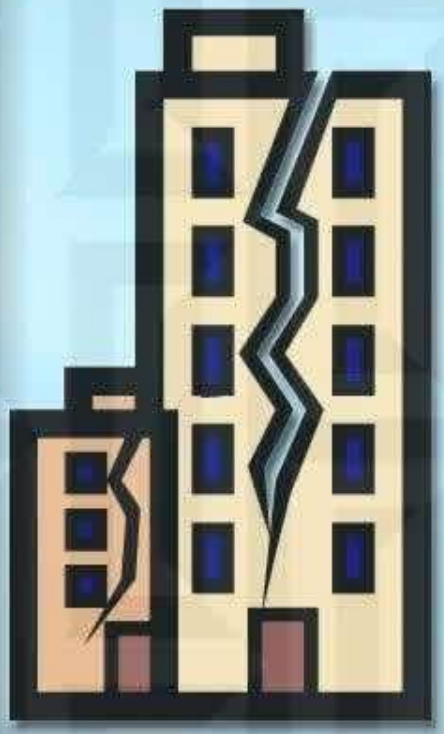
EARTHQUAKE RESISTANT BUILDING CONSTRUCTION



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COURSE OUTCOMES

Subject: - WIND AND SEISMIC ANALYSIS 6CE3-01

- **CO 1:-**This subject will provide the understanding of different types of structural systems, symmetry and asymmetry in buildings.
- **CO 2:-** To understand different type of loads considered and taken in to account when designing the building especially DL/LL/IL/EL
- **CO 3:-** To understand different types of construction for Earthquake Load and wind load and various provisions specified by Bureau of Indian standards**.**
- **CO 4:-** To understand the design criteria of the buildings/ Roof (general &special)/ building components and the modern techniques involved in construction**.**

AGENDA

- What is Earthquake?
- Types of Earthquake
- How Earthquake Occurs?
- Causes and Effects of Earthquake
- Seismic Waves
- Seismic Performance and Design
- Improving Earthquake Resistant Of The Minor Building
- Shear Walls
- Advantages of Shear Walls
- Earthquake Resisting Structure Techniques
  - Base Isolation Method
  - Energy Dissipation Device (Seismic Dampers)
  - Keeping Building Up thrust
- Conclusion

WHAT IS EARTHQUAKE

- They are natural disasters of a generally unpredictable nature
- It is the shaking of earth due to the movement of earth's crust
- A sudden, rapid shaking of the earth caused by the breaking and shifting of rocks beneath the earth surface.

TYPES OF EARTHQUAKE

There are two types of earthquake:

- Inter plate earthquake
- Intra-plate earthquake

In both types of earthquake, during earthquake at fault strike slip(horizontal movement) & dip slip (vertical movement)

HOW EARTHQUAKE OCCURS?

- Because of Earth's rotation and other energy factors different shells or the rock layers constantly move or slid past each other.
- Different continental mass fragments of lesser densities float and move overriding the denser rock layers.

This causes earthquake.

CAUSES OF EARTHQUAKE

- Earthquakes are causally related to compression or tensional stresses .
- Volcanic eruptions, rock fall, landslides, and explosions can also cause a quake.

FAULT

A fault is nothing but a crack or weak zone inside the Earth. When two blocks of rock or two plates rub against each other along a fault, they don't just slide smoothly.

As the tectonic forces continue to prevail, the plate margins exhibit deformation as seen in terms of bending, compression, tension and friction. The rocks eventually break giving rise to an earthquake, because of building of stresses beyond the limiting elastic strength of the rock.

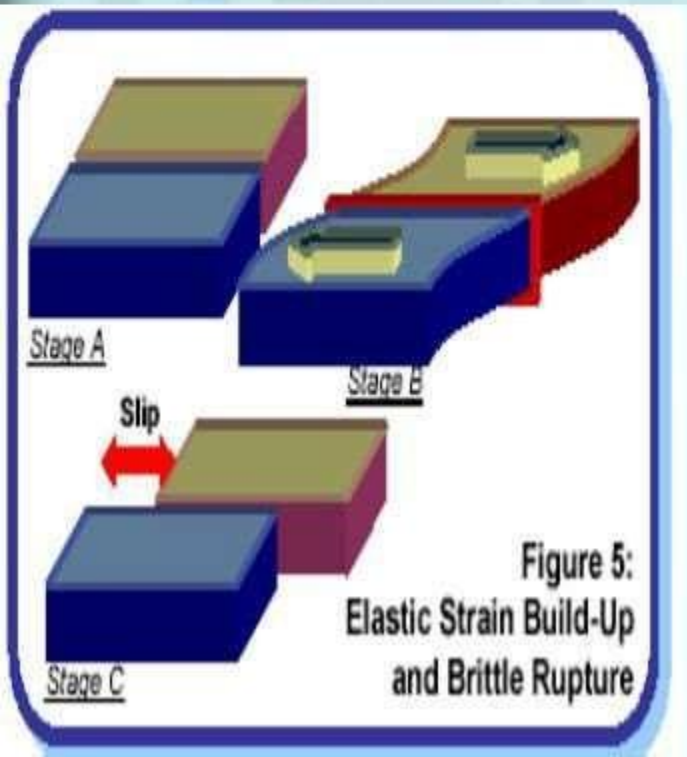
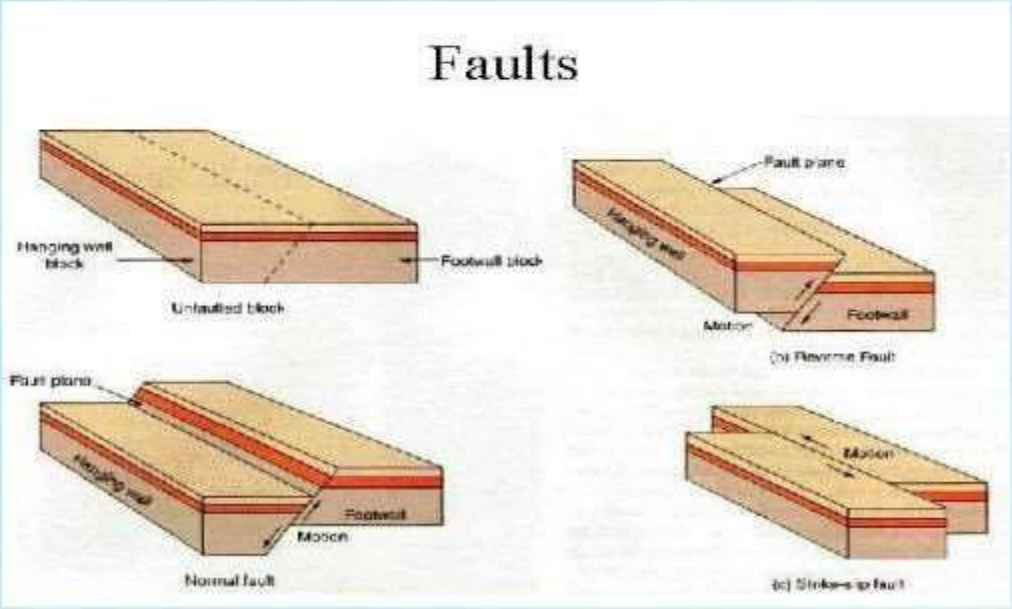


