MODULE-5

Natural Hazards and Safety

Introduction

A hazard is a natural disaster that pertains to a natural phenomenon that causes injury/ loss of life or damage to property/environment. **A disaster is an event that occurs suddenly/unexpectedly in most cases and disrupts the normal course of life** in the affected area. It results in loss or damage to life, property, or the environment. This Loss is beyond the coping capacity of the local affected population/society. And therefore requires external help.

An earthquake is a trembling of the ground that results from the sudden shifting of rock beneath the earth's crust. Earthquakes may cause landslides and rupture dams. Earthquakes occur along faults, which are fractures or fracture zones in the earth across which there may be relative motion.

The main characteristics of an earthquake are the following:

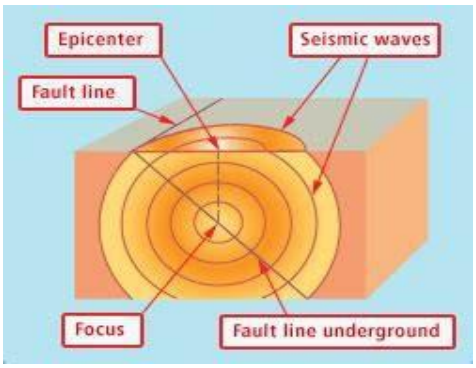
- They are sudden movements of the earth that happen in the internal layer of the earth.
- They happen naturally and spontaneously.
- They are caused by the collision of the tectonic plates.
- They move by means of vibrations that travel through the earth's crust.
- Can be measured by means of scales.
- Depending on their intensity, earthquakes can cause great destruction and death.

Physics of earthquakes

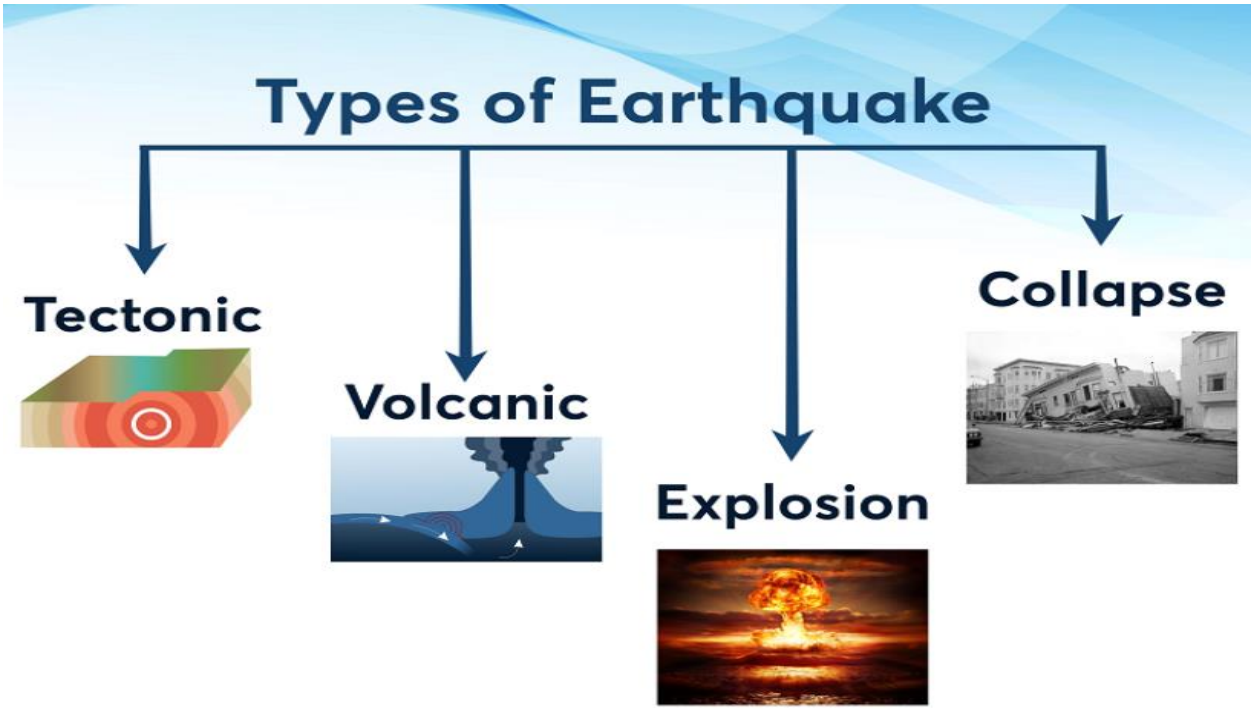
The forces generated in Earth's crust are typically described in terms of the shear stress and the shear strain. The shear stress is the force per unit area applied tangent to a plane. The shear strain is a dimensionless quantity that describes the distortion of a body in response to shear stress;

