Earthquakes Happen

Easy Low Cost Ways to Make Your Home Earthquake Survivable
The City of Oakland can help you strengthen your wood-frame home to survive the next earthquake.

The Bay Area’s last big earthquake over a decade ago is a fading memory for many Oakland residents. That earthquake’s epicenter was 60 miles away. The next “Big One” could strike right here in Oakland along the Hayward fault.

Experts say it could happen at any time. The next Bay Area earthquake will shake Oakland neighborhoods up to 12 times harder than the 1989 earthquake. That’s strong enough to topple a wood-frame house if it’s not securely anchored to its foundation.

Is your Oakland home at risk?
Chances are: yes — because it’s probably old. According to Alameda County housing records, 3 out of 4 homes in Oakland were built before 1950. This is long before earthquake safety became a part of California’s architectural consciousness.

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Today, after a half-century of engineering advancements – and many earthquake lessons later – building codes are far tougher. New wood-frame houses are built with bolts around the foundation to anchor the house down, and wood-frame foundation walls have numerous plywood panels nailed on the interior to prevent their collapse.

Most houses in Oakland and other Bay Area cities have never been strengthened. So, your home may be decades behind the standard of earthquake ‘fitness’ that was considered acceptable for new houses at the time of the 1994 Northridge earthquake – and since that disaster, the standard has been raised even higher!

Is your home at risk of damage in future disasters? Probably so, considering the prevalence of older unstrengthened homes in Oakland. That risk can never be eliminated. However, upgrading your home with prudent, disaster-safety improvements will substantially reduce your risk.

The City of Oakland has published this booklet to help you make your home stronger and safer.
To check your home's earthquake fitness, all you need is a flashlight and a willingness to get a little dirty. The place to start is the crawl space underneath your home.

**Items you can do yourself:**

- **Is your house properly bolted down to its foundations?**
  The wood 2x4 or 2x6 that rests directly on the foundation is called the “mud sill.” Until the 1950s, home builders often did not bolt the mud sills to the foundation. This creates a serious structural weakness that can allow your home to slide off its foundation during an earthquake. The mud sill should be bolted at four feet to four feet eight-inch intervals, and a bolt should be located within one foot of every joint or step in the mud sill, but no closer than nine inches to the end of the board. If the mud sill is not bolted, or inadequately bolted, this is a job you can consider doing yourself.

- **Next, examine the cripple wall.**
  Check to make sure your cripple walls are braced with plywood to resist motion. Even if your cripple walls have cross-bracing, they are not strong enough for earthquakes unless you add plywood. This is a job you can do yourself.

- **Make sure your hot water heater is properly strapped.**
  Is your hot water heater earthquake safe? Heavy shaking can move or topple a non-strapped water heater. Non-flexible gas or water lines may cause a fire or serious water damage if the lines rupture or break.

**Items you’ll need a contractor for:**

- **Check for faulty materials in the concrete and the wood framing.**
  The foundation is a common area of structural weakness, so check your foundation to make sure it's in good condition. Sometimes the concrete, brick or stone rubble used in foundations is too porous, crumbly or unsound to provide adequate strength. If the foundation material chips or flakes when you poke it with a screwdriver, it may be unsafe. If so, your home is still subject to earthquake damage, even if you've bolted it down and installed plywood on the cripple walls. Do you see any obvious evidence of dry rot or insect damage in the wood? If so, you will need to remove and replace the damaged wood. It's a good idea to hire a structural pest control inspector to look for damage not easily seen except by a trained eye.

- **If your home has a chimney, check it for bracing**
  Check the overall condition of the mortar and bricks for cracks or looseness. Weak mortar can be easily scraped off with a screwdriver. A sound brick should easily withstand a sharp hammer blow. Fractures should be easy to see at close range. If in doubt, consult a professional for an evaluation.
The first step to take...

If you find your home does not have anchor bolts, or has too few, you need to install them!

Bolting the mud sill to the foundation is one of the most cost-effective ways to protect your property from severe structural damage and one of the best investments you can make in your real estate “nest egg.” Anchor bolts cost as little as $3 each (depending on size) so the perimeter of the average size home can be bolted for a couple of hundred dollars.

There are 2 kinds of anchor bolts.

The first thing you need to determine is which kind will work best for you.

Expansion Bolts
When you tighten the nut on an installed expansion bolt, the bolt’s other end expands to grip the concrete. When the bolt is inserted properly, you will actually feel it “grab” the foundation as you tighten the nut. Test at least one out of every four new bolts for tightness with a torque wrench applying 40 foot-pounds of pressure.

