

EARTHQUAKE

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Abhijit's House

Abhijit's house where his friends with two parent's friends present there.

- Abhijit : Hello, Suman, how are you?
- Suman : Well, what is about you?
- Abhijit : Not well, we have a bad news.
- Suman : What?
- Abhijit : My father has come today with some injuries?
- Suman : How? What happens with him?
- Abhijit : You know, he went to North Bihar for an official tour. But unfortunately, the Guest House in which he was staying was completely damaged by Nepal earthquake. He is now on complete bed rest.
- Suman : I hope is is now out of danger(!)
- Suman : Wait. I am just going to your house with our friends.
- Abhijit : Yes, Everything is now under control. I am also coming to college , wait for a second.....
- Suman : OK, really it is very unfortunate that after so much of progress in earthquake science, we are still do not have any method to predict the occurrence of earthquake.
- Abhijit : Let's go to our class teachers to discuss on this topic in more detail.
- Suman : It a good idea.

College Class Room

Discussions amongst them about the Nepal earthquake.

Abhijit and his friends are present.

Meanwhile class teacher comes to the class.

Students (Abhijit and his friends): Sir, today we would like to know about the recent Nepal earthquake or about the earthquakes as a whole.

Teacher : Very good. But unfortunately it is not possible for me to talk on earthquake. I am not an expert in this line.

Students : But we are interested to know about earthquake.

Teacher : I am also interested to know about the earthquake. Because we are living in the highest earthquake hazard zone in India.

Students : Kindly help us, Sir.

Teacher : Yes, I have a suggestion for you. You may approach the Principal of our college with a request to arrange an interactive lecture on earthquake by a seismologist. I am sure, she will respond positively.

Students : Very good suggestion, Sir. We shall meet our Principal Mam today.

Principal's Office Room

Students : Mam, may we get in?

Principal : Oh Yes, come in. Please take your seats. Well, now tell me the reason of your coming.

Students : Mam, we have a humble request to you.

Principal : OK, how can I help you?

Students : Mam, we are interested to know about earthquake – its origin, intensity, magnitude, prediction, etc. So, we request you kindly to organize a talk on earthquake by an expert in the field for our benefit.

Principal : Very good. I shall try my best to fulfil your desire. I shall arrange an invited talk within this week, if possible.

Students : Thank you, Mam.

Principal : OK, it will be my pleasure.

Big Class room/Seminar Hall

Persons present

1. Invited Professor of Geology
2. Principal of the Higher Secondary School/College
3. Interested Teachers (3)
4. Students (more than 100)

Principal : Respected Professor Deka, interested teachers present and my dear students. As earlier decision, today, we have invited Prof Deka, renowned Professor of Geology to deliver an invited talk on “Earthquake” for the benefit of the students and teachers. We should know about earthquake, because, it is a burning topic of today. A big earthquake can bring devastations to mankind. Now, I would like to request Prof. Deka to deliver the invited talk on earthquake.

Professor : Thank you Principal Baruah. My dear teachers and students, I am very much grateful to the authority of the school for inviting me to talk something about earthquake, the burning topic of today.

All of you know that it is not possible at all to speak everything of earthquake within a short time. Still, I shall try my best to speak something about earthquake for the benefit of the teachers and students, in particular. I also invite the teachers and students to interact with me and ask questions on the topic.

Now, let us start the session of today’s topic. Before going to talk on earthquake, and as an opening question for the talk, I would like to know from the students –

Is earthquake a natural disaster?

Student : Yes Sir, we know. Earthquake is a disaster caused by nature.

Professor : Correct. There are also other natural disasters. Actually, disasters are nothing but the destructive hazardous events. Earthquake is the most destructive event in terms of loss of life and property. It may come all on a sudden without giving any earlier warning.

Teacher : You kindly tell us about the global scenario of earthquakes.

Professor : Oh, yes.
On an average, two earthquakes of magnitude 8 are reported to occur globally every year. United States, Japan, China and India have experienced several damaging earthquakes in the past. In India, more than 650 earthquakes of magnitude >5 have been reported since 1890.

Student : Sir, give us a simple idea about the earthquake.

