Is Your Home Protected

From Earthquake Disaster?

A Homeowner’s Guide to Nonstructural Earthquake Retrofit
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architectural illustrations

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Earthquakes occur suddenly with little or no warning, during any season and at any time of day. Although the West Coast generally has the greatest earthquake activity, the potential for earthquakes exists in almost every corner of the United States. More than 3,360 Americans have died during earthquakes in the last century, and homes in all 50 states have suffered damage in the last 250 years.¹

So, what can you do to protect yourself, your home and its contents from earthquakes? This brochure will help you by providing information about:

• key areas of your home that are especially susceptible to damage;
• ways you can reduce damage to your home and belongings; and,
• what you can do to protect yourself and your family.

The information and suggestions presented in this brochure range from simple weekend tasks that require basic carpentry skills to involved projects that may require professional assistance. Before starting on any activity, make sure you are comfortable with the required skill level. If you are uncertain, contact a professional engineer, architect or building contractor.

¹Based on U.S. Geological Survey numbers.
What Your Home Experiences

Imagine that a strong earthquake strikes where you live. Loose items fall and break. Cabinets and bookcases tip over, blocking exits. Dust billows everywhere. Gas and water lines break, and phone and electrical service are interrupted for days. Your home may collapse, slide off its foundation or simply come apart at the seams.

Figure 4 illustrates how your home reacts in an earthquake. Because it is not able to move in sync with the surrounding ground, your home and its contents can experience substantial damage.
What You Can Do

You can protect your home by modifying it, or retrofitting it, in two different ways:

Nonstructural retrofits protect your home’s contents against damage with little cost and effort. Examples of retrofits include:

- securing water heaters, large appliances, bookcases, pictures and bulletin boards;
- latching cabinet doors; and
- using safety film on windows.

To complete these improvements simply follow the instructions in this brochure. In most cases, you won’t need a building permit. It’s a good idea, however, to contact your local building department to make sure.

*Structural retrofits strengthen your home’s structure or skeleton so it can better withstand the force of an earthquake. Your home’s structure is made up of many different parts, or components, which must work together in order to resist an earthquake.

Modifications to your home’s structure tend to be quite involved and generally require the expertise of a registered design professional (engineer, architect or building contractor) and your local building department’s approval (see note * below).

If you have any questions or concerns about what you see, contact a professional engineer or architect.

(*Structural retrofit not covered in this brochure. If you live in the Pacific NW... for information on the HOME RETROFIT program to strengthen your house from earthquakes, contact your building department or call (206) 615-0288. You can also visit: www.seattle.gov/projectimpact *)
In this section, you will learn inexpensive and easy ways to protect yourself against some of the damage earthquakes can cause inside your home. Start by looking for objects that could fall and break during an earthquake. Consider items such as water heaters, bookcases and light fixtures, as well as items that are difficult to replace because they have monetary or sentimental value. As you conduct your inspection, think about ways in which you can protect them from damage. If you have any questions about the changes you should make, contact a professional engineer, architect or contractor.

**Bookcases**

It’s true that bookcases are great for storing books, toys and supplies. They can, however, shake and tip over in an earthquake, causing considerable damage or injury. For this reason, make sure all bookcases are securely fastened to nearby walls.

One way to do this is to attach either L-brackets or Z-brackets to the bookcase and the wall after pre-drilling holes in each. Be sure to use a bracket that can accommodate the fasteners you are using. See Figure 5 on the next page for details.
Bolt back to back through frame with #8 (or larger) machine screws, oversized washers and nuts. No more than 12” apart.

Metal, plastic, or wood ledge barriers prevent objects from falling.

Exterior Bracket

Interior Bracket

Attach object with museum gel, or large patches of hook & loop material (such as Velcro®).

Exterior Z-Bracket

Interior L-Bracket

Exterior L-Bracket

General Notes:
- Bracket to Bookcase (Interior or Exterior)
  #8 (or larger) wood screws; or
  #8 (or larger) machine screws with washers and nuts
- Bracket to Wall (Interior or Exterior)
  Wood-stud wall: 3” long, #8 (or larger) wood screws
  Masonry wall: 3” long, #8 (or larger) screws with plastic anchors, or 3/16” diameter (or larger) masonry screws

Figure 5: Securing Bookcases (views looking from above)
Attaching the bracket to the bookcase:
• For wood bookcases, attach the bracket with #8 (or larger) wood screws. The screw should be long enough to secure the bracket to the shelf without punching through and creating a sharp edge.
• For plastic and metal bookcases, use #8 (or larger) machine screws with washers and nuts to ensure that the bracket will stay in place. The screw should be long enough to accommodate the bracket, shelf, washer and nut.

