

“Review of Design and Comparative Analysis of Applications in Earthquake-Resisting RC Structures and LRB Structures”

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Abstract— 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 a) exposure conditions b) geological conditions of proposed site c) topographical parameters d) geological parameters that includes: soil type, bearing capacity of soil

The purpose 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.

- The method of base isolation was developed in an attempt to mitigate the effects of earthquakes on buildings during earthquakes and has been practically proven to be the one of the very effective methods in the past several decades.
- Base isolation consists of the installation of support mechanism which decouples the structure from earthquake induced ground motions.
- Base isolation allows to filter the input forcing functions and to avoid acceleration seismic forces on the structure.
- If the structure is separated from the ground during an earthquake, the ground is moving but the structure experienced little movement.

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

I. INTRODUCTION

General Overview

The method of base isolation was developed in an attempt to mitigate the effects of earthquakes on buildings during earthquakes and has been practically proven to be the one of the very effective methods in the past several decades. Base isolation consists of the installation of support mechanism which decouples the structure from earthquake induced ground motions. Base isolation allows to filter the input forcing functions and to avoid acceleration seismic forces on the structure. If the structure is separated from the ground during an earthquake, the ground is moving but the structure experienced little movement.

Earthquake

Earthquake is basically a naturally phenomenon which causes the ground to shake. The earth's interior is hot and in a molten state. As the lava comes to the surface, it cools and new land is formed. The lands so formed have to continuously keep drafting to allow new material to surface. According to the theory of plate tectonics, the entire surface of the earth can be considered to be like several plates, constantly moving. These plates brush against each other or collide at their boundaries giving rise to earthquakes. Therefore regions close to the plate boundary are highly seismic and regions further from the boundaries exhibit less seismicity. Earthquakes may also be caused by other actions such as underground explosions.

Purpose of base isolation

In the branch of structural engineering, the building is designed for the earthquake resistance, not for the earthquake proof.

During the earthquake, a ground motion induces an inertia force in both directions which is a creation of building mass & earthquake ground acceleration. Therefore, it is essential that the building should have adequate strength and stiffness to resist the lateral load induce during the earthquake.

In the construction field, it is not good practice to rise the strength of the building indeterminately. In high seismicity regions, the accelerations causing inertial forces in the building may exceed one or even two times the acceleration due to gravity. In this case, base isolation technique is used to mitigate earthquake effects

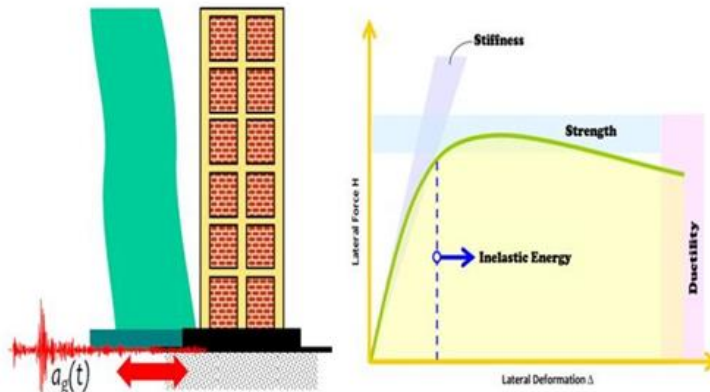


Fig1.1: Purpose of the base isolation and Demand during ground motions

Principle of base isolation

The basic principle of base isolation is to transform the response of the building so that the ground can move below the building without transferring these motions into the building. The assumption of the ideal system is a complete separation between ground and structure. In actual practice, there is a contact between the structure and the ground surface.

which will be equivalent to the ground acceleration and there will be nil relative displacements between the structure and the grounds. The structure and substructure move with the same amount. A building with a perfectly stretchy diaphragm will have an immeasurable period; for particular type of structure, when the ground beneath the structure travels there will be zero acceleration induced in the structure and the relative displacement between the structure and ground will be equivalent to the ground displacement. In this case, structure will not change but the substructure will move.

