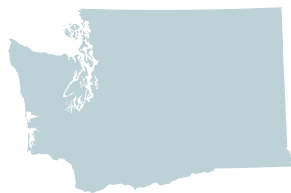
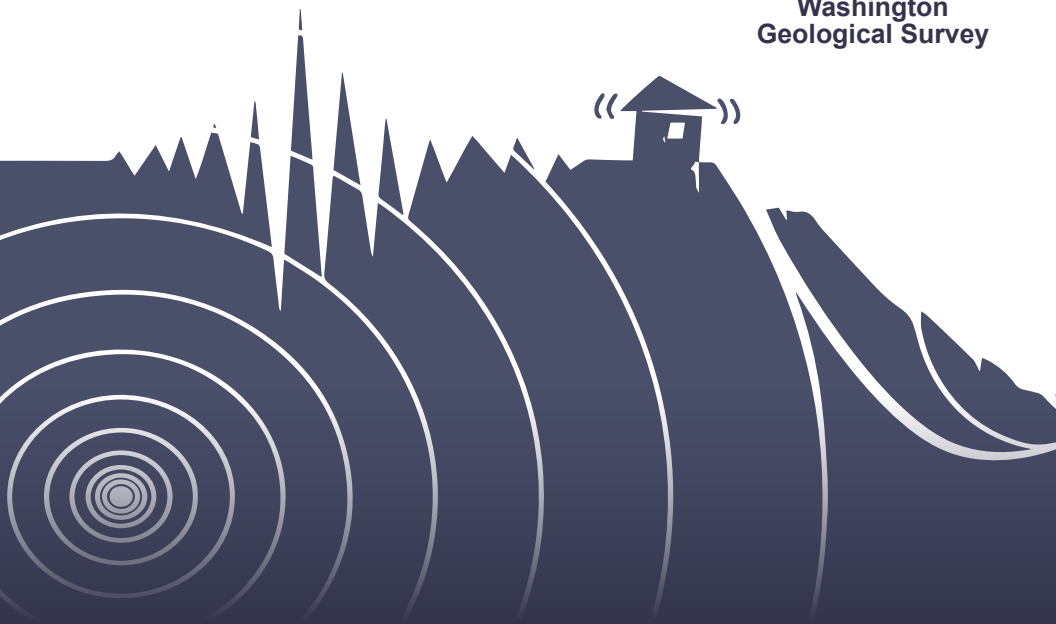


