RESEARCH ARTICLE OPEN ACCESS

Earthquake Analysis of Structure by Base Isolation Technique in SAP

T. Subramani[1], J. Jothi [2], M. Kavitha[3]
[1]Professor & Dean, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions University, Salem, India.
[2]PG Student of Structural Engineering, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions University, Salem,
[3]Managing Director, Priyanka Associates, Civil Engineering Consultant and Valuers, Salem

ABSTRACT
This paper presents an overview of the present state of base isolation techniques with special emphasis and a brief on other techniques developed world over for mitigating earthquake forces on the structures. The dynamic analysis procedure for isolated structures is briefly explained. The provisions of FEMA 450 for base isolated structures are highlighted. The effects of base isolation on structures located on soft soils and near active faults are given in brief. Simple case study on natural base isolation using naturally available soils is presented. Also, the future areas of research are indicated. Earthquakes are one of nature IS greatest hazards; throughout historic time they have caused significant loss offline and severe damage to property, especially to man-made structures. On the other hand, earthquakes provide architects and engineers with a number of important design criteria foreign to the normal design process. From well established procedures reviewed by many researchers, seismic isolation may be used to provide an effective solution for a wide range of seismic design problems. The application of the base isolation techniques to protect structures against damage from earthquake attacks has been considered as one of the most effective approaches and has gained increasing acceptance during the last two decades. This is because base isolation limits the effects of the earthquake attack, a flexible base largely decoupling the structure from the ground motion, and the structural response accelerations are usually less than the ground acceleration. In general, the increase of additional viscous damping in the structure may reduce displacement and acceleration responses of the structure. This study also seeks to evaluate the effects of additional damping on the seismic response when compared with structures without additional damping for the different ground motions.
KEYWORDS: Earthquake Analysis, Structure, Base Isolation Technique, SAP

I. INTRODUCTION

The structures constructed with good techniques and machines in the recent past have fallen prey to earthquakes leading to enormous loss of life and property and untold sufferings to the survivors of the earthquake hit area, which has compelled the engineers and scientists to think of innovative techniques and methods to save the buildings and structures from the destructive forces of earthquake.

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.

Base isolation concept was coined by engineers and scientists as early as in the year 1923 and thereafter different methods of isolating the buildings and structures from earthquake forces have been developed world over. Countries like US, New Zealand, Japan, China and European countries have adopted these techniques as their normal routine for many public buildings and residential buildings as well.

Hundreds of buildings are being built every year with base isolation technique in these countries. This paper describes the development of base isolation techniques and other techniques developed around the world. As of now, in India, the use of base isolation techniques in public or residential buildings and structures is in its inception and except few buildings like hospital building at Bhuj, experimental building at IIT, Guwahati, the general structures are built without base isolation techniques.

National level guidelines and codes are not available presently for the reference of engineers and builders. Engineers and scientists have to accelerate the pace of their research work in the direction of developing and constructing base isolated structures and come out with solutions which are simple in design, easy to construct and cost effective as well.

Many significant advantages can be drawn from buildings provided with seismic isolation. The isolated buildings will be safe even in strong earthquakes. The response of an isolated structure can be ½ to 1/8 of the traditional structure. Since the super structure will be subjected to lesser earthquake forces, the cost of isolated structure compared with the cost of traditional structure for the same earthquake conditions will be cheaper. The seismic isolation can be provided to new as well as existing structures. The buildings with provision of isolators can be planned as regular or irregular in their plan or elevations.

Researchers are also working on techniques like tuned mass dampers, dampers using shape memory alloys etc. Tuned mass dampers are additional mass on the structure provided in such way that the oscillations of the structure are reduced to the considerable extent. The mass may be a mass of a solid or a mass of a liquid. Dampers using shape memory alloys are being tried as remedy to earthquake forces. In this system, super elastic properties of the alloy is utilized and there by consuming the energy in deformation at the same time the structure is put back to its original shape after the earthquake.

II. EARTHQUAKES

Earthquakes occur throughout the world, but the vast majority occurs along narrow belts which are a few tens to hundreds of kilometers wide. These belts mark boundaries on the planet's surface that are very active geologically.(Fig.2.1)

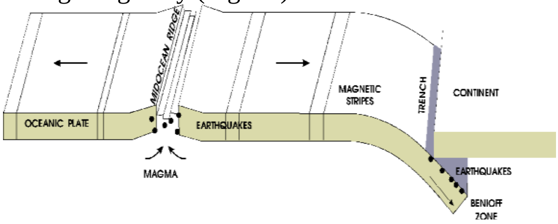

Fig.1.1 Earthquake boundaries

2.1 What is an earthquake?

Earthquakes are the Earth's natural means of releasing stress. When the Earth's plates move against each other, stress is put on the upper mantle (lithosphere). When this stress is great enough, the lithosphere breaks or shifts. As the Earth's plates move they put forces on themselves and each other. When the force is large enough, the crust is forced to break. When the break occurs, the stress is released as energy which moves through the Earth in the form of waves, which we feel and call an earthquake. (Fig.2.2)