Attaching the bracket to the walls:
• For wood stud walls, use 3-inch long #8 (or larger) wood screws to attach each bracket to the wall. Place screws in the wood studs to assure that they are properly supported. Use a stud locator to find the best places.
• For stone or masonry walls, place plastic anchors in the holes before you screw in 3-inch long #8 (or larger) screws or consider using 3/16-inch diameter (or larger) masonry screws.

➤ For a bookcase with a solid back, you can pass screws directly through the back into the wall. Use washers to spread contact over a larger area between the screw and the bookcase's back. If you are working with a wood stud wall, use a stud locator to find the best locations for the 3-inch long #8 (or larger) wood screws. For a stone or masonry wall, use plastic anchors with the #8 (or larger) screws or use 3/16-inch diameter (or larger) masonry screws.

➤ You can prevent items on shelves from falling by installing ledge barriers made from strips of wood, metal or plastic. Cut them to fit the shelf and attach them with glue or mechanical fasteners. You can finish the barriers to match the shelves. See Figure 5 for details.

➤ Place heavy items on lower shelves.

➤ You can stabilize bookcases that are not against walls by attaching them back-to-back with #8 (or larger) machine screws, oversize washers and nuts. See Figure 5.

➤ Affix large, heavy items, such as plants and aquariums, and other breakables directly to the shelf to keep them from falling. You can apply hook and loop material (such as Velcro®) or museum gel (or museum wax) to secure these items. For added protection, use metal, plastic or wood ledge barriers. See Figure 5 for details.

Necessary Tools and Materials
• L- or Z-brackets
• Fasteners
• Plastic anchors for masonry walls
• Variable speed drill and bits
• Screwdriver
• Stud locator
• Wood, plastic or metal strips
• Paint or wood finish
• Hook and loop material (Velcro®) or museum gel/wax
Cabinets and Drawers

Like bookcases, cabinets can tip over and their doors can open, spilling their contents. Furthermore, the drawers, which sometimes have sharp edges, can slide out and hurt you, or your family.

➢ To secure them, do the following:

• Attach cabinets to the wall and floors using L-brackets or Z-brackets. Again, be sure to use brackets that can accommodate the diameter of the fasteners. You should follow the specific directions given in Figure 6 and in the “Bookcases” section for securing the bracket to the wall and cabinet.

Figure 6: Cabinets and Drawers

Top connections tie units together for a more stable configuration. Use steel straps with #8 (or larger) machine screws with nuts and washers.

Brackets for fastening units to:

Wood Stud Walls:
Use #8 (or larger) wood screws with 3” min. embedment in studs.

Masonry Walls:
Use 3” long #8 (or larger) screws with plastic anchors or 3/16” diameter (or larger) masonry screws.

Cabinets:
Use #8 (or larger) machine screws with nuts and washers.

Provide self-locking door latches or mechanical cabinet catches.

Install self-locking or mechanical drawer closures (baby-proof latches, drawer lock, or other specialty latches).
• You can fasten several units together to form a wider footprint using #8 (or larger) machine screws.

➢ Attach simple mechanical or self-locking latches to cabinet drawers so they cannot slide open.

➢ Install mechanical or self-locking latches to prevent your cabinet doors from swinging open and spilling their contents. Your local hardware store has a large variety of latches, many of which are small, unobtrusive and easy to operate. See Figure 6 for details.

➢ Most of us place heavy objects such as televisions, computers and stereos on top of cabinets, bookcases and tables. You should fasten these items down so they will not slide off during an earthquake. Several methods of attachment are shown in Figure 7.
Picture Frames and Bulletin Boards

The photographs, bulletin boards and artwork you display in your home add to its character. But these items can easily fall during an earthquake if you do not fasten them properly to a wall in the following way:

➢ Use closed screw-eyes, instead of traditional picture hangers, for securing picture frames, bulletin boards and mirrors.

• Depending on the weight of the object and the screw-eye’s maximum weight limit, screw one or more closed screw eyes into wall studs. Use a stud finder to figure out where to put them.

• Attach picture wire to one side of the frame. Thread the wire through the closed screw-eye, fastening it securely to the other side of the frame. See Figure 8.

• If you use an open screw-eye instead of a closed screw-eye, be sure to close it with pliers once you have hung the picture.

➢ Always mount heavy or sharp wall hangings away from areas where they could fall on children.