Epoxy Bolts (chemical anchors)
If you have an older foundation, or a foundation material other than concrete, and worry about cracking it with the pressure of expansion bolts, consider using epoxy bolts (also called chemical anchors) appropriate for the foundation materials; concrete, brick, masonry or stone. Measure, drill and clean the holes per the manufacturer’s instructions. Be careful not to drill deeper than the bolt’s length. Before you place the bolt in the hole, inject the epoxy mixture into the hole (sometimes a metal screen is installed too). Press the bolt into place and wait for the epoxy to harden (usually 24 hours). Once the epoxy has hardened, tighten the nut with an adjustable wrench until the washer just begins to indent the wood mud sill. Epoxy bolts can be a bit more time-consuming to install. However, they are very effective, and are the preferred method, even in sound concrete foundations.
1. Mark and measure
Mark the places for each bolt on the mud sill. Make the first mark between nine and twelve inches from the corner, and then measure another four feet to four feet eight-inches for the next bolt, and so on. Continue this pattern along all of the foundation walls. Place an extra bolt within nine to twelve inches from any joint or step in the mud sill.

2. Drill the holes
Using the rotary hammer drill equipped with an appropriately-sized carbide bit, drill down through the mud sill at least seven inches into the concrete. Pay special attention to the tool’s operating instructions before drilling.

3. Clean the holes
Use flexible tubing or a bulb type instrument to gently blow the concrete dust out of the hole. This is especially important if you are using epoxy bolts.

Note: In less sound concrete, brick or other material, do not use a hammer (impact) drill. Instead, use a standard rotary drill with a bit designed for drilling brick.

4. Install the bolts
Expansion bolts are designed to be hammered into place. This can be done without damaging the bolt threads by turning the washer and nut past the end of the bolt and tapping on the end of the bolt shaft to hammer the assembly into place. Follow the manufacturer’s instructions for epoxy bolts. Once the bolt is in place, tighten the nut down firmly using an adjustable wrench.
**Stepped foundation**

If your house is built on a hill or even a slight grade, you probably have some step-like offsets in your foundation. On every step the mud sill must be bolted down, even if it is adjacent to another bolted step.

- **5/8” bolts with plate washers 3/16” x 2” x 2”**
- **7” minimum depth**

**Minimum of 2 bolts per Step**

- **9” minimum**
- **12” maximum to end of plate**

**Foundation anchor plate**

If you don’t have working room above the mud sill to drill straight down, you can secure the mud sill to the foundation with an anchor plate. This is a metal plate that is nailed or screwed to the top of the mud sill and bolted to the side of the foundation. Anchor plates are not suitable for non-concrete foundations or unsound concrete.

**This is a job for a licensed professional**

If you have a masonry chimney, it may not withstand the force of a strong earthquake. You should have your chimney evaluated by a licensed professional. The Oakland Building Services Division Permit Center has handouts illustrating various strengthening methods. The safest chimney is a lightweight metal one.
Bolts are not enough
Even when your house is bolted to its foundation, the sideways (lateral) force of an earthquake can make the weakest part of your house (typically the cripple walls) buckle and collapse. Plywood sheets should be nailed to the cripple walls on all sides of your house. These sheets create “shear panels” that give the house lateral strength. Old-fashioned 2x4 or 2x6 cross-braces and horizontal siding are not strong enough to resist earthquake forces.

1. How much and where?
Determine the number and size of plywood braced panels you will need and where they should be placed. The number and length of panels needed will depend on the height and the length of each section of cripple wall and how many stories the cripple wall supports. For all houses, panels should be placed at both ends of each cripple wall section. For a single-story house, additional panels should be spaced evenly so that not less than 50 percent of the total length of each cripple wall section is braced. For two story houses, panels should be spaced to cover not less than 80 percent of each cripple wall section. For optimum strength, use the longest piece of plywood possible; avoid using multiple pieces of plywood to form your four to eight foot panels. The distribution of plywood panels should be “balanced” by keeping the panels approximately equal in length and as evenly spaced as your condition allows. For example, a cripple wall which is 52 feet long and 20 inches in height in a single-story house would require a minimum of 26 feet of braced panels. A typical solution would be a 4 foot plywood panel at each end and three 6 foot panels evenly spaced between the end panels. A cripple wall with 14” high studs or less should be solid blocked or continuously sheathed with plywood.

