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Earthquake Risk Management in India: Causes & Concerns

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ABSTRACT: *Earthquake is one of the most destructive natural hazard. They may occur at any time of the year, day or night, with sudden impact and little warning. They can destroy buildings and infrastructure in seconds, killing or injuring the inhabitants. Earthquakes not only destroy the entire habitation but may de-stabilize the government, economy and social structure of the country. But what is an earthquake? It is the sudden shaking of the earth crust. The impact of an earthquake is sudden and there is hardly any warning, making it impossible to predict.India's high earthquake risk and vulnerability is evident from the fact that about 59 per cent of India's land area could face moderate to severe earthquakes. During the period 1990 to 2006, more than 23,000 lives were lost due to 6 major earthquakes in India, which also caused enormous damage to property and public infrastructure. The occurrence of several devastating earthquakes in areas hitherto considered safe from earthquakes indicates that the built environment in the country is extremely fragile and our ability to prepare ourselves and effectively respond to earthquakes is inadequate. During the* ***International Decade for Natural Disaster Reduction (IDNDR)*** *observed by the United Nations (UN) in the 1990s, India witnessed several earthquakes like the Uttarkashi earthquake of 1991, the Latur earthquake of 1993, the Jabalpur earthquake of 1997, and the Chamoli earthquake of 1999. These were followed by the Bhuj earthquake of 26 January 2001 and the Jammu & Kashmir earthquake of 8 October 2005 and so on. This paper emphasize on the causes and concerns related to the earthquake risk management in India.*

KEYWORDS: Hypocentre, Epicentre, Richter Scale, Mercalli Scale, Seismograph.

INTRODUCTION: Earthquakes occur suddenly with little or no warning, during any season and at any time of day. Earthquakes are one of the most destructive of natural hazards. An earthquake occurs due to sudden transient motion of the ground as a result of release of elastic energy in a matter of few seconds. The impact of the event is most traumatic because it affects large areas, occurs all of a sudden and is unpredictable. They can cause large scale loss of life and property and disrupts essential services such as water supply, sewerage systems, communication and power, transport, etc. They not only destroy villages, towns and cities but the aftermath leads to destabilize the economy and social structure of the nation. The Earth's surface is broken into many different plates, which float on top of the Earth's quasi-liquid mantle. Typically, one plate interacts with another by either colliding with it, sliding past it or pushing itself underneath it. These areas along which plates interact are known as geological faults. As plates move over time, the edge of one plate often catches itself on another, forcing that portion of the fault to remain motionless while stress builds. Eventually, the fault reaches a breaking point and slips suddenly, sometimes by yards or sometimes only by inches. This sudden vertical or lateral (sideways) movement releases seismic waves, which we feel as an earthquake. The point where the fault first slips is located deep within the earth and is called the **hypocenter**. Directly above that, on the earth's surface, is the **epicenter**.

Seismologists estimate the size, or magnitude, of an earthquake in several different ways. The **Richter scale** measures the size of the earthquake's waves (amplitude); whereas, the moment magnitude scale estimates the total energy released during the slip of a fault. Because the moment magnitude scale is more objective than the Richter scale, it is now more commonly used.The amount of movement you experience during an earthquake doesn't depend just upon its magnitude. Where you're located in relation to the earthquake's **epicenter** also has an effect. The farther away you are, the less shaking you feel, since the seismic waves lose energy as they travel through the earth. Imagine a drop of water hitting the surface of a pond. As the circular waves travel away from the impact, they lose energy and reduce in size and frequency. In time, they disappear altogether.Also, the kind of soil underneath and around you plays a large role in how much of the earthquake you experience. Unlike water, soil is not uniform through out. The soil type can have a dramatic effect on the way seismic waves travel through the earth. For instance softer, less compact soil can

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actually increase the forces. More stable soils, such as bedrock or compacted fill, dissipate an earthquake's energy more quickly. Three major factors – an earthquake's magnitude, your proximity to the epicenter and the condition of the soil around you – determine the amount of shaking you feel. The **Modified Mercalli Intensity scale** measures this intensity by evaluating the earthquake's effect on you and your home.

