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ORIGIN, CAUSES AND IMPACT OF EARTHQUAKES.

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Abstract: *The devasting1991:Uttarkashi;1993:Kilari;!997:Jabalour;1999:Chamoli and 2001:Bhuj earthquakes presented examples of seismic effects on non-engineered structures and as well as engineered structures. Highly damaged columns in the open ground floors of many multistoreyed buildings emphasized the importance of seismic design of structures. The performance of reinforced concrete frame structures, load bearing masonary structures, steel structures, timber framed structures and their failure mechanism though seismic forces, attributes to the knowledge for remedial measures in earthquake prone regions. This technical paper presents the origin and causes of earthquake for general understanding*

Keywords: Nature, Environment, Seismic waves, Earthquake damage, Continental drift, Tectonic plates

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INTRODUCTION

Nature is the beauty of peace, truth, love and happiness. Organisms and Environment are the two components of nature which are interdependent, mutually reactive and interrelated. "Ecology is the science of all the relations of all organisms to all their environments". The earth's living organisms interacting with their physical environment may be considered on a giant, vast ecosystem, which is the largest and most nearly self-sufficient biological system and thus the planet earth along with the atmosphere (air, land, water) that sustains life is known as biosphere. Biosphere extends into about 7 km of the earth surface itself, downward into the ocean to depth of about 10.67 km and vertically in to the air to about 10 km, where life is found to exist

The word**" Sustainable**", according to Webster's 10th New Collegiate Dictionary is defined as follows : **Of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.**

The design, construction and Operation of our cities has been a major factor in the degradation of our environment," Say's Berkebite," and a more holistic approach to planning and community building can improve the economic and social vitality of our society as well as to restore the environment".

EARTH STRUCTURE

The research is have been able to establish that the Earth is a multilayered body by the Geophysical method or seismic surveying. The Earth consist of a series of shells differing from one another in mineralogy, density, elastic properties, temperature and pressure.

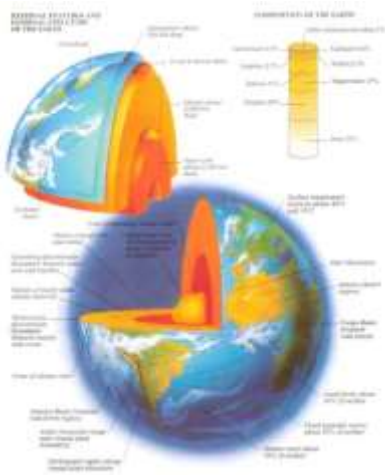


Fig (1) show's section through part of the globe and the characteristics of the constituent shells. The outer shell, which is called the crust is in turn composed of several layer's. The upper layer

is made up of stratified sedimentary rock several kilometers thick on the average, below which a granite layer lies which sometimes comes up to the surface. The granite layer is about 10 km thick in valley's and up to 40 km downwards there is a layer of basalt whose thickness runs into 30 km under valley's and into 20 km under ridges. On the average the crust is 40 km thick under continental shields, being 60 to 70 km thick under high mountains. In contrast to its continental counterpart, the ocean crust is much thinner (6 to 8 km thick), the basalt lying right under the sedimentary rock.

FIG :STRUCTURE OF THE EARTH'S CRUST. 1.CORE 2. MANTLE 3. CRUST .

The outer crust is separated from the under lying stratified material, referred to as the MANTLE, by a surface called the Mohorovicic discontinuity after the Jugoslav seismologiest who discovered it when studying the propagation of seismic waves during the crat earthquake of 1909. At the Mohorovicic discontinuity, the propagation velocity of seismic waves abruptly changes which is indicative of a difference in density and elastic properties between the crust and upper mantle materials. The Earth's rocks, especially those forming crust, contain radio active elements which decay and emit heat.

