

- (a) Eat healthy food to supply heat to the body and drink non-alcoholic beverages to avoid dehydration.
- (c) Wear several layers of lightweight and warm clothes, rather than one layer of heavy clothing. The outer garments should be tightly woven and water-repellent.
- (d) Keep dry. Change wet clothing frequently to prevent loss of body heat.
- (e) Maintain proper ventilation when using kerosene, heater or coal oven to avoid toxic fumes.
- (f) In case of non availability of heating arrangement, go to public places where heating arrangements are made by administration.
- (g) Cover your head, as most body heat is lost through the top of the head and cover your mouth to protect your lungs.
- (h) Avoid over work. Over exertion can cause heart attack.
- (i) Watch for signs of frostbite: loss of feeling and white or pale appearance on fingers, toes, ear lobes and the tip of the nose.
- (j) Watch for signs of hypothermia (subnormal body temperature): uncontrolled shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness and apparent exhaustion.

2.3. HYDROLOGICAL DISASTERS

(I) Floods

A flood inundates a floodplain. There are different types of floodplains and they are based on the type of flooding that forms them.

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Most floods fall into one of three major categories:

♦ **Riverine flooding:** A watershed is an area that drains into a lake, stream or other body of water. Other names for it are basin or catchment area. Watersheds vary in size. Larger ones can be divided into sub-watersheds. The boundary of a watershed is a ridge or divide. Water from rain and snowmelt are collected by the smaller channels (tributaries) which send the water to larger ones and eventually to the lowest body of water in the watershed (main channel). Channels are defined as features on the ground that carry water through and out of a watershed. They may be called rivers, creeks, streams or ditches. They can be wet all the time or dry most of the time. When a channel receives too much water, the excess flows over its banks and into the adjacent floodplain. Flooding that occurs along a channel is called riverine flooding. What happens in a watershed will affect events and conditions downstream. Terrain helps determine the dynamics of riverine flooding. In relatively flat areas, shallow, slow-moving floodwater may cover the land for days or even weeks.

Overbank flooding occurs when downstream channels receive more rain or snowmelt from their watershed than normal, or a channel is blocked by an ice jam or debris. For either reason, excess water overloads the channels and flows out onto the floodplain.

♦ **Coastal flooding:** Hurricanes and severe storms cause most coastal flooding. Persistent high wind and changes in air pressure push water toward the shore, causing a storm surge which can raise the level of a large body of water by several feet.

♦ **Shallow flooding:** Shallow flooding occurs in flat areas where a lack of channels means water cannot drain away easily. Shallow flood problems fall into three categories: sheet flow, ponding and urban drainage.

- (a) **Sheet flow:** Where there are inadequate or no defined channels, floodwater spreads out over a large area at a somewhat uniform depth in what's called sheet flow.
- (b) **Ponding:** In some flat areas, runoff collects in depressions and cannot drain out, creating a ponding effect. Ponding floodwaters do not move or flow away. Floodwaters will remain in the temporary ponds until they infiltrate into the soil, evaporate or are pumped out. Ponding is especially a problem in glaciated areas, where glaciers carved out depressions; in areas where caves and sinkholes are common, and in other areas where man-made features, such as roads and railroad embankments, have blocked outlets.
- (c) **Urban drainage:** An urban drainage system comprises the ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake or the ocean. Other man-made features in such a system include yards and swales that collect runoff and direct it to the sewers and ditches.

Causes of floods

- (a) Heavy and torrential rains
- (b) Continuous rainfall.
- (c) Highly sinous and meandering courses of river
- (d) Large scale deforestation
- (e) Increased urbanization
- (f) Faulty agricultural practices
- (g) Blocking of natural flow of water.
- (h) Change in landuse pattern.

Effects of Floods: Floods impact on both individuals and communities, and have social, economic, and environmental consequences. The consequences of floods, both negative and positive, vary greatly depending on the location and extent of

flooding, and the vulnerability and value of the natural and constructed environments they affect.

Positive effects

- (a) Soil of the flood plains is renewed and enriched by nutrients.
- (b) Sedimentation over a large area replenishes the top soil.
- (c) Floods provide sand for building materials.

