UNIT 5 EARTHQUAKE

Structure

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5.0 OBJECTIVES

After studying this Unit, you should be able to:

• describe an Earthquake;
• discuss the general characteristics of earthquakes;
• briefly describe the Instrumental and Non-Instrumental precursors;
• understand the vulnerability of different regions of the country through seismic zoning;
• analyse the impact and effects of an earthquake; and
• discuss the nature of damage.

5.1 INTRODUCTION

Earthquakes are considered to be one of the most dangerous and destructive natural hazards. The commencement of this phenomenon is usually sudden with little or no warning. It is not yet possible to predict earthquakes and to make preparation against damages and collapse of buildings and other man-made structures. In effect, earthquake consists of a sudden shaking (vibrations) of the ground caused by disturbances in the earth's crust. An earthquake generates a set of horizontal and vertical vibrations of the ground which result in destruction of structures.

Earthquakes may be defined as a natural phenomenon which tends to create panic due to the trembling vibrations or sudden undulation of a portion of earth's crust caused by splitting of a mass of rock (Tectonic) or by volcanic or other disturbances.

This Unit provides a general discussion about earthquakes. We will first explain the general characteristics of earthquakes. Besides this precursors: (instrumental and non-instrumental) and vulnerability of the different regions of the country will be discussed to analyse the impacts and effects of earthquake. Lastly nature of damage caused by earthquakes will be described.

5.2 GENERAL CHARACTERISTICS

Earthquakes occur sudden by with little or no warning. However, following a major earthquake, the after-shocks may sometimes indicate the likelihood of a further earthquake. On some occasions, an earthquake may be preceded by a less
The basic characteristics of an earthquake are the following:

- It is not yet possible to predict magnitude, time and place of occurrence of an earthquake.
- The onset is usually sudden.
- Earthquake prone areas are generally well identified and well known on the basis of geological features and past occurrences of earthquakes.
- Major effects arise mainly from ground movement and fracture or slippage of rocks underground. The obvious effects include damage (usually very severe) to buildings and infrastructures along with considerable casualties.
- About 200 large magnitude earthquake (M>6.0) occur in a decade.
- The world's earthquake problem seems to be increasing with the increased population, high rise buildings and crowded cities.

The exact spot underneath the surface of the earth at which an earthquake originates is known as "focus" while the point lying on the ground surface vertically above the focus is defined as "epicenter" of the earthquake. The seismic shocks originating at a depth of about 50 km or less below the surface are termed as shallow focus earthquakes; otherwise these are known as deep focus earthquakes.

The energy released at the focus, due to the elastic rebound of rocks, creates the earthquake and is a measure of the power of the earthquake.

The power (energy) of an earthquake is reckoned in terms of its "magnitude" which is measured on an open-ended Richter. But it is not a linear scale and not even a logarithmic scale. This will be clearly understood from the following Table 5.1 which gives the equivalence of earthquake magnitude (on Richter Scale) and the equivalent energy release by the explosion of a certain mass of TNT which is the well known measure of explosive power in any blast. The Richter scale derives its name from the scientist who proposed it.

**Table 5.1**

<table>
<thead>
<tr>
<th>Magnitude of Earthquake (on Richter Scale)</th>
<th>Approximate Equivalent TNT mass in terms of explosive power</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>170 gm</td>
</tr>
<tr>
<td>3.0</td>
<td>180 kg ((180 \times 10^3 \text{ gm}))</td>
</tr>
<tr>
<td>6.0 (like Latur, 1993)</td>
<td>5700 tonne ((570 \times 10^7 \text{ gm}))</td>
</tr>
<tr>
<td>8.5 (Like Assam 1897 &amp; 1950)</td>
<td>28700000 tonne ((287 \times 10^{11} \text{ gm}))</td>
</tr>
</tbody>
</table>

From the above, it should be clear that the energy released by an earthquake increases enormously as the magnitude on Richter Scale rises. Another way to appreciate the enormous destruction potential of an 8.5 magnitude earthquake is to know that the energy released is approximately equal to 10,000 Hiroshima type Atom Bombs. It may be noted from Table 5.1 that each integer increase of magnitude on Richter Scale represents about 33 times increase in the energy released.

