URP-302: Urban Hazard and Risk Management

Topic 4: Earthquake

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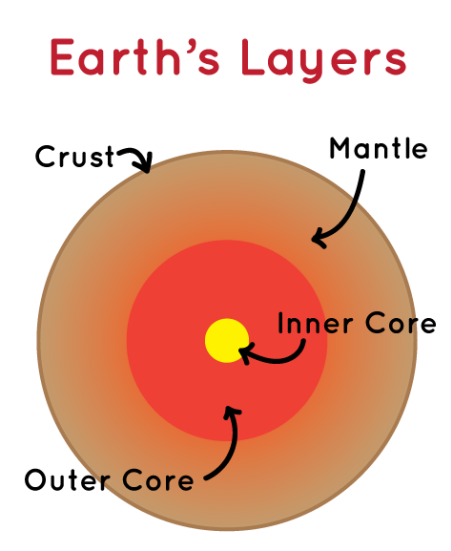
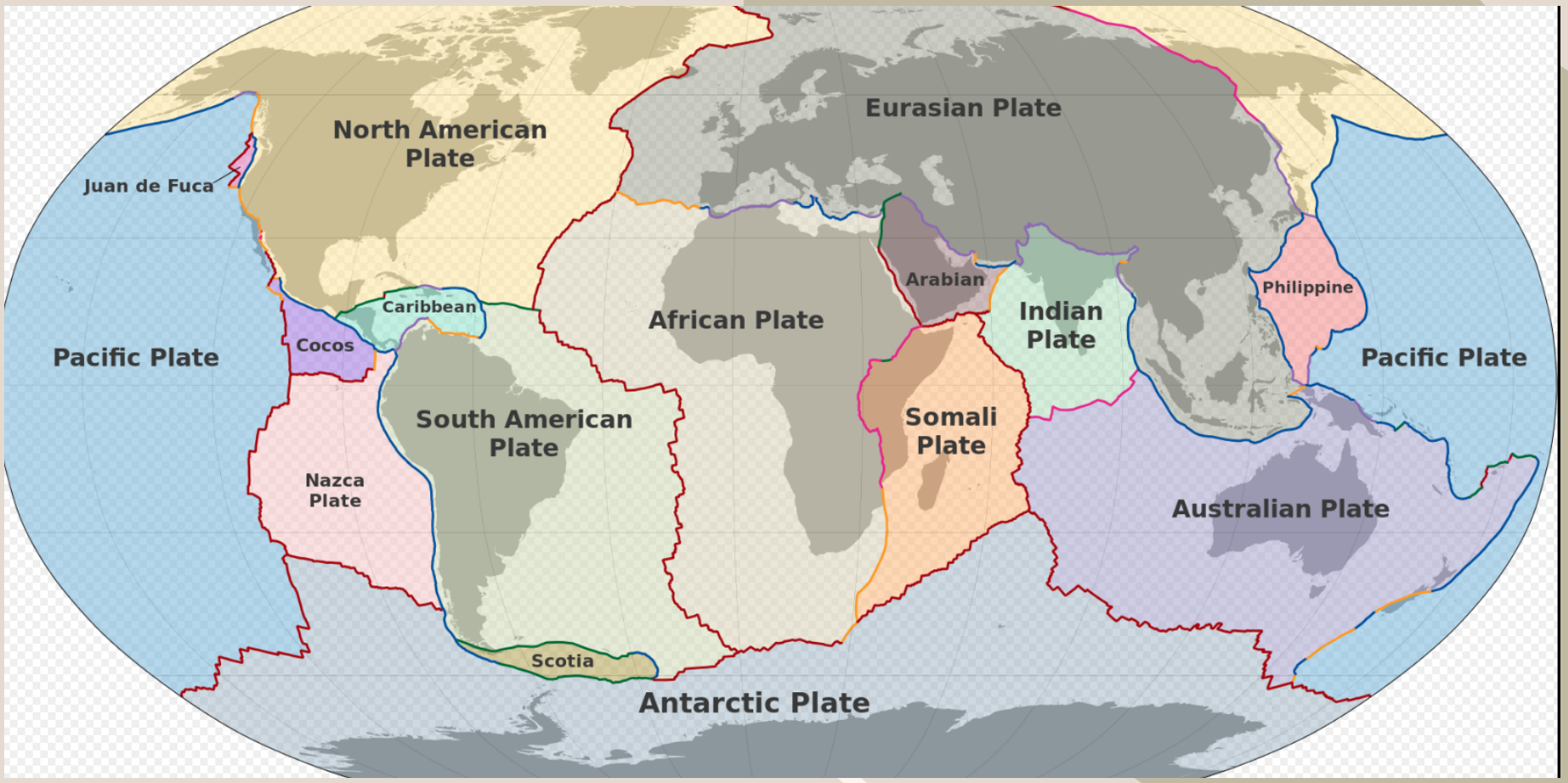
What is Earthquake?

An earthquake is a natural event caused by a **sudden release of extreme energy** from the earth's crust, resulting in **shaking and displacement** of ground along with the creation of **seismic waves.**

- Earthquake shaking may cause loss of life and destruction of property. Buildings may fall or sink into the soil.
- Rocks and soil may move downhill at a rapid rate.

