

Lesson 5. Protecting Against Earthquake Damage

Introduction

After an earthquake hits, it's too late to protect your home or business from damage. But you can limit future earthquake damage. Sometimes, a little time and a few dollars are all you need.

How Great Is Your Risk of Earthquake Damage?

About 5,000 earthquakes can be felt each year in the United States. Earthquakes occur most frequently west of the Rocky Mountains. Historically, however, the most violent earthquakes struck the central United States. All 50 States and all U.S. territories are vulnerable to earthquakes. Forty-one States or territories are at moderate to high risk. Since 1900, earthquakes have hit 39 States.

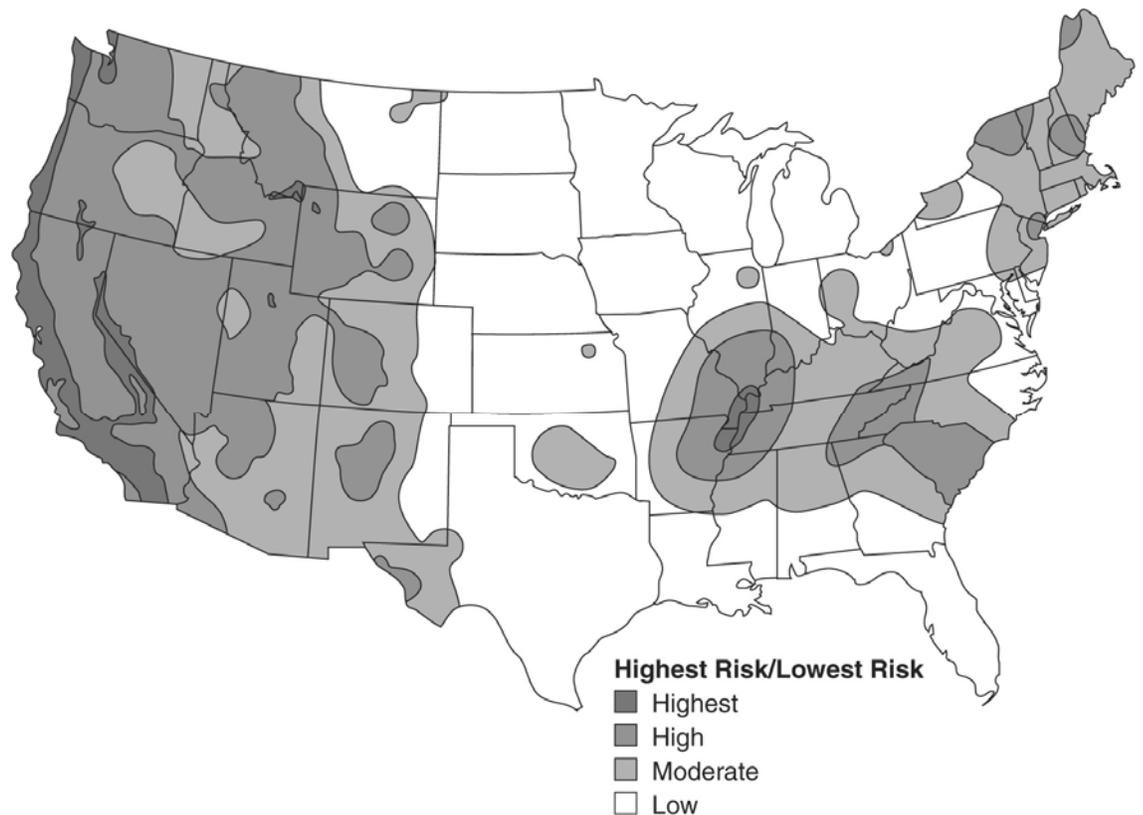


Figure 1. Seismic Hazard Map

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How Great Is Your Risk of Earthquake Damage? (Continued)

Self-Assessment Questions:

- Is your home and/or business located west of the Rocky Mountains?
 Yes No

 - Is your home and/or business located in one of the following areas?
 - Northeastern Arkansas
 - Southeastern Missouri
 - Western Tennessee
 - Kentucky
 - Southern Illinois Yes No

 - In which risk zone is your home or business located?
 Highest High Moderate Low
-

Nonstructural Protective Measures

A number of measures can help to avoid earthquake damage, including:

- Securing heavy furniture and other items.
 - Securing loose items and equipment.
 - Fastening water heaters.
 - Securing propane and fuel tanks.
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Securing Heavy Items

Consider each piece of heavy, tall furniture in the building, such as bookcases, china hutches, and storage racks. Move or secure items that could fall over or block an exit in an earthquake.