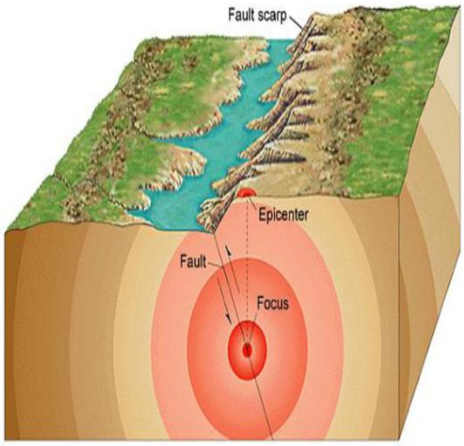

Fig.2.2 A narrow Zone

Rock breakage is called *faulting* and causes a release of energy when stored stress is suddenly converted to movement. Vibrations known as *seismic waves* are produced - they travel outwards in all directions at up to 14 kilometers per second. At these speeds, it would take the fastest waves only 20 minutes to reach the other side of the Earth by going straight through its centre - that's a distance of almost 13,000 kilometers. The waves distort the rock they pass through, but the rock returns to its original shape afterwards.

The *epicenter* is the point on the Earth's surface directly above the source of the earthquake. The source, also known as the *focus*, can be as deep as 700 kilometers. Earthquakes do not occur deeper than this because rocks are no longer rigid at very high pressures and temperatures - they can't store stress because they behave plastically. Smaller events occur more frequently - in fact, most earthquakes cause little or no damage. A very large earthquake can be followed by a series of smaller *aftershocks* while minor faulting occurs during an adjustment period that may last for several months.

2.2 Where do earthquakes occur?

No part of the Earth's surface is safe from earthquakes. But some areas experience them more frequently than others. Earthquakes are most common at *plate boundaries*, where different tectonic plates meet. The largest events usually happen where two plates are colliding - this is where large amounts of stress can build up rapidly. About 80 percent of all recorded earthquakes occur at the circum-Pacific seismic belt.

Intraplate earthquakes occur less commonly. They take place in the relatively stable interior of continents, away from plate boundaries. This type of earthquake generally originates at more shallow levels.

2.3 Types of earthquakes

There are three different types of earthquakes: tectonic, volcanic, and explosion. The type of earthquake depends on the region where it occurs and the geological make-up of that region. The most common are tectonic earthquakes. These occur when rocks in the Earth's crust break due to geological forces created by movement of tectonic plates. Another type, volcanic earthquakes occur in conjunction with volcanic activity. Collapse earthquakes are small earthquakes in underground caverns and mines, and explosion earthquakes result from the explosion of nuclear and chemical devices.

The **P wave**, or primary wave, is the fastest of the three waves and the first detected by seismographs. They are able to move through both liquid and solid rocks. P waves, like sound waves, are compressional waves, which mean that they compress and expand matter as they move through it.

S waves, or secondary waves, are the waves directly following the P waves. As they move, S waves shear, or cut the rock they travel through. S waves cannot travel through liquid because, while liquid can be compressed, it can't shear. S waves are the more dangerous type of waves because they are larger than P waves and produce vertical and horizontal motion in the ground surface.

Both P and S waves are called **body-waves** because they move within the Earth's interior. Their speeds vary depending on the density and the elastic properties of the material they pass through, and they are amplified as they reach the surface. (Fig.2.3)

The third type of wave, and the slowest, is the **surface wave**. These waves move close to or on the outside surface of the ground. There are two types of surface waves: **Love waves**, that move like S waves but only horizontally, and **Rayleigh waves**, that move both horizontally and vertically in a vertical plane pointed in the direction of travel.

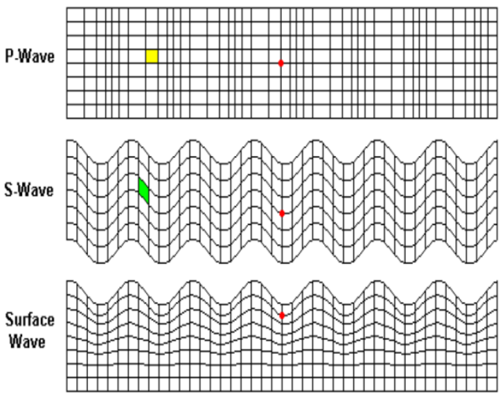

Fig.2.3 Seismic Waves

2.4 Determining the Depth of an Earthquake

Earthquakes can occur anywhere between the Earth's surface and about 700 kilometers below the surface. For scientific purposes, this earthquake depth range of 0 - 700 km is divided into three zones: shallow, intermediate, and deep. Shallow (crustal) earthquakes are between 0 and 70 km deep; intermediate earthquakes, 70 - 300 km deep; and deep earthquakes, 300 - 700 km deep.

In general, the term "deep-focus earthquakes" is applied to earthquakes deeper than 700 km. All earthquakes deeper than 700 km are localized within great slabs of shallow lithosphere that are sinking into the Earth's mantle. The most obvious indication on a seismogram that a large earthquake has a deep focus is the small amplitude of the recorded surface waves and the uncomplicated character of the P and S waves.

2.5 Measuring the Severity of Quakes

Earthquake sizes are compared by measuring the maximum heights of the seismic waves at a distance of 100 kilometers from the epicenter. The range in possible heights is used to construct the *Richter scale*.(Fig.2.4) The scale divides the size of earthquakes into categories called *magnitudes*. The magnitude of an earthquake is an estimate of the energy released by it.

