2.1 Preamble

Chapter 2 provides components of the different types of base isolation systems.

2.2 Parts of Base Isolation Systems

Since seismic isolation system has become more popular over the past few decades, the technology is advanced and there are many different base isolation systems available. Elastometric devices and gliding devices are the two main groups into which the devices could be separated. Above isolation techniques, which both have some inherent dampening, are used to shift the fundament a1 building frequency outside of the earthquake excitation range, which lowers accelerations and lowers the associated lateral inertia forces. A particular collection of characteristics, such as lateral rigidity, yield strength, maximum deformations under severe seismic loading, residual deformation, and the ability to revert to the original location, etc., define the devices of both groups. The aforementioned specifications for several devices that are currently on the market are outlined in this chapter.

2.3 Elastometric Bearing

Since they are made of elastometric material, elastometric devices live up to their name and are effective. Their resilience is their main benefit. Deformations caused by service load and durability, however, can be a problem. NRB, LRB and HDRB are examples of popular elastometric devices. In this part, the specifics of the aforementioned technologies will be covered.

2.3.1 Natural Rubber Bearing (NRB)

Natural rubber or neoprene is used to make laminated rubber bearings, another name for natural rubber bearings, synthetic rubber used for its strength and durability and for its resemblance to natural rubber in behavior (Ehrlich, Flexner, Carruth, & Hawkins, 1980). Figure 2 depicts natural rubber bearing setup.

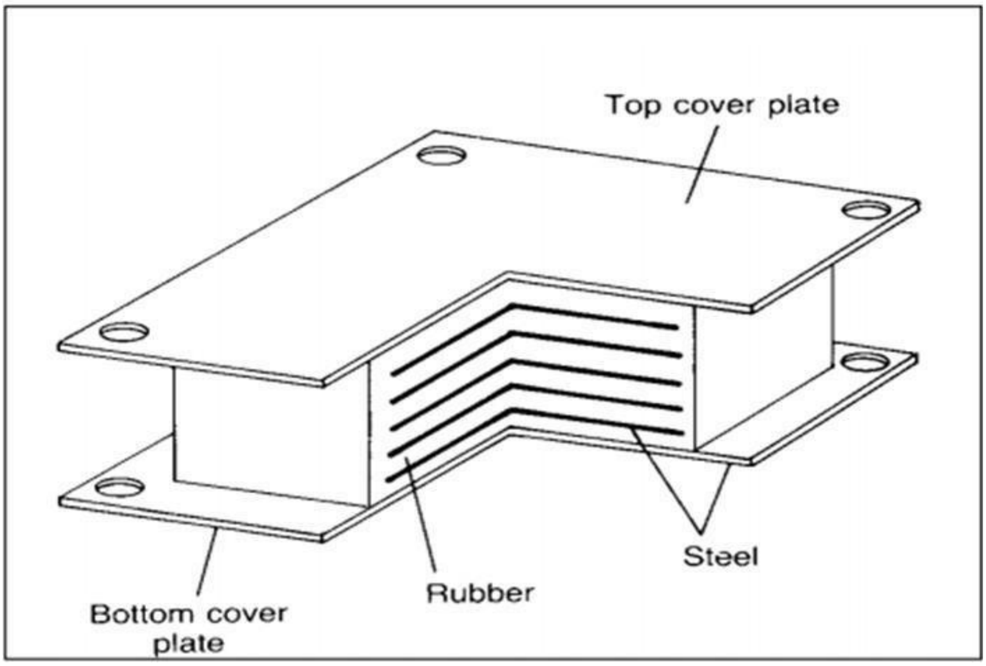

Figure-2. NRB Schematic

Shim layers made of rubber and steel alternate in natural rubber bearings. In order to create a composite bearing, these layers are fused together using the crosslinking process under temperatures and pressure. Shims made of steel stiffen the bearings vertically and stop an isolated structure from wobbling. Shims made of steel also prevent latex prevent blowing up when under severe axial compressive loads. Shims have no impact on the bearings' axial stiffness because this property is governed by the elastic material's shear modulus. The bearings are sandwiched between two sizable endplates to make it easier to attach the foundations and isolator mat.

The main drawbacks of natural rubber bearings are their poor absorption and low stiffness, which make them incapable of withstanding service wind loads. Natural rubber bearings typically have a 2-3% critical damping. In order to cope with service and strong seismic loads, natural rubber bearing support structures typically need further damping mechanisms, including such viscous or hysteretic dampers. However, damping qualities can be improved by altering the elastometric material's characteristics.

