

The Problem

Houses that are not bolted to the foundation can move off their foundations during earthquakes.

How to Identify

- ✓ Go down into the crawl space – the area between the first floor and the foundation – to find out if your house is bolted to its foundation.
- ✓ Look for the heads of anchor bolts that fasten the sill plate – the wooden board that sits directly on top of the foundation – securely to the foundation. (See *Figure 14a*, page 15)
- ✓ You should be able to see the large nuts, washers, and anchor bolts, installed at least every 4 to 6 feet along the sill plate. Steel plates are sometimes used instead of anchor bolts. (See *Figure 14b*, page 15)

Remember

- It is very expensive to lift a house, and place it back on its foundation.
- Homes moving off their foundations can cause gas lines to rupture, which in turn can result in fires.



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Figure 13 - This home wasn't bolted and slid off its foundation. Sometimes the damage can be so bad that houses have to be demolished.

If your home has no foundation, or an old concrete foundation, see page 30.

Slab Foundations

Some homes are built directly on concrete slabs. These houses do not have crawl spaces and cripple walls.

Nearly all homes with slab foundations that were originally built to code will have anchor bolts or straps.

However, if the house is not bolted to the slab, you have an earthquake weakness.

Newer homes generally have anchor bolts or straps.

If you have an unfinished garage, you may be able to see the anchor bolts.

You are not required to remove siding, drywall or plaster to determine if your house has anchor bolts.

The Solution

Drill holes through the sill plate into the foundation and install anchor bolts. (See *Figure 14a*)

If there is not enough room to drill, you can attach steel plates to hold the sill plate to the foundation. (See *Figure 14b*)

Anchor bolts have to be installed properly for them to be effective.

You must obtain the proper permits from your local Building Department before beginning work.