At a depth of 50 to 100 km below the surface, there is a well pronounced layer of asthenosphere (or tectosphere) about 200 km thick, where the velocity of transverse waves suddenly falls which indicates that there the materials less hard than elsewhere above and that some of it is probably molten. Specialist believed that those portion are directly responsible for volcanism and that are located near the crust areas where intensive folding takes place.

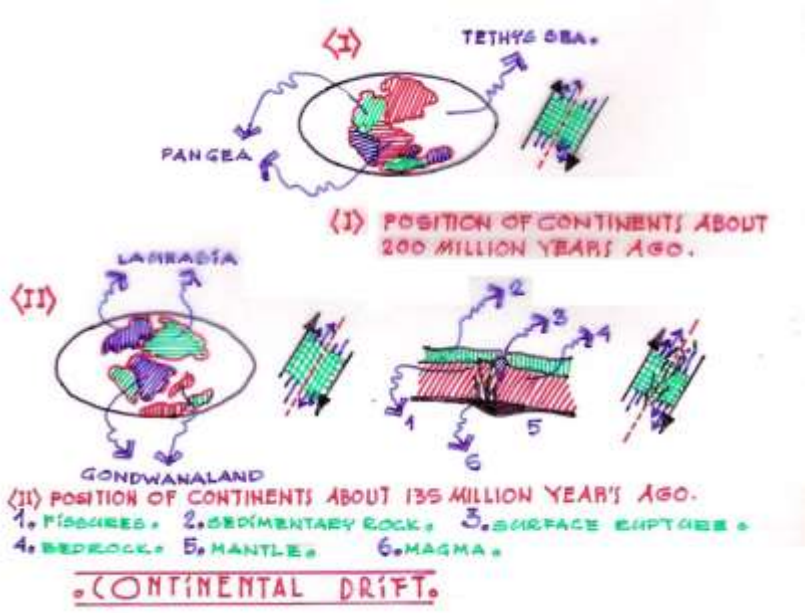
Below the lower mantel lies the core whose outer portion is believed to be a molten state and whose central portion, called the inner core, is assumed to be solid.

CONTINENTAL DRIFT

In 1915, The German scientist Alfred Wegener published a book "The origin of continents and oceans in which he advanced a new theory, the theory of continental Drift." This theory claimed that the changes in the appearance of the Earth were mainly due to the shifting of ocean's. The theory of Continental Drift assumes that the continents plough through the oceans like massive ships.

350 MILLION YEAR'S AGO:

During the early Carboniferous period large continental masses, Laurasia in the North and Gondwanaland in the south, began drifting towards each other.



250 MILLION YEAR'S AGO:

In the late carboniferous period Laurasia and Gondwana land collided, creating a super continent Pangea, (and a great ocean called Panthalassa) which remain largely intact until late Triassic times. A large gulf called Tethys opened up in the regions we now recognise on the Mediteranean & the Alpine-Himalaya's mountain belts and about 135 million years ago Pangaea broke apart to form a cluster of northern continents named Laurasia and cluster of southern continent named gondwana and gap between them was filled with ocean.

PLATE TECTONICS :