Professor : Earthquake event is not simple, it is a complex phenomenon. Simply, earthquakes are earth tremors. They are powerful manifestations of sudden releases of strain or pressure energy accumulation during extensive time intervals. They radiate seismic waves of various types which propagate in all directions, through the earth's interior. The passage of seismic waves through rocks cause shaking that we feel as earthquakes.

Teacher : It is of course a good definition. But we have some queries. Sir what are the strain energy and seismic waves?

Professor : Good questions. I have already told you, it is a complex phenomenon. Still, I shall try to explain it in a simple manner. The building up of strain energy along the fault planes which are relative displacement or slippage of rocks along ruptures and subsequent release of accumulated pressure energy in the form of earthquake.

Teacher : Students, is it clear for you?

Student : Yes Sir, we have also some book knowledge about earthquakes.

Professor : Next, I shall tell you about seismic waves. You know, seismic waves are earthquake generated waves inside the earth. Actually, these are elastic vibrations. These waves are namely P, S and surface or L-waves. P-wave generated by an earthquake, is the primary or push or

the fastest longitudinal wave travelling away from an earthquake source. S-wave is the secondary wave, travels 1.7 times slower than the P-wave and consists of elastic vibrations transverse to the direction of travel. These waves are not much damageable. Surface wave or L-wave originates after P-and S-waves near the surface and speed is less than P-and S-waves. Surface waves are the most damageable and destructive waves. This type of wave is also known as Rayleigh wave named after Rayleigh who recognized this type wave in 1887.

Student : Sir, why surface waves are much more destructive?

Professor : Of course, very good question.
Anyhow, surface waves are generated nearer to the surface. Hence, surface waves may cause great damage due to rapid displacement in the ground.

Teacher : Sir, we have heard about centre, epicenter of earthquake. Kindly tell something for the students.

Student : Yes Sir, tell us about these.

Professor : Definitely. It is a part of my lecture.
Listen.
The earthquake occurs as result of the motion along an active fault i.e. by the rapture of rocks. The place or source where the rapture originates is called the 'centre' or the 'focus' and the place directly above this on the ground surface is called the 'epicenter'. Depth or distance between the centre and the epicenter is known as the focal depth.

Student : Sir, it is clear that active fault is responsible for the occurrence of an earthquake. How can we know that there is a fault or not?

Professor : Yes, we can identify this type of fault after field study. Now, this type of fault can also be identified on good resolution satellite images which may be obtained from remote sensing data providers. We are now using landsat imageries which are popular, since they are found freely in websites and useful to delineate unconsolidated deposits sitting on fault zones. Indian remote sensing satellites also provide similar data.

Teacher : Sir, kindly tells us whether an earthquake may originate at deep seated condition or shallow depth condition inside the earth?

Professor : No, earthquake may occur at any depth inside the earth. If an earthquake occurs within a depth of 50 Kms, it is called shallow focus earthquake. If an earthquake occurs at a depth of 700 Kms or more than that, it is called deep focus earthquake.
Students, do you have any idea about the earthquakes which are much more hazardous, shallow focus or deep focus?

1st Student : Deep focus, Sir.

2nd Student: No Sir, shallow focus.

3rd Student: No idea, Sir.

Professor : 2nd student's answer is right.
Shallow focus earthquakes are much more destructive than deep focus. Because deep focus earthquakes originate away from the ground surface.
Students, you please note that, the recently occurred Nepal earthquake is also known as shallow focus earthquake. We shall discuss it later on.

Student : Sir, severity of an earthquake depends upon only on type?

Professor : Obviously not. It depends upon intensity and magnitude.
Intensity is description of the effects of an earthquake at a particular place, based on observations of damage, using a descriptive scale since 1931 known as modified Mercalli's scale. A map showing intensities at individual locations may be contoured based on isoseismics, which are the lines of equal intensity. An isoseismal map provides a representation of variations of shaking over the region surrounding the earthquake. Based on intensity, an earthquake may be more damageable, medium damageable or less damageable. The scale was first introduced by Mercalli in 1902 with ten grades of intensity. This original Mercalli scale was later used by Wood and Newman in 1931 to develop the Modified Mercalli scale.
Students, any query about intensity?

Student : No Sir, it is clear for us.