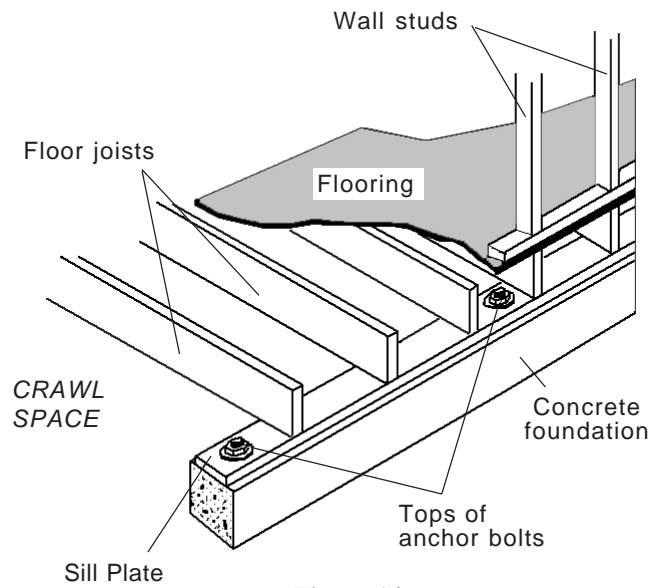


Figure 14a

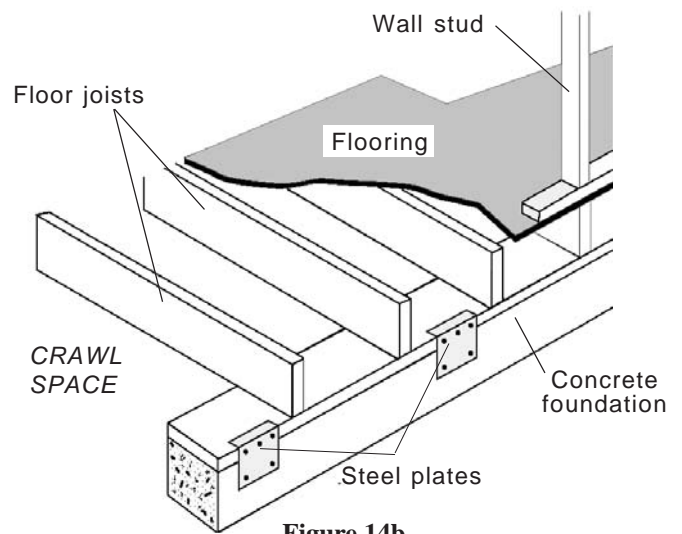


Figure 14b

Figure 14 —Anchor bolts or steel plates. A home’s crawl space may be formed by a cripple wall (*see next page for description*) between the foundation and the floor joists or the floor joists may rest directly on the sill plate. In either case, you should be able to see the heads of anchor bolts or steel plates installed at appropriate intervals. These fixtures fasten the sill plate to the foundation.

Comparison of Cost: Preventing vs. Repairing Earthquake Damage	
Project Cost	Cost to Repair after an Earthquake
\$250 to \$5,000	\$25,000 to total value of home (if completely destroyed).

The Problem

Wooden floors and stud walls are sometimes built on top of an exterior foundation to support a house and create a crawl space. (See Figure 17, page 17)

These are called cripple walls and they carry the weight of the house.

During an earthquake, these walls can collapse if they are not braced to resist horizontal movement.

If the cripple wall fails, the house may shift or fall.

How to Identify

- ✓ Go under the house through the crawl space, to see if there are any cripple walls.
- ✓ If there are cripple walls, check to see if they are braced.
- ✓ There should be plywood panels adequately nailed to the studs OR there should be diagonal wood sheathing. (See Figure 16)
- ✓ If you have neither of these, the cripple walls are probably insufficiently braced or unbraced.
- ✓ Horizontal or vertical wood siding is not strong enough to brace cripple walls.

Remember

- It is very expensive to lift a house, repair the cripple wall, and put it back on its foundation



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Figure 15 - Damage to home due to cripple wall failure.

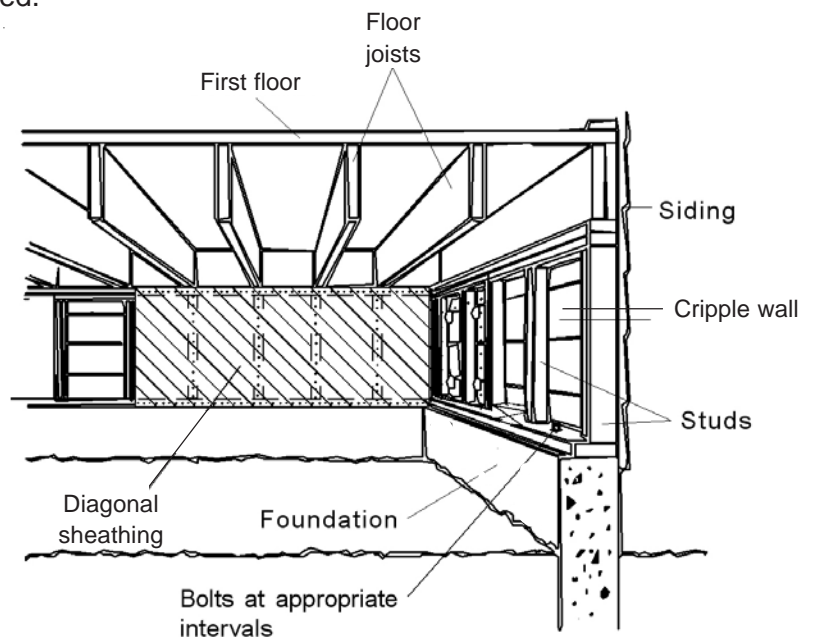


Figure 16 - Diagonal Sheathing. Common in older homes.

The Solution

Plywood, or other wood products allowed by code, should be nailed to the studs.

The following are important:

- Type of wood product used
- Plywood thickness
- Nail size and spacing
- Do not cover vents.