What is an Earthquake ?

An earthquake is the movement or trembling of the ground produced by the sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, and collapse of caverns. Stress accumulates in response to tectonic forces until it exceeds the strength of the rock. The rock then breaks along a preexisting or new fracture called a fault. The rupture extends outward in all directions along the fault plane from its point of origin **(focus)**. The rupture travels in an irregular manner until the stress is relatively equalized. If the rupture Page 2 of 52 disturbs the surface, it produces a visible fault on the surface. Earthquakes are recorded by seismograph consisted of a seismometer, a shaking detector and a data recorder. The moment magnitude of an earthquake is conventionally reported, or the related and mostly obsolete **Richter magnitude**, with magnitude 3 or lower earthquakes being mostly imperceptible and magnitude 7 causing serious damage over large areas. Intensity of shaking is measured on the modified Mercalli scale. In India **Medvedev-Sponheuer-Karnik scale**, also known as the **MSK or MSK-64**, which is a **macroseismic intensity scale**, is used to evaluate the severity of ground shaking on the basis of observed effects in an area of the earthquake occurrence. Due to earthquake seismic waves are generated and measurements of their speed of travel are recorded by seismographs located around the planet.

Causes of Earthquakes: An Earthquake is a series of underground shock waves and movements on the earth's surface caused by natural processes within the earth's crust.Earthquakes are caused by natural tectonic interactions within the earth's crust and it is a **global phenomena**. They may arise either due to the release of energy from the strained rock inside the Earth or tectonic movements or volcanic activity. The sudden release of accumulated energy or stresses in the earth or sudden movement of massive land areas on the earth's surface cause tremors, commonly called earthquakes.

Seismic Waves: Large strain energy released during an earthquake travel as seismic waves in all directions through the Earth's layers, reflecting and refracting at each interface. These waves are of **two types** - body waves and surface waves; the latter is restricted to near the Earth's surface. **Body waves** consist of **Primary Waves (P-waves)** and **Secondary Waves (S-waves)**, and **surface waves** consist of **Love waves** and **Rayleigh waves**. Under P-waves, material particles undergo extensional and compressional strains along the direction of energy transmission, but under Swaves, oscillate at right angles to it. Love waves cause surface motions similar to that by Swaves, but with no vertical component. Rayleigh wave makes a material particles oscillate in an elliptic path in the vertical plane (with horizontal motion along direction of energy transmission).

Magnitude: Magnitude is a quantitative measure of the actual size of the earthquake. Professor Charles Richter noticed that (a) at the same distance, seismograms (records of earthquake ground vibration) of larger earthquakes have a bigger wave amplitude than those of smaller earthquakes; and (b) for a given earthquake, seismograms at farther distances have a smaller wave amplitude than those at close distances. This prompted him to propose the now commonly used magnitude scale, the Richter Scale. It is obtained from the seismograms and accounts for the dependence of waveform amplitude on epicentral distance. This scale is also called **Local Magnitude scale**. There are other magnitude scales, like the Body Wave Magnitude, Surface Wave Magnitude and Wave Energy Magnitude. These numerical magnitude scales have no upper and lower limits; the magnitude of a very small earthquake can be zero or even negative.

Intensity: Intensity is a qualitative measure of the actual shaking at a location during an earthquake, and is assigned as Roman Capital Numerals. There are many intensity scales. Two commonly used ones are the **Modified Mercalli Intensity (MM!) Scale** and the **MSK Scale**. Both scales are quite similar and range from I (least perceptive) to XII (most severe). The intensity scales are based on three features of shaking -perception of people and animals, performance of buildings, and changes in natural surroundings. The distribution of intensity at different places during an earthquake is shown graphically using isoseismals, lines joining places with equal seismic intensity.

