Putting Down Roots in Earthquake Country
Your Handbook for Earthquakes in Utah

Developed by the:
Utah Seismic Safety Commission
Utah Division of Homeland Security
Utah Geological Survey
University of Utah Seismograph Stations
Structural Engineers Association of Utah

In cooperation with the:
U.S. Geological Survey
Federal Emergency Management Agency
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Utah is “Earthquake Country”

This handbook provides information about the threat posed by earthquakes in Utah, particularly along the Wasatch Front, and explains how you can prepare for, survive, and recover from these inevitable events. If you live or work in Utah, you need to know why you should be concerned about earthquakes, what you can expect during and after an earthquake, and what you need to do beforehand to be safe and protect your property.

Much has been learned about the earthquake threat and vulnerability in Utah:

**We know earthquakes occur here**
Utah is not on a boundary between tectonic plates, where most of the world’s earthquakes occur. Rather, Utah is in the western part of the North American plate. Most of Utah’s earthquakes, particularly moderate to large earthquakes in the Wasatch Front and southwestern Utah, occur as a result of tectonic forces within the plate. Also, many small earthquakes in east-central Utah are induced by underground coal mining.

**We know large and damaging earthquakes are certain to occur in the future**
Large, damaging earthquakes in Utah are most likely to occur in a belt that extends north-south through the center of the state (see page 4), essentially following Interstate Highway 15, where there are many active faults capable of producing earthquakes. Moderate to large earthquakes (generally magnitude 6 and greater) can kill and injure many people and cause substantial damage to buildings, roads, bridges, and utilities.

**We know how to reduce losses in future large earthquakes**
Improved building codes are in force statewide, some older buildings have been strengthened, and steps are being taken to upgrade schools and other critical facilities. Some Utah residents have secured their homes to better withstand shaking, created emergency plans and disaster supply kits, and held home earthquake drills.

**BUT we have not done enough to be prepared for the next large earthquake:**

**Few households have disaster plans**
If an earthquake occurred right now, where would you go to be safe? If you are at work and your children are at school when the earthquake occurs, how will you get back together?

**Few households have disaster supply kits**
You will likely be on your own without vital services in the hours and days following an earthquake. Are you prepared with water, food, first aid supplies, and medications?

**Few homeowners have taken steps to retrofit their homes**
Utah has many houses that predate modern earthquake building codes. Is your home bolted to its foundation? If you live in an older building, has it been retrofitted? Is your water heater strapped? Could unsecured furniture or objects fall and cause injury or damage?
Utah and the Intermountain West are Seismically Active

Geologic evidence shows that movement on the Wasatch fault and other faults in Utah can cause earthquakes of magnitude 6.5 to 7.5 having potentially catastrophic effects. However, it can be difficult to understand how to use this knowledge to make us safer in our daily lives. Should we care only if we live along the Wasatch Front, or are other places in Utah just as dangerous?

This section (pages 2-11) describes where earthquakes occur in Utah and explains how earthquakes will shake the ground and cause damage in other ways, such as liquefaction and landslides (see pages 10 and 11). Technical terms used throughout this pamphlet are explained in the Glossary (see page 33).

Stretching of the Crust Produces Movement on Faults
Many earthquakes occur near the boundaries of tectonic plates, where shifting of Earth's crust takes place along faults as the giant plates slowly move relative to each other. Utah is not on a plate boundary, but many faults in the state can produce large earthquakes. Between Utah's Wasatch Range and California's Sierra Nevada, tectonic forces within the western part of the North American plate combine with high heat flow from the underlying mantle to literally stretch the crust in an east-west direction at the rate of about half an inch per year. In response to this stretching, the rigid crust breaks and shifts along faults, and the fault movement produces earthquakes.

Intermountain Seismic Belt
Utah straddles the boundary between the extending Basin and Range Province to the west and the relatively more stable Rocky Mountains and Colorado Plateau to the east. This boundary coincides with an area of earthquake activity called the Intermountain Seismic Belt, or ISB (see pages 3 & 4). Utah's longest and most active fault, the Wasatch fault, lies within the ISB. Unfortunately, the heavily populated Wasatch Front (Ogden – Salt Lake City – Provo urban corridor) and the rapidly growing St. George and Cedar City areas are also within the ISB, putting the vast majority of Utah's residents at risk.

Horizontal Extension Creates Normal Faults
Stretching, or horizontal extension, of the crust produces a type of dipping (or inclined) fault called a “normal” fault. The movement of normal faults is characterized by the crust above the fault plane moving down relative to the crust below the fault plane. This up/down sense of movement differs from movement on strike-slip faults like the San Andreas in California, where the crust on one side of the fault slides horizontally past the crust on the other side. Earthquakes in Utah can be generated by movement on a variety of different types of faults, but the faults that are considered capable of generating large surface-faulting earthquakes are mainly normal faults in and near the margin of the Basin and Range Province in western and central Utah.

For more information go to:
Fault Scarp Formation

In a large normal-faulting earthquake the amount of vertical movement on the fault deep in the Earth’s crust is sufficient to rupture and offset the ground surface, producing a steep break or scarp. Geologic evidence shows that individual prehistoric earthquakes on the Wasatch fault produced scarps 6 to 12 feet high. Similar-sized scarps have formed during historical surface-faulting earthquakes in the region, such as the scarp shown below, which formed during the 1983 magnitude 7.3 Borah Peak earthquake in Idaho (surface faulting has broken and offset the concrete-lined ditch in which the people are standing). Over time, repeated movement on a normal fault eventually produces a mountain range on the uplifted crustal block (for example, the Wasatch Range) and a valley or basin on the downdropped block (for example, Salt Lake Valley). (Photo courtesy of Walter Arabasz)

Surface Faulting in Utah

In historical time, Utah has had only one earthquake large enough to form a fault scarp. The 1934 magnitude 6.6 Hansel Valley earthquake was near the threshold magnitude for surface rupture, and produced a small scarp in an unpopulated area north of Great Salt Lake. In Salt Lake City, 80 miles away, ground shaking from this earthquake was strong enough to cause adjacent 6- and 10-story buildings to sway and batter against each other and clock equipment to shake loose from the City and County Building’s 12-story clock tower and crash down through the building. (Photo courtesy of the F.J. Pack Collection, Special Collections Department, University of Utah Libraries)
Most of Utah’s Populated Area Lies Within an Active Earthquake Belt

### Historical quakes of about magnitude (M) 5.5 and larger in the Utah region*

<table>
<thead>
<tr>
<th>Year</th>
<th>Magnitude</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1884</td>
<td>M 6</td>
<td>Bear Lake Valley</td>
</tr>
<tr>
<td>1887</td>
<td>M 5.5</td>
<td>Kanab</td>
</tr>
<tr>
<td>1900</td>
<td>M 5.5</td>
<td>Eureka</td>
</tr>
<tr>
<td>1901</td>
<td>M 6.5</td>
<td>Richfield</td>
</tr>
<tr>
<td>1902</td>
<td>M 6</td>
<td>Pine Valley</td>
</tr>
<tr>
<td>1909</td>
<td>M 6</td>
<td>Hansel Valley</td>
</tr>
<tr>
<td>1910</td>
<td>M 5.5</td>
<td>Salt Lake City</td>
</tr>
<tr>
<td>1914</td>
<td>M 5.5</td>
<td>Ogden</td>
</tr>
<tr>
<td>1921</td>
<td>M 6</td>
<td>Elsinore (two events)</td>
</tr>
<tr>
<td>1934</td>
<td>M 6.6</td>
<td>Hansel Valley</td>
</tr>
<tr>
<td>1959</td>
<td>M 5.7</td>
<td>Utah-Ariz. Border</td>
</tr>
<tr>
<td>1962</td>
<td>M 5.7</td>
<td>Richmond</td>
</tr>
<tr>
<td>1966</td>
<td>M 6.0</td>
<td>Utah-Nev. Border</td>
</tr>
<tr>
<td>1975</td>
<td>M 6.0</td>
<td>Utah-Idaho Border</td>
</tr>
<tr>
<td>1992</td>
<td>M 5.9</td>
<td>St. George</td>
</tr>
</tbody>
</table>

*Sizes of shocks before 1934 are approximate.

### Making a Home in Utah’s Earthquake Belt…

### Why Should I Care?

The University of Utah Seismograph Stations (UUSS) is a research, educational, and public-service entity that operates a monitoring network of more than 200 regional and urban seismic stations in Utah and neighboring areas, including the Yellowstone National Park region. For more information about UUSS, recent earthquakes, and other earthquake information products, see http://quake.utah.edu
Utah Faces a Dual Earthquake Threat —and Earthquakes in Utah Aren’t Just a Wasatch Front Problem

Threat 1 (time scale of 100s to 1000s of years):
Infrequent large surface-faulting earthquakes (M 6.5 to 7.5) on mapped active faults, such as the Wasatch fault.

