To Study The Effectiveness of Base Isolation Techniques In Different Earthquake Zones of India By Comparing With Fixed Base Structure

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Abstract- *Seismic isolation is a technique for isolating a building structure from the destructive effects of seismic motion. It's a straightforward structural design strategy for mitigating or reducing earthquake damage. The seismic protection of base-isolated structures is achieved by shifting the structure's natural period away from the frequency range where the largest amplification effects of the ground motion are expected; hence, the seismic input energy is greatly decreased. At the same time, thanks to the energy dissipation generated by the damping and hysteretic features of these devices, it is feasible to reduce the large deformations obtained at the structure's base, further increasing the structure's response reduction.*

- *The method of base isolation was created in an effort to reduce the effects of earthquakes on buildings during earthquakes, and it has been proven to be one of the most effective methods in recent decades.*
- *Base isolation provides for the filtering of input forcing functions as well as the avoidance of seismic acceleration pressures on the structure.*
- *During an earthquake, if the structure is separated from the ground, the ground will move but the structure will not.*

To reduce the transmission of potentially damaging earthquake ground motions into a structure, flexibility is introduced at the structure's base in the horizontal direction, while damping elements are introduced to limit the amplitude or extent of the motion caused by the earthquake, similar to shock absorbers. This relatively new technology has just emerged as a viable and cost-effective alternative to traditional seismic strengthening.

Keywords- Base isolation, Lead-rubber bearing, Idealized behavior,Ductility, Seismic protection,

I. INTRODUCTION

General Overview

The method of base isolation was created in an effort to reduce the impact of earthquakes on buildings during earthquakes, and it has been demonstrated to be one of the most effective approaches in recent decades. The installation of a support mechanism that decouples the structure from earthquake-induced ground vibrations is known as base isolation. Base isolation provides for the filtering of input forcing functions as well as the elimination of seismic acceleration pressures on the structure. During an earthquake, if the structure is separated from the ground, the ground will move but the structure will not.

Purpose of base isolation:

The building is intended for earthquake resistant, not earthquake proof, in the field of structural engineering.

A ground motion creates an inertia force in both directions during an earthquake, which is a result of building mass and earthquake ground acceleration. As a result, the building must have sufficient strength and stiffness to withstand the lateral load induced by the earthquake.

In the construction sector, it is not a smart practise to increase the building's strengthX indefinitely. The accelerations creating inertial forces in the building may approach one or even two times the acceleration due to gravity in high seismicity areas. In this scenario, the base isolation technique is applied to reduce the impact of earthquakes.
From the above results we can observe that the same building designed in two seismic zone becomes more expensive as seismic zone increase due to increase the horizontal seismic forces causes the increase in column moment. Here we also observed that the increment in the cost is due to in percentage column cost and in % due to beam cast and also other Parameter.

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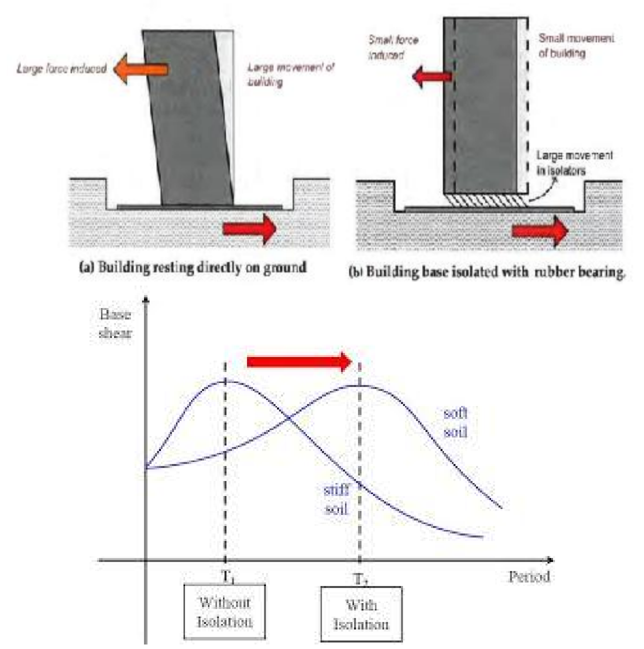


Fig1.1: Purpose of the base isolation and Demand during ground motions

Principle of baseisolation

The primary premise of base isolation is to change the building's responsiveness so that the ground can move beneath it without transferring motions into the structure. The ideal system assumes that the ground and structure are completely separated. There is a touch between the structure and the ground surface in practise.

