

Is Your Home Protected



From Earthquake Disaster?



A Homeowner's Guide to Nonstructural Earthquake Retrofit

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architectural illustrations

W. Spaulding, AIA

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table of contents



introduction	4
earthquakes and your home	5
What You Can Do.....	6
nonstructural retrofits	7
Bookcases	7
Cabinets and Drawers	10
Picture Frames and Bulletin Boards	12
Ceiling Lights, Suspended Ceilings and Hanging Fixtures	13
Windows and Doors	15
Large Appliances	15
Water Heaters	16
home improvement project list	22
checklist	23

introduction

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.

Damage in
San Francisco's
Marina District.



J. Preli

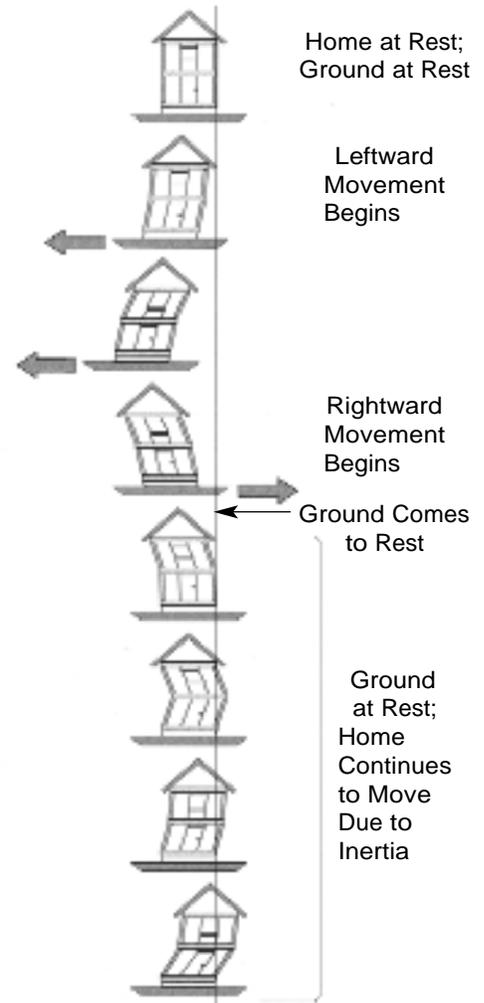
¹Based on U.S. Geological Survey numbers.

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.

Figure 4: Your Home in an Earthquake



USGS, Reagor

A sand boil near El Centro, Calif. provides evidence of an earthquake.



EERI, J. Egan

Building collapse in Marina District, San Francisco, Calif.

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.



USGS, C. Stover



NOAA/NGDC

Top: Structure shifted on its foundation in Watsonville, Calif.
Bottom: Nonstructural kitchen damage, Northridge, Calif.

nonstructural retrofits

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

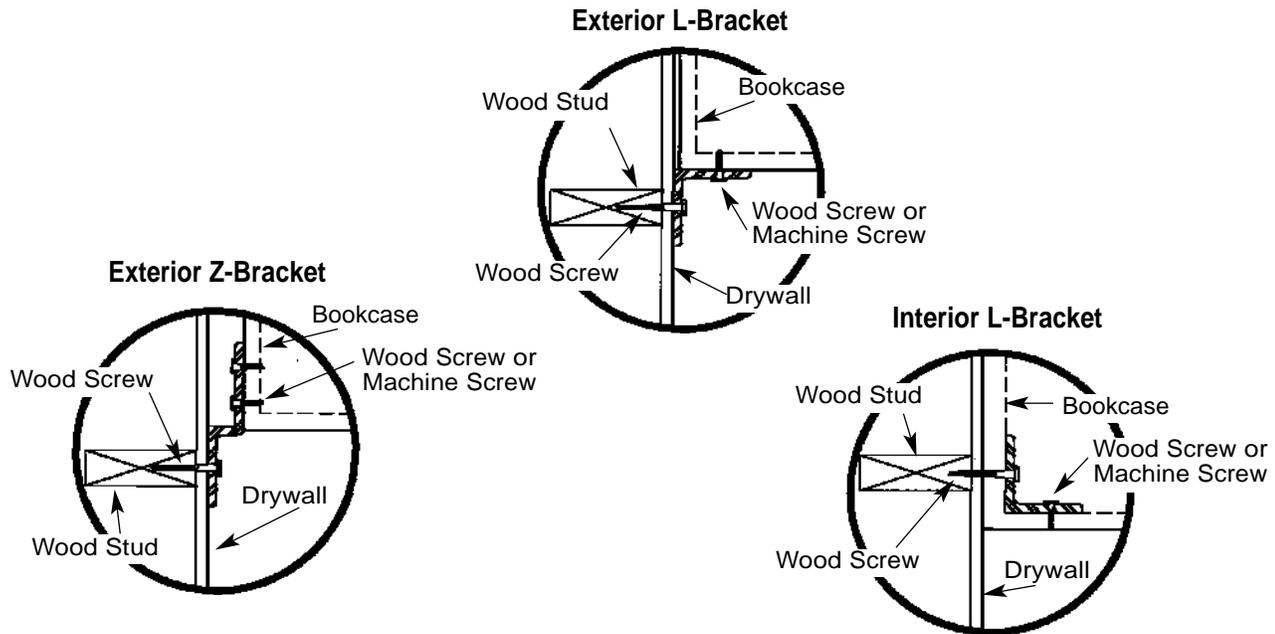
It's true that bookcases are great for storing books, toys and supplies. They can, however, shake and tip over in an earthquake, causing considerable damage or injury. For this reason, make sure all bookcases are securely fastened to nearby walls.