When the stress at a point in the crust exceeds a critical value, called the local strength, a sudden failure occurs. The plane along which failure occurs is called the fault plane and the point where failure initiates is called the focus. Typically, there is a sudden displacement of the crust at the fault plane following the failure and elastic waves are radiated. This is an earthquake.

For most earthquakes, the displacement occurs at an existing geological fault, that is, a plane that is already weak



Types of Earthquakes



1. Tectonic Earthquakes

The earth's crust is composed of loose, cracked fragments of land referred to as tectonic plates. These plates are capable of moving slowly and gradually. The movement of these plates occurs in different forms; towards each other, away from each other, sliding past each other or colliding with each other. A huge tremor occurs when two moving tectonic plates slide over one another. This type of earthquake is known as a tectonic earthquake.

Tectonic earthquakes are the most prevalent kinds of earthquakes in the world. Its magnitude may be small or large. Tectonic earthquakes have caused most of the planet's mass destruction. Tremors triggered by tectonic earthquakes are always severe, and if their magnitude is high, they are capable of bringing down an entire city in seconds.

2. Volcanic Earthquakes

Compared to tectonic earthquakes, volcanic earthquakes are less prevalent. They typically take place before or after an eruption. Volcanic earthquakes come in two forms: long-period volcanic earthquakes and volcano-tectonic earthquakes. Volcano-tectonic earthquakes usually happen after a volcanic eruption. During an earthquake, magma erupts from inside the earth's crust leaving space behind. The space left after magma eruption must be filled. To fill it, rocks move toward the space resulting in severe earthquakes.

On the other hand, a long period of volcanic earthquake takes place after a volcanic eruption. Some days prior to the massive explosion, the magma inside the earth's crust experiences rapid changes in heat. The change in heat triggers seismic waves, resulting in an earthquake.

3. Explosion Earthquakes

These are caused by nuclear explosions. They are, essentially, man triggered kind of earthquakes and represent the biggest impact of modern-day nuclear war. During the 1930s nuclear tests conducted by the United States, numerous small towns and villages were devastated as a result of this grave act.

4. Collapse Earthquakes

These kinds of earthquakes are generally smaller and most commonly occur near underground mines. They are sometimes referred to as mine bursts. Collapse earthquakes are instigated by the pressure generated within the rocks. This kind of earthquake leads to the collapse of the roof of the mine instigating more tremors. Collapse earthquakes are prevalent in small towns where underground mines are located.

Seismograph of Earthquakes

The seismograph is a device that detects and draws the vibrations of the ground and is based on the operation of a simple pendulum. A seismograph's oscillation frequency depends on the **pendulum's resonance frequency. T**he length of the pendulum axis determines the type of seismograph and earthquakes to be measured, and the formula for obtaining the period of an oscillation is as follows:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

where:

- T: is the period of the pendulum expressed in seconds;

- L: is the length of the wire that supports the mass;
- g: is the value of the acceleration of gravity, and on Earth, it is equal to 9.81 m / s ^{2}.

Richter scale (M_L), a quantitative measure of an earthquake's magnitude (size), was devised in 1935 by American seismologists Charles F. Richter and Beno Gutenberg.

The earthquake's magnitude is determined using the logarithm of the amplitude (height) of the largest seismic wave calibrated to a scale by a seismograph.

On the original Richter scale, the smallest earthquakes measurable at that time were assigned values close to zero on the seismograph of the period.

Since modern seismographs can detect seismic waves even smaller than those originally chosen for zero magnitudes, it is possible to measure earthquakes having negative magnitudes on the Richter scale.

Each increase of one unit on the scale represents a 10-fold increase in the magnitude of an earthquake. In other words, numbers on the Richter scale are proportional to the common (base 10) logarithms of maximum wave amplitudes.

Each increase of one unit also represents the release of about 31 times more energy. Then that is represented by the previous whole number on the scale. (That is, an earthquake measuring 5.0 releases 31 times more energy than an earthquake measuring 4.0.)

