

## EARTHQUAKES

### INTRODUCTION

An earthquake is a sudden slipping or movement of a portion of the Earth's crust or plates, caused by a sudden release of stresses. Earthquake epicenters are usually less than 25 miles below the Earth's surface and are accompanied and followed by a series of vibrations. Earthquakes occur without any obvious warning.

### DAMAGE CAUSED BY EARTHQUAKES

Earthquakes are such a risk because shaking ground can:

- Cause buildings to move off of their foundations or collapse.
- Damage utilities, structures, and roads.
- Cause fires and explosions.
- Cause structural instability, such as dam failures that can trigger flash floods.

Earthquakes can also trigger landslides and avalanches or tsunamis. After an earthquake, it is important to listen for emergency instructions.

Together, all of these types of damage threaten lives, property, and the environment.

### LIKELIHOOD OF AN EARTHQUAKE

Twenty-six urban areas in all parts of the United States are identified as carrying significant risk of earthquake:

- The Western United States, particularly along the San Andreas Fault in California, the Cascadia Subduction Zone in western Oregon and Washington, and up the Alaskan coast
- The New Madrid Fault Zone in Missouri

A few pockets on the east coast, including coastal South Carolina and New England

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#### EARTHQUAKE STATISTICS

- More than 75 million Americans in 39 states face significant risk from earthquakes.
- California's 17 million people face the highest risk, followed by the residents of western Washington State.
- Four million people are within the destructive reaches of the New Madrid Fault.

Hundreds of tremors are felt each year, particularly in California. Major earthquakes are rare, however. Five major earthquakes have occurred in the last century in the United States. They occurred in:

- San Francisco, 1906 (700 - 800 lives lost)
- Alaska, 1964 (131 lives lost)
- San Fernando, California, 1971 (65 lives lost)
- Loma Prieta (Northern California), 1989 (66 lives lost)
- Northridge (Southern California), 1994 (61 lives lost)

There is no seasonal or yearly cycle of earthquake occurrence; earthquakes can happen at any time. Major earthquakes appear to occur in cycles of between 50 and 275 years.

An earthquake may last for seconds or minutes, while aftershocks may occur for months after the main earthquake.

#### THE RICHTER SCALE

Earthquakes are classified, based on the Richter Scale, as:

- Small: 5.0-5.9
- Moderate: 6.0-6.9
- Major: 7.0-7.9
- Great: 8.0 or greater

The Richter Scale measures earth movement caused by an earthquake. The Richter Scale has a logarithmic base, so each increment on the scale is multiplied by a factor of 10.

For example, an earthquake of magnitude 8.6 would not be twice as violent as one of 4.3, but rather would be 10,000 times worse. The 10 fold is in regard to amplitude. The actual energy released by an earthquake increases 31 times for each whole number increment.

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#### EARTHQUAKE PREPAREDNESS

- Develop a home earthquake plan so that you know what to do during and after an earthquake.
- Conduct earthquake drills with your family or coworkers. Locate safe spots (e.g., under a sturdy table), and identify danger zones (e.g., near windows).
- Develop a plan for reuniting all family members after an earthquake occurs.
- Develop a family communication plan. This includes identifying an out of state contact, informing that person of the duties and expectations that duty entails.
- Keep supplies on hand, including food and water for 3 days, a flashlight with extra batteries, a portable radio, a fire extinguisher, and tools (see Assembling and Storing a Disaster Supply Kit in Unit 1).

To continue with preparedness:

- Store heavy and breakable objects on low shelves. Weed killers, pesticides, and flammable products should be stored on bottom shelves or in closed cabinets with latches. Chemicals will be less likely to create hazards if they are stored in lower, confined locations.
- Secure bookshelves, water heaters, and tall furniture to wall studs. Install latches on all cabinets, and anchor overhead lighting fixtures. Secure items that might fall, such as televisions.
- Have a licensed professional install flexible pipe to avoid gas or water leaks. This pipe should be inspected regularly, and replaced every ten years.
- Move beds away from windows.
- Move or secure hanging objects over beds, couches, and other places where people sit or lie.
- Keep shoes and a flashlight under the bed. Keeping shoes under the bed ensures quick access to prevent cutting feet on glass and reduces the risk that glass could fall into them.

It is a good idea to consult a structural engineer to evaluate your home. Ask questions about home repair and strengthening for exterior features, such as porches, decks, sliding doors, canopies, carports, and garage doors.