Figure 5: Elastic Strain Build-Up and Brittle Rupture

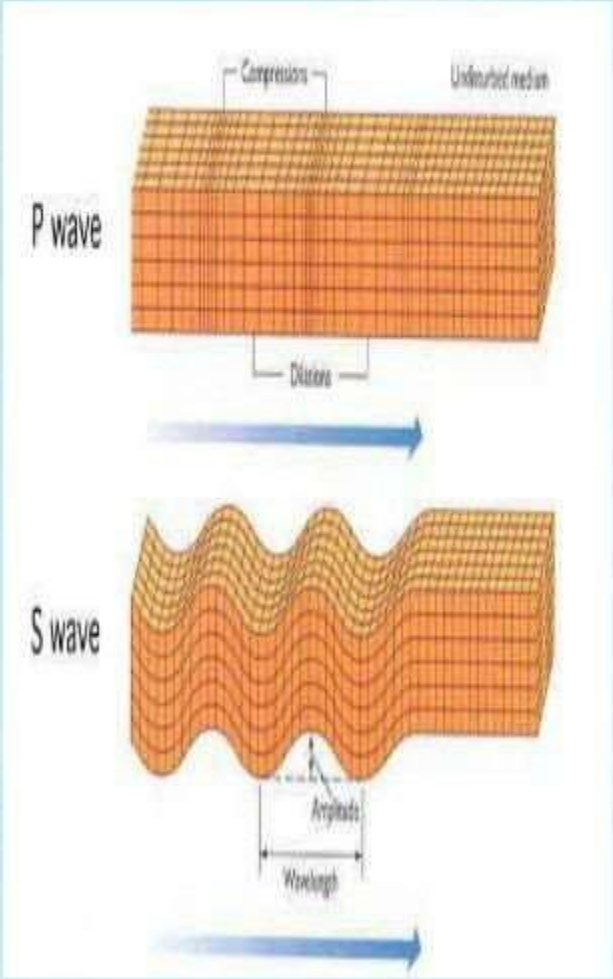


SIESMIC WAVES

- They are of two types:
  - Body waves-
    - 'P' waves:- travels through solids and fluids.
    - 'S' waves:- travels through solids

- surface waves:-

Slowest and damaging



EFFECTS OF EARTHQUAKE

- Ground motion
- Landslides
- Ground displacement
- Liquefaction
- Tsunamis
- Aftershocks

Earthquake Do Not Kill People

Improperly Designed Structures Do!

SEISMIC PERFORMANCE

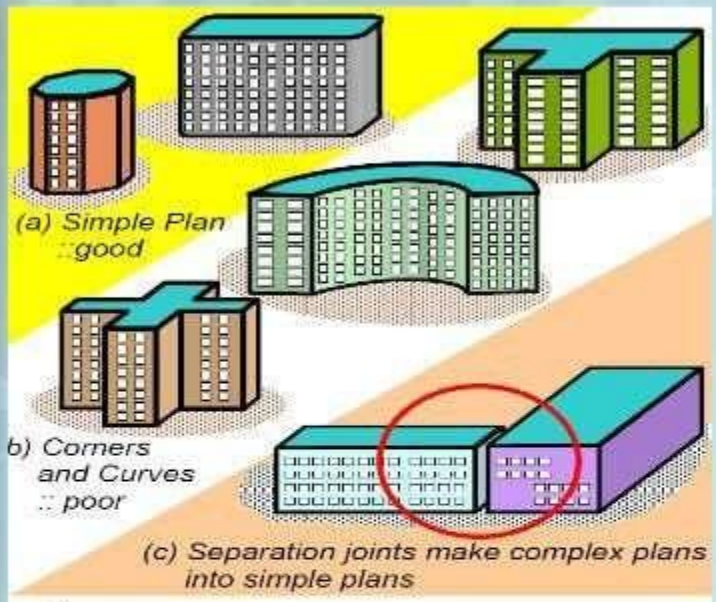
- Ability of structure to sustain its function viz. safety and serviceability at earthquake.

SEISMIC DESIGN

- It is Authorized engineering :-
  - Procedure
  - Principles
  - Criteria

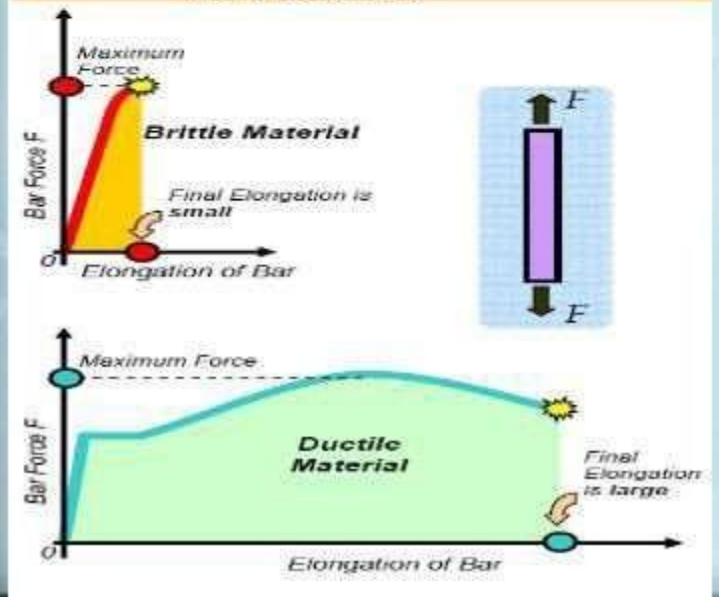
  To design structures subject to earthquake exposure