Earth Layers and Tectonic Plates



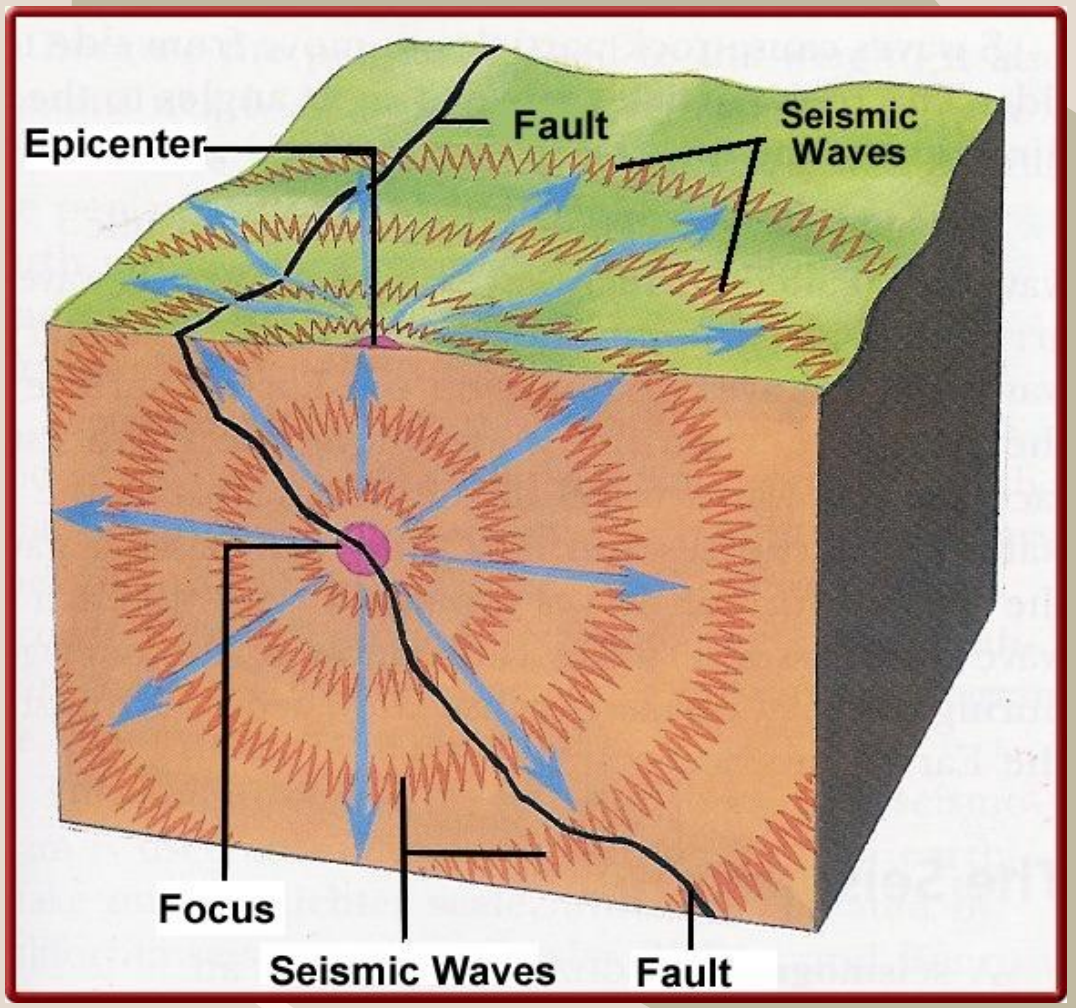


- Due to the semi-solid state of the mantle, the tectonic plates (pieces of the earth's crust) are constantly moving.
- This tectonic movement causes the earthquake.

Definition

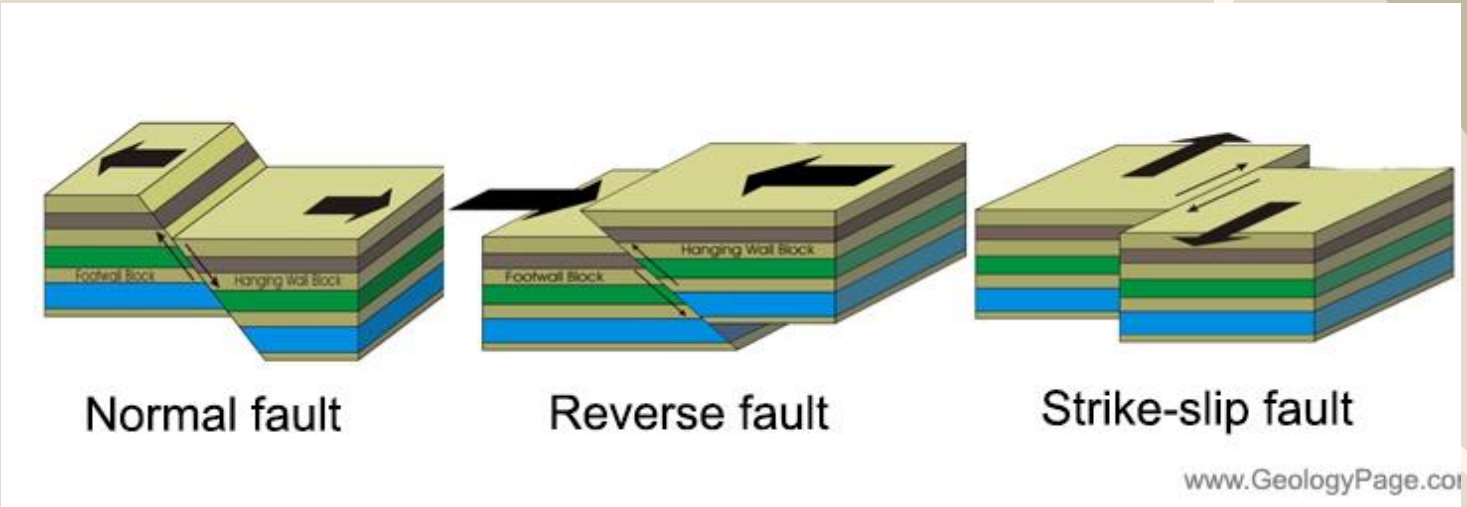
- **Earthquake:** Vibration of the earth produced by rapid release of energy.
- **Hypocenter/Focus:** Point inside the earth where the earthquake originates
- **Epicenter:** Spot on the earth's surface directly above the focus.
- **Seismic waves:** Energy moving outward from the focus of an earthquake