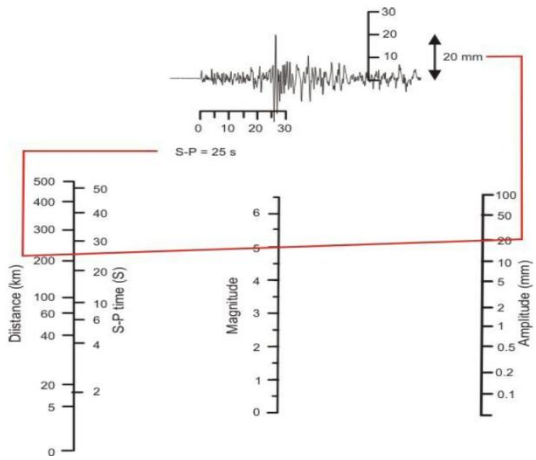

Fig.2.4 The Richter Scale

The Richter Scale is used to measure the amount of energy released in a given earthquake. The Richter reading won't be affected by the observer's distance from the earthquake. There are many other factors that contribute to the damage, such as the underlying rocks, building construction and poulation density. The Richter reading by itself does not give enough information to tell what the effects will be in any particular place. That said, however, in general, the larger the Richter reading, the greater the damage will be close to the epicenter.

In recent years, scientists have used a variety of magnitude scales to measure different aspects of the waves produced by an earthquake. These different magnitude scales reflect a greater complexity than can be represented by Richter's original scale. These different scales sometimes lead to confusion when different magnitude readings are reported for the same quake.

These different readings reflect different aspects of the quake. Especialy in large quakes, these differences can be substantial. For instance, the 1964 Alaska quake was originally recorded as 8.6 Magnitude. Now scientists think that a 9.2 Magnitude more accurately reflects that quake's intensity.

The Mercalli Scale of earthquake damage measures the intensity of an earthquake at a particular place. It uses the type and amount of damage. Unlike the Richter Scale, it does not measure the absolute strength of the earthquake, but how strongly it is felt at a particular place.

2.6 How do we measure the size of an earthquake?

In populated areas, the effects seen during an earthquake depend on many factors, such as the distance of the observer from the epicenter(Fig.2.5).Generally, magnitudes of: less than 3.4 are recorded only by seismographs .5-4.2 are felt by some people who are indoors are felt by many people and windows rattle 4.9-5.4 are felt by everyone, while dishes break and doors swing 5.5-6.0 cause slight building damage with plaster cracking, and bricks falling 6.0-6.9 cause much building damage and houses move on their foundations 7.0-7.4 cause serious damage with bridges twisting, walls fracturing, and many masonry buildings collapsing 7.5-7.9 cause great damage and most buildings collapse more than 8.0 cause total damage with waves seen on the ground surface and objects are thrown in the air.

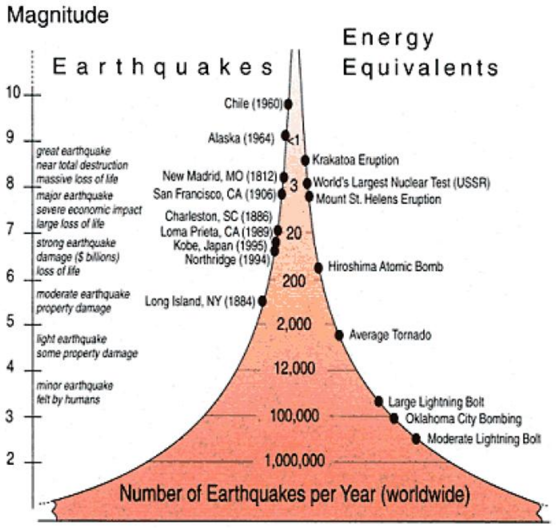

Fig.2.5 Earthquake Statistics

2.7 Factors that Affect Damage

Earthquakes cause many different kinds of damage depending on:

- the strength of the quake,
- distance,
- type of underlying rock or soil and
- The building construction.

A given Richter reading will produce vastly different amounts of damage in different parts of the world. Even the same quake can have very different effects in neighboring areas. Many areas much closer to the quake suffered only minimal damage.

The combination of uncompacted soil with a lot of water in it led to a phenomenon called liquefaction. Liquefaction occurs when the ground loses its cohesion and behaves like a liquid. When this happens during an earthquake it can result in increased intensity of the shaking, or landslides. It can also cause collapse of buildings. Another factor that has a major effect on the damage is the building method and materials used. Unreinforced masonry has the worst record since it has little ability to flex or move without collapsing. Wood frame buildings, or reinforced buildings, on the other hand, can hold together under quite severe shaking.

III. Types of Damage

3.1 Building Collapse

People can be trapped in collapsed buildings. This is the type of damage that leads to the worst casualties. The worst thing to do in a quake is to rush out into the street during the quake. The danger from being hit by falling glass and debris is many times greater in front of the building than inside.

3.2 Buildings knocked off their foundation

Buildings that can otherwise withstand the quake can be knocked off their foundations and severely damaged.

3.3 Landslides

Buildings can be damaged when the ground gives way beneath them. This can be in the form of a landslide down a hill, or liquifaction of soils. Ground movement can change the whole landscape.