#### DURING AN EARTHQUAKE

During earthquakes, most injuries result from people being hit by falling objects and shattered glass, rather than being hurt in collapsing buildings. Many injuries can be avoided if people take appropriate steps to prepare.

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Follow these measures to stay safe during an earthquake:

- Drop, cover, and hold. Move only as far as necessary to reach a safe place. Most persons injured in earthquakes move more than 5 feet during the shaking.
- If indoors, stay there until the shaking stops. Many fatalities occur when people run outside, only to be killed by falling debris from collapsing walls. It is safer to stay indoors until the shaking stops and it is safe to exit. When going outdoors, move quickly away from the building to prevent injury from falling debris.

There is a 20% chance of an equal or larger quake in the 2 hours following an earthquake.

- If outdoors, find a spot away from buildings, trees, streetlights and power lines, and overpasses. Drop to the ground and stay there until the shaking stops. Injuries can occur from falling trees, street lights and power lines, or building debris.
- If in a vehicle, pull over at a clear location free of hazards and stop. Stay in the vehicle with seatbelt fastened until the shaking stops. Turn on the radio to get information regarding the quake and any damage to roadways that may have occurred.

Tips based on the area in which you live:

- If in a high-rise building, expect the fire alarms and sprinklers to go off during an earthquake. Check for and extinguish small fires. Do not use the elevators.
- If in a coastal area, move to higher ground. Earthquakes often generate tsunamis.
- If in a mountainous area or near unstable slopes or cliffs, be alert for falling rocks and other debris that could be loosened by the earthquake. Also, watch for landslides that could be triggered by the earthquake.

Immediately following an earthquake, you should:

- Check yourself for injuries. Often, people tend to check on others without checking themselves. You will be better able to help others if you are not injured or if you have received first aid for your injuries.
- Protect yourself from further danger by putting on long pants, a long-sleeved shirt, sturdy shoes or work boots, and work gloves.

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#### AFTER AN EARTHQUAKE

After you have taken care of yourself, you should:

- Look for and extinguish small fires. Fire is the most common hazard following earthquakes. Extinguishing small fires and eliminating fire hazards will minimize the risk of a fire getting out of control.
- Clean up spills. By cleaning up medicines, bleaches, flammables, and other spills, it is possible to prevent many small but potentially dangerous hazardous materials emergencies.
- Inspect the home for damage. Aftershocks can cause additional damage to unstable buildings. If there are major cracks in the chimney or foundation or if the home or utilities have been moved by the earthquake, get everyone out of the home. Take photographs of the home and its contents to document insurance claims.
- Help neighbors who may require assistance.
- Tune to the Emergency Alert System (EAS) for emergency information and instructions.
- Expect aftershocks. Aftershocks often occur minutes, days, or weeks following an earthquake. When aftershocks occur, drop, cover, and hold. Remember that there is a 20% chance of an equal or larger quake within a few hours.

#### EARTHQUAKE MYTHS AND FACTS

<b>Myth:</b>	<b>“Mega-Quakes” can happen.</b>
<b>Fact:</b>	Strictly speaking, mega-quakes of magnitude 10 or more are possible; however, scientists agree that they are implausible. The magnitude of an earthquake is related to the length of the fault on which it occurs—the longer the fault, the larger the earthquake. The San Andreas Fault is only 800 miles long. To generate an earthquake of 10.5 magnitude would require the rupture of a fault that is many times the length of the San Andreas Fault. No fault long enough to generate a magnitude 10.5 earthquake is known to exist. The largest earthquake ever recorded was a magnitude 9.5 on May 22, 1960 in Chile on a fault that is almost 1,000 miles long.
<b>Myth:</b>	<b>Earthquakes only occur on the West Coast in the United States.</b>
<b>Fact:</b>	Earthquakes can strike any location at any time. But history shows they

