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Experimental Effect of Base Isolation System on Non Linear Behaviour of Building Structure under Earthquakes.

[1]Mr. Yash Karbhari Badhe, [2]Prof. P. B. Autade.

M.E Civil (Structural Engineering)

[1]PG Student, Department of Civil Engineering, P. D. V. Vikhe Patil College of engineering Ahmednagar

[2]Professor, Department of Civil Engineering, , P. D. V. Vikhe Patil College of engineering Ahmednagar Pune, India.

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Abstract - *The damage to structures, when shaken by an earthquake, is due to factors like too much load on the structure (caused by post plan approval modification- like a 10 storey building in Ahmedabad which had a terrace garden cum pool and so it collapsed in the Jan 2000 Gujarat earthquake- though all equally tall structures all around it did not collapse); poor distribution of structural load creating joints or walls which give way under the sudden excess load due to vibration; poor foundations- too shallow for the height of the structure, built on land reclaimed from water bodies but soil not compacted etc. This shows how necessary it is to follow the building code prescribed for a given area/ region by the government. In earthquake prone areas like Japan, Indonesia, California etc. some techniques have been used which enable the structure to reduce the amplitude of vibrations by making the foundation or load bearing structure move as if Lead rubber bearing is used. There are also prescribed designs for the RCC framework and the way load is transmitted to the foundations by interlinking etc. The earthquake resistant structure has made possible to guarantee a better performance of buildings, when they are subjected to seismic actions. Therefore it is convenient that current codes for design of building become conceptually when defining the various parameters governing the structure exposure conditions, geological conditions of proposed site, topographical parameters, geological parameters that includes: soil type, bearing capacity of soil The purposed of this work is to study analysis, design and estimate of high rise structure in various zones. And also compare the earthquake resistant structure and lead rubber bearing structure for same zones, if we can compare this building structure we can find out difference in construction cost also which is economical safe for us.*

Keywords— Seismic protection, base isolation, idealized behaviour, hysteresis loop, ductility, installation technique.

I. INTRODUCTION

General Overview

In recent years base isolation has become a progressively applied structural design technique for buildings and bridges in high seismicity regions. Many types of structures like residential, commercial, industrial and institutional have been built using this approach, and many others are in the planning and design phases. Most of the structures are constructed with the use of rubber and frictional pendulum bearings. The introduction of the isolation system using the characterization of the sliding system. This system work based on the transformation of the limiting shear across the isolation interface. In the construction industry, various sliding systems have been recommended and some have been used. In China, most of the buildings are constructed using the sliding system in which selected sand used at the sliding interface. In South Africa, nuclear powers plant constructed by introducing isolation system encompassing a lead-bronze plate sliding on the stainless-steel with an elastomeric bearing. The friction-pendulum system is a sliding system using a special interfacial material sliding on stainless steel and used for several projects in the U S, both new and retrofit construction.

Purpose of base isolation

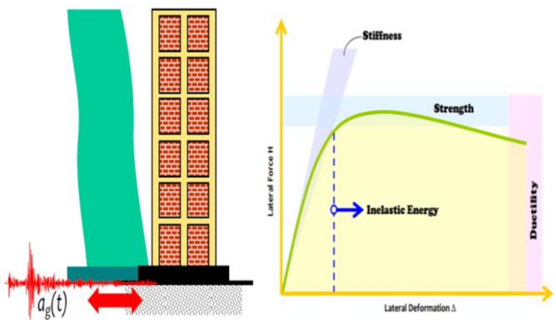


Fig1.1: Purpose of the base isolation and Demand during ground motions

Base isolatation system plays important role at the time of earthquake. When ground shakes vibratation are transferred toward top of building which causes damage to the structure. To overcome this Base isolatation System e.g. LRB is provided in the structure.

Lead rubber bearings

Lead Rubber Bearing is one of the base isolation techniques which can be use in structure In which Lead core, Rubber Layers, Internal Shim Plates are provided. LRB can be provided in a shape of circle or square. LRB plays important role in absorption of Horizontal loading produced at the time of earthquake.

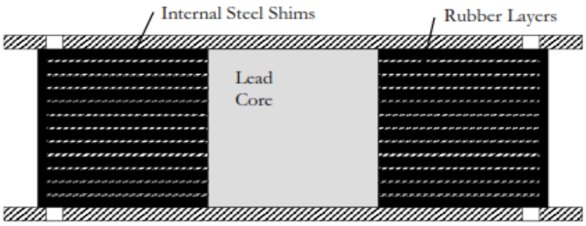


Fig1.3: Lead rubber bearing section

Implementation of the isolator in buildings

Use of isolator in the structure is decided by structural engineer because economy must be our first priority but for other earthquake resistance technique if LRB is economical than other it can be use in structure.