Move heavy items, such as pictures, mirrors, or tall dressers, away from beds and places where people sit.

Securely anchor all large kitchen and laundry equipment to the floor, wall, or countertop, depending on the item. Such equipment includes:

- Stoves and ovens.
- Built-in and countertop microwave ovens.
- Garbage compactors.
- Dishwashers.
- Refrigerators and freezers.
- Clothes washers and dryers.
- Ironing equipment.

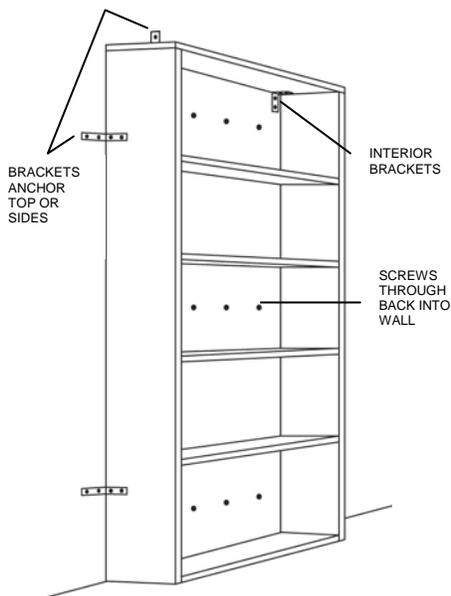


Figure 2 shows methods to anchor heavy, tall furniture to vertical wall studs, concrete, or masonry with steel angle brackets.

Fasten heavy objects to the building structure and not just to a movable wall in your home or office.

Even large, heavy objects that appear stable should be secured to the wall. The heavier the furniture, the stronger the restraints need to be. A heavily loaded file cabinet requires much stronger restraints to keep it from overturning than a light file cabinet with the same dimensions.

Figure 2. Anchoring a Tall Bookcase

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Securing Heavy Items (Continued)

Keep in mind some important guidelines for anchoring heavy items to walls or ceilings.

- Make sure the screws penetrate the studs behind the wall. Gypsum board, drywall, plaster, and other wall coverings are not strong enough to hold heavy furniture during an earthquake.
- For wood studs (typically located 16 or 24 inches on centers), use a minimum 1/4" diameter by 3" lag screws.
- For metal studs, use #12 sheet-metal screws long enough to penetrate the flange material. For concrete or masonry walls, use concrete anchor bolts.
- If wall studs do not line up with the furniture, consider installing a wood 2" x 4" or steel horizontal mounting strip to the studs near the top of the items to be anchored. Furniture can then be anchored to the mounting strip without regard to the stud locations.
- When possible, bolt file cabinets together (and to the wall studs) to form a more stable shape.
- Anchor eyebolts to wall studs for hanging heavy items such as pictures, mirrors, and shelving. Securely attach picture wires to picture frames.
- Make sure overhead light fixtures and hanging plants are anchored to the structural support above the ceiling. Ask a carpenter or an electrician to determine whether light fixtures and modular ceiling systems are securely fastened.

Securing Loose Items and Equipment

You can use a variety of methods and products to secure items stored in cabinets or placed on tables, desks, shelves, and countertops. Examples of products include adhesive-backed latches; nylon and elastic cords; wire, plastic, and elastic guardrails; and shelf edges to prevent equipment from falling on the floor.