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	<p>occur in the same general patterns over time, principally in three large zones of the earth. The world's greatest earthquake zone, the circum-Pacific seismic belt, is found along the rim of the Pacific Ocean, where about 81 percent of the world's largest earthquakes occur. That belt extends from Chile, northward along the South American coast through Central America, Mexico, the West Coast of the United States, the southern part of Alaska, through the Aleutian Islands to Japan, the Philippine Islands, New Guinea, the island groups of the Southwest Pacific, and to New Zealand. The second important belt, the Alpide, extends from Java to Sumatra through the Himalayas, the Mediterranean, and out into the Atlantic. This belt accounts for about 17 percent of the world's largest earthquakes, including some of the most destructive. The third prominent belt follows the submerged mid-Atlantic ridge. The remaining shocks are scattered in various areas of the world. Earthquakes in these prominent seismic zones are taken for granted, but damaging shocks occur occasionally outside these areas. Examples in the United States are New Madrid, Missouri, and Charleston, South Carolina. Many decades to centuries, however, usually elapse between such destructive shocks.</p>
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<b>Myth:</b>	<b>The 1906 San Francisco earthquake was the deadliest ever.</b>
<b>Fact:</b>	Though well known, the magnitude 7.8 San Francisco earthquake and ensuing fire killed 700 - 800 and razed large sections of the city. It was the most deadly in U.S. history, but that doesn't make it the worst the world has seen, by far. The deadliest earthquake in recorded history struck Shensi province in China in 1556, killing about 830,000 people. The 1976 magnitude 7.8 earthquake which struck Tangshan, China killed somewhere between 250,000 and 800,000 people. In 2003, the magnitude 6.5 earthquake in Bam, Iran killed more than 40,000 people. The earthquake in Chile on May 22, 1960, is the strongest to be recorded in the world with magnitude 9.5, and killed more than 4,000. For the record, the largest U.S. earthquake occurred on March 28, 1964, in Alaska. It was a magnitude 9.2 quake and took 131 lives.
<b>Myth:</b>	<b>California has the most earthquakes in the country. . . .</b>
<b>Fact:</b>	Alaska registers the most earthquakes in a given year, with California placing second. California, however, has the highest risk and most damaging earthquakes because of its greater population and extensive infrastructure. Florida and North Dakota have the fewest earthquakes each year.
<b>Myth:</b>	<b>The ground can open up during an earthquake.</b>
<b>Fact:</b>	A popular cinematic device is a fault that opens during an earthquake to swallow up an inconvenient character, but gaping faults exist only in movies and novels. The ground moves across a fault during an earthquake, not away from it. If the fault could open, there would be no friction. Without friction, there would be no earthquake. Shallow crevasses can form during earthquake induced landslides or other types of ground failures. Faults, however, do not gape open during an earthquake.

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<b>Myth:</b>	<b>California will eventually fall into the ocean.</b>
<b>Fact:</b>	The ocean is not a great hole into which California can fall, but it is itself land at a somewhat lower elevation with water above it. It's absolutely impossible that California will be swept out to sea. Instead, southwestern California is moving horizontally northward towards Alaska as it slides past central and eastern California. The dividing point is the San Andreas fault system, which extends from the Salton Sea in the south to Cape Mendocino in the north. This 800 mile long fault is the boundary between the Pacific Plate and North American Plate. The Pacific Plate is moving to the northwest with respect to the North American Plate at approximately 46 millimeters (2 inches) per year (the rate your fingernails grow). At this rate, Los Angeles and San Francisco will one day (about 15 million years from now) be next-door neighbors, and in an additional 70 million years, Los Angeles residents will find themselves with an Alaska zip code!
<b>Myth:</b>	<b>People can stop earthquakes.</b>
<b>Fact:</b>	We cannot prevent earthquakes from happening (or stop them once they've started). However, we can significantly mitigate their effects by characterizing the hazard (e.g., identifying earthquake faults, unconsolidated sediment likely to amplify earthquake waves, and unstable land prone to sliding or liquefying during strong shaking), building safer structures, and preparing in advance by taking preventative measures and knowing how to respond.



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<b>Myth:</b>	<b>Lots of small earthquakes can prevent large earthquakes.</b>
<b>Fact:</b>	Seismologists have observed that for every magnitude 6 earthquake there are about 10 of magnitude 5, 100 of magnitude 4, 1,000 of magnitude 3, and so forth as the events get smaller and smaller. This sounds like a lot of small earthquakes, but there are never enough small ones to eliminate the occasional large event. It would take 32 magnitude 5's, 1000 magnitude 4's, and 32,000 magnitude 3's to equal the energy of one magnitude 6 event. So, even though we always record many more small events than large ones, there are far too few to eliminate the need for the occasional large earthquake.
<b>Myth:</b>	<b>We can predict earthquakes.</b>
<b>Fact:</b>	Earthquake prediction is the holy grail for earthquake scientists, but there currently is no accepted method to accomplish the goal of predicting the time, place and magnitude of an impending quake. Research into earthquake prediction continues. However, the USGS approach has been to focus on providing long-range forecasts of the likelihood locations and impacts of damaging earthquakes. For example, scientists estimate that over the next 30 years the probability of a major earthquake occurring in the San Francisco Bay area is 62% and 60% in Southern California. Scientists are also able to predict the type of ground motion to expect based on the geology and the history of earthquake activity of the region. Engineers and building code developers use these models of site response to improve the safety of structures, thereby reducing the ultimate earthquake risk.