Buildings with a perfectly stiff diaphragm have a nil fundamental natural time period. The ground motion induces acceleration in the structure

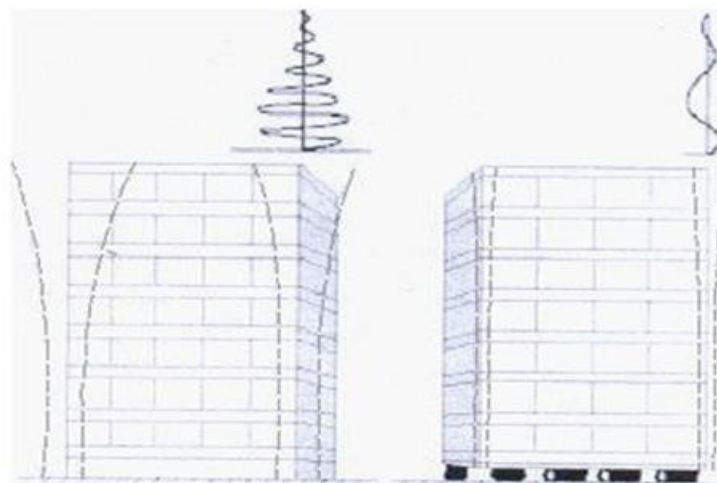


Fig1.2: Principle of the base isolation Lead rubber bearings

It is designed of a lead plug force-fitted into a pre-formed hole in an elastomeric bearing. The lead core provides rigidity under service loads and energy dissipation under high lateral loads. Top and bottom steel plates, thicker than the internal shims, are used to accommodate mounting hardware. The entire bearing is encased in cover rubber to provide environmental protections

When exposed to low lateral loads the lead-rubber bearing is rigid both laterally and vertically. The lateral stiffness results from the

high elastic stiffness of the lead plug and the vertical rigidity result from the steel-rubber construction of the bearing. The period shift effect characteristic of base isolation system developed due to at higher load levels the lead yields and the lateral stiffness of the bearing is expressively reduced. As the bearing is cycled at large displacements, such as during moderate and large earthquakes, the plastic deformation of the lead absorbs energy as hysteretic damping. The equivalent viscous damping produced by this hysteresis is a function of displacement and usually ranges from 15% to 35%

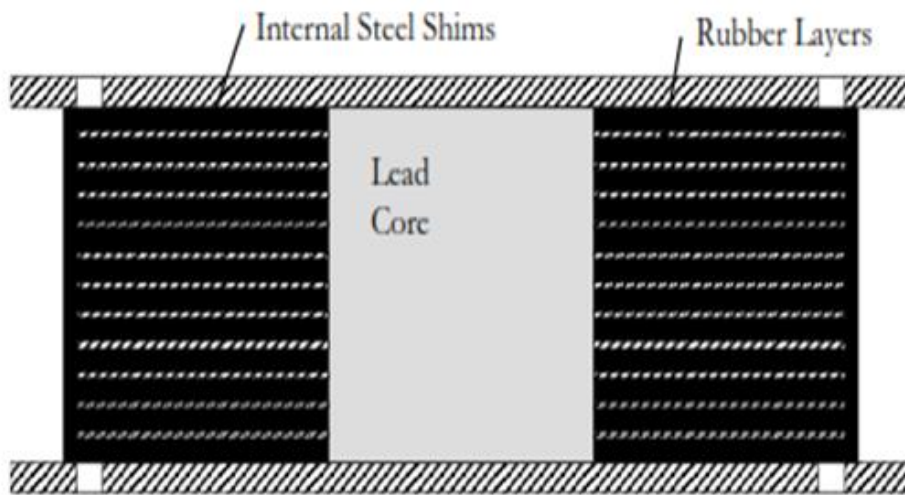


Fig1.3: Lead rubber bearing section

A major benefit of the LRB system is it combines the functions of rigidity at service load levels, elasticity at earthquake load levels and damping into a single compact unit. These properties make the lead-rubber bearing the maximum shared type of isolator used where high levels of damping are required or for structures where rigidity under services loads is important. As for HDR bearings, the elastomeric bearing formulations are also applicable for the design of LRBs.

