

DANGER FROM DEPTS- EARTHQUAKES

By M.M.Munshi

It is hard to realize that the crust of the earth is so constantly being molded anew. The fact that gigantic forces are continuously at work, shaping the rocks of which the crust consists, thrusting them into enormous folds, twisting them cracking and breaking them. The process is so slow and gradual that we are rarely aware of it. But then in Latur or Uttarkashi, Gujrat or Kashmir and POK suddenly major earthquakes take place; Ground shakes very violently, cracks appear on the surface, buildings and other structures crash hundreds or even thousands die. It is only then that we become aware of tremendous forces at work beneath our feet. Although devastating earthquakes are very few in number but earthquakes are not an uncommon occurrence. If we include all the shocks from the very greatest to the very smallest something like a million earthquakes take place every year. Furthermore we now know that earthquakes have been occurring in great numbers since time immemorial as far as human records go. On an average of about 10,000 earthquakes classified as grade 4 and higher on Richter's Scale are recorded annually, out of which 5 to 10 cause significant damage

Causes of Earthquakes

There have been fanciful earthquake legends. These are hardly more fantastic than the theories about the quakes that were advanced by the learned men in the past. In our own day however on-the-spot investigations and the use of precision long range instruments have gradually lifted the veil of mystery that once shrouded the quaking of the earth. The study of earthquakes now forms a distant science known as **seismology**. (from Greek words meaning earthquake science)

Tectonic

The great majority of earthquakes are caused by a sudden dislocation of the earth's underground structure as a result of strains and stresses. Such earthquakes are called tectonic from the Greek word *tecton* meaning "builder". A widely accepted theory is that these dislocations are based on **Isostasy** The condition of balance between adjoining parts on earth's surface. The force of gravity pulling all things toward the centre of gravity being responsible for this condition. Objections were raised that existence of side by side of mountains and low lying plains disprove the isostatic theory. Do not the lofty Himalaya for example far outweigh the Indo-gangetic plain to the south The simple answer to this was found to be "no" Experts of geodetic and geological surveys of India have measured the comparative masses of Himalayas and Indo-Gangetic plains and came to the conclusion that Himalayas were made up of comparatively lighter mass. All over the world in similar fashion the various segments of which the earth is composed are balanced against one another As already indicated that the geological processes are continuously at work altering the face of the earth by weathering, denudation and force of the flowing water, gradually grinding the mountains resulting in debris piling up in nearby plains A state of imbalance results. The force of gravity however seeks to restore the former balance. As a result rocky material underlying layers of the crust are transferred from the area which has received the products of erosion (piled up material) to the one that has been stripped of the material. The rock under

The rock under pressure flows from one area to another and sets up tremendous stress and strains in the surrounding rock structure and finally cracks it.

Shrinking

According to another dislocation theory when the earth was born it was initially in a gaseous state it became a molten liquid finally it cooled down until a crust was formed at the outer surface. The cooling continued under the crust and as a result earth began to shrink. Naturally the crust would become too large as the cooling continued it would wrinkle and finally collapse by folding and warping. This would bring dislocations at depth and great masses of rock would be thrust upward to form mountain ranges. This theory is open to many objections main being that it is by no means certain that earth was formed by in that way. Even if it was formed like that we would expect the outer space of the earth to show numerous comparatively and closely spaced like that of a shriveling apple. Actually the great mountain are widely separated and concentrated in few belts

Volcanic.

Certain earthquakes are not tectonic but are associated with volcanoes. These are due to volcanic explosions or to fractures occurring within the structure of a volcano. The volcanic explosions can be violent in the vicinity of a volcano but their effects are not felt at considerable distances

Some earthquakes however minor are caused by roof collapse of underground caverns and channels in limestone\ dolomite country, but these are of a limited and local nature.