Necessary Tools and Materials

• Stud locator
• Screwdriver
• Variable speed drill and bits
• Screw-eyes or screw-hook
• Heavy picture wire
• Pliers

Helpful hint: A screw-hook may be easier to manage than a screw-eye.
Ceiling Lights, 
Suspended Ceilings 
and Hanging Fixtures

If they aren’t well attached and supported, 
ceiling lights, suspended ceilings and hang-
ing fixtures, such as chandeliers and ceiling 
fans, can fall in an earthquake and serious-
ly injure those below. Here are some ways 
to protect yourself:

➢ Secure ceiling lights to supports using 
safety cables.

• Use a chain strap or a minimum 14-
gauge wire to attach the light fixture to 
a nearby ceiling support. Locate the 
support visually or use a stud locator. 
Be sure to leave the safety cables slack; 
they should not support the weight of 
the lights under normal circumstances. 
See Figure 9 for details.

• If your ceiling light has a cover, keep it 
from falling during an earthquake by 
fastening it to the fixture itself or to the 
home’s permanent structure.

• Pay special attention to your home’s 
fluorescent lights. Installing plastic 
sleeves over the fluorescent light tubes 
will keep the glass from scattering if 
they break. As an alternative, consider 
using Teflon® fluorescent lights, which 
are shatter-resistant.

➢ Use safety cables every few feet to 
attach suspended or false ceilings to the 
structure of your home.

• Use chain straps, plumber’s strapping 
(metal strapping with holes) or heavy 
wire (minimum 14-gauge) to secure sus-
pended or false ceilings. See Figure 9.
Make sure chandeliers, ceiling fans, other suspended fixtures and hanging plants are safely secured to the permanent structure.

- Connect all suspended items to strong supports with safety cables capable of supporting each item's entire weight. Each cable should remain slack and not support the item's weight under normal circumstances.
- Keep in mind that hanging items tend to sway easily. Make sure these objects will not collide with anything if they swing in an earthquake.

General Notes
- For exposed fluorescent light bulbs use protective sleeves.
- Secure light covers in place.
- To secure a wire or chain, use a minimum of 3 tight turns in 1-1/2” at each end.
Windows and Doors

Your home’s windows and glass doors may seem harmless enough. But in an earthquake, glass can break explosively, seriously injuring anyone nearby. One way to protect yourself and your family from broken glass is to apply safety film to windows and glass doors:

➤ Use a protective film (minimum thickness of 4 mils) on all types of glass, including tempered glass and annealed glass. You can buy it in rolls at your local hardware and home improvement stores, or contact the International Window Film Association for the nearest distributor. Be sure to install the film according to the manufacturer’s instructions.

➤ As an alternative, consider professional installation.

Large Appliances

An earthquake can cause refrigerators, washing machines and other large appliances to slide or fall over. Heavy objects on wheels may roll if brakes or stops are not provided and locked. To secure these items:

➤ Anchor large appliances to walls using safety cables or straps. The restraint should be located in the mid- to upper-portion of the appliance. Use the following method:

• Choose a screw-eye that is sized appropriately for the appliance. For example, use a 3/8-inch diameter screw-eye (or larger) for a refrigerator.

• For wood stud walls, use a stud locator to find the best wall location to install the screw-eye. For stone or masonry walls, place plastic anchors in the pre-drilled holes before you install the screw-eye.

• Connect coated wire cable to the screw-eye at one end and to a snap-hook fastener at the other end.

• Attach the cable to the appliance with the snap-hook fastener.

➤ Replace rigid water or gas connections on large appliances with flexible connectors.

• Check to see if your local building codes allow you to use flexible connectors and whether a professional must install them.

➤ Always lock the rollers of any large appliances or pieces of furniture.

Necessary Tools and Materials

• Coated wire cable or other strapping system
• Screwdriver
• Variable speed drill and bits
• Stud locator
• Screw-eyes
• Hook fasteners
• Flexible connectors
• Plastic anchors
Water Heaters

Water heaters can move or tip over in an earthquake and the broken water pipe can flood your home, destroying ceilings, floors, walls, furniture, artwork and family photos. If your heater runs on flammable gas and the gas line breaks, the situation becomes far more serious.

In many areas of the country where earthquakes are common, local building codes may require that water heaters be laterally braced or strapped to resist seismic forces. Most hardware stores sell retrofit kits for different-sized water heaters. In addition, several generic restraint systems are available. Before you decide on a retrofit method, check with your local building department and make sure that it is approved for use in your area or goes beyond what is required by your local building code.