Measuring Earthquakes: Earthquakes can be described by the use of two distinctively different scales of measurement demonstrating magnitude and intensity. Earthquake magnitude or amount of energy released is determined by the use of a **seismograph** which is an instrument that continuously records ground vibration. The scale was developed by a seismologist named Charles Richter. An earthquake with a magnitude 7.5 on the **Richter scale** releases 30 times the energy than one with 6.5 magnitudes. An earthquake of magnitude 3 is the smallest normally felt by humans. The largest earthquake that has been recorded with this system is 9.25 (Alaska, 1969 and Chile, 1960). The second type of scale, the **earthquake intensity scale** measures the effects of an earthquake where it occurs. The most widely used scale of this type was developed in 1902 by Mercalli an Italian seismologist. The scale was extended and modified to suit the modern times. It is called the **Modified Mercalli Scale**, which expresses the intensity of earthquake effect on people, structure and the earth's surface in values from I to XII. With an intensity of VI and below most of the people can feel the shake and there are cracks on the walls,but with an intensity of XII there is general panic with buildings collapsing totally and there is a total disruption in normal life.

Can we predict Earthquakes: With the present state of knowledge of science, it is not possible to predict earthquakes. It is so because the physics involved in earthquake genesis is very complex. The mechanism of earthquake generating processes is still not adequately understood us because of involvement of multi-component parameters in earthquake genesis. Earthquake forecasting and prediction is an active topic of geological research. Geoscientists are able to identify particular areas of risk and, if there is sufficient information, to make probabilistic forecasts about the likelihood of earthquakes happening in a specified area over a specified period. These forecasts are based on data gathered through global seismic monitoring networks, high-density local monitoring in knowing risk areas, and geological field work, as well as from historical records. Forecasts are improved as our theoretical understanding of earthquakes grows, and geological models are tested against observation. Long-term forecasts (years to decades) are currently much more reliable than short to mediumterm forecasts (days to months). It is not currently possible to make deterministic predictions of when and where earthquakes will happen. For this to be possible, it would be necessary to identify a **'diagnostic precursor'**– a characteristic pattern of seismic activity or some other physical, chemical or biological change, which would indicate a high probability of an earthquake happening in a small window of space and time. So far, the search for diagnostic precursors has been unsuccessful. Most Geoscientists do not believe that there is a realistic prospect of accurate prediction in the foreseeable future, and the principal focus of research is on improving the forecasting of earthquakes.

Typical adverse effects

Physical damage: Damage occurs to human settlement, buildings, structures and infrastructure, especially bridges, elevated roads, railways, water towers, pipelines, electrical generating facilities. Aftershocks of an earthquake can cause much greater damage to already weakened structures. Secondary effects include fires, dam failure and landslides which may block water ways and also cause flooding. Damage may occur to facilities using or manufacturing dangerous materials resulting in possible chemical spills. There may also be a breakdown of communication facilities. The effect of an earthquake is diverse. There are large number of casualties because of the poor engineering design of the buildings and close proximity of the people. About 95 per cent of the people who are killed or who are affected by the earthquake is because of the building collapse. There is also a huge loss to the public health system, transport and communication and water supply in the affected areas.

INDIA - Basic Geography and Tectonic Features: India lies at the northwestern end of the **Indo-Australian Plate**, which encompasses India, Australia, a major portion of the Indian Ocean and other smaller countries. This plate is colliding against the huge **Eurasian Plate** and going under the Eurasian Plate; this process of one tectonic plate getting under another is called **subduction**. A sea, **Tethys**, separated these plates before they collided. Part of the lithosphere, the Earth's Crust, is covered by oceans and the rest of the continents. The former can undergo subduction at great depths when it converges against another plate, but the latter is buoyant and so tends to remain close to the surface. When continents converge, large amounts of shortening and thickening takes place, like in the Himalayas and the Tibetan.

Three chief tectonic sub-regions of India are the **mighty Himalayas** along the north, **the plains** of the Ganges and other rivers, and **the peninsula**. The Himalayas consist primarily of sediments accumulated over long geological time in the Tethys. The Indo-Gangetic basin with deep alluvium is a great depression caused by the load of the Himalayas on the continent. The peninsular part of the country consists of ancient rocks deformed in the past Himalayan-like collisions. Erosion has exposed the roots of the old mountains and removed most of the topography. The rocks are very hard, but are softened by weathering near the surface. Before the Himalayan collision, several tens of millions of years ago, lava flowed across the central part of peninsular India, leaving layers of basalt rock. Coastal areas like Kachchh show marine deposits testifying to submergence under the sea millions of years ago.