2. Measure, mark and cut
To provide adequate strength, each plywood sheet must be nailed along all edges, and along the interior studs. In most cases, the cripple wall studs are flush with the mud sill and with the “top plates” (located at the top of the cripple wall). This provides an even nailing surface for each plywood edge. However, if the cripple wall is set back from the edge of the mud sill, you will have to add blocking between the wall studs to create a nailing surface for the plywood. Measure the height from the top of the double top plate to the bottom of the mud sill. If your condition requires blocking above the mud sill, then measure to the bottom of the cripple studs. Cut the plywood so that it covers this area and reaches from the center of one stud to the center of another. Mark the center of each stud on the foundation and above the top plates. These marks will provide a nailing guide. Remember, you must nail the plywood securely to all studs at the specified nail spacing. Also, note the location of any pipes so you can cut rounded notches in the plywood to fit around them.

Retrofit Checklist
- 1/2” CDX five-ply plywood (do not use “shop-grade” plywood)
- 8-penny or 10-penny common nails
- Drill
- Saw
- Hammer
- Nail gun
- Measuring tape
- Chalk line
- Dust mask and protection for eyes and ears

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3. Blocking
Often the mud sill is wider than the stud wall or embedded into the concrete foundation too deeply to allow nailing along its edge. If so, you will need to add a piece of wood 2x4 or 2x6 blocking on top of the mud sill, as shown, to provide a nailing surface. Install blocking to fit over the anchor bolts per the City’s plan set, and nail it to the mud sill using four 10-penny common nails. Blunt the tips of the nails and stagger them across the wood to prevent splitting. If the blocks still split, you may have to pre-drill the nail holes. To prevent dry rot or termite damage, it is a good idea to use foundation grade redwood or a pressure-treated wood for the blocking.

4. Nailing
This task requires a lot of nailing, and a nail gun speeds the work, eases the wear and tear on your arm, and minimizes wood splitting. Whether you use a nail gun or a hammer, nails are a critical part of effective bracing. Each sheet of plywood must be nailed every four inches around the edges and every twelve inches along all interior studs and cross bracing in the “field” area. The edge nails provide most of the strength and the field nails prevent the center of the sheet from bowing outward during an earthquake.
5. **Repeat on all walls**

With the first sheet of plywood nailed into place, repeat the process to create a braced wall of plywood in sheets no shorter than four feet in length. Remember, long continuous sheets provide maximum strength. When you are installing adjacent pieces of plywood, make sure they join at the center of a stud or that an additional stud has been added to provide for proper nailing. Also, check the cripple walls for termite and dry rot damage, and replace any damaged materials before installing the plywood shear panels. Where cripple wall studs are spaced more than 16” on center, the panels should be applied in the long direction across the studs.

6. **Ventilation holes**

With the plywood in place, drill 2 1/2” to 3” diameter ventilation holes in each sheet. These holes should be centered between each set of studs and 5 1/2” above the mud sill and 5 1/2” below the bottom of the top plates. The holes will provide ventilation and allow inspection of the cripple wall and mud sill bolts. Drill only one hole if the plywood sheet is less than 18” tall. If your wall has an exterior ventilation screen, you should cut a hole in the plywood opposite the screen and similar to it in size. Don’t forget to add blocking around this vent hole and nail the plywood edges at 4” on center.

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**Strap Your Hot Water Heater**

If a water heater falls during an earthquake, it could break a gas line and start a fire. To minimize this risk from your water heater, add flexible connections to both the gas and water lines to reduce the danger from fire or a water leak. To keep the water heater from toppling over, wrap it with two bands of 3/4” x 24 gauge perforated steel (commonly known as plumber’s tape). Connect the bands to nearby wall studs with metal struts cut to length from 1/2” diameter wall “EMT” conduit. Each end of the strut is then flattened, drilled and bent at an angle to fit the wall. For more details and instructions contact the Oakland Permit Center at (510) 238-3443.
1. What are the benefits of strengthening my home?
When an earthquake occurs, your home will have a better chance of surviving and may only sustain minimal damage. Also, retrofitting may lower your earthquake insurance premiums and deductible. In some cases, insurance companies will not insure a home that is not strengthened. Increasing your home’s earthquake fitness enhances its value and improves its salability.

2. Is a Building Permit required?
The Oakland Permit Center staff can help you to determine whether the work you plan requires a building permit. Most work can be reviewed over the counter, while more complex projects require plan submittal for engineering plan check.

3. Is it important that I obtain a Building Permit?
Absolutely. Insurance companies, universities, local building departments, the engineering community, and the media all recognize that the Bay Area has entered a period of increased seismic risk and that proper strengthening can prevent earthquake damage to homes. A building permit protects you via the inspection process and provides a record that the work was done in accordance with accepted standards.

4. If I strengthen my home, will my property taxes be increased?
No. This type of work is specifically exempt from tax re-assessment. For more information, contact the Alameda County Office of the Assessor at (510) 272-3787.