□ 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.



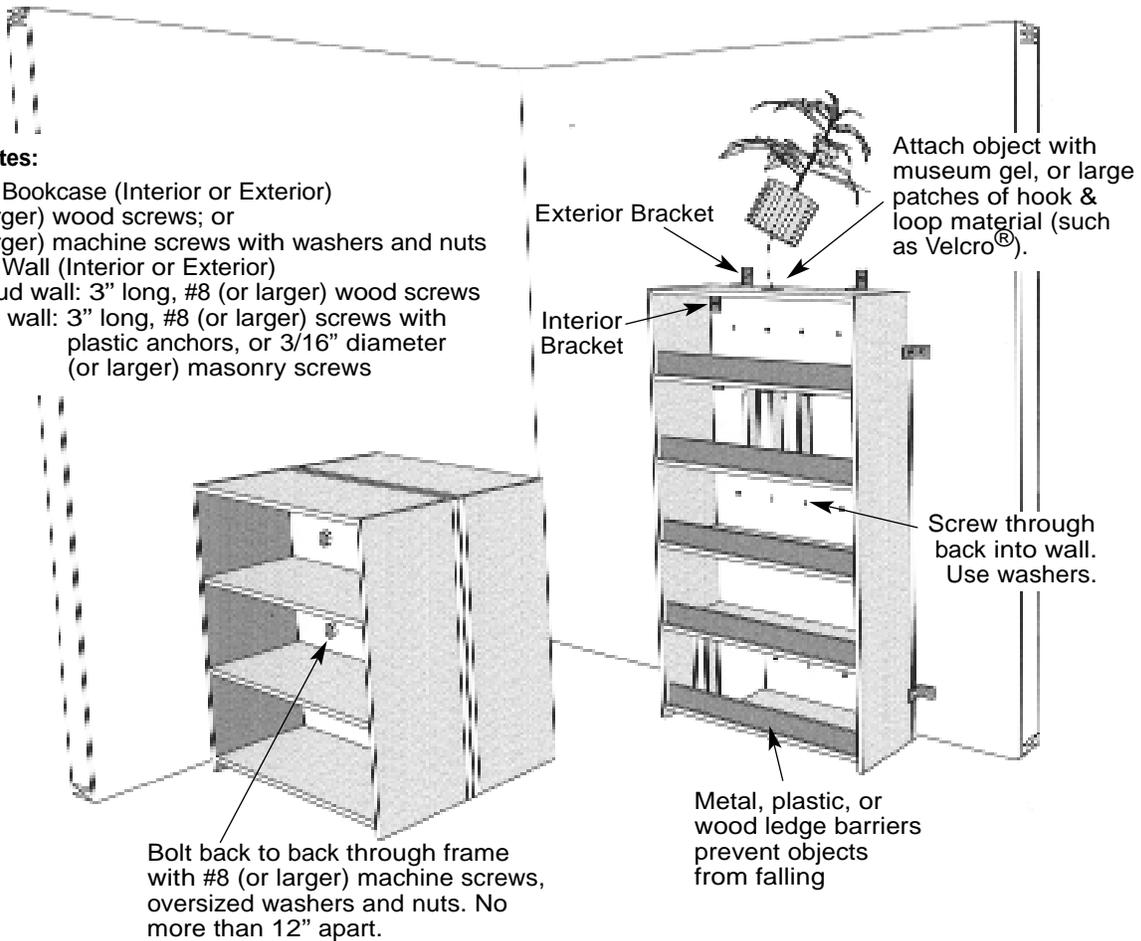
Fallen bookcases at the Lawrence Livermore Lab, Livermore, Calif.

Figure 5: Securing Bookcases (views looking from above)



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



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.