NRB, however, are easy to install and produce. Additionally, it is simple to understand, analyze, and consequently design their behavior. Neoprene and Natural rubber are recognized to keep a stable shear modulus during age, hence the impacts of creep and stiffness degradation over time are minimal. (Naeim & Kelly, 1999).

2.3.2 Lead Rubber Bearing (LRB)

LRB are far better able to provide enough rigidity for wind loads and superior damping properties than NRB. Apart from the presence of any number of cylindrical metals inserts in centre, as seen in Figures 3, the LRB arrangement is same as of natural rubber bearings. Whenever the lead plug and rubber are being used together, the device behaves bilinearly. When there are lower delivery wind loads, high rigidity of the lead plug, which draws the majority of the load, and arrangement is very stiff. At very strong seismic stresses, lead deforms plastically, lowering the device's stiffness to just that of rubber. The lead plug's plastic deformation results in a hysteretic loss of energy as well. During intense events, the lead plug changes shape similarly to rubber, but rather produces heat or discharges by transforming kinematic energy into heat. Therefore, the plug's hysteretic nature aids in minimizing the amount of energy which the structure has collected. As a result, LRB possess desirable hysteretic damping qualities, which improves the system's structural response. Amount of energy lost depends on the maximum bearing displacement. LRB are indeed easily installed, produce, interpret, and create. (Naeim & Kelly, 1999).

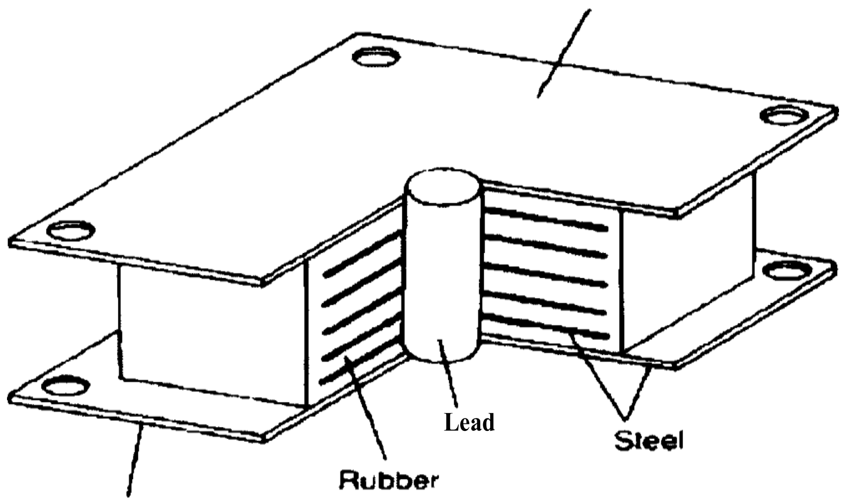

Figure-3. LRB Schematic

2.3.3 High Damping Rubber Bearing (HDRB)

HDRB replace existing damping mechanisms. Their composition is similar to that of NRB, with the exception of the elastometric material used. A greater amount of damping is possible with the use of additives such as carbon, lubricants, and resins. By using fillers, the damping was enhanced to 20–30percent of the critical damping.

HDRB have strong hardness and high yielding at shear strains under 20%. For controlling deformations during service wind loads, this behavior is helpful. With stresses larger than 120%, stiffness and absorption both increase. As a result, when subjected to significant earthquake loads, this behaviour efficiently absorbs energy, limits deformations, and provides sufficient rigidity for service wind forces. HDRB have the same benefits as the aforementioned devices in terms of with ease production & use. (Naeim & Kelly, 1999).

2.4 Moving Mechanisms

The ability of moving mechanism to remove effect of torsion in irregular constructions is their main benefit. This is as a result of the fact that the axial force exerted on a sliding mechanism by mass is proportionate to the frictional force used in sliding devices. As a result, torsional effects in asymmetric buildings are eliminated since the centre of rigidity of the isolation system and the centre of gravity of the building coincide (Kunde & Jangid, 2003) and (Trombetti, Ceccoli, & Silvestri, 2001). Pure friction devices, robust friction-based devices, and friction pendulums are some of the frequently used sliding base isolation devices. The following section will go over the specifics of the aforementioned devices. They can also be employed for a variety of constructions because of their susceptibility to seismic excitation frequency content.

2.4.1 Natural Friction Bearing

The first kind of sliding mechanism are natural friction bearings. They effectively stand in for a sliding joint that separates the ground from superstructure. Because the load is insufficient to overcome the friction force at rest, the framework behaves like a fixed base building when subjected to service wind loads. High seismic stresses cause static friction to disappear, and the bearing moves. Effort is lost in the bearings through

Coulomb damping caused by friction. The axial force and the friction coefficient determine the lateral force necessary to remove static resistance. By choosing the right resources for the bearings' sliding surfaces, the friction factor can be managed. Two significant limitations are the need for routine servicing to maintain a steady friction factor as the bearings ages and the challenge of getting the building to center on its own following a quake (Kunde & Jangid, 2003).