Consult your local Building Department for permit requirements before starting work.

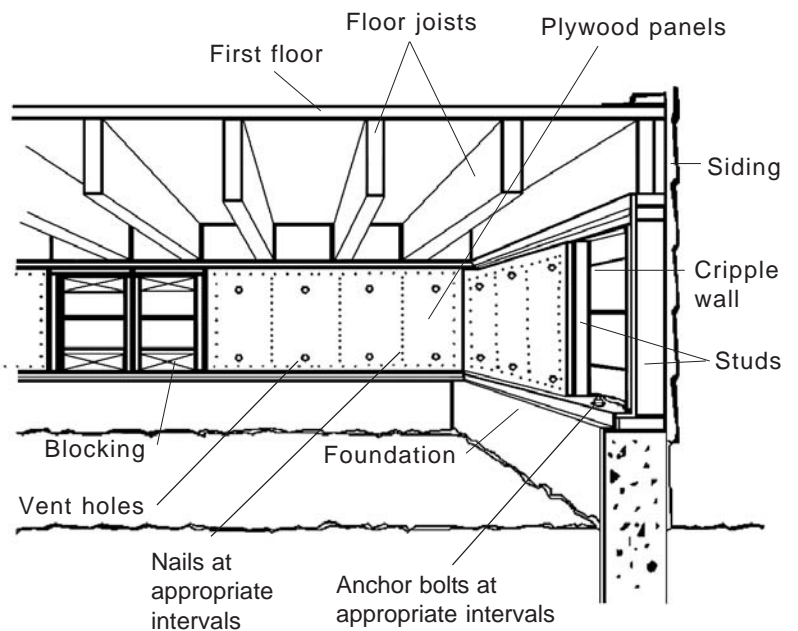
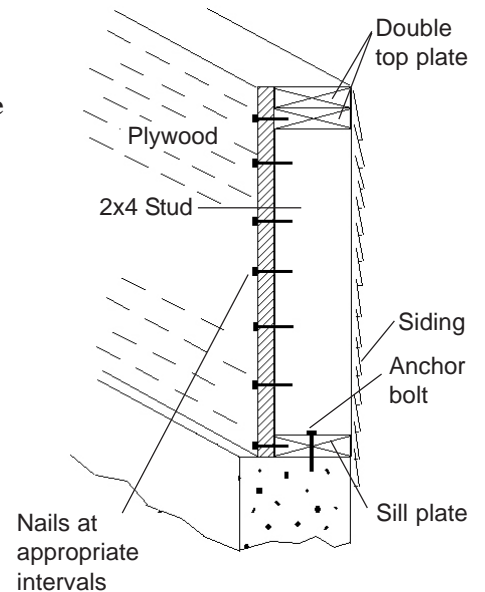


Figure 17—Plywood or diagonal sheathing strengthens weak cripple walls. If your home has a cripple wall between the foundation and the first floor, and the wall is not braced with plywood or diagonal sheathing, the house may fall or shift off its foundation during an earthquake.



How-to Resources

Please see standard plans and details:
http://www.slocity.org/communitydevelopment/Residential_Seismic_Retrofit_Plan.pdf

Comparison of Cost: Preventing vs. Repairing Earthquake Damage	
Project Cost	Cost to Repair after an Earthquake
\$500 to \$2,500	\$25,000 to total value of home (if completely destroyed).

The Problem

The outside of the house is supported by wood posts resting on unconnected concrete piers. Siding is often nailed to the outside of the posts, making them not easily visible.

During an earthquake these posts can fail, if they are not braced against swaying.

If the posts fail, the house may shift or fall.

How to Identify

- ✓ Go under the house to see if there is a continuous foundation under the outside walls.
- ✓ If you do not see a continuous foundation you may have an earthquake weakness.
- ✓ If you see only unconnected concrete piers and wood posts, or only wood posts, supporting the outside walls, you have an earthquake weakness.