3.4 Fire

Fires often break out following earthquakes. Fires can easily get out of control since the earthquake. There are many demands made on the emergency response systems that slow down response to fires.

3.5 Tsunami

Underwater earthquakes, volcanoes, or landslides can produce a tsunami or tidal wave. This wave can travel very rapidly thousands of miles across the ocean. In deep water the tsunami may only raise the ocean level by a few centimetres, hardly enough to notice. But as it approaches land, the shallower water causes the wave to build in height to as much as 10-20 meters or more and suddenly flood coastal areas.

Tsunamis carry a lot of energy and when they hit the coast strong currents can cause massive erosion of the coastline as well as tearing apart buildings it encounters. Typically a tsunami will last for a period of hours with successive waves drastically lowering and raising the sea level. Although scientists now understand the causes of tsunamis, there are many local factors including the slope of the seafloor at a given location, the distance and direction of travel from the earthquake that will determine the severity of the resulting wave.

IV. BASE ISOLATION OF STRUCTURES

It has often been suggested that base isolation of buildings may be achieved by introducing base supports with large elastic flexibility for horizontal motions. While such isolators may operate satisfactorily during type 1 (impulsive) earthquakes they would allow the cyclic build-up of intolerable base translations, and of considerable loads on the building, during the longer type 2 and type 3 earthquakes.

A base-isolated structure with a fundamental period of less than 1.0 second may be represented approximately by a single mass with a flexible support, for the purpose of computing its dynamic response to earthquake attack. This model is quite accurate for buildings with periods of less than 0.5 seconds. Since all the masses of a base-isolated building have comparable accelerations the deformed shape of the building is almost the same as for "uniform" horizontal loads, that is loads proportional to building weights. The total mass may then be taken at the centre of gravity of the building, and its support should allow it the same translations as the centre of gravity. This may be achieved by a support which gives an effective period of T e = 0.85 T,

where T is the fundamental period of the building. (The relationship may be derived from Raleigh's period formula when suitable approximations are made). The accuracy of the single-mass model is increased by large inelastic deformations of the isolator, and the model is not invalidated by moderate inelastic deformations of the building. When the maximum base shear has been obtained by dynamic analysis then the maximum member loads and the maximum deformations may be determined accurately by static calculation, with the base shear force distributed uniformly over the building.

The choice of the flexibility of the base mounts and of the effective force of the hysteretic dampers depends on the sizes of the design earthquakes, and on the characteristics and installed costs of the base-isolator components. A suitable compromise between building protection and isolator costs may be achieved with flexible mounts of laminated rubber having an effective rubber height of 6 inches, and with steel-bar hysteretic dampers which provide an effective damper force of 5% of the building weight.
Such laminated rubber mounts can be selected to give to a rigid building a period of 2.0 seconds, in the absence of the hysteretic dampers. Then from the period formula for a single-mass resonator it is found that the mount stiffness is 0.0255 W in where W is the weight of the building. The two stiffness values for the bilinear loop, which approximates the load-deflection curves of typical steel-beam dampers, designed for maximum deflections of 8 inches, are 2.94Q in ~1 and 0.18Q in _ 1 , where Q is the effective damper force.

4.1 DESIGN WITH BASE ISOLATION

When checking the aseismic design of a base-isolated reinforced-concrete building a normal overcapacity factor of 1.25 times is assumed. If the design is controlled by beam-end moments it may still be desirable to proportion the members for an inverted triangle distribution of loads despite the actual uniform distribution. This will give a further reserve of 20% to 30% and hence the overall reserve may be taken as 50%. Further the provision for triangular loads will increase the effective bilinear stiffness ratio for moderate ductility factors.

Consider as an example a reinforced concrete building of 3 storeys with a fundamental period of 0.25 seconds, and with an overall viscous damping of 0.05. If the design base shear is for a yield level of 0.12W, and if the members are designed for a triangular load distribution, then the elastic reserve may be taken as 50% and the effective base yield level as 0.18W. From Figs. it is found that the building remains elastic until the ground accelerations reach 1,2 times those of the El Centro earthquake. For 1.5 and 2.0 times the El Centro earthquake the ductility demands are 1.5 and 3.7 respectively, assuming a bilinear stiffness ratio of 0.15. For comparison with the base-isolated building, the ductility demands are given for the building without base isolation, with a design base share of 0.16W, and with a viscous damping of 0.05. For an overcapacity factor of 1.25 the yield load is 0.2W.

The equivalent weight W p of a single mass system may be taken as 90£ of the building weight, so that the yield load is 0.22 W e . From Figs it is found that the building reaches its yield level for accelerations of 0.25 times the El Centro earthquake and that the ductility demands for 1.0, 1.5 and 2.0 times the El Centro accelerations are 6.2, 11.5 and 18.5 respectively. The ratio of maximum member ductility to the above overall ductilities will be much higher and more variable for a range of earthquakes than the corresponding ratio for base-isolated buildings, for the reasons enumerated earlier.

The high ductility demands on the no isolated building, when under severe earthquake attack, would lead rapidly to lower yield levels and to negative bilinear slope ratios which would further increase ductility demands and lead to rapid failure. The ductility demands for the isolated and the non-isolated buildings are given in Fig.

