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# Comparative Study on Fixed Base And Base Isolation Having Regular And Irregular RC Frames (G+5 & G+20) By Using Etabs

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**Abstract —** Buildings are actually designed as per rules and regulations which are prescribed in building codes. All specific requirements of code and assuming a linear elastic behaviour for the structural members. It is also required to know the actual behaviour of the building that were designed for earthquake forces during the Seismic excitation. The present study demonstrates the effect of lead rubber bearing base isolator for symmetric and asymmetric low and high rise structures. the Comparative investigation of different parameters of low and high rise structures like storey displacements, storey drifts, storey shear, storey overturning movement and model period and frequencies.The buildings which are studies in this thesis are 5 and 20 stories RC frames which are design for gravity and earthquake loads using linear Dynamic analysis procedure i.e. time history analysis method and using FEM tool i.e. ETABS 2016 structural analysis software. Base isolation Technic is a most effective technology in earthquake resistant design. The four models of RC frames are analysed and modelling is done in ETABS, from the time history analysis results. Base isolation technic is reduces Ductility demands on the buildings, and minimize the deformations of the buildings. The Base isolation system increase the flexibility at the base of the building and which helps in Energy Dissipation due to the horizontal seismic forces. Storey drift and storey shear also reduces in the base isolated buildings. From the time history Analysis Acceleration, velocity, displacement are low for base isolated structures. It make the structure rigid and stiffer.

**Index Terms:** fixed base, base isolation, lead rubber bearing and time history analysis

## 1. Introduction

A seismic tremor is unexpected tremor or development of the World's outside layer, which begins normally at or beneath the surface. The word characteristic is essential here, since it prohibits stun waves caused by atomic tests, man-made blasts, and so outside. The whole world is comprised of plates. The intersection between the two plates is called as the blame. This blame in the Indian Setting is the principle limit blame stretching out through the landscape locale the distance from west along Himachal Pradesh through Uttaranchal, Bihar, Assam to Burma. That plate descends through Andaman-Nicobar Islands and Inlet of Bengal and into Indonesia. As the plate moves, the stones are subjected to pressure, all of a sudden a break creates and this crack is called as a quake.

In this way, it is the prime duty of a basic (outline) designer to draw out the parameters from past encounters and consider all the conceivable dangers that the structure might be subjected to, later on, with the end goal of safe plan of the structure. With the goal of change in the execution of structures subjected to seismic tremors auxiliary specialists have created techniques through the Limited component PC innovation/programming which effectively demonstrate, break down and show the outcomes in a fastidious way. Research in the Structural Building is come to considerably more extensive skylines than what one could have ever envisioned. The advancement in the software engineering and innovation was acknowledged by the Basic specialists as it spared a ton of human time and exertion. Construction regulations require that structures be intended to withstand a specific power of ground increasing speed, with the force of the ground movement relying upon the seismic peril. In glare of the high powers bestowed to the structure by the quake, the structures are generally intended to make them yield. The objective of tremor designing is to limit death toll because of the crumple of the yielding structure. Prior the aim of the auxiliary originators was to outline a structure that can oppose the tremor incited powers, which brought about weak structure having basic segments with overwhelming areas and consequently surprising expense of development. An essential advancement in the planning methods came as point of confinement states. The presentation of the breaking point state systems prompted the improvement of execution based plan of the structures, which gave slim individuals and economy in development expenses and decrease time required for the development with better execution level. The utilization of malleability, for dissemination of the vitality discharged by the seismic tremors to the structure, gave the fashioners adequate space for

judging the execution of the structures and checking the same while planning. The plan of the structures in view of the execution under the stacking may well be anticipated by displaying the structure numerically. This can be proficiently done by any of the product accessible in the market, for basic displaying, examination and outline. The expectation of the execution of a structure, intended for a predetermined example of loadings and level of wellbeing holds great significance for the honing auxiliary/plan engineers.