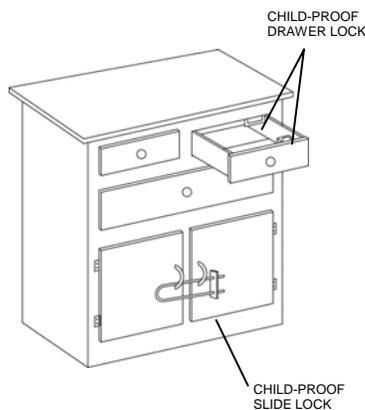


Figure 3. Securing Drawers and Cabinets

One way to prevent the accidental opening of drawers and cabinet doors is to install latches such as barrel bolts, safety hasps, and child-proof locks. Most hardware and home supply stores stock a variety of latches. Figure 3 shows two types of child-proof locks: one for drawers and one for cabinet doors. Most types of permanent latches can be installed easily and will not interfere with opening and closing of drawers and doors. The slide lock shown on the cabinet doors can be used on cabinets that do not need to be opened frequently; it is easily installed and removed.

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Securing Loose Items and Equipment (Continued)

To prevent damage to items stored in drawers and cabinets, you can:

- Put latches on cabinet doors, especially at home in your kitchen and at work or in school laboratories.
- Store breakable items such as bottled foods, glass, and china in low, closed cabinets with latches.
- Store weed killers, pesticides, and flammable products on bottom shelves in sturdy, closed, latched cabinets that are fastened to the wall or floor.

Following are some measures you can use to secure items on desks, tables, shelves, and countertops:

- Add lips to shelves to prevent costly items from sliding off their supports. Install edge restraints (such as wood molding) on bookshelves and storage shelves, or use elastic cords or wire guardrails to keep items from falling off open shelves.
- Fasten heavy or precious items to shelves or tables.
- Use easy tack putty to secure fragile objects on shelves.
- Keep breakable items in original packing boxes, when possible.
- Move incompatible chemicals to prevent mixing if the containers break.

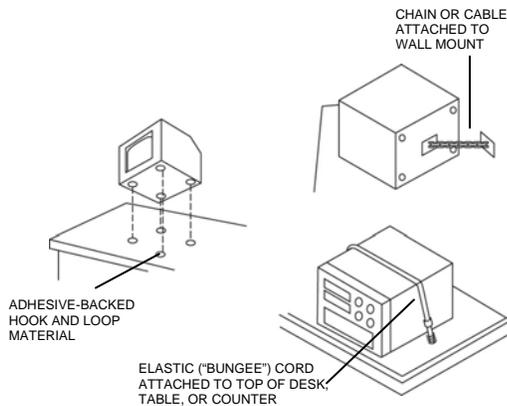


Figure 4. Securing Computer Equipment

The tremors caused by even minor earthquakes can easily move personal computer systems, stereo systems, television sets, and other small appliances that typically sit on desks, tables, and countertops. If they fall, they can be damaged beyond repair.

As shown in Figure 4, you can protect desktop computers and other small appliances by restraining them in a variety of ways. Some methods, such as using hook-and-loop material (Velcro for example), require no tools. Others, which include using chain, cables, or elastic cord ("bungee" cords, for example), will usually require simple hand tools.

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Fastening Water Heaters

Strapping the water heater to wall studs and having flexible gas and water lines installed will greatly reduce the risk of fire and water damage in an earthquake. All gas heaters and appliances should be connected to the gas pipe through flexible tubing.

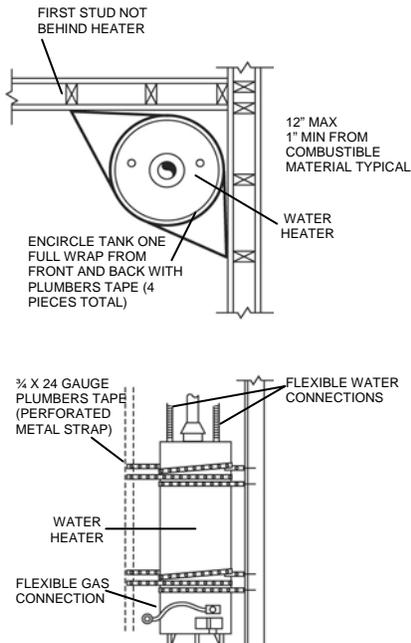


Figure 5 Top: Overhead View of a Water Heater Secured in a Corner or Closet: Bottom: Side View of a Water Heater Secured in a Corner or Closet

Figure 5 shows overhead and side views of a water heater secured in a corner or closet.

