Study of Base Isolated Building

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Abstract - *Base isolation also known as seismic isolation engineering. Is one of the most effective vibration control techniques in current earthquake engineering practice (Separating or decoupling structure from its foundation) Its main function is to mitigate the damage in structures exposed to strong ground motions, through both the increment of fundamental period of vibration and adequate addition of damping. This leads to diminish floor acceleration and drift ratios and also help structures in surviving potentially devasting seismic impact through a proper initial design or subsequent modifications. Currently this technology is applied in many earthquake prone zones in the world including leading countries like United State, Japan, Newzealand, etc.*

Problem statement:

The damage to built environment during recent earthquake has demonstrated the need for seismic risk assessment that is capable of predicting the consequences of earthquakes. The collapse of engineered and non engineered structures during earthquakes is chief contributor to loss of lives and injuries to people. In India itself there are 80 million buildings which are vulnerable and pose unprecedented risk, if earthquake strikes. The greatest challenge therefore, is to reduce considerable loss of human life and property. This can be done by constructing structures with base isolation techniques in order to make safer structures that keep many lives and property safe during earthquake. Hence, study of base isolation of building is important.

Methodology:

Under this project a low rise structure will be analyzed using ETABS software (design programs are developed especially for building systems)

1. without considering base isolation.

2. Considering base isolation.

3. Comparison of results in the above two cases. The project will also involve study of earthquake engineering and of base isolation technique which will help in enhancing knowledge in this particular field. This will help in designing structure for BI.

Introduction

A natural calamity like an earthquake has taken the toll of millions of lives through the ages in the unrecorded, and recorded human history. A disruptive disturbance that causes shaking of the surface of the earth due to underground movement along a fault plane or from volcanic activity is called earthquake. The nature of forces induced is reckless, and lasts only for a short duration of time. Yet, bewildered are the humans with its uncertainty in terms of its time of occurrence, and its nature. However, with the advances made in various areas of sciences through the centuries, some degree of predictability in terms of probabilistic measures has been achieved. Further, with these advances, forecasting the occurrence and intensity of earthquake for a particular region, say, has become reasonably adequate, however, this solves only one part of the problem to protect a structure - to know what's coming! The second part is the seismic design of structures - to withstand what's coming at it! Over the last century, this part of the problem has taken various forms, and improvements both in its design philosophy and methods have continuously been researched, proposed and implemented.

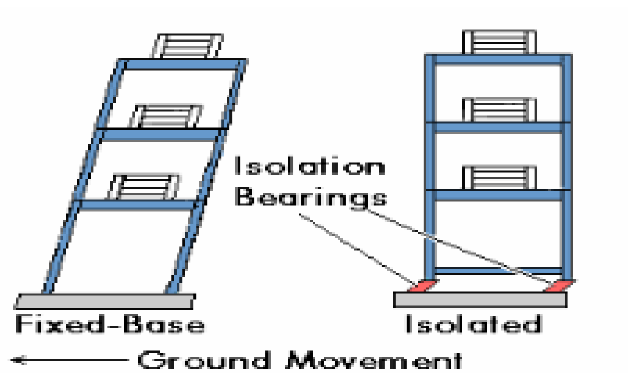
The earthquakes in the recent past have provided enough evidence of performance of different type of structures under different earthquake conditions and at different foundation conditions as a food for thought to the engineers and scientists. This has given birth to different type of techniques to save the structures from the earthquakes effects. Conventional seismic design attempts to make buildings that do not collapse under strong earthquake shaking, but may sustain damage to non-structural elements and to some structural members in the building. This may render the building non-functional after the earthquake, which may be problematic in some structures, like hospitals, which need to remain functional in the aftermath of the earthquake. Two basic technologies are used to protect buildings from damaging earthquake effects. These are Base Isolation Devices and Seismic Dampers. Base isolation is also known as 'seismic base isolation' or 'base isolation system'.

Seismic isolation separates the structure from the harmful motions of the ground by providing flexibility and energy dissipation capability through the insertion of the isolated device so called isolators between the foundation and the building structure.