Tsunami:

The word 'Tsunami' literally means "harbor wave."

A tsunami is a catastrophic ocean wave, usually caused by a submarine earthquake, an underwater or coastal landslide, or a volcanic eruption. Waves radiate outward from the generating impulse at speeds of up to 500 miles (800 km) per hour, reaching maximum heights of 100 feet (30 meters) near coastal areas

Characteristics of Tsunami

Tsunamis are among Earth's most infrequent hazards and most of them are small and non-destructive.

*Over deep water, the tsunami has very long wavelengths

*when a tsunami enters shallow water, its wavelength gets reduced and the period remains unchanged, which increases the wave height.

*Tsunamis have a small amplitude (wave height) offshore. This can range from a few centimetres to over 30 m in height. However, most tsunamis have less than 3 m wave height.

*It radiates in all directions from the point of origin and covers the entire ocean.

*It generally consists of a series of waves, with periods ranging from minutes to hours.

*These are the waves generated by tremors and not by earthquakes themselves.

*There is no season for tsunamis and not all tsunamis act the same. It cannot be predicted where, when, and how destructive it will be. A small tsunami in one place may be very large a few miles away.

*An individual tsunami may impact coasts differently. A tsunami can strike any ocean coast at any time. They pose a major threat to coastal communities. The effect of a Tsunami would occur only if the epicenter of the tremor is below oceanic waters and the magnitude is sufficiently high.

The speed of the wave in the ocean depends upon the depth of the water. It is more in the shallow water than in ocean deep. Causes of Tsunami.

How are tsunamis generated?

A Tsunami can be generated only through the vertical movement of the seafloor. Most Tsunamis are generated by earthquakes. Volcanic eruption, underwater explosion, landslides, and meteorite impacts are some other causes of tsunamis.

Causes

The details of the causes of the Tsunami is explained below-

Earthquake – Tsunami is generated by the earthquake because of the disturbance of the seafloor and is formed generally with vertical displacement. Most Tsunami is generated by earthquakes that occur along the subduction boundaries of plates along the ocean trenches. The size of the Tsunami is related to the size of the earthquake.

Underwater explosion – A Nuclear Testing by the US generated Tsunami in 1940 and 1950s in Marshall Island.

Volcanic eruption – Volcanoes that occur along the Coastal waters can cause several effects that can cause a tsunami.

Landslides – Earthquakes and volcanic eruptions generally generate landslides, these landslides when moving into the Oceans, bays, and lakes can generate tsunamis.

Meteorite Impacts – Though no historic example as such of meteorite impact has caused tsunamis, the apparent impact of a meteorite about 5 million years ago produced tsunamis leaving deposits along the Gulf Coast of Mexico and the United States.

Engineering Measures

1) Through the development and installation of enormous building shock absorbers, sliding walls, and Teflon foundation pads, these structures are able to help Japanese buildings withstand the immense stresses and strains imposed on them during violent events like earthquakes.

2)Another part of Japan's engineering solutions revolves around the construction of massive sea walls -- sometimes up to around 40 feet (12 meters) tall. Such enormous structures are designed to help protect highly populated areas.

3)Other engineering solutions include the design and construction of monstrous floodgates that are intended to channel, tamper, or redirect incoming tsunami waves away from critical infrastructure and population centers. These can be absolutely huge, up to 51 feet (15.5 meters) tall.

Landslide

A landslide is the movement of rock, earth, or debris down a sloped section of land. Landslides are caused by rain, earthquakes, volcanoes, or other factors that make the slope unstable.

Landslides have three major causes:

Geology, morphology, and human activity.

*Geology refers to characteristics of the material itself. The earth or rock might be weak or fractured, or different layers may have different strengths and stiffness.

*Morphology refers to the structure of the land. For example, slopes that lose their vegetation to fire or drought are more vulnerable to landslides. Vegetation holds soil in place, and without the root systems of trees, bushes, and other plants, the land is more likely to slide away.

A classic morphological cause of landslides is erosion, or weakening of earth due to water.

Types of Landslides.

Falls Landslides It means falling of some material or debris or rocks etc., from a slope or a cliff which leads to a collection of this debris at the base of the slope.

Topple Landslides: These can occur because of some fractures between the rocks and the tilt of the rocks because of gravity without collapsing. Here, we see the forward rotational movement of the material.