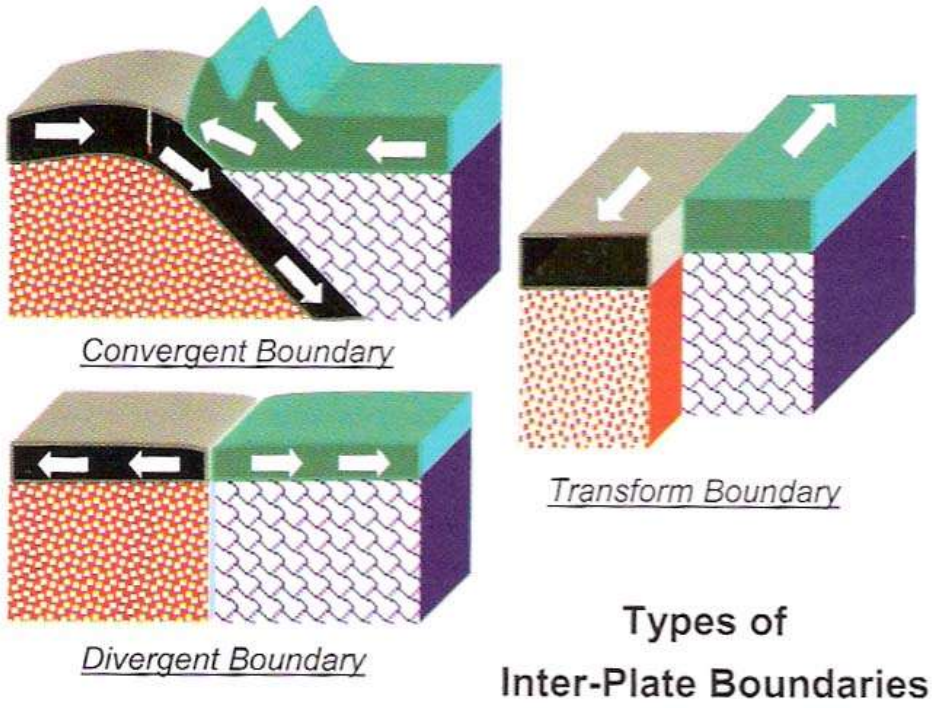
Observation of the earth's surface motion with some portion of the crust and some portion of mantle sinking and some going up. It has been also found that the crust executes horizontal motions on the hot molten outer core. This sliding of Earth mass takes place in pieces called **Tectonic plates**. This is so, because the crust of the earth is not a complete single shell of granite and basalt but a mosaic of several region segments, called plates. These plates include not only the Earth's solid upper crust, but also parts of the denser mantle below called Asthenosphere, and carry the continents and oceans on their like mammoth rafts. The plates with an average thickness of 100 km float on the Asthenosphere and move continuously against one another at a rate of up to 20 cm a year. Continents form only a part of the plates; the surrounding oceans form the rest of the plates.

The surface of the earth consist of seven major tectonic plates and many smaller ones (Fig).The relation of inter plate movement is defined by the type of plate margin: Constructive, Destructive and Conservative.

Constructive plate movement is well illustrated in the Atlantic ocean. At the mid-ocean ridge, new ocean floor is continuously being produced as the Americas move further apart

Tectonic plates

from Europe and Africa.Destructive plate movement is found on all side of Pacific Ocean, as the various plates slide down beneath the surrounding lithosphere.Conservative plate movement can cause the most destructive earthquakes. Earthquake arises where adjacent plates slide past one another along transform faults, such as the San Andreas Fault in California.



The ocean ridges are formed when two plates move apart and there are rifts in the crust i.e. known as **DIVERGENT** boundaries. In another case two plates move side by side along the same or in opposite direction is known as **TRANSVERCE** boundaries. Sometimes the plate in the front

is slower and the late behind comes and collides, through this the mountains are formed is known as **CONVERGENT** boundaries. The relative movement of these boundaries is approximately 10 cm per year.

ELASTIC REBOUND THEORY:

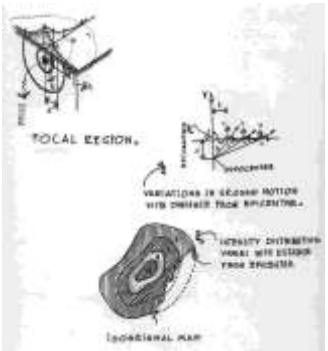
Rocks are elastic materials and so elastic strain energy is stored in them during the deformations that occur due to the gigantic tectonic plate actions in the earth. Due to the sudden slip at the fault the large amount of elastic strain energy released and spreads out as seismic waves that travels through the body and along the surface of the
earth which we experience as vibrations and shaking of Earth is the cause of Earthquake. The Earth Scientist know this as the Elastic Rebound Theory.