In the most open case, seismic plan can be seen as a two stage process. The in the first place, and generally most critical one, is the origination of a compelling auxiliary framework that should be arranged with due respect to exceedingly essential seismic execution targets, running

from workableness contemplations to life security and crumple counteractive action. This progression includes the specialty of seismic building, since no unbending principles can, or should, be forced on the designer's imagination to devise a framework that satisfies seismic execution targets, as well as pays tribute to utilitarian and financial limitations forced by the proprietor, the modeler, and different experts engaged with the outline and development of a building. As expected thing, this procedure of creation depends on judgment, experience, and comprehension of seismic conduct, as opposed to thorough numerical details. Dependable guidelines for quality and solidness targets, in glare of the basic information of ground movement and versatile and inelastic powerful reaction attributes, should get job done to arrange and harsh size a viable auxiliary framework. There are numerous accessible procedures for the examination of the structures and to analyse their execution under the given stacking, the most precise among them being the Non-Direct Time History investigation. For the structures with less significance or seismic peril, some other regular strategies have been created called as Non-Direct Static techniques (NSPs) and straight unique techniques most ordinarily known as reaction range strategies. The outcomes got from these systems could possibly be exact.

Seismic tremors are the most unexpected and demolishing of each and every cataclysmic occasion, which are incredibly difficult to save over outlining properties and life, against it. From now on keeping in mind the conclusion goal to overthrow these issues we have to distinguish the seismic execution of the manufactured condition through the improvement of different expository systems, which guarantee the structures to withstand amid visit minor quakes and create enough alert at whatever point subjected to significant tremor occasions. So that can spare however many lives as could reasonably be expected. There are a few rules everywhere throughout the world which has been over and over refreshing on this theme. The examination strategy measuring the quake powers and its request contingent upon the significance and cost, the technique for investigating the structure shifts from straight to nonlinear. Yet, these days need and request of the most recent age and emerging population has made the modeller or architects unavoidable towards arranging of sporadic designs. Thus tremor designing has comes into a critical branch of structural building

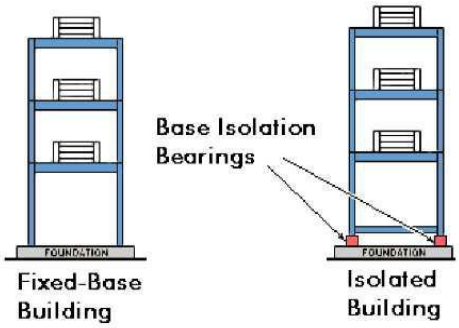
**1.1 Fixed Base & Base Isolated Buildings**

a) What Is Fixed Base Buildings?

Which Buildings are resting directly on the ground those type of buildings are called fixed base buildings

b) What is Base Isolated Buildings?

Which Buildings superstructure and foundation are separated by connecting isolation devices those type of buildings are called base isolated buildings.Base isolation is the most popular technology in earthquake resistant design of structures




**1.2 Types of Isolation Bearings**

**a) Elastomeric Bearings**

1. Low-Damping Natural or Synthetic Rubber Bearing
2. High-Damping Natural Rubber Bearing
3. Lead-Rubber Bearing (Low damping natural rubber with lead core)

**b) Sliding Bearings**

1. Flat Sliding Bearing
2. Spherical Sliding Bearing

**1.3 Lead-Rubber Bearings**

Lead rubber bearings consist of a series of alternating rubber and steel layers. In addition, rubber cover is provided on the top, bottom, and sides of the bearing to protect the steel plates

**Major Components:**

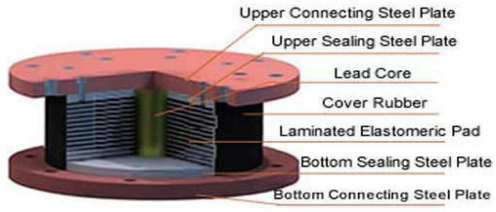
**1. Rubber Layers:**

Rubber layers are Provide lateral flexibility to the bearings

**2. Steel Shims:**

Steel shims are Provide vertical stiffness to the bearings **3. Lead Plug:**

Lead plug is Provides source of energy dissipation and provide high initial stiffness to bearings (provides wind loading restraint)