IMPROVING EARTHQUAKE RESISTANCE OF MINOR BUILDING



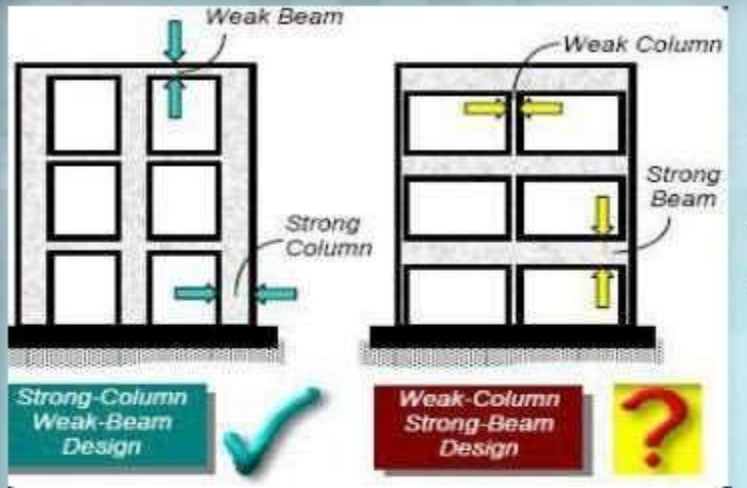
- Size of building

"Simpler the Plan, Better the Performance"

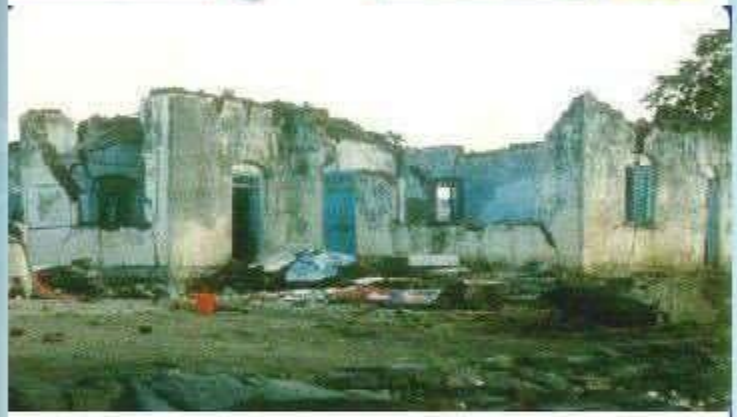


- Construction materials

"R.C.C. preferable than P.C.C"



➢ "Strong-column, weak-beam"



(a) Building with no horizontal lintel band: collapse of roof and walls

➢ "Horizontal Band necessary throughout the masonry"

(b) A building with horizontal lintel band in Killari village: no damage

"LATUR EARTHQUAKE INCIDENT"

" Avoid soft storey-continue walls in ground storey"

Bhuj incident

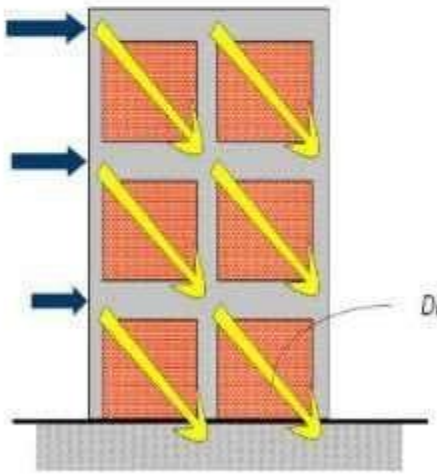


Figure 9
Avoid Open Ground Storey – Continue Walls in Ground Storey

Configuration of building

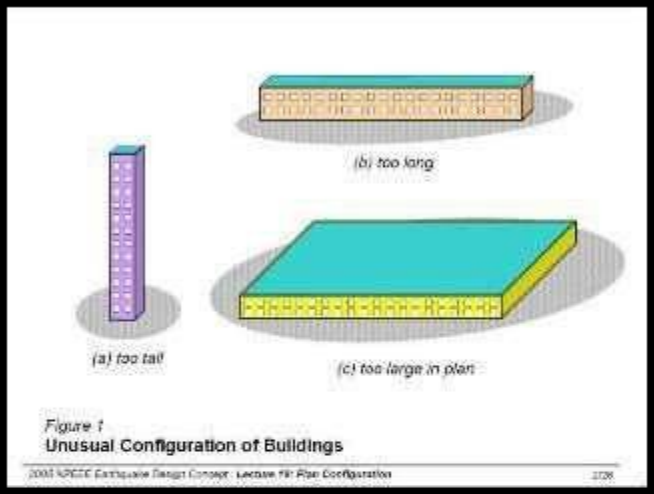


Figure 1
Unusual Configuration of Buildings

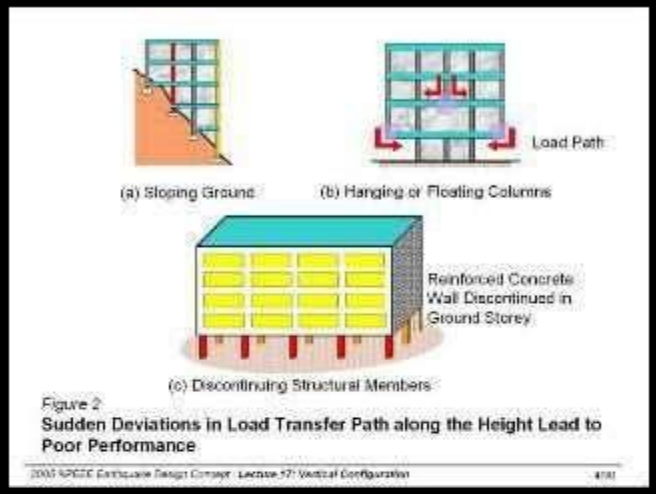


Figure 2
Sudden Deviations in Load Transfer Path along the Height Lead to Poor Performance