Base isolation is a passive control system; meaning thereby that it does not require any external force or energy for its activation. It is necessary to understand why base isolation is needed to enhance performance levels of the structure subjected to seismic excitations. To design structure in such a way, that it may withstand the actual force by fixed base structure elastically, is not feasible in two senses. First, the construction cost of the structure will be highly uneconomical. Second, if the overall strength of the structure is increased by making it more rigid, then it will be at the expense of imparting actual ground forces to the structural contents, thus causing heavy non-structural damage. Apparently, as the name implies base isolation tries to decouple the structure from the damaging effects of ground motion in the event of an earthquake. Base isolation is not about complete isolation of the structure from the ground. Most of the base isolation systems that have been developed over the years provide only 'partial' isolation. 'Partial' in the sense that much of the force transmitted, and the consequent responsive motions are only reduced by providing flexibility and energy dissipation mechanisms with the addition of base isolation devices to the structure.

Base isolation, as a strategy to protect structure from earthquake, revolves around a few basic elements of understanding:

1. **Period-shifting of structure:** Base isolator is a more flexible device compared to the flexibility of the structure. Thus, coupling both an isolator and the superstructure together increases the flexibility of the total isolated structural syste m. In this way, this technique lengthens the structures natural time period away from the predominant frequency of the ground motions, thus evading disastrous responses caused due to resonance.
2. **Damping and cutting of load transmission path:** A damper or energy dissipater is used to absorb the energy of the force to reduce the relative deflection of the structure with respect to the ground.
3. **Minimum rigidity:** It provides minimum rigidity to low level service loads such as wind or minor earthquake loads.



Purpose of base isolation

A design philosophy focused on capacity leads to a choice of two evils:

1. Continue to increase the elastic strength. This is expensive and for buildings leads to higher floor accelerations. Mitigation of structural damage by further strengthening may cause more damage to the contents than would occur in a building with less strength.

2. Limit the elastic strength and detail for ductility. This approach accepts damage to structural components, which may not be repairable. Base isolation takes the opposite approach, it attempts to reduce the demand rather than increase the capacity. We cannot control the earthquake itself but we can modify the demand it makes on the structure by preventing the motions being transmitted from the foundation into the structure above.

There are six major types of base isolation devices which are widely adopted for seismic base isolation.

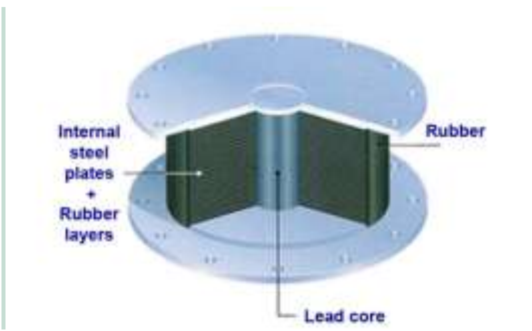
- Elastomeric Bearings.
- High Damping Bearings.
- Lead Rubber Bearings.
- Flat Slider Bearings.
- Curved Slider Bearings or Pendulum Bearings.
- Ball & Roller Bearings.

Elastomeric Base Isolation Systems

The developments in rubber technology made the base isolation a practical reality. In the implemented projects of base isolation worldwide, it is observed that elastomeric based systems are the most common. Typically, these systems consist of big rubber block, which can be natural or synthetic that are generally characterized by high vertical stiffness compared to the horizontal stiffness and damping capacity. The vertical stiffness is kept close to rigid, as the structural members are designed to take care of the vertical force component of the seismic excitation. Providing high vertical stiffness also prevents undesirable bouncing motion that is induced if vertical flexibility is provided. A

Laminated Rubber Bearing

The laminated rubber bearings (LRB) represent the most commonly used elastomeric isolation system. LRB isolators have cylindrical rubber bearings, which are reinforced with steel shims. Shims and rubber is placed as alternate layers. Steel plates are also provided at the two ends of the isolator. The steel shims boost the load carrying capacity, thus the structure is stiff under vertical loads and flexible under horizontal loads. The steel shims also help to confine the rubber from bulging out. The damping constant of the system varies considerably with the strain level of the bearing. The system operates by decoupling the structure from the horizontal components of the earthquake ground motion by interposing a layer of low horizontal stiffness between the structure, and its foundation. The isolation effects in this type of system are produced not by absorbing the earthquake energy, however by deflecting through the dynamics of the system.