Negative Effects: Negative effects generally outweigh the positive effects of floods. These are

- (a) **Loss of Human life:** Hundreds and thousands of people lose their lives after a single flood event by drowning, structure collapse and water borne diseases.
- (b) **Destruction of human settlements:** People become homeless after a flood event because of entering of flood water in their homes.
- (c) **Agricultural Damage:** Large scale agricultural land becomes useless and devastated after floods. This affects the economy as well as future food supplies.
- (d) **Loss of property:** Floods damage the built structures like roads, bridges, railway network, communication systems etc. There is a considerable loss of property.
- (e) **Environmental effects:** After the flood event there is left behind a lot of pollutants, solid waste, mud, garbage etc which poses a environmental hazard.

Flash flooding: Flash floods are short-term events, occurring within 6 hours of the causative event (heavy rain, dam break, levee failure, rapid, snowmelt and ice jams) and often within 2 hours of the start of high intensity rainfall. A flash flood is characterized by a rapid stream rise with depths of water that can reach well above the banks of the creek. A severe storm that drops much rainfall in a short time can generate a flash flood. All flash floods strike quickly and end swiftly. Areas with steep

slopes and narrow stream valleys are particularly vulnerable, as are the banks of small tributary streams. In hilly areas, the high-velocity flows and short warning time make flash floods hazardous and very destructive. In urban areas, flash flooding can occur where impervious surfaces, gutters and storm sewers speed runoff. Flash floods also can be caused by dam failure, the release of ice-jam flooding, or collapse of debris dams.

Causes of Flash Floods: The causes of flash floods can be broadly classified into two main groups; these are either meteorological (intense precipitation) or geo-environmental.

Intense rainfall flash floods: Intense rainfall is the most common cause of flash flooding. It is associated with three meteorological phenomena: cloudbursts, stationary monsoon troughs, and monsoon depressions.

(a) **Cloudbursts:** A cloudburst is an extreme form of precipitation, sometimes with hail and thunder, which normally lasts no longer than a few minutes but is capable of creating flood conditions. Cloudbursts occur when air masses are heated intensely and rise rapidly to form thunderclouds. When these clouds interact with the local topography, they often move upwards, especially if the atmospheric flow is perpendicular to the topographic features. Intense precipitation typically involves some connection to monsoon air masses, which originate in the tropics and are typically warm and heavily laden with moisture. A lack of wind aloft prevents the dissipation of thunderclouds and facilitates concentrated cloudbursts which typically deposit precipitation in a small localised area.

(b) **Monsoon trough:** Intense rainfall can also be caused by the prolonged stationary positioning of an inter-tropical convergence zone (ITCZ), commonly called a monsoon

trough. An ITCZ is an elongated zone or low pressure system which typically sits along the mountain range.

- (c) **Monsoon depressions:** Intense monsoon depressions seldom reach the mountain areas during the monsoon season. They are occasionally caused by strong westerly waves over northern Kashmir, which cause heavy to very heavy rainfall in the lower Kashmir and Jammu Valley, resulting in devastating flash floods. Westerly waves moving across Kashmir and the northern parts of Pakistan can strengthen the monsoon depression. In July 2005, this type of a depression moved into Punjab and Kashmir and caused heavy rainfall in the upper catchment of the Chenab River. Since the mountain catchments are very steep, the river flooded quickly.

Geo-environmental causes of flash floods: Geo-environmental factors can also precipitate flash flooding. The main geo-environmental factors to causes flash floods are the outburst of a landslide dam and the outburst of a glacial lake.

- (a) **Outburst of landslide dams:** The mountain regions are prone to recurrent and often devastating landslides because of the steep and unstable slopes. Excessive precipitation and earthquakes can cause the slopes to landslide. The landslides and debris flow can form temporary dams across river courses, impounding immense volumes of water. A landslide dam outburst flood (LDOF) can occur when these makeshift dams are overtopped or water breaks through.
- (b) **Outburst of glacial lakes:** Glacial lakes form as glaciers recede, and their formation is directly related to climate variability. When glaciers recede they leave behind large voids that are filled with melt-water; these are moraine-dammed glacial lakes. Moraine dams are structurally weak and unstable; they undergo constant changes due to slope failures, slumping, and

other such effects. When a moraine dam fails catastrophically the result is a glacial lake outburst flood (GLOF).

Impacts of Flash floods: Flash flood waters flow at high speed and carry large amounts of debris. These debris laden waters can cause the loss of life and can sweep away critical infrastructure that is the lifeline of mountain communities. Some of the destruction which is caused by flash floods is immediately apparent while some subtly undermines existing structures and the true damage is not seen until some later time. Some of the destruction is short term while some has long term detrimental effects on the environment and the socio-economic life of communities.