Threat 2 (time scale of 10s of years):
More frequent moderate-size (M 5 to 6.5) earthquakes below the threshold of surface faulting. If they occur under an urban area, as happened in the 1962 Magna earthquake (see photo below), considerable damage can result.

More than 36,000 earthquakes have been located by the UUSS in the Utah region since 1962. The Wasatch Front is part of a regional “Intermountain Seismic Belt” (see map on page 3).

Half of the 16 damaging earthquakes in Utah of magnitude 5.5 and larger since 1850 have occurred outside the Wasatch Front area in central and southwestern Utah.

One of the largest historical earthquakes in Utah was a damaging shock of magnitude 6.5 near Richfield in 1901. The Sevier Valley area between Richfield and Marysvale has had eight earthquakes of magnitude 5 and larger.

Thousands of mining-induced earthquakes (as large as magnitude 4.2), caused by underground coal mining, have been located by the UUSS in Carbon, Emery, and eastern Sevier Counties.

In the Uinta Basin, an earthquake of magnitude 4.5 in 1977 caused minor damage north of Duchesne. Earthquakes as large as magnitude 4.9 have been induced both by oil and gas production and deep fluid injection in the Colorado-Utah border region.
WHY SHOULD I CARE?

The Wasatch Fault

One of the longest and most active normal faults in the world, the 240-mile-long Wasatch fault extends from Malad City, Idaho, south to Fayette, Utah. The fault is subdivided into 10 segments, averaging 25 miles in length; each segment generally ruptures independently and is a separate source of large earthquakes.

Although scientists are unsure as to how many small to moderate-size historical earthquakes can be attributed to slip on the Wasatch fault at depth, the geologic record shows that numerous large (magnitude 6.5-7.5), surface-faulting earthquakes have taken place on the Wasatch fault over the past 10,000 years.

Map showing the Wasatch fault (red line) and other faults (black lines) in Utah that may be the sources of large earthquakes.

A: The Wasatch fault (white arrows) typically extends along the base of the Wasatch Range, as seen in this view to the east near Mapleton in Utah County. (Photo courtesy of Rod Millar)

B: In some areas, the Wasatch fault (white arrows) trends away from the mountain front, as seen here in this view to the northeast in Salt Lake Valley along Highland Drive near 3900 South. (Photo courtesy of Rod Millar)

C: At this location at the mouth of Little Cottonwood Canyon in Salt Lake Valley, the Wasatch fault (white arrows) is the site of the G.K. Gilbert Geologic View Park. (Photo courtesy of UGS)
At least 25 surface-faulting earthquakes have taken place on the Wasatch fault during the past 10,000 years. All but two of these earthquakes occurred on the five central segments (Brigham City to Nephi). The amount of time between surface-faulting earthquakes on these five segments is about 300-400 years. For any individual central segment, the average time between such earthquakes is longer – about 1,200 to 2,400 years. In comparison, segments on the ends of the Wasatch fault have intervals of 10,000 years or more between surface-faulting earthquakes. The most recent large earthquake on the Wasatch fault took place about 350 years ago on the Nephi segment.

Geologic information for Wasatch fault earthquakes comes largely from trenches excavated across fault scarps. Twenty research sites, many of which had more than one trench, have been investigated on the Wasatch fault. These trench studies provide information on the timing and size of prehistoric surface-faulting earthquakes.

Radiocarbon dating of organic debris found in this trench (excavated in spring 2007) across the northern Weber segment indicates the timing of recent large earthquakes. During these earthquakes, the ground surface was displaced vertically about 10 feet. (Photo courtesy of UGS)
Most Earthquake Damage Is Caused By Shaking...

The intensity of shaking that a building or structure will experience during an earthquake is highly variable, but generally depends on three main factors:

- The magnitude of the earthquake—the larger the quake, the stronger the shaking.
- The distance from the earthquake—the closer to the source of the earthquake, the greater the shaking.
- The type of ground material beneath the structure—soils may amplify the shaking; hard bedrock does not.

U.S. Geological Survey National Seismic Hazard Map of Utah

- On this map, the strongest shaking based on long-term forecasts is generally expected along major faults, such as the Wasatch fault, and in areas of greatest historical seismicity such as the Intermountain Seismic Belt.
- Intense shaking can damage even strong modern buildings and their contents.
- Much of Utah has a moderate to high likelihood of future intense shaking.

Generalized east-west cross section through the eastern part of Salt Lake Valley, showing the response to seismic waves generated during a Wasatch fault earthquake. Earthquakes generate seismic waves at a wide variety of frequencies, and certain frequency waves may be amplified by local soil conditions.

- In Salt Lake Valley, areas with thick, soft, clayey soil amplify low-frequency seismic waves, yielding slow rolling-type shaking that can damage tall buildings and long-span overpasses.
- Areas with thin, stiff (e.g., sandy and gravelly) soil over bedrock amplify high-frequency seismic waves, which yield vigorous ground vibrations that cause more damage to short (1-2 story) buildings, such as houses.
Strong ground shaking from a magnitude 7 or greater earthquake along one of the segments of the Wasatch fault (see map, page 7) will cause major losses. However, we do not need to wait for these earthquakes to occur to estimate what they could do to Wasatch Front communities. Using FEMA’s Hazards U.S. (HAZUS) loss-estimation model, we can estimate the extent of future damage and take actions now to reduce potential losses and plan for recovery.

**Magnitude or Intensity?**

Magnitude is a measure of the energy released in an earthquake – a single value that depends on the area of fault rupture and amount of slip. For example, the 1934 Hansel Valley earthquake had a magnitude of 6.6. The largest expected earthquakes in Utah are magnitude 7.0-7.5.

Intensity is a measure of the strength of ground shaking at a particular place, and varies by location, proximity to the source of the earthquake, and type of material underlying the site. The intensity scale ranges from low (I) to high (XII). Near the epicenter of the Hansel Valley earthquake, the intensity reached VIII; however, in Salt Lake City, intensity levels were about VI.

**Geologic site conditions affect ground shaking**

- This map shows the distribution of different soil types in Salt Lake Valley.
- The intensity of shaking is influenced by the type of materials underlying an area.
- Deep sediment-filled basins and soft soils (e.g., wet clay) amplify and prolong low-frequency shaking; shallow, stiff soils amplify high-frequency shaking.

**Wasatch fault segment**

<table>
<thead>
<tr>
<th>Building losses ($ billions)</th>
<th>Displaced households</th>
<th>Life-threatening injuries and fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brigham City</td>
<td>3</td>
<td>14,000</td>
</tr>
<tr>
<td>Weber</td>
<td>16</td>
<td>57,000</td>
</tr>
<tr>
<td>Salt Lake City</td>
<td>42</td>
<td>150,000</td>
</tr>
<tr>
<td>Provo</td>
<td>14</td>
<td>48,000</td>
</tr>
<tr>
<td>Nephi</td>
<td>1</td>
<td>4,000</td>
</tr>
</tbody>
</table>

Losses estimated for a magnitude 7 earthquake on each of the central segments of the Wasatch fault (see page 7).

Map showing levels of strong ground shaking expected in a magnitude 7.0 earthquake on the Salt Lake City segment of the Wasatch fault. The highest levels of ground shaking in Salt Lake Valley will likely occur adjacent to the Wasatch fault zone.
Earthquakes Also Cause Damage in Other Ways….

Although most earthquake damage is caused by shaking, other damaging effects of quakes can be just as devastating. For example, in the 1992 magnitude 5.9 St. George earthquake, the greatest damage to houses occurred as a result of a massive landslide in Springdale.

**DAMAGED INFRASTRUCTURE**

Earthquakes often damage roads and bridges, hindering rescue and recovery efforts and causing accidents. Water and sewer pipeline breaks result in water loss that can contaminate surface and ground water, and cause “sinkholes” that undermine roads and buildings. Damage to natural gas and electrical distribution systems can cause fires, as well as major service outages, and damage to petroleum pipelines can cause oil spills. The photo below shows damage to a bridge on the Santa Monica freeway (Interstate 10) in the 1994 magnitude 6.7 Northridge, California, earthquake. This bridge was similar in construction to older bridges along Utah freeways.