The primary waves (or P-waves) from the focus are transmitted due to longitudinal vibrations set up within the earth. These waves have the velocity of
the order of several kilometers per second and cause the preliminary tremors on
the surface of the earth. These waves create an effect of horizontal pull and push
and are also called pull and push waves.

The secondary (or S-waves) on the other hand are transmitted due to transverse
vibrations. These are known as surface or slow waves. Even though the
amplitude and size are small compared to other waves, these are the most
destructive since they create vertical up and down movements in the ground
surface as against horizontal oscillation due to longitudinal waves.

While the "magnitude" of an earthquake defines the energy released by the event
the "intensity" of the earthquake will depend on the particular place where it is
measured. Obviously the intensity will decrease as the distance from the
epicenter increases.

5.3 INSTRUMENTAL AND NON-INSTRUMENTAL

We have already stated it is not yet possible to predict earthquakes. However,
sometimes there are some indication that would indicate that perhaps an
earthquake would occur. Such indications are called "precursors". These could
be either instrumental, i.e., those that are measured by instruments or
non-instrumental, i.e., those which can only be perceived and not measured.
Needless to say, the non-instrumental precursors are more subjective.

Some of the generally recognized precursors are listed below:

<table>
<thead>
<tr>
<th>Instrumental Precursors</th>
<th>Non-Instrumental Precursors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fore-shocks &amp; after shocks</td>
<td>Sudden rise or fall of water level in wells and</td>
</tr>
<tr>
<td>Statistical pattern of shocks.</td>
<td>lakes.</td>
</tr>
<tr>
<td>Uplift or subsidence of ground.</td>
<td>Mud and sand shows up in surface waters.</td>
</tr>
<tr>
<td>Faults, displacements in Earth’s Crust</td>
<td>Increase in salinity of water.</td>
</tr>
<tr>
<td>Tilt and strain of underground rock</td>
<td>Advance and retreat of seas.</td>
</tr>
<tr>
<td>formations.</td>
<td>Unusual behaviour of animals.</td>
</tr>
<tr>
<td>Changes in electric resistance of</td>
<td></td>
</tr>
<tr>
<td>rocks.</td>
<td></td>
</tr>
<tr>
<td>Changes in earth’s magnetic field.</td>
<td></td>
</tr>
<tr>
<td>Emission of Radon gas from the ground.</td>
<td></td>
</tr>
<tr>
<td>Unusual sounds from inside earth.</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of Precursors

The above Table shows that precursors have been useful some time or the other,
although none by itself is expected to help the prediction of earthquakes. The
problem is how to know which precursor should take precedence at any given
Typology of Disasters - 1

time and place. More often than not, false or untenable conclusions seem to hold the sway, and the pros and cons do not lead to any agreement regarding the usefulness of these precursors for prediction of earthquakes.

Some studies have been made to assess which of these precursors are readily activated before or during various earthquakes. However, it has not yet been possible to draw operationally usable criteria for predicting earthquakes on the basis of precursors (instrumental and non-instrumental). More observation and studies are required.

Check Your Progress 1

Note: i) Use the space given below for your answers.
      ii) Check your answer with that given at the end of the Unit.

1) What do you understand by an Earthquake?

2) Discuss the general characteristics of an Earthquake.

3) List some of the Instrumental and non-Instrumental Precursors.

5.4 VULNERABILITY

Disasters result from vulnerable societies being exposed to a hazard. There can be physical vulnerability, social vulnerability and economic vulnerability released to an earthquake disaster.
Physical vulnerability relates to old and non-engineered buildings, infrastructure. The vulnerability of buildings is dependent on their designs, shape, materials used, construction techniques, maintenance and proximity of buildings. The weightage attached to each factor will vary according to the characteristics of the particular earthquake.

Infrastructure may be considered in three broad groups: transport systems (roads, railways, bridges, airports, port facilities); utilities (water, sewerage and electricity telecommunications) and flood protection structures such as dams and embankments.