Base Isolation Techniques

In traditional seismic design approach, strength of the structure is suitably adjusted to resist the earthquake forces. In base isolation technique approach, the structure is essentially decoupled from earthquake ground motions by providing separate isolation devices between the base of the structure and its foundation. The main purpose of the base isolation device is to attenuate the horizontal acceleration transmitted to the superstructure. All the base isolation systems have

certain features in common. They have flexibility and energy absorbing capacity. The main concept of base isolation is to shift the fundamental period of the structure out of the range of dominant earthquake energy frequencies and increasing the energy absorbing capability. Presently base isolation techniques are mainly categorized into three types viz.

- Passive base isolation techniques
- Hybrid isolation with semi-active device
- Hybrid base isolation with passive energy dissipaters

Implementation of the isolator in buildings

The first question in the mind of a structural engineer is that when to use isolation in the building, the simple answer is when it provides a more effective and economical alternative than other methods of use for earthquake safety. If the design for earthquake loads requires strength or detailing that would not meet required for other load conditions then base isolation may be feasible.

When we evaluate structures, which meet this basic criterion, then the best way to assess whether your structure is suitable for isolation is to step through a checklist of items which make isolation either more or less effective.

The Weight of the Structure:

The base isolation system is more efficient for the structures which have heavy masses. To effective isolation can be achieved with the help of the long period of the response. As we know the period is an inherent property of the structure which is relative to the square root of the mass M and contrariwise proportional to the square root of the stiffness K .

The Period of the Structure:

The structures whose fundamental natural time period is less than 1 second are most suitable for the isolation system. For example, buildings which are usually less than 10 stories and for elastic types of structure, such as steel moment frames, probably less than 5 stories

Seismic Conditions Causing Long Period Waves:

Some sites have a travel path from the epicenter to the site such that the quake motion at the site has a extended period of motion. This condition most often occurs in alluvial basins and can cause resonance in the isolated period range. Isolation may make the response worse instead of better in these situations. Examples of this type of motion have been recorded at Mexico City and Budapest

Subsoil Condition: Isolation works best on rock and stiff soil sites. The soft soil has a similar effect to the basin type conditions mentioned above; it will modify the earthquake waves so that there is an increase in long period motion compared to stiff sites. Soft soil does not rule out isolation in itself but the efficiency and effectiveness will be reduced.

Near Fault Effects:

One of the most controversial aspects of isolation is now well the system will operate if the earthquake occurs close to the structure. Adjacent to the fault, a phenomenon termed "throw" can occur. This is characterized by a long dated, high-velocity pulse in the ground acceleration record. Isolation is being used in near-fault locations, but the cost is usually higher and the evaluation more complex. In reality, any structure near to a fault should be evaluated for the "fling" effect and so this is not peculiar to isolation.

Aspect Ratio of Structural System: Maximum practical isolation devices have been developed to operate under compression loads. Sliding systems will separate if vertical loads are tensile; elastomeric based systems must resist tension loads by tension in the elastomer. In tension, cavitation occur at relatively low stresses which reduce the stiffness of the isolator; For these reasons, Isolation systems are generally not practical for structural systems that rely on tension elements to resist lateral loads.

5) To design and study the effectiveness of lead rubber-bearing and friction pendulum bearing used as base isolation system.