Figure 10: Retrofitted Water Heater

Water heater burned in residential fire caused by a gas leak.

Note: See general notes on next page for additional information
Secure water heaters (up to 50 gallons) to stud walls using the simple, generic method detailed in Figures 10 through 12.

- You can anchor the water heater using items that are readily available from the local hardware store.
- To begin: fasten two 2 x 4 wood blocking strips to the nearby wall - one at a height within the upper one-third (1/3) of the water heater and the other within the lower one-third (1/3) of the water heater. The lower 2 x 4 should be at least four (4) inches above the water heater control. If you are working with a wood or metal stud wall, attach the blocking directly to the studs. Use a stud locator to find the studs.

**Figure 11: Straight Wall Configuration**

- Ø refers to the connection’s diameter.

**General Notes: Blocking Attachment to Wall**

1) Wood Stud Wall: Use two (2) #16 (or minimum 1/4”Ø) x 3-1/2“ lag screws with hex head and washer under head of screw.
2) Concrete or Masonry Wall: Use 3/8”Ø masonry anchors with 1-5/8” embedment into existing wall at 12”-16” on center.
3) Steel Stud Wall: Use two (2) #10-16 self-drilling sheet metal screws with hex head and washer under head of screw.
4) Wood and Steel Stud Walls: Center screws on studs.
**Necessary Tools and Materials**

- 2 x 4s
- Stud locator
- Screwdriver
- Hammer drill & bits (stone & masonry walls)
- Variable speed drill & bits (wood & metal stud walls)
- Various fasteners
- Heavy-duty shelving brackets
- Plumber’s strapping
- Flexible connector

- Fasten heavy-duty shelving brackets to the wood blocking. These brackets should fit snugly against the water heater.

- Wrap plumber’s strapping (metal strapping with holes) around the heater and secure it to the brackets.

  ➤ Remember: Use flexible, not rigid, water and gas connectors and check with local building code officials to see if you must hire a licensed plumber to modify the connections.

  ➤ Make certain all adult and teenage family members know where to locate the gas shut-off valve and how to operate it.

**General Notes: Blocking Attachment to Wall**

1) Wood Stud Wall: Use two #16 (or minimum 1/4"Ø) x 3-1/2" lag screws with hex head and washer under head of screw.

2) Concrete or Masonry Wall: Use 3/8"Ø masonry anchors with 1-5/8" embedment into existing wall at 12"-16" on center.

3) Steel Stud Wall: Use two (2) #10-16 self-drilling sheet metal screws with hex head and washer under head of screw.

4) Wood and Steel Stud Walls: Center screws on studs.

**Figure 12: Corner Wall Configuration**

Use one (1) heavy-duty shelving bracket in four (4) places.

Attach bracket to blocking with two (2) #16 (or min. 1/4"Ø) by 1-1/2" lag screws.

Extend blocking at least two (2) studs beyond bracket attachment.

Attach bracket to 2 x 4 Wood Blocking four (4) places.

Use minimum 3/4" plumber’s strapping. Wrap around water heater and provide snug fit.

Attach bent ends of strapping with a minimum 1/4" Ø x 1” hex bolt. Use washers under head and nut. Keep 1” between end of strapping and center of bolt.

Attach bracket to plumber’s strapping with a minimum 1/4" Ø x 3/4” hex bolt. Use a washer under the nut. Keep 1” between end of bracket and center of bolt.

Existing Wall

Attach blocking to wall, see General Notes, below.

- Ø refers to the connection’s diameter.

Helpful Hint: To install an earthquake Water Heater fastner and product info, see next 3 pages
Securing the Water Heater

Securing your hot water tank

Secure your water heater.

- There should be very little space between the water heater and the wall. If there is more than 1 or 2 inches, attach a wooden block to the wall studs with long lag screws (see illustration on page 20). The purpose is to prevent the heater from tipping backwards.

- Wrap the heavy-gauge metal strapping 1 1/2 times around the tank. Start by placing the strapping at the back of the tank. Bring it to the front and then take it back to the wall (see illustration).

- Secure this strapping to the wall studs or the wood block using several 1/4” x 3” or longer lag screws with oversized washers. If you are securing it directly into concrete, use 1/4” expansion bolts in place of the screws.

Commercially available kits like this one come complete with the strapping, lag screws, washers, spacers, and tension bolts. These kits can be purchased at many local hardware stores, and are recommended.

- Replace all copper and metal piping with flexible natural gas and water line connectors.