Protect Your Home and Property

A Homeowner's Guide to Earthquakes in Washington State



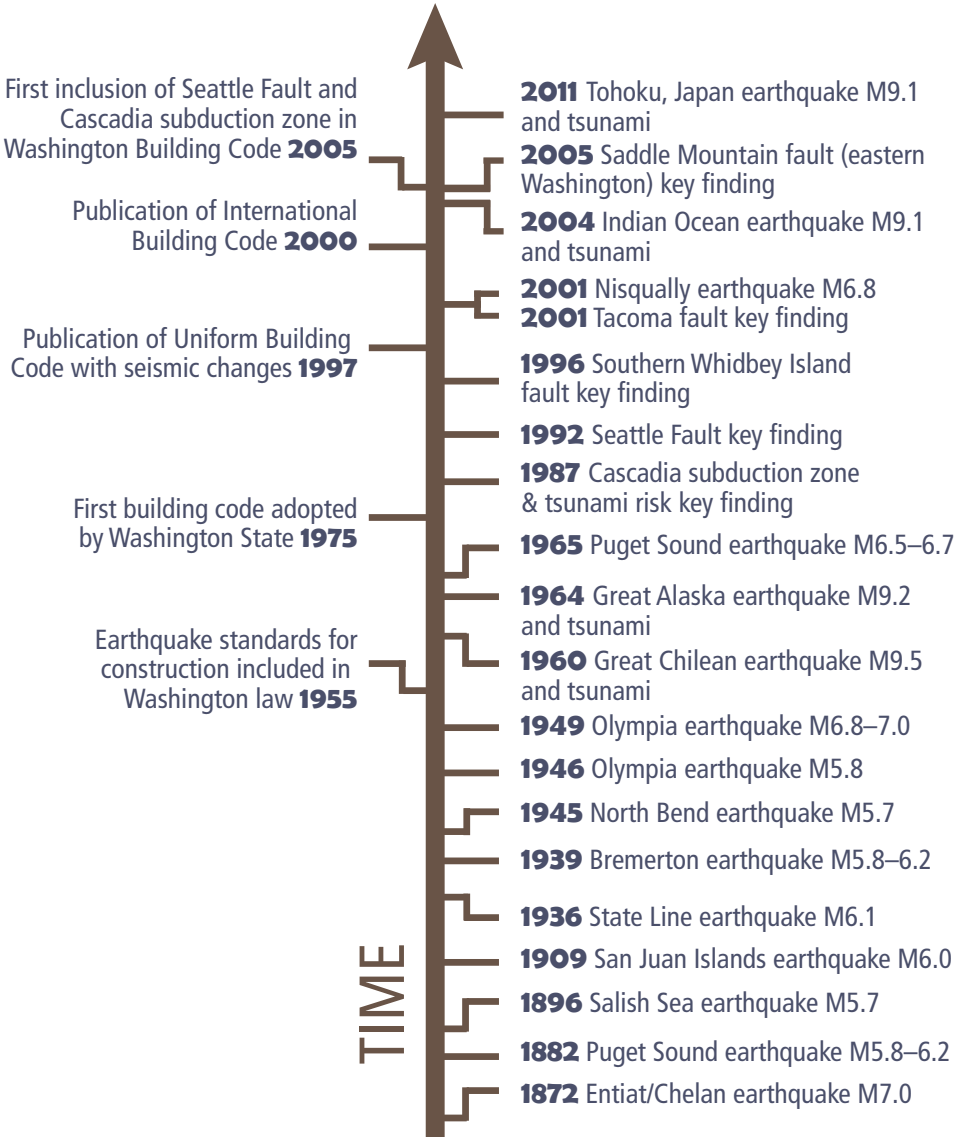
Washington
Geological Survey



**WASHINGTON STATE HAS ONE OF THE
HIGHEST **EARTHQUAKE RISKS** IN THE COUNTRY.
PREPARATION BEFORE A MAJOR EARTHQUAKE
MAY SAVE YOUR LIFE AND MAY
ALSO SAVE YOU MONEY.**

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Knowledge of earthquake hazards improves with scientific discovery of active faults and from case studies of seismic events. Updates to building codes accommodate the latest understanding of seismic hazard and advancements in earthquake engineering. **The building code used during the construction of your house may no longer be sufficient for currently known earthquake hazards.**



Timeline of earthquake building code changes (left) compared against significant earthquakes, key fault discoveries, and key publications (right).

INTENT OF THIS BOOKLET

This booklet provides homeowners with some guidance regarding earthquake hazards as they pertain to the home. It is meant to:

- introduce the types of earthquake hazards in Washington.
- point to maps and resources to assess the risks an earthquake may pose to your home.
- demonstrate that the structural and nonstructural components of your home can be fortified to withstand earthquake hazards.
- suggest ways to better prepare yourself, your family, and your property for an earthquake.

**NOTE:
THIS IS *NOT* A HOW-TO GUIDE**

Preparation is your greatest defense against earthquake hazards and damage. Though seismic retrofits address the main causes of collapse and life safety in a home, they do not ensure that a home will be undamaged. Damage to the interior of a home in a major earthquake may still occur, even with proper seismic retrofitting.

**LIMITATIONS OF THIS BOOKLET**

This booklet focuses on one- or two-family homes. Structures larger than two-family homes or taller than three stories are larger, heavier, more complex, and more vulnerable than single-family homes.

A professional engineer, licensed contractor, architect, and (or) local building official/permitting department can provide guidance on retrofits.