**FIRES**

Earthquakes in urban areas are often followed by destructive fires because gas lines break, electrical shorts ignite fires, damaged water tanks and broken pipes limit water for firefighting, and clogged roads and collapsed bridges prevent access for firefighters. The photo above is an aerial view of Balboa Boulevard in Granada Hills in the 1994 magnitude 6.7 Northridge, California, earthquake showing street flooding, flames due to a broken natural gas line, and burned homes.

**HAZARDOUS MATERIALS**

Earthquake damage can cause releases of hazardous materials from refineries and other chemical storage and distribution systems, research and industrial laboratories, manufacturing plants, and railroad tank cars. The photo above shows a train derailment in Northridge in the 1994 magnitude 6.7 Northridge, California, earthquake that released sulfuric acid from a tanker car.

**LANDSLIDES**

Earthquakes can trigger landslides that damage roads, buildings, pipelines, and other infrastructure. The home in Springdale, shown below, was destroyed when a hillside gave way in the 1992 magnitude 5.9 St. George earthquake 27 miles to the west.

**LIQUEFACTION**

Earthquake shaking can cause certain soils to behave like a liquid and lose their ability to support structures. Liquefaction often causes buried gas and water lines to break. The highest potential for liquefaction is in low-lying areas where saturated loose, sandy soils and poorly compacted artificial fill are found. Geologic evidence in Utah indicates that severe ground deformation caused by liquefaction has occurred during large prehistoric earthquakes. The photo below shows liquefaction-related damage to a road at Moss Landing State Beach on Monterey Bay following the 1989 magnitude 6.9 Loma Prieta, California, earthquake.
Surface faulting along normal faults causes subsidence and tilting on the downdropped side of the fault. The photo below shows abandonment of the south shore of Hebgen Lake in the 1959 magnitude 7.5 Hebgen Lake earthquake as the lake bed tilted to the north toward the fault. Flooding may occur along the east shores of Great Salt Lake and Utah Lake accompanying tectonic subsidence from surface-faulting earthquakes on the Wasatch fault.

(From U.S. Forest Service Miscellaneous Publication 907)
Response of Buildings
to Earthquakes

Much like an automobile on a winding roadway, buildings sway to the effects of earthquakes. Foundations connect structures to Earth and they play a very important part in determining how much force a building can resist. Engineers study this critical interface and may choose to “cushion” the effect by using special foundation designs.

The soil underlying the built environment is an important ingredient in determining the effects of earthquakes on structures.

- Soft, clayey soils tend to increase the motion at the ground surface and thereby amplify the effects on buildings and structures.
- Rock doesn’t tend to change the earthquake energy nearly as much and is more predictable in its response.

A building’s configuration and height also play an important role in determining the effects an earthquake will have on its performance.

- Square or rectangular buildings typically perform better than irregular-shaped buildings.
- Tall buildings respond by swaying back and forth.
- Short structures are jarred from side to side as the earthquake releases its force at the ground surface.

The materials from which a building is constructed help determine how it performs during an earthquake.

- Steel and wood are considered flexible or “ductile” and tend to absorb the energy.
- Concrete and masonry are more “rigid” and, unless detailed properly, will transfer the ground motion directly into the structure.

Earthquakes shake buildings from the ground up, and an important consideration for performance is the length of time the ground shakes. The longer the ground shakes, the more chance the structure will be unable to resist the effects. Building materials can resist temporary “overstress,” but when stretched beyond their limits, will break, much like a paper clip bent back and forth will eventually break.

While the building’s “bones” or structure are of primary importance when considering overall life safety, the portions not responsible for helping it to stand up are also a major contributor to damage following an earthquake. The so-called “non-structural” elements such as bookcases, shelves, ceiling tiles, and light fixtures often cause significant problems which can be addressed or anticipated before an earthquake. Just as buildings need to be designed and braced for these lateral loads, non-structural components require similar consideration.

Unreinforced Masonry Buildings (URMs)

One building type of particular concern in Utah is masonry constructed without steel reinforcement. URMs were a popular building style when the state was first being settled.

Bricks are created from clay which is burned in ovens at high temperatures. This material was both readily available here and familiar to the early settlers.

Many residences, in addition to commercial buildings, are URMs and were constructed without the knowledge of how these structures performed in earthquakes. Unfortunately, experience now suggests this is one of the most dangerous building types and evidence of its poor performance in earthquakes throughout the world is well documented.

In addition to buildings, virtually all structures are susceptible to potential damage from an earthquake. Dams, bridges, pipelines, storage tanks, and roadways are but a few of the parts of the built environment which can be damaged by an earthquake’s forces.

These infrastructure elements are often taken for granted and not until after an earthquake are they viewed as critical components, necessary for maintaining our standard of living. The infrastructure we rely upon can be fragile in ways we may not understand until after we’ve lost their benefit.
The ABCs of Seismic Building Codes

Seismic building codes increase building integrity and ensure the future safety of communities. These codes result in earthquake-resistant buildings, but not earthquake-proof buildings. Seismic codes are intended to protect people inside buildings by preventing collapse and allowing for safe evacuation. Structures built according to the current code should resist minor earthquakes undamaged, resist moderate earthquakes without significant structural damage, and resist severe earthquakes without collapse.

A moderate earthquake that does not significantly damage a building can still seriously hurt or kill people. Buildings are full of items such as light fixtures, heating ducts, windows, and suspended ceilings that can fall on people or block escape routes. The exteriors of buildings can also pose many hazards to people walking by or exiting during or following an earthquake including falling bricks, parapets, window glass, or other facades.

Steel-frame tall buildings and newer wood-frame short buildings are usually (but not always) the safest structure types. Exceptions to those generalizations are due to variables such as the configuration of the building, the quality of construction and inspection, the design of the joints, and the manner in which seismic waves strike a particular site.

Building codes provide minimum design and construction requirements for providing life safety. However, there are some structures with high occupancy, critical response services (fire, police, hospitals), and vulnerable populations (schools, nursing homes) that should be built above minimum requirements. Building codes use importance factors to allow for designing above these minimum requirements. It is also important to protect utilities and infrastructure since damage to these critical structures leads to more life loss, larger economic loss, greater social disruption, and slower community response to earthquakes.

The seismic provisions of building codes are based on earthquake hazard maps (example at right) which show the probabilities of certain levels of earthquake shaking in particular areas. The code requirements reflect the fact that some places are more likely than others to have strong earthquakes. Utah has areas with a high likelihood of strong earthquakes, similar to states with the greatest likelihood along the West Coast as shown in the maps at right.

In Utah, seismic codes made substantial improvements in construction as early as the mid-1970s. Buildings constructed prior to this time may be seismically unsafe. However, buildings constructed in the 1980s would also not be as seismically safe as a building constructed today under the current seismic codes. In order to keep up with the current state of the art in seismic design, building codes are currently revised every 3 years to incorporate new knowledge.
Utah’s People, Economy, and Infrastructure Are Increasingly Vulnerable to a Wasatch Fault Earthquake

- Nearly 80% of Utah’s population lives within 15 miles of the Wasatch fault in the Wasatch Front area (see map at right).
- More than 75% of Utah’s economy is concentrated in Salt Lake, Utah, Davis, and Weber counties—above the Wasatch fault, which projects beneath the developed Wasatch Front valleys.
- Most of Utah’s state government facilities are located within 15 miles of the Wasatch fault.
- Major interstate transportation corridors and the Salt Lake International Airport are located within 15 miles of the Wasatch fault.
- By 2030 the population in the Wasatch Front area is projected to grow to 2.8 million, a 50% increase over 2005.
- To meet the needs of the dramatically growing population along the Wasatch Front, $14.4 billion of new transit and highway infrastructure is planned over the next three decades.

Earthquake risk (the probability of loss or damage) is increasing with population growth and development.
**Big Quakes Will Affect You**

**Utah Isn’t California**

Geographically this is true, Utah is not California. However, many earthquakes are recorded and located each year in the Utah region—currently, about 800 per year on average, excluding mining seismicity. Most of these earthquakes are small and not felt. Since 1850, sixteen damaging shocks of about magnitude 5.5 and larger have occurred in the Utah region (page 4). California certainly has more “wake-up calls,” where earthquakes of about magnitude 6.5 and larger that cause fatalities and major structural damage typically occur once or twice per decade.

Scientific studies in Utah indicate that “Big Ones” occur somewhere in the Wasatch Front area on a time scale of a few hundreds of years. These are high-energy earthquakes of about magnitude 7 during which the ground is suddenly displaced vertically about 10 feet at the fault line. Within tens of miles of the epicenter there is a high potential for major structural damage and casualties (see page 14). In Utah, many seismically vulnerable buildings increase the damage potential. On a geological time table, Utah is due for its next “Big One”—and, unfortunately, is a lot like California in this regard.