Remember

- Horizontal or vertical wood siding is not strong enough to brace pier-and-post foundations.
- Major structural repairs, like lifting an entire house to repair the posts and putting it back, are very expensive.



California Seismic Safety Commission



California Seismic Safety Commission

Figure 18 - The pier-and-post foundation under this home shifted during a recent earthquake.

The Solution

Consult a licensed architect or engineer, and a licensed building contractor who specializes in foundations, to fix this problem.

It may be possible to make the foundation safer by bracing the posts.

You might be better off to add a new foundation and plywood walls in the crawl space to make sure that the house will not shift or fall off its foundation during an earthquake.

How-to Resource

- Detailed information for engineers can be found in the [International Existing Building Code](#), published by the International Code Council.

Comparison of Cost: Preventing vs. Repairing Earthquake Damage	
Project Cost	Cost to Repair after an Earthquake
\$1,000 to \$25,000	\$20,000 to total value of home (if completely destroyed).

The Problem

Unreinforced masonry—brick, concrete block, or stone—foundations often cannot resist earthquake shaking. They may break apart, or be too weak to hold anchor bolts. Homes may shift off such foundations during earthquakes, damaging the walls, floors, utility lines, and home contents.

How to Identify

- ✓ If your home's foundation is brick or stone, and looks like one of the foundations shown in the photos here, it is probably unreinforced.
- ✓ If there is a space filled with grout between the inner and outer faces of a brick foundation (where anchor bolts and reinforcing steel could be installed), it may be reinforced.
- ✓ If the outside of the foundation is covered, you may have to look under the house to see the type of foundation you have.
- ✓ If you are not sure what to look for, seek the services of a licensed engineer to determine if your foundation is reinforced or not.

Remember

- It is cheaper to do this before an earthquake damages the house than after.



California Seismic Safety Commission

Figure 19 - This is an unreinforced stone foundation. They typically fail during earthquakes.



California Seismic Safety Commission

Figure 20 - Note the bricks exposed in this unreinforced masonry foundation.

The Solution

There are several ways to fix this problem.

The most common approach is to replace all or part of the existing foundation with a poured reinforced concrete foundation.

Another solution is strengthening the unreinforced brick or stone foundation, which is generally expensive.

Seek the help of a licensed architect or engineer, and a licensed foundation contractor or general contractor.

How-to Resource

- Detailed information for engineers can be found in the [International Existing Building Code](#), published by the International Code Council.

Comparison of Cost: Preventing vs. Repairing Earthquake Damage	
Project Cost	Cost to Repair after an Earthquake
\$15,000 to \$50,000	\$15,000 to total value of home (if completely destroyed).

The Problem

The large opening of a garage door and the weight of a second-story room built over the garage can result in the walls being too weak to withstand earthquake shaking.

When the narrow sections of the wall on each side of the opening are not reinforced or braced, the weakness is worse.

How to Identify

- ✓ Is the garage door opening in line with the rest of the house? (See Figure 30)
 - If this is the case, additional bracing **may not** be needed.
- ✓ Is the house shaped like Figure 31? If this is the case, are there braces or plywood panels around the garage door opening?
 - If there are no braces or plywood panels, strengthening may be needed.
- ✓ Consult a licensed architect or engineer to determine the strengthening required.

Remember

- Many homes with this weakness have been severely damaged in past earthquakes.



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Figure 29 - This mountain home was built over a garage, and its walls were not strong enough to withstand an earthquake.

HOUSE VIEWED FROM ABOVE



Figure 30 - If the wall of the main house is in line with the wall containing the door of a garage with a room over it, the adjoining wall may help brace the garage.