Professor : Now, let me tell you about magnitude. It is different from the intensity. It is measured by Richter Scale. O. Charles F. Richter invented this type of scale to measure the size of an earthquake in 1935. It is calculated from the amplitude of the seismic waves and is closely related to the energy released by an earthquake. Richter scale is logarithmic scale developed to accommodate a very wide range of energy. Scale is from 1 to 10. So, based on energy release, scale may be 1, 2, 3 like this upto 10.

Student : Now, it is clear Sir, about intensity and magnitude.

Teacher : For measurement of magnitude, definitely we have instrument. If so, what is the name of the instrument? I know it. But for the benefit of the students, you please tell them.

Professor : Oh sure. Seismograph is the instrument for recording motions, both small and big, of the earth's surface caused by seismic waves. The simplest earthquake recording system consists of a sensor and digital recorder. The record is known as a seismogram. Location and magnitude of an earthquake are calculated from a seismogram.

Student : Sir, we have less knowledge about the earthquake zones of India. So, please tell us about the zones.

Professor : Sure, you should know the earthquake zones. Listen my students. Based on the occurrence and severity of earthquakes, five earthquake zones have been made in India, of which the lowest intensity zones Zone-I and Zone-II were later on merged as Zone-II. At present there are four zones from Zone-II to Zone-V.

The entire Himalayan belt bordering Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Uttar Pradesh and Bihar; all the northeastern states, namely, Sikkim, Meghalaya, Assam, Mizoram, Arunachal Pradesh, Nagaland and Tripura; Bhuj region in Gujarat and the Andaman Nicobar islands largely fall under seismic hazard zone-V.

Again, you should know that there is no aseismic zone in India.

Students : From your talk, it is clear that there is no any area which is not under non-earthquake area.

Professor : No at present.

Student : Sir, we have heard some old and new theories about the origin of the earthquakes. So, I like to know about the origin of earthquakes.

Professor : Of course, there are many theories, old and new, about the origin or causes of earthquakes. Let us discuss at the beginning about some old thoughts. We cannot say that these are theories.

Listen.

Centuries ago, people believed that mysterious shakings of the earth were caused by the restlessness of a monster that was supposed to be supporting the globe. In Japan, it was a great spider, in some parts of South America, it was whale, and some of the North American Indians believed that the earth rested on the back of a giant tortoise.

Student : Sir, what are the clues?

Professor : I shall tell you later on along with the recent theory. Anyhow, the Greek Philosopher Aristotle told that all earthquakes caused by air or gases struggling to escape from subterranean cavities. This idea of imprisoned gases was gradually modified into a theory that earthquakes were caused by gases trying to escape from volcanoes.

Students, these are the ideas of the past about the causes or origin of earthquakes.

But believable idea originated from tectonic cause.

In 1910, H.F. Reid postulated a theory known as the elastic rebound theory based on tectonism. According to this theory, the earthquakes are related to fault i.e. ground displacement is an established fact. The great San Francisco earthquake of California in April 18, 1906 was the result of a displacement along the 965 km long San Andreas Fault. After that, he postulated this theory.

- Student : Sir, it is seen that faults are associated with most the earthquakes.
- Professor : Yes.Now, I shall give you the recent theory of earthquake's origin. Can you tell me, what is this theory?
- Student : Is it plate tectonics theory?
- Professor : Absolutely correct.
The basic idea in that the earth's outermost part (called the lithosphere) consists of several large and fairly stable slabs of about 100 kms thick solid rocks called plates which move horizontally at a speed of several centimeters per year. Motion of these plate indifferent directions is considered to be the basic cause of earthquakes. At the boundary of these moving plates, they collide with each other and form large mountain belt as in case of the Himalayas or moves away from each other as in the case of Pacific Atlantic ridge. Large areas of moving plates that cannot move further are consumed at the deep grooves called trenches or subduction zones.
- Student : Sir, earlier you told about the spider, monster, whale, tortoise regarding the origin of earthquakes. I think that the basic idea of this theory bears close similarity with earlier thoughts.
- Professor : Of course, but the old thoughts have no any scientific reason, as we have found in Plate Tectonics theory. Do you know, Herri Hess whoentirely associated with this theory, called it 'Geopoetry'.
- Teacher : How many plates are present in the earth and where they are present?
- Professor : Thank you, you ask me a good question. There are about 12 big and small plates that they are floating over the mantle layer, also called asthenosphere, of the earth.
Student, there are three layers inside the earth like crust, mantle and core.
Anyhow, Indian and Eurasian plates are two important plates.
As you know, the Himalayan mountain range is the dramatic outcome of the collision of Indian and Euroasian plates some 40 million yearsago.