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**How likely is a “Big One*”?**

<table>
<thead>
<tr>
<th>Earthquake Source</th>
<th>Annual Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Lake City segment of the Wasatch fault</td>
<td>1 in 450 to 1 in 1600</td>
</tr>
<tr>
<td>One of the Wasatch fault’s five central segments (Brigham City to Nephi, see page 7)</td>
<td>1 in 300 to 1 in 400</td>
</tr>
<tr>
<td>One of 30 active faults in the Wasatch Front region (see page 6)</td>
<td>1 in 200</td>
</tr>
</tbody>
</table>

* A large surface-faulting earthquake of about magnitude 7

Sources: Likelihood calculated by the University of Utah Seismograph Stations from data provided in UGS, USGS, GeoHaz Consultants, and URS Corporation reports.

**Average Frequency of Earthquakes in the...**

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Wasatch Front Frequency</th>
<th>Entire Utah Region Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 3.0</td>
<td>3 per year</td>
<td>8 per year</td>
</tr>
<tr>
<td>≥ 4.0</td>
<td>1 every 2 years</td>
<td>1 per year</td>
</tr>
<tr>
<td>≥ 5.0</td>
<td>1 every 10 years</td>
<td>1 every 5 years</td>
</tr>
<tr>
<td>≥ 5.5</td>
<td>1 every 20 years</td>
<td>1 every 10 years</td>
</tr>
<tr>
<td>≥ 6.0</td>
<td>1 every 50 years</td>
<td>1 every 30 years</td>
</tr>
<tr>
<td>≥ 7.0</td>
<td>[based on geological evidence, time scale of 100s of years - see page 7]</td>
<td></td>
</tr>
</tbody>
</table>

≥ Greater than or equal to

* Based on historical record and instrumental monitoring (largest historical shock was M 6.6 in 1934); excludes foreshocks, aftershocks, and human-triggered seismic events

Source: University of Utah Seismograph Stations

**Reality Check**

(for comparing to the chance of a “Big One”)

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>Your Annual Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart disease</td>
<td>1 in 450</td>
</tr>
<tr>
<td>Cancer</td>
<td>1 in 530</td>
</tr>
<tr>
<td>Stroke</td>
<td>1 in 2100</td>
</tr>
<tr>
<td>Motor-vehicle accident</td>
<td>1 in 6500</td>
</tr>
</tbody>
</table>

Source: Centers for Disease Control and Prevention; causes of death in the U.S. in 2005, the most recent year for which data are available.
WHY SHOULD I PREPARE?

Your Life Could Change Unexpectedly in the Next Quake. Consider...

Where will your family be?

- Your children may be at school, day care, or other activities.
- Family members may be at work or commuting.
- Pets may run away or be injured.

Will you have medical services?

- The 911 emergency system will likely be overloaded.
- Hospitals and other medical facilities may be damaged.
- Emergency rooms and trauma centers may be overwhelmed.
- Assisted living, critical care, and other health services such as dialysis may not be operational.

Will you be able to get home?

- Road damage and closures may restrict your ability to travel by car.
- Public transportation, including buses, TRAX, trains, and airports may experience closures or interruptions in service.
- Commute times may be dramatically increased.

After the 2001 magnitude 6.8 Nisqually earthquake, this school in the Puget Sound area of Washington was closed for repair. (Earthquake Engineering Research Institute photo)

Pets are not allowed in most emergency shelters. Do you have a plan to feed and care for your animals after an earthquake?

This hospital in Sylmar, California, had to be demolished after the 1971 magnitude 6.7 San Fernando earthquake. (Photo courtesy of USGS)

The 1989 magnitude 6.9 Loma Prieta earthquake caused this section of the San Francisco-Oakland Bay Bridge to collapse. (Photo courtesy of USGS)
Will you be able to stay in your home?

This porch on a wood-frame house failed during the 1989 magnitude 6.9 Loma Prieta earthquake. The "red tag" indicates that this home is unsafe and must not be entered or occupied. (Photo courtesy of USGS)

Can you live without the services you rely on?

- Water may be in short supply.
- Natural gas and electric power may be out for days or weeks.
- Garbage and sewage services may be interrupted.
- Telephone, Internet, cell phone, and wireless communications may be overloaded or unavailable.
- Mail service may be disrupted or delayed.
- Gasoline may be in short supply, and rationing may be necessary.
- Bank operations may be disrupted, limiting access to cash, ATMs, or online banking.
- Grocery, drug, and other retail stores may be closed or unable to restock shelves.

How will the American Red Cross Help?

After an earthquake, the American Red Cross will help in the following ways:

- Opening and operating emergency shelters.
- Providing food at shelters and feeding locations and through mobile distribution.
- Obtaining and delivering other needed items such as water, baby supplies, and blankets.
- Assisting with the immediate mental-health needs of those affected.
- Providing for basic health needs at shelters and other locations.
- Helping with initial recovery through casework and referrals to other agencies and partners.
- Providing blood and blood products.

For more information go to: http://utahredcross.org

How will your job be affected?

- Businesses may sustain damage and disruption—many small businesses require a long time to reopen or do not survive disasters.
- Your income may be affected—payroll checks or direct deposits may be delayed.
- Your workplace may become a temporary shelter for you or others.
- Supplies and deliveries will be interrupted.

This business in Santa Cruz, California, was nearly destroyed in the 1989 magnitude 6.9 Loma Prieta earthquake. (Photo courtesy of USGS)
Your Financial Situation Could Be Affected by a Quake...

Aid may not be immediately available following a major disaster. Without proper planning, the financial impact of an earthquake on you and your family could be devastating. Although many things are out of your control after a quake, your ability to recover financially depends on a number of factors that you can control. Prepare and follow a financial disaster recovery plan and you will be more likely to recover successfully. Consider the following:

**Will you have money, food, and medicine?**

- Bank operations may be disrupted, limiting access to cash, ATMs, or online banking.
- Food, drug, and other retail stores where you shop may be closed or unable to restock shelves.

**Will you be able to recover financially?**

- You are still responsible for your existing debts, such as mortgage, lease, car, and credit-card payments.
- You may not have access to important financial records.
- Your assets are at risk without sufficient earthquake insurance.
- If you have earthquake insurance and experience loss, begin working with your insurer to file a claim as quickly as possible.

**Will your insurance cover your losses?**

- Homeowner’s and renter’s insurance policies do not cover losses related to earthquakes.
- A separate earthquake insurance policy is one way to help protect your home, in addition to seismic retrofitting.
- Earthquake insurance also helps with additional living expenses in the days and weeks after earthquakes.
- Only 17% of Utah homeowners have earthquake insurance.

Don’t be fooled!—Myth number 3

“HOMEOWNER’S INSURANCE WILL COVER ANY DAMAGE TO MY HOME OR BELONGINGS CAUSED BY AN EARTHQUAKE.”

Most residential property insurance policies do not cover damage resulting from earthquakes. A separate earthquake insurance policy is one way to protect your home and the investments you have made in personal belongings. Investigate your options carefully to ensure that your assets are sufficiently protected.
Does your small business have a recovery plan?

- A business disaster recovery plan will make your business better able to survive in a post-disaster environment.
- Although physical assets can be replaced, emotional and social changes that affect businesses and their customers may remain long after a disaster.
- Businesses may not return to their previous revenue levels after a disaster; however, some businesses such as construction are likely to be in great demand following an earthquake.

What will the Government do for you?

- Federal disaster relief programs are designed to help you get partly back on your feet but not to replace everything you lose.
- The Department of Homeland Security’s Federal Emergency Management Agency (FEMA) is tasked with responding to, planning for, and mitigating disasters.
- After the President signs a major disaster declaration, FEMA cooperates with other agencies, such as the Small Business Administration (SBA), in providing disaster relief.
- The primary form of disaster relief is low-interest loans to eligible individuals, homeowners, and businesses made available through the SBA to repair or replace damaged property and personal belongings not covered by insurance.
- The maximum SBA personal-property loan is $40,000, and the maximum SBA real-property loan for primary home repair is $200,000.
- FEMA disaster grants for emergency home repairs and temporary rental assistance are only available to individuals and households who do not qualify for loans.
- The average FEMA grant is less than $15,000 (the maximum is $26,200)—not enough to rebuild a home in Utah!
- The Farm Service Agency (FSA) offers loans to assist agricultural businesses.

USEFUL WEB SITES

Ready Your Business:  
http://beready.utah.gov/business.html

Business Disaster Planning:  
http://www.acputah.org

Business Preparedness Information:  
http://www.ready.gov/business/
The Seven Steps to Earthquake Safety...