Distribution pattern of Earthquakes in India: India falls quite prominently on the **'Alpine - Himalayan Belt'**. This belt is the line along which the Indian plate meets the Eurasian plate. This being a convergent plate, the Indian plate is thrusting underneath the Eurasian plate at a speed of 5 cm per year. The movement gives rise to tremendous stress which keeps accumulating in the rocks and is released from time to time in the form of earthquakes.

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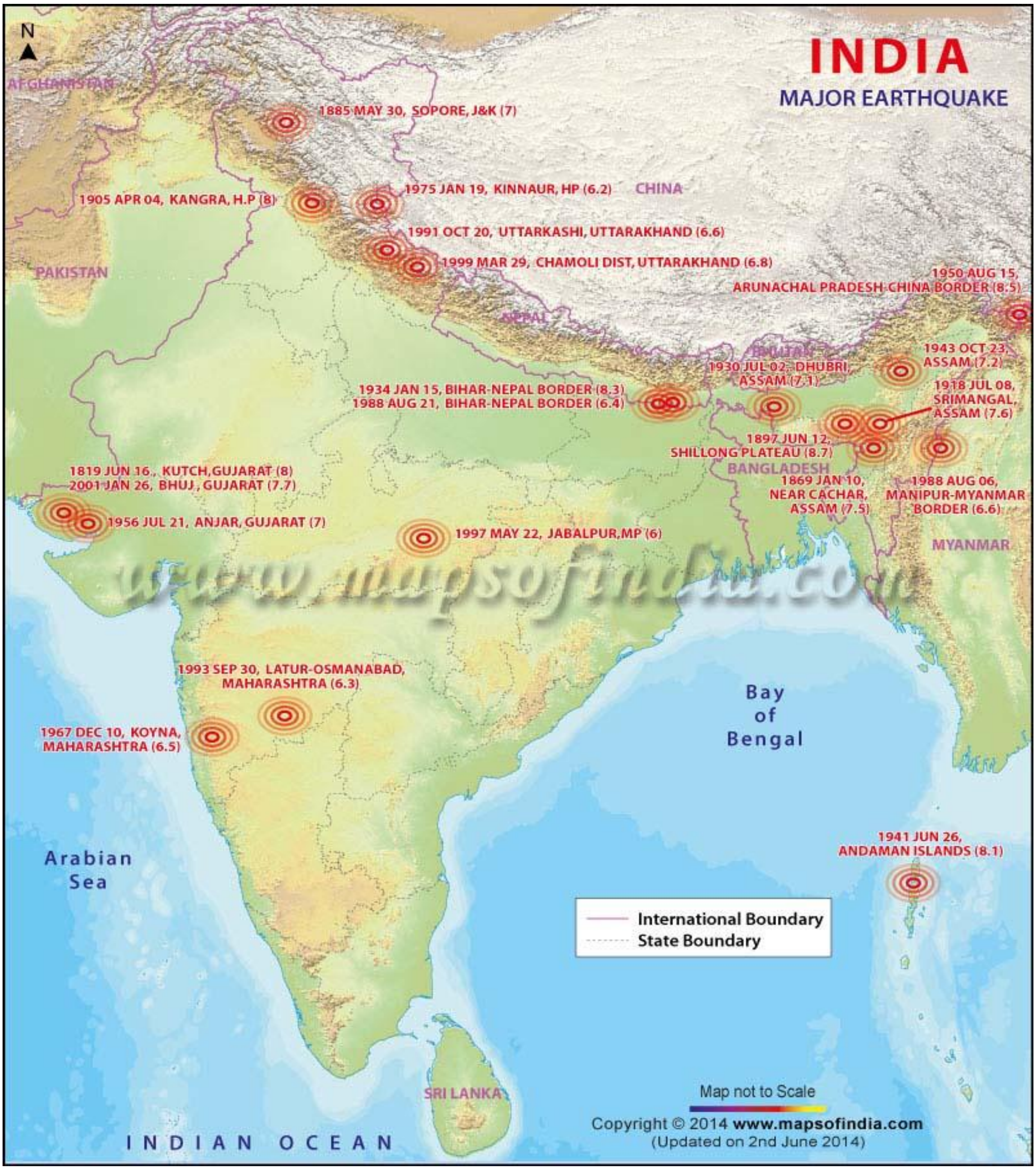