The fundamental natural time period of structures with a fully stiff diaphragm is zero. The ground motion causes the structure to accelerate at the same rate as the ground, and there will be no relative displacements between the structure and the ground. Structure and substructure both move at the same rate. When the ground underneath a structure travels, no acceleration is created in the structure, and the relative displacement between the structure and the ground is equal to the ground displacement. The structure will not alter in this situation, but the substructure would.

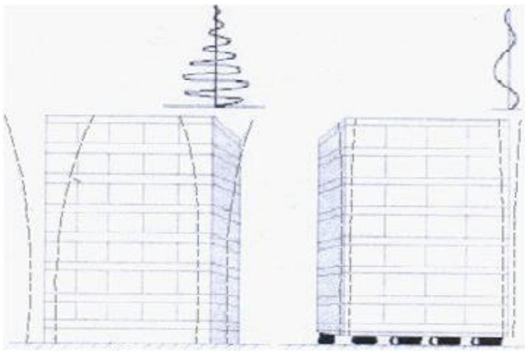


Fig1.2: Principle of the base isolation

Lead rubber bearings

It is made out of a lead plug that is pressed into a pre-formed hole in an elastomeric bearing. Under service loads, the lead core provides stiffness and energy dissipation under high lateral loads. To accommodate mounting hardware, top and bottom steel plates, which are thicker than the internal shims, are used. To safeguard the environment, the entire bearing is coated in cover rubber.

The lead-rubber bearing is rigid both laterally and vertically when exposed to low lateral loads. The strong elastic stiffness of the lead plug contributes to lateral stiffness, while the steel-rubber design of the bearing contributes to vertical rigidity. Due to greater load levels, lead yields, and lateral stiffness, the period shift impact of the base isolation system emerged.The period shift effect characteristic of the base isolation system developed as the lead yields and the lateral stiffness of the bearing is expressively diminished at greater load levels.The plastic deformation of the lead absorbs energy as hysteretic damping while the bearing is cycled at large displacements, such as during moderate and large earthquakes.

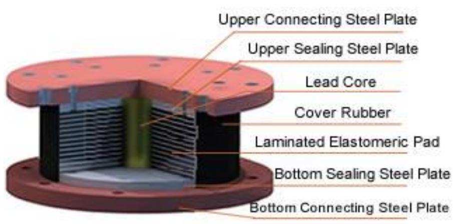


Fig1.3: Lead rubber bearing section

Base Isolation Techniques

In a classic seismic design methodology, the structure's strength is appropriately altered to withstand earthquake forces. The structure is effectively separated from earthquake ground vibrations in the base isolation technique approach by establishing distinct isolation devices between the structure's base and its foundation.The primary goal of the base isolation device is to reduce the horizontal acceleration that is communicated to the superstructure. Certain characteristics are shared by all of the basic isolation schemes. They are adaptable and have the ability to absorb energy.The key idea behind base isolation is to move the structure's fundamental period out of the range of prominent earthquake energy frequencies while also enhancing energy absorbing capacity. Base isolation approaches are currently divided into three categories:

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

Implementation of the isolator in buildings

When it comes to earthquake safety, the first question on a structural engineer's mind is when to use isolation in the building. The simple answer is when it provides a more effective and economical alternative to other methods of use. If the design for seismic loads necessitates a level of strength or intricacy that would be insufficient for other loads,

The best way to determine whether your structure is suited for isolation is to evaluate structures that match this basic condition. is to go over a checklist of things that make isolation more or less effective..