**1.4 PARAMETRIC DESIGNOF BASE ISOLATORS (i.e. LEAD RUBBER BEARINGS)**

1. The maximum vertical reaction(R) of the building is taken from The ETABS.
2. The model period (t) taken from ETABS and we have to calculate fundamental time period (Tb) of the structure i.e. 3times of model period.
3. Now we have to calculate effective stiffness ( ), from the vertical reaction(R) and fundamental time period (Tb). =
4. Than we have to calculate design displacement ( Sd or DD), from the spectral acceleration (Sa) valuewhich is taken from ETABS
5. Now we have to calculate The energy dissipation per cycle (◀) can be approximately calculated by assuming for a very small post yield stiffness as◀=2↕┌Where we have to take ¶ value is 10%=0.10And we have to calculate short term yield force ⊥is ⊥
6. And we have to calculate post yield horizontal stiffness Kd┌ = ┌ ─
7. And we have to calculate yield displacement strength → from the following equation⊥ →= 9┌ And we have to calculate The yield force Fy is given by = ┌-→.
8. Now we have to Define base isolation device that is lead rubber bearing in ETABS from the above values i.e. effective stiffness (┌), post yield horizontal stiffness Kd and yield displacement strength →

**1.5 Importance of Base Isolation**

When ground shakes by an earthquake-the fixed base building will shake violently and building swings left and right than building will be collapsed. Base isolated building will shake less and building remain steady state. The building resting on LRB When ground shakes by an earthquake. Thus Forces can be reduced by LRB. In isolated building Small movements are occurred in Superstructure and large movement occurred within isolators only

**1.6 Scope of the Study**

The present study demonstrates the effect of lead rubber bearing for symmetric and asymmetric low and high rise structures. The buildings which are studies in this Thesis are 5 and 20 stories RC frames which are design for gravity and earthquake loads. The structures are surveyed utilizing nonlinear dynamic analysis and seismic code IS-1893:2002 and using ETABS 2016

**1.7 Objectives of the Study**

**The present work aims at the following objectives:**

To evaluate the response of low-rise and high-rise symmetrical and asymmetrical buildings under non-linear dynamic analysis. To evaluate the response of base isolated Buildings compared to fixed base Buildings. Comparative investigation of different parameters of low and high rise structures like storey drifts, storey shear, storey overturning

movement, time period and maximum story displacement

**1.8 Application of Base Isolation**

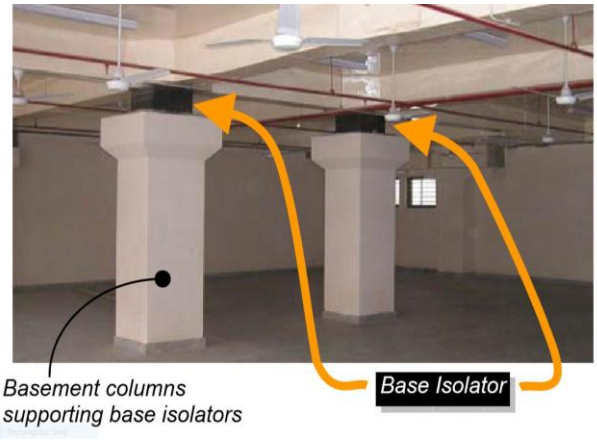
It was firstly implemented in New-Zealand in 1974. Base isolation system used in numerous buildings in countries like Italy, Japan, New Zealand, and USA. LA city hall is the tallest base isolated building in the world it is in Los Angeles and its height is138m.