Seismic Zones

As we all know that India is divided into 5 earthquake zones:

- i. Zone 1
- ii. Zone 2
- iii. Zone 3
- iv. Zone 4
- v. Zone 5

Current division of India into earthquake hazard zones does not use Zone 1, no area of India is classed as Zone 1

PROBLEM STATEMENT

To study the influence of the different base isolated system on the linear dynamic characteristics of the symmetrical and unsymmetrical structures subjected to the lateral earthquake by performing response spectrum analysis in ETAB 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 present work is focused on the impact of different base isolated systems like Lead rubber bearing on the seismic performance of structure.
- The comparative study between base isolated structure and fixed base structure is carried out by ETAB 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 structure using Response spectrum method.
- To design and study the effectiveness used as base isolation system in ETAB.

Limitations of study

- ✓ Experimentation work cannot be done for all cases as casting models with base isolation building would be very costly so we have to be dependent on software analytical study.
- ✓ Manual calculations would be very tedious for a 3D framebuilding.

SCOPE OF THE STUDY

The present study focuses on the analytical investigation of the influence of the different base isolated system on the seismic response of the structure subjected to a lateral seismic load.

- 1) Study of types of base isolators, their constituent elements.
- 2) The present work isXfocused on the impact of different base isolated systems like Lead rubber bearing and friction pendulumbearing on the seismic performance of the symmetrical and unsymmetrical structure.
- 3) The comparative study between base isolated structure and fixedbase structure is carried out by Experimental and Analytical Study.
- 4) The parametric studyXwas carried out to study the linear dynamic characteristics considering different isolated systems used in the structure using Response spectrum method.



Zone 5: Zone 5 covers the areas with the highest risks zone that suffers earthquakes of intensity MSK IX or greater. The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use

this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero period) level earthquake in this zone. It is referred to as the Very

High Damage Risk Zone. The region of Kashmir, the western and central Himalayas, North and Middle Bihar, the North-East Indian region and the Rann of Kutch fall in this zone. Generally, the areas having trap rock or basaltic rock are prone to earthquakes.

Zone 4: This zone is called the High Damage Risk Zone and covers areas liable to MSK VIII. The IS code assigns zone factor of

0.24 for Zone 4. The Indo-Gangetic basin and the capital of the country (Delhi), Jammu and Kashmir fall in Zone 4. In Maharashtra, the Patan area (Koyananager) is also in zone no-4. In Bihar the northern part of the state like- Raksaul, Near the border of India and Nepal, is also in zone no-4 that "almost 80 percent of buildings in Delhi will yield to a major quake and in case of an unfortunate disaster, the political hub of India in Lutyens Delhi, the glitz of Connaught Place and the magnificence of the Walled City will all come crumbling down.

Zone 3: The Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone. This zone is classified as Moderate Damage Risk Zone which is liable to MSK VII. and also 7.8 The IS code assigns zone factor of 0.16 for Zone 3.

Zone 2: This region is liable to MSK VI or less and is classified as the Low Damage Risk Zone. The IS code assigns zone factor of 0.10 (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) for Zone 2.

II. LITERATURE REVIEW

Pranesh Mrunal and Ravi Sinha

In this paper, behaviour of structures isolated using VFPI subjected to near source ground motions has been numerically examined. 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.

Bruno Briseghella et.al.

Results had been compared among the original building and buildings retrofitted by different interventions. Although both retrofitting strategies can reduce the seismic vulnerability of existing building, the comparison pointed out building retrofitted with a "Lift up" technique patented by SOLES Ltd., executed by CONST and presented in the following, exhibited better performance than "column cut" technique. The technique has been

successfully applied to the mentioned building under the consultancy of BOLINA Engineering Ltd. and the works are just finished.

By Lin Su et.al.

In this paper a comparative study of effectiveness of various base isolators is carried out. These include the laminated rubber bearing with and without lead plug and several frictional base isolation systems. The structure is modelled as a rigid mass and the accelerograms of the NOOW 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. It is shown that, under design conditions, all base isolators can significantly reduce the acceleration transmitted to the superstructure.

Sarvesh K.Jain and Shashi K.Thakkar

This paper consists of analytical study of base-isolation for buildings with higher natural period ranging from 1.0 to 3.0 second. Different possibilities are explored to increase the feasibility of base isolation for such type of buildings. Strategies proposed in this study are (i) increasing superstructure stiffness, (ii) increasing superstructure damping and (iii) increasing flexibility of isolation system. It is observed that the effectiveness of base isolation for these buildings may be increased by incorporating such provisions.