Earthquakes in Utah are inevitable, but damage from them is not! Steps you can take before, during, and after earthquakes will help make you and your family safer and reduce your injuries, damage, and losses:

- First and foremost, plan for the personal safety of you and your loved ones.
- Look into the safety of your home, workplace, and child’s school—don’t be afraid to ask your landlord, boss, or school’s principal if they are aware of the hazards and have taken measures to make these places safer and more earthquake resistant.
- Find out if your home, workplace, and child’s school could be subjected to seismic hazards, such as landsliding or liquefaction, in addition to strong shaking.
- Don’t forget to think about likely economic impacts to you and your family from a major quake (see pages 18, 19, and 31).

The seven steps described in this section will help you to be safer in earthquakes. They are arranged as measures you should take before, during, and after quakes. In addition to following the steps at home, they should also be followed at schools and workplaces. If everyone makes an effort to follow these steps, billions of dollars could be saved, injuries avoided, and many deaths averted in the next big earthquake!

You’ve learned your earthquake hazards, now follow these seven steps . . .

**BEFORE A QUAKE:**

**STEP 1.** Identify potential hazards in your home and begin to fix them (page 22).
**STEP 2.** Create a disaster-preparedness plan (page 24).
**STEP 3.** Create disaster kits (page 25).
**STEP 4.** Identify your building’s potential weaknesses and begin to fix them (page 26).

**DURING A QUAKE:**

**STEP 5.** Protect yourself during earthquake shaking (page 28).

**AFTER A QUAKE:**

**STEP 6.** After the quake, check for injuries and damage (page 29).
**STEP 7.** When safe, continue to follow your disaster-preparedness plan (page 30).
FOLLOW THE SEVEN STEPS TO EARTHQUAKE SAFETY

1. Identify potential hazards in your home and begin to fix them (page 22)
2. Create a disaster-preparedness plan (page 24)
3. Create disaster kits (page 25)
4. Identify your building’s potential weaknesses and begin to fix them (page 26)
5. Protect yourself during earthquake shaking (page 28)
6. After the quake, check for injuries and damage (page 29)
7. When safe, follow your disaster-preparedness plan (page 30)
STEP 1 Identify Potential Hazards in Your Home and Begin to Fix Them

The first step to earthquake safety is to look around your home and identify all unsecured objects that might fall during shaking.

START NOW by moving heavy furniture, such as bookcases, away from beds, couches, and other places where people sit or sleep! Also make sure that exit paths are clear of clutter.

Simple and inexpensive things that you can do now will help reduce injuries and protect belongings in a quake. Most hardware and home-improvement stores carry earthquake-safety straps, fasteners, and adhesives that you can easily use to secure your belongings.

The following tips describe simple solutions to situations in your home that could be dangerous during earthquake shaking. If these have not yet been done in your home, take action now:

Hanging objects

Art and other heavy objects hung on walls may fall, and glass in pictures and mirrors may shatter.

- Place only soft art, such as unframed posters or rugs and tapestries, above beds or sofas.
- Hang mirrors, pictures, and other hanging objects on closed hooks.

Objects on open shelves and tabletops

Collectibles and other loose objects can become dangerous projectiles.

- Hold collectibles, pottery, and lamps in place by using removable earthquake putty, museum wax, or quake gel.

Furniture

Tall, top-heavy furniture, such as bookcases and entertainment centers, may fall and injure you.

- Store heavy items and breakables on lower shelves.
- Secure both top corners of tall furniture into a wall stud, not just to the drywall.
- Flexible-mount fasteners, such as nylon straps, allow furniture independent movement from the wall, reducing strain on studs.

Don’t be fooled!—Myth number 4

“QUAKE INJURIES ARE ALL FROM COLLAPSING BUILDINGS.”

Many people think that all injuries in earthquakes are caused by collapsing buildings. Actually, most injuries in quakes are from objects that break or fall on people. For example, in the 1994 magnitude 6.7 Northridge earthquake, 55% of quake-related injuries were caused by falling objects, such as televisions, pictures and mirrors, and heavy light fixtures.
Water and gas pipes

Water or gas pipes anywhere in your home can break. Water leaks can cause extensive damage, and gas leaks are a major fire hazard.

- Have a plumber evaluate, replace, and properly secure rusted or worn water and gas pipes.
- If not already done, have a plumber replace rigid gas connections to water heaters, stoves, dryers, and other gas appliances with flexible (corrugated) stainless-steel gas connectors (see below).
- Excess-flow gas-shutoff valves for individual appliances, which stop gas flow in case of a catastrophic leak, are also now available for use with flexible connectors.

Water heaters

Unsecured water heaters may fall over, rupturing rigid water and gas connections.

- Water heaters should be anchored to wall studs or masonry with metal straps and lag screws. Kits are available at hardware stores and home centers.
- If not already done, have a plumber install flexible (corrugated) copper water connectors.

In the kitchen

Glassware and china may crash to the floor if cabinet doors are unsecured. Gas appliances can shift, rupturing their gas connections.

- Secure all cabinet doors, especially those overhead, to help prevent contents from falling out during quakes. Use latches designed for child proofing or earthquake or boat safety.
- Secure refrigerators and other major appliances to walls using earthquake appliance straps.

In the garage or utility room

Items stored in garages and utility rooms can fall, causing injuries, damage, and hazardous spills or leaks.

- Move flammable or hazardous materials to low areas that are secure.
- Ensure that items stored above or beside vehicles cannot fall, damaging or blocking them.

Home electronics

Large electronic devices may fall, causing injuries and damage. They are also costly to replace.

- Secure TVs, stereos, computers, and microwave ovens with flexible nylon straps and buckles for easy removal and relocation.

For more information on making your home safer in earthquakes go to: http://beready.utah.gov
Will everyone in your household know how to react during and after strong earthquake shaking? To be ready for the quakes that are certain to happen in Utah, it is important that your family have a disaster-preparedness plan. Hold occasional earthquake “drills” to practice your plan. Share your disaster plan with your neighbors and discuss key points with babysitters, house sitters, and house guests. Your plan should include most of the following:

**Plan NOW to be safe during an earthquake:**
*In a strong earthquake, individual survival skills will be crucial.*

- Practice “drop, cover, and hold on.” (See STEP 5, page 28)
- Identify safe spots in every room, such as under sturdy desks and tables.
- Learn how to protect yourself no matter where you are when an earthquake strikes. (See STEP 5, page 28)

**Plan NOW to respond after an earthquake:**
*Doing the following will enable you to help your family and others after a strong quake.*

- Keep shoes and a working flashlight next to each bed.
- Teach everyone in your household to use emergency whistles and (or) to knock 3 times repeatedly if trapped. Rescuers searching collapsed buildings will be listening for sounds.
- Identify the needs of household members and neighbors with special requirements or situations, such as use of a wheelchair, walking aids, special diets, or medication.
- Take a Red Cross first aid and CPR (cardiopulmonary resuscitation) training course. Learn who in your neighborhood is trained in first aid and CPR.
- Know the locations of utility shutoffs and keep needed tools nearby. Know how to turn off the gas, water, and electricity to your home. Only turn off the gas if you smell or hear leaking gas. (See STEP 6, page 29)
- Get training from your local fire department in how to properly use a fire extinguisher.
- Install smoke alarms and test them monthly. Change the battery once a year, or sooner if the alarm emits a “chirping” sound (low-battery signal).
- Check with your fire department to see if there is a Community Emergency Response Team (CERT) in your area. If not, ask how to start one.

**Plan NOW to communicate and recover after an earthquake:**
*Don’t wait until the next earthquake to do the following.*

- Locate a safe place outside of your home for your family to meet after the shaking stops.
- Establish an out-of-area contact person who can be called by everyone in the household to relay information.
- Provide all family members with a list of important contact phone numbers.
- Determine where you might live if your home cannot be occupied after an earthquake or other disaster (ask friends or relatives).
- Learn about the earthquake plan developed by your children’s school or day care, and keep your children’s school emergency release cards current.
- Keep copies of insurance policies, financial records, and other essential documents in a secure location, such as with your household disaster kit. Include a household inventory (a list and photos or video of your belongings).

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**Your family may be sleeping when the next strong quake hits Utah. After the shaking stops, the lights may be out and broken glass and other dangerous debris may litter the floor, making it unsafe to walk barefoot. Keep a flashlight and a pair of sturdy shoes secured to or within reach of everyone’s bed. A good way to do this is to use a drawstring bag tied to a bedpost at the head of the bed for each occupant.**
STEP 3 Create Disaster Kits

Personal Disaster Kits

Everyone in your family should have their own personal disaster kits. These kits are collections of supplies they may need when a quake strikes.