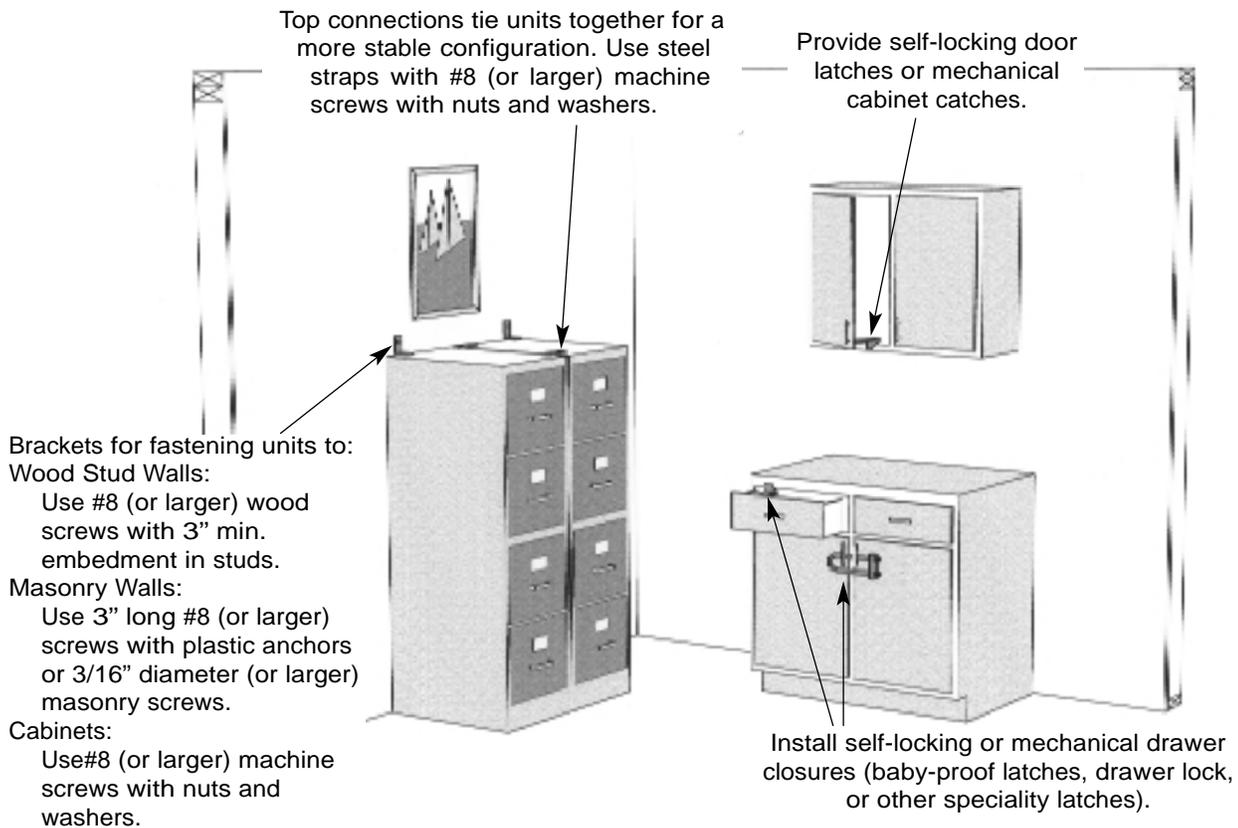
- To secure them, do the following:
 - Attach cabinets to the wall and floors using L-brackets or Z-brackets. Again, be sure to use brackets that can accommodate the diameter of the fasteners. You should follow the specific directions given in **Figure 6** and in the “Bookcases” section for securing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



EERI Coalinga Earthquake Reconnaissance Team, S. Rihdal, Cal. Poly.

Interior damage to kitchen, Coalinga Junior High School, Coalinga, Calif.

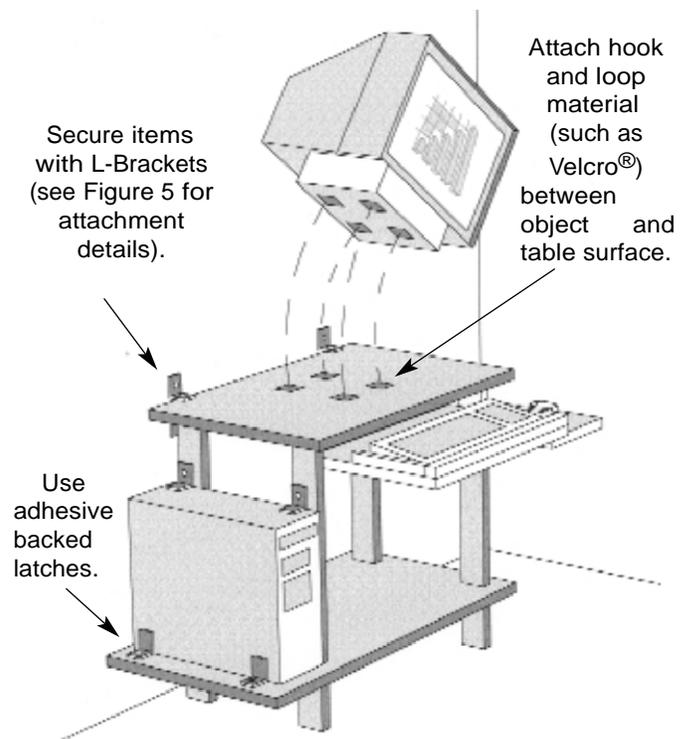
Figure 6: Cabinets and Drawers



- 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**.

Figure 7: Secure Heavy Objects




Necessary Tools and Materials

- L- or Z-brackets
- Fasteners
- Door or drawer latches
- Plastic anchors for masonry walls
- Variable speed drill and bits
- Screwdriver
- Stud locator



J. Preli

Damage to framed pictures, Northridge, Calif.

Picture Frames and Bulletin Boards

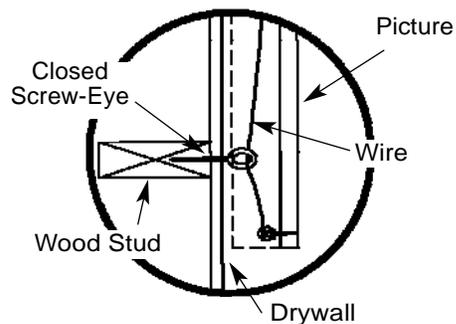
The photographs, bulletin boards and artwork you display in your home add to its character. But these items can easily fall during an earthquake if you do not fasten them properly to a wall in the following way:

- 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

Figure 8: Secure Picture Frame to Wall



Ceiling Lights, Suspended Ceilings and Hanging Fixtures

If they aren't well attached and supported, ceiling lights, suspended ceilings and hanging fixtures, such as chandeliers and ceiling fans, can fall in an earthquake and seriously 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 suspended or false ceilings. See **Figure 9**.



