frames with V type bracing and inverted V type bracing. Seismic coefficient method (linear static analysis) has been conducted to evaluate the effect of different arrangements of bracing members in the building frame and influence of the different steel cross-section. For this study, a fifteen story building assumed to be situated at seismic zone IV as per the seismic zone map of India. Three steel profiles ISA, ISMC and ISMB were utilized as bracing members by considering same cross-sectional area. For modeling and analysis work computer software StaadproV8i was used. Result of this study revealed that inverted V bracing reduces the bending moment, shear force, storey drift and node displacement significantly. It was also found that the various arrangements of bracing systems has great influence on seismic performance of the building frame and double angle section give better result as compared to ISMB and ISMC section.

M.Vijayakumar, Mr. S.Manivel, Mr. A.Arokiaprakash [5] has done the work on Acceleration due to natural calamity is inevitable in tall structures. The taller of the building capture a higher rate of the acceleration than the ground floor due to gravity and resulting in structural damage. Various types of studies are in progress so as to put forward a successful model that withstands the natural calamity that effect the state of the building structure. Structural engineering plays a vital role in providing a solution that safe guards the structure as such. Bracings are used to provide stability and resists lateral loads were the base isolation technology provides passive structural vibration control. X, V and Chevron bracings provided in different sides of building and the effect of base shear in building columns is absorbed for steel bracing with and without using lead rubber bearing as base isolator. The force impact on the structure with X, V and Chevron Bracings is measured for the simulated model for different cases using SAP2000 v18 software.

T.Dinesh Kumar, S.Manivel, A.Arokiaprakash (Apr-2016) [6] has done the work on Base isolation technique is widely used to safeguard building structures from damaging effects of earthquakes. The installation of base isolators at base of a structure increases the time period and reducing resonance of structure providing safety of structure against seismic forces. The type of base isolator taken for this study is Lead rubber bearing. The base isolation system have to perform three functions, they are horizontal flexibility, energy dissipation and rigidity to ensure its performance to isolate the seismic forces to safeguard buildings from earthquakes. The Lead rubber bearing quite does it well than other isolators so mostly these isolators are used widely. The study is performed to compare steel-concrete-composite structures of fixed and base isolated conditions. Predicting the behavior of steel concrete composite structures with varying storey heights under seismic loads using response spectrum analysis under fixed and base isolated condition will provide sufficient information and confidence to go in for steel concrete composite construction in India. For this study a 10 storey Steel-Concrete-Composite structures is considered and a Response spectrum analysis is carried out in ETABS2015. The Lead rubber bearing is designed as per UBC97 and was used in analysis of Base isolation systems. Time period of base isolated structures is comparatively higher than building under fixed condition and with the reduced base shear at base of the structures prove the efficiency of base isolated structures compared to fixed base structures and serves better during earthquakes. It is fount that Concrete structure with base isolation is more effective in seismic prone areas compared to other structures (Steel-SRC-CFT) considered in this study.

3. Objectives of the work

In the present study the seismic response of multi-storied building without and with Base isolation using various types of Bracings. The seismic analysis of the structure with base isolation will be carried with the following objectives.

1. To carry out the modeling and analysis for various types of Bracings with fixed base and base isolated structure for 20 story building using ETABS software.
2. To study the earthquake ground motion on these models.
3. To design and study the effectiveness of lead rubber bearing isolator.
4. To analyze the structure for both static and dynamic cases by providing the isolators.

5. To provide horizontal flexibility and vertical stiffness to the building.
6. To compare the fixed and isolated structures for both static and dynamic properties.
7. To study the results of displacement, story shear, base shear, story drift and story acceleration.
8. To study the behavior of various types of Bracings with fixed base and base isolated structure for 20 story building under strong ground motion.

3.1 BUILDING PROPERTIES

Plan: 24 x 24 m
No. of bays in X direction: 4
No. of bays in Y direction: 4
Each Storey height: 3 m
Beam size: 600 X 800 mm
Column size: 400 X 500 mm
Slab thickness: 150 mm
Bracing: ISMB 200

3.2 MATERIAL PROPERTIES

Grade of Concrete for column: M30
Grade of Concrete for beam: M30
Grade of Steel: Fe 415
Grade of Steel Bracing: Fe250
Density of Concrete: 25kN/m^3
Poisson's ratio of Concrete: 0.2

3.4 EARTHQUAKE LOAD DATA

Calculated Time period, T = 1.62 s
Earthquake Zone: V
Soil Type: II (Medium soil)
Importance factor, I: 1
Reduction factor, R: 5
Damping ratio: 5%

4. Result and Analysis

4.1 Natural Time Period

Table 1: Time Period for Fixed Base and Base Isolation

Models Considered	Base Isolation (sec)	Fixed Base (sec)
RCC Frame Without Bracings	5.081	2.763
RCC Frame With X-Bracings	4.455	1.138
RCC Frame With V-Bracings	4.763	1.196
RCC Frame With Inverted V-Bracings	4.434	1.127

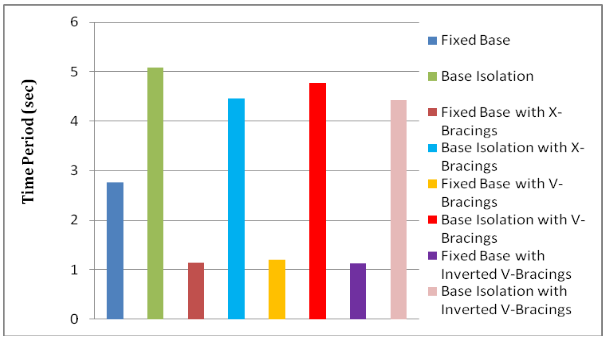


Figure 1: Comparison between Fixed Base and Base Isolation

4.2 Storey Displacement

Table 2: Storey Displacement for Fixed Base and Base Isolation

Models Considered	Base Isolation (mm)	Fixed Base (mm)
RCC Frame Without Bracings	274.13	63.854
RCC Frame With X-Bracings	104.618	12.801
RCC Frame With V-Bracings	129.836	13.438
RCC Frame With Inverted V-Bracings	103.758	12.536