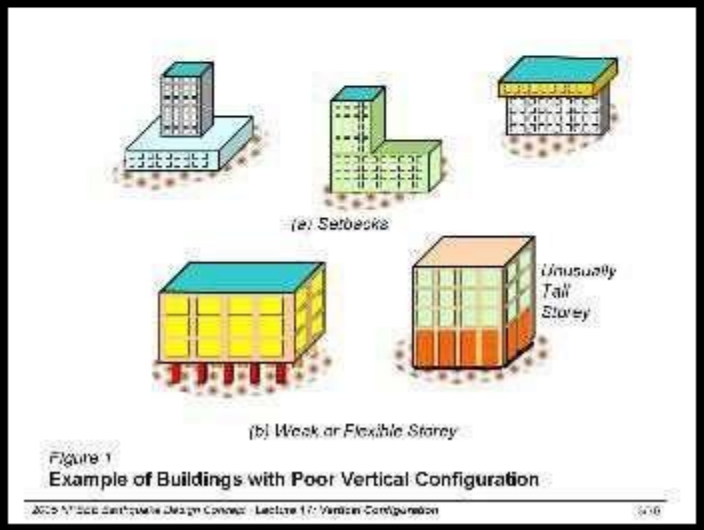


Figure 1
Example of Buildings with Poor Vertical Configuration

QUALITY CONTROL

Special care is needed in construction to ensure that the elements meant to be ductile are indeed provided with features that give adequate ductility.

Thus, strict adherence to prescribed standards of construction materials and construction processes is essential in assuring an earthquake-resistant building.

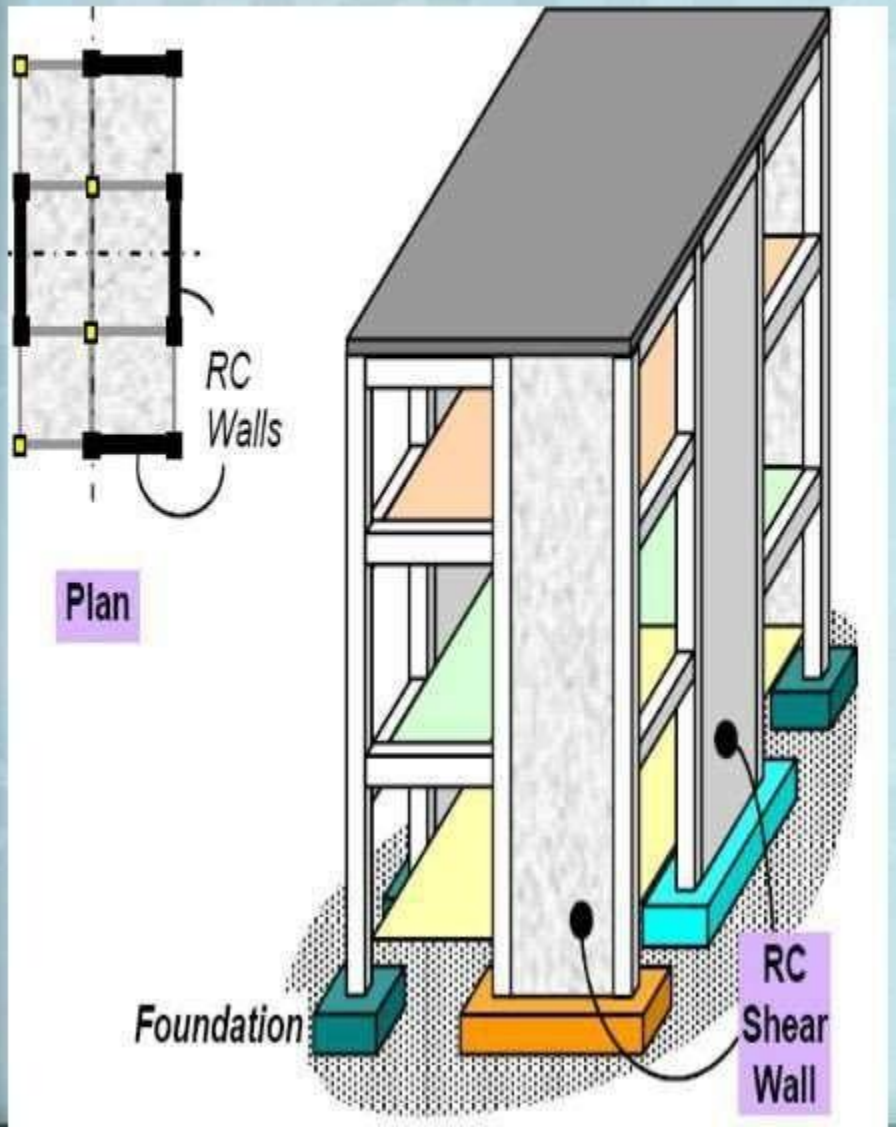
ELEMENTS OF GOOD QUALITY CONTROL

1.Regular testing of construction materials at qualified laboratories (at site or away)