To secure a water heater in a corner or closet, you will need the following materials:

- 3/4" x 24-gauge perforated steel plumbers tape.
- 1/4" diameter x 3" lag screws and flat washers or 1/4" expandable anchors with 2" embedment for concrete or masonry walls.

Follow the directions below to secure a water heater in a corner or closet:

- The water heater should be 1" to 12" away from the corner walls.
- Locate the wall studs on both sides of the water heater (not behind it).
- Anchor plumbers tape (a flexible steel strap) to a wall stud with 1/4" diameter x 3" lag screw and flat washer.
- From about 9" from the top of the tank, wrap the plumbers tape all the way around the tank in a clockwise direction. Then anchor the tape to the stud on the other wall. Make sure the tape is tight.
- Repeat the process, again about 9" from the top of the tank, but this time wrap the tape in a counterclockwise direction.

Repeat the process two more times about 4" from the bottom of the tank. Wrap one band of tape in a clockwise direction and the other band of tape in a counterclockwise direction.

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Fastening Water Heaters (Continued)

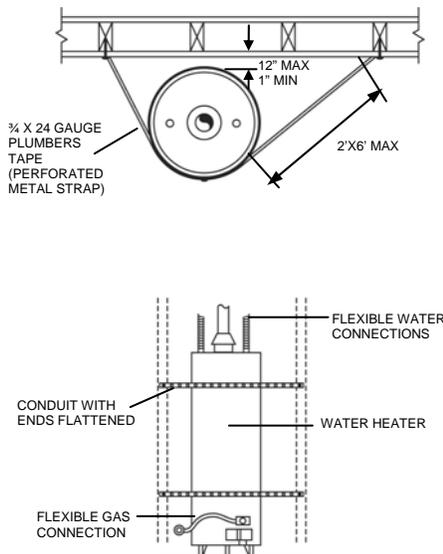


Figure 6
Top: Overhead View of a Water Heater Secured on a Straight Wall
Bottom: Side View of a Water Heater Secured on a Straight Wall

Figure 6 shows overhead and side views of a water heater secured on a straight wall.

To secure a water heater on a straight wall, you will need the following materials:

- 3/4" x 24-gauge perforated steel plumbers tape.
- 1/2" diameter conduit.
- 1/4" diameter x 1" round head machine screws with nuts and flat washers.
- 1/4" diameter x 3" lag screws and flat washer or 1/4" expandable anchors with 2" embedment for concrete or masonry walls.

Follow the directions below to secure a water heater on a straight wall:

- The water heater should be 1" to 12" away from the wall.
- Locate the wall studs on both sides of the water heater (not behind it).
- Wrap plumbers tape around the tank 9" from the top and 4" from the bottom. Secure tape with round head machine screw, flat washers, and nut.
- Cut four pieces of conduit to size. The conduit is used as angle bracing from the wall studs to the tank.
- Flatten 1" at each end of the conduit and bend 45 degrees. Drill holes 1/2" from each end.
- Anchor the conduit to the wall studs. Use 1/4" diameter x 3" lag screw and flat washer. Then anchor the conduit to the plumber's tape. Use 1/4" diameter x 1" round head machine screw, washer, and nut.

If you're using gas, have your utility company or a licensed plumber install a flexible hose where the gas line connects to the water heater at its base. Install flexible hoses for the water connections as well.