Plate tectonics

According to another dislocation theory far below the ocean bottom draw with them blocks of earth's crust about 80 to 100 kms thick of the size of continents As these continental blocks referred by earth scientists **drifting lithosphere** or simply **tectonic plates** move with speed of 1 to 18 cms per year; when their edges collide give rise to mountain ranges thrust faults and also causing earthquakes of tremendous devastation. Plates drifting apart create continental margins, oceanic trenches and mid oceanic ridges. Detailed discussion on plate tectonics is beyond the scope of this article

The stresses and strains within the rock structure, whatever their cause may be take a long time in building up. Finally even a slight additional force may prove to be last straw that breaks the camel's back; and cause a rupture in the rocks to take place. The additional force or trigger force as it is called may one of the many possible factors. It may be alternate expansion and contraction due heat from the sun during the day and cooling that follows at night. It may be due to pressure exerted by oceanic tides At last the underlying rocks yield to pressure that has been exerted upon those and more or less extensive breaks take place. If the forces that have been

The shaking of earth may prove to be trigger force for rock crashing down the mountain slopes and soil moving on a downward grade. It also may cause sand and mud to be thrust up from the bowels of the earth. What happens in this case is that earthquakes open up cracks through which ground water is sucked downwards. Then cracks are violently closed again forcing out the water and giving rise to temporary streams as happened in the recent Gujrat earthquake. Sometimes sand or mud or whatever comes in the way is also forced out along with the water. Sometimes fertile land is ruined by sand which is thrown up.

Tsunami

Thus far we were discussing earthquakes that are felt on land. Earthquakes also take place in great numbers in oceans of the earth which make up three quarters of the earth's surface. Quake that is felt at sea is called **submarine earthquake** or simply **seaquake**. Those on the ships in the vicinity of such quakes it seems as if the vessel is pounding some submerged obstruction like a reef or something. Submarine earthquakes may bring about flood waves. Submarine earthquakes may bring about flood waves, but certain conditions must be fulfilled before such waves can start. The earth fracture must reach the ocean floor, furthermore the fracture has to be vertical or it must occur on a steep slope as to cause under water landslides. If one section of the ocean bed is raised in this way, the water above it moves towards the adjoining section, in order to fill up the gap. The moment this water acquires will cause it to rush past the lowered area; then, when a great quantity of this water is built up beyond the area the moment is reversed. This to-and-fro motion will be transmitted to the surrounding water. The waves set up by submarine earthquakes were popularly known as tidal waves which was a misnomer since these waves have nothing to do with the gravitational pull of sun or moon. A more appropriate name is **seismic sea waves** Japanese call these waves "**tsunami**" and this name has been universally accepted.

Tsunami can travel great distances with a speed of about 600 to 750 kms per hour. Tsunami can hardly be observed on the high seas for the reason the total volume of water that is effected is small compared with the volume of the ocean. But when tsunami reaches a coast its effects are devastating. First the water withdraws all along the shore as a low tide had occurred. Then a solid wall of water returns and overflows the land. The destruction caused by tsunami of December 2004 effecting, Samatra, Andaman-Nicobar, Tamilnadu, Kerala and Shrilanka will be remembered by several generations.

Field study

In a typical field study, experts gather as much information as possible about an earthquake from questionnaires given to people within the effected area and from on-the-spot study. After considering all the evidence, the experts decide which of the intensity on Richters Scale would apply to this or that place. The figure is then entered on the map. After a map has a good many entries of this sort, a line is drawn through the points showing the highest intensities. Then another line is drawn through the places next highest intensities and third line and so on. These lines which generally form a series of closed concentric curves. Within the innermost of these lines the experts will determine the epicenter of the quake with considerable degree of accuracy. The field study of the earthquake is often very difficult. It could not be applied to quakes occurring at sea. Even in regions where there is an adequate no. of witnesses the results may be unsatisfactory.

at work straining the the crust upwards, there will be a vertical displacement (break) If the forces are exerting horizontally. horizontal displacement takes place.

The source of an earthquake known as **focus** or **hypocenter** may be near the surface or deep within the crust. Based upon its depth from the **epicenter** (point on surface vertically above the focus) seismologists differentiate between shallow, intermediate and deep foci (plural of focus). The motion of earth's crust caused by earthquake waves may be so slight they will not be felt by anybody. We come to know about them because they are recorded by precision long range instruments called seismographs. In other cases that is earthquakes with intensity of 3.5 or above on Richter's scale may be distinctly felt. These may cause a certain amount of swaying and rattling but will not bring about any visible changes on the surface of the earth, nor will they cause any noticeable damage. By far the largest number of earthquakes are one or the other of these two types

In other quakes with intensity of 6.6 and above the shaking of earth is very violent. The ground beneath lurches this way and that. Articles of furniture get thrown, poles and trees sway violently. The support of buildings get dislocated, building walls get cracked. If the quake is unusually severe buildings, bridges and other structures crash to the ground. In severe earthquakes cracks and rents may form on the surface. Adjoining sections along the rents may be displaced horizontally as much as 6 mts. There may be vertical displacements also. Gaps may also be formed but these are comparatively slight depth. There is no scientific foundation for the belief that that vast gaps open swallow houses or whole villages and then close leaving no trace.