Vulnerability analysis is especially concerned with the risk faced by critical facilities (sometimes termed "life-lines") which are vital to the functioning of societies in disaster situations especially such as incase of earthquakes. These facilities include hospitals, dispensaries and emergency services. Special consideration is given also to protect heritage buildings of great cultural and historical importance.

Social Vulnerability

Records of past earthquake disasters suggest that the following groups of people are particularly at risk and require special attention:

- Single parent families;
- Women, particularly when pregnant or lactating;
- Mentally and physically handicapped people;
- Children; and
- The elderly and the infirm

Poor people are less concerned with infrequent hazards. If there are groups whose livelihoods are at risk, living or working in densely populated areas, with low perceptions of risk and without institutional support, the cumulative effect would be high social vulnerability.

Economic Vulnerability

It measures the risk of hazards causing losses to economic assets and processes. It focusses on evaluating the direct loss potential (i.e., damage or destruction of physical and social infrastructure and its repair or replacement cost, as well as crop damage and losses to the means of production); indirect loss potential (i.e., the impact on cost of production, employment, vital services and income-earning activities); and secondary effects (epidemics, inflation, income disparities and isolation of outlying areas). With the insights provided by economic vulnerability analysis, it is possible to estimate direct and indirect losses and to design ways and means to mitigate them in relation to the estimated costs of relief/recovery actions and mitigation measures required.

5.5 IMPACT AND EFFECTS

In general terms, typical impacts and effects of earthquake disasters tend to be:

- Loss of Life.
- Injury
- Damage to and destruction of property including crops.
Typology of Disasters - 1

- Disruption of production.
- Disruption of lifestyle.
- Loss of livelihood.
- Disruption to essential services.
- Damage to national infrastructure and disruption to administrative and organizational systems.
- Sociological and psychological after-effects.

The following problem areas need particular attention in case of Earthquake disasters:

- Severe and extensive damage, creating the need for urgent counter measures, especially search and rescue, and medical assistance.
- Difficulty of access and movement.
- Widespread loss of or damage to infrastructure, essential services and life support systems.
- Recovery requirements (e.g., restoration and rebuilding) may be very extensive and costly.
- Occurrence of earthquakes in areas where such events are rather rare may cause problems due to lack of public awareness.

5.6 NATURE OF DAMAGE

Damage due to earthquakes depends on various factors listed below:

a) **Nature of Earthquakes:** It includes various parameters like magnitude, intensity, duration and ground acceleration due to earthquake. Higher the value of these parameters, higher will be the resultant damage.

b) **Geological and Soil Conditions:** Geology and Soil conditions play a very important role in the amount of damage due to any earthquake. In hilly areas damages are severe due to various aftereffects of earthquakes such as landslides, blockage of connecting roads, diversion of river flows and damage to dams. The intensity of earthquake is directly related to the type of supporting soil layers. The structures built on the solid rock and firm soil generally perform better. There are cases in which the intense vibrations from the earthquake "liquefied" the soil and buildings tilted on to the ground because the foundation became loose.

c) **Quality of Construction:** Construction quality is very important for safety of buildings. Building designs must be such as to ensure that the building has the adequate strength, and will remain as one unit while subjected to vibrations and significant deformation, otherwise it will suffer great damage. The great loss of life and property due to poor construction practices can be seen in major earthquakes.

d) **Sociological Factors:** Various sociological factors such as density of population, time of occurrences, community preparedness are very important for limiting the resultant damage.

A short list of the more damaging earthquakes that occurred in India since the very-great earthquake of 1897 in Assam has already been given in Unit 4.
The nature of the damage that can occur as a result of any earthquake may well be imagined. Everything based upon the stability of the earth is rudely disturbed. If the tilt or displacement of the ground disrupts the equilibrium, structures fall. Gravity spares nobody. Therefore, the maximum damage is noticed in the case of tall buildings. If these are not designed to withstand any substantial ground movement, they will fall. Tall buildings and roofs are the first casualties. In the wake of their collapse, most damage to life is done to those who are inside the house. Many will be hit by falling debris or get trapped inside the collapsed building. Persons trapped under the debris, shouting pathetically for help, constitute a truly gruesome sight. Sometimes steel beams have to be cut before the victims can be rescued.