Since the dominant periods of earthquake motions tend to increase with earthquake magnitude the results of period increases of 1.25 and 1.5, for earthquakes with amplitudes of 1.5 and 2.0 times the accelerations of the El Centro earthquake, are also included on Fig. While the largest earthquakes considered will occur very infrequently it is desirable that buildings should have a good probability of surviving them without collapse.

V. RESPONSE OF BASE-ISOLATED STRUCTURES

The base shears computed for a single-mass model of a linear elastic building of period T, mounted on the isolator described in the last section and then subjected to P a times the accelerations recorded at El Centro, May 1940, N S component; a typical type 2 earthquake. In the following this record will be referred to as the El Centro earthquake. An overall viscous damping of 0.03 of critical was assumed for the building and the mounts.

It is seen that for P a = 1.0, **1.5** and 2.0, the maximum base shares are approximately 0.15W, 0.20W, and 0.29W, respectively. The corresponding base translations, which may be derived from the loads required to deform the isolator, are 2.9 inches, 4.4 inches, and 7.0 inches, respectively. For comparison Fig. also gives the corresponding base shares for non-isolated single-mass resonators with a viscous damping of 0.05.

An attractive solution for a frame building which contains a few shear walls is the provision of support for the shear walls by vertical solid-steel bars, 3 to 4 feet in length, with the upper and lower ends of the bars rigidly anchored to a shear wall and to the foundations respectively. The columns of the frames are supported on laminated rubber mounts. For horizontal translation of the building the solid steel bars act as vertical cantilever dampers, and they also act as ties to prevent rocking of the walls due to building overturning moments.

The transverse stiffness of the rubber mounts provides adequate resistance against the P - A forces arising from translation of the short steel bars. The ductility demands which arise when a yielding building of 0.35 seconds period is mounted on the base isolator are given in Fig. The load-deformation characteristics of the building were represented by bilinear hysteresis loops with slope ratios, R, which is the ratio of slope in the plastic range to slope in the elastic range, of 0.1, 0.15 and 0.2.

The ductility demands were computed for accelerations of 1.5 and 2.0 times those of the El Centro earthquake. It is seen that, for a building with a bilinear slope ratio of 0.15, yield force levels of 0.13W and 0.17W restrict the ductility demand to 4.0 for earthquake amplitude multipliers of1.5 and 2.0 respectively. The curves of Fig.2 have been calculated specifically for a building elastic period of 0.35 seconds; however they should apply approximately to all short-period buildings.

It may be shown that the attack of a type 1, impulsive, earthquake on a base isolated building is a little less severe than the attack of a type 2 earthquake of the same maximum ground velocity and acceleration. It is evident from Fig that the building bilinear slope ratio has an important influence on the ductility demands on a base isolated building. While tests on reinforced concrete beam-column connections suggest a slope ratio of 0.1 or less for a reinforced concrete frame, tests on complete reinforced concrete buildings give much higher values when the ductility demands are moderate.

This high slope ratio is presumably caused partly by progressive formation of member hinges and partly by the beam action of the floor slabs, which do not participate fully in the hinging of associated beams. If a slope ratio of 0.1 may not be available the design should be modified to achieve it, or member yield levels set which will prevent the formation of a complete mechanism under design earthquakes.

Base isolation reduces the attack on short-period buildings to an even greater extent than is indicated by the low ductility demands of Fig. A short period building, when base-isolated, has its period increased to about 0.7 seconds for moderate vibration amplitudes, and to effective periods of about 1.2 and 2.0 seconds respectively for earthquake accelerations of 1.0 and 2.0 times the accelerations of the El Centro earthquake.

Again the dominant periods of angular accelerations of the ground must be at least as short as the dominant periods of linear accelerations of the ground and therefore base isolators will prevent dynamic amplification of the associated torsional forces. The severe resonant attacks which may occur on the appendages of non-isolated buildings are suppressed by base isolation. The effective building period is increased well beyond the dominant periods of most earthquakes, and the overall period is amplitude dependent* and heavily damped during severe earthquakes.

These three factors reduce the floor spectra and hence reduce the attack on building appendages. Base isolation provides large reductions in the earthquake attack on short-period buildings, and it gives a structure which can be designed simply and accurately. Isolation may provide a considerable reduction in the attack on buildings with longer fundamental periods, say greater than 0.7 seconds, but the design of such isolated buildings is more complex as there may be more than one significant mode of vibration, and for slender buildings overturning effects may be important. A study of such buildings is now in progress.

VI. PERFORMANCE OF BASE ISOLATED BUILDING

Geological and seismological discoveries during the 20th century have helped initiated the development of seismic building codes and earthquake resistant buildings and structures. The improvement in seismic design requirements has led to more robust, safe and reliable buildings. but in past condition ,that time was not provided base isolator from the building therefore in earthquake time many buildings was collapse , many people were dead etc.

Additionally, newly constructed freeway overpasses collapsed, two dams were damaged while others receiving minor damage and some buildings subsided or caught fire. Some of the additional damage was caused by ground fracturing and landslides. In 2001 Peru Earthquake and El Salvador earthquake, several hospitals were damaged. that past studies many buildings, Dams, Pipe line, Hospitals buildings, costly materials this are seriously damages and some buildings was collapse and people were died.