O.P. Gomse, S.V. Bakre (2011)

In the present study, the analysis of fixed base and base- isolated 3-D four storied building is performed. The behavior of building structure resting on the elastomeric bearing is compared with a fixed base structure under maximum capable earthquake. The isolation system consists of isolation pads between columns and foundation increase the fundamental natural period of vibration of the structure which reduces floor acceleration, inter-story drifts and base shear of the structure. It is very essential to estimate the accurate peak base displacements of the base isolated structure when it is subjected major earthquake near the location of the fault earthquake. In such cases, the isolator deforms excessively because near-fault earthquakes contain long period velocity pulses which may coincide with the period of the base isolated

structures. To investigate the response of isolated structure bidirectional non-linear time history analysis were performed for G+4 storey structure designed as per UBC 97. From the comparative study, they concluded that base isolated shows best seismic response than the fixed base system. The base isolation technique is one of the best examples of the effective seismic resistance system.

Ajay Sharma, R.S. Jangid

It was observed that the high initial stiffness of the isolation system excites higher modes in base-isolated structure and generate floor accelerations and story drift. Such behavior of the base-isolated building especially supported on sliding type of isolation systems can be detrimental to sensitive equipment installed in the building. On the other hand, the bearing displacement and base shear found to reduce marginally with the increase of the initial stiffness of the initial stiffness of the isolation system.

Fabio Mazzaand, Alfonso Vulcano

The comparative study between different base- isolation techniques, in order to evaluate their effects on the structural response and applicability limits under near- fault earthquakes, is studied. In particular, high-damping- laminated-rubber bearings are considered, in case acting in parallel with supplemental viscous dampers, or acting either in parallel or in series with steel-PTFE sliding bearings.

P. Bhaskar Rao and R. S. Jangid

The experimental results are compared with the analytical results to verify the mathematical force-deformation behavior of the isolation system. There was a good agreement between the experimental and analytical response of the structural models. In addition, the response of the isolated system is found to be less in comparison to the corresponding response without isolation system, implying that the isolation is quite effective in reducing the acceleration response of the system. The presence of restoring force device along with the sliding system reduces the base displacement without a significant increase in superstructure acceleration. In addition, the response of the structural models has also been investigated for a real earthquake ground motion and it has been found that the isolation devices are effective in reducing the seismic response of structures.

AratiPokhrel, Jianchun Li, Yancheng L, NicosMaksisd, Yang Yu (2016)

They concluded that the base isolation system works as a flexible element as well as a sliding element that increases the fundamental period of the structure and prevents the transmission of the earthquake force. For the structure to remain elastic, the limiting drift ratio is 0.5%. This limit value is over exceeded for all the ground motions when the structure is the fixed base. In contrast, when the structure is isolated, the superstructure remains elastic for three of the ground motions, whereas only for the Northridge 1994 ground motion the superstructure doesn't remain elastic. So, the nonlinear (inelastic) analysis is recommended

Minal Ashok Somwanshi, Rina N. Pantawane (2015)

The comparative study between fixed and base-isolated structure is carried using different parameters like maximum shear force, maximum bending moment, base shear, and story drift and story acceleration. The effect of the base isolated system on the symmetrical and un-symmetrical structure is investigated under the strong ground acceleration. From the analytical study, they concluded that for all the models of the symmetrical as well as non-symmetrical buildings zero displacement at the base of the fixed building and in case of the isolated building considerable amount of lateral displacement seen at the base of the structure. As floor height increases lateral displacements of the fixed base building increase significantly as compared to the base isolated building.