The Weight of the Structure:

Self-weight of structure is consider in the provision of LRB. More the weight response period is more so that isolation is more effective.

The Period of the Structure:

As we know practical isolation systems don't provide an infinite period, rather they shift the period to the 1.5 to 3.5 second range. If the structure is already in this period range then do not get much benefit from isolation, although in some cases energy dissipation at the base may help. This is used quite often in bridges with a long period, less so for buildings.

Aspect Ratio of Structural System:

A general rule of thumb is that the system should be suitable for isolation provided significant tension does not occur at any isolator location for the Design Level Earthquake. Tension is accepted for the Maximum Considered Earthquake but may complicate the analysis. If tensile stresses in elastomeric bearings exceed the cavitation limit then the effect of the reduced axial stiffness may need to be assessed; for sliding systems, uplift will occur at these locations and again, the effect of this may need to be assessed.

Problem Statement

To study the influence of the different base isolated system on the symmetrical structures subjected to the lateral earthquake by performing response spectrum analysis in ETabbs and performing Experimental Study of fixed Base and Base Isolated structure on Shake Table.

Objective of the project

- Study of types of base isolators, their constituent elements.
- The current work is focused on the impact of different base isolated systems like Lead rubber bearing on the seismic performance of structures.
- The comparative study between base isolated structures and fixed base structures is carried out by ETabs software & Compare the Factors like column, footing, etc.
- The parametric study was carried out to study the linear dynamic characteristics considering different isolated systems used in the structures using Response spectrum method.
- To design and study the effectiveness used as base isolation system in ETabs.

Limitations of study

- Experimental study for all type of building is not possible because its experimental cost goes high so we are dependent on software for analytical data.
- Manual calculations are tedious for a 3D frame building.

Scope of the study

The current study focused on effect of base isolation system at the time of earthquake when lateral forces are produced due to motion of ground.

- Study of types of base isolators, their elements.
- The current study is focused on the effect of different base isolated systems like Lead rubber bearing and friction pendulum bearing on the seismic performance of the symmetrical and unsymmetrical structure.
- The comparative study between base isolated structure and fixed base structure is carried out by Experimental and software like ETabs and SAP.

- The parametric study was carried out to study the linear dynamic characteristics considering different isolated systems used in the structure using Response spectrum method.
- To design and study the effectiveness of lead rubber-bearing and friction pendulum bearing used as base isolation system.

Fabio Mazzaand, Alfonso Vulcano

In particular, the first solution with HDLRB-type isolators has been compared with different solutions obtained by means of the addition of viscous dampers (acting in parallel) or steel-PTFE sliding bearings (acting either in parallel or in series), assuming different values of the parameters characterizing the behavior of the supplemental seismic devices. The from the study following inference can be drawn in-parallel combination of isolators and viscous dampers (BIPD), as well as the analogous one with isolators and sliding bearings (BIPS, proved to be favorable for controlling the relative displacement of the isolators: the choice of increasing the equivalent damping ratio (ξD), for the BIPD system, or the sliding ratio (αS), for the BIPS system, corresponds to a reduction of the isolator displacement, even though, for the same increase of ξD or αS, this effect has been ever-smaller. However, the use of the BIPS system can need re-centering after an earthquake, in case the elastic restoring force produced by the elastomeric isolators does not exceed the friction threshold imposed by the sliding bearings. The in-series combination of isolators and sliding bearings (BISS) is not always favorable, for increasing values of αS, in reducing the residual displacement of the isolation system.

Bruno Briseghella et.al.(2020)

Moreover, the re-centering of this system may present some difficulty when the residual displacement is a combination of out-of-phase movements between the isolators and the sliding bearings placed on them. With reference to the ductility demand for the RCC frame members, the adoption of the BIPD system or the BIPS one does not guarantee in all the cases a better performance for increasing values of D or αS, respectively. However, the BISS system proves to be generally effective for controlling the structural and on-structural damages of the framed building, producing an amplification of the fundamental vibration period and limiting the maximum acceleration transmitted to the superstructure.

By Lin Su et.al (2021)

The structure is modelled as a rigid mass and the accelerograms of the new component of the El Centro 1940 earthquake and the N90W component of the Mexico City 1985 earthquake are used. The performances of different base isolation devices under a variety of conditions are evaluated and compared. Combining the desirable features of various systems, a new design for a friction base isolator is also developed and its performance is studied. Response of typical structural systems isolated with VFPI and other isolation systems under near-source ground motions have been investigated. The traditional isolation systems are found to be of limited effectiveness in reducing the response of structures while VFPI show significant reduction in response.