Therefore to protect the earthquake effects/earthquake damages to the buildings and Life safety for people also important then after research are to be found out after by using Base isolator to the buildings, the base isolator are provided at the basement level to absorbing the earthquake energy or earthquake forces and safe for damages to the buildings after in all past buildings provide the base isolator. Only Functional or important buildings base isolator is provided i.e. Museum, Shopping Mall, Hospital, Factory, Dams, and Airports etc. Many countries the base isolator is provided such as India, Japan, United state of America, China etc.

Base Isolation

Base isolation is defined as a flexible material which is provided at base to reduce the seismic forces of any structure. why base isolation is provide at the basement level because the base isolation reduces ground motion transmitted to the superstructure above the isolator, reducing the response of a typical structure and the corresponding loading. They are located strategically between the foundation and the building structure and are designed to lower the magnitude and frequency of seismic shock permitted to enter the building. They provide both spring and energy absorbing characteristics. Figure6.1 1 illustrates the behaviour change of structure without isolator and with isolator incorporation.

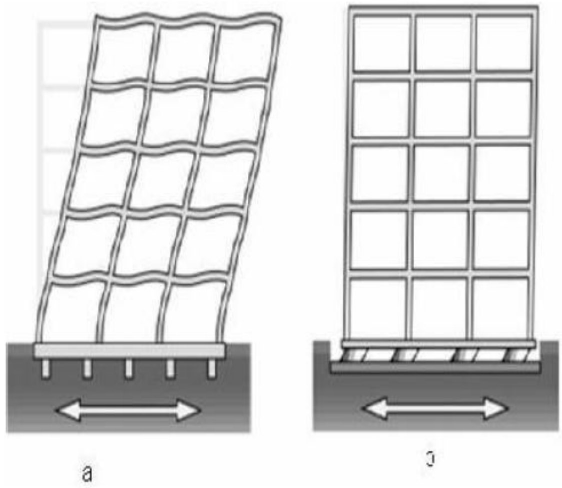

Figure6.1 The behaviour change of structure without isolator and with isolator incorporation.

VII. PRINCIPLE OF BASE ISOLATION

The basic objective with seismic isolation is to introduce horizontally flexible but vertically stiff components (base isolators) at the base of a building to substantially uncouple the superstructure from high-frequency earthquake shaking. The basic concept of base isolation system is lengthening the natural period of the fixed base building.

The benefits of adding a horizontally compliant system at the foundation level of a building can be seen in Figure 7.1, (a) using an acceleration response spectrum. Increasing the period of the structure reduces the spectral acceleration for typical earthquake shaking. Displacements in isolated structures are often large and efforts are made to add energy dissipation or damping in the isolation system to reduce displacements as shown in Figure, (b) using a displacement response spectrum. The addition of damping to the isolation systems serves to reduce displacements in the seismic isolators, which can translate into smaller isolators.

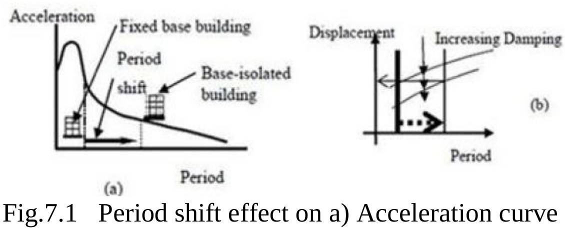

Fig.7.1 Period shift effect on a) Acceleration curve b)Displacement curve

Many advantages of base isolation is the life is very important for human being and important equipments, materials also. The need of present study is the traditional method of providing earthquake resistant to a structure is by increasing its strength as well as energy absorbing capacity, to reduce the damage of structure by increasing relative displacement of structure when subjected to earthquake, to save the structure from earthquake ground motion and keep it to minimum hazard level.

Basic elements of base isolation

- A flexible mounting so that the period of vibration of the building is lengthened sufficiently to reduce the force response.
- A damper of energy dissipater so that the relative deflections across the flexible mounting can be limited to a practical design level.
- A means of providing rigidity under low (service) load levels such as wind and braking force.

TYPES OF BASE ISOLATERS

`The most common use of base isolator in building is

- Laminated Rubber (Elastomeric) Bearing.
- High Damping Rubber (HDR) Bearing.
- Lead Rubber Bearing (LRB)
- Sliding bearings
- Friction Pendulum (FPS) System Bearing.

Laminated Rubber (Elastomeric) Bearing: It is composed of alternating layers of rubber that provide flexibility and steel reinforcing plates that provide vertical load-carrying capacity. At the top and bottom of these layers are steel laminated plates that distribute the vertical loads and transfer the sheer force to the internal rubber layer. On the top and bottom of the steel laminated plate is a rubber cover that provides protection for the steel laminated, shown in figures.

The steel plates in the bearing force the lead plug to deform in shear. This bearing provides an elastic restoring force and also, by selection of the appropriate size of lead plug, produces required amount of damping. The force deformation behaviour of the bearing is shown in Figure3b. Performance of LRB is maintained during repeated strong earthquakes, with proper durability and reliability.

Sliding bearings: For small vibrations, shear deformation of the rubber layers provides the same isolation effect as conventional multilayer rubber bearings.