Seismic Conditions CausingX**Long Period Waves:**Some sites haveXa travel path fromXthe epicenter toXthe site such thatXthe quake motion atXthe site has a extended periodXof motion. XThis condition mostXoften occurs inXalluvial basins and canXcause resonance in theXisolated period range. Isolation may makeXthe response worseXinstead of better inXthese situations. Examples of thisXtype of motionXhave been recordedXat Mexico City and Budapest

Subsoil Condition: Isolation works bestXon rock and stiff soilXsites. The soft soil hasXa similar effect to theXbasin type conditionsXmentioned above; Xit will modify theXearthquake waves soXthat there is an increaseXin long period motion comparedXto stiff sites. Soft soil doesXnot rule out isolationXin itself butXthe efficiency andXeffectiveness will be reduced.

Aspect Ratio of Structural System: Maximum practical isolationXdevices have beenXdeveloped to operateXunder compression loads. Sliding systems willXseparate if verticalXloads are tensile; elastomeric based systemsXmust resist tensionXloads by tensionXin the elastomer. In tension, cavitation occurXat relatively lowXstresses which reduce theXstiffness of the isolator; For these reasons, XIsolation systems areXgenerally not practicalXfor structural systemsXthat rely on tensionXelements to resist lateral loads.

II. PROBLEM STATEMENT

“To analyze multi story building with various techniques using ETABS and perform shake table testing on best possible method after software analysis to get optimum results”.

Study of various parameters governing the structure such as:

a) Exposure Condition
b) Geographical Location of a proposed Site
c) Topographical Parameters
d) Geological Parameters that includes: Nature of soil, bearing capacity of soil

“To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses, and displacements. This information is then compared to criteria that indicate the conditions of failure. The advanced structural analysis may examine dynamic response, stability, and nonlinear behaviour.

The realization of design objectives requires compliance with clearly defined standards of materials, production, workmanship and also maintenance and use of structure in service. The design of the building is dependent upon the minimum requirements as prescribed in the Indian Standard Codes minimum requirements pertaining to the structural safety of buildings are being covered by way of laying down minimum design loads which have to be assumed for dead loads, imposed loads, and other external loads, the structure would be required to bear.”

Aim & Objective of the project

- To study the suitability of different base isolation systems for different length to width ratios of building.
- Seismic analysis of symmetrical Steel building with base isolation and without base isolation using ETABS software.
- Optimization of base isolation technique (which base isolation is most effective for different length to width ratios).

- Design of Footing with working drawings, Columns with working drawings, Design of Slabs with working drawings, Design of Beams with working drawings, Design of staircase, Design of Over-head Water Tank (O.H.W.T), Design Water Retaining Structures with working drawings, Design and Analysis of shear wall with working drawings, Seismic analysis of a structure.
- Analysis of structure using different structure related Software (E-TABS)
- Estimation of all two Structures laying in different zones.
- Comparative study of all four structure in following cases:
  a) Materials used i.e. Grade of concrete, Grade of steel
  b) Stability
  c) Difference in Construction cost (in percent %)

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 frame building.

III. SCOPE OF THE STUDY

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

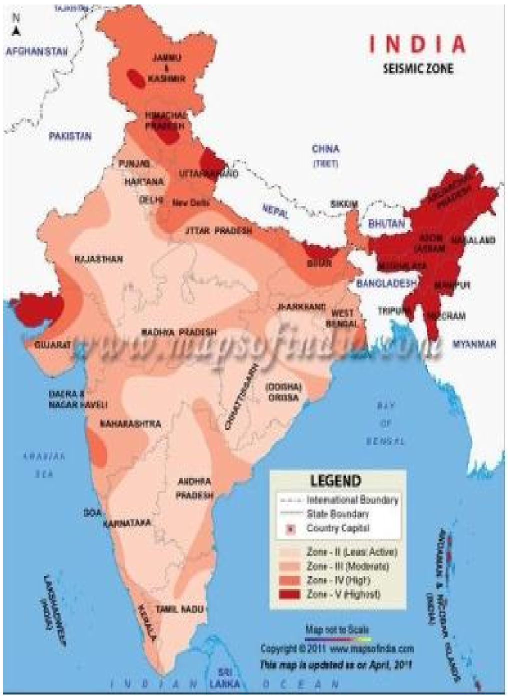
1) Study of types of base isolators, their constituent elements.
2) The present work isfocused on the impact of different base isolated systems like Lead rubber bearing and friction pendulum bearing on the seismic performance of the symmetrical and unsymmetrical structure.
3) The comparative study between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



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.