Personalize these kits and keep them where they can easily be reached—at home, in the car, at work or school. A backpack or other small bag is best for these kits so that they can be easily carried in an evacuation. Include the following items:

- Medications, a list of prescriptions, copies of medical insurance cards, doctors’ names and contact information.
- Medical consent forms for dependents.
- First aid kit and handbook.
- Spare eyeglasses, personal hygiene supplies, and sturdy shoes.
- Bottled water.
- Whistle (to alert rescuers to your location).
- Emergency cash.
- Personal identification.
- List of emergency contact phone numbers.
- Snack foods high in calories.
- Emergency lighting—light sticks and (or) a working flashlight with extra batteries and light bulbs (hand-powered flashlights are also available).
- Comfort items, such as games, crayons, writing materials, and teddy bears.

Household Disaster Kit

Electrical, water, transportation, and other vital systems can be disrupted for several days after a large earthquake. Emergency response agencies and hospitals will likely be overwhelmed and unable to provide you with immediate assistance.

To help your family cope after a strong earthquake, store a household disaster kit in an easily accessible location, preferably outdoors (not in your garage). This kit, which complements your personal disaster kits, should be in a large watertight container that can be easily moved and should hold at least a 3- to 5-day supply of the following items:

- Drinking water (minimum one gallon per person per day).
- First aid supplies, medications, and essential hygiene items, such as soap, toothpaste, and toilet paper.
- Emergency lighting—light sticks and (or) a working flashlight with extra batteries and light bulbs (hand-powered flashlights are also available).
- A hand-cranked or battery-operated radio (and spare batteries).
- Canned and packaged foods and cooking utensils, including a manual can opener.
- Items to protect you from the elements, such as warm clothing, sturdy shoes, extra socks, blankets, and perhaps even a tent.
- Heavy-duty plastic bags for waste and to serve other uses, such as tarps and rain ponchos.
- Work gloves and protective goggles.
- Pet food and pet restraints.
- Copies of vital documents, such as insurance policies and personal identification.

Note: Replace perishable items like water, food, medications, and batteries on a yearly basis.

For more information on earthquake preparedness plans and disaster kits go to:

**Telephone book:**
The front section of your local phone book

**Be Ready Utah**
http://beready.utah.gov

**Rocky Mountain Power**
http://www.rockymtnpower.net/Article/Article36707/html

**Questar Gas**
http://www.questargas.com/brochures/index.html#SAFETY

A Special Note About Children

**Before the next earthquake,** spend time with your kids to discuss what might occur. Involve them in developing your disaster plan, preparing disaster kits (ask them what game or toy they want to include), and practicing “drop, cover, and hold on.”

**In the days after a quake,** kids need extra contact and support. They may be frightened and under great stress, and aftershocks won’t let them forget the experience. Parents may have to leave children with others in order to deal with the emergency, and this can be scary. Whenever possible, include your children in the earthquake recovery process.

Resources for kids to learn about disaster preparedness:
http://www.fema.gov/kids/
http://earthquake.usgs.gov/4kids/
Identify Your Building’s Potential Weaknesses and begin to Fix Them

Is your house, condo, or apartment strong enough to withstand an earthquake?

Use the following quiz to see if your home is likely to be so badly damaged in a future earthquake that people might be injured or that it would be unsafe to occupy. If your home scores above a 17 on the quiz, you probably should have a structural engineer evaluate it unless it has been strengthened in the last few years. They will check to see if your home is strong enough to keep you and your family reasonably safe in an earthquake. The engineer will look for the following:

- Is your house properly connected to the foundation?
- Is there plywood on the exterior walls of your house?
- Are there anchors attaching the roof and floor systems to the walls?
- Is your house constructed out of unreinforced masonry?
- Do you have large openings like a garage door that may require better bracing?

The following quiz will help you to determine the adequacy of your house in resisting a seismic event. Once you have identified the areas requiring retrofitting, prioritize how and when to fix them, and get started. Local building departments and the Structural Engineers Association of Utah are excellent available resources.

### Structural-Safety Quiz for Homes and Other Buildings

1. When was your home built?
   - Before 1970 = 6 points
   - 1970 – 1980 = 3 points
   - After 1980 = 1 point

2. How many stories and what style is your home?
   - 2 or more stories above grade with stepped floors, split levels, or large openings in floors = 5 points
   - 2 or more stories above grade with flat floors, no steps in the floor, and no large openings in floors = 3 points
   - 1 story rambler above grade = 1 point

3. What is the construction material of the exterior walls?
   - Unreinforced masonry bearing walls = 7 points
   - Wood or reinforced masonry with full height brick veneer = 3 points
   - Wood or reinforced masonry = 1 point

4. What are the foundation walls constructed from?
   - Stacked rock or brick = 5 points
   - Concrete = 1 point
   - Slab on grade with no basement = 0 points

5. Where is your house located? (see map, page 8)

   - Low = 1 pt
   - Medium = 3 pts
   - High = 5 pts
   - Very High = 8 pts

Total points = __________

If your home scores 17 or more points on the quiz, you probably should have an engineer, architect, or contractor evaluate it.

### EXAMPLES:

1. 1975 2 story with basement in West Valley City w/ brick
   \[3 + 3 + 3 + 1 + 5 = 15\]

2. 1958 1 story no basement URM Rambler in West Valley City
   \[6 + 1 + 7 + 0 + 5 = 19\]

3. 1995 2 story with basement in Salt Lake City (brick veneer)
   \[1 + 3 + 3 + 1 + 8 = 16\]
Utah Parapet Ordinance

On October 28, 1983, two girls, 6 and 7, were killed by falling debris from a parapet on a business in Challis, Idaho, as they walked to school. Challis is about 13 miles north of the epicenter of the 1983 Borah Peak earthquake (magnitude 7.3). Photos 1 and 2 are taken of damaged buildings from this earthquake in the nearby town of Mackay, Idaho. These deaths were the first deaths caused by an earthquake in the USA since more than 50 were killed in the San Fernando earthquake in California on February 9, 1971.

The 1962 Cache Valley earthquake (magnitude 5.7) is another example of falling debris from parapets. Arrows in Photo 3 show the path of bricks that tumbled from the parapet of a drugstore onto the roof of the City Cafe in Lewiston, Utah. Luckily this cafe in Lewiston was not open when the earthquake occurred (see Photo 4). Photo 5 shows damage to an unreinforced masonry building in the 2008 magnitude 6 Wells, Nevada, earthquake.

In response to the damage from past earthquakes, a parapet bracing ordinance was enacted in 1991 in Utah. This ordinance requires that a licensed engineer evaluate the adequacy of parapet bracing and the connection of the walls to the roof framing when a commercial building (built prior to 1975) is to undergo a re-roof. The exact wording of this ordinance can be found in the Utah Uniform Building Standards Act Rules, Statewide Amendments to the IBC (R156-56-704).

The bracing of parapets, creating strong wall-to-roof framing connections and bracing or elimination of other roof appendages (i.e. chimneys and cornices) can be one of the simplest and most cost-effective seismic upgrades that can be made to a building.

The figures at left show typical details that can be used to brace parapets and chimneys. These figures are based on details found in a State of Utah publication titled “The Utah Guide for the Seismic Improvement of Unreinforced Masonry Buildings” and may be viewed online at http://homelandsecurity.utah.gov/hazards/earthquake.htm. (Photos 1 and 2 by O. Kasteler, courtesy of the Deseret News; photos 3 and 4 courtesy of the Salt Lake Tribune; photo 5 courtesy of Craig dePolo - Nevada Bureau of Mines and Geology)
STEP 5 Protect Yourself During Earthquake Shaking

The previous pages have concentrated on getting you ready for future earthquakes in Utah, but what should you do when the shaking starts?

If you are indoors...

- “DROP, COVER, AND HOLD ON.” If you are not near a desk or table, drop to the floor against an interior wall and protect your head and neck with your arms.
- Avoid exterior walls, windows, hanging objects, mirrors, tall furniture, large appliances, and cabinets filled with heavy objects.
- Do not go outside until well after the shaking stops!

In bed
Hold on and stay there, protecting your head with a pillow. You are less likely to be injured staying where you are. Broken glass on the floor can cause injuries; be sure to put shoes on before stepping on the floor (see STEP 2, page 24)!

In a high rise building
DROP, COVER, AND HOLD ON. Avoid windows and other hazards. Do not use elevators. Do not be surprised if sprinkler systems or fire alarms activate.