Gap Analysis

- As the aspect ratio increases moments in the column decreases considerably for wind load cases, whereas the moments remain same for all aspect ratio for gravity loads.
- Nonlinear time-history analysis for multiple site-specific ground motion is characteristic of the design of base isolated structures.
- As the height of the building increases moments in the column increases for low rise building and remain constant for medium for medium height buildings.
- Column moments are considered critical while designing for tall buildings.

METHODOLOGY

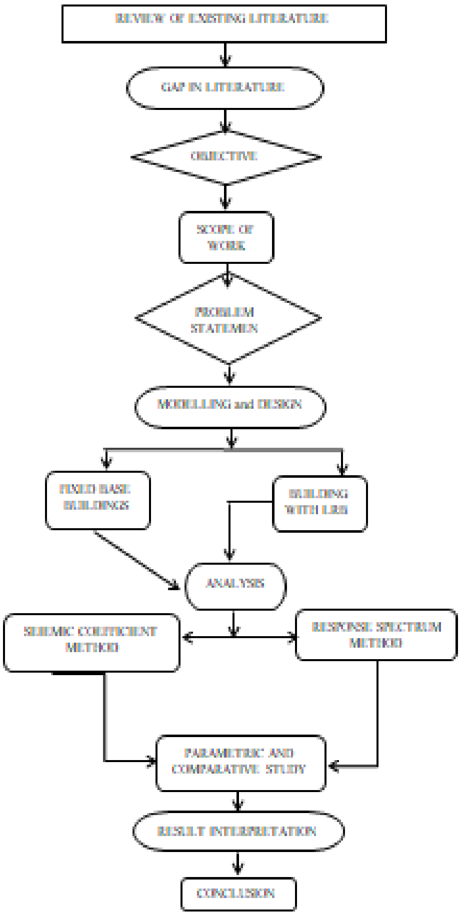


Fig1.4: Flowchart of Methodology

MODELLING & DESIGN

The building model is designed on finite element method software ETabs. Two models are designed on it one with fix base and other with base isolation technique used with LRB. Both models are designed for G+12 Buildings. In that important element like slab, beam, column is provided but other elements are neglected. Area of building is considered as 400m^2 and seismic zone III.

Loads Acting on Buildings

Gravity Loads

Gravity loads include self-weight of building, floor finish which is 1.5 kN\m^2 and live load which is 2 kN\m^2 as per IS 875(part-II) for a residential building which would acting on the structure in its working period. We have also considered wall load as live load on internal beams as 7.5 kN\m^2 and on external beams 13kN/m^2

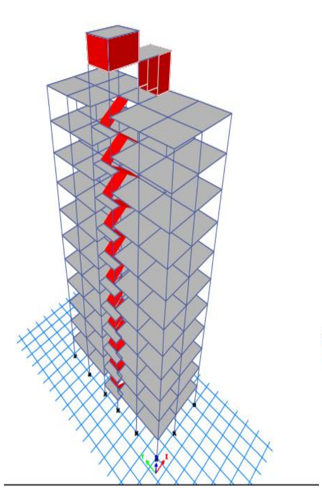
Lateral Loads

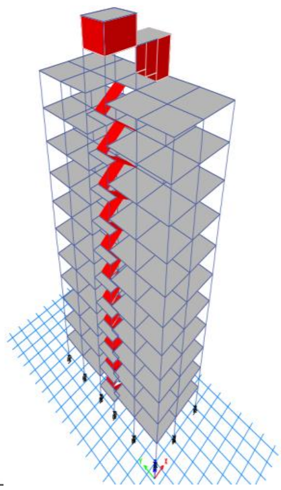
The different between lateral load and vertical load, the lateral load effects on buildings are differs and increases rapidly with increase in height. Most lateral loads are live loads whose main component is horizontal force acting on the structure. Lateral loads would be a wind load, an Earthquake load, and an earth pressure against a retaining wall. Most lateral loads vary in intensity depending on the buildings, geographic location, structural material, height and shape.