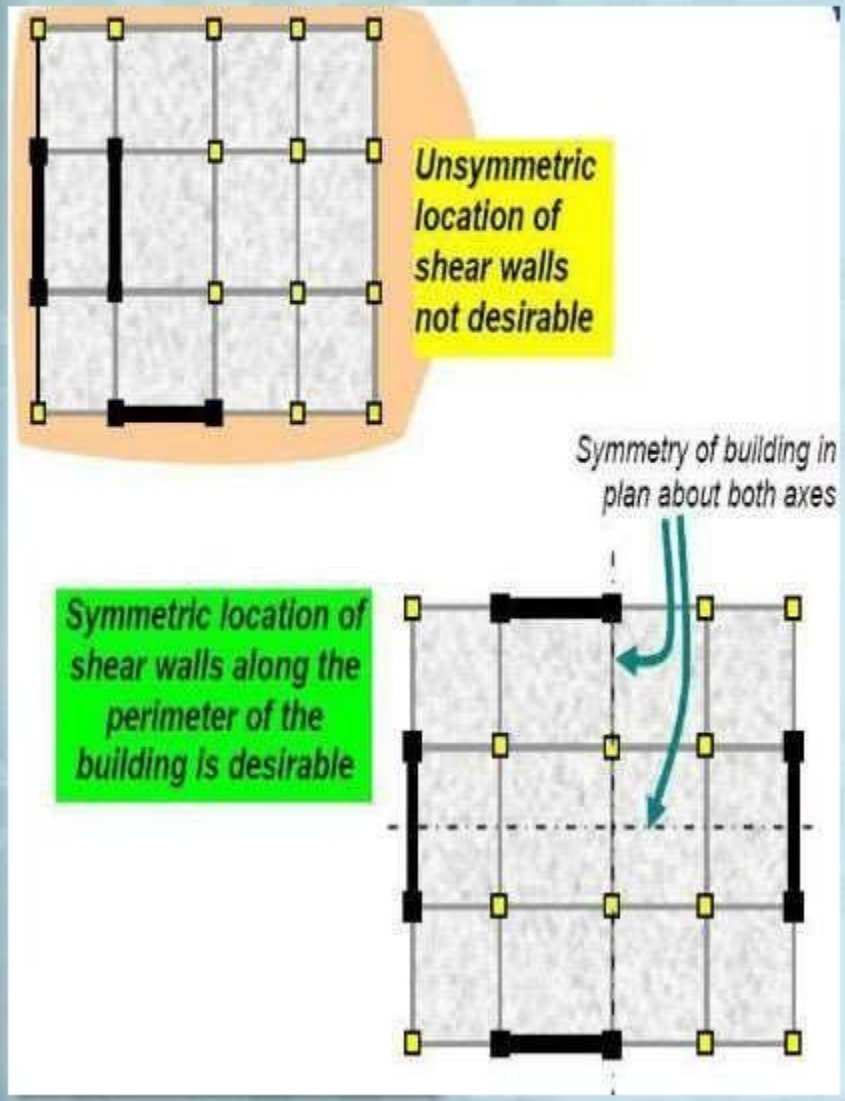
2. Periodic training of workmen at professional training houses, and

3. On-site evaluation of the technical work

SHEAR WALL



- Vertically oriented wide beams
- It carries seismic loads down to the bottom of foundation
- Provides large strength and stiffness to buildings
- Thickness generally varies from 150mm to 400mm in high rise buildings.



- Should be symmetrical in plan along both the axes
- The opening provided in shear walls should be symmetrical
- Effective when located along the exterior perimeter of building

ADVANTAGES OF SHEAR WALLS

- Efficient in terms of:-
  - Cost
  - Effectiveness
  - Construction

- Helps in minimizing the effect on non-structural elements. E.g. Glass, Windows

- It is said that:-

"We cannot afford to build concrete buildings meant to resist severe earthquakes without SHEAR WALL"

EARTHQUAKE RESISTING STRUCTURES TECHNIQUES

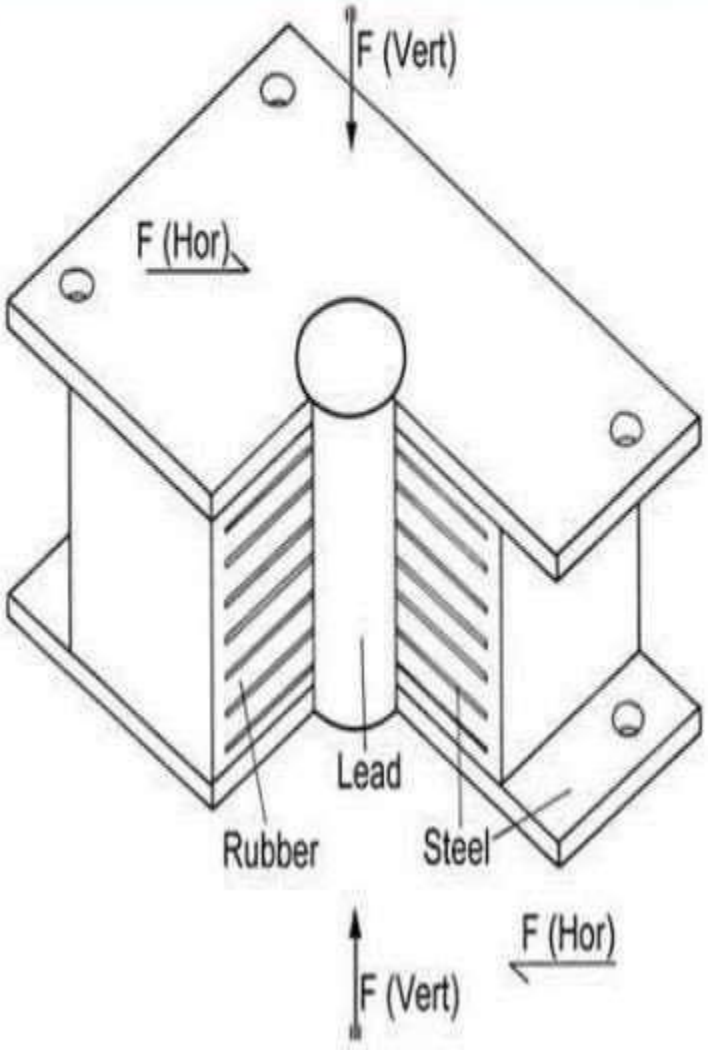
- Base Isolation Method
- Energy Dissipation Device
  - (Seismic Dampers)
- Keeping Building Up thrust