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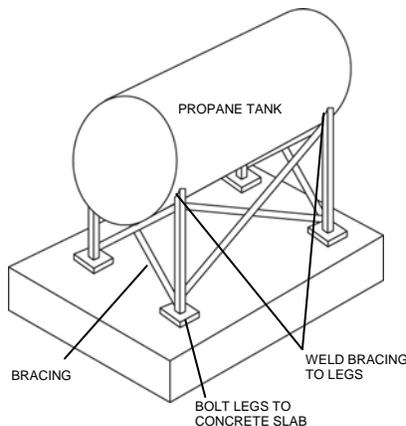
Anchoring Fuel Tanks and Wood-Burning Stoves

Fuel oil and propane tanks can slide or overturn in an earthquake, rupturing the tank or breaking the supply line and causing a fire. Even when a tank remains on its legs, the supply line can be ruptured. Escaping gas can then cause a fire.

Similar problems can occur with smaller, compressed gas cylinders, which are often stored inside a house or garage. Compressed gas cylinders have to be periodically replaced, and therefore cannot be permanently anchored, but you can use chains to attach them to a wall so that they will remain upright.

Take the following steps to secure fuel and propane tanks:

- Move tall, heavy objects that could fall and rupture the fuel or propane tank in an earthquake.
- Have a contractor install a flexible hose connection between the tank and supply line, and where the supply line enters the house.



One way to prevent damage to propane tanks and compressed gas cylinders is to anchor and brace them securely.

Figure 7 shows how the legs of a propane tank can be braced and anchored.

Using a flexible connection on the supply line will help reduce the likelihood of a leak.

Figure 7. Securing a Propane Tank

Wood-burning and other free-standing stoves also pose a fire hazard in an earthquake. To secure a stove:

- Anchor the stove to the floor.
- Fasten stovepipe sections together to prevent separation.

You will most likely need a contractor for this work. Make sure all work conforms with local building codes.

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Structural Protective Measures

You can make many changes yourself at relatively low cost if you have basic carpentry skills. Otherwise, contact a licensed professional about making the necessary changes to your home or business. Contact your local building department to modify details to fit local building codes.

If your home has a perimeter foundation, make sure the sill plate of the house is securely bolted to the foundation. Consult with your building department before deciding what to do.

A variety of products called “hold downs” are available for securing walls to the foundation.

Test the wood near the foundation by probing it with a pointed instrument. If you can penetrate the wood easily, it probably has wood decay and should be replaced with new pressure-treated wood.

Have a contractor inspect any deep cracks in the foundation.

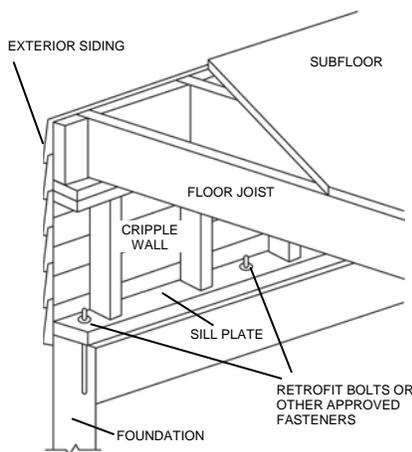


Figure 8. Sill Plate Bolted to Foundation

As shown in Figure 8, the sill plate of a house rests directly on top of the foundation. (This figure shows the sill plate for a house built on a cripple wall and crawl space foundation, a type of construction that is especially susceptible to earthquake damage.)

If the sill plate is not securely anchored, an earthquake can cause it to shift on the foundation. When this occurs, there is a greater potential for severe damage as well as injury to you and members of your family.

One way to increase the stability of your house and reduce earthquake damage is to have the sill plate bolted or otherwise anchored to the foundation. In the method shown in the figure, bolts long enough to pass through the sill plate and penetrate several inches into the foundation are installed every few feet along the base of the exterior walls. This method is not limited to cripple wall construction; it can also be used for a house built on a basement or slab-on-grade foundation or on another type of crawl space foundation.