Sounds etc

The sounds that accompany an earthquake are generally awe-inspiring. Most of these do not come from the earth at all. They represent the violent creaking of the buildings deafening crash of masonry bricks stone and plaster, the shouts and screams of victims, rumble of landslides from hillsides and the like. However some sounds do arise from the ground; or to put it differently, the vibrations with frequency of 20 per second or above set up by a rupture of the rocks are audible to the human ear. Some earthquakes have frequencies below 20 vibrations per second are not audible to human ear and as such are not heard at all. But however certain animals and birds pick up with frequencies with less than $1/20$ become restless before the human get aware of the impending earthquake. Ancient Chinese observed unusual behavior of certain animals immediately before an impending earthquake although they realized it much latter. Certain birds immediately fall silent, certain fly away from their perches on trees, building or ground. Water birds suddenly leave water, horses cattle dogs become restless and try to move into open spaces.

Secondary effects

The secondary effects of an earthquake can be deadly. Fire may break out because of broken gas mains or pipes, electrical short circuits, heating stoves, kitchen fires etc. There may be no water to fight the flames due breakage of water mains. These often more damage and loss than the earthquake itself. More damage was caused by fire than the earthquake itself at San Francisco in 1907.

As those near the centre of the disturbance may have been so unnerved at the time that they cannot give a clear account of what they saw or felt.

Seismology

Fortunately seismologists have developed an ingenious instrument that can detect the motion within the earth's crust caused by an earthquake even if it takes place thousands of kms away. Earthquakes are registered and recorded in **seismograms** by using highly sensitive measuring instruments known as **seismographs**. The direction, distance and energy of an earthquake can be derived from the data in the seismograms, i.e. the amplitude of the waves generated by an earthquake. Energy is expressed as **magnitude**, which is computed on the basis of **ground amplitude**. Wave duration and a calibration function. As already indicated the earthquakes are classified on the **Richter Scale** of earthquake magnitude according to the maximum amplitude measured at distance of about 100 kms from the epicenter. Magnitude values generally range from 0 to 7.7-8.6 but the scale has **no upper limit**.

The energy is released at the focus of an earthquake spreads in the form of elastic waves through the earth's interior as (1) **longitudinal** and (2) **transverse waves**. Longitudinal (also known as **primary** or **P waves**) move faster and arrive at a distant given point earlier than transverse waves (also known as **secondary** or **S waves**). The slowest but most highly energized are **surface waves** (also known as **rayleigh** or **L waves**). The source of an earthquake known as the focus or hypocenter may be near the surface or deep within the earth's crust. Based upon its distance vertical depth from the epicenter seismologists distinguish between shallow, intermediate and deep focus of the earthquake.

Any type of seismograph is fundamentally a pendulum. It is based on the principle that because of its inertia the heavy mass of the pendulum bob at the end of the pendulum will remain still when ground lurches beneath it. A recording pen attached to the pendulum bob traces out the motion on paper wound a revolving drum which is kept revolving. To avoid the friction pen is generally a light spot that is reflected from a mirror and produces a fine black line on photographic paper.

Seismology has also proved exceedingly useful in exploring the earth's interior. Physical (drilling bore) holes have reached maximum depth of 13 kms equivalent to only about 0.2 of the earth's radius. We learn a great deal more about the structure of the earth's interior from seismic waves that penetrate to the earth's core and beyond.

Prediction of earthquakes

Except for approximate location/demarcation of earthquake prone seismic zones the earthquake science has not made much progress regarding prediction of the timing and specific location of earthquakes. Even very experienced seismologists today disagree about whether the location time, magnitude of an earthquake can be predicted. However researchers have been trying to identify reliable signs for decades; using automatic recording devices, they systematically measure changes in specific characteristics temperature chemical composition, gas concentration (radon), electrical ground water resistance, ground water levels, spring behavior, moments along fault lines, and deformations of earth's surface. All these phenomena's can – but not necessarily – predict or pinpoint earthquake activity.