- Student : Is Indian Plate is still moving?
- Professor : Yes. The Indian Plate is still penetrating deeper inside the Eurasian Plate at an estimated rate of about 5cm/year.
- Teacher : Is there any fault associated with this seismic zone?
- Professor : Definitely due to accumulation of stress, the faults occur.
- Second Teacher: I think faults occur in the subduction zone due to stress.
- Professor : Yes.
- Professor : Let us discuss about interplate, intraplate and Stable Continental Region (SCR).
The general theory of plate tectonics has implications for our understanding of earthquake. It is our understanding that a larger number of earthquakes occur along the edges of interacting plates. These are known as interplate earthquakes and they are related to the rate of movements of plates. An earthquake, associated with the inner continental seismic belt is considered as intraplate earthquake. Very rarely earthquakes do occur in the more stable and older parts of the continents. These are called Stable Continental Region (SCR) earthquakes. The 1993 Killary earthquake is considered as a typical example. Earthquakes may occur in SCR after a long gap.
- Teacher : That means, there is no any aseismic zone in India?
- Professor : Yes. Early days, it was thought that SCR is aseismic zone. But a present, SCR is also included under seismic zone.
- Student : What are the earthquake prone areas of the world?
- Professor : There are three well defined earthquake prone areas of the world. Based on frequent and attained great intensity, there are a few well defined zones of seismic activities, called the seismic belts. The most well defined earthquake belt is found around the Pacific coast termed as the 'Circum Pacific Belt'. This area is most frequently subjected to seismic shocks as much as 75% of the total global earthquakes. The earthquakes in the region occur due to subduction of the Pacific

Oceanic Plate beneath the continental plates. The highest earthquake prone areas within this belt are Japan, Western Mexico, Malayasia and Philippines.

Another well-defined earthquake belt is the Alpine-Himalayan Belt. This belt spreads from the East Indies through the Himalaya upto the Alps in Europe. About 21% of the global earthquakes originate in this belt. The earthquakes originating here are mostly shallow focus. It is known as 'zone of fracture'. Another belt is Mid-Oceanic Ridges which includes the sub-marine mountains underlying the centre of the Atlantic, India and South Pacific Oceans.

Apart from these, there are some minor earthquake belts like the rift valleys which are formed due to faulting of East and Central Africa.

Student : Sir, can we predict an earthquake?

Professor : The answer is almost negative. It is not possible to predict most of the earthquakes. But a very few earthquakes could be able to predict like Haiseng earthquake occurred in China in 1975.

Now, what do you mean by earthquake prediction can, you tell me?

Student : Yes Sir.
Prediction means the forecast.

Professor : Yes, it is partially correct. But what type of forecast? Forecast meanstime interval, place of location and magnitude of the future occurring an earthquake.

Student : Sir, kindly tell us more about prediction.

Professor : Prediction may be classified in two categories.
(a) Long term prediction.
(b) Short term prediction.

A long term prediction is now quite feasible since historical records and earthquake observations have delineated the active zones and experience has shown that earthquakes occur again and again in the

same region as they have been occurring in the past. So we may expect same will happen in future also.

A short term prediction is operating a 'warning' system which may save life and movable properties.

There are many precursors which can be used for prediction of earthquake.

Student : Sir, kindly tell us about different types of predictions.

Professor : Please listen. Foreshocks are the warning of coming of an earthquake, because these occur days before the main event. The most successful prediction based on this method is considered to have achieved in case of Haicheng earthquake occurred on Feb 4 in 1975.

A large earthquake is generally preceded and followed by many smaller shocks. The largest earthquake is called the main shock. The smaller ones that precede the main shock are called foreshocks and subsequent shocks are called aftershocks.

Seismic gaps which are inactive segment of the plate might become active with seismicity due to accumulation pressure in the site.

Since 1994, Zhonghao Shou, a Chinese chemist living in New York made a dozens of earthquake predictions based on cloud patterns with certain claimed success.

Students, have you heard about GPS, the Global Positioning System?

Student : Yes Sir.