https://youtu.be/RqqqSnaTfQo?feature=shared



Types of Fault

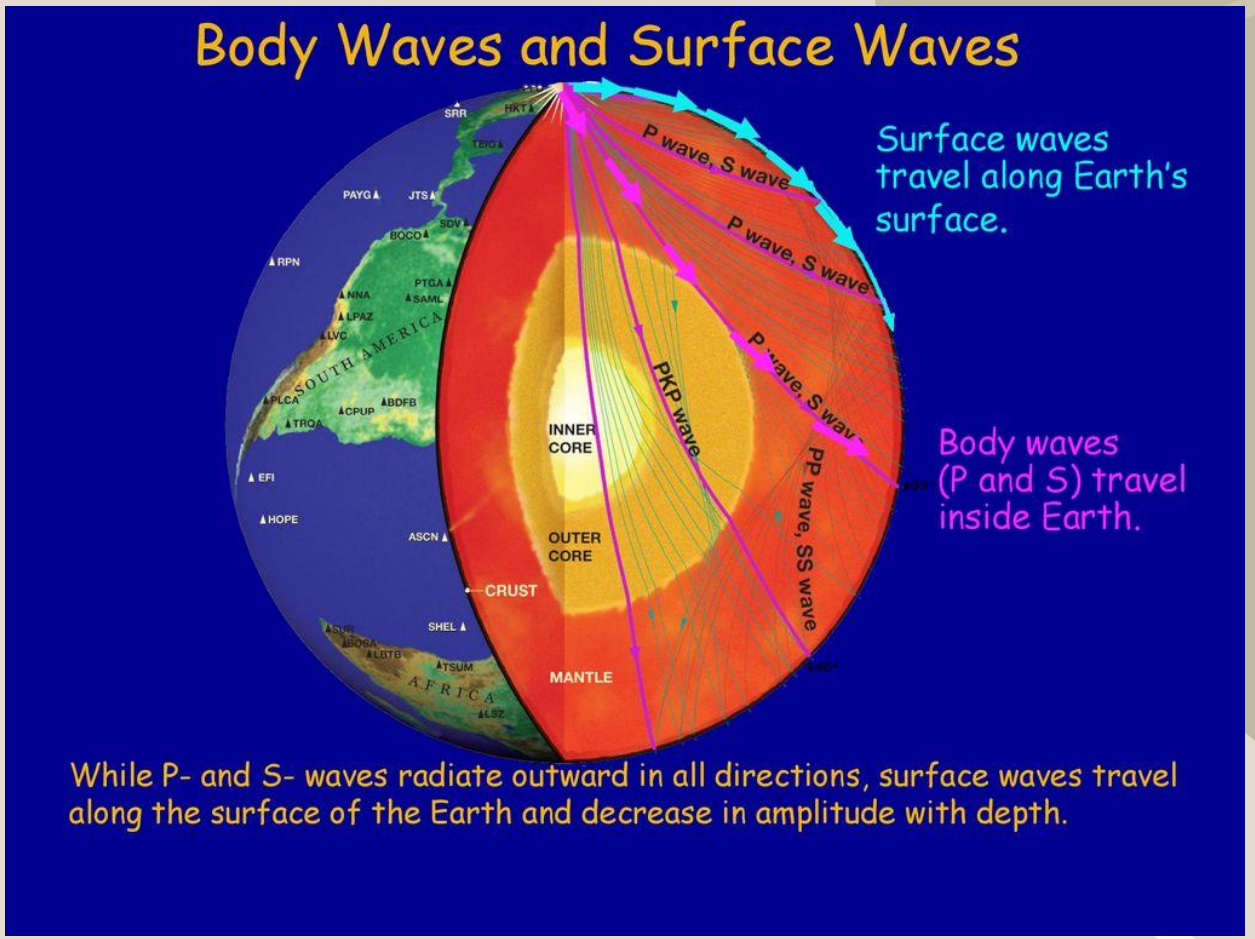
- **Normal fault:** It is caused due to tension forces. The hanging wall moves downward relative to the footwall.
- **Reverse fault/ Thrust fault:** It is caused due to compression force. The hanging wall moves upward relative to the footwall.
- **Strike-slip fault:** It is caused by shear force. The ground is shifted parallel to the earth's surface due to horizontal shear forces.



- https://youtu.be/r5fS__4MA44

Seismic Waves

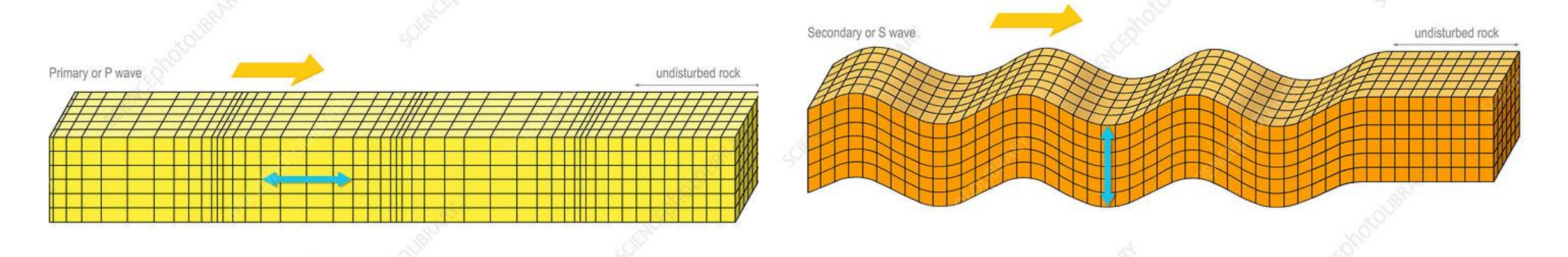
Two types of waves are generated during an earthquake: **Body waves and Surface waves**