PROBLEM STATEMENT

G+2, G+4, G+6, G+8 storied buildings are modeled using conventional beams, columns & slabs. These buildings were given square geometry with plan dimensions of 25m x 25m. They are loaded with Dead, Live and Seismic Forces (according to IS: 1893(Part-1)-2002). These models are then analyzed using response spectrum method for earthquake zone V of India (Zone Factor = 0.36). The details of the modeled building are listed below. Importance Factor (I) =1. The performance of the models is recorded through ETABS to present a brief idea about the role of base isolation in protecting the structure against earthquake hazards. The following assumptions were made before the start of the modeling procedure so as to maintain similar conditions for both the models:

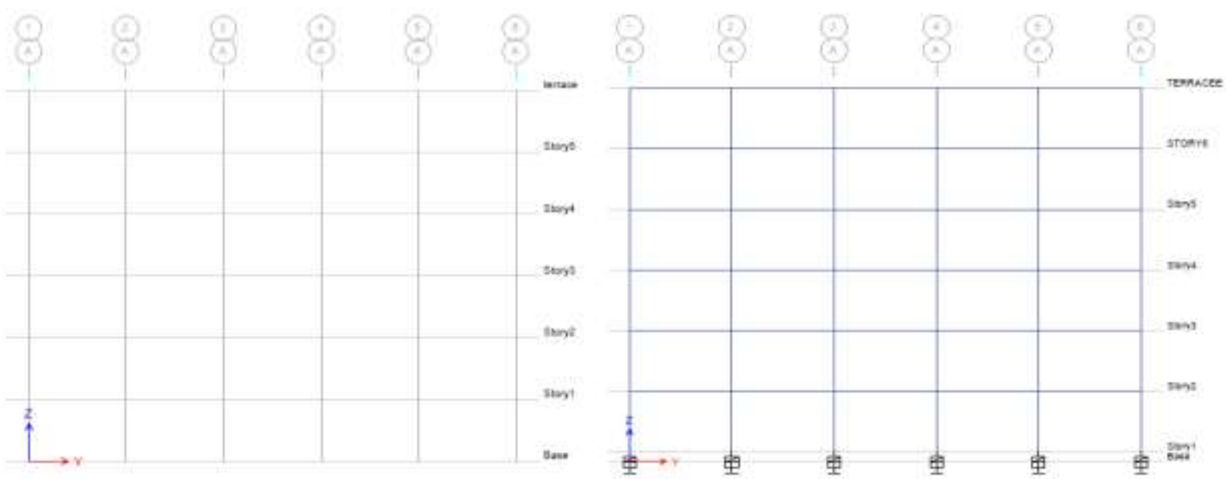
1. Only the main block of the building is considered. The staircases are not considered in the design procedure.

2. The building is to be used for residential purposes, so we mainly focus on the response of the frame configuration.

3. At ground floor, slabs are not provided and the floor is resting directly on the ground. 4. The beams are resting centrally on the columns so as to avoid the conditions of eccentricity. This is achieved automatically in ETABS.

5. For all structural elements, M20 & Fe 415 are used. 6. The footings are not designed. Supports are assigned in the form of either fixed supports (for fixed base building) or link supports (for base isolated building).

7. Seismic loads are considered in the horizontal direction only (X & Y) and the loads in vertical direction (Z) are assumed to be insignificant.



Modeling

Description of Models

- Model 1 = Fixed Base
- Model 2 = Base isolated (LRB)

Building details

- Structure = RCC (OMRF)
- Structure Type = Plan Regular Structure
- Plan Diameter = 25mx25m
- Height of each Storey = 3.3m
- In X-direction = 5 bay of 5m length
- In Y-direction = 5 bay of 5m length

Material Properties

- Grade of concrete = M20
- Grade of steel = Fe415
- Density of concrete = 25KN/m3

Section Properties

- Beam size =230mmx450mm
- No of storey of building-

1. 2 storey(column -300mmx300mm)
2. 4 storey(column- 350mmx350mm)
3. 6 storey(column-400mmx400mm)
4. 8 storey(column-400mmx400mm