CONSIDER PURCHASING EARTHQUAKE INSURANCE

Check if your homeowner's insurance policy covers damage from earthquakes. If not, it might be worth the additional cost of an earthquake and (or) flood insurance policy. More information at: insurance.wa.gov/earthquake-insurance



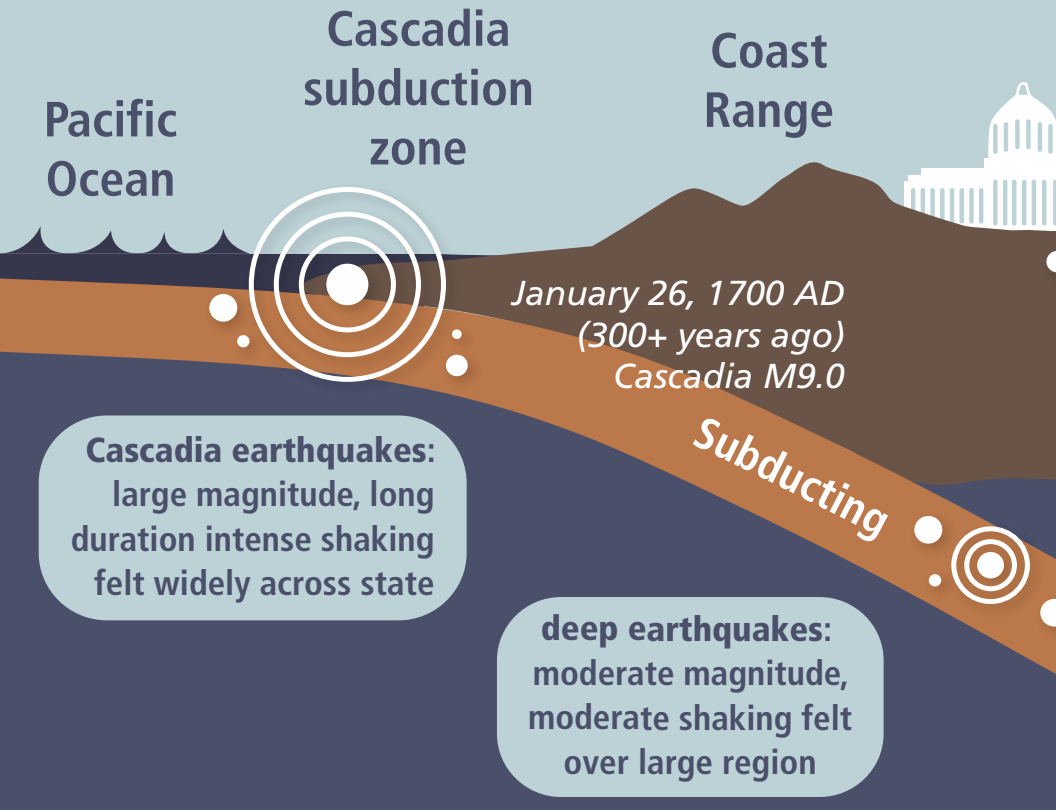
CONSIDER HIRING A PROFESSIONAL

While some people can do some seismic retrofits on their own, it may be preferable to hire a professional with experience. You may also want to contact a licensed geotechnical engineer and (or) engineering geologist to assess the potential for landslides, liquefaction, or earthquake ground shaking to affect your property.

The following resources may help in your decision to hire professionals to assess your property's seismic risk and the best methods to address that risk.

- **Washington State Department of Labor & Industries**
lni.wa.gov/licensing-permits/contractors/hiring-a-contractor
- **Washington State Department of Licensing**
dol.wa.gov/business/professionals.html
- **Seattle Department of Construction & Inspections**
seattle.gov/documents/Departments/SDCI/Forms/EarthquakeHomeRetrofitPlanset.pdf
- **Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings**
fema.gov/media-library/assets/documents/92229
- **Homebuilder's Guide to Earthquake-Resistant Design and Construction**
fema.gov/media-library/assets/documents/6015
- **Reducing the Risks of Nonstructural Earthquake Damage**
fema.gov/media-library/assets/documents/21405

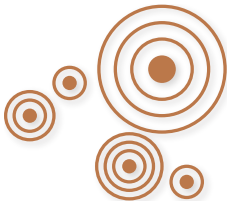
WEST



Cascadia earthquakes:
large magnitude, long
duration intense shaking
felt widely across state