Seismic Waves

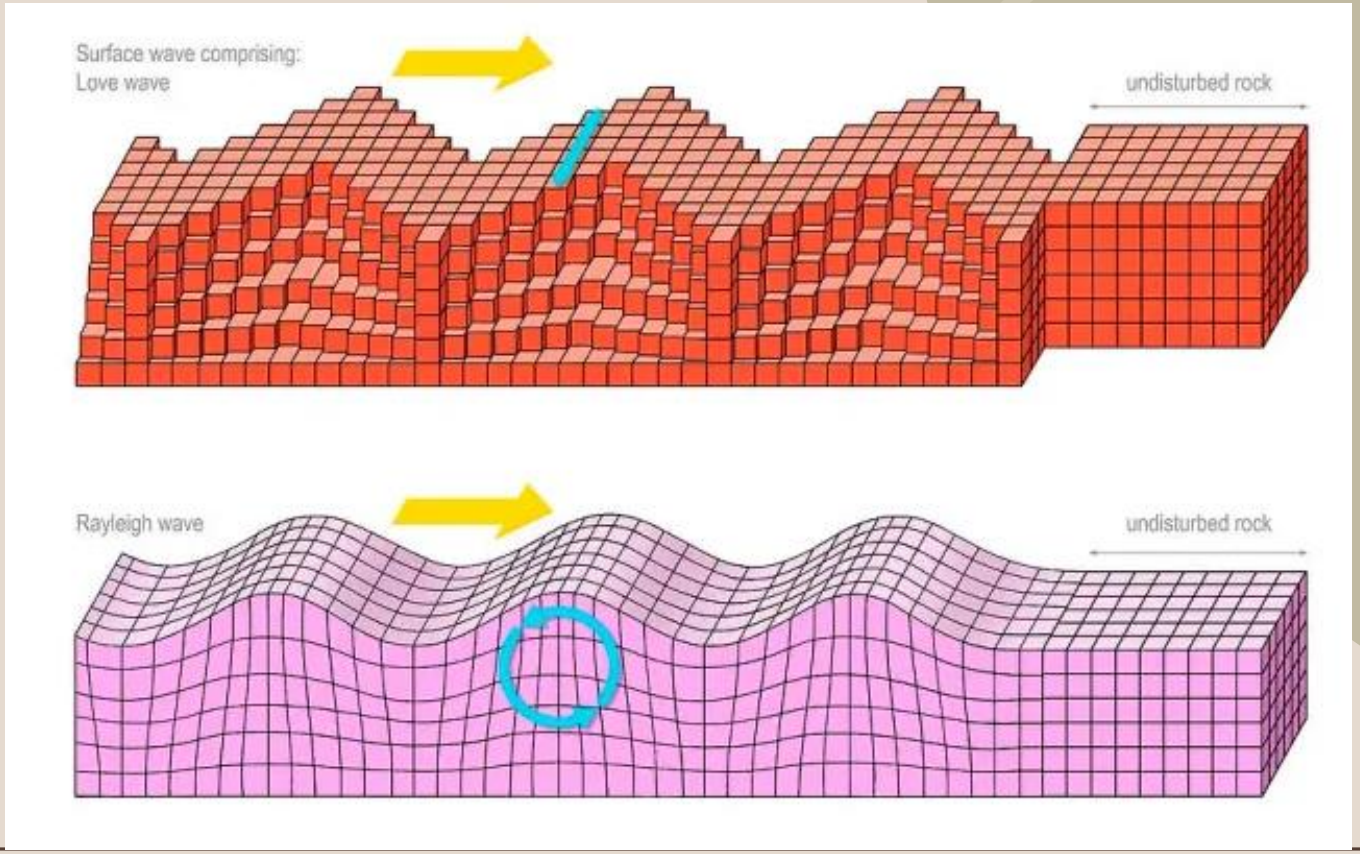
Two types of waves are generated during an earthquake:

- **Body wave:** it travels through the Earth's inner layer
  - **P-wave (Primary wave):** Primary waves are compressional/ push-pull waves. They propagate parallel to the direction of the wave.
  - **S-wave (Secondary wave):** This wave is known as shear wave. It propagates perpendicular to the direction of the wave.
- https://i0.wp.com/geologyscience.com/wp-content/uploads/2023/11/Primary-Waves-P-Waves.gif?resize=640%2C453&ssl=1