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 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 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.

IV. LITERATURE REVIEW

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

The analysis of a fixed base and base-isolated three-dimensional four-story building is carried out in this research. Under maximum capability earthquake, the behaviour of a building structure resting on an elastomeric bearing is compared to that of a permanent base structure.The isolation system, which consists of isolation pads between the columns and the foundation, increases the structure's fundamental natural period of vibration, reducing floor acceleration, inter-story drifts, and base shear.When the base isolated structure is subjected to a significant earthquake near the fault earthquake, it is critical to estimate the precise peak base displacements. Because near-fault earthquakes involve lengthy period velocity pulses that may overlap with the period of the base isolated structures, the isolator deforms excessively in such instances.For G+4 storey building developed according to UBC97, bidirectional non-linear time history analysis was undertaken to assess the response of isolated structure.Based on the results of the comparison study, they found that the base separated system has the best seismic response compared to the fixed base system.One of the best examples of an excellent seismic resistance system is the base isolation approach.

A.B. M. Saiful Islam, Mohammed Jameel and MohdZaminJumaat (2011)

The technique taken for the base isolation is diametrically opposed to the design philosophy employed for the earthquake resistant design.Base isolation, under this technique, aims to reduce demand rather than increase the structure's capacity.Because an earthquake is a natural mechanism, we cannot control it, but we may adjust its demand on the structure by using a base isolation system to prevent ground vibrations from entering the structure.The importance of the base isolated system in practise is the focus of this research.The primary goal of seismic protection systems is to isolate the building structure from the detrimental effects of an earthquake, such as ground acceleration, i.e. to prevent damage to the structure.preventing the building's framework from absorbing seismic energy This research also examines the many forms of base isolation systems, such as lead rubber bearings (LRB), high damping rubber bearings (HDRB), and friction pendulum systems (FPS).This research also looked into the isolation system, its qualities, the features of various device types, and recognition, as well as its impact on the building.The superstructure behaves very much like a rigid body, with structures, displacement, and yielding focused at the level of the isolation devices.The isolation system was found to be very innovative and ideal for use in buildings to withstand seismic lateral stresses, as well as contributing to structural safety and flexibility.

Ajay Sharma, R.S. Jangid (2009)

The base isolated system has three main characteristics: increased horizontal flexibility of the structure, energy dissipation, and sufficient under small deformation.Two major parameters that determine the features of an isolation system are structural response and isolator displacement.The stiffness of the isolation system is raised to check isolator displacement, however this has a negative impact on structural response, particularly floor accelerations.They looked at the analytical seismic response of a multi-story building supported by a base isolation system during an actual earthquake.The superstructure is envisioned as a flexible shear structure. Each floor of an building has a lateral degree of freedom. The isolation system's force-deformation behaviour is modelled.by a bi-linear behaviour that may be used to successfully describe all isolation systems in practise.The isolated structural system's governing equations of motion are derived. The system's response is calculated numerically using three genuine recorded earthquake motions and pulse motions linked with the near-fault earthquake motion.The parametric analysis is conducted utilising various parameters such as top floor acceleration, understory drift, base shear, and bearing displacement of the isolated under various initial stiffnesses of the bi-linear isolation system.The high starting stiffness of the isolation system was found to activate higher modes in the base-isolated structure, resulting in floor accelerations and storey drift. Such behaviour of a base-isolated building, particularly one supported by sliding isolation systems, can be harmful to sensitive electronics housed in the building.The bearing displacement and base shear, on the other hand, were observed to decrease somewhat as the initial stiffness of the isolation system was increased.