EARTHQUAKE:

Earthquakes results from continuous geological transformation in our planet. According to the theories the tectonic plates of which the world's surface consists are in constant movement if it is near the site of friction between these plates the earthquake occurs. It takes place after gradual release of strain energy. This release causes a movement or tremor on the earth's surface which we experience as earthquake.

India was part of super continent called Gondwana land and had shared land boundaries with Africa, Antarctica and Australia. But around 100 million years ago, it broke away from Madagascar and headed towards Asia. At a geologically fast pace of 12 cm a year. It then crushed into Asian land marks.

Under the impact the Indian Plate buckled at the edges and cracked causing the Himalayas to rise. When the subcontinent broke away and sped towards Asia, the platue was scene of spectacular volcanic activity. That flooded the area with basalt. Much of it collected in the area called the Deccan trap that compasses more than half of Maharashtra including Latur. How this ancient rifts both on the trap and the rest of the plateau, which form natural river valleys, like the Narmada, Godawari and Mahanadi seem to become active.

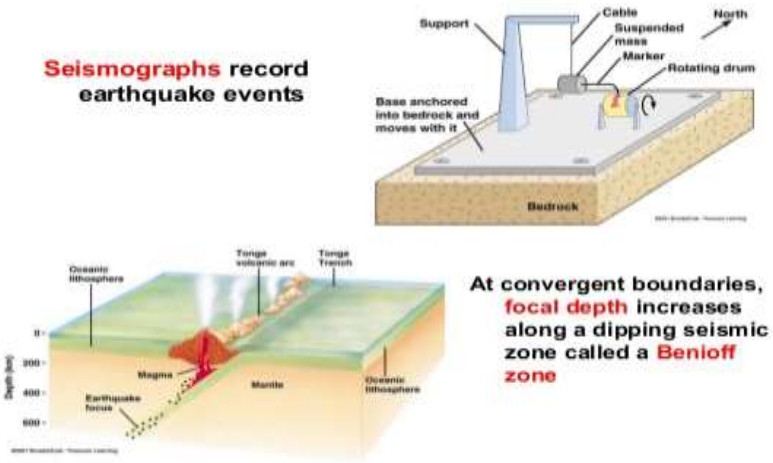


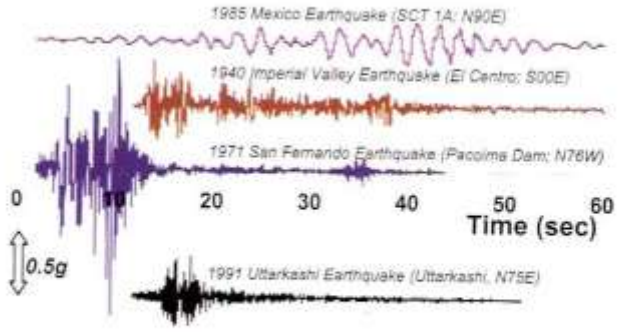
RECORDING INSTRUMENT:

In order to record ground motion parameters during earthquakes, quite a number of countries have set up networks of seismograph stations. The instruments employed operate in the tiggered mode, that is, they are started (triggered) automatically by the arrival of a shock of definite intensity.

The earliest device which could detect the occurrence of an earthquake at quite a long distance from the epicenter was make in China by chjang Heng (78-139 AD). It consisted of vessel which contained a pendulum connected to radial movable levers. The end of each lever was attached to the jaws of a dragon who held a ball in his mouth.

The advent of new seismographs gave a fresh impetus to seismometric research and enabled seismologists to evaluate quantitatively ground motion parameters during earthquakes.





Some typical recorded accelerograms

EPICENTRE:

The intensity of an earthquake on the Earth's surface and, in consequence, the associated damage to buildings and other structures depend on a number of factors. The most important of these are the hypocentral distance C and the amount of energy released by the sudden rupture of the material at the f ocus. The distance C and be determined as the hypotenuse (OK in Fig) of a right triangle

$C^2 = \Delta^2 + h^2$

Where A is the epicentral distance defined as the distance from the epicentre (the point on the Earth's surface located directly over the hypocentre) to point K on the Earth's surface where the earthquakes intensities being determined and h is the depth of the hypocentre.