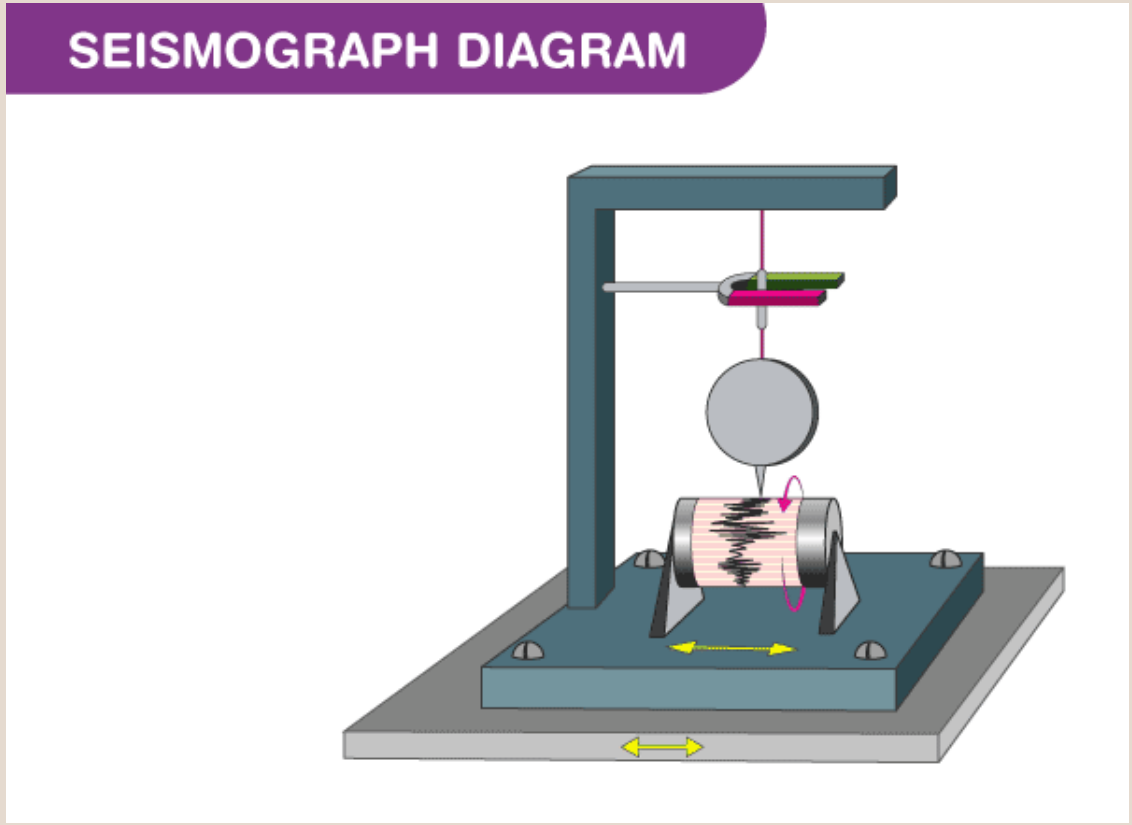
Seismic Waves

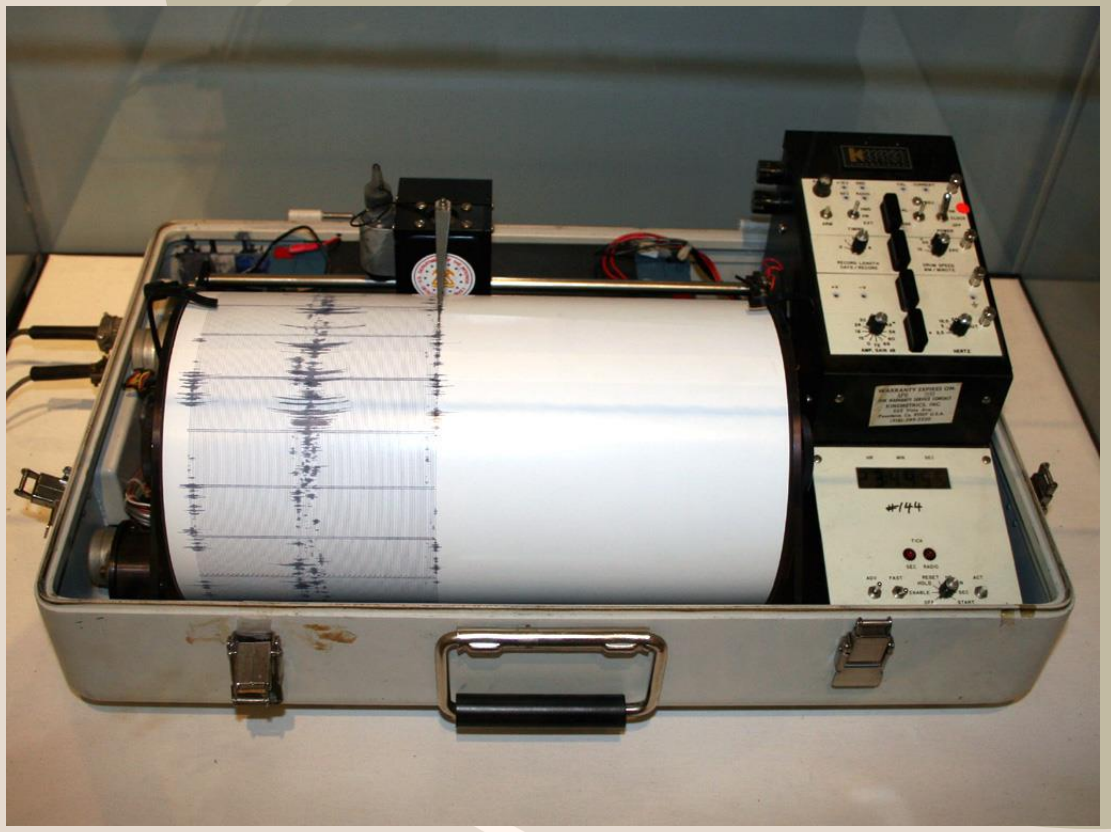
- **Surface Wave:** it travels along the earth's surface
  - **Love wave:** It has pure side-to-side/ horizontal motion.
  - **Rayleigh wave:** It involves both vertical and horizontal motion. It creates a rolling motion.



Measuring Earthquake

- **Seismometer:** Instrument that detects seismic waves
- **Seismograph:** Record the intensity and amplitude of seismic waves.
- https://youtu.be/pmf4TXroRJM?feature=shared





Magnitude of Earthquake

- The intensity and strength of an earthquake is measured on the **Richter Scale**, invented by Charles Richter in 1935.
- It is a logarithmic scale. It means that each level in the scale is **10 times stronger** than the previous level.
- The maximum amplitude recorded in a seismograph at 100 kilometers from the epicenter is used to calculate the scale.