5. How much does seismic strengthening cost?
Studies have shown that the typical costs of home strengthening range from a few hundred to a few thousand dollars. You can save money by doing some or all of the work yourself.

6. Do I have to hire a Contractor?
All of the work described in this brochure can be performed by a homeowner with basic carpentry skills. If you want to hire a contractor, use the standards mentioned in this booklet to help you shop for bids.

7. Do I have to hire an Architect or an Engineer?
No. For retrofit foundation anchor bolt and shear panel installation, we do not require plans. We do, however, require a detailed written description of the proposed installation (e.g. “bolting mud sill to existing foundation with 5/8” x 10” bolts every 4 feet in accessible areas”).

8. How do I find a Contractor?
The best way to find a contractor is through personal references, or through some of the agencies listed on the following page of this handbook. Ask the contractor that you select to provide at least three references.

9. Can the City recommend contractors?
No. However, a booklet on “How to Hire a Contractor” is available at the Permit Center or from the State Contractor’s License Board.

Caution: Tool Safety
Always read instructions before operating any power tools. If you are unfamiliar with the operation of any tool, ask an expert for some advice before you start. Rotary hammer drills and hole saws can be tricky and especially jarring to your body if you are not experienced in their proper use. Be sure to wear adequate eye protection, earplugs and gloves.
Additional Seismic Retrofit Resources and Earthquake Safety Information

- **Oakland's Building Services Division** is responsible for the City’s earthquake strengthening standards and administers the building permit and plan review process. Call 510-238-3443.

- **Oakland Fire Department's Project Impact/Project SAFE** can provide disaster safety and emergency preparedness information through its Office of Emergency Services at 510-238-3938.

- **Citizens of Oakland Respond to Emergencies (CORE)** is a free training program that teaches self-reliance skills and helps neighborhoods establish response teams to take care of themselves during the first 72 hours after a disaster. Call 510-238-6351.

- **California Governor's Office of Emergency Services Coastal Region Office** in Oakland has a Resource Center with a video lending library and publications on disaster safety. Visit www.oes.ca.gov/ or call 510-286-0895.

- **American Red Cross, Alameda County, Oakland Office** gives health and safety training to the public and provides relief to victims of disaster. For more information Call 510-595-4400 or visit www.bayarea-redcross.org.

- **Association of Bay Area Governments (ABAG)** provides earthquake awareness information specific to the San Francisco Bay Area and techniques for mitigating earthquake hazards. Visit www.abag.ca.gov/bayarea/eqmaps/eqmaps.html or call 510-464-7900.

- **California Contractors State License Board (CSLB)** To obtain a copy of the helpful booklet, “What You Should Know Before You Hire a Contractor,” call CSLB’s automated help line 1-800-321-2752 or visit their web site www.cslb.ca.gov and read it online. You may also verify a contractor’s legal status by entering the license number on the telephone system or on the web site.

- **Building Education Center**: This not-for-profit agency in Berkeley offers do-it-yourself classes, seminars and publications on earthquake retrofitting. Call 510-525-7610.

### Financial Resources

- **Seismic Retrofit Grant Program** Sponsored by the Oakland Fire Department’s Project Impact/Project SAFE and the California Department of Insurance. Low-income homeowners may be eligible to receive limited grant money for approved seismic retrofit measures. Contact the California Department of Insurance at 916-492-3280 for more information and an application.

**Residential Mitigation Loans** Many financial institutions provide home equity financing that can be used for mitigation and other home improvements. Property owners may want to first consult banks with which they have already established a lending relationship.

Below are lenders that have developed loans specifically directed at mitigation improvements:

- **Fannie Mae/FEMA Project Impact Prevention Loan** This is a consumer installment loan offered at competitive interest rates available to homeowners in the Bay Area for home improvements that help prevent property damage from certain natural disasters such as fire, flood and earthquakes. Call 1-800-7-FANNIE or their lender, Volt Viewtech at 1-888-621-5511.

- **Washington Mutual Bank** This bank, also a FEMA Project Impact Partner, can set up a “home equity” type loan, with competitive rates that could be used exclusively for mitigation improvements by homeowners. Call 1-800-933-3590.

- **Oakland Residential Lending Services** provides a variety of housing rehabilitation loans and grants to low and moderate income homeowners located in designated target areas of the City’s Community Development Districts. Seismic improvements are encouraged as a part of these residential enhancements. Call 510-238-3909.
Bolting your mud sill to the foundation and adding plywood to the cripple walls are the two most cost-effective steps you can take to strengthen your home for earthquakes.

Find out more at www.oaklandnet.com