deep earthquakes:
moderate magnitude,
moderate shaking felt
over large region

WHY EARTHQUAKES HAPPEN IN WASHINGTON

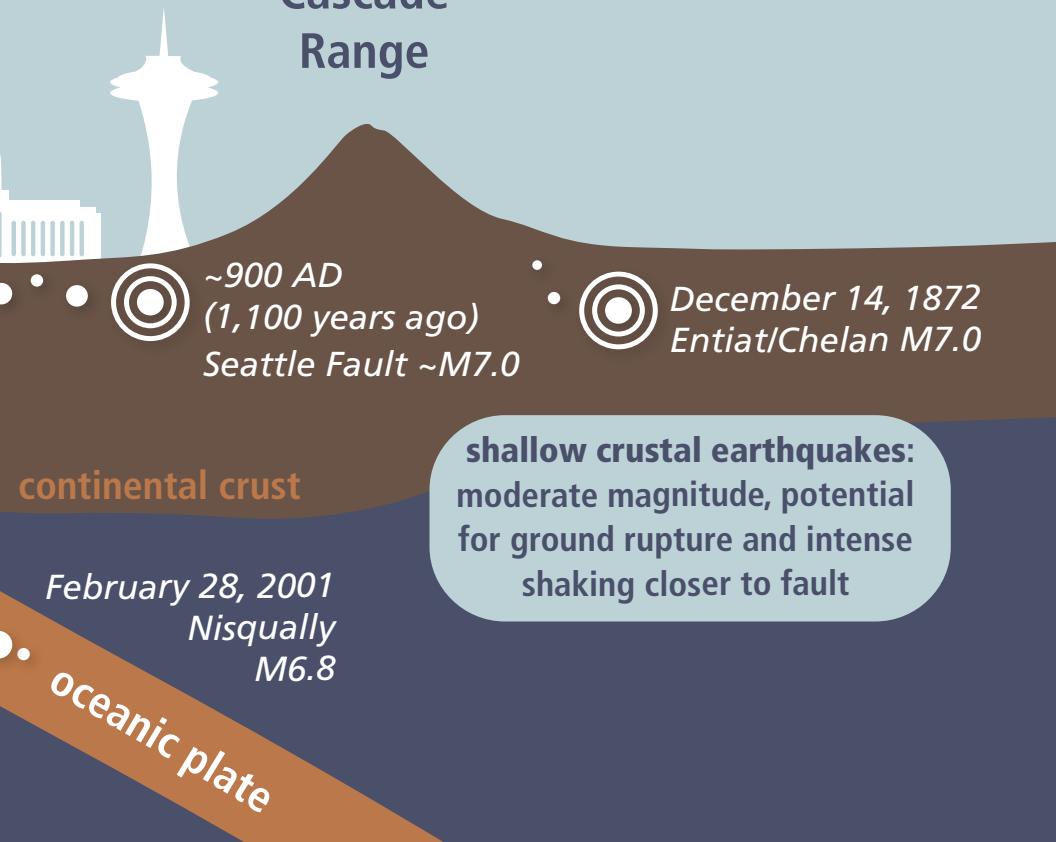


Just off the Washington coast is the Cascadia subduction zone (CSZ), a major tectonic plate boundary where oceanic crust is pulled beneath the North American continent. Subduction involves friction between tectonic plates. Right now, the CSZ is stuck, building up stress until the next big earthquake happens and releases it. As the subducting oceanic plate descends, it also bends and tears, which generates deep earthquakes like the 2001 Nisqually earthquake.

Near the surface of Washington State, shallow earthquakes occur along faults in the crust such as the Seattle and Entiat faults.