BASE ISOLATION

Figure 13
Piers with the lead-rubber bearings at Bhuj District Hospital

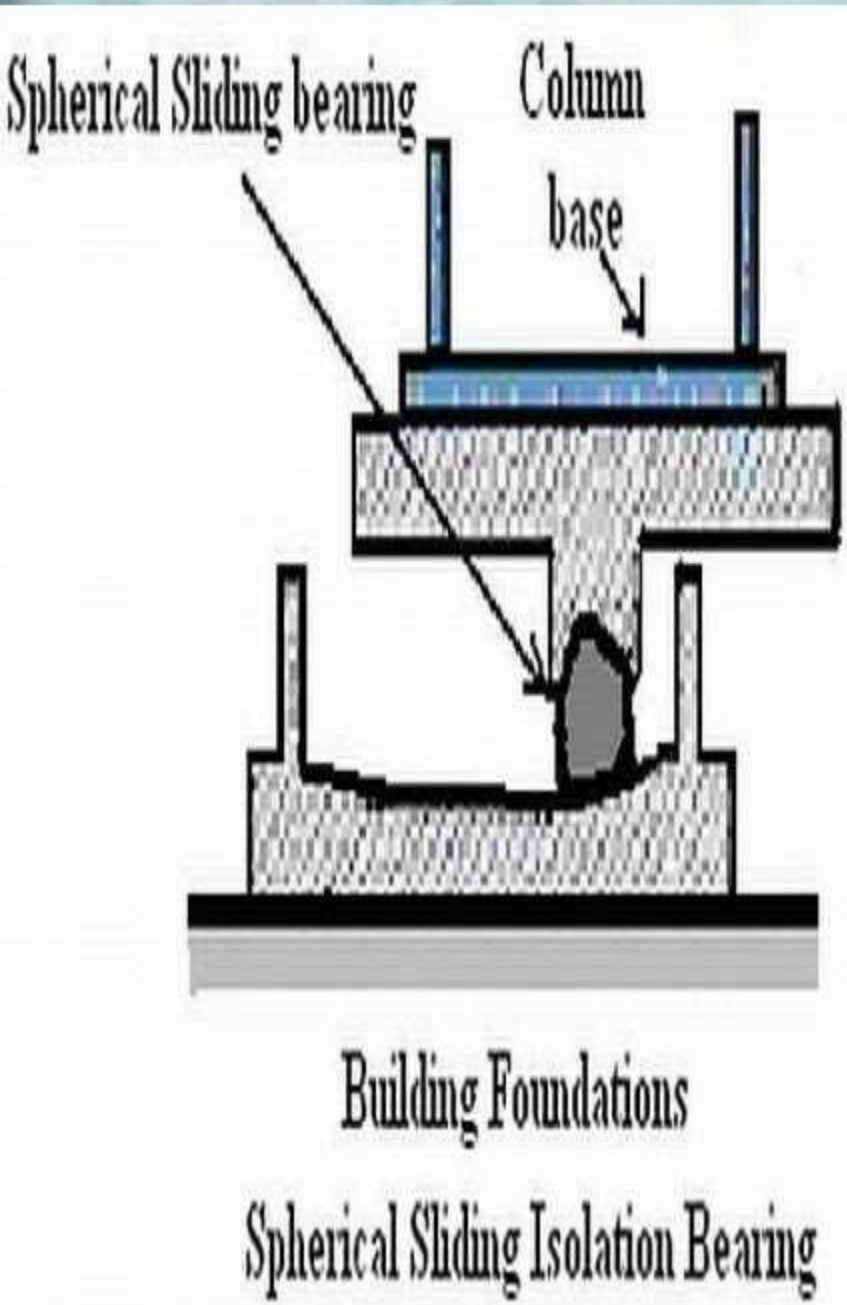
- Introduces flexibility to the structures
- Building is rested on flexible pads (Base Isolators)
- When earthquake strikes the building does not moves
- It is suitable for hard soil only

TYPES OF BASE ISOLATOR



- ***Lead-Rubber Bearing:-***

  - Frequently used for base isolation
  - made from layers of rubber sandwiched together with layers of steel
  - Very stiff and strong in the vertical direction
  - Flexible in horizontal direction.



➢ Spherical Sliding Isolation:-

- ❖ It uses bearing pads that have a curved surface and low-friction materials similar to Teflon
- ❖ During an earthquake the building is free to slide both horizontally and vertically
- ❖ It will return to its original position after the ground shaking stops.

BASE ISOLATION IN INDIA

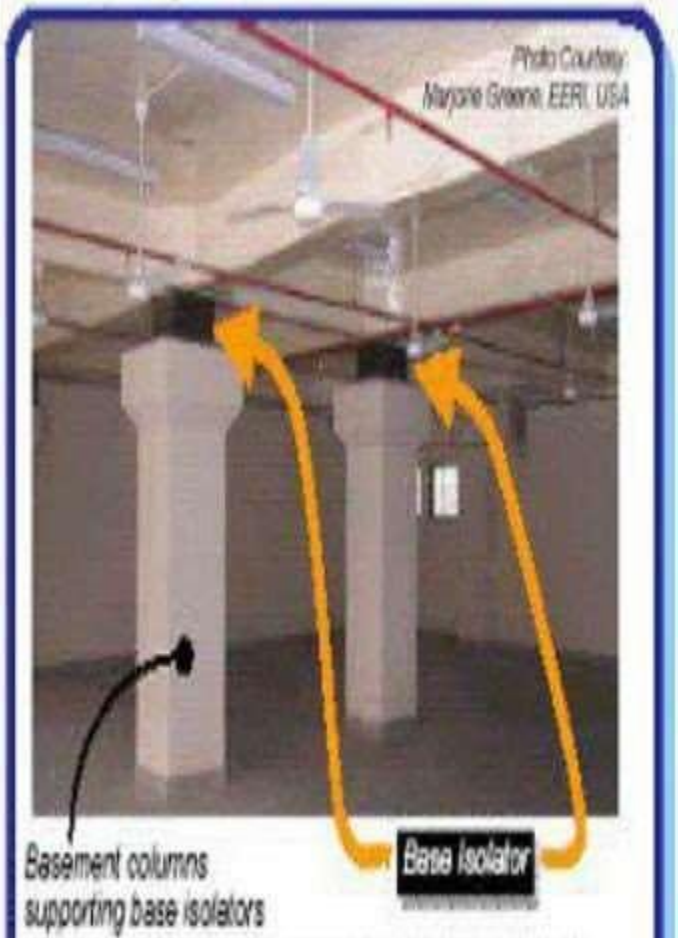
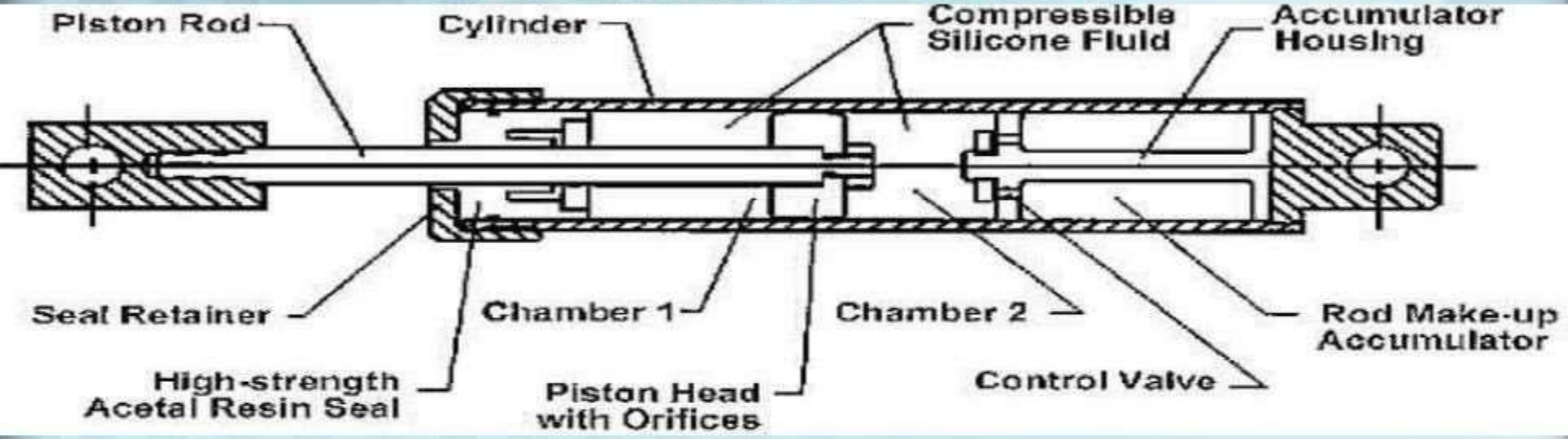