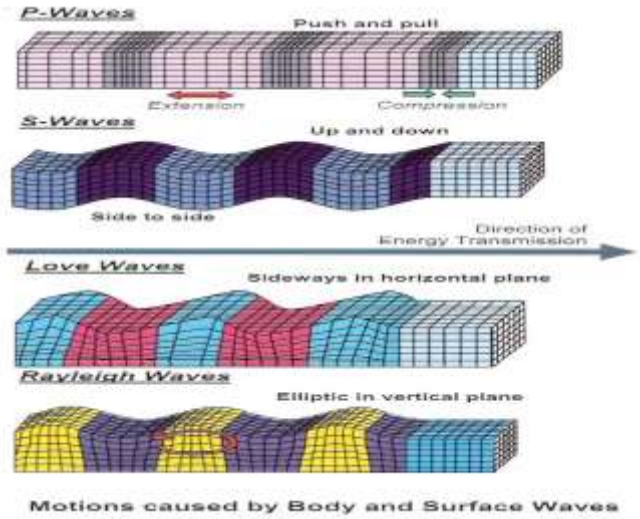
SEISMIC WAVES:

- Surface waves are restricted to near the earth surface.
- **Body waves** – consist of

1) Primary waves - Material particles undergoes extensional and compressional strains along direction of energy transmission

2) Secondary waves – Arrives at a given point after P-wave passed & passes through only denser materials

- The slowest moving seismic waves are knowned as **"Surface waves"** or **"L-waves"** that consist of **Love waves** & **Rayleigh waves**
- S- waves in association with effects of L- waves cause max. damage to structure by their racking motion on surface in both vertical & horizontal direction.



Motions caused by Body and Surface Waves

OCCURRENCE AND IMPACT OF EARTHQUAKES:

Earthquake is a one of the natural environmental disaster which may causes due to the manmade or Geological deformation takes place within the earth. Actually the strain energy is released due to tectonic plates movements which we experience as tremors on the earth surface known as **Earthquake**.

Most of the earthquakes in the world are occurred along the boundaries of the tectonic plates called as "**Inter-plate Earthquake** "(eg. 1897-assam Earthquake) and number of Earthquakes occurs within the plate itself, away from the plate boundaries called as "**Intra-plate earthquake**".

Shortly 300 thousand earthquakes are occurred yearly in all over the world. Fortunately most of them take place in inhabitable regions. All the while some earthquakes are having their foci near to the related area so which tends to damages to shelter of living beings.

India has also witnessed many 'great" earthquakes of magnitude large than 8.0. During the period 1897 to 1950, the country was hit by four such earthquakes: Assam earthquake of 1897 (magnitude 8,7); Kangra earthquake of 1905 (magnitude 8.6), Assam-Tibet earthquake (magnitude 8,7), The maximum intensity of shaking experienced during these earthquakes was also higher than what we have experienced in the recent years: MMI of XII in the Assam earthquakes of 1897 and 1950, and X in the Kangra and Bihar-Nepal earthquakes. Clearly, India faces the threat of earthquake in the 1988, 1991 and 1993 events,

Three moderate-sized, but enormously disastrous, earthquakes hit India during tbe period 1988-2001: Bihar earthquake of August 21,1988, (magnitude 6.6; about 282 deaths in India and 722 in Nepal); Uttarkashi earthquake of October 20,1991, (magnitude 6.6; about 768 deaths); the Killari (Latur) earthquake of September 30,1993, (magnitude 6.4; about 10000 deaths) and the Bhuj (Gujarat) earthquake January 26,2001, (magnitude 7.7; about 13805 deaths). The maximum shaking intensity in these earthquakes was VIII-IX on the Modified Mercalli Intensity (MMI) scale. Comparable to these earthquakes in India, the North ridge earthquake of January 17,1994, in California, USA, was of magnitude 6.6 and maximum shaking intensity of Dt-X, but caused only 57 deaths. It is clear that an earthquake of similar magnitude and shaking intensity could be more disastrous in a developing country and this is due to differences in the types and quality of constructions.