Slides: It is a kind of landslide when a piece of the rock slides downwards and gets separated from it.

Spread: It happens on flat terrain and gentle slopes and can occur because of softer material

Causes of Landslide

Landslides are caused by various factors, which are mentioned below:

*It can be caused because of heavy rain.

*Deforestation is also one of the main reasons for landslides because trees, plants, etc., keep the soil particles compact and due to deforestation, the mountain slopes lose their protective layers because of which the water of the rain flows with unimpeded speed on these slopes.

*It can be caused by earthquakes as well.

Effects

Short Term Impacts

*The natural beauty of the area is damaged.

*Loss of life and property

*Roadblocks

*Destruction of railway lines

*Channel blocking because of the falling of rocks.

*It leads to the diversion of river water, which can cause floods as well.

Long Term Impacts

*Landscape changes can be permanent.

*The loss of fertile land or cultivation land.

*Erosion and soil loss can lead to environmental problems.

*Population shifting and migration.

*Effects on the sources of water.

*Some roads can be damaged or closed permanently.

Prevention and Mitigation

The following measures can be taken in this regard:

*Early warning systems and monitoring systems should be there.

*Hazard mapping can be done to identify the areas which are more prone to landslides.

*Restriction on the construction in the risky areas should be imposed.

*Afforestation programs should take place.

*Restricting development in landslide areas and protecting the existing ones.

*The country should specify codes or standards etc. For the construction of the buildings and other purposes in such areas of risk.

*Insurance facilities should be taken by the people to deal with the loss.

*Terrace farming should be adopted in hilly areas.

*Response teams should be quick to deal with landslides if they occur.

Forest fires can be defined as any uncontrolled and non-prescribed combustion or burning of plants in a natural setting such as a forest, grassland, bushland, or tundra, which consumes natural fuels and spreads based on environmental conditions.

Methodology

4.1 Frequency ratio model and its application

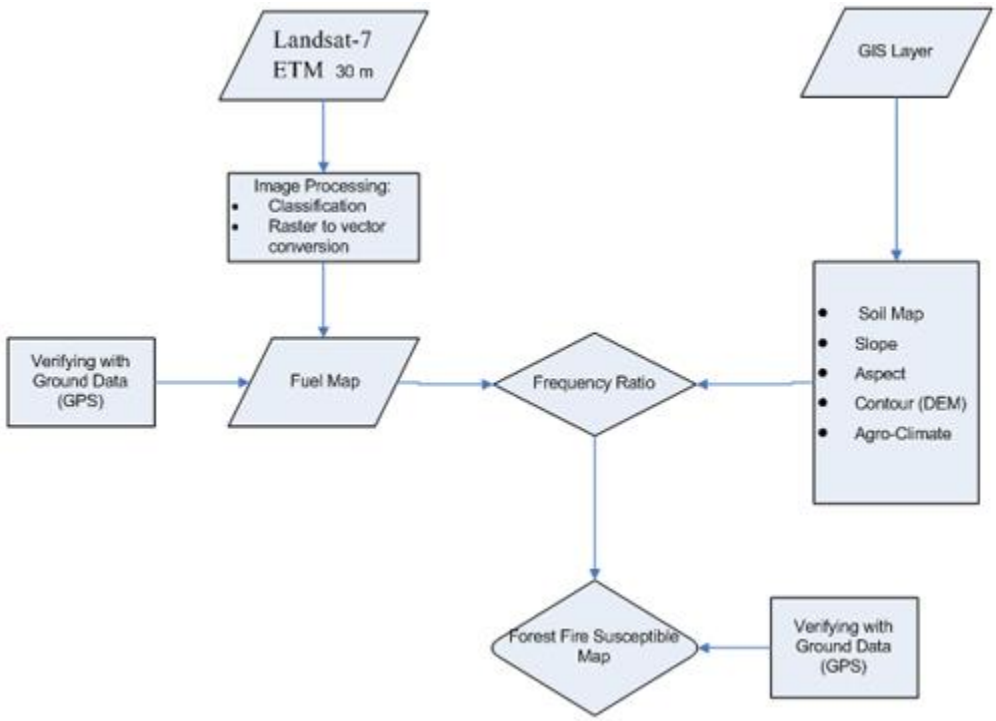
Frequency ratio approaches are based on the observed relationships between the distribution of hotspot and each hotspot-related factor, to reveal the correlation between hotspot locations and the factors in the study area. Using the frequency ratio model, the spatial relationships between hotspot-occurrence location and each factor contributing to hotspot occurrence were derived. The frequency is calculated from an analysis of the relation between the hotspot and the attributing factors. In the relation analysis, the ratio is that of the area where hotspots occurred to the total area so a value of 1 is an average value. If the value is greater than 1, it means a higher correlation and a value lower than 1 means a lower correlation.