*EERI Coalinga Earthquake Reconnaissance Team
S. Rithai, Cal. Poly.*

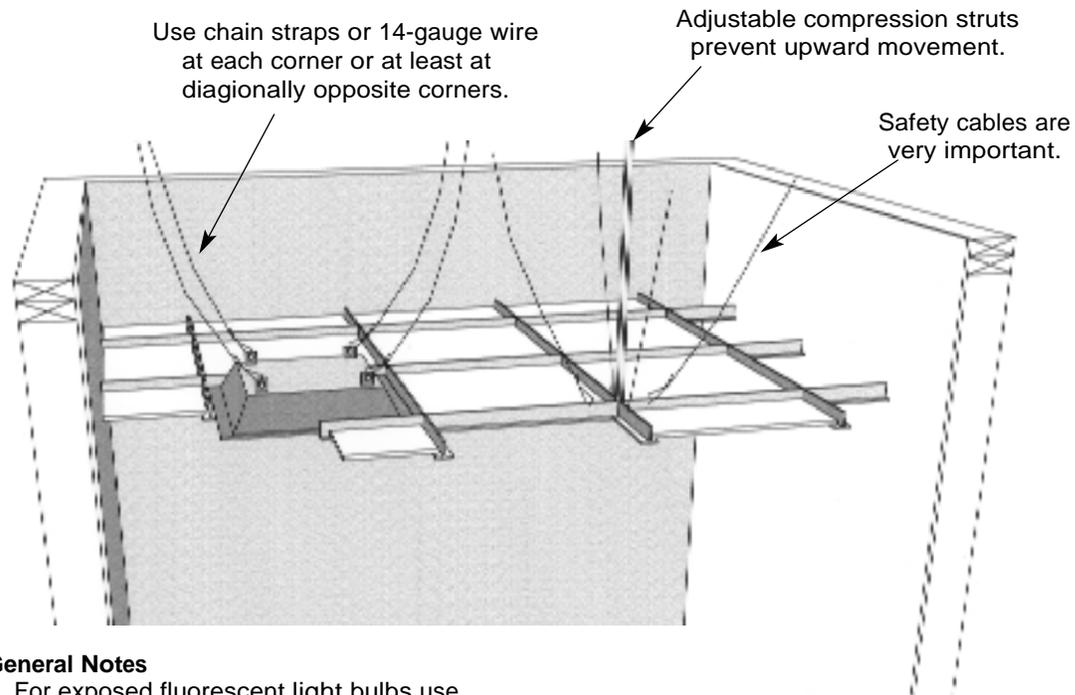


EERI, S. Swan, EQE Inter.

Top: Failure of pendant light fixtures in the Dawson Elementary School library, Coalinga, Calif.
Bottom: Damage to suspended ceiling and recessed ceiling lights, Philippines.

- Use screws, bolts or other appropriate fasteners to attach the safety cables to both the suspended ceiling and the permanent structure.
- You can prevent the ceiling panels from flying upward by installing adjustable compression struts. Contact your suspended ceiling manufacturer for details. See **Figure 9**.

Figure 9: Secure Lights and Suspended Ceilings



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.



Necessary Tools and Materials

- Safety cables, chain straps, heavy wire or plumber's strapping
- Fasteners
- Adjustable compression struts
- Screwdriver
- Variable speed drill and bits
- Stud locator
- Plastic sleeves for fluorescent lights
- Light covers

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.

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



Damaged building, Coalinga, Calif.