Vinod kumar Parma and G.S.Hiremath

The main objective of this work is to compare the response of the building such as Time period and Base shear for 15 storied RC plan and vertical irregular building with and without base isolation by considering the time history analysis. The result obtained from analysis was time period and base shear .Time period for base isolated structures are higher than that of fixed base structures. Due to base isolators, base shear is reduces in each direction(X and Y) as compared to fixed base building. Increase in flexibility of the system, time period of the structure is also increases. By the analysis it is observed that base isolation increases the flexibility at the base level of building. Time period of the structure increases by the use of lead rubber bearing which helps in less transfer of lateral forces at time of earthquake.

G.P. Chandradhara and M.B. Vikram

The main objective of this study is to study the effect of wind load on gravity load. Variations of bending moment and axial force in columns are considered to study the behaviour of frames. This study present the wind effects on building with different aspect ratio using ETABS. It is concluded that wind effect reduces as aspect ratio of building reduces. As the aspect ratio increases moments in column decreases considerably for wind load cases.

Manoj U. Deosarkar and S.D. Gowardhan

In this research, 6-storey RCC structures are designed as isolated and fixed base. We will examine the response of the building isolated using combined isolation system consisting of high-damping rubber bearing; lead rubber bearing and friction pendulum system at the base column are used. Nonlinear time history analysis is considered in modelling. At the end of analysis time period, storey shear and storey displacement are compared for isolated and fixed base structure. It is observed that combined isolation system helps to increase time period and storey displacement and to decrease storey shear, storey drift and storey acceleration. It is observed that fixed base building have zero displacement at base of building whereas, all base isolated buildings models shows increase in amount of lateral displacement at base.

Md. Mohiuddin Ahmed et.al.

The seismic performance of both regular shape and irregular shape building depends on height of the building along with other important structural parameters. Increasing the building height increases base shear and base moment at the base of the building. During earthquake slender building are more vulnerable than any other building. The outputs of this present study will help other engineers and researchers to understand to understand the influence of vertical aspect ratio on building parameters. Base shear increases gradually with increase in building heights. The base shear is obtained lower for 5 storeys building and higher for 20 storey buildings. Storey over turning moment increases gradually with increase in building height. Lowest value is obtained in case of 5 storey building where as highest in case of 20 storeys building.

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.

III. METHODOLOGY

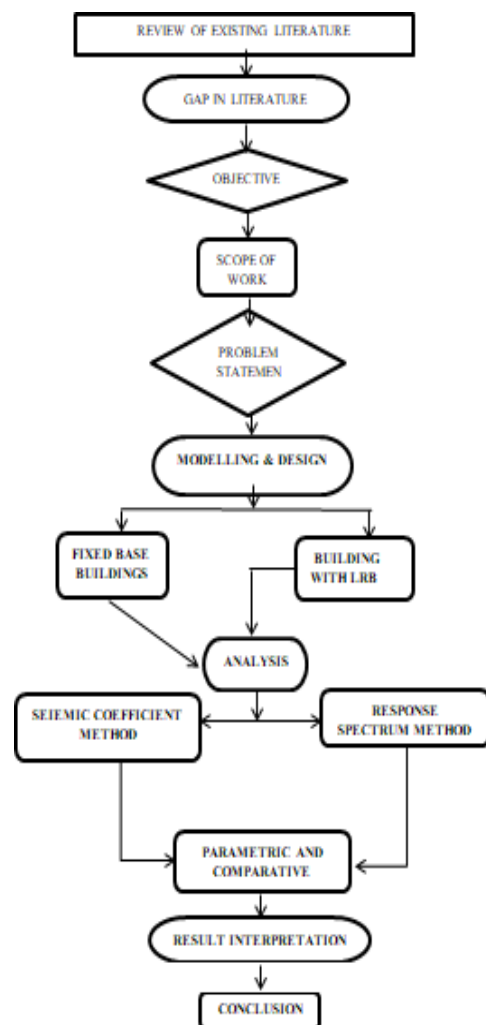


Fig1.4: Flowchart of Methodology

MODELLING & DESIGN

The buildings are modelled using the finite element software ETABS. The analytical models of the building include all components that influence the mass, strength, stiffness and deformability of structure. The building structural system consists of beams, columns, and slab. The non-structural elements that do not significantly

influence the building behaviour are not modelled. Modal analysis and Response spectrum analysis are performed on models. In present work, 3D RC 12 storied buildings of different dimension according to aspect ratio differ by 0.5 is taken which has area of 400 m² situated in zone III, is taken for the study in which two cases has been considered one with fixed base and second with base isolation using Lead rubber bearing.