- Slab Thickness = 150mm
- Wall Thickness = 230mm

Load Consideration

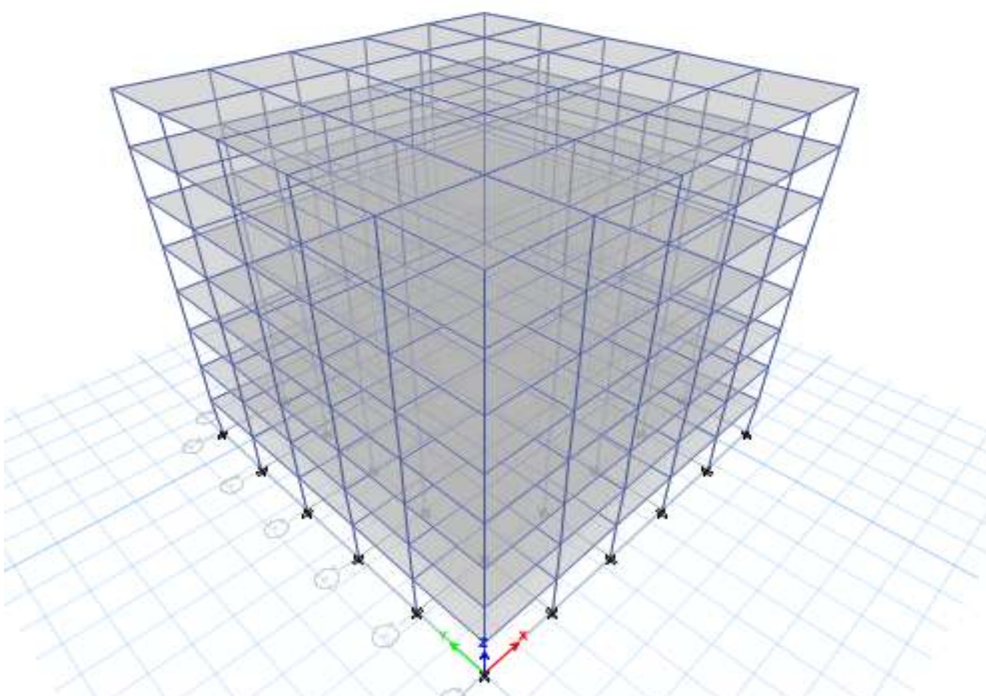
- Gravity Load: Dead load = Column, Beam, Slab
- Live load = 3KN/m2
- Floor Finish = 1KN/m2
- Lateral Load of Response Spectrum Analysis: Soil Profile type = Medium

- Seismic Zone Factor = Zone 5
- Response Reduction Factor = 5.0
- Importance Factor = 1.

Characteristics of Lead Rubber Bearing – Isolators are provided above every footing at 0.54m above base level. Properties of LRB are mentioned below:

- Vertical stiffness (linear) = 223705KN/m
- Horizontal stiffness (linear) = 26617.6KN/m
- Horizontal stiffness (Nonlinear) = 26617.6 KN/m

No. of storey	2	4	6	8
Max.displacement	16.619	22.459	29.399	37.762
Max. drift	0.001381	0.001173	0.001266	0.001561
Fundamental time period(s)	1.23	1.57	1.844	2.248
Base shear	217.0087	511.4633	737.9688	845.2436