Earthquake Load

Earthquake loading is a result of the dynamic response of the structure to the shaking if the ground. Earthquake loads are another lateral live load. They are very complex and potentially more damaging than wind loads. It is quite fortunate that they do not occur frequently. The Earthquake creates ground movements that can be categorized as a “shake”, “rattle” and “roll”. Every structure in an Earthquake zone must be able to withstand all three of these loadings of different intensities. Although the ground under a structure may shift in any direction, only the horizontal components of this movement are usually considered critical in analysis. The magnitude of horizontal inertia forces induced by earthquakes depends upon the mass of structure, stiffness of the structural system and ground acceleration.

ETab Model

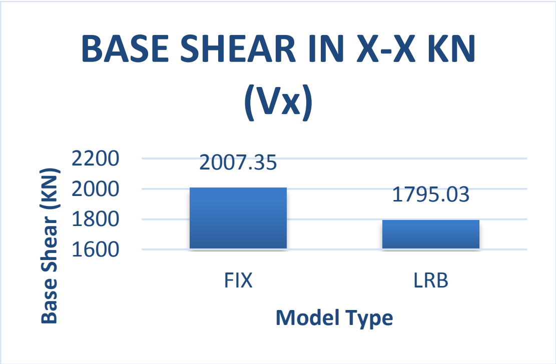




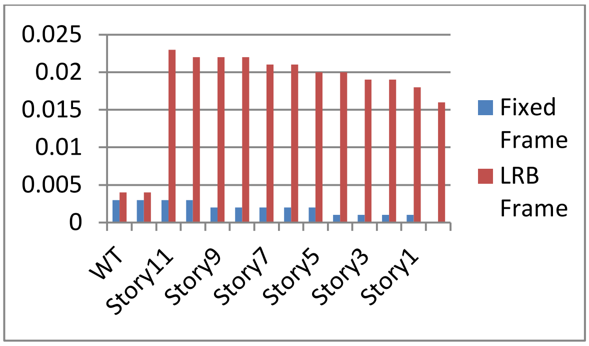
G+12 Fixed Based Model **G+12 LRB MODEL**

RESULTS

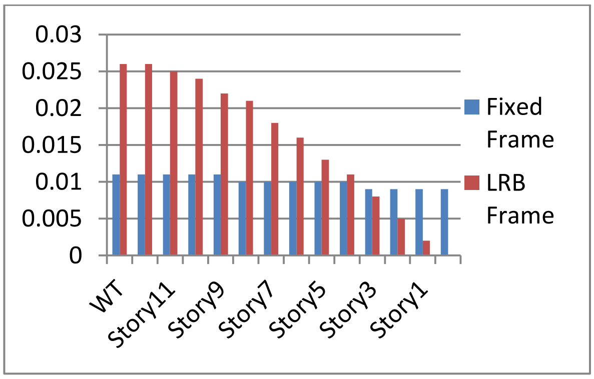
Base Shear



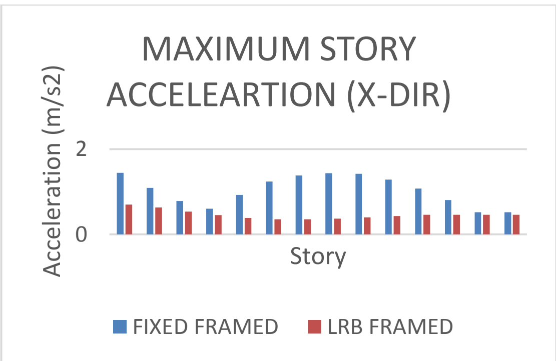
Maximum Story Displacement (X Direction)



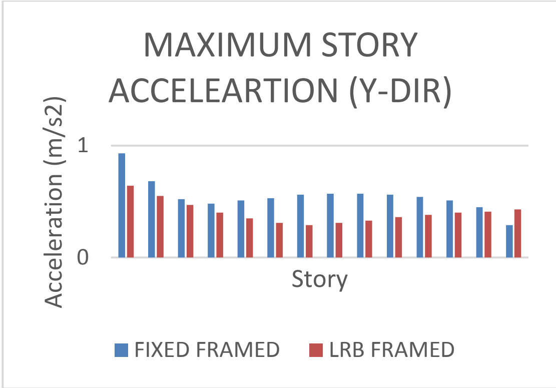
Maximum Story Displacement (Y Direction)



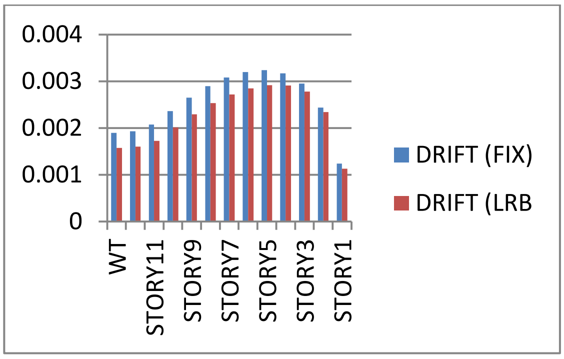
Story Acceleration Ux (M/Sec2)