At work
DROP, COVER, AND HOLD ON. Know your workplace’s earthquake safety plan and put it into action. When safe, move to a specified meeting location.

In a public building or theater
DROP, COVER, AND HOLD ON if possible. If in a theater seat, duck down and protect your head and neck with your arms. Don’t try to leave until the shaking is over. Then walk out slowly, watching for fallen debris or anything that could fall on you in aftershocks.

If you are outdoors...

Move to a clear area if you can safely do so; avoid buildings, powerlines, trees, and other hazards. Always assume fallen powerlines are live.

Near tall buildings
Windows, facades, and architectural details are often the first parts of a building to collapse. Get away from this danger zone when shaking starts. Take refuge in a safe building or an open space.

Driving
When able, safely pull over to the side of the road, stop, and set the parking brake. Avoid overpasses, bridges, powerlines, signs, trees, and other things that might collapse or fall on the vehicle. Stay inside the vehicle until the shaking is over. If a powerline falls on the vehicle, stay inside until a trained person removes the hazard.

In a stadium
Stay at your seat and protect your head and neck with your arms. Don’t try to leave until the shaking is over. Then exit slowly, avoiding debris and watching for anything that could fall in aftershocks.

Below a dam
Dams can fail during a major earthquake. Catastrophic failure is unlikely, but if you are downstream from a dam, you should know flood-zone information and have prepared an evacuation plan. For more information go to the Utah Division of Water Rights Dam Safety Program at http://www.waterrights.utah.gov/daminfo/default.asp.

Don’t be fooled!—Myth number 6

“The Triangle of Life Survival Method is the best method to use inside a building to survive an earthquake.”

False. The best survival method inside a building is to Drop, Cover, and Hold On under a table, desk, or chair. This survival method protects individuals from objects falling from walls and shelves. It also provides a level of protection from structural failures. If a table or desk is not available, stand in a doorway or next to an inside wall.
STEP 6 After the Quake, Check for Injuries and Damage

Once earthquake shaking has stopped, follow your disaster preparedness plans (see Step 2, page 24). Most importantly:

**Check for injuries**

NOTE: The manual in your first aid kit and the front pages of your telephone book have instructions on first aid measures.

- Check yourself for serious injuries before helping others. Protect your mouth, nose, and eyes from dust.
- If a person is bleeding, put direct pressure on the wound. Use clean gauze or cloth, if available.
- If a person is not breathing, administer rescue breathing.
- If a person has no pulse, begin CPR (cardiopulmonary resuscitation).
- Do not move seriously injured persons, unless they are in immediate danger of further harm.
- Cover injured persons with blankets or additional clothing to keep them warm.

**Check for damage causing hazardous conditions**

- **Fire**—If possible, put out small fires in your home or neighborhood immediately. Call for help, but don’t wait for the fire department.

- **Gas leaks**—Only turn off the gas if you suspect a leak because of broken pipes or detect the odor or sound of leaking natural gas. Use a manual gas shut off wrench to close your main gas valve by turning it counterclockwise. Don’t turn gas back on by yourself—wait for the gas company! (Your telephone book has information on this topic.)

- **Damaged electrical wiring**—Shut off power at the main breaker switch if there is any damage to your home wiring. Leave the power off until the damage is repaired! (Your telephone book also has information on this topic.)

- **Downed utility lines**—If you see downed power lines, consider them energized and keep yourself and others well away from them. Never touch downed power lines or any objects in contact with them!

- **Falling items**—Beware of heavy items tumbling off shelves when you open closet and cupboard doors.

- **Spills**—Use extreme caution; when in doubt, leave your home! Spilled medicines, drugs, or other relatively nontoxic substances can be cleaned up. Potentially harmful materials, such as bleach, lye, garden chemicals, paint, and gasoline or other flammable liquids should be isolated or covered with an absorbent material, such as dirt or cat litter.

- **Damaged masonry**—Stay away from brick chimneys and walls. They may be weakened and could topple during aftershocks. Don’t use a fireplace with a damaged chimney, as this could start a fire or trap toxic gases in your home!

If your home is seriously damaged...

If your home is structurally unsafe or threatened by a fire or other secondary disaster, you need to evacuate. However, shelters may be overcrowded and initially lack basic services, so do not leave home just because utilities are out of service or your home and its contents have suffered moderate damage. If you evacuate, tell a neighbor and your family point-of-contact where you are going. Take the following, if possible, when you evacuate:

**Bring to a shelter:**

- Personal disaster supply kits (see STEP 3, page 25).
- Supply of water, food, and snacks.
- Blanket, pillow, and air mattress or sleeping pad.
- Change of clothing and a jacket.
- Towel and washcloth.
- Diapers, formula, food, and other supplies for infants.
- A few family pictures or other small comfort items, such as dolls or teddy bears for children.
- Personal identification and copies of household and health insurance information.
- Books and games (especially for children).

However, do not bring

- Pets (service animals for people with disabilities are allowed—bring food for them).
- Large quantities of unnecessary clothing or other personal items.
- Valuables that might be lost, stolen, or take up needed space.
STEP 7 When Safe, Continue to Follow Your Disaster-Preparedness Plan

Once you have met your and your family’s immediate needs after the next strong Utah earthquake, continue to follow your disaster-preparedness plan (see Step 2, page 24).

The first days after the quake...

In the days following a damaging quake, pay special attention to the following:

Safety first
- Do not re-enter your home until you know it is safe.
- Be sure there are no gas leaks at your home before using open flames (lighters, matches, candles, or grills) or operating any electrical or mechanical device that could create a spark (light switches, generators, chain saws, or motor vehicles).
- Check for chemical spills, faulty electrical wiring, and broken water lines. Water in contact with faulty wiring is a shock hazard.
- Unplug broken or toppled light fixtures or appliances. These could start fires when electricity is restored.
- Never use the following indoors: camp stoves, kerosene or gas lanterns or heaters, gas or charcoal grills, or gas generators, as these can release deadly carbon monoxide gas or be a fire hazard in aftershocks.

Be in communication
- Turn on your portable or car radio and listen for information and safety advisories.
- Place all phones back on their cradles.
- Call your out-of-area contact, tell them your status, and then stay off the phone—emergency responders need the phone lines for life-saving communications.
- Check on your neighbors.

Check your food and water supplies
- If power is off, plan meals so as to use up refrigerated and frozen foods first. If you keep the door closed, food in your freezer may be good for a couple of days.
- If your water is off, you can drink from water heaters, melted ice cubes, or canned vegetables. Avoid drinking the water from swimming pools or hot tubs; use it to fight fires.

The first weeks after the earthquake...

This is a time of transition. Although aftershocks may continue, you will now work toward getting your life, your home and family, and your routines back in order. Emotional care and recovery are just as important as healing physical injuries and rebuilding a home. Make sure your home is safe to occupy and not in danger of collapse in aftershocks. If you were able to remain in your home or return to it after a few days, you will have a variety of tasks to accomplish while reestablishing routines:

Tasks
- If your gas was turned off, you will need to arrange for the gas company to turn it back on.
- If the electricity went off and then came back on, check your appliances or electronic equipment for damage.
- If water lines broke, look for water damage.
- Locate or replace critical documents that may have been misplaced, damaged, or destroyed.
- Contact your insurance agent or company right away to begin your claims process.
- Contact the Federal Emergency Management Agency (FEMA) to find out about financial assistance (see page 19).
- If you cannot live at your home, set up an alternative mailing address with the post office.

The American Red Cross (ARC) offers immediate emergency assistance with housing needs. ARC also supports shelter operations prior to a Presidential declaration of a Federal disaster.

Once a Presidential declaration has been issued, FEMA may activate the “Assistance for Individuals and Households Program.” This program includes:
- Home-repair cash grants; the maximum of Federal grant available is $26,200.
- Housing assistance in the form of reimbursement for short-term lodging expenses at a hotel or motel.
- Rental assistance for as long as 18 months in the form of cash payment for a temporary rental unit or a manufactured home.
- If no other housing is available, FEMA may provide mobile homes or other temporary housing.