2.4.2 Cable Friction Bearing

Figure 4 depicts the basic layout of cable friction bearings. A typical sliding bearing, strong tension cables, and, if required, a fracture fastened in the centre make up the apparatus. Restrainer cables prevent excessive superstructure displacement during severe earthquake events. It's not intended to break, the shear bolt during light and moderate earthquakes, preventing the need to replace the bearing. The shear bolt snaps under intense earthquake pressures, causing sliding to become active. As a result, there is a reduction in the transfer of seismic forces to the superstructure. Friction between the teflon and stainless steel plates dissipates energy while cables prevent excessive relative displacements (Wancheng, Binbin, Pakchiu, Xinjian, & Zhaojun, 2012).

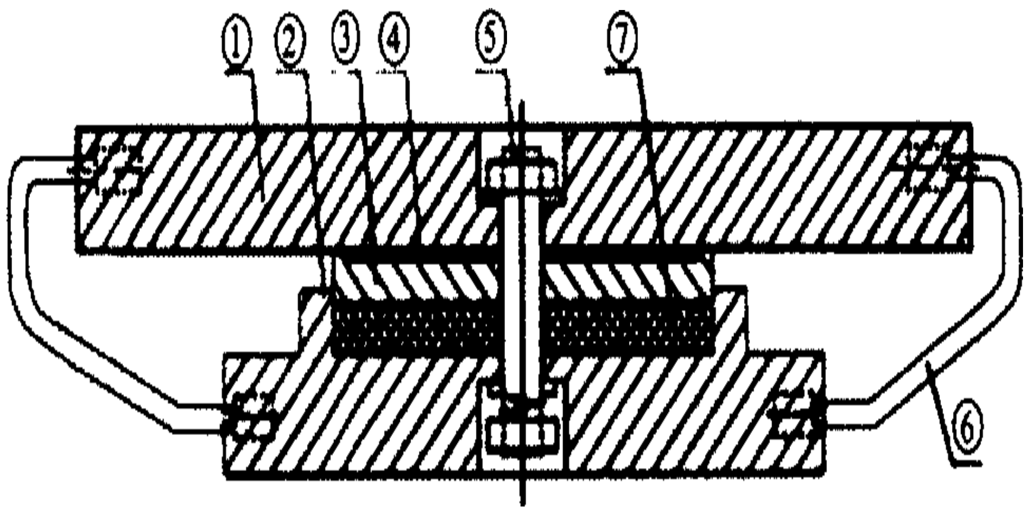

Figure-4. Cable Friction Bearing Schematic

2.4.3 Resilient Friction Base Isolators

Figure 5 shows numerous flat metal plates make up the durable friction-base isolators with a center or outer rubber cores that can glide past one another. The rings are covered in an extremely flexible rubber band that shields them from dust and rust. Teflon is applied to the sliding plates to lessen friction. The rubber cores aid in distributing the horizontal deformation and pace uniformly along the isolator's height. Identification of resilient friction-base isolators is based on the sliding components' friction coefficient and the rubber cores' overall lateral stiffness. It is possible to sustain service wind loads thanks to the friction that generates between the plates. The principal energy dissipater during seismic stresses is friction damping, as rubber has a limited ability to dampen. Rubber cores are simply inserted and not attached to the sliding rings, creating a sturdy friction-base isolator is a pretty simple process. (Mostaghel & Khodaverdia, 1987).