Fig: map showing major earthquakes in India.

Seismic Zones of India: Bureau of Indian Standards, based on the past seismic history, grouped the country into four seismic zones, viz. **Zone-II, -III, -IV and –V.** Of these, Zone V is the most seismically active region, while zone II is the least. The **Modified Mercalli (MM) intensity**, which measures the impact of the earthquakes on the surface of the earth, broadly associated with various zones, is as follows:

Seismic Zone Intensity on MM scale:

II (Low intensity zone) VI (or less)
III (Moderate intensity zone) VII
IV (Severe intensity zone) VIII
V (Very severe intensity zone) IX (and above)

Broadly, **Zone-V** comprises of entire northeastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Rann of Kutch in Gujarat, parts of North Bihar and Andaman & Nicobar Islands. **Zone-IV** covers remaining parts of Jammu & Kashmir and Himachal Pradesh, Union Territory of Delhi, Sikkim, northern parts of Uttar Pradesh, Bihar and West Bengal, parts of Gujarat and small portions of Maharashtra near the west coast and Rajasthan. **Zone-III** comprises of Kerala, Goa, Lakshadweep islands, and remaining parts of Uttar Pradesh, Gujarat and West Bengal, parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Orissa, Andhra Pradesh, Tamilnadu and Karnataka. **Zone-II** covers remaining parts of the country.