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Structural Protective Measures (Continued)

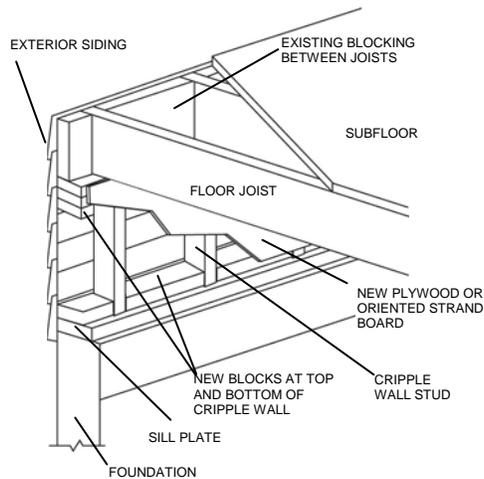


Figure 9. Bracing a Cripple Wall

Some houses are built on cripple walls. As shown in Figure 9, a cripple wall is a short wall that rests on the foundation and supports the floor and exterior walls. If the cripple wall is not braced, it can shift during an earthquake. When this occurs, there is a greater likelihood that your house will be severely damaged and that you and members of your family will be injured.

If your house is built on cripple walls, one way to increase its stability and reduce earthquake damage is to brace the cripple walls. In this method, horizontal blocking that consists of 2" x 4" boards is added between the vertical studs at the top and bottom of the cripple wall and, if necessary, at other locations between the studs. New vertical studs can also be added if necessary. Plywood or oriented strand board is then nailed to the interior face of the cripple wall. Also, nails are added through the existing blocking between floor joists to ensure that the floor is securely attached to the cripple wall.

Masonry chimneys pose a real hazard in earthquakes, especially the free-standing section above the roof line. To prevent the chimney from breaking away from the house, you may need to have it secured to the framing of the roof with sheet metal straps and angle bracing. Have the chimney inspected by a professional to determine the best method.

An indepth Homeowner's Guide to Earthquake Retrofit is available online at from the Institute for Business and Home Safety (www.ibhs.org/publications). This guide gives step-by-step illustrated instructions on how to complete both structural and nonstructural repairs, as well as pricing estimates and equipment lists.

Success Stories

Poulsbo, Washington

In late 1998, Doris Chapot purchased a two-story Cape Cod-style home built in 1902 that for years served as the First Lutheran Church parsonage. In 1940, the parsonage was moved to its present location. It was set on posts and concrete pier blocks, but nothing more was done to ensure its safety from earthquake damage.

At the time of purchase, a building inspector suggested that Chapot have an earthquake retrofit done to ensure positive connections among beams, posts, and pier blocks. Forty piers were braced with a gusset system that included a 2-foot, triangle-shaped plywood tying the posts to the concrete pier. All of the posts around the perimeter were tied together in the front and the back with 2-foot by 6-foot posts, and nails were strategically placed. Because pier blocks were different shapes, bendable metal connections were used for attaching the posts.

The retrofit project was completed on February 26, 2001. On February 28, a large 6.8 magnitude earthquake, with the epicenter located in the Nisqually basin in western Washington State, caused an estimated \$2 billion in damages. Movement was felt as far north as Vancouver, British Columbia, and as far west as Salt Lake City, Utah.

Chapot was on the second floor during the earthquake. “I’ve been through many earthquakes during my lifetime and the house rode beautifully.”

After a careful inspection under the house, not even a hint of damage was detected. “Not one thing in the house fell or broke! It feels so good to be safe!”

Success Stories (Continued)

Los Angeles, California

Anheuser-Busch operates a large brewery just a few miles from the epicenter of the January 17, 1994, Northridge Earthquake. The facility serves the company's markets throughout the Southwest and Pacific regions. Because it is in a high earthquake-hazard area, Anheuser-Busch initiated a risk reduction program at the brewery in the early 1980s.

A risk assessment of critical buildings and equipment was performed. Those with unacceptable levels of risk were seismically upgraded, without impacting daily operations.

Seismic reinforcements were designed for a number of buildings and the critical equipment contained within, including buildings housing beverage production and vats where the beer is stored and aged.