HOUSE VIEWED FROM ABOVE

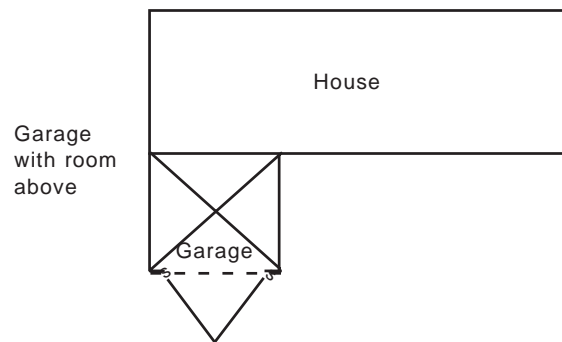


Figure 31—Additional bracing. Home configuration where there is no in-line wall. Additional bracing may be appropriate in this situation.

The Solution

Consult a licensed architect or engineer to design plywood paneling or a steel frame around the door opening (See Figure 32).

Have plans drawn.

Obtain a permit from your local Building Department.

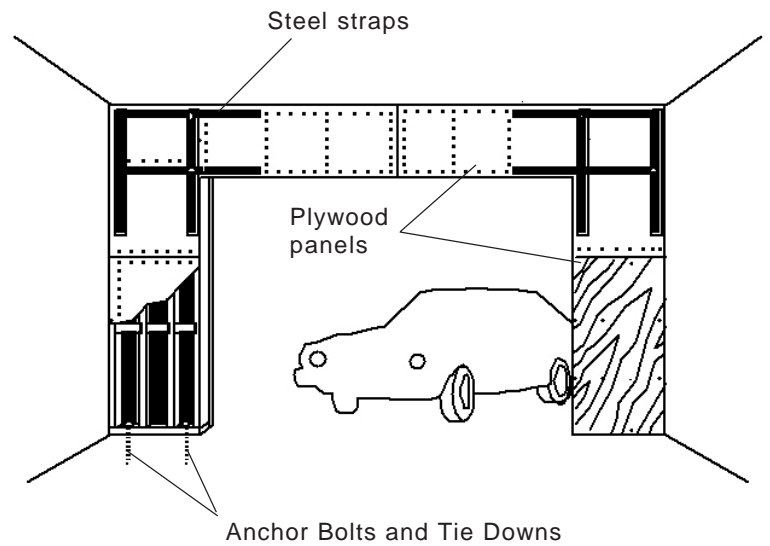


Figure 32—Bracing garage walls. If your house has a room over the garage, the garage walls may not be strong enough to hold up during an earthquake unless they are braced with plywood panels and steel straps.

How-to Resource

- Detailed information can be found in the [International Existing Building Code](#), published by the International Code Council.

Comparison of Cost: Preventing vs. Repairing Earthquake Damage	
Project Cost	Cost to Repair after an Earthquake
\$5,000 to \$25,000	\$15,000 to total value of home (if completely destroyed).

OTHER EARTHQUAKE-RELATED CONCERNS

OTHER CONCERNS

Unreinforced Masonry Chimneys

The Problem

Many chimneys are built of unreinforced brick or stone. During an earthquake these can collapse or break and fall on the roof.

When the chimney fails, the falling stones and bricks can:

- Cause injuries
- Damage the house
- Damage cars

Tall slender chimneys are most vulnerable.

How to Identify

- ✓ Check the mortar between the bricks or stones with a screwdriver. If it crumbles when you pick at it, the chimney may be a hazard.
- ✓ Inspect the attic and floor spaces for metal ties that should be holding the chimney to the house.
- ✓ Determining whether a chimney is susceptible to earthquake damage is not always easy. When in doubt, consult a licensed engineer or contractor.

Remember

- Do not locate patios, children's play areas, or parking spaces near a questionable chimney.
- Tell family members to get away from chimneys and fireplaces during earthquakes.



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Figure 33 - This unreinforced chimney fell during a recent earthquake.



Gina Selvadurai

Figure 34 - Morgan Hill Earthquake. Broken chimney fell on roof.

The Solution

Tear down the old or damaged chimney and replace with a newly constructed chimney.