Figure: Los Angeles city hall constructed by using Base Isolators (138m height)

**1.9 Application of Base Isolation in India**

In India, base isolation technique was first implemented after the 1993 Killari (Maharashtra) Earthquake, i.e. two single storey buildings (one school building and another shopping complex building). After the 2001 Bhuj (Gujarat) earthquake, the four- Storey Bhuj Hospital building was built with base isolation technique. Where 280 LRB are used, now it can withstand magnitude 10 on rector scale. India is a prone to earthquakes, especially in the Gujarath region. Most of the new buildings coming up in Gujarath have an earthquake resisting design i.e. base isolated buildings. But such buildings are very common anywhere else in our country due to the fact that most of our country are free from major earthquakes. In India various seismic zones have been identified and Hyderabad falls in zone 2, and Hyderabad metro project is made an earthquake resistant. If you observe in metro project, you can see Sliding Bearings i.e. Flat Sliding Bearings, Which Are Isolation Devises. This flat sliding bearings are used in metro project for connecting pier and precast segment i.e. hallow black, to energy dissipation and to resist tremor effect

Figure: Newly constructed Bhuj Hospital in Gujarath




**1.10 Examples of Computer Software for Analysis of Base-Isolated Structures**

- ETABS
- SAP2000
- DRAIN-2D
- 3D-BASIS

**1.11 Design Parameters for Base Isolation Systems**

there is no Indian code for base isolated structures

2000 NEHRP (United States) & 2000 IBC are some of the codes, which provides general guidelines for design of base isolation systems.

**A. General Philosophy of Building Code Provisions**

No specific isolation systems are

described All isolation systems must:

- Remain stable at the required displacement
- Provide increasing resistance with increasi ng displacement
- Have non-degrading properties under repeate d cyclic loading
- Have quantifiable engineering parameters

**B. Design Objectives of Building Code Provisions**

**Minor and Moderate Earthquakes**

- No damage to structural elements
- No damage to nonstructural components
- No damage to building contents

**Major Earthquakes**

- No failure of isolation system
- No significant damage to structural elements

No extensive damage to nonstructural components

- No major disruption to facility function
- Life-Safety

**II. Case study**

**2.1Building Description**

***Model 1:*** **G+5 Irregular RC Frame**

In the first model, a 5 storied reinforced concrete frame building situated in zone V, is taken for the purpose of study. The plan area of building is 36 x 36m with 3m as height of each typical storey. It consists of 6 bays in X-direction and 6 bays in Y-direction. The total heights of the buildings were 15m

**Figure: Model-1 Plan View 2.2**

**Structural Components of the Building**

The column, beam dimensions are detailed in the below tables:

Table 4.2 Structural dimensions of 5 storied building

**2.3 General Data Collections**

The buildings located in Zone V. Table 4.3 presents a summary of the building parameters. The details of the building are given below

| S.No. | Description | Information | Remarks |
|---|---|---|---|
| 1 | Plan size | 36mx36m | ------- |
| 2 | Building heights | 15m | ------- |
| 3 | Number of storey's above ground level | 5 | ------- |
| 4 | Number of basements below ground | 0 | ------- |
| 5 | Type of structure | RC frame | ------- |
| 6 | Open ground storey | Yes | ------- |
| 7 | Special hazards | None | ------- |
| 8 | Type of building | Regular frame with open ground storey | IS-1893:2002 Clause 7.1 |
| 9 | Horizontal floor system | Beams & Slabs | ------- |
| 10 | Software used | ETABS 2016 | ------- |

| S. No. | Specifications | Values |
|---|---|---|
| 1 | Slab Thickness | 150mm |
| 2 | Beam dimensions | 230x500mm |
| 3 | Column dimensions | 300x450mm |
| 4 | Grade of concrete | M30 |
| 5 | Grade of steel | Fe-415 |
| 6 | Unit weight of concrete | 25kN/$m^3$ |
| 7 | Live loads: (a) Floor load (b) Floor finishes | 3kN/$m^2$ 1.25kN/$m^2$ |
| 8 | Importance factor | 1.0 |
| 9 | Seismic zone factor | 0.36 |
| 10 | Response reduction factor | 5 |

**2.4Pre-Processing Steps In Etabs-2016**

Step 1: Defining the materials.
Step 2: Defining the section properties (beam, column & slab)
Step 3: Defining loads Load patterns, Load cases, Load combinations
Step 4: Assigning loads
Step 5: Defining Time history data
Step 6: Defining Base isolators and assign to base isolators