- (a) **Socioeconomic Impacts:** Landslides and debris flows can have major socioeconomic impacts and can affect people, their homes, possessions, industrial establishments, and lifelines such as highways, railways, and communication systems. The indirect effects of flash floods are also many and can encompass aspects as diverse as reducing real estate values, causing the loss of industrial, agricultural, and forest productivity; and causing the loss of tourist revenues by damaging land or facilities or by interrupting transportation systems.
- (b) **Environmental Impacts:** Flash floods take a great toll on the natural environment. Mudflows can cover terraced lands with boulders and debris and can damage standing crops laying waste to agricultural fields. In the foothills and plains of the river valleys, floods often deposit coarse sediment, which not only damages valuable crops but also renders the land infertile. Floods cause severe bank erosion and the loss of soil. Debris flow aggrades river beds, divert flows, and can cause riverine floods. When rivers change their course, the environmental setting is altered.

2. **Herd segregation:** Segregating animals into classes gives the herd a better chance of getting needed feed supplies. Segregation makes possible the preferential treatment of vulnerable classes. The older dry cows can be moved to the poorer forage fields. Pregnancy testing is a useful tool to identify heavily pregnant cows for special feeding, especially young cows that are pregnant for a second time.
3. **Optimizing use of drought-affected paddock:** Cattle do not graze well areas located far away from watering points. Use of a drought-affected paddock can be encouraged by providing local water facilities, with supplementary hand feeding as an attractant.
4. **Attention to contaminated water supplies:** Polluted surface waters represent a death trap for drought-weakened cattle. Fencing may be necessary to separate cattle from undesirable water holes. Salinity may increase with the depletion of the water table, with the water becoming too salty for the herd. The upper limit of total soluble salts should not exceed 8500 ppm. In addition, the sum of chlorides and sulphates of calcium and magnesium should not exceed 1400 ppm.

2.4. GEOLOGICAL DISASTERS

(I) Landslides

Landslide is a collective word which notifies all types of mass movements of rock fragments, soil, including water and ice. These mass movements are triggered by forces of different weathering processes. The sliding of these materials is due to their position and force of gravity. Landslide may also be defined as the down slope movement of material under the force of gravity.

