

Earthquake Basics

There are characteristics of earthquakes and their risks that you must be clear about yourself before you start talking about them to others. Over the years, earth scientists, engineers, and others who spend much of their time studying earthquakes have developed a set of terms relating to earthquakes that have very precise meanings, but which are often confusing or meaningless to those outside the field. This brief highlights some of the key concepts that commonly arise in discussions about seismic safety.

Every Earthquake is Unique

Each earthquake is a unique combination of characteristics: location, magnitude, depth, type of fault, mechanism of fault rupture, and direction of rupture. In addition, the soils in the area determine how fast seismic waves move, how quickly their energy dissipates, and whether or not they focus on particular sites. Thus, although we like to draw lessons by comparing one earthquake to another, these comparisons can only go so far.

Magnitude is the Usual Measure of an Earthquake

The magnitude of an earthquake describes the absolute size of the event. It is a measure of the energy released by the earthquake. Generally, higher magnitude earthquakes have greater shaking intensities at the epicenter, shake for a longer time, and affect a larger area. Several magnitude scales are currently in use, and they are all different, especially for larger earthquakes. The well-known Richter scale is one magnitude scale, but seismologists have increasingly begun to favor the *moment magnitude scale* because it gives more reliable results for larger earthquakes and those more distant from recording devices.

Intensity is Another Way to Describe an Earthquake's Size

Earthquake intensity scales qualitatively describe the effects of ground shaking rather than the energy released. While an earthquake is described by a single magnitude, it will produce a range of shaking intensities across an area. Because the intensities describe what the shaking feels like and how it affects different types of structures, they are terms that most people understand. In the United States we use a scale that ranges from Intensity I (“Not felt except by a very few under especially favorable conditions”) to Intensity XII (“Damage total”). Intensity is usually greatest near the earthquake epicenter, and less away from the epicenter, but it can increase in certain areas of poor soil.

Earthquakes of Similar Magnitudes May Have Different Effects

Two earthquakes of magnitude 6.5 can cause dramatically different levels of ground shaking because they may differ in depth or mechanism of fault rupture. The 2001 magnitude 6.8 Nisqually earthquake, for example, shook a wide area near Seattle but caused much less damage than the 1994 magnitude 6.7 Northridge earthquake in Los Angeles because the Nisqually earthquake was extremely deep and did not cause severe shaking at the earth's surface. Earthquakes of similar magnitude can also cause differing levels of damage according to their proximity to populated areas. The 1995 magnitude 6.9 earthquake in Kobe, Japan, was much more devastating than the Northridge quake

because the strongest shaking was in the most densely populated areas of Kobe, whereas the strongest shaking in the Northridge quake was under the mountains north of Los Angeles.

Smaller Earthquakes Can Cause Damage and Injuries

Earthquake damage at any given point depends on magnitude, distance to the rupture, the local soil conditions, and the building types, so even smaller magnitude earthquakes (between 5 and 6) can cause considerable damage and injuries in particular localities.

Softer Soils are usually Less Safe than Firm Ground

Generally speaking, softer soils shake more than firmer soils. Sandy and water-saturated soils can also experience *liquefaction*, in which the ground turns to mush during the shaking and loses its ability to support structures.

It's not only about the Fault Line

Everyone in a seismically active region should be concerned, not just those located “on the fault line.” Because earthquake waves radiate out from faults and cause damages over large areas, seismic safety precautions are important region-wide. It is more important to worry about overall seismicity of an area than to know only the location of faults. The most current U.S. Geological Survey seismic hazard maps of the U.S. are at <http://geohazards.cr.usgs.gov/eq/>.

Unknown Faults often Cause Earthquakes

Earthquakes can strike on faults that were previously unrecognized. Many such earthquakes, for example the 1994 Northridge quake, have been extremely damaging. Because, by definition, earthquakes on unknown faults can't be anticipated, it is more prudent to focus on an area's overall seismicity in determining its earthquake risks.

Seismologists can Estimate Long-term Earthquake Probabilities

Based on historic earthquakes and evidence of prehistoric earthquakes, seismologists are able to estimate the long-term probabilities of earthquakes in seismically active areas. These estimates, however, are only approximate, because we do not have enough years of records to make statistically reliable estimates. The estimates are useful as a basis for seismic building codes, as well as for comparing hazard between regions, and do give some indication of the likelihood of future damaging earthquakes.

We know where large earthquakes have occurred in the United States in the past few hundred years. We know that similarly large earthquakes will occur again, and in some places more probably than in others. We do not know precisely where or when they will happen or how strong they will be. When speaking with a lay audience, it is generally better to avoid technical terms like “expected return period,” and to say something like, “From historical evidence, we expect an earthquake on this fault about every 180 years, and it has been 179 years since the last one.” Earth scientists also say, “An earthquake of this magnitude in this area has about a 50% chance of happening sometime in the next 30 years.”

Short-term Earthquake Prediction is not Possible

Seismologists are not able to predict imminent earthquakes, as a weather forecaster can predict a hurricane. Due to the physical characteristics of fault rupture, such predictions may never be possible. Because earthquakes occur without warning, increased seismic safety is vital.

An Earthquake can Occur at Any Time

If seismologists say that a damaging earthquake has a 50% chance of occurring in your region during the next 30 years, that can be translated to mean that it has approximately a 2% chance of occurring in any given year. The probability is the same this year as it will be next year or two years from now. People often speak of earthquakes occurring sometime in the future, but the truth is that they can happen *right now*. Because earthquakes occur without warning, communities must be prepared in advance. There are many options for a community. They can take steps to reduce the number of unsafe old buildings or move people out of them. They can adopt codes that ensure new buildings will be earthquake-resistant. They can strengthen vulnerable buildings. They can modernize their infrastructure and make it more damage-resistant. Or they can reduce the financial consequences of damages through insurance.

What is Infrastructure?

A community is served by many networks—utilities, transportation routes and systems, and communications systems—that support the daily flow of life and commerce. These infrastructure elements are frequently damaged in earthquakes and, when they are, can threaten lives and property, and seriously disrupt the routines of community life. Fires can result from electrical downed electrical wires or ruptured gas mains. Interruptions to water, sewer, electrical power or gas service will affect the lives of everyone, very negatively over time. Interruptions to communications will quickly have large personal and business impacts. Broken transportation links make it difficult or impossible for life or commerce to flow anywhere. Damage to one or two infrastructure elements poses a problem that most communities can work around, but damage to all or most of the elements is a disaster that will grind everything to a halt. Protecting infrastructure against earthquake damage is very important and can be accomplished either through retrofit or replacement.