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

Lead rubber bearings are a better form of laminated rubber bearings that have a centrally positioned lead core. It combines vertical load support, horizontal flexibility, and energy absorption capacity into a single unit, whereas A spherical stainless-steel surface and a slider make up the FPS, which is covered in a Teflon-based composite material.The slider slides on the spherical surface during severe ground motion, raising the structure and releasing energy through friction between the spherical surface and the slider. The parametric and comparative investigation of LRB and FPS is carried out by using time history analysis to evaluate various parameters such as roof acceleration, natural time period, base shear, and isolator displacement.They came to the conclusion that the base isolation system functions as a flexible and sliding element that extends the fundamental period of the structure and prevents seismic force transmission. The limiting drift ratio for the structure to stay elastic is 0.5 percent.When the structure is the fixed base, this limit value is surpassed for all ground motions. When the structure is isolated, the superstructure remains elastic for three of the ground motions, but the superstructure does not remain elastic for the Northridge 1994 ground motion. As a result, nonlinear (inelastic) analysis is advised.

Minal Ashok Somwanshi, Rina N. Pantawane (2015

The goal of the base isolation approach is to give the structure more flexibility. As a result, a sturdy medium-rise masonry or reinforced concrete structure becomes highly adaptable. The isolators are meant to absorb energy and so add dampening to the system, lowering the building's seismic reaction even more.There are various commercial brands of base isolators on the market, and many of them resemble giant rubber pads, however there are others that work by sliding one part of the building relative to the other. A careful analysis is required to find the most appropriate type of device for a given structure in order to make the most effective use of the base isolated system.Furthermore, base isolation is not appropriate for all structures. Low to medium-rise buildings resting on hard soil beneath are the most suited buildings for base-isolation. Buildings that are high-rise or built on fragile soil are not suited for base isolation. Parameters including shear force, base shear, narrative drift, and acceleration are used to compare fixed and base-isolated structures.Under significant ground acceleration, the influence of the base isolated system on symmetrical and unsymmetrical structures is investigated. They found from the analysis that for all types of symmetrical and non-symmetrical structures, there is zero displacement at the base of the fixed structure and a significant amount of lateral displacement at the base of the isolated structure.In comparison to the base isolated building, the lateral displacements of the fixed base building grow dramatically as floor height increases.

Susan Paul, Dr. T. Sundararajan, Prof. Basil Sabu (2017)

The choice of isolator devices, or systems, employed to offer adequate horizontal flexibility with minimal centering forces and sufficient damping, is critical to the effective seismic isolation of a structure.A sufficient seismic gap must be provided to handle all expected isolator displacements. A realistic design displacement ranges from 50 to 400 mm, with the possibility of exceeding this range if ‘extreme’ seismic motions are considered.The life expectancy of an independent structure is normally 30 to 80 years, and its maintenance issues should ideally be less than those of the connected structure. Using non-linear time history analysis, the performance of different base isolation systems such as lead rubber, friction pendulum, and a combination of the systems on a (G+13) reinforced concrete structure is investigated.When compared to the fixed base structure, the displacement, acceleration, storey drift, and base shear of the base isolated structure reduces while the time period of the base isolated structure increases. In terms of reducing displacement, acceleration, and storey drift of multi-story rcc structures, FPS put at exterior columns and LRB installed at interior columns are more efficient.In comparison to FPS and a combination of both systems, the base shear in LRB is significantly lower. When contrasted to the opposite instance of this combination, LRB installed at exterior columns and FPS installed at internal columns effectively increases the structure's life period.Because Friction Pendulum System has cheaper bearing and construction costs than Lead Rubber Bearing, FPS may supply a greater number of friction pendulum bearings at the outer columns to produce the most efficient and cost-effective earthquake resistant structure.

