

1. Earthquakes and How They Affect Buildings

1.1. *The Nature of Earthquakes*

Earthquakes are among the scariest natural disasters. They occur suddenly and usually last less than a minute but have a potential to cause significant human and economic losses. At this time, earthquakes cannot be predicted with certainty, although in general, regions prone to earthquakes are known – both in India and on the global scale.

The earth's crust is made up of rocky plates that are in constant motion with respect to each other, building up stress between them. An earthquake occurs when this stress can no longer be withstood by the rocks and is released suddenly. When this happens, rocks crack and slide past each other causing the ground to vibrate. The slippage emits large amounts of energy in the form of waves that travel through the interior of the earth and across the surface, similar to the waves emanating from a stone dropped into a still pond. The source of an earthquake is usually located several kilometers below the surface. This is where the stress release actually takes place and is called the hypocenter. The point on the surface above the hypocenter is called the epicentre of the earthquake. Earthquakes are usually short in duration, ranging from a few seconds to a few minutes, depending on their magnitude and other factors.

The most widely accepted indicators of the size of an earthquake are its magnitude and intensity. Magnitude (M) is a quantitative measure of the released energy, while earthquake intensity is a qualitative assessment based on the effects of the earthquake as observed. Observations of the performance of building structures, natural phenomena, human perceptions, and animal behaviours are essential for evaluating the earthquake intensity. An earthquake is characterized by a unique magnitude; however, the shaking intensity varies depending on the distance from the epicentre. Typically, the largest intensity is observed in the vicinity of the epicentre, and it diminishes with distance. The Medvedev-Sponheuer-Karnik (MSK) Scale is used for measuring earthquake intensity in India. It is composed of 12 increasing levels of intensity designated by Roman numerals that range from imperceptible shaking (intensity I) to catastrophic destruction (intensity XII) (Wikipedia 2017). The lower numbers on the intensity scale generally deal with the manner in which the earthquake is felt by people, while the higher numbers (V and higher) are based on observed building damage.

The stress that causes an earthquake is created by a movement of almost rigid plates, called tectonic plates. These fit together rather like a jigsaw puzzle and make up the outer shell of the earth (also called earth's crust). These plates float on a dense molten liquid layer beneath them. A map illustrating the various tectonic plates that constitute the surface of the earth is shown in Figure 1-1. The tectonic plates move at such a slow rate (approximately the same rate as a fingernail grows) that the motion is imperceptible. Over time, however, this small movement can build up enough stress to produce significant earthquakes. For example, the Indian plate is moving northwards towards the Eurasian plate at a rate of