During earthquakes fire gives rises to heavy losses of properties and gives as it is happened during the earthquakes of 1906 in San Franscico and the 1923 earthquake in Tokyo.

According to UNESCO over 350 thousand people perished in earthquake in 1925-50, the structural damage totaling 10 billion dollar's. The Tokyo earthquake alone took a nearly 140- thousand toll of the nation's population.

The occurrence of earthquake in the same place has different schedule like it may occur once every few decades or even centuries of each earthquake has a different intensity or temper. So the anti-seismic measures which are helpful to one earthquake will be useless or even harmful in another but through previous experiences some methods are still helpful. The R.C.C. structures proved seismic stability and fire resistance in the first great earthquake over any other materials.

Similarly pioneered by the U.S.S.R. analysis, prefabricated large panel buildings are provide the adaptability to earthquake resistance construction by improving the methods of joint between them later which is common place in Bulgaria, Yugoslavia, Japan and other countries lying in seismic regions. It has been also observed that structural steel or wooden building able to withstand earthquakes, although they are inferior to R.C.C in fire resistance.

Date	Event	Time	Magnitude	Max. Intensity	Deaths
16 June 1819	Cutch	11:00	8.3	VIII	1,500
12 June 1897	Assam	17:11	8.7	XII	1,500
8 Feb. 1900	Coimbatore	03:11	6.0	X	Nil
4 Apr. 1905	Kangra	06:20	8.6	X	19,000
15 Jan. 1934	Bihar-Nepal	14:13	8.4	X	11,000
31 May 1935	Quetta	03:03	7.6	X	30,000
15 Aug. 1950	Assam	19:31	8.5	X	1,530
21 Jul. 1956	Anjar	21:02	7.0	IX	115
10 Dec. 1967	Koyna	04:30	6.5	VIII	200
23 Mar. 1970	Bharuch	20:56	5.4	VII	30
21 Aug. 1988	Bihar-Nepal	04:39	6.6	IX	1,004
20 Oct. 1991	Uttarkashi	02:53	6.6	IX	768
30 Sep. 1993	Killari (Latur)	03:53	6.4	IX	7,928
22 May 1997	Jabalpur	04:22	6.0	VIII	38
29 Mar. 1999	Chamoli	12:35	6.6	VIII	63
26 Jan. 2001	Bhuj	08:46	7.7	X	13,805

SOME PAST EARTHQUAKE IN INDIA

PREDICTION OF EARTHQUAKE:

Practically, we never know where, when or how seismic loads are going to manifest. Due to the dynamic character of seismic loading it is difficult to predicate explicity in the design. Severity of ground shaking at a given location during an earthquake can be minor, moderate and strong, relatively minor shaking occurs frequently, moderate shaking occasionally and strong shaking rarely. So to simplify the problem we might design buildings in terms of the most probable maximum loads to make earthquake-proof buildings but it would lead to nowhere because the structures would be too robust, too expensive and labour

consuming to allow their wide spread construction and lastly there is no surety whether or not they will be subjected to loads for which they designed support. Hence from the economic point of view it is wiser not to waste money on making the structures earthquakes-proof throughout instead to make buildings earthquake-resistant; such buildings resist the effects of ground shaking, although they may get damaged severely but will not collapse during a strong earthquake.

Therefore the responsibility of the expert designer is to design and build structures which would not collapse or sustain heavy damage when exposed to seismic loading and to protect people and things against the deadly power of nature. This is the major objective of seismic design codes throughout the world. Hence precaution should be taken while erecting the structures in seismic regions that they should be earthquake resistance on the one hand and carry the imposed loads safety and economically on the other.