Effects of Earthquake

Structural Damage

Damaged road and rail tracks

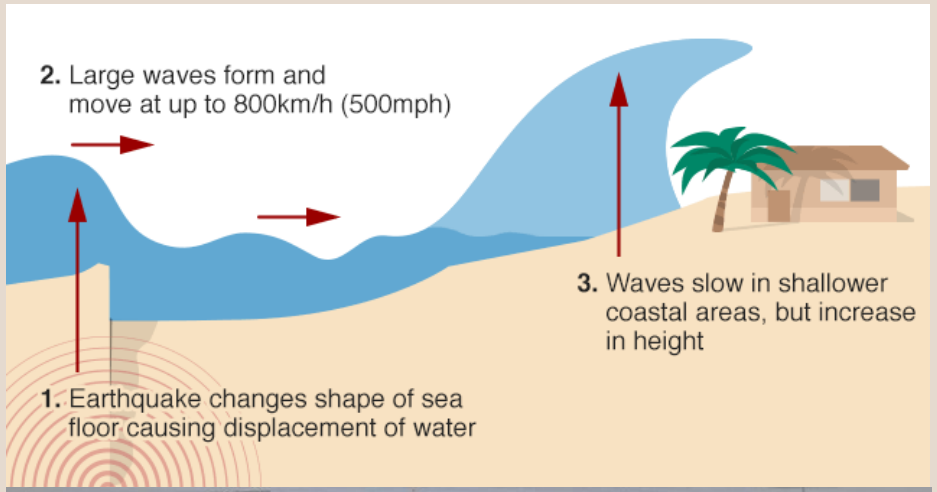
Effects of Earthquake

Landslide

Avalanches /snowslide

Fire Hazard (due to broken electric and gas line)

Effects of Earthquake



Tsunami

October 9, 2005

September 15, 2002

Change in water course
(Neelum river, Kashmir)

Earthquake Safety Measures

Earthquake Resilient Building

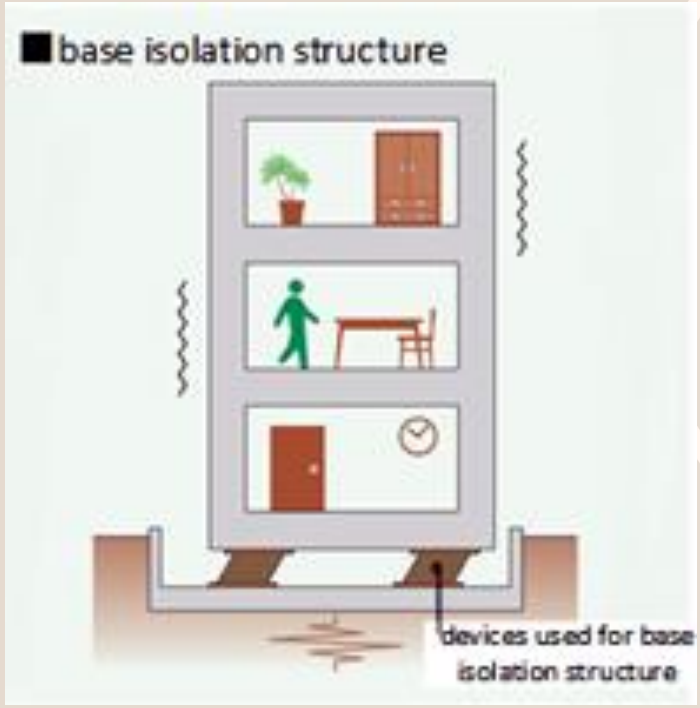
- When an earthquake occurs, it sends shock waves throughout the ground in short, rapid intervals that extend in all directions. Buildings are generally equipped to handle vertical forces, but they cannot traditionally handle side-to-side forces emitted from earthquakes.
- The difference in movement between the bottom and top of the buildings causes them to collapse.
- Methods of creating earthquake-proof buildings:
  - Creating a flexible foundation
  - Counter forces with damping
  - Shield building from vibrations
  - Reinforcing building structure
  - Earthquake resilient material

Read this: https://www.bigrentz.com/blog/earthquake-proof-buildings

Earthquake Resilient Building

1. **Flexible Foundation:** .In this method, the base is isolated from the ground. The building is constructed on top of flexible steel and rubber pads. When an earthquake hits, only the base moves and the structure remains steady.

https://acropolis-wp-content-uploads.s3.us-west-1.amazonaws.com/flexible-foundation-1.mp4



Earthquake Resilient Building

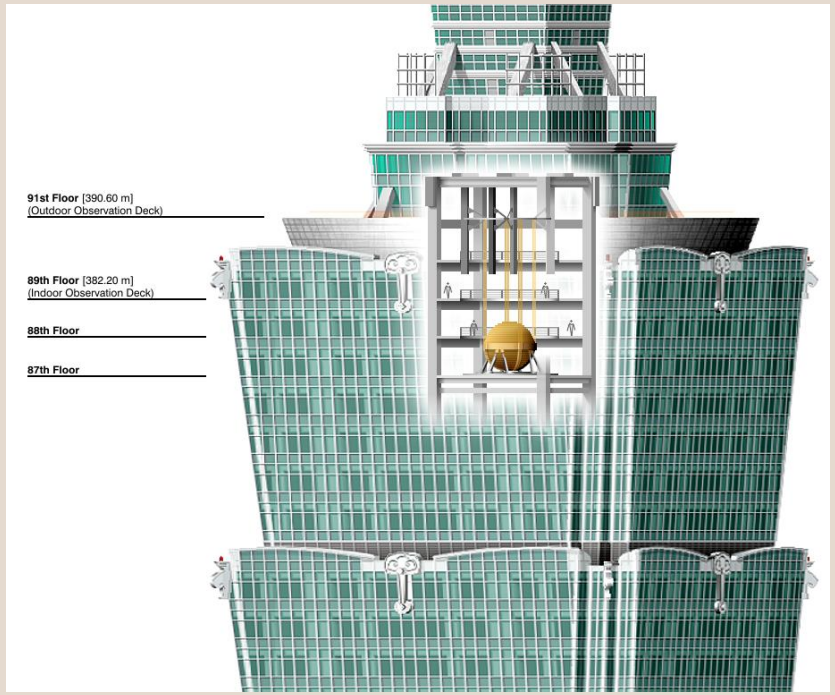
2. Counter Forces with Damping: It works similarly like a shock absorber. It can be done in two ways: Vibrational Control Device & Pendulum Power.