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<b>Myth:</b>	<b>Animals can predict earthquakes.</b>
<b>Fact:</b>	Changes in animal behavior cannot be used to predict earthquakes. Even though there have been documented cases of unusual animal behavior prior to earthquakes, a reproducible connection between a specific behavior and the occurrence of an earthquake has not been made. Because of their finely tuned senses, animals can often feel the earthquake at its earliest stages before the humans around it can. This feeds the myth that the animal knew the earthquake was coming. But animals also change their behavior for many reasons, and given that an earthquake can shake millions of people, it is likely that a few of their pets will, by chance, be acting strangely before an earthquake.
<b>Myth:</b>	<b>It's been raining a lot, or very hot--it must be earthquake weather!</b>
<b>Fact:</b>	Many people believe that earthquakes are more common in certain kinds of weather. In fact, no correlation with weather has been found. Earthquakes begin many kilometers (miles) below the region affected by surface weather. People tend to notice earthquakes that fit the pattern and forget the ones that don't. Also, every region of the world has a story about earthquake weather, but the type of weather is whatever they had for their most memorable earthquake. It is also a myth that big earthquakes always happen at a particular time of day.
<b>Myth:</b>	<b>Good building codes mean safe buildings.</b>
<b>Fact:</b>	Architects and engineers are using knowledge learned from past earthquakes to make roads, bridges, and buildings safer in the event of major earthquakes. Local officials are also enacting new building codes to ensure new buildings are built with earthquake safety in mind. This includes both improving the design of new buildings and bridges as well as strengthening older units to incorporate the latest advances in seismic and structural engineering. But the best building codes in the world do nothing for buildings built before that code was enacted. While the codes have been updated, the older buildings are still in place. Fixing problems in older buildings—also known as retrofitting—is the responsibility of the building's owner.

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<b>Myth:</b>	<b>Earthquakes kill people.</b>
<b>Fact:</b>	<p>In an earthquake, the severity of the shaking can cause manmade and natural structures and the contents within these to fail or fall and injure or kill people. There have been large earthquakes with very little damage because they caused little shaking and/or buildings were built to withstand that shaking. In other cases, smaller earthquakes have caused great shaking and/or buildings collapsed that were never designed or built to survive shaking. Much depends on 2 variables: geology and engineering. From place to place, there are great differences in the geology at and below the ground surface. Different kinds of geology will do different things in earthquakes. For example, shaking at a site with soft sediments can last 3 times as long as shaking at a stable bedrock site such as one composed of granite. Local soil conditions also play a role, as certain soils greatly amplify the shaking in an earthquake. A soft, loose soil will shake more intensely than hard rock at the same distance from the same earthquake. Fires are another major risk during earthquakes as gas lines may be damaged and particularly hazardous.</p>
<b>Myth:</b>	<b>During an earthquake you should head for the doorway.</b>
<b>Fact:</b>	<p>That's outdated advice. In past earthquakes in unreinforced masonry structures and adobe homes, the door frame may have been the only thing left standing in the aftermath of an earthquake. Hence, it was thought that safety could be found by standing in doorways. In modern homes doorways are no stronger than any other parts of the house and usually have doors that will swing and can injure you. <b>YOU ARE SAFER PRACTICING THE "DROP, COVER, AND HOLD" maneuver under a sturdy piece of furniture like a strong desk or table. If indoors, stay there. Drop to the floor, make yourself small and get under a desk or table or stand in a corner. If outdoors, get into an open area away from trees, buildings, walls and power lines. If in a high-rise building, stay away from windows and outside walls, stay out of elevators, and get under a table. If driving, pull over to the side of the road and stop. Avoid overpasses and power lines. Stay inside your car until the shaking is over. If in a crowded public place, do not rush for the doors. Crouch and cover your head and neck with your hands and arms. You should practice the "DROP, COVER AND HOLD" method at work and at home at least twice a year.</b></p>

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<b>Myth:</b>	<b>Everyone will panic during the Big One.</b>
<b>Fact:</b>	A common belief is that people always panic and run around madly during and after earthquakes, creating more danger for themselves and others. Actually, research shows that people usually take protective actions and help others both during and after the shaking. Most people don't get too shaken up about being shaken up!