USGS, M. Hopper

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



Ben Rotholz

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

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

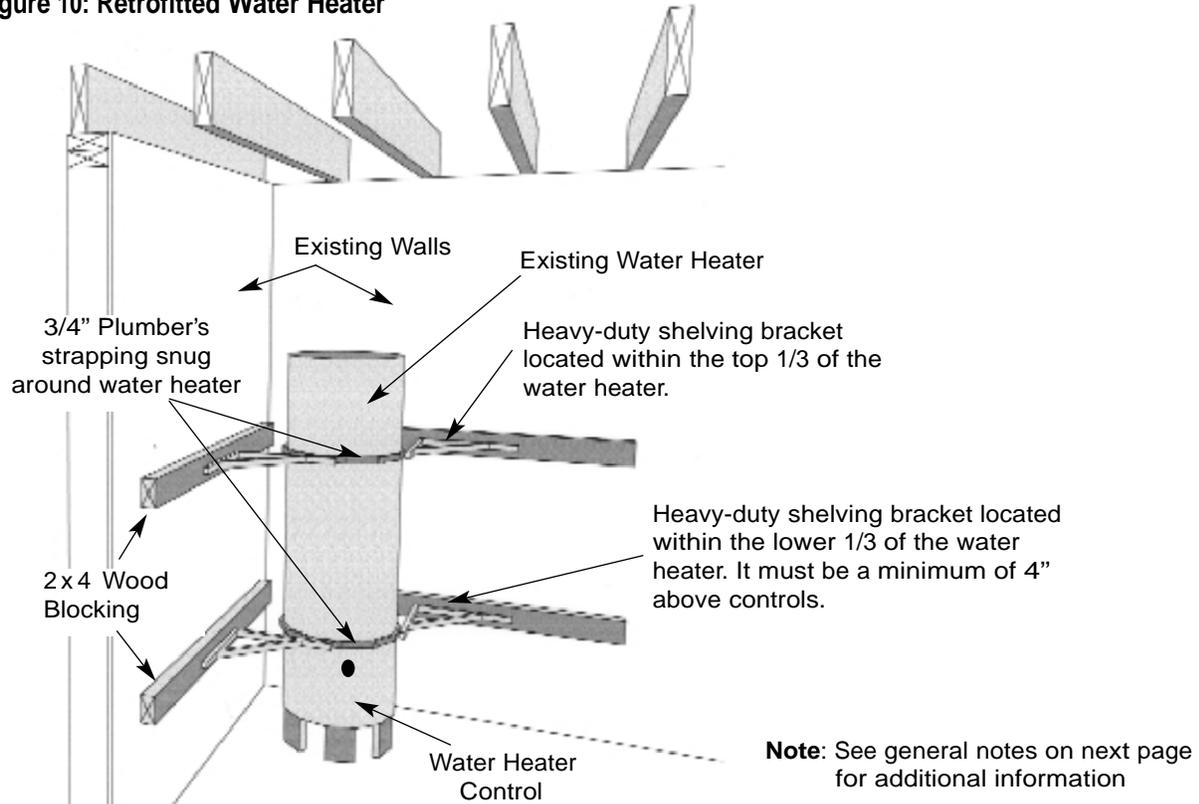
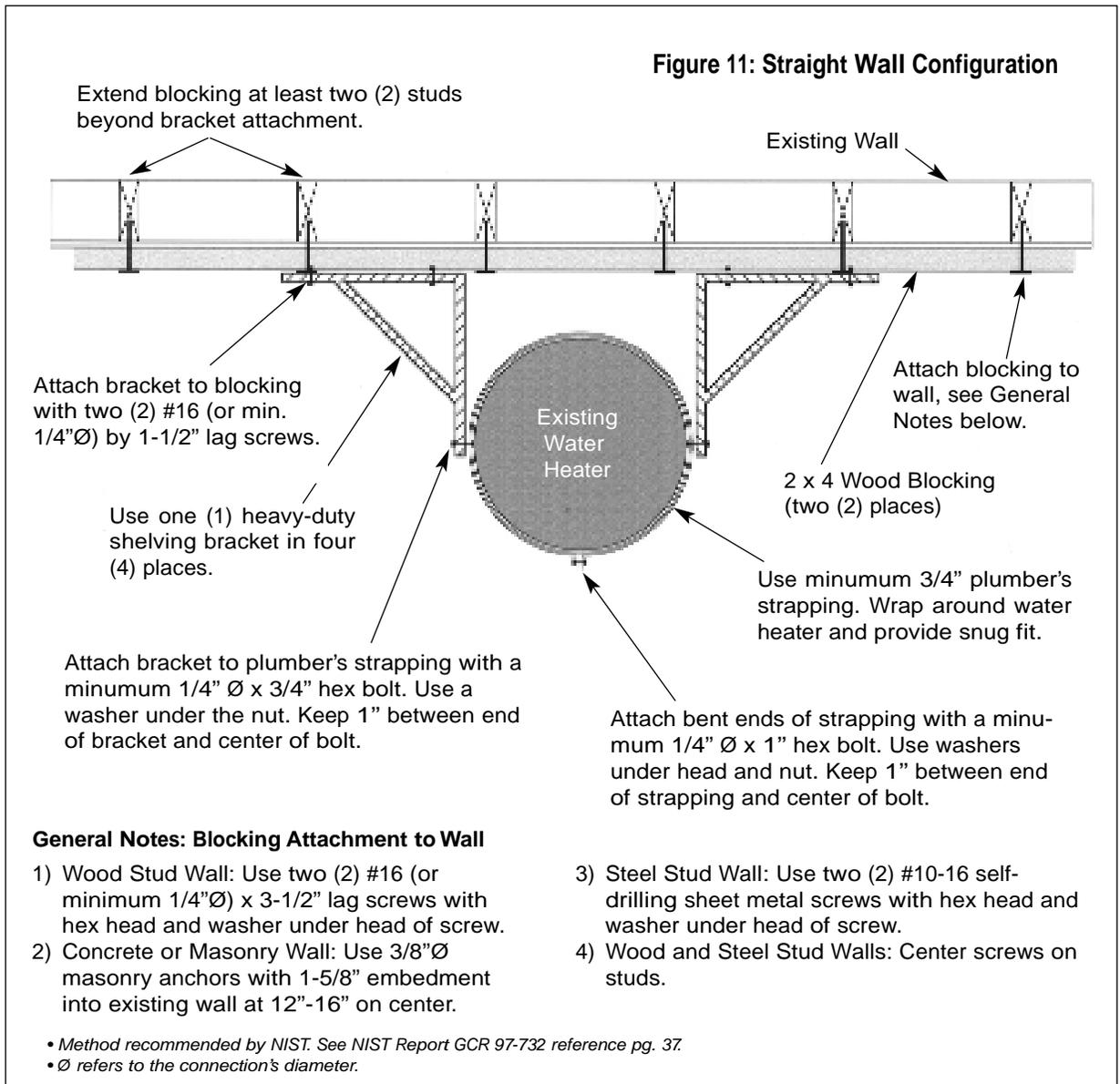