- **Vibrational Control Device:** In this method, dampers are placed between columns and beams. Each damper consists of a cylinder with a piston, filled with silicone oil. When an earthquake hits, the building vibration transfers into the piston and pushes against the oil.
- https://acropolis-wp-content-uploads.s3.us-west-1.amazonaws.com/vibration-control.mp4
- As a result, the kinetic energy is converted to heat energy, and dissipates the force.

Earthquake Resilient Building

2. Counter Forces with Damping:

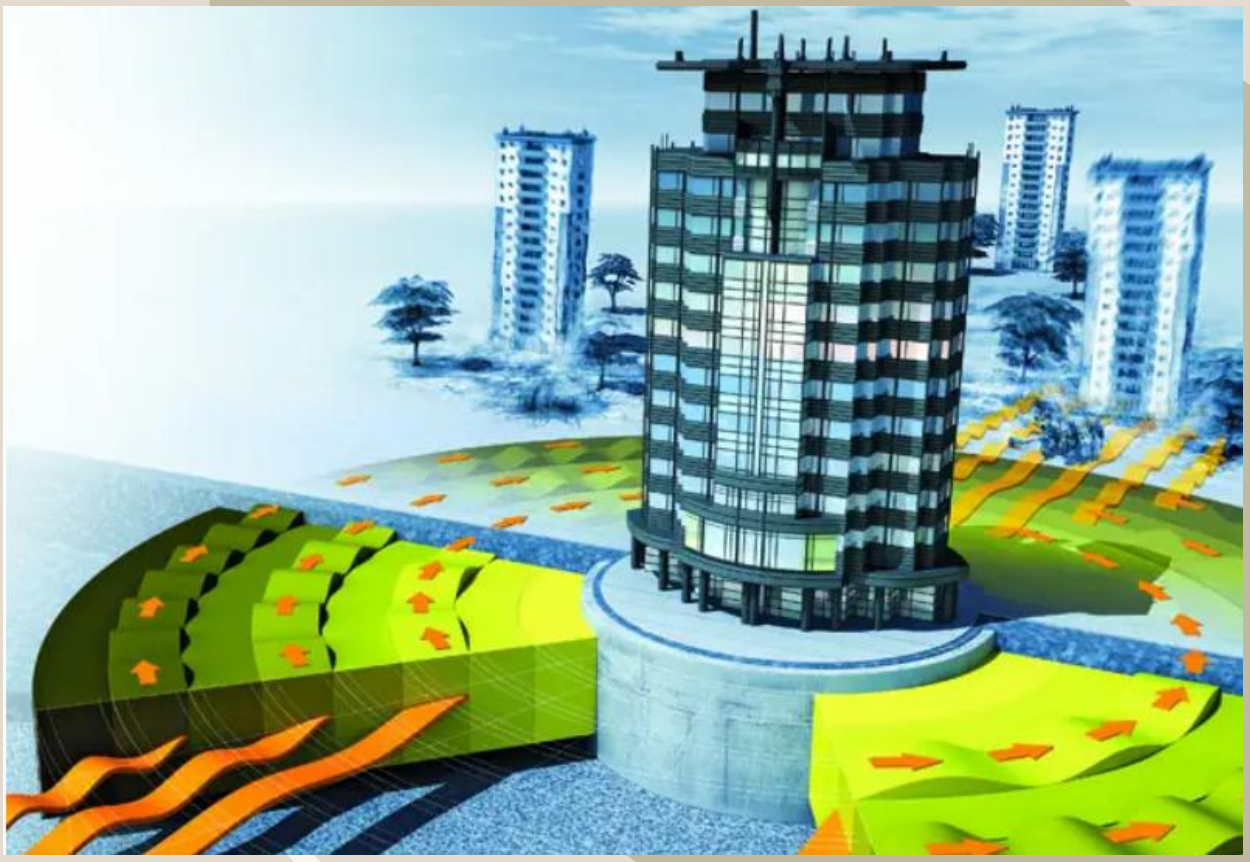
- **Pendulum Power:** It is usually used in skyscrapers. A large ball/ weight is suspended from steel cables. When the building begins to sway, the ball moves in the opposite direction and stabilizes the building.
- https://acropolis-wp-content-uploads.s3.us-west-1.amazonaws.com/pendulum-1.mp4



Earthquake Resilient Building

3. Shield building from vibration:

- In this method concentric rings of plastic and concrete are buried at least 3 feet beneath the foundation of the building.
- These rings channel the seismic waves away from the building and dissipate into the ground.