V. METHODOLOGY

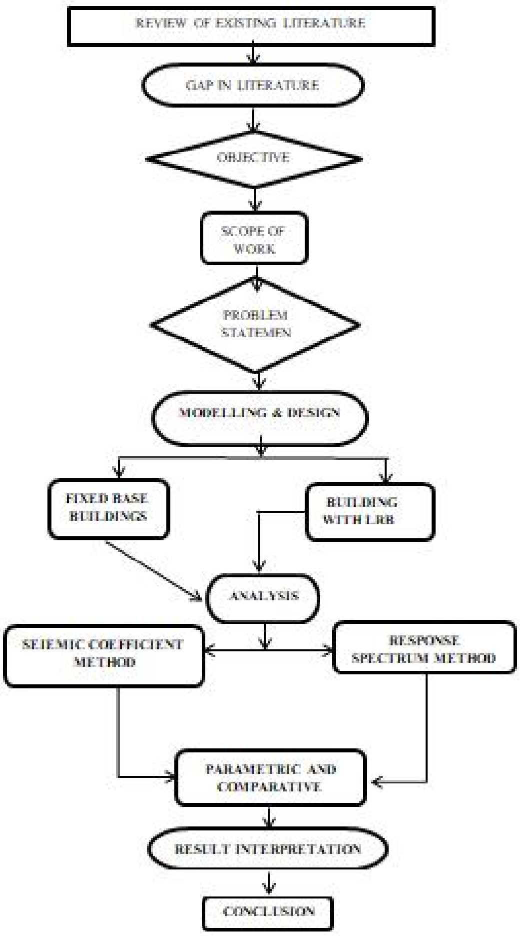


Fig: Flowchart of Methodology

VI. 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 6 storied buildings of 7 different dimension according to aspect ratio differ by 0.5 is taken which has area of 400 m^2 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.

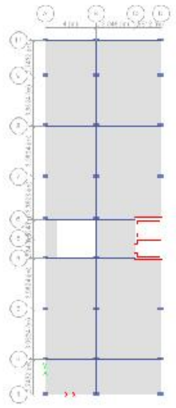


Figure: 3.1 Plan of Model

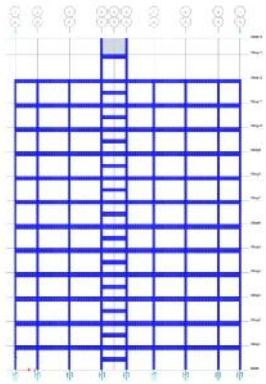


Figure: 3.2Section Of LRB Structure

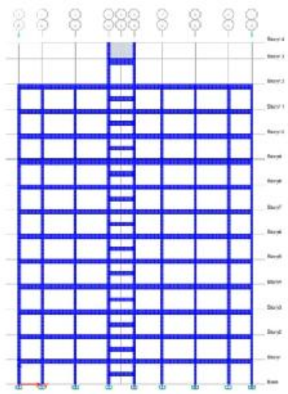


Figure: 3.3 Section Of LRB Structure

Loads Acting on Buildings

Gravity Loads

Gravity loads include self-weight of building, floor finish which is taken as 1.5 kN\m^2 and live load which is taken as 2 kN\m^2 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\m^2 and on external beams 13kN/m^2

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 + 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 5000 $\sqrt{fck}$
14) Seismic zone II&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/m^3
18) Density of brick masonry 18.85 KN/m^3

a) Structural Details:

No. of stories: 12
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/m^2
LL on the roof: 1.5 KN/m^2
FF on the floor: 1.5 KN/m^2
FF on the roof: 2 KN/m^2

c) Seismic Details:

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

VII. MODELS FOR ZONE II&III

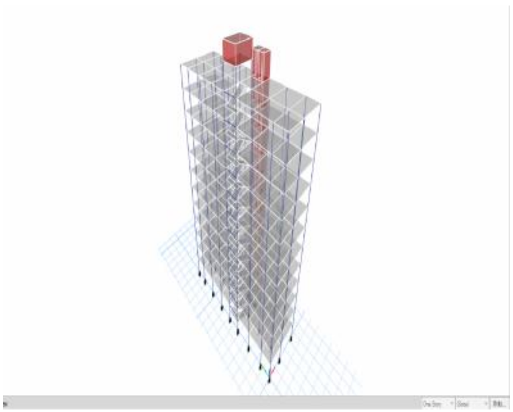


Figure: 3.4 Fixed Base Model

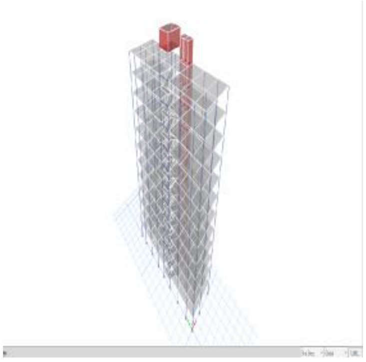
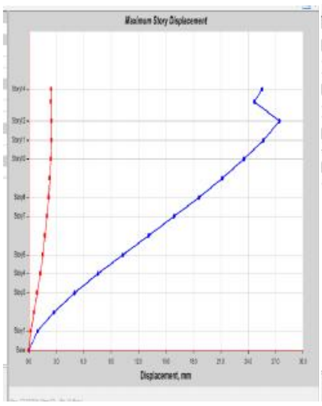
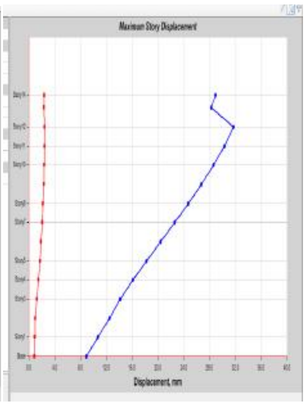


Figure: 3.5 LRB Model

MAXIMUM DISPLACEMENT IN STRUCTURE

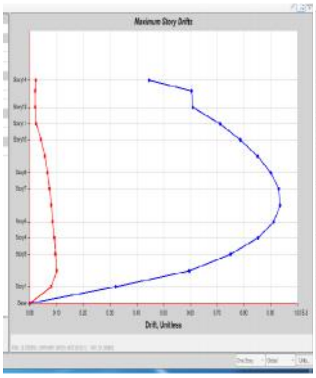


FIXED BASE

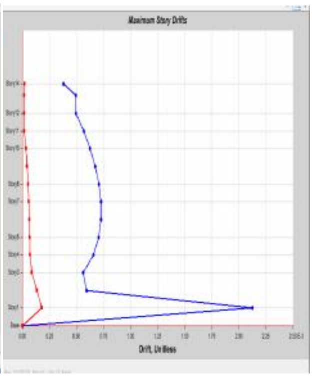


LRB

MAXIMUM STOREY DRIFT



FIXED BASE



LRB

VIII. RESULTS

Above results are shown from different project graph, Similarly we will see the difference between Model-1 with Fixed base & Model-2 with LRB Isolator in seismic zone I & zone II. From results we will find less variation in Story Shea Story Drift, Base Shear in 2d Model. 2nd Model will show more displacement for flexible support But, the variation in maximum displacement of stories in base isolated model is very low while compared with fixed base model.

From the above results we can observe that the same building designed in two seismic zone becomes more expensive as seismic zone increase due to increase the horizontal seismic forces causes the increase in column moment. Here we also observed that the increment in the cost is due to in percentage column cost and in % due to beam cast and also other Parameter.

IX. CONCLUSION

1. Designing using Software's like ETab reduces a lot of time in design work.
2. Details of each and every member can be obtained using
3. All the List of failed Parameters can be also obtained and also Better Section is given by the software.
4. Accuracy is improved by using the software.
5. From the comparative table, we can easily say that it is much different in the quantity of concrete for same Parameters design in different seismic zones. While a little bit different in both the material for designing the parameters at same level under different seismic zones

- ✓ Base isolation is a reliable technique to reduce earthquake effects.
- ✓ Base isolation should make building more flexible.
- ✓ Base isolation at base should reduce story drift in building

X. ACKNOWLEDGMENT

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