For large vibrations, sliding materials slide to provide the same deformation performance as large-scale isolation systems. Friction pendulum system (FPS): Sliding friction pendulum isolation system is one type of flexible isolation system suitable for small to large-scale buildings. It combines sliding a sliding action and a restoring force by geometry. Functions of FPS are same as SSR system.

Analysis of isolation systems
The isolation system are

- Linear Static Analysis
- Linear Response Spectrum Analysis
- Non-Linear Static Analysis
- Linear Time History Analysis
- Nonlinear Time History Analysis

Linear Static Analysis :-

Linear analysis methods give a good indication of elastic capacity of the
structures and indicate where first yielding will occur. The linear static method of analysis is limited to small, regular buildings.

Linear Response Spectrum Analysis:-

Linear response-spectrum analysis is the most common types of analysis used. This is sufficient for almost all isolation system base on LRB and / or HDR bearings.

Non-Linear Static Analysis :-

In a nonlinear static analysis procedure the building model incorporates directly the nonlinear force-deformation characteristics of individual's components and elements due to inelastic material response. Several methods (ATC40, FEMA273) existing and all have in common that the nonlinear for –deformation characteristics of the building is represented by a Pushover curve, i.e. a curve of base shear vs. top displacement, obtained by subjecting the building model to monotonically increasing lateral forces or increasing displacements, distributed over the height of the building in correspondence to the first mode of vibration until the building collapses. The maximum displacements likely to be experienced during a given earthquake are determined using either highly damped or inelastic response spectra.

Linear Time History Analysis:-

Linear Time History Analysis provides little more information than the response spectrum analysis for a much greater degree of effort and so is rarely used.

Nonlinear Time History Analysis:-

Nonlinear Time History Analysis can be used for all isolation systems regardless of height, size, geomentry, location, and nonlinearity of the isolation system.

Properties of Isolator

The design of base isolator and to calculate properties of isolator

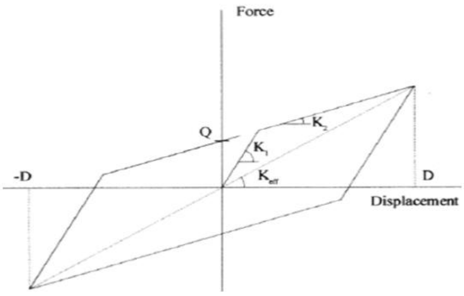

Fig Parameters for bilinear modelling of isolator

1) Design Displacement(D)

$$D = \frac{g}{4 \times \pi^2} \cdot \frac{C_{vd} \times T_D}{B_D} \quad \textbf{(a)}$$

2) Effective Stiffness (Keff)

$$K_{eff} = \frac{W}{g} \cdot \left(\frac{2 \times \pi}{T} \right)^2 \quad \textbf{(b)}$$

3) Energy Dissipated Per Cycle (WD=ED) :-

$$W_D = E_D = 2\pi K_H D^2 \beta \quad \text{(c)}$$

4) Calculate Yield Strength (Q):-

$$W_D = E_D = 4Q(D - D_Y)$$

Neglect "Dy"

$$W_D = 4QD \quad \text{(d)}$$

Yield Strength (Q):-

$$Q = \frac{W_D}{4 X D} \quad \text{(e)}$$

5) Post Yield Stiffness (K2) :-

$$K_{eff} = K_H = K_2 + \frac{Q}{D}$$

K_2 is calculate (f)

6) Yield Displacement (dy) :-

$$dy = \frac{Q}{K1 - K2}$$

$$\left\{ \frac{K_1}{K_2} = 10 \right\}$$

$$dy = \frac{Q}{10K2 - K2} \quad \{ K_1 = 10K_2 \} \quad \text{(g)}$$

7) **Correction**

$$W_D = E_D = 4Q(D - D_Y)$$

Put the value D_Y. Then to calculate Q value (h)

8) Assuming the relationship between Elastic Stiffness (K1) :- K1=10K2 (i)

9) Effective Damping :-

$$\beta e = \frac{4Q(d - dy)}{2\pi K_{eff} d^2} \quad \text{(j)}$$

In fixed base structure is not design because the fixed building supports is fixed and it is not a design but in other case Base isolated building, design of base isolator and therefore to calculate isolator properties by using formulae (a), (b), (c), (d), (e), (f), (g), (h), (i), (j). Then after firstly to calculate load on building column then this load value is put on the Standard formulae. isolator property to calculate Effective Stiffness (Keff), Effective Damping ,Post yield stiffness (k2)& Elastic Stiffness (K1) , Yield Strength (Q),post yield stiffness ratio(i) .Finally total value is calculated and this value will be assign for isolator in SAP-10 model. The modelling of base isolators has been done in SAP using Joint 1 link element type as rubber isolator.

VIII. DESIGN EXAMPLE

The present study has been concentrated on an eight storied (G+8) buildings. The buildings considered have a plan dimension of 22.4m in Length and 14.08m width of the building the plan and elevation of buildings is shown in fig. It has seven bay in the longitudinal direction and three bays in the transverse direction. The height of each story of the building is 3.3m and a column height of 1.5m has been extended below the plinth beams.