Story Acceleration Uy (M/Sec2)

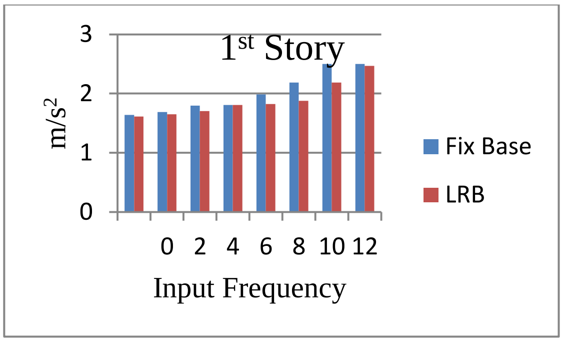


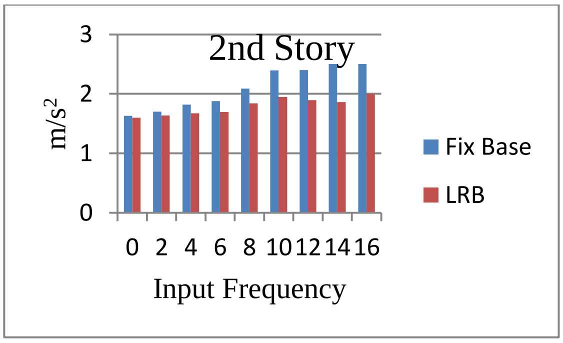
Story Drift

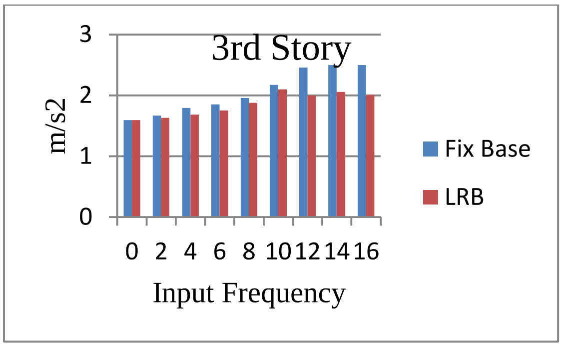


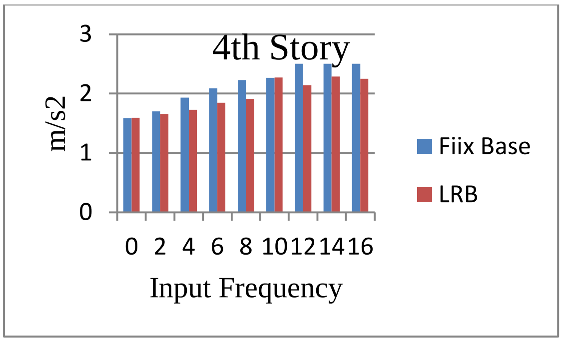
Manual Model Results

All Data is in Acceleration and frequency format.









CONCLUSION

From the Experimental Study using Shake Table the displacement and Acceleration of the Base Isolated Structure are much less than the fixed Base structure. The Base Isolated Structure is more stable for External frequency applied during Shake Table Test as compared to fixed Base Structure. Story displacement, Story acceleration, base shear and drifts are reduced considerably in case of the base isolated structure than the fixed base structure for symmetrical and unsymmetrical building in both directions. In all the case story displacement and drifts are within permissible limit as per codal provision of IS1893:2016.

Discussion

The study of base isolated structures like Lead Rubber Bearing, Friction Pendulum Bearing and fixed base structures is carried out. The results obtained from the response spectrum method for symmetrical and unsymmetrical building with different base condition like fix base and base isolated are shown below

- Story shear reduced after the lead rubber bearing (LRB) is provided as base isolation system which reduces the seismic effect on building.
- Base shear is also reduced after providing LRB which makes structure stable during earthquake.
- Story drift are reduced in higher stories which makes structure safe against earthquake.
- Point displacements are increased in every stories after providing LRB which is important to make a structure flexible during earthquake.
- Finally it is concluded that after LRB is provided as base isolation system it increases the structures stability against earthquake and reduces reinforcement hence make structure economical.
- Hence, it is to conclude that we have got the desired outcomes thus the design of LRB is safe.

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