Essential services such as water mains, drainage systems, and electrical transmission lines are seriously damaged. Broken water mains cause flooding of the area and leave no water for drinking or for fire-fighting. The sparking of high tension overhead electric cables cause fires, setting ablaze whatever combustible material is in the vicinity. Leaks from cooking gas cylinders or supply lines also cause fires.

Disrupted drainage lines spread noxious fluids and give rise to diseases and epidemics.

Geological faults in the Earth’s crust become activated and accentuate displacement of the ground, producing gaping fissures in which human beings and animals are known to have been engulfed. Telephone and telegraph poles fall down and the services go out of order. Communications are seriously hampered or altogether stopped. Railway lines are twisted out of shape and rail communication to and from the affected area is broken off. In some cases the only access to the affected area is by helicopter.

Large dams in the vicinity may be affected, and in some cases may even burst and cause severe floods. On the coast, huge waves called tsunamis lash the shore and bring down houses and other structures and dislocate fishing and navigation.

Creation of new islands is a rare phenomenon but does occurs due to some earthquakes, which originate below the sea bed. The new islands were composed of loose sand and clay mostly and are eroded due to sea waves and tides.

Check Your Progress 2

Note:  
1) Use the space given below for your answers.
2) Check your answer with that given at the end of the Unit.

1) Briefly discuss the types of vulnerability due to earthquakes.
2) What are the impacts and effects of an Earthquake? Discuss

3) On what factors does the nature of damage depend in an Earthquake?

5.7 LET US SUM UP

This Unit discussed the phenomenon of earthquake and defined the relevant terms. It throws light on the general characteristics and precursors. It also highlighted the vulnerability situation, impact and effects of an earthquake. Lastly, nature of damage due to earthquake has been described.

5.8 KEY WORDS

Epicenter : The point on the Earth's surface directly above the focus of an earthquake.

Magnitude : A measure of earthquake's power that describes the amount of energy released.

Non-engineered : A structure that has been constructed without proper engineering design and supervision.

TNT : Trinitrotoluene (an explosive material).

5.9 REFERENCES AND FUTURE READING


Check Your Progress 1

1) Your answer should include the following points:
   - Earthquakes are considered to be one of the most dangerous and destructive natural hazards.
   - This phenomenon is usually sudden with little or no warning.
   - It consists of a shaking of ground caused by disturbances in the earth crust.
   - It is not possible to predict earthquakes and to make preparation against damages and collapse of buildings and other man-made structures.

2) Your answer should include the following points:
   - It is not yet possible to predict the magnitude, time and place of occurrence.
   - The onset is usually sudden.
   - Earthquake prone areas are generally well identified on the basis of geological features and past occurrences of earthquake.
   - Major effects arise mainly from ground movement and fracture or slippage of rocks underground.
   - The obvious impacts include damage to buildings and infrastructure along with considerable casualties.

3) Your answer should include the following points:
   **Instrumental Precursors**
   - Occurrence of foreshocks and aftershocks
   - Statistical pattern of shocks.
   - Uplift or subsidence of ground.
   - Changes in gravity.

   **Non-instrumental Precursors**
   - Sudden rise or fall of water level in wells and lakes.
   - Mud and sand shows up in surface waters.
   - Changes in flows of natural springs.
   - Unusual behavior of animals.

Check Your Progress 2

1) Your answer should include the following points:
   - Physical vulnerability
   - Social vulnerability
   - Economic vulnerability
2) Your answer should include the following points:
   - Loss of life, livelihood, economic loss and injury.
   - Damage to and destruction of property.
   - Damage to and destruction of crops.
   - Disruption of production, lifestyle and essential services.
   - Sociological and psychological after-effects.

3) Your answer should include the following points:
   - Magnitude of an Earthquake.
   - Geological and soil conditions.
   - Quality of construction.
   - Sociological factors.