ORIGIN AND CAUSES OF EARTHQUAKES

"SEISMOLOGY" :

The word which is derived from the Greek "Seismos" meaning earthquake was first used by Robert Mallet a British Scientist and engineer about in 1880 A. D. Seismology is the study of earthquakes and the internal structure of the earth.

Structural seismology is a part of seismology concerned with the study of seismic phenomena or applied to earthquake resistant construction. The rest of seismology regards to study of location of seismically active areas and the prediction of motion character of ground.

The great Russian Scientist M. Lomonosov (1711-1765 AD) in his works "A word on the Birth of Metals by the shaking of Earth (1757) and "About Earth Layer's " (1763); Lomonosove suggested quiet a number of concepts which hold true to this day. He established which is an outcome of never ending activities deep inside the earth.

I. Mushketov, one of the founders of seismology in Russia in 1888 : "Earthquake have always been mankind" scourge inspiring panic terror, which is why man has always been prone to regard them as a heavenly punishment for his sin's or a kind of devil's with witchcraft, or a whim of an underground monster".

In Ancient times, progressive - minded people tried to explain the nature of earthquakes by linking them to other surrounding phenomenus, although the way they put it was for from being true.

To study the subterranean processes and the Earth interior itself, there were practically no experimental mean's of studying. How, experimental data to formulate fundamental concept concerning the structure of earth is based upon the breakthrough in material and geophysical methods but even today the reliability of knowledge

lies within the limits of more or less substantiated hypothesis. Considering that the distance from the surface of the earth to the center of the globe is about 6370 km and the research worker do not allow to take samples from deeper than about 10 km, of the Earth body, this implies that almost all of the Earth Body is left unexplored. (On December 27,1983, a bore hole drilled in the Kola Peninsula reached a depth of 12 km).

SEISMIC SURVEYING :

One of the most reliable geophysical method is seismic surveying through it velocities at which elastic waves propagate in various Earth's layer can be measured. It is a well known fact that the propagation velocity of elastic waves depends on the type of wave and on the density and hardness of the media in which the waves propagate. Alongwith seismic surveying, gravimetry and magnetonetry which are like wise useful in exploring the Earth interior.

SEARCH FOR SOLUTIONS :

Ignoring superstitions, the scientific thinking to minimise earthquake losses, has concentrated efforts on :

i) Prediction
ii) Prevention or pre-emption, and
iii) Protection against them.

In California, Japan and erstwhile USSR, considerable attention was devoted to the "prediction" of earthquake during the decade from mid-sixties to mid-seventies. Several parameters were worked upon, but none gave reliably repeatable results. Some success was indicated by observing ground "deformation" around known fault zones but percentage of success was not high. "Pre-emption" was also tried, but without encouraging results. Therefore, attention has been diverted wholly towards "protection" aspect by building structures in a way that they can resist earthquakes without serious damage. This brings forth the question : "What are the forces in magnitude and direction to allow for in design so that the losses are minimised".

Consequently, the programme of measuring forces, actually exerted by earthquakes was intensified through installation of "accelerographs" at suitable places in addition to "seismograph".

Thousands of such instruments have now been installed and, a good deal of knowledge of earthquake forces to become available. Drastic decrease in losses of life and property during strong earthquakes in California, Japan and other countries has justified concentration of attention on this programme. Elsewhere, losses continue to be heavy since that knowledge has not been put into practice due to ignorance and poverty. The

provision for earthquake resistant measures in traditional buildings (or any other form of construction) does increase cost. This increase varies greatly with the form of constructions.

Prediction of earthquake is now only a scientific curiosity because unless it can be precise in terms of size, location and time of occurrence, it is not useful to general public for safe of life and movable assets.

CONCLUSIONS:

The study of origin, causes and impact of earthquake enhance the knowledge to understand the failure mechanism of structures in different location, effect of earthquake in various types of building configuration and planning, designing, materials and techniques to be adapted in different seismic zones.

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