Figure 11: Straight Wall Configuration

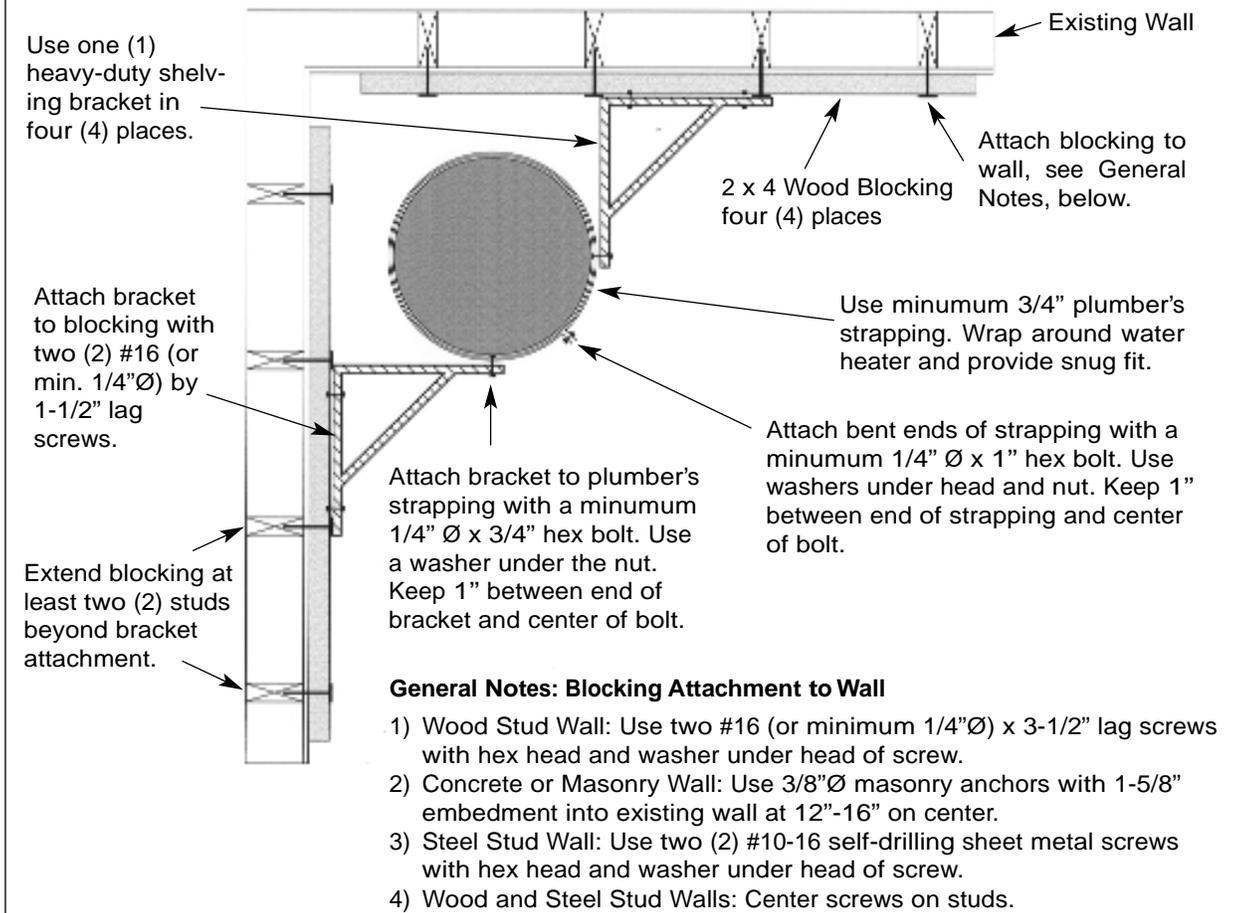


Secure water heaters (up to 50 gallons) to stud walls using the simple, generic method detailed in **Figures 10 through 12**.

- 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

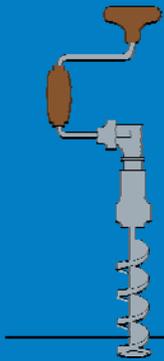
height within the upper one-third (1/3) of the water heater and the other within the lower one-third (1/3) of the water heater. The lower 2 x 4 should be at least four (4) inches above the water heater control. If you are working with a wood or metal stud wall, attach the blocking directly to the studs. Use a stud locator to find the studs.

Figure 12: Corner Wall Configuration



• Method recommended by NIST. See NIST Report GCR 97-732 reference pg. 37.
 • Ø refers to the connection's diameter.

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.

Reducing Earthquake Hazards: Securing Your Water Heater

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.