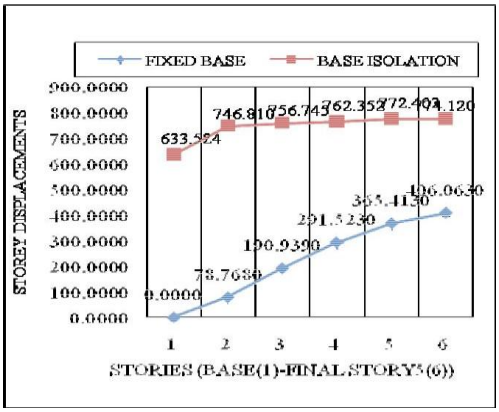
NOTE: Remaining Three Models Also Done By the Same Procedure.

## III. Results and Discussions

### 3.1 Comparison of Storey Displacements between Fixed Base and Base Isolation

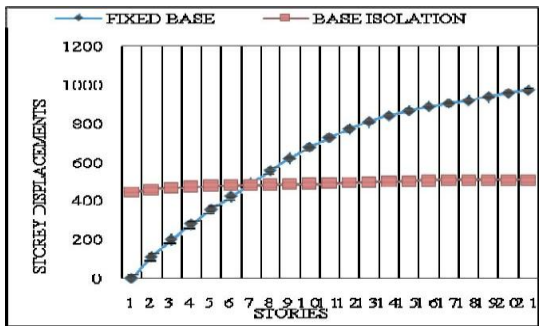
| | | | FIXED BASE | BASE ISOLATION |
|---|---|---|---|---|
| **Storey** | **Elevation** | **Location** | **X-Dir** | **X-Dir** |
| | m | | mm | mm |
| Base | 0 | Top | 0.0000 | 633.524 |
| Storey 1 | 3 | Top | 78.7680 | 746.810 |
| Storey 2 | 6 | Top | 190.9390 | 756.745 |
| Storey 3 | 9 | Top | 291.5230 | 762.352 |
| Storey 4 | 12 | Top | 365.4130 | 772.403 |
| Storey 5 | 15 | Top | 406.0630 | 774.120 |

**Storey Displacements graph:**




Discussion: From Graphwhich are time history analysis results it can be seen in fixed base building, storey Displacement Increases with increased height of the building.In base isolated building Displacements are occurred in the isolation devices only, the storey Displacement slightly Increases with increased height of the building. This effect we can see clearly in higher storey results i.e. G+20 Irregular RC Frame In bellow graph

**Storey Displacements graph of higher storey**




Graph: 5.1 (B) Model-3 Storey Displacements between Fixed Base &Base Isolation

**Discussion**: From this higher storey results we can see here in fixed base buildings Storey displacements increases with increasing height of the building but in Base isolated buildings increments are very less with increasing height of the building so base isolated building superstructure is remain in steady state

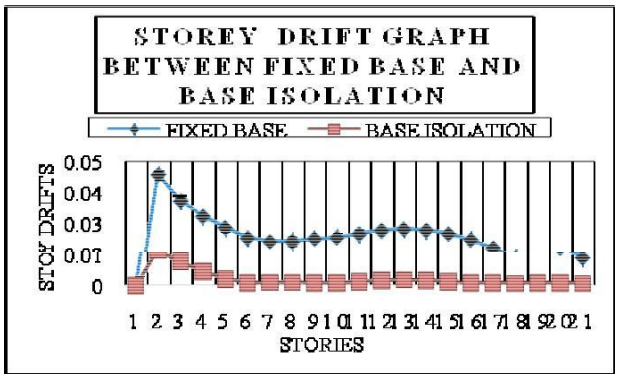
### 3.2 Comparison of Storey Drifts between Fixed Base and Base Isolation

| | | | Fixed Base | Base Isolation |
|---|---|---|---|---|
| **Story** | **Elevation** | **Location** | **X-Dir** | **X-Dir** |
| | m | | | |
| Base | 0 | Top | 0 | 0 |
| Storey 1 | 3 | Top | 0.026256 | 0.037948 |
| Storey 2 | 6 | Top | 0.037399 | 0.007774 |
| Storey 3 | 9 | Top | 0.033528 | 0.005985 |
| Storey 4 | 12 | Top | 0.025770 | 0.004075 |
| Storey 5 | 15 | Top | 0.014714 | 0.004032 |