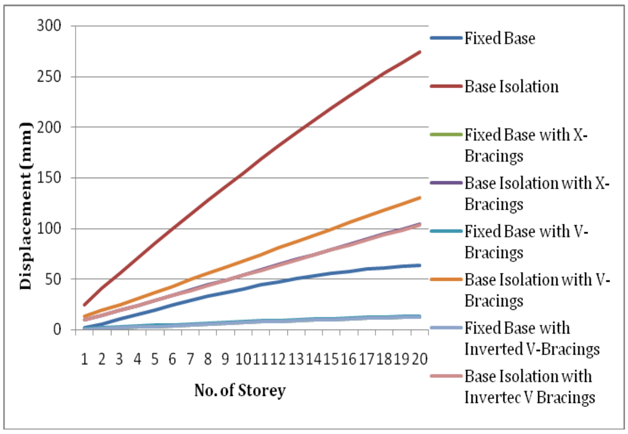


Figure 2: Storey Displacement for Fixed Base and Base Isolation

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4.3 Storey Drift

Table 3: Storey Shear for Fixed Base and Base Isolation

Models Considered	Base Isolation (mm)	Fixed Base (mm)
RCC Frame Without Bracings	0.006123	0.000597
RCC Frame With X-Bracings	0.001768	0.000162
RCC Frame With V-Bracings	0.002677	0.000293
RCC Frame With Inverted V-Bracings	0.001794	0.000159

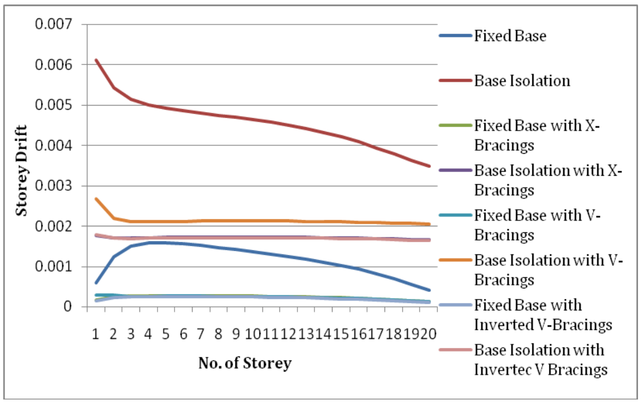

Figure 3: Storey Shear for Fixed Base and Base Isolation

4.4 Acceleration

Table 4: Storey Acceleration for Fixed Base and Base Isolation

Models Considered	Base Isolation (mm/sec²)	Fixed Base (mm/sec²)
RCC Frame Without Bracings	707.79	941.69
RCC Frame With X-Bracings	347.91	587.51
RCC Frame With V-Bracings	498.46	560.7
RCC Frame With Inverted V-Bracings	533.54	588.52

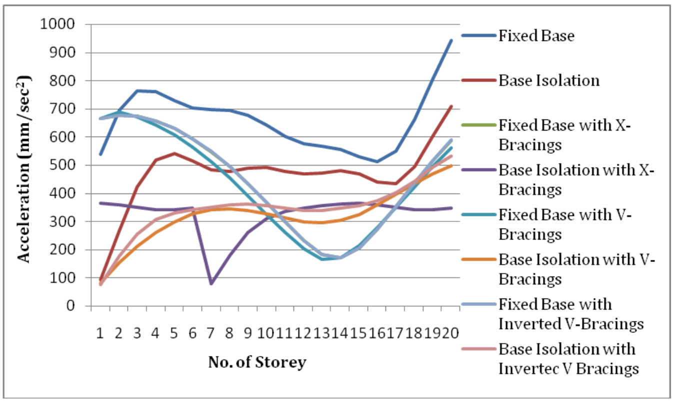

Figure 4: Storey Acceleration for Fixed Base and Base Isolation

5. Conclusion

In this dissertation work an attempt has been made to check the performance of RC frame building with and without Bracings under fixed base and isolated base for medium soil conditions for seismic zone V. static and dynamic analysis is carried out to compare the results.

Totally 8 different models of 20 storey are considered for the analysis. The analysis results are tabulated and compared. Following are the major conclusions drawn from those results,

- Storey displacement is increased for the isolated base models compared to fixed base.
- Storey drift is reduced for the isolated base models compared to fixed base.
- Structural response of the building is reduced in isolated base models compare to fixed base models.
- Mode period increases in Lead Rubber Bearings (LRB) when compared with fixed base building. Because, flexibility is more in Lead Rubber Bearing compared to fixed base.
- Building without Bracings, mode period is less when compared to building with Bracings. Because mass participates less in without Bracings when compared to with Bracing building.
- Even storey acceleration also reduced for the base isolated structures
- In this study, it is observed that the performance of building with base isolation technique is much better than fixed base one.
- The parameters such as displacement and drift have been analyzed. Hence it is seen that displacement is higher in base isolation when compared to fixed base.
- The main factor governing the building is its storey drift. The study shows that drift is very much reduced in base isolation.

- Though the cost of installation adds to drawback of base isolation, but the performance proves its necessity in hospitals, public places and essential buildings. Hence from the study, it can be observed that various bracing system performs better by the use of base isolation in seismic prone area.

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