AFTERSHOCK Go back to STEP 5

FINISH UP...
A Review of Money Matters: Financial Impacts of Earthquakes

Following a quake, disaster aid may not be immediately available, so you should plan ahead. If you have prepared a financial disaster recovery plan, you are more likely to recover successfully after a quake. Financial recovery planning resources are available from:

- **Operation Hope Emergency Financial First Aid Kit:**

  http://www.redcross.org/services/disaster/beprepared/FinRecovery/

- **Federal Emergency Management Agency (FEMA):**
  http://www.fema.gov/about/process

- **Small Business Administration:**
  http://www.sba.gov/disaster_recov/index.html

### Your financial disaster recovery kit

After a damaging earthquake, you will need copies of essential financial documents, as well as emergency cash. Keep these items together, current, and stored in a fire-proof document safe. Consider purchasing a home safe or renting a safe deposit box. Some essential items in your financial disaster recovery kit are:

- Birth certificates.
- Marriage license/divorce papers and child custody papers.
- Passports and driver’s licenses.
- Social security cards.
- Naturalization papers and residency documents.
- Military/veteran’s papers.
- Critical medical information.
- Cash, in the event ATM or bank services are disrupted.
- Certificates for stocks, bonds, and other investments.
- Bank statements.
- Credit card numbers.
- A list of phone numbers for financial institutions and credit card companies where you have accounts.
- Insurance policies.
- An inventory of your household possessions.
- Appraisals of valuable jewelry, art, antiques, and heirlooms.
- Home improvement records.
- A backup of critical files on your computer (also keep a copy at work).
- A list of names, phone numbers, and e-mail addresses of critical personal and business contacts.
- Deeds, titles, and other ownership records for property such as homes, autos, RVs, and boats.
- Powers of attorney, including healthcare powers of attorney.
- Wills or trust documents.

### For help in the first week after an earthquake—contact:

Your county office of emergency services

**American Red Cross:**
http://utahredcross.org
1-800-328-9272

**Utah Division of Homeland Security:**
http://homelandsecurity.utah.gov/home/

**Federal Emergency Management Agency (FEMA):**
http://www.fema.gov/assistance

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**Don’t be fooled!—Myth number 7**

“I DON’T NEED TO WORRY ABOUT EARTHQUAKES—THE GOVERNMENT WILL SAVE ME!”

Many people wrongly believe that the U.S. Government will take care of all their financial needs if they suffer losses in an earthquake. The truth is that Federal disaster assistance is only available if the President formally declares a disaster. Even if you do get disaster assistance, it is usually a loan that you must repay, with interest, in addition to mortgages and other financial obligations you still owe, even on damaged property. If you don’t qualify for loans, grants may be available to you. However, these are only designed to meet your most immediate needs, not to replace your losses (see pages 18 and 19).
Earthquake Information on the Web

After an earthquake, knowing more about what just happened can reduce fears and help you understand what to expect next. Online earthquake information products include:

Location and magnitude of recent earthquakes

Within 1 to 2 minutes of an earthquake, its location and magnitude are available at several web sites, including:
http://quake.utah.edu/ and
http://earthquake.usgs.gov/

“ShakeMap”

Within 5 to 10 minutes of most felt earthquakes (magnitude 3.0 and greater in the Wasatch Front area), a “ShakeMap” is posted on the Web. This map shows the range of shaking intensities across a region. Every quake has only a single magnitude, but it produces a wide range of shaking intensity values over the area in which it is felt.

ShakeMaps use data from seismic instruments to provide a rapid picture of where the strongest shaking occurred. These maps help to identify areas where a quake’s impact is greatest and are used by emergency managers to speed disaster response. ShakeMaps are available at
http://quake.utah.edu/shake/ or
http://earthquake.usgs.gov/eqcenter/shakemap/

“Did You Feel It”—Tell us what you felt!

Personal experiences of the effects of an earthquake are very valuable to scientists. When you have felt a quake, please report your observations by using a quick survey found on the U.S. Geological Survey “Did You Feel It?” website at http://pasadena.wr.usgs.gov/shake/imw/.

When you fill out the survey, your observations of actual damage and shaking are combined with those of thousands of other people. The quake’s shaking intensities, derived from these observations, are displayed by ZIP code on a “Community Internet Intensity Map.”

Who monitors Utah’s earthquakes?

Seismic monitoring in the Utah region is conducted by the University of Utah Seismograph Stations (UUSS) in partnership with the U.S. Geological Survey (USGS) as part of the Advanced National Seismic System (ANSS).

For more information go to:
http://quake.utah.edu/
http://earthquake.usgs.gov/research/monitoring/anss/
Aftershocks. Earthquakes that follow the largest shock of an earthquake sequence. They are smaller than the “mainshock” and can occur over a period of weeks, months, or years. In general, the larger the mainshock, the larger and more numerous the aftershocks and the longer they will continue.

Epicenter. The point on Earth’s surface above where an earthquake begins at depth in Earth’s crust.

Fault. A fracture or crack along which the two sides slide past one another.

Fault Scarp. A steep linear break or escarpment formed where a fault ruptures the ground surface.

Fault segment. A part of a fault that ruptures independently of other parts of the fault. One or more segments may rupture in a single earthquake.

Foreshock. An earthquake that precedes the largest quake (“mainshock”) of an earthquake sequence. Foreshocks may occur seconds to weeks before the mainshock. Not all mainshakes are preceded by foreshocks.

Intesity. A measure of ground shaking describing the local severity of an earthquake in terms of its effects on Earth’s surface and on humans and their structures. The Modified Mercalli Intensity (MMI) scale, which uses Roman numerals, is one way scientists measure intensity.

Landslide. A mass movement of soil, mud, and (or) rock down a slope.

Liquefaction. The process that occurs when an earthquake shakes wet sandy soil until it behaves like a liquid, allowing sand to “boil up” to the surface, buildings to sink, or sloping ground to move.

Magnitude (M). A number that represents the size of an earthquake, as determined from seismographic observations. An increase of one unit of magnitude (for example, from 4.6 to 5.6) corresponds approximately to a 30-fold increase in energy released [by definition, a two-unit increase in magnitude—for example, from 4.7 to 6.7—represents an increase in energy released of 1,000 times]. Quakes below magnitude 2.5 are not generally felt by humans.

Mainshock. The largest quake of an earthquake sequence, possibly preceded by smaller foreshocks and commonly followed by aftershocks.

Normal fault. An inclined fault along which the upper side moves downward relative to the lower side. Utah’s Wasatch fault is a good example.

Retrofit. Strengthening an existing structure to improve its resistance to the effects of earthquakes.

Rupture (fault). The area of Earth through which fault movement occurred during an earthquake. For large quakes, the section of the fault that ruptured may be several hundred miles in length. Ruptures may or may not extend to the ground surface.

Seiche. Waves “sloshing” in a lake as a result of earthquake ground shaking. Waves caused by landsliding into a reservoir or displacement of the lake bed are termed a surge.

Seismic hazard. The potential for damaging effects caused by earthquakes. The level of hazard depends on the magnitude of likely quakes, the distance from the fault that could cause quakes, and geologic conditions at a site.

Seismic risk. The chance of injury, damage, or loss resulting from seismic hazards. There is no risk, even in a region of high seismic hazard, if there are no people or property that could be injured or damaged by a quake.

Seismograph. A sensitive instrument that detects and records seismic waves generated by an earthquake.

Strike-slip fault. A generally vertical fault along which the two sides move horizontally past each other. The most famous example is California’s San Andreas fault.

Surface faulting (surface fault rupture). Propagation of an earthquake-generating fault rupture to the surface, displacing the surface and forming a scarp.

Tectonic Plate. Earth’s outer shell is composed of large, relatively strong “plates” that move relative to one another. Movements on the faults that define plate boundaries produce most earthquakes.

Tectonic Subsidence. Downdropping and tilting of a basin floor on the downdropped side of a fault during an earthquake.
**Why should I care?** (pages 1-11)

- Recent Earthquakes in Utah: [http://quake.utah.edu/](http://quake.utah.edu/)
- Earthquake Information Center: [http://quake.utah.edu/EQCENTER/eqcenter.htm](http://quake.utah.edu/EQCENTER/eqcenter.htm)
- University of Utah Seismograph Stations: [http://quake.utah.edu](http://quake.utah.edu)
- University of Utah Project WEST: [http://www.met.utah.edu/west](http://www.met.utah.edu/west)

**Why should I prepare?** (pages 12-19) and **What should I do?** (pages 20-30)

- American Red Cross: [http://utahredcross.org](http://utahredcross.org)
- Be Ready Utah: [http://beready.utah.gov](http://beready.utah.gov)
- Citizen Corps: [http://citizencorps.utah.gov](http://citizencorps.utah.gov)
- Structural Engineers Association of Utah: [http://seau.org](http://seau.org)
- Utah Association of Contingency Planners: [http://www.acputah.org](http://www.acputah.org)

**What else should I know?** (pages 31-33)

- Utah ShakeMaps: [http://quake.utah.edu/shake/](http://quake.utah.edu/shake/)