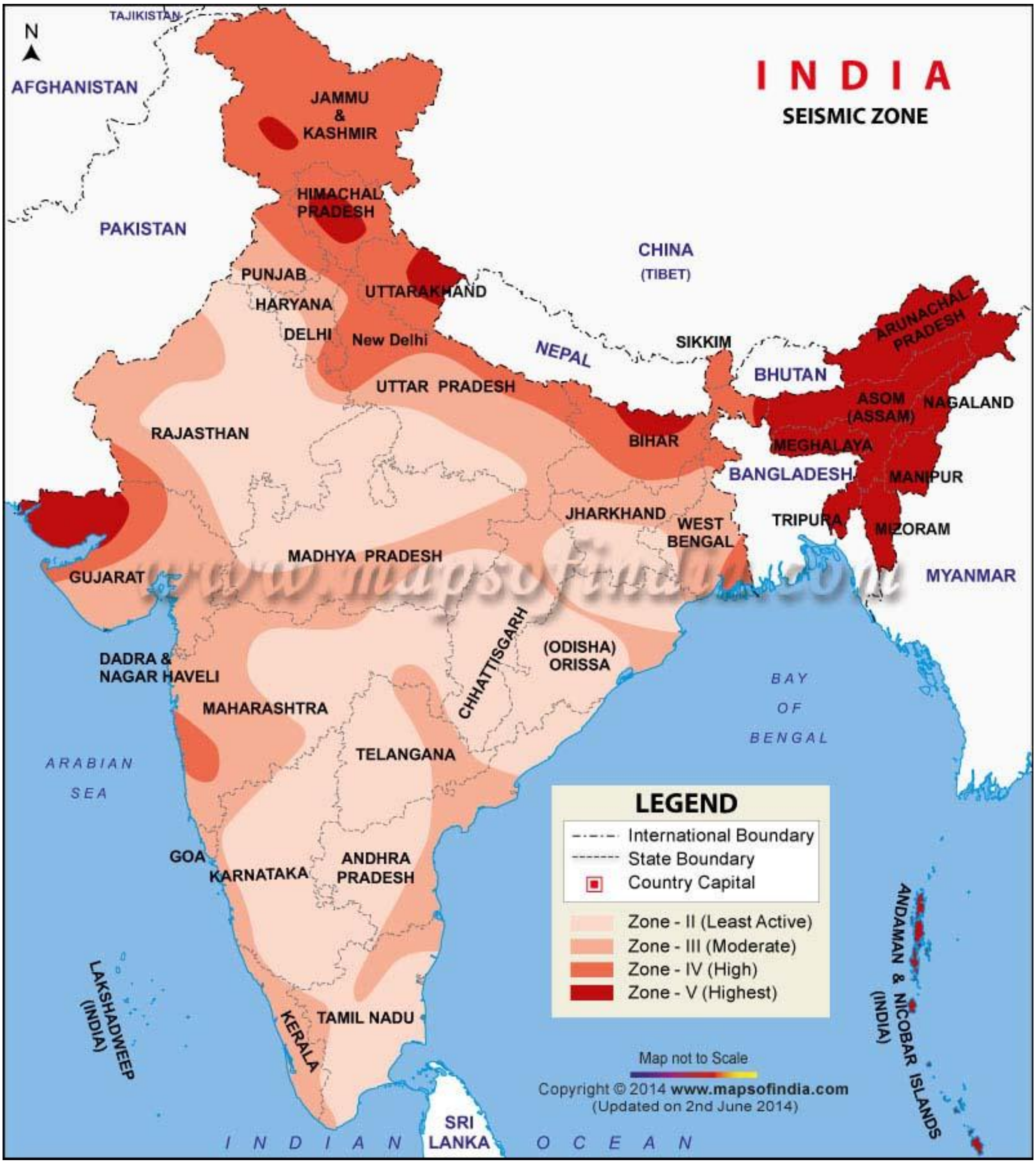

fig: map showing seismic zones of India.

Possible risk reduction measures

Community preparedness: Community preparedness is vital for mitigating earthquake impact. The most effective way to save you even in a slightest shaking is **'DROP, COVER and HOLD'**.

Planning: The **Bureau of Indian Standards** has published building codes

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and guidelines for safe construction of buildings against earthquakes. Before the buildings are constructed the building plans have to be checked by the Municipality, according to the laid down bylaws. Many existing lifeline buildings such as hospitals, schools and fire stations may not be built with earthquake safety measures. Their earthquake safety needs to be upgraded by retrofitting techniques.

Public education: Educating the public on causes and characteristics of an earthquake and preparedness measures. It can be created through sensitization and training programme for community, architects, engineers, builders, masons, teachers, government functionaries teachers and students.

Engineered structures: Buildings need to be designed and constructed as per the building by laws to withstand ground shaking. Architectural and engineering inputs need to be put together to improve building design and construction practices. The soil type needs to be analyzed before construction. Building structures on soft soil should be avoided. Buildings on soft soil are more likely to get damaged even if the magnitude of the earthquake is not strong . Similar problems persist in the buildings constructed on the river banks which have alluvial soil.

Earthquake Safety Tips

Before & during:

- Make your house earthquake resistant and secure heavy furniture and objects.

- Choose a couple of family meeting places; pick easy to identify, open and accessible places that you can easily reach. Prepare to be self-sufficient for a minimum of three days.

- If inside, stay inside**."DROP, COVER and HOLD**! **Drop** under firm furniture**. Cover** as much of your head and upper body as you can. **Hold** onto the furniture. Move to an inside wall and sit with your back to the wall, bring your knees to your chest and cover your head. Stay away from mirror and window. Do not exit the building during the shaking.

- If outdoors, move to an open area away from all structures, especially buildings, bridges, and overhead power lines.

After:

- Move cautiously, and check for unstable objects and other hazards above and around you. Check yourself for injuries.

• Anticipate aftershocks, especially if the shaking lasted longer than two minutes.

• Stay out of damaged buildings. Listen to the radio or watch local TV for emergency information and additional safety instructions.

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