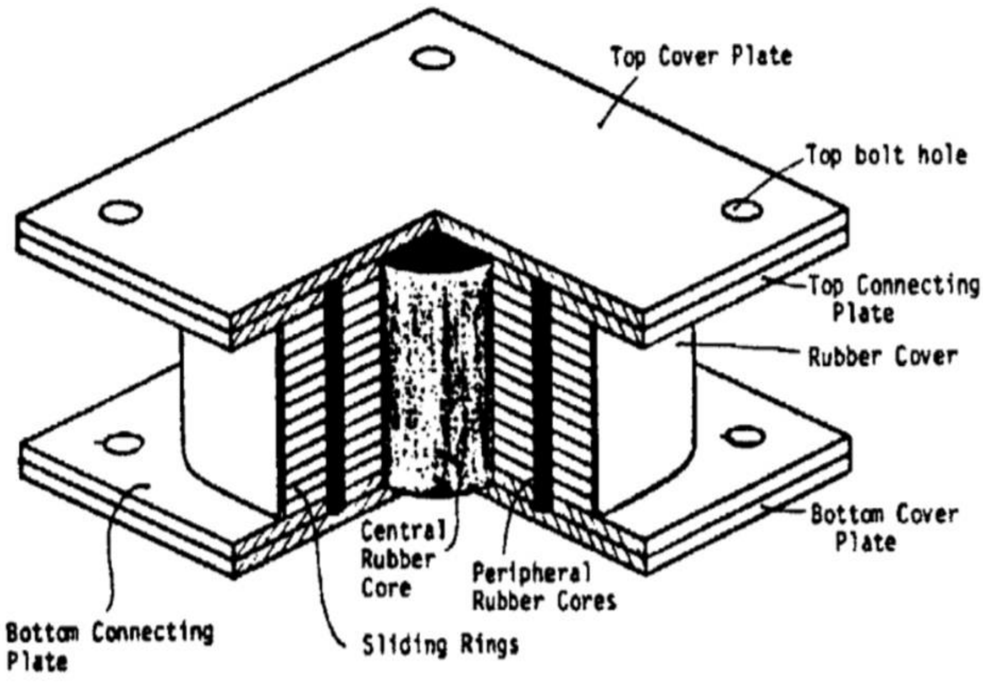

Figure-5. Resilient Friction Base Isolators Schematic

2.4.4 Friction Pendulum Bearing (FPB)

The motions of sliding and pendulum are combined in friction pendulum bearings. A FPB is shown schematically in Figure 6. They consist of a concave spherical mounted on the surface of a chrome surface, which is supported by an articulated slider. The slider is protected by a layer of Teflon or some other coated bearing material. Friction coefficient at high speeds around the two plates is 0.1, & 0.05 at low speeds. Devices using friction pendulums function as fuses and are triggered by quake stresses similarly to conventional sliding bearings that are more than that of the static friction value. These bearings deliver horizontal loads that consist of a mixture of static friction and restoring force by elevating the round surface.

The bearing's restoring force is inversely related to the concave surface's curvature radius and proportionate to the weight the bearing is able to support. As a result of static friction, these bearings do not deflect (display stiffness) when subjected to service wind loads, which is an exceptionally desirable quality. Moreover, Due to transverse force within a given bearing is inversely related to the amount of the structure's burden that it supports, the centre of stiffness of the support system and the structure's centers of mass are inextricably linked, preventing the likelihood of torsional effects. In shake-table experiments, this property has been verified by (Zayas, Low, & Mahin, 1987). FPS also exhibit strong stability and little susceptibility to the frequency content of seismic excitation (Mokha, Constantinou, Reinhorn, & Zayas, 1991).

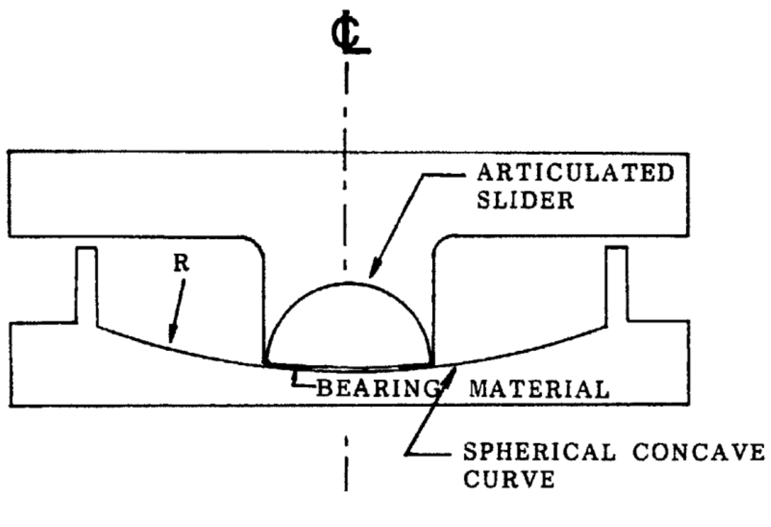

Figure-6. Friction Pendulum Bearing Schematic

2.5 Limiting Devices

Limiting devices may be needed in event of a severe quake to keep the structure from moving. This is crucial for elastometric bearing systems since they are susceptible to instability at large lateral strains. Excessive lateral deflections run the risk of colliding with nearby structures, which could result in serious injuries or even fatalities.

To prevent the bearing systems from deflecting excessively, stiff or flexible devices may be used. However, if a building collides with a limiting device during an earthquake, structural amplitudes could increase and cause localized damage to the structure or support system which happen as a result of impact. Therefore, creating a suitable restricting configuration is a crucial step inside the base isolation design stage.