Figure 2: View of Basement in Bhuj Hospital building – *built with base isolators after the original District Hospital building at Bhuj collapsed during the 2001 Bhuj earthquake.*

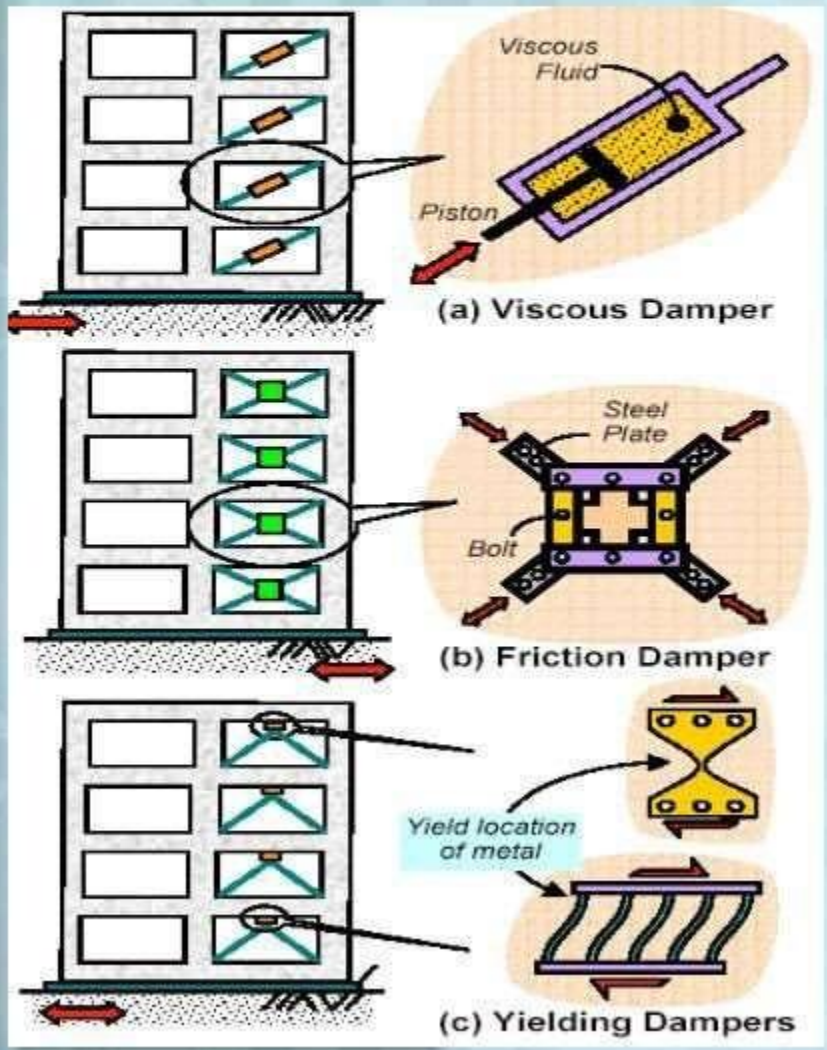
- In India base isolation technique was first demonstrated after 1993 Killari EQ
- Two single storey building were built with rubber base isolators resting on hard ground
- The four storey bhuj hospital building was built with base isolation technique after 2001 bhuj EQ