Professor : Right.
The GPS, a comparatively recent technology, has significant contribution along with satellite remote sensing and it is possible to predict Land Surface Temperature (LST) conditions before and after an earthquake.

Thermal infrared datasets were used to study, the thermal scenario before and after Bhuj earthquake in Gujrat and the Bam earthquake in Iran showed thermal anomaly associated with these earthquakes.

Dilatancy is another recently developed method of earthquake prediction. It is based on the monitoring of anomalous behavior of some physical parameters. The term dilatancy was initially used by Reynolds to describe the opening of very minute fractures in rocks under the influence of stresses and the resultant in elastic increase in their volume. The stress build up is accompanied by volume expansion due to development of microstructures until the rock breaks up along fault plane.

Some other precursors are geomagnetic variations, deep electric current, ground resistivity and self-potential variations, ground water level fluctuations, Radon gas emission, etc.

In China and Japan, abnormal animal behaviours have been used since long for earthquake prediction.

Teacher : Sir, is it possible to prediction earthquake by a single device?

Professor : No. But multidisciplinary approaches have been recommended as effective means for earthquake prediction. Synthetic Aperture Rader Satellite, Thermal infrared, Ground Penetrating Radar (GPR) are some of the recent devices recently used for earthquake prediction.

Professor : Do you know the event of Nepal earthquake?

Student : Yes Sir, we have heard about Nepal earthquake occurred recently in Nepal. But we do not know the cause. Kindly tell us about this earthquake.

Professor : Students, Nepal was badly struck on April 25, 2015 by the worst earthquake in 80 years. About 20,000 people were killed by this earthquake. Even Bihar has also suffered lost life and property. The magnitude in Richter scale was 7.9 and the epicenter was at Lumjung, 80 Kms North West of Kathmandu. This earthquake originated at the depth of about 14.8 kms.

Do you know why this earthquake was so devastating?

Student : Yes Sir. Because it was a shallow focus earthquake. Moreover, its epicenter is away only 80 Kms from the capital of Nepal.
Am I correct Sir?

Professor : Yes you are correct. You know Nepal is situated on the Himalayan active earthquake zone. Because Nepal Himalayas is characterised by some thrust faults at subduction zone of two plates.
Can you tell what are those two plates?

Student : Yes Sir, Indian and Eurasian plates.

Professor : Correct.
Student can we tell me why so many peoples died occurring of this earthquake, especially in Kathmandu?

Student : For the occurrence of the earthquake, Sir.

Professor : That is not the exact cause. Because, there is saying “Earthquakes do not kill but unsafe building’s do”. So, unsafe buildings were responsible for killing.

Student : For safety, what type of buildings is necessary?

Professor : Earthquake resistance buildings.

Student : Can this be done with the construction or after wards?

Professor : Actually care is to be taken at the time of construction. For weak structures, to make it seismically safe, retrofitting can be made.

Teacher : In your talk, it is clear that we cannot predict an earthquake in most of the cases, especially in India. So precautionary devices should be taken at the time of event.
Am I correct Sir?

Professor : Partially correct. Because, precautionary measures should be taken before and at the time and also after the major event. Because, after the

major event, there might be some after shocks which may continue for more than two days.

Student : Why after shocks are coming, Sir.

Professor : For adjustment of the plates.

Meanwhile Principal enters the hall.

Principal : Are you gainful from the talk?

Student : Yes Sir, we are very much gainful.

Principal : Sir, we are very grateful to you for your delivered talk on earthquake. In future also, we may ask for your help for the benefit of the students.

Thank you Sir.

The meeting is over.

Abhijit's House

Abhijit : Suman, Subasis, Mustak; Please come here.

Suman : Uncle, are you now feeling comfortable?

Abhijit's Dad : Yes, I am now recovering well.

Are you coming from the college?

Suman : Yes. College authority had arranged a talk by an expert on earthquake. That was a very informative talk.

Abhijit : Friends, come to the dining hall.

Mustak : Aha, I am feeling thirsty. Tea and snacks will be good combination. Am I correct Subasis?

Subasis : Oh Yes, Mustak. By-the-by, we will meet at my house tomorrow to work out an action plan for public awareness in our locality.

Abhijit : That is fine, we have societal responsibility and we shall volunteer ourselves.