To calculate the Forest Fire Susceptibility Index (FFSI), each factor's frequency ratio values were summed to the training area as in equation (1). The hotspot susceptibility value represents the relative susceptible to forest fire occurrence. So the greater the value, the higher the susceptible to forest fire occurrence and the lower the value, the lower the susceptible to forest fire occurrence.

FFSI = Fr1 + Fr2 + …… + Frn (1)

(FFSI: Forest Fire Susceptibility Index; Fr: Rating of each factors' type or range) The forest fire susceptibility map was made using the FFSI values and for interpretation is shown in Figure 2.

This study consists of development of Forest Fire Susceptible Map. Figure 2 shows flowchart of methodology.



Fire:

A fire occurs when the elements i.e. heat, fuel, oxygen and chemical chain reaction are present and combined in the right mixture. A fire can be prevented or extinguished by removing any one of the elements in the fire tetrahedron. Essentially all four elements must be present for fire to occur, heat, fuel oxygen, and a chemical chain reaction

SOURCES OF FIRE HAZARDS

Fuels include solids, liquids, vapors, and gases. Solid fuels wood, fabrics, synthetic materials, packing materials, papers, etc.,

Liquid fuels flammable liquids (e.g., nitro phenol, ammonium nitrate, and potassium chlorate, paint and oil-soaked rags, cotton or cellulose soaked with sulphuric acid, etc.,.).Other sources include flame, sparks, spontaneous ignition, and self-combustible chemicals. (Khanna, 1992).

PREVENTION OF FIRE HAZARDS

*Well-planned design and layout

*Properly ventilated systems

*Chemical data sheets

*Proper training of personnel

*Proper maintenance of surroundings

*Use of fire extinguishers, alarms, sensors, detectors

*Firefighting equipment

*Sprinkler systems

Fireproofing means applying certain products over the materials or structures which minimize the escalation of fire and thus plant operators get sufficient to act against the fire.

Typically, fireproofing is designed to protect the structural steel which supports high-risk or valuable equipment.

The failure point is generally considered to be 1000°F, as this is the point where steel has lost approximately 50% of its structural strength.

The aim then is to prevent structural steel from reaching 1000°F for some period of time. Tanks, pressure vessels, and heat exchangers may experience a significant cooling effect from liquid contents and so, less fireproofing protection is generally required.

Some thermal insulation systems may serve a dual role as fireproofing and this is common with some pressure vessels. Piping may be insulated but it is not generally considered to be fireproofed.

Fire safety regulations

Major Laws in India Governing Fire Safety and Governance

The National Building Code of India, 2016

Part 4 of the National Building Code (NBC) of India, 2016, is titled 'Fire and Life Safety'.

*It covers the requirements for fire prevention, life safety in relation to fire and fire protection of buildings.

*The code specifies occupancy-wise classification, constructional aspects, egress requirements and protection features that are necessary to minimise danger to life and property from fire.

*It specifies the demarcations of fire zones, restrictions on constructions of buildings in each fire zone, classifications of buildings based on occupancy, types of building construction according to fire resistance of the structural and non-structural components and other restrictions and requirements necessary to minimize danger of life from fire, smoke, fumes or panic before the buildings can be evacuated.

The code broadly covers the following areas:

Fire prevention: This covers aspects of fire prevention pertaining to the design and construction of buildings. It also describes the various types of building materials and their fire rating.

Life Safety: This covers life safety provisions in the event of a fire and similar emergencies, also addressing construction and occupancy features that are necessary to minimize danger to life from fire, smoke, fumes or panic.

Fire Protection: Covers significant appurtenances (accessories) and their related components and guidelines for selecting the correct type of equipment and installations meant for fire protection of the building, depending upon the classifications and type of building.

The guidelines for fire drills and evacuations for high-rise buildings are also specified in NBC Part 4. It mandates the appointment of a qualified fire officer and trained staff for significant land uses.