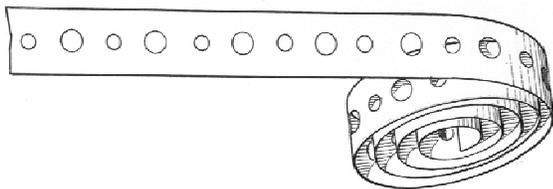
You can protect this valuable resource by securing your water heater to the wall studs.

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.

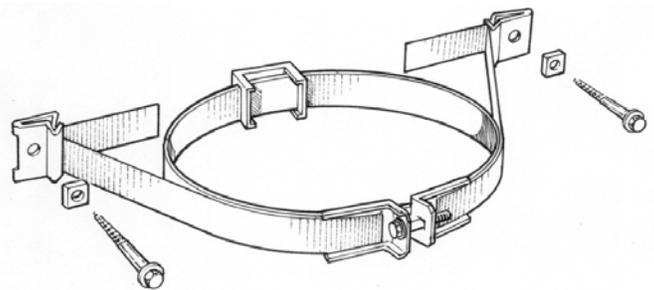
Do **NOT** use this. This is plumber's tape.



Use heavy-gauge strapping instead

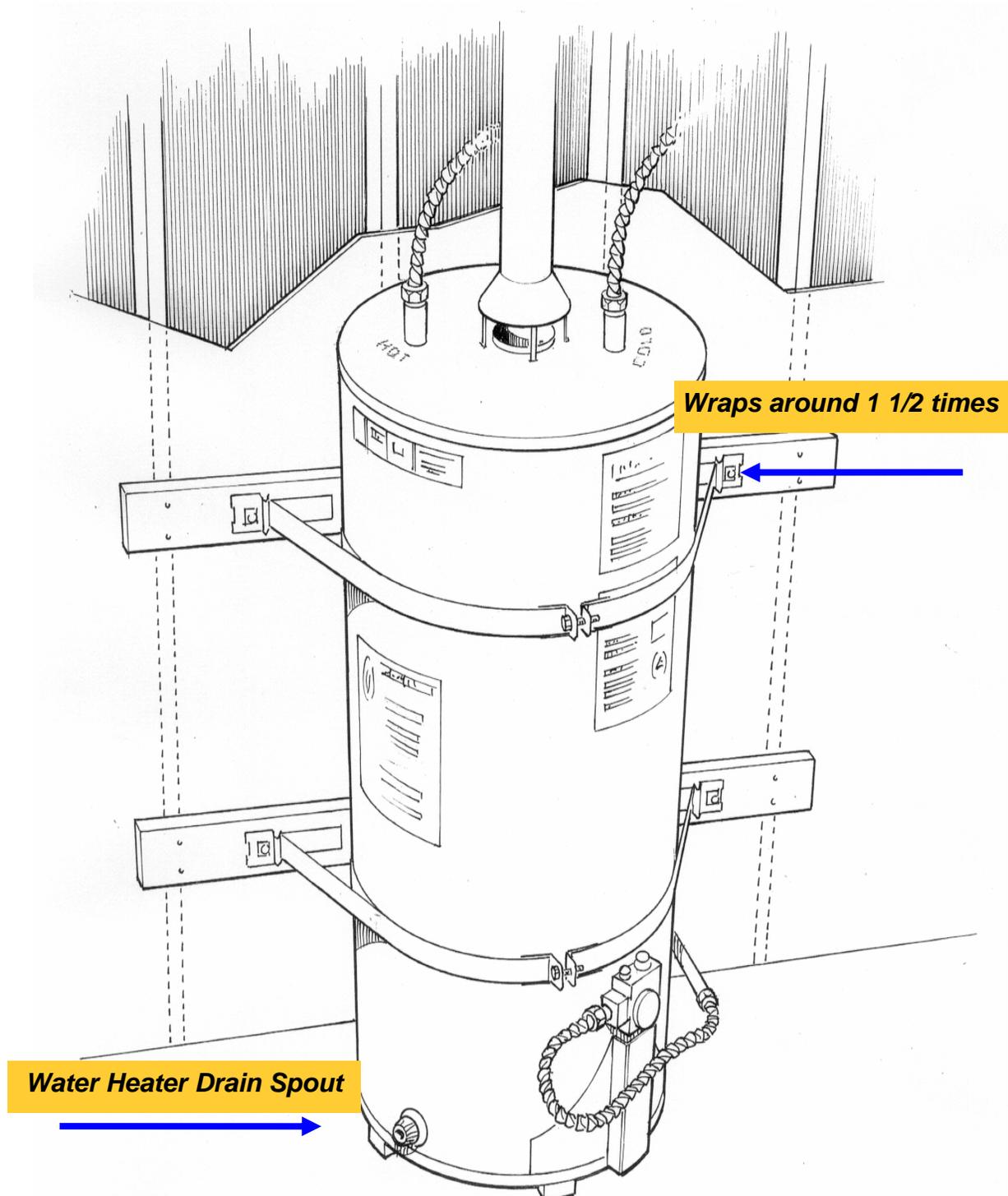
When securing your water heater:

- 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. The purpose is to prevent the heater from tipping backwards.
- Wrap the heavy-gauge metal strapping 1½ 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.
- 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.
- Replace all copper and metal piping with flexible natural gas and water line connectors.



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.