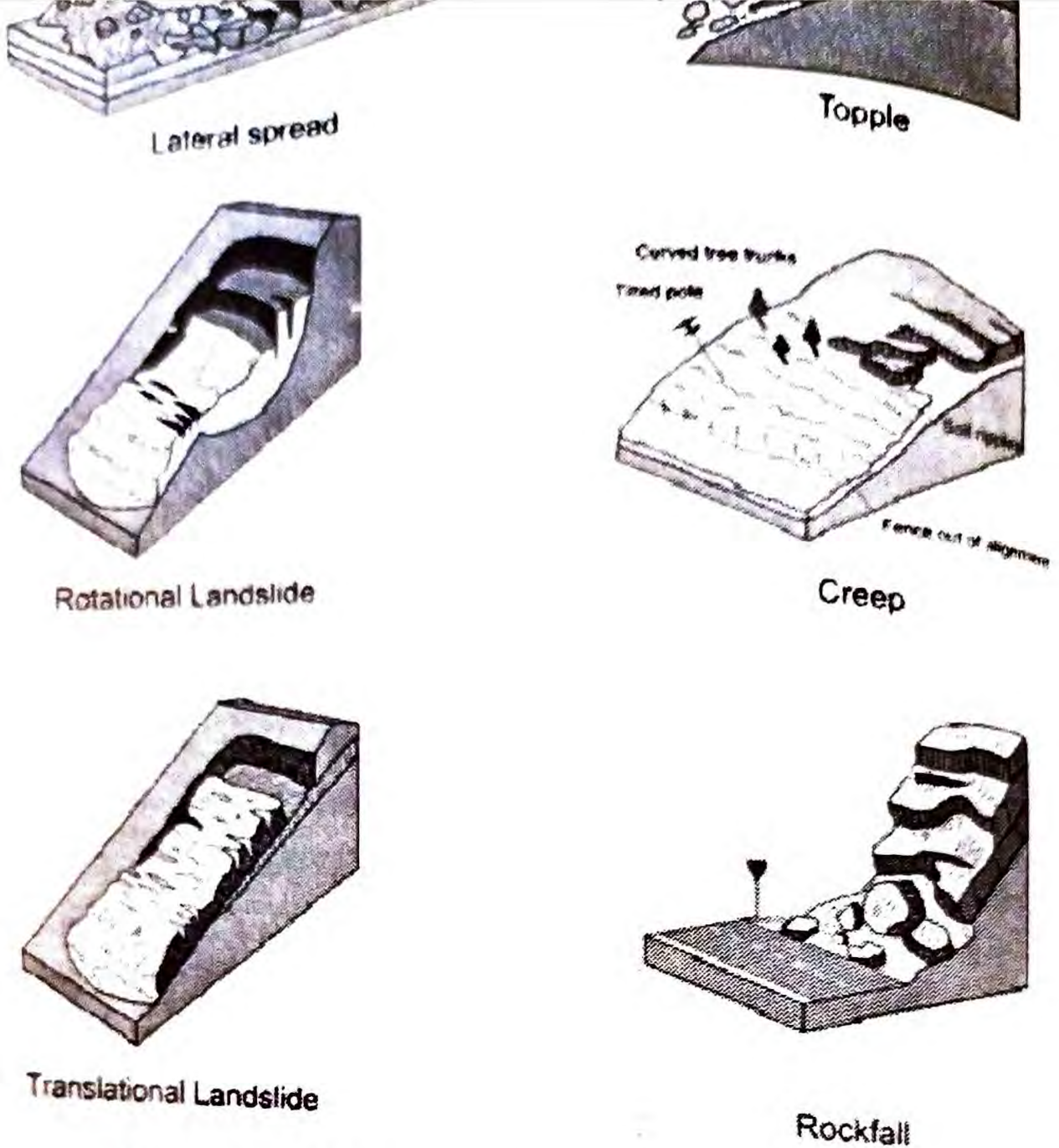


Figure 2.1: Different types of mass movements.

Causes of Landslides

The movement of material on slopes depend upon the ratio between the shearing forces (stress) and resistance of materials to shearing forces. This can be depicted as

$F_s = \text{Strength or shearing resistance of materials}$
 magnitude of shearing forces.

Where F_s = factor of safety.

There are two major categories under which different factors causing landslides fall

These are

- A. Triggers which increase shearing stress and
- B. Factors which reduce the resistance of materials to shearing stress.

The factors that trigger landslides are both man made as well as natural. Activities of man like road construction, deforestation, dams and reservoirs had accelerated the triggering of landslides. Factors that trigger landslides are:

- (i) **High magnitude earthquakes in landslide prone regions:** An Earthquake is a tremor or movement in the Earth's crust. They are a deadly and unpredictable type of natural disaster and are the leading reason for landslides or Rock falls occurring worldwide. Loose soil, rocks and boulders can easily be dislodged from hilly areas and allowed to move downhill when the violent shaking of the ground transpires. Landslides are more likely to take place when the earthquake is of a high magnitude.
- (ii) **Heavy rainfall and flash floods:** Gravity is an invisible force that pulls all objects towards Earth. The effect of gravity is more prominent on a steep slope or on a hilly area. When rain falls, water enters or infiltrates into the top soil which makes the soil become heavier and therefore more vulnerable to the pull of gravity. When soil absorbs all the water that it is capable of holding, it is said to be saturated. Soil is therefore heaviest and most susceptible to the effects of gravity, when saturated. When large areas of soil become saturated on steep slopes, the pull of gravity causes the top layers of the soil to slide downhill, therefore resulting in a landslide.
- (iii) **Mining activities on slopes of hills:** Mining activities destabilises the slopes thus causing landslides.
- (iv) **Construction of roads by cutting of slopes:** Road construction on slopes and in mountainous areas involve

cutting on the slopes which destabilises the slopes. These conditions lead to landslides even after a moderate rain.

- (v) **Heavy snowfall:** Heavy snowfall adds weight and causes landslides.

Effects of landslides

Landslides cause a number of adverse impacts. These impacts are

- (i) **Loss of Human life:** Landslides that occur in inhabited regions impact human lives. The debris covers the human settlements in no time thus causing considerable loss of life.
- (ii) **Infrastructural Damage:** Landslide badly impact infrastructural facilities such as telephone lines, electricity supplies, water pipe lines, buildings, roads and other transport means.
- (iii) **Destruction of agricultural crops:** Landslides affect the fields that are established on hill slopes and foothills. Mud flow and mass slip of earth destroys the agricultural crops.

(II) Avalanches

An avalanche can be defined as the quick movement of snow down a mountain. Avalanches can be of two main types:

- (i) **Loose-snow (or Sluff)** avalanches and (ii) **Slab** avalanches.

