GH0002 / **GEOHAZARDS / Seismogenic (Earthquakes)**

Ground Shaking (Earthquake)

Definition

Earthquake ground shaking is the movement of the Earth's surface produced by seismic waves that are generated when an earthquake occurs (adapted from USGS, no date).

Reference

USGS, no date. Earthquake glossary. United States Geological Survey (USGS). earthquake.usgs.gov/learn/glossary/?term=ground%20motion Accessed 14 October 2020.

Annotations

Synonyms

Seismicity, Shaking intensity, Ground motion, Ground vibration, Local ground response, Vibration.

Additional scientific description

Earthquake ground shaking is produced by waves that are generated by sudden slip on a fault that travel through the Earth and along its surface (USGS, no date a). All earthquakes, both natural and man-made, generate seismic waves. Seismic waves radiate outward from the earthquake origin, forming a circular wave front that causes shaking over an extended region (Stein and Wysession, 2003).

The strength and duration of the ground shaking at any given location depends on many factors, predominantly the magnitude of the earthquake, distance to earthquake origin, and local soil conditions. Thus, at each site, ground shaking from an earthquake is unique and can vary significantly from location to location (USGS, no date b).

Ground shaking is the predominant seismic hazard (secondary seismic hazards include liquefaction, surface rupture, landslides etc.), causing more than 90% of earthquake damage and losses (National Institute of Building Sciences Building Seismic Safety Council, 2010).

Earthquake ground shaking scales with the source earthquake's magnitude, as well as the distance from the earthquake to a particular location, the depth of the earthquake, and the properties of the rock and soil between the earthquake and a given observation site.

Earthquake magnitudes are given using one of several broadly equivalent scales, with the 'moment magnitude' scaling being the preferred measure of an earthquake's size, as it quantifies the energy released by the earthquake (USGS, no date c). The magnitude scale is logarithmic; each increase of 1 magnitude unit (i.e., 4.3 to 5.3) represents an order of magnitude (factor of 10) increase in the amplitude of seismic measurements, and a factor of 32 increase in the energy release of an earthquake (USGS, no date a). Earthquakes of Magnitude 7.0 and above tend to cause widespread, intense ground shaking; while earthquakes of Magnitudes 6.0 to 6.9 may cause local damage. Note that damage may be more severe and widespread for an earthquake of a given magnitude and other characteristics in regions of fragile buildings and high-density populations.

Metrics and numeric limits

Although there is no globally agreed metric available, there is a global earthquake risk model (GEM, 2018) and other initiatives from the Global Earthquake Model Foundation (GEM) including a Global Exposure Database for Multi-Hazard Risk Analysis. The Peak Ground Acceleration method for measuring ground shaking is the preferred approach (Pagani et al., 2018), but global use is limited by the distribution of instrumentation.

There are many different metrics for measuring ground shaking at a particular location:

Qualitative intensity measures, like the Modified Mercalli intensity (MMI) scale, and similar scales such as the Medvedev-Sponheuer-Kárník (MSK) scale or the European Macrointensity Scale (EMS-98) (Grünthal, 1998) describe the severity of an earthquake in terms of its effects on the Earth's surface and on people and structures (USGS, no date a). MMI values range from I (not felt) to XII (Total Damage), and the threshold for structural damage begins at VI, although this varies with the fragility of buildings in a given region. For some earthquake reporting agencies, MMI XI and XII are no longer assigned and MMI X is available but has not been applied in recent times. Since 1931, it has become clear that many of the phenomena described by Wood and Neumann (1931) were less related to ground shaking, and more to other factors that would promote widespread destruction (Dewey et al., 1995).

Quantitative measures are direct measures of ground shaking by seismic instruments. A widely used and preferred metric for the strength of ground shaking is Peak Ground Acceleration (PGA). PGA is calculated as the greatest increase in velocity recorded by a particular station during an earthquake (USGS, no date a), and typically given in units of g (Earth's gravitational acceleration on its surface; 9.81 m/s2). It is an appropriate measure because the physical force exerted by the ground motions against any object on the surface is proportional to the peak acceleration. For engineering purposes, additional metrics such as spectral acceleration, which measure the forces experienced by structures at specified frequencies to which the structures may be particularly vulnerable. Generally, PGA values of less than 0.1 g are not expected to cause much damage, while values of between 0.2 g and 0.8 g may cause moderate damage; anything above this is expected to be very damaging (USGS, no date b). It is important to note that the amount of damage caused by ground motions of any given intensity in an area are highly dependent on the strength of infrastructure in that area. The largest recorded ground motion to date was 4.3 g in the 2008 Iwate-Miyagi earthquake, Japan (Yamada et al., 2010).

Ground shaking can last from a few seconds in small earthquakes to several minutes in the largest earthquakes.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Earthquakes are part of the natural tectonic process and will always occur (Stein and Wysession, 2003). Earthquakes, and therefore earthquake ground shaking, cannot be prevented, but their impacts on life, property, and the economy can be managed (National Institute of Building Sciences Building Seismic Safety Council, 2010).

Seismic risk from ground shaking is best managed through accurate estimation of the likelihood of seismic ground shaking at damaging levels, implementation of and conformance to appropriate building codes, and governmental and popular awareness and preparation for earthquakes.

References

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Coordinating agency or organisation

Global Earthquake Model Foundation (GEM).