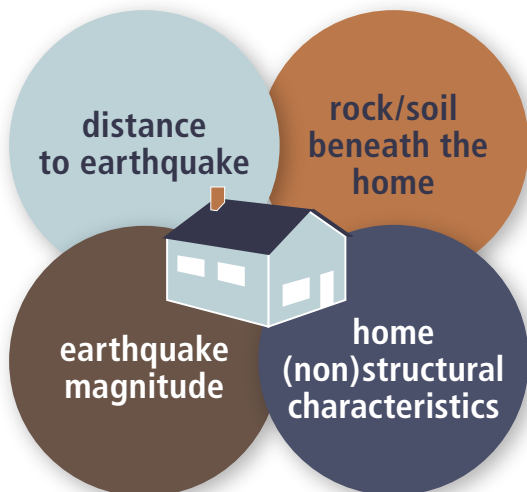
Cascade Range

EAST

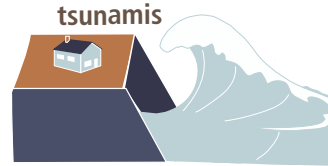
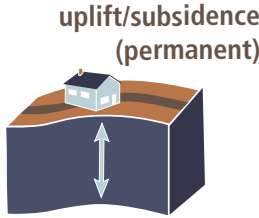
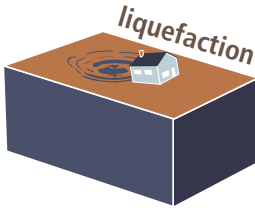
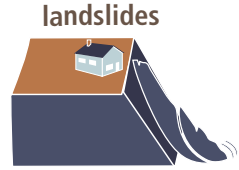
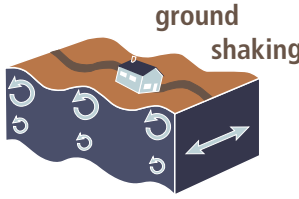
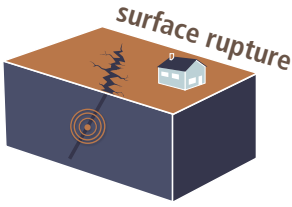


FACTORS AFFECTING EARTHQUAKE DAMAGE




Once an earthquake occurs, damage to a home depends on factors such as: the earthquake magnitude, its distance from your home, the rock/soil beneath your home, and your home's structural and nonstructural characteristics.

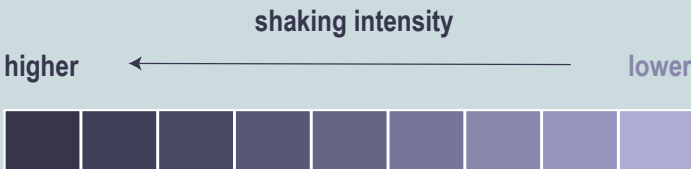


PRIMARY EARTHQUAKE HAZARDS IN WASHINGTON



The map to the right shows the maximum shaking intensity that has a significant chance of happening in the next 50 years.

-  tsunami hazard area
-  potentially active fault
-  damaging earthquake since 1871



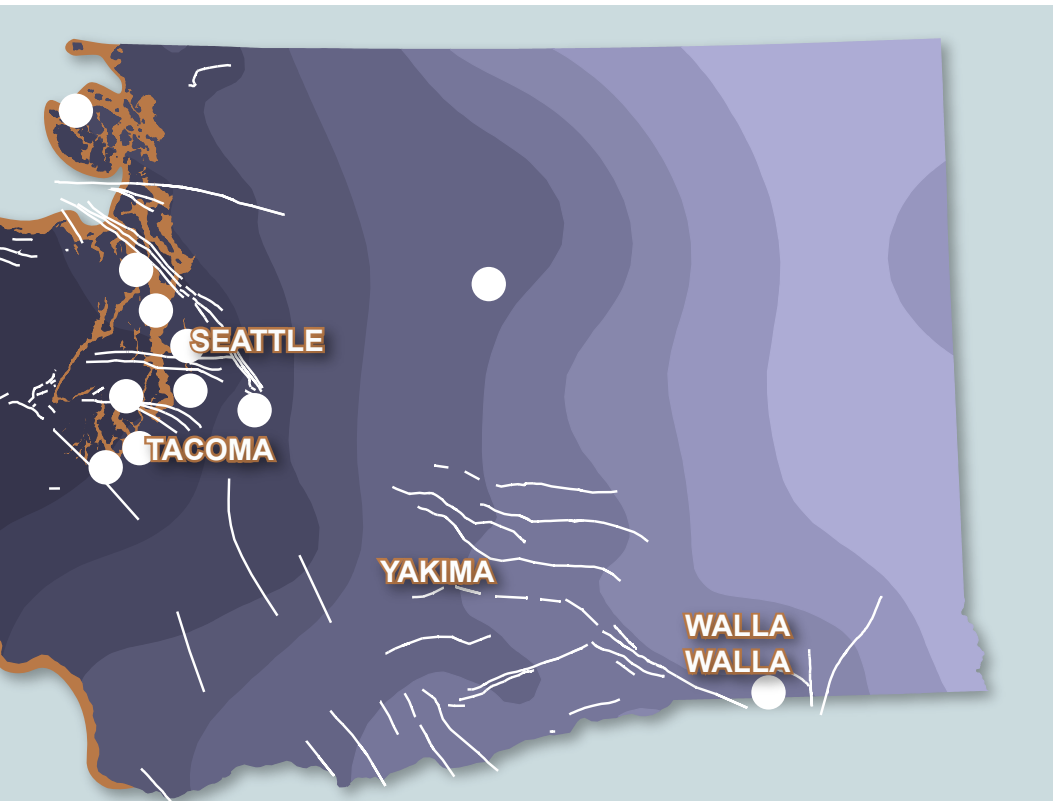
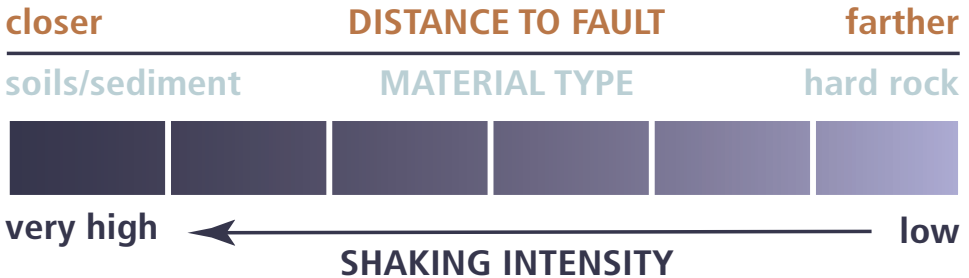
Cascadia subduction zone