Securing Your Water Heater

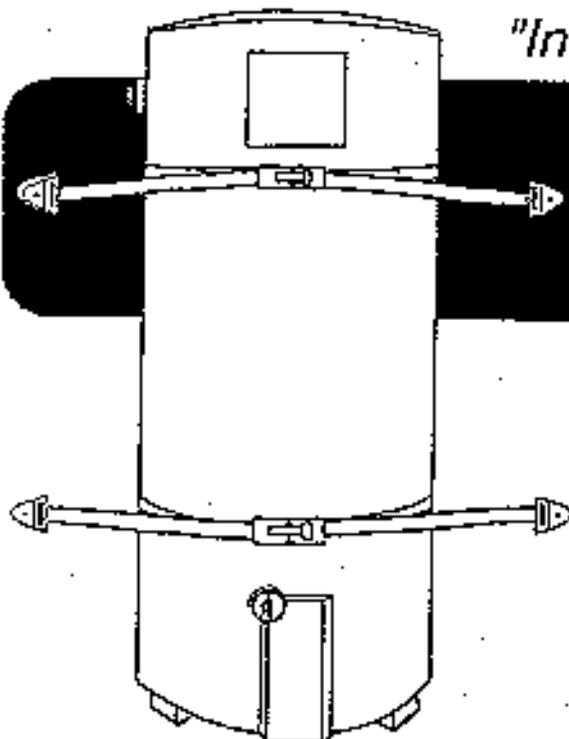


Water heaters are an excellent supply of emergency water. **Make sure the electricity or natural gas is shut off before opening the drain.** The water can be accessed from the drain spout at the bottom of the tank. This is made easier by connecting a garden hose to the drain spout. Open a faucet somewhere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

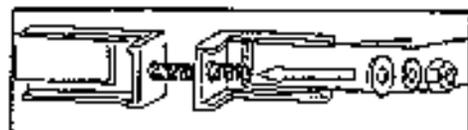
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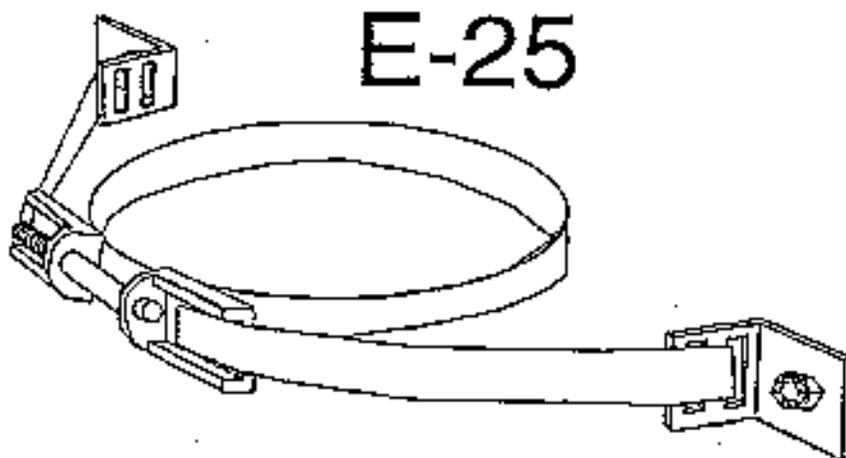
- *INSTALLS QUICKLY*
- *ALL FASTENERS INCLUDED*
- *COMPLIES WITH 1994 CODE*
- *NO SPECIAL TOOLS NEEDED*
- *FOR UP TO 40 GALLON HEATERS*
- *ACCEPTED DSA GENERIC DESIGN*
- *TESTED BY MAJOR CA PUBLIC UTILITY*



PATENT PENDING

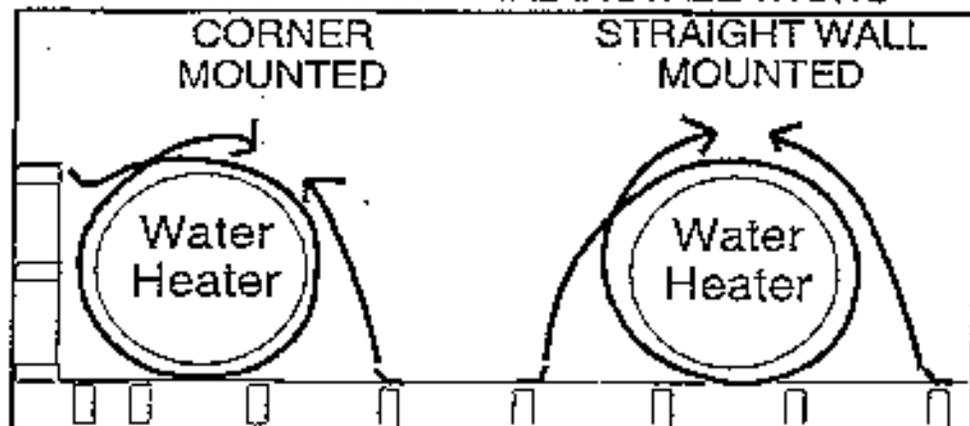


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TYPICAL RESIDENTIAL INSTALLATIONS



PENDING

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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.



Category \$

- 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.



Category \$\$

- Reinforce cripple wall;
- Strengthen narrow walls on either side of garage opening;
- Anchor unreinforced chimneys.



Category \$\$\$

- 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.



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



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