**Discussion:** From the table and Graphwhich are time history analysis results it can be seen storey drifts in x-direction very less in base isolated building when compared to fixed base building in base isolated building storey drift in x-direction at top storey reduced by 72% when compared to fixed base building. This effect we can see clearly in higher storey results i.e. G+20 Irregular RC Frame We Can see In Bellow Graph

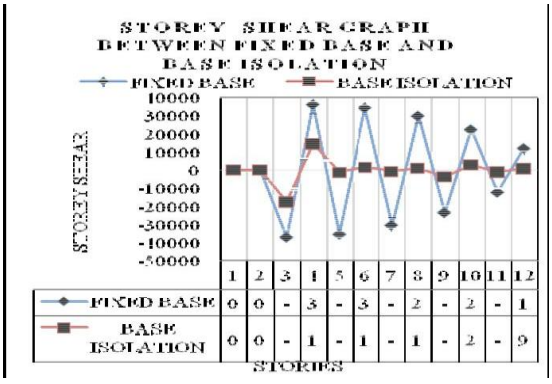
Graph: Model-3StoreyDrifts between Fixed Base &Base Isolation along X-Direction

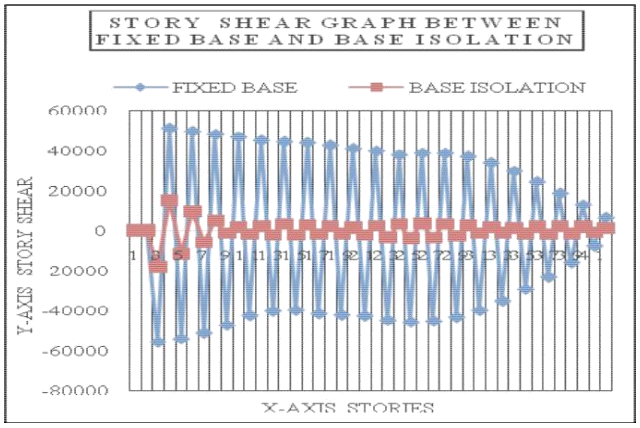
**Discussion:** From this higher storey results we can see here Storey drift is less in base isolated building as compared to fixed base. Storey drifts are reduced in higher stories which makes structure safe against earthquake




### 3.3 Comparison of Storey Shear between Fixed Base and Base Isolation

| | | | Fixed Base | Base Isolation |
|---|---|---|---|---|
| **Storey** | **Elevation** | **Location** | **X-Dir** | **X-Dir** |
| | m | | kN | kN |
| Base | 0 | Top | 0 | 0 |
| | | Bottom | 0 | 0 |
| Storey1 | 3 | Top | -37133.3 | -17660.7 |
| | | Bottom | 35950.5 | 14555 |
| Storey2 | 6 | Top | -35488 | -1313.62 |
| | | Bottom | 34180.9 | 1620.57 |
| Storey3 | 9 | Top | -30526.7 | -807.87 |
| | | Bottom | 29652.5 | 1013.34 |
| Storey4 | 12 | Top | -23558.6 | -3697.11 |
| | | Bottom | 22154.8 | 2925.15 |
| Storey5 | 15 | Top | -12354.9 | -1136.96 |
| | | Bottom | 11825.9 | 913.96 |