Earthquake resistant construction

The first building designed to resist earthquake shock was erected by an American architect Frank Lloyd Wright between 1916 and 1922. It survived the earthquake of 1923 virtually undamaged. In the years since architects have adapted special methods of stable or flexible construction USA, Japan and other earthquake prone areas of the world. A number of countries have enacted suitable building regulations during the past few years Cellular construction techniques and "sandwich" structure composed of steel and rubber plates built into the foundations of high rise buildings absorb earthquake shocks. Steel structure are generally much safer than masonry buildings of brick and stone. Wood framed buildings also offer satisfactory earthquake resistance if certain

safety requirements are met with. School, college or other public buildings are subject to stringent regulations. Recent experience has shown that many bridges highway ramps and similar structures need upgrading to meet safety requirements. Loose substrata, especially made up fills or embankments are very susceptible to earthquake damage. Much depends on the quality of construction in developing countries. High rise buildings with underground parking and shops without built in steel and rubber in foundations are particularly vulnerable. One shivers at the thought if places like Delhi Gurgaon are hit by earthquakes. Although earthquakes cannot be prevented precautionary measures prevent damage significantly

Disaster management

In industrialized countries threatened by earthquakes such as Japan, Italy and US (especially California) Plans have been made for response to natural disasters. School children in Japan and California learn as how to behave when danger threatens. Public emergency disaster exercises are conducted on a broad basis in Japan. Plans are modified, improved upon to experience gained in such emergencies California has established a network of decentralized emergency aid stations staffed and equipped to meet specific local needs The central Japanese authority failed to respond adequately and in time during the Kobe earthquake

In India we are far behind in disaster management there are no permanent aid stations, no emergency exercises are taken up. The committees are dominated by beurocracy who till very recently had no or hardly any experience of managing disasters. The buck is still passed to armed and para military forces who to their credit despite lacking specific training for the purpose have carried out selfless service in rescue and relief operations that has been appreciated by all concerned

The recent demand by victims of Uri – Tangdhar earthquakes that relief should be handled \ entrusted to Army rather than to civil administration should be an eye opener for politicians and civil administrators Many times the relief and rescue operations are hampered by frequent visits by VIPs to the effected areas

But it is heart rendering to note that the quick response which followed the Tsunami of Dec 04 and the recent Uri-Tangdhar earthquake was remarkable

Seismic Waves

Regional earthquake

0 2 4 8 min



Nearby earthquake

0 2 4 min



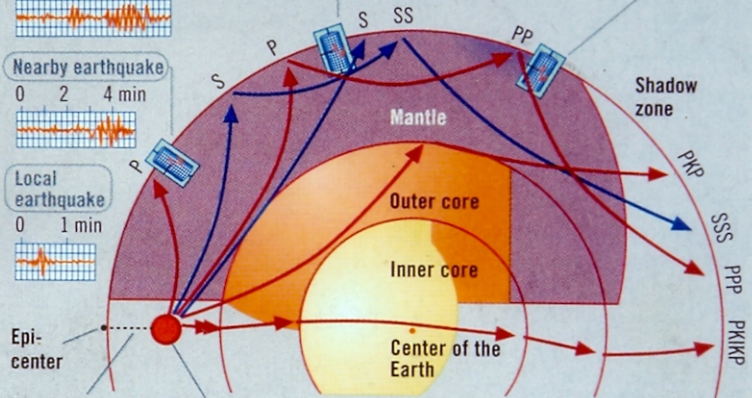
Local earthquake

0 1 min



Nearby earthquake

0 4 8 12 16 min

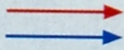


Epi-center

Focal depth

Hypocenter

Longitudinal wave (P)
Transverse wave (P)



Spread of seismic waves
P(S) direct waves,
PP(SS) single reflection,
PPP(SSS) double reflection,
K part of wave passing through Earth's core,
KIK part of wave passing through the inner Earth core
(Diagram is not to scale.)



Configuration of a vertical seismograph

Rotating drum
Pendulum weight

These two diagrams show how the seismograph works. Left: before an earthquake shock; right: during a shock. Note that it is the framework that has moved, and not the bob of the pendulum.

