NATURAL RUBBER AGAINST NATURAL CALAMITY

Earthquake is a natural calamity and when it strikes with tremendous force, mankind becomes paralysed. The devastating impact of earthquake causes heavy damage to buildings and structures, occupants and materials.

An earthquake is ground *oscillations of a very large* amplitude and low frequency. It is the horizontal component of these movements which cause severe damage to the buildings and structures. To overcome the damaging effects of earthquake, the conventional approach is to design buildings and structures providing adequate strength and stiffness which would be sufficient to withstand a given level of earthquake generated force. Proper structural design and careful selection of structural members such as columns and beams can enable the construction of earthquake resistant structures. However, the cost of Construction of such structures will be rather high and the structures may not always be 100 per cent quake-proof. This has led to the vital need for following a better scientific and cost effective approach for the design and construction of quake resistant structures. The basic approach for designing quake-proof structures has changed from providing extra strength to the structures to reducing earthquake generated forces acting upon them. Seismic isolation can be achieved by allowing the structure to move a little on its foundation during the earthquake. That is, in this approach the super structure is uncoupled from the seismic ground motion thereby reducing the probable damage level of the structure. Thus, techniques in design and construction of buildings generally being practised now-a-days are;

* **Base Isolation**
* **Energy dissipation Devices.**

Base Isolation

During an earthquake, the ground under each building tends to move. The buildings responds to this by undergoing a displacement, in the direction opposite to the ground motion, due to inertia. The inertial forces acting on a building are the most significant of all these generated during an earthquake.

The extent of inertial forces acting on the building is proportional to the acceleration of the building during ground motion. Owing to the complex nature of earthquake ground motion, buildings tend to *vibrate back and forth in* varying directions. In the case of a conventional non-isolated building, as a result of the impact of earthquake, the building undergoes deformation. Depending upon the severity of the earthquake, a conventionally designed building developes cracks and sometimes totally crumbles down causing deadly damage to the inhabitants and their possessions. In the case of a base-isolated building, the inertial forces acting on the building are considerably reduced, resulting in the building and its occupants being completely unaffected by earthquakes. The buildings are actually decoupled from the horizontal component (which causes maximum damage) of the earthquake ground motion by interposing a layer with sufficiently low horizontal stiffness (and having very high vertical stiffness) between the foundation and the structure.

Rubber has long been recognised as a useful engineering material. During the mid 50s, rubber-metal laminated bearings were developed to replace the older roller type metallic bearings used in bridges to isolate it from the damaging stresses and strains of bridge expansion and contraction. This technique has also proved effective in the isolation of buildings from other forms of vibration. Later rubber bearings with suitable modifications were tried to isolate buildings from the atrocities of earthquakes. With a number of years of continuous efforts, scientists were able to design and develop reliable rubber-steel laminated bearings for seismic isolation.

For base isolation, the commonly used material is a rubber bearing, preferably made out of Natural Rubber (NR). R & D work on NR bearings for isolating seismic vibrations started in 1976 at the Earthquake Engineering Research Centre (EERC) [now Pacific Engineering Research Centre] of the University of California at Berkeley. The work was undertaken as a joint effort of the EERC and the Malaysian Rubber Producers Research Association (MRPRA), UK. Rubber bearings are easy to manufacture, are unaffected by time and are resistant to environmental degradation. The bearings are made by vulcanisation-bonding of compounded rubber to thin steel reinforcing plates. Rubber bearings have been very succesfully used for buildings up to seven or eight storeys in height since 1980s. Research is still going on in this line for further improvement and innovation of seismic isolators.

The major attraction of steel laminated rubber bearings for seismic isolation are

- ◆ Relatively easy to make
- ◆ Economical
- ◆ Longer life
- ◆ Maintenance free
- ◆ No moving parts like metallic bearings
- ◆ Resistant to environmental hazards
- ◆ Additional damping mechanism required due to the inherent damping characteristics of the rubber.

Design requirements

◆ Base isolation bearings must bear heavy loads for long periods of time while also being capable of large deformation during an earthquake. That is they must satisfy requirements for spring characteristics and ability to deform.

◆ Ageing and creep characteristics are important in designing seismic rubber bearings for its durability and safety.

◆ Damping characteristics of the rubber compounds : increased damping ability of rubber compounds will adversely affect creep characteristics and temperature dependency. Therefore, optimal design is required to achieve high functional, high damping rubber bearing with low creep and low temperature dependency.