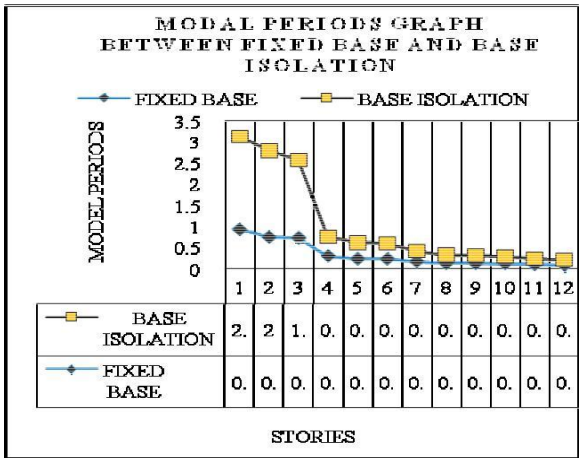




Graph: 5.1 (E) Model-3StoryShear between Fixed Base &Base Isolation along X-Direction

**Discussion:** From this results we can said that Storey shear is less in base isolated buildings as compared to fixed base Building

### 3.4 Comparison of Modal Periods and Frequencies between Fixed Base and Base Isolation

| | | FIXED BASE | | BASE ISOLATION | |
|---|---|---|---|---|---|
| **Case** | **Mode** | **Period** | **Frequency** | **Period** | **Frequency** |
| | | Sec | cyc/sec | Sec | cyc/sec |
| Modal | 1 | 0.924 | 1.082 | 2.192 | 0.456 |
| Modal | 2 | 0.746 | 1.34 | 2.026 | 0.494 |
| Modal | 3 | 0.73 | 1.37 | 1.829 | 0.547 |
| Modal | 4 | 0.305 | 3.279 | 0.446 | 2.243 |
| Modal | 5 | 0.239 | 4.176 | 0.37 | 2.703 |
| Modal | 6 | 0.236 | 4.23 | 0.356 | 2.805 |
| Modal | 7 | 0.181 | 5.515 | 0.228 | 4.396 |
| Modal | 8 | 0.136 | 7.329 | 0.18 | 5.554 |
| Modal | 9 | 0.136 | 7.368 | 0.177 | 5.655 |
| Modal | 10 | 0.132 | 7.601 | 0.153 | 6.554 |
| Modal | 11 | 0.109 | 9.156 | 0.12 | 8.35 |
| Modal | 12 | 0.095 | 10.478 | 0.114 | 8.75 |




**Discussion**: From the above results which are time history analysis results it can be seen in fixed base building Modal Periods are decreases and Frequencies are increases. In base isolated building Modal Periods are increases and Frequencies are decreases. So mode periods are increased in base isolation which increases reaction time of structure during an earthqual **Conclusions:** From the above comparative study the different parameter results are shows that.

1. **Storey Displacements**: in fixed base building storey Displacements Increases with increased height of the building.In base isolated building Displacements are occurred in the isolation devices only.
2. **Storey Drifts:** storey drifts are very less in base isolated building when compared to fixed base building. In base isolated building storey drift at top storey reduced by 72% when compared to fixed base building. This effect we can see clearly in higher storey results graph.
3. **Storey Shear:** in base isolated building storey shear is reduced in each story when compared to fixed base building. This means after the use of Lead rubber bearing as base isolator then structure becomes flexible in horizontal direction than seismic force is dissipated. so the storey shear is reduced. This effect we can see clearly in higher storey results graph
4. **Modal Periods and Frequencies:** seen in fixed base building Modal Periods are decreases and Frequencies are increases. In base isolated building Modal Periods are increases and Frequencies are decreases. So mode periods are increased in base isolation which increases reaction time of structure during an earthquake.

From the above results it is concluded that.

Base isolation is good technology to protect structures like buildings, bridges, airport terminals and nuclear power plants etc. from tremor effect

From the above Results it is concluded that, base isolated structure are best in Earthquake prone areas.

The overall results suggested that base isolators are excellent seismic control devices for low and high rised symmetric and asymmetric Buildings.

**Scope for Further Study:**

As the various researchers are getting attracted towards the NLTHA, the scope of the studies under the particular topic can be stretched to wide horizons.

1. Soil structure interaction has always attracted many researchers as an interesting topic for static procedures.

Non-linear time history analysis could also be performed for base rotation loading to study the effect of rotational loading on the structure

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