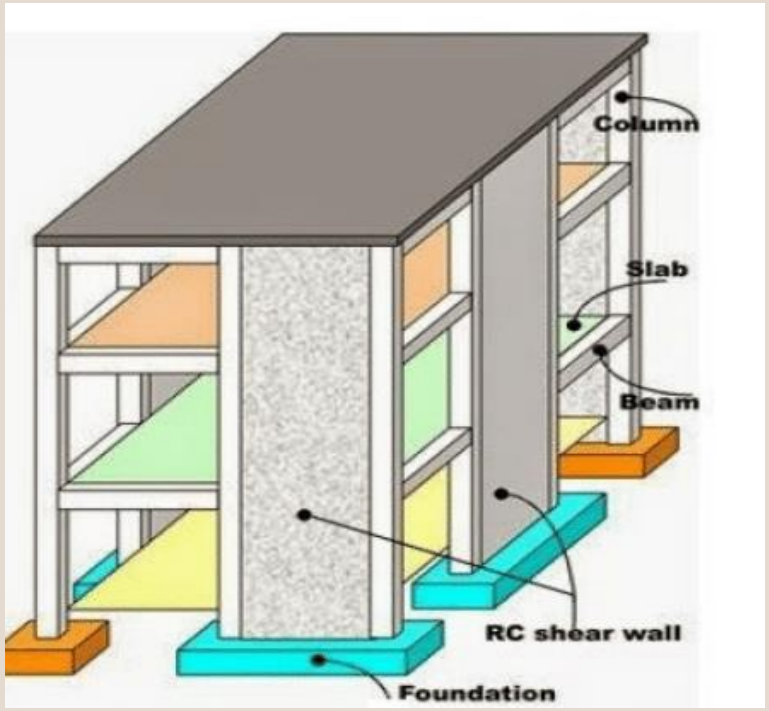


Earthquake Resilient Building

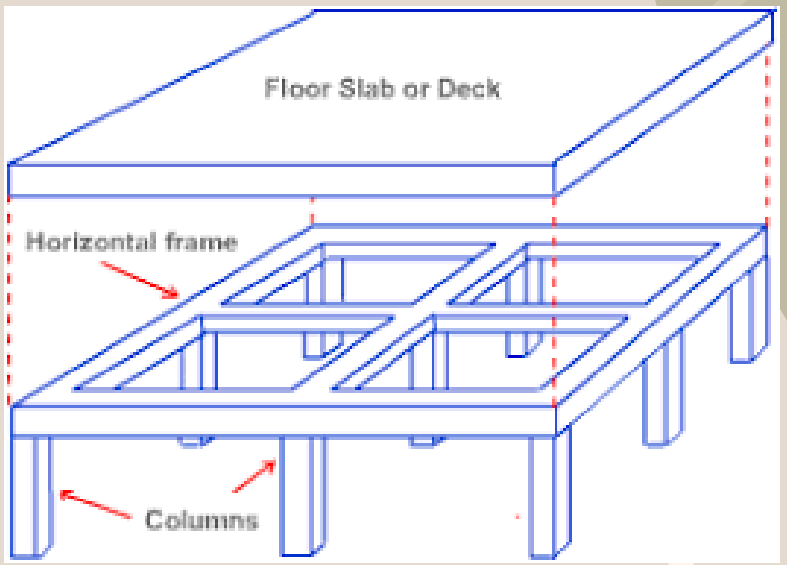
4. Reinforce building structure:

- To withstand collapse, buildings must redistribute the forces. Shear walls, cross braces, diaphragms etc. can help to redistribute the force.
- Shear walls help the building to keep its shape during an earthquake. These walls are often supported by diagonal cross braces.
- Cross bracing helps to increase load capacity.
- Diaphragms distribute forces between horizontal and vertical structures.

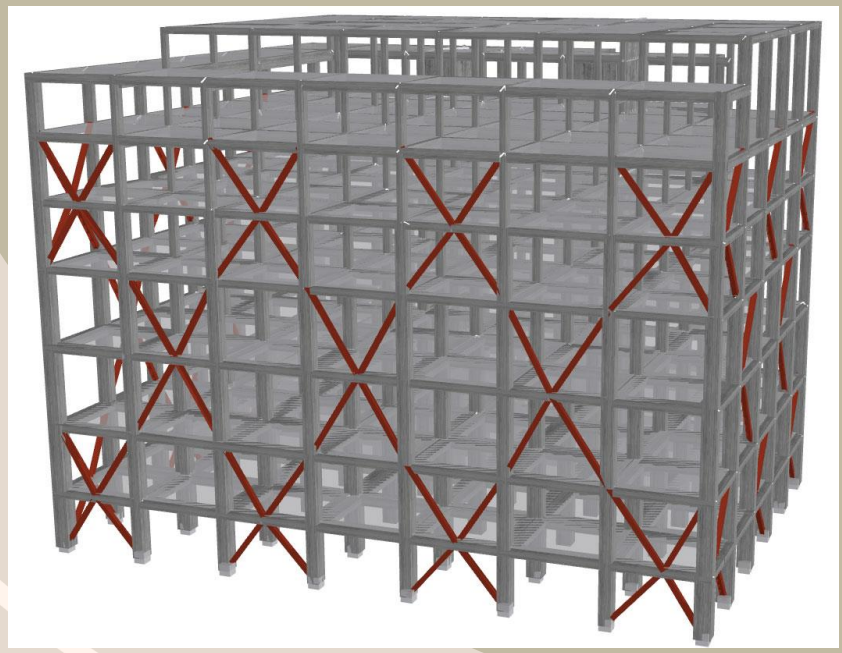
Earthquake Resilient Building



Shear wall



Diaphragm



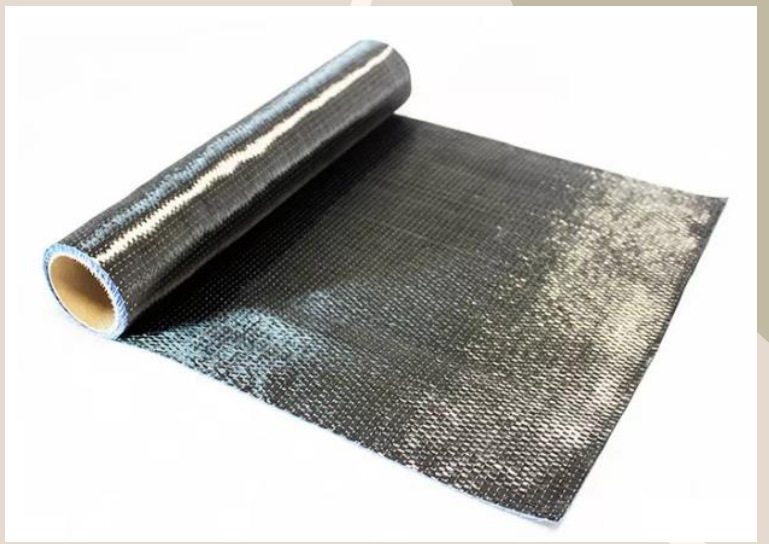
Cross braces

Earthquake Resilient Building

5. Earthquake Resistant Materials:

- **Steel** and **timber** are more ductile materials and allow buildings to bend without breaking.
- **Shape memory alloy**: can endure the strain and revert to its original shape
- **Fiber-reinforced plastic:** made from a variety of polymers — can be wrapped around columns and provide up to 38% added strength and ductility.

Shape memory alloy



Fibre Reinforced Plastic

Thank you