◆ Seismic isolation systems are critical to the foundation of a building and must have longer serviceability. Therefore, a production method which consistently produces bearings within close tolerances and high quality is essential. A high level of quality control in areas like production of rubber compound, heat history at the time of vulcanisation and long term stability of adhesion is needed.

Agencies and consultants engaged in production of seismic isolation devices

1. Lead rubber Bearings

developed by Robinson Seismic Ltd.

◆ The New Zealand Department of Scientific and Industrial Research pioneered a number of seismic-isolation and energy absorbing devices during the 1970s and 1980s. The most well known of this is the lead rubber bearing invented in Wellington by Dr. Bill Robinson, now at Robinson Seismic Ltd. This bearing is now installed world wide.

Lead Rubber Seismic bearing or earthquakes shock absorbers are capable of protecting buildings, bridges or any other structures from even the strongest earthquakes.◆

The bearing is a lead core surrounded by inter layered sheets of steel and rubber. During an earthquake the lead deforms and is stretched sideways as the earth shakes. Infact, it is able to move sideways to a distance equal to its height. The rubber and steel then pull it back into shape ready for the next shock. A typical bearing is less than half a metre high. During an earthquake, a structure fitted with the bearing will actually stay still, while the ground shakes beneath.

2. Seismic isolation devices-Bridgestone

Bridgestone started development of seismic isolation devices in 1981 and as spent 10 years for research especially in the areas of design, materials, adhesion between steel and rubber components, manufacturing and quality control.

Even though the theoretical aspects of base isolation using rubber bearings are sound, everyone is more interested in the actual performance of such isolators in buildings during earthquakes. To cite an example, the University of Southern California Teaching Hospital (SCTH) in Los Angeles an eight-storey building, is supported on 68 nos of lead rubber isolators and 81 elastomeric isolators. During the 1994 Los Angeles earthquake, while many other buildings in the neighbourhood collapsed, the SCTH was totally unaffected and the hospital patients did not even realise that there had been an earthquake.

The first base-isolated building in the United States was the Foothill Communities Law and Justice Centre near Los Angeles. This four storied building designed for a Ritcher magnitude of 8.4, the maximum credible earthquake for that site was completed in 1985 and 98 rubber isolators of multi-layered natural rubber bearings reinforced with steel plates were used for the construction. The building housing the Italian Telephone Company, S.I.P, Ancona, Italy was the first based-isolated building in Europe. The first large base-isolated building in Japan was completed in 1986 and upto 1998, more than 550 base-isolated buildings have been approved by the Ministry of Construction. Currently the largest base-isolated building in the world is the West Japan Postal Computer Centre, located in Sanda, Kobe Prefecture. It is a six storey building of 47,000 sq. metre supported on 120 rubber isolators.

Energy Dissipation Devices

During an earthquake, a certain amount of vibrational energy is transferred to buildings by ground motion. Buildings have an inherent capacity to damp this energy. Buildings will, however, dissipate energy either by undergoing large scale movement or sustaining internal strains in beams and columns. Both of these will result in varying degrees of damage to the buildings.

By equipping a building with additional devices capable of damping, the seismic energy entering the buildings can be reduced and hence the buildings will be safe. Different types of dampers such as Friction Dampers Metallic Dampers, and Viscoelastic Dampers are available for the purpose.

Conclusions

Natural Rubber can come to the rescue of mankind during a devastating earthquake. The recent Gujarat tragedy should encourage Indian architects to properly design and construct buildings and structures at affordable cost, using Natural Rubber based steel laminated bearings in earthquake prone areas.

The following suggestions are made for effectively implementing the base isolation technique for construction of earthquake proof building.

- Take steps for constructing a 5 or 6 storey building on NR based seismic isolators.
- Take immediate steps for including base isolation system using NR based isolators in the BIS code of Practice for the construction of earthquake resistant buildings.
- Constitute a high power committee consisting of Architects, Builders, Structural Engineers and Rubber Technologists for drawing up practical and effective ways and means for the implementation of base isolation technique for the construction of buildings in more earthquake prone area.

Concerted efforts are immediately required on a time bound basis by rubber technologists, builders and architects for developing indigenous technology for the production and use of natural rubber based isolators capable of protecting buildings and structures from earthquakes. The Rubber Board can take an active role in the process.

-K.S. Gopalakrishnan,
Director (T&TC), Rubber Board
Courtesy : Indian Rubber Journal