- (i) **Loose-snow avalanches:** Loose-snow avalanches are also termed as sluffs. These are made up of surface and/or near-surface snow that is not well-bonded. They begin at a single point, gathering more loosely-bonded snow crystals from the surface of the snowpack as they descend, gradually fanning out. These types of avalanches are characterised by 'V' shape pattern.

engineer with some engineering expertise) for advice on reducing additional landslide problems and risks. Local authorities should be able to tell you how to contact a geotechnical expert.

(IV) Earthquakes

An earthquake is a sudden shaking of the surface of earth caused by the endo-genetic forces from the interior of earth. The shaking may range from a slight vibration to strong vibrant shaking that causes fissures on the surface of earth and collapsing of buildings. "An earthquake is a form of energy of wave motion transmitted through the surface layer of the earth in widening circles from a point of sudden energy release, the focus" (Strahler, 1976).

Causes of Earthquakes: Earthquakes are generally caused by tectonic disequilibrium. This disequilibrium may be caused due to various factors occurring in the interior of earth or on the surface of earth. These include

- (i) Volcanic eruptions.
- (ii) Folding and Faulting.
- (iii) Unwrapping and down-wrapping.
- (iv) Hydrostatic pressure of man-made water bodies like reservoirs and lakes.
- (v) The tectonic movements of plates.

Earthquake Theories: Different theories have been propounded from time to time to explain the causes of earthquakes. Important among them are

- (i) **Elastic rebound theory:** According to this theory earthquakes are caused by the fractures and faults in the earth's crust and mantle.
- (ii) **Plate tectonic theory:** As per this theory the crust of earth is composed of solid and moving plates of continental and oceanic crust. Earth's crust consists of 6 major plates (Eurasian plate, American plate, African plate, Indian plate, Pacific plate and Antarctic plate) and 20 minor plates. These plates are constantly in motion with respect to each other powered by the internal thermal energy of earth. These moving plates form three different kinds of plate boundaries. These are
 - (a) **Constructive plate Boundary:** Also termed as divergent boundary. A divergent boundary occurs when two tectonic plates move away from each other. Along these boundaries, lava spews from long fissures and geysers spurt superheated water. Frequent earthquakes strike along the rift.
 - (b) **Destructive Plate Boundary:** When two plates come together, it is known as a convergent boundary. The impact of the two colliding plates buckles the edge of one or both plates up into a rugged mountain range, and sometimes bends the other down into a deep seafloor trench. A chain of volcanoes often forms parallel to the boundary, to the mountain range, and to the trench. Powerful earthquakes shake a wide area on both sides of the boundary.
 - (c) **Conservative plate Boundary:** Two plates sliding past each other forms a transform plate boundary.

Natural or human-made structures that cross a transform boundary are offset split into pieces and carried in opposite directions.

Characteristics of Earthquakes

The place of origin of an earthquake is called focus. Focus is always beneath the surface and the depth may vary from place to place. The place straight above the focus is called as hypocentre. The point where seismic waves are observed for the first time is the epicentre of the earthquake.

The waves originating from the earthquake are called as seismic waves. Seismic waves move away from the focus or hypocentre. Seismic waves are of following different types

- (a) **Primary waves (P-waves):** P-waves are also known as compression waves. These are the fastest kind of seismic waves, and are the first to 'arrive' at a seismic station. The P waves can move through solid rock and fluids, like water or the liquid layers of the earth.
- (b) **Secondary wave:** The second type of body wave is the **S-wave**, which is the second wave you feel in an earthquake. An S-wave is slower than a P-wave and can only move through solid rock, not through any liquid medium.
- (c) **Love wave:** It's the fastest surface wave and moves the ground from side-to-side. Confined to the surface of the crust, Love waves produce entirely horizontal motion.
- (d) **Rayleigh wave:** A Rayleigh wave rolls along the ground just like a wave rolls across a lake or an ocean. Because it rolls, it moves the ground up and down, and side-to-side in the same direction that the wave is moving. Most of the shaking felt from an earthquake is due to the Rayleigh wave, which can be much larger than the other waves.

Primary and secondary waves are the body waves and Love and Rayleigh waves are surface waves. These waves are recorded with the help of seismograph or seismometer.

Measurement of Earthquakes

Earthquakes can be measured using 2 scales -the Richter scale or the Mercalli Scale.

Richter Scale: The Richter scale measures the energy of an earthquake. This is a logarithmic scale, which means that for every single unit increase in scale there is a tenfold increase in power of an earthquake. Therefore a magnitude 6 is 10 times more powerful than a magnitude 5, and 100 times more powerful than a magnitude 4. The higher the magnitude of an earthquake the less frequent it's occurrence.