Loads Acting on Buildings

Gravity Loads

Gravity loads include self-weight of building, floor finish which is taken as 1.5 kN/m² and live load which is taken as 2 kN/m² as per IS 875(part-II) for a residential building that would be acting on the structure in its working period. We have also considered wall load as imposed load on internal beams as 7.5 kN/m² and on external beams 13kN/m²

Lateral Loads

In contrast to the vertical load, the lateral load effects on buildings are quite variable and increases rapidly with increase in height. Most lateral loads are live loads whose main component is horizontal force acting on the structure. Typical lateral loads would be a wind load, an Earthquake load, and an earth pressure against a beachfront 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, uncertain 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.

Analysis Data for All Models

- 1) Type of Building: RCC Framed Structure
- 2) Number of story: 12 (Plinth + Ground + 4 Floors)

- 3) Plan Size Different for each model
- 4) Floor to floor height: 3 m. (Total Height = 31.5 m)
- 5) Height of plinth: 1.5 m.
- 5) Depth of foundation: 3.0 m.
- 7) External walls: 230 mm thick
- 8) Internal walls: 115 mm thick
- 9) Height of parapet 1.5 m
- 10) Materials: M30, Steel Fe500
- 11) Loads:

a) Dead loads

- i) Slab: 25 D KN/m²
D is depth (Thickness) of slab in meter.

- ii) Floor finish: 1.5 KN/m²

b) Live load 2 KN/m²

- 12) Slab Thickness: 125 mm
- 13) Elastic Modulus of concrete $\sqrt{5000 f_{ck}}$
- 14) Seismic zone III
- 15) Size of Beams 230 mm X 450 mm
- 16) Size of Columns 300 mm X 450 mm
- 17) Density of Concrete 25 KN/m³
- 18) Density of brick masonry 18.85 KN/m³

a) Structural Details:

No. of stories: Ten
 Floor to floor Height: 3m Type of Building: Commercial
 Size of Beams: 230 X 450 mm
 Size of Columns: 600 X 600mm The thickness of Slab: 150mm

The thickness of the internal and external wall: 230 mm
 The height of the Parapet wall: 1.2 m

b) Loading Details:

LL on the floor: 3 KN/m²
 LL on the roof: 1.5 KN/m² FF on the floor: 1.5 KN/m²
 FF on the roof: 2 KN/m²

c) Seismic Details:

Type of Frame: RC buildings with SMRF Type of Soil: Hard
 I factor: 1.5
 R factor: 5

IV. CONCLUSION

The present work focuses on the analytical investigation of the influence of the different base isolated system on the seismic response of the structure subjected to a lateral

seismic load. The comparative study between 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 story 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

V. Discussion

- 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.
- Storey displacement, Storey 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 storey displacement and drifts are within permissible limit as per codal provision of IS1893:2016.
- From the linear dynamic analysis, the fundamental natural time period of the fix base is much less as compared base isolated system for all models considered. The time period obtained from the analysis is in comparison with the empirical expression given by the IS 1893:2016.
- The base shear is much greater for fix base structure as compared base isolated structure for all models in both x and y-direction.
- From the linear dynamic analysis for multi storey symmetrical and unsymmetrical structures, the Storey displacement, storey acceleration, base shear and drifts are considerably less in case of the

FPS models than the LRB models.

- Finally it is concluded that base isolation system is significantly effective to protect the structures against moderate as well as strong earthquake ground motion.

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