Several steps can be taken to reduce the risk of damage from falling chimneys, depending upon the type of chimney you have. They include:

- Add plywood panels at the roof or above the ceiling joists to prevent the brick or stone from falling into the house.
 - This can be done by layering plywood above the ceiling, in the house’s attic, or nailing plywood under the shingles when reroofing.
- Replace the upper chimney with metal flues.
- Strengthen the existing chimney.
 - This can be a complicated process, depending upon the construction and height of the existing chimney.

Consult your local Building Department and obtain necessary permits first.

How-to Resource

- Reconstruction and Replacement of Earthquake Damaged Masonry Chimneys, City of Los Angeles, Department of Building & Safety, Information Bulletin #P/BC-2002-70.



Figure 35 - Photo showing damaged chimney removed. Note that the fireplace is now not functional.

Comparison of Cost: Preventing vs. Repairing Earthquake Damage	
Project Cost	Cost to Repair after an Earthquake
\$2,000 to \$12,000	\$15,000 to total value of home (if completely destroyed).

No Foundation

- The Problem** Some older houses were built on wood beams laid directly on the ground, without foundations. These houses may shift during earthquakes, causing structural damage and breaking utility lines.
- How to Identify** Look under the house. If you see no concrete or masonry around the outside walls, the house may lack a foundation.
- What Can Be Done** You may need to add a foundation to make the house earthquake resistant. Just as when strengthening or replacing an unreinforced masonry foundation, you will require the advice of a licensed architect, engineer, or foundation contractor.

Old Concrete Foundation

- The Problem** Some older concrete foundations were made with sand or stone that interacted chemically over time, and the concrete eventually crumbles and becomes too soft to withstand earthquake forces.
- How to Identify** Inspect the foundation for large cracks in the concrete, concrete crumbling off the foundation, or concrete crumbling when you pick at it with a screwdriver.
- What Can Be Done** You may need to replace some or all of the foundation. You should consult a licensed foundation contractor or an engineer.

GETTING THE WORK DONE

PLANS, PERMITS, AND CONTRACTORS

- Decide which strengthening project or projects you are going to do.
- Get the necessary building permits first.
 - If you are “doing-it-yourself,” you still need the proper permits.
 - For more complex projects, have a licensed architect or engineer draw up the necessary plans and specifications.
 - ✓ Interview two or three architects or engineers.
 - ✓ Ask for references or former clients.
 - ✓ Talk to references or former clients.
 - ✓ Compare experience, ideas, and fees.
 - Submit the plans for approval to your local building department.
 - Remember: the building codes are designed for your safety.
- Select your licensed contractor.
 - First make sure the contractor is properly licensed.
 - Interview at least two or three contractors.
 - Ask your licensed architect or engineer for recommendations.
 - Ask for references or former clients.
 - Talk to references or former clients.
 - Compare experience, fees, and terms of contract.
 - Get at least three written bids for the construction work.
 - The lowest bid may not be the best bid.
- Keep all plans, permits, and other records of your strengthening project.
 - Provide future buyers of your home with these.

There are many publications that describe strengthening projects in detail.

Visit the California Seismic Safety Commission’s website at www.seismic.ca.gov, which provides many useful links.

- Get the documents that relate to your project and read them.
 - This will help you to better understand what the architect or engineer is doing, and also what the contractor is doing.
- The International Existing Building Code Appendix Chapter 3 contains the best current guidelines. Ask your local Building Department to review a copy.

If your home has been designated as “historical,” you also may need to comply with the *California Historical Building Code*.

- Contact your local Building Department for further help with this.

REMEMBER

Whether you do it yourself, or hire a contractor, **you need permits** from your local Building Department.

It costs far less to correct earthquake weaknesses before an earthquake than to repair the damage after an earthquake.

If your home is damaged in an earthquake, you will probably also have other costs such as lodging, medical, etc.

DON'T HESITATE - MITIGATE!