ENERGY DISSIPATION DEVICE-SEISMIC DAMPERS



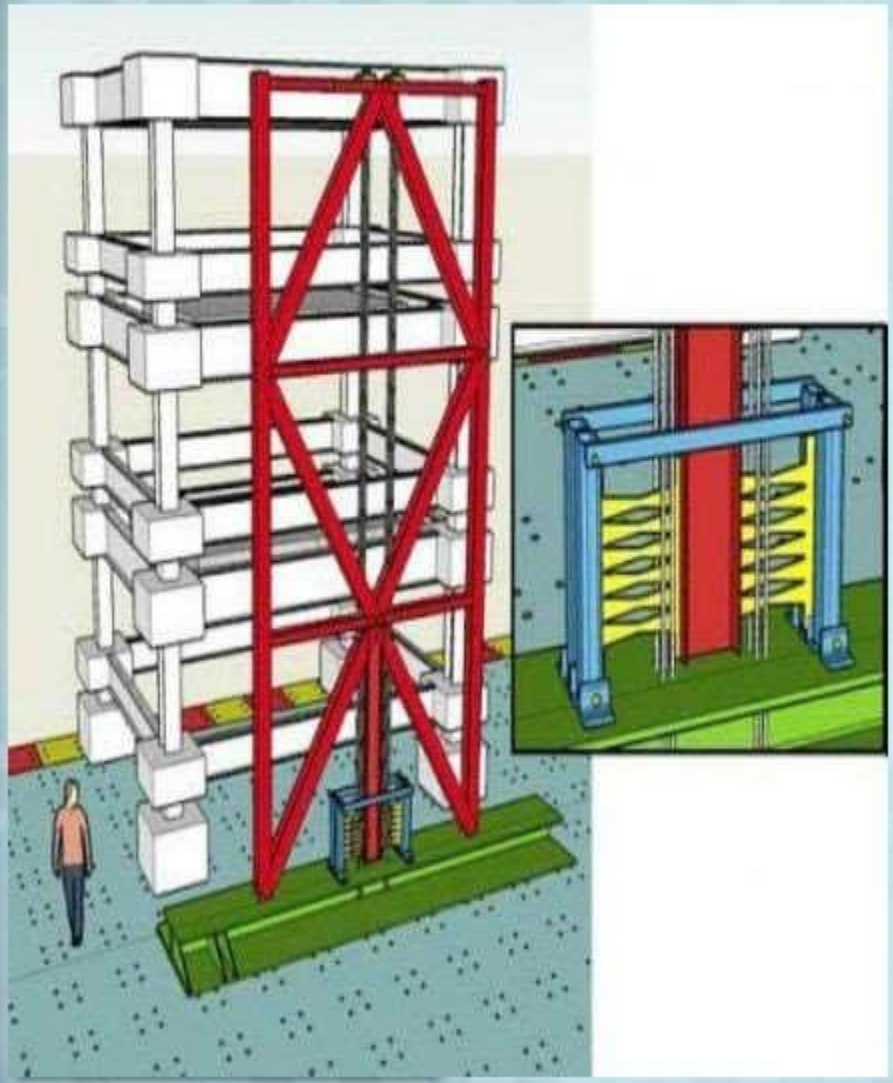
- These are used in place of structural elements such as diagonal braces
- Acts like the hydraulic shock absorbers in cars
- When seismic energy is transmitted through them, dampers absorb part of it, and thus damp the motion of the building.

TYPES OF SEISMIC DAMPERS



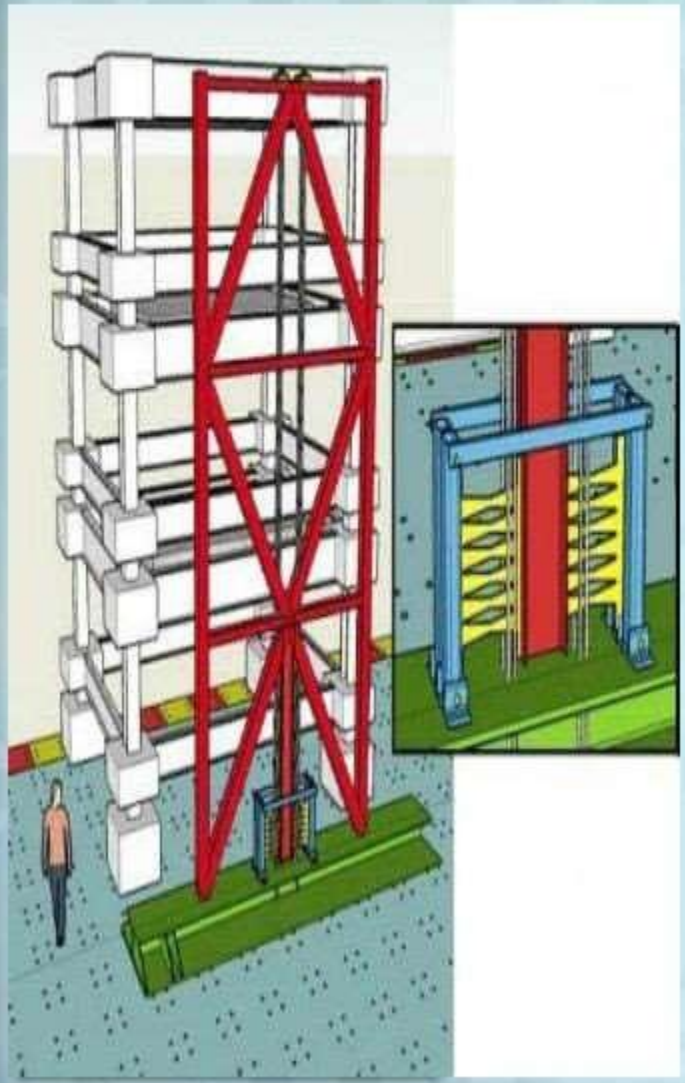
- **Viscous Dampers** *(energy is absorbed by silicone-based fluid passing between piston cylinder arrangement)*
- **Friction Dampers** (energy is absorbed by surfaces with friction between them rubbing against each other),
- **Yielding Dampers** (energy is absorbed by metallic components that yield).
- **Viscoelastic Dampers** (energy is absorbed by utilizing the controlled shearing of solids)

KEEPING BUILDING UP-RIGHT



- Recently discovered technique of Japan
- It has found to be survived even in extreme earthquakes

CONCEPT



- When the quakes strikes the system dissipates energy in the building cores and exteriors
- The frames are free to rock up and down within fittings fixed at their bases

IS CODES

IS 1893 (Part I), 2002, *Indian Standard Criteria for Earthquake Resistant Design of Structures* (5th Revision)

IS 4326, 1993, *Indian Standard Code of Practice for Earthquake Resistant Design and Construction of Buildings* (2nd Revision)

IS 13827, 1993, *Indian Standard Guidelines for Improving Earthquake Resistance of Earthen Buildings*

IS 13828, 1993, *Indian Standard Guidelines for Improving Earthquake Resistance of Low Strength Masonry Buildings*

IS 13920, 1993, *Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces*

CONCLUSION

While Earthquake Are Inevitable, Each earthquake Need Not Convert
Into A Disaster... As What Comes In Between Is
The Culture of Safety And Prevention

Let us Work Together to Build a Culture of Prevention !


Thank
You