Changes to strapping recommendations

Experts have modified the recommended procedure for strapping water heaters because many tanks burst through their strapping in both the 1989 Loma Prieta (San Francisco) and the 1994 Northridge (Los Angeles) earthquakes. Experts recommend these two important changes:

1. Secure both the top and the bottom, rather than just the top or just the middle, of the hot water tank.

2. Use heavy-gauge metal strapping rather than plumber’s tape. Many water heaters in both the 1989 and the 1994 earthquakes burst through the plumber’s tape that was intended to keep them secure. Plumber’s tape has been found to be too brittle to be effective.

Protected source of water – or a puddle

Fresh water after a disaster may be as close as your water heater – provided, of course, that it remains standing upright. A typical water heater holds 30 to 50 gallons of water.

However, this supply of water is extremely vulnerable to the ground undulation (swells and rolls) and ground acceleration of earthquakes, causing them to tip over.

You can protect this valuable resource by securing your water heater to the wall studs.
Getting Ready ...

The future is the past in preparation.

Water heaters are an excellent supply of emergency water. Water can be accessed from the drain spout - this is made easier by connecting a garden hose to the drain spout. Open a faucet somewhere in the house to allow the water to drain easier. Make sure the electricity or natural gas is shut off before opening the drain.

Wraps around 1 1/2 times.
"Introducing the new low cost..."

SPACEMAKER STRAPS

- Installs quickly
- All fasteners included
- Complies with 1994 code
- No special tools needed
- For up to 40 gallon heaters!
- Accepted DSA generic design
- Tested by major CA public utility

E-25

Wraps around 1 1/2 times.

Typical residential installations:

- Corner mounted
- Straight wall mounted

State of California
Architect
CA - OSA
93-00002
Pending

Spacemaker Company (714) 542-4649 Fax (714) 542-4675
### home improvement project list

This list of home improvements divides the different retrofits into cost categories. The categories reflect the cost of each individual item. The cost will be slightly higher if you hire someone to complete the work. You or your contractor can tackle these projects one at a time, but remember, the more you do the stronger your home becomes.

<table>
<thead>
<tr>
<th>Category</th>
<th>Projects</th>
</tr>
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<tbody>
<tr>
<td>$</td>
<td>Fasten bookcases and cabinets to nearby walls; Install latches on cabinet doors and drawers; Secure electronic equipment, artwork and other breakable items to the tops of bookcases and cabinets; Anchor large appliances to nearby walls; Secure pictures and bulletin boards to walls; Attach safety cables to light fixtures, suspended ceilings and other hanging items; Apply safety film to windows and doors; Secure water heater to nearby wall.</td>
</tr>
<tr>
<td>$$</td>
<td>Reinforce cripple wall; Strengthen narrow walls on either side of garage opening; Anchor unreinforced chimneys.</td>
</tr>
<tr>
<td>$$$</td>
<td>Add anchor bolts or steel plates to foundation; Secure post-and-pier foundation; Modify floor system; Strengthen wood-framed walls; Reinforce masonry walls; Retrofit roof system; Evaluate unique room additions.</td>
</tr>
</tbody>
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checklist

How well will your home resist damage during a 3.0 earthquake? How about one that is a 6.0 or greater? Most homes typically will need some type of reinforcement to withstand a major earthquake. Here is a checklist that will help you focus on how to strengthen your home.

To answer some of these questions you may need to enter uncomfortable or small spaces. You may want to have an experienced inspector or professional engineer or architect check your home, instead. Whatever choice you make, take some time to do this before the next earthquake strikes.

Observation
Unsecured bookcases and cabinets
Cabinet doors and drawers that swing open easily
Electronic equipment and artwork that can topple
Pictures and bulletin boards that can fall
Hanging fixtures and suspended ceilings
Large appliances that can tip over
Unprotected windows and doors
Water heater that can tip over
Home not anchored to foundation
Weak cripple wall
Unsound post-and-pier foundation
Weak floor system
Inadequate walls
Unreinforced masonry
Poor roof support
Unsecured chimney
Room over garage
Unique addition

Recommendation
Fasten to nearby walls
Install latches
Secure items to bookcases and cabinets
Fasten securely to walls
Attach safety cables
Anchor to nearby walls
Apply safety film
Secure to nearby wall
Add anchor bolts or steel plates
Reinforce cripple wall
Secure post-and-pier foundation
Modify floor system
Strengthen wood-framed walls
Reinforce masonry walls
Retrofit roof system
Anchor unreinforced chimney
Strengthen the support
Have engineer evaluate