Mercalli scale: Mercalli scale measures the effects of the earthquake and runs from 1 to 12. The higher up the scale the more damage is experienced by people and building structures. The largest ever recorded was in Valdivia in Chile in 1960 and recorded 9.5 on the scale.

Effects of Earthquakes: Most earthquake-related deaths are caused by the collapse of structures and the construction practices play a tremendous role in the death toll of an earthquake.

The primary effects of earthquakes are ground shaking, ground rupture, landslides, tsunamis, and liquefaction. Fires are probably the single most important secondary effect of earthquakes.

- (i) **Slope failures and landslides:** The shaking of ground as a result of earthquake leads to landslides and slope failures in mountainous regions. These may lead to extensive damage to man-made structures like transport network and buildings.
- (ii) **Damage to Infrastructure:** The shaking of ground during an earthquake may inflict a damage to built

structures like towers, bridges etc. The major effect of an earthquake is the construction failures. More is the magnitude of an earthquake more is the damage caused by the earthquake. In addition to structure of buildings the nature of materials of which a buildings is made also play a role in damage caused by the earthquake.

- (iii) **Effects on towns and cities:** Towns and cities are the worst affected in an earthquake, as the buildings collapse and cause widespread damage. The damage is more in developing countries where population is more and buildings are closely built without any proper building codes. The debris and rubble further stops the rescue operations. The essential services like water supply, electricity, communication networks are also extensively damage and take a considerable time to get repair.
- (iv) **Loss of Human life:** It is not the magnitude of the earthquake that matters the more but it is the damage caused by the earthquake in terms of loss of human life. Earthquakes lead to huge loss of human life. The Kangra earthquake of India in 1905 was of magnitude 8.6 and 20,000 people lost their lives while the 1976 Tangshang earthquake of China measured 7.8-8.1 lead to death of 7,50,000 people.
- (v) **Fires:** Fires are the secondary effects of earthquakes. The collapsing of buildings cause severe fire incidents in houses, factories, commercial buildings due to short-circuits, gas leakage, chemical spillage etc.
- (vi) **Collapsing of Dams and Flash floods:** Shockwaves in the earthquakes can collapse large dams and cause flash floods. The San Fernado earthquake of 1971 in USA cracked the Van Norman Dam and threatened the low lying areas of flash floods.

- (vii) **Tsunamis:** Strong earthquakes in the undersea region with magnitude greater than 7.0 on Richter scale can create Tsunamis that can cause damage on coastal areas. The 2004 Tsunami of Indian Ocean was a result of an earthquake off the coast of Sumatra.

Management of Earthquakes

Earthquake management can be divided into pre- disaster and post disaster activities. These involve following measures

- I. **Pre disaster Phase:** In pre-disaster phase of earthquake following measures are taken to reduce disaster affects. The measures are
 - (i) Survey and mapping of seismic hazard zones.
 - (ii) Risk assessment of seismic zones.
 - (iii) Initiate precautionary and protective measures.
 - (iv) Earthquake reduction, mitigation, preparedness, including infrastructure (temporary shelters, kerosene, clothing's, potable water, transport and communication systems, alternate power supply, tents etc.)
 - (v) Identification of different factors that add to vulnerability like
 - (a) Location of human settlements in earthquake prone regions
 - (b) Identification of weak and old buildings which are not earthquake safe
 - (c) Identification of buildings with high density population
 - (vi) Disaster Preparedness:
 - (a) To avoid the human settlements in earthquake risk zone

- (b) To construct earthquake safe buildings
- (c) To avoid constructing high rise buildings in earthquake prone regions
- (d) To train people about safety drills in case of an earthquake.

II. Post Disaster Phase: Post disaster phase involves following stages

(a) Rescue and Relief: After the disaster has happened the immediate need is of rescue and relief measures. These are

- Search for victims and rescuing them using man-power and machinery.
- Providing food, clothes, safe drinking water and medical help.
- Restoring various systems like electricity, transport and communication.

(b) Rehabilitation, Reconstruction and Recovery: These include following works

- Restoration of basic services.
- Repair of damaged structure.
- Revitalization of economy
- Construction of new houses
- Physical and mental recovery of disaster victims.
- Restoration of social and cultural life

(V) Volcanic Disasters

Volcanic disasters are the result of explosive type of volcanic eruptions as well as silent lava flow from fissures. Volcanic eruptions happen when lava and gas are discharged from a volcanic vent.