The Northridge Earthquake produced very strong ground motion, causing extensive damage in the immediate vicinity of the brewery. However, post-earthquake surveys conducted by the company's engineering consultants indicated that none of the retrofitted structures sustained damage. Onsite facilities of lesser importance to the business had not been strengthened and consequently sustained damage, requiring repairs. None of the vats, which are essential to the brewery's operations, were damaged. The brewery was quickly returned to nearly full operations following minor cleanup, repairs, and restoration of the offsite water supply.

Anheuser-Busch conservatively estimates that had seismic strengthening not been performed, direct and business interruption losses at the brewery could have exceeded \$300 million. According to Anheuser-Busch, this is more than 15 times the actual cost of the loss control program.

Clearly, this loss control program paid for itself in the Northridge Earthquake event.

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Summary: Key Steps To Protect Against Earthquake Damage

This lesson reviewed the following steps you can take to protect your home or business against earthquake damage.

- Secure heavy furniture and other items.
- Secure loose items and equipment.
- Fasten water heaters.
- Secure propane and fuel tanks.
- Anchor wood-burning and free-standing stoves.
- Bolt the sill plate of the building to the foundation.
- Brace cripple walls.
- Secure chimneys to roof framing.

The protective measures you consider depend on where your house or business is located.

Is your location at moderate to high risk of earthquakes? If so, decide which protective measures make the most sense in your situation, and take appropriate nonstructural and structural protective measures.

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Earthquake Protection Resources

A number of resources offer indepth information that can help you learn more about particular earthquake protection options.

FEMA Resources

The following publications are available through the FEMA website at http://www.fema.gov/hazards/earthquakes/nehpr/home_school.shtm

- Avoiding Earthquake Damage: A Checklist for Homeowners
- Reduce Your Risk From Natural Disasters
- Earthquake Backgrounder
- Earthquake Fact Sheet
- How To Series: Protecting Your Property from Earthquake
- FEMA 74-Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide. Third Edition
- FEMA 232-Home Builder's Guide to Seismic Resistant Construction

For additional information on earthquakes and earthquake mitigation, consult:

National Earthquake Hazard Reduction Program Agencies

- National Institute of Standards and Technology (NIST) . <http://www.nist.gov>
- National Science Foundation (NSF) <http://www.nsf.gov>
- United States Geological Survey (USGS) <http://www.usgs.gov>
- USGS's Advanced National Seismic System (ANSS) <http://www.anss.gov>

Federal Partners

- National Aeronautics and Space Administration's (NASA) Earth Observatory <http://earthobservatory.nasa.gov>
- National Oceanic and Atmospheric Administration's (NOAA) West Coast and Alaska Tsunami Warning Center (WCATWC) <http://wcatwc.arh.noaa.gov>
- NOAA's National Tsunami Hazard Mitigation Program <http://www.pmel.noaa.gov/tsunami-hazard>

Regional Consortia

- Cascadia Region Earthquake Workgroup (CREW) <http://www.crew.org>
- Central United States Earthquake Consortium (CUSEC) <http://www.cusec.org>
- Northeast States Emergency Consortium (NESEC) <http://www.serve.com/NESEC>
- Western States Seismic Policy Council (WSSPC) <http://www.wsspc.org>

Lesson 5. Protecting Against Earthquake Damage

Test Yourself

The questions below review key points about protecting your home or place of business from earthquake damage. After completing the questions, you can check your answers on the answer sheet located after the course glossary.

1. Earthquakes occur most frequently _____ of the Rocky Mountains.
2. Nonstructural measures to avoid earthquake damage include: (Mark all that apply.)
 - Securing heavy furniture.
 - Fastening water heaters.
 - Elevating the structure.
 - Securing propane and fuel tanks.

3. Identify three examples of kitchen or laundry equipment that should be securely anchored to the floor, wall, or countertop.

4. Select the protective measure on the right that would be used to protect the structure on the left, and write the appropriate letter on each blank space.

___ Sill plate	a. Bolt securely to the foundation
___ Cripple wall	b. Secure with sheet metal straps and angle bracing
___ Chimney	c. Brace with horizontal blocking

5. All 50 States and all U.S. territories are vulnerable to earthquakes.

___ True ___ False