A solid slab of thickness 150mm has been considered for all storeys. As per IS: 875(Part-2)-1987, Live load intensity of 3 kN/mm2 has been assumed on each storey and the roof has been assumed a uniform live load intensity in 1.5 kN/mm2. The modelling has been performed by sap-2000 Non linear v 10.0 Software. The seismic zone is IV. Grade of concrete is M20 and for steel Fe415. The values of various factors have been assumed as per IS: 1893(Part-1) -2002. The design of members has been carried out as per IS: 456-2000 the beam and column has been design by IS: 456-2000(5).

The fixed base and Base isolated building performance point is calculated by using SAP-2000 software and story drift is for EQ-X and EQ-Y direction is calculated and hinges also form to the structure.(Fig.8.1)

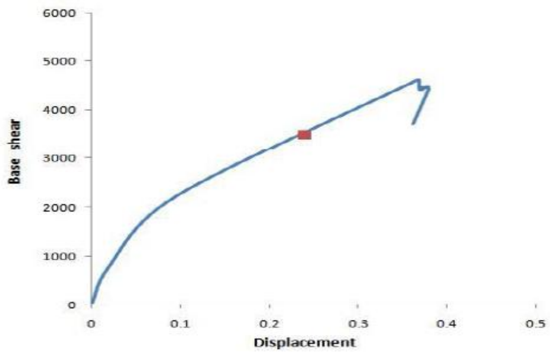

Fig.8.1 Fixed base building Performance point

IX. CONCLUSION

In the present study, functional building has been designed to compare fixed & base isolated building, In case of fixed building performance point is observed at base shear value is less than that of base isolated building and displacement is fixed base building also less than base isolated building .The present study has been concentrated on a typical plan for the 8 story buildings. The performance of the building should be studied with different plans.

Their performance of base isolator is best than fixed based building, it can be used for general purposes or initial cost of structure increases tremendously. But safety it should be providing at such as hospitals, police station, & public places etc. it should be provided. It is observed that in case of fixed base building it is not possible to achieve the Intermediate occupancy and Life Safety performance level but it is possible in base isolated building. It is observed that the story drift at EQ-X direction fixed base building and base isolated building is same & story drift at EQ-Y direction fixed base building is more than base isolated building.

The design of short-period buildings is much more accurate and controlled with base isolation than without isolation. The long effective periods and high dampings "standardize" the earthquake attacks while base-isolation simplifies and "standardizes" the building response. The main inelastic components are a standard range of devices with reliable performance which can be thoroughly checked in the laboratory. The building loads are approximately static in their effects and their distribution is accurately defined. Hence the demands on the building components can be computed by straight-forward static techniques. Base isolation suppresses several factors which act as severe constraints on the architectural design of a non isolated building. These factors include the provision of a high overall ductility factor, the dynamic effects of irregularities and appendages, and provision for substantial building deformations. Certain type 3 earthquakes can be expected to extend the very severe ductility demands, encountered in the analysis of short-period non-isolated buildings, to buildings of longer period. Base isolation should prove particularly effective in providing earthquake resistance for longer period buildings in microzones which give such type 3 earthquakes.

REFERENCES

[1]. Jessica Irene wiles, Dr. Sutton F. Stephens, S.E. *An overview of the technology and design of base isolated buildings in high seismic regions in the United States*.
[2]. Refer by J.M.Ferritto
[3]. B. M. Saiful Islam*, Mohammed Jameel and Mohd Zamin Jumaat ,*Seismic isolation in buildings to be a practical reality: Behavior of structure and installation technique*, Department of Civil Engineering, University of Malaya, Kuala Lumpur, Malaysia. Accepted 17 February, 2011
[4]. Aung Chan Win, *Analysis and Design of Base Isolation for Multi-Storied Building*, GMSARN International Conference on Sustainable Development: Issues and Prospects for the GMS 12- 14 Nov.2008.
[5]. T. K. Datta Indian Institute of Technology Delhi, India, Seismic analysis of structure.
[6]. IS: 456 (2000), *Plain and Reinforced Concrete - Code of Practice*, Bureau of Indian Standards, New Delhi.
[7]. Newmark, N.M. and Rosenblueth, E. : Fundamentals of Earthquake Engineering, Prentice-Hall 1971, pp. 225-228, and 343-345.
[8]. Skinner, R.I., Kelly, J.M., and Heine, A.J., *Hysteretic Dampers for Earthquake-Resistant Structures*, Int. J. Earth. Engg Struct. Dyn., Vol. 3, No.3, 1975.
[9]. Skinner, R.I., Kelly, J.M., and Heine, A.J., *Energy Absorption Devices for Earthquake Resistant Structures*, Proc. 5th Wld. Conf. Earthq. Engng, Session 8C, Rome, Italy (1973).
[10]. Robinson W.H. and Greenbank L.R., *An Extrusion Energy Absorber Suitable for the protection of Structures During an Earthquake*. In press - Int. J. Earthq. Engng Struct. Dyn. 1975.
[11]. Robinson W.H., Greenbank L.R., *Properties of an Extrusion Energy Absorber*. This Conference, May 1975.
[12]. Lindley, P.B., *Engineering Design with Natural Rubber*, N.R. Technical Bull., 3rd edn, Natural Rubber Producers Research Association, London, 1970.
[13]. Skinner, R.I., Beck, J.L. and Bycroft, G.N., *A Practical System for Isolating Structures from Earthquake Attack*, Int. J. Earthq. Engng Struct. Dyn. Vol 3, No. 3, 1975.