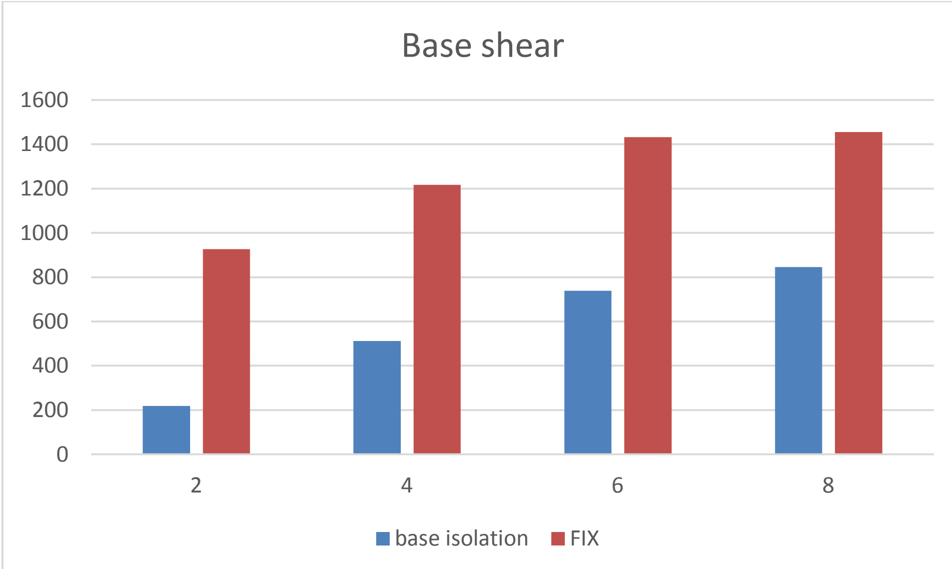


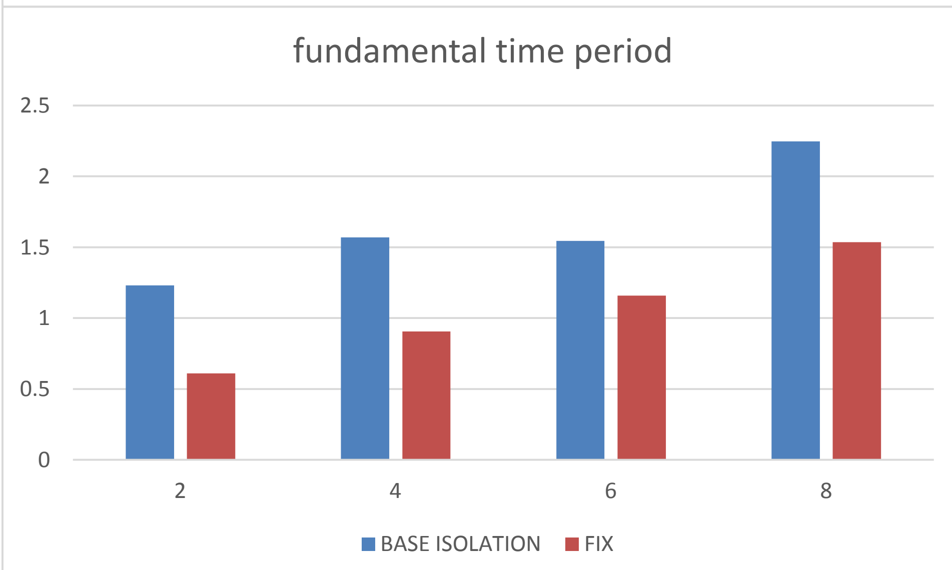
Results

Base isolated building

No. of storey	2	4	6	8
Max.displacement	10.22	18.042	24.49	33.221
Max. drift	0.001587	0.001685	0.001566	0.001586
Fundamental time period	0.611	0.906	1.158	1.535
Base shear	926.73	1216.87	1433.1671	1438.9288

Fixed base building





CONCLUSIONS

Fixed base model base isolated model by providing lead rubber bearing these eight models were analyzed by response spectrum analysis from these building models following conclusions can be made.

Earthquake forces on the shaking.

1. Increase of natural period. As result of the increased flexibility of the system, natural period of the structure increased distancing natural period of the system from the predominant periods of the expected earthquake actions.

2. Reduction of base-shear. Reduction of the base-shear force is evident in the model with implemented seismic isolation.

3. Increase of displacements. Increased flexibility of the system led to increase of the total displacements due to the elasticity of the existing isolation.

4. Reduction of interstorey drifts. Implementation of the isolation system resulted into the reduction of the interstorey drifts to negligible level, so it can be said that they practically do not exist. This reduction enables the structure to behave as almost ideally stiff. In this way the damage risk of the structural and non-structural elements is minimized

5. Base isolation allows for a reduction in structural elements of building with less ductile detailing needed.
6. Because the building is protected from major damage, repair cost following an earthquake will be lower to non existent

Finally it is concluded that after LRB is provided as base isolation system it increases the structures stability against earthquake.

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