GROUND SHAKING

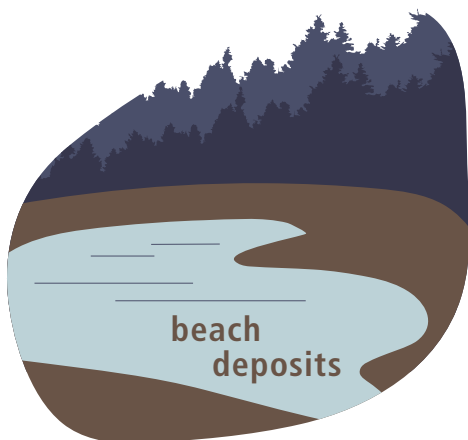
The closer you are to the fault along which an earthquake occurs, the more intense the shaking may be. Most of the known active faults in Washington lie close to population centers.

Ground shaking intensity depends partly on rock/soil type. Soft materials and loose soils common near bodies of water and formerly glaciated areas (for example, the Puget Sound region) amplify the shaking, whereas hard rocks shake less severely.



LIQUEFACTION

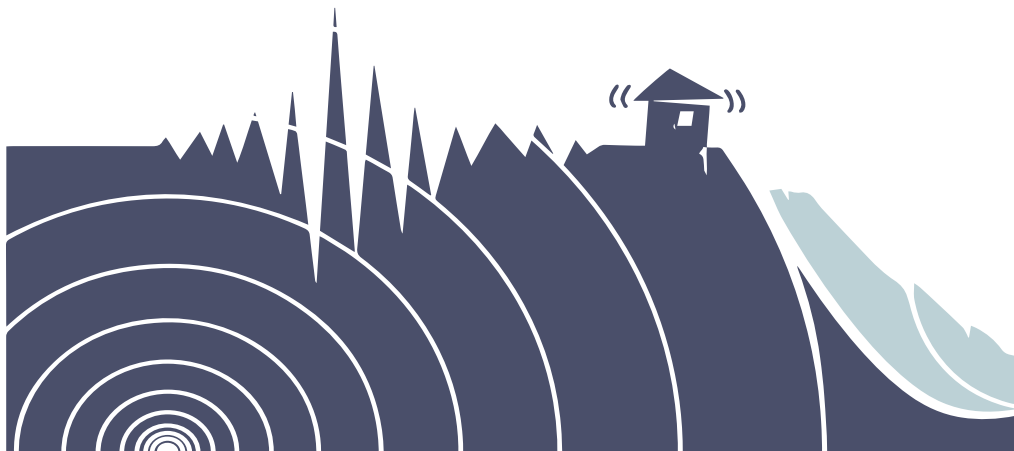
When ground shaking occurs in water-saturated sediment, the sediment can behave like a liquid (much like quicksand) which could cause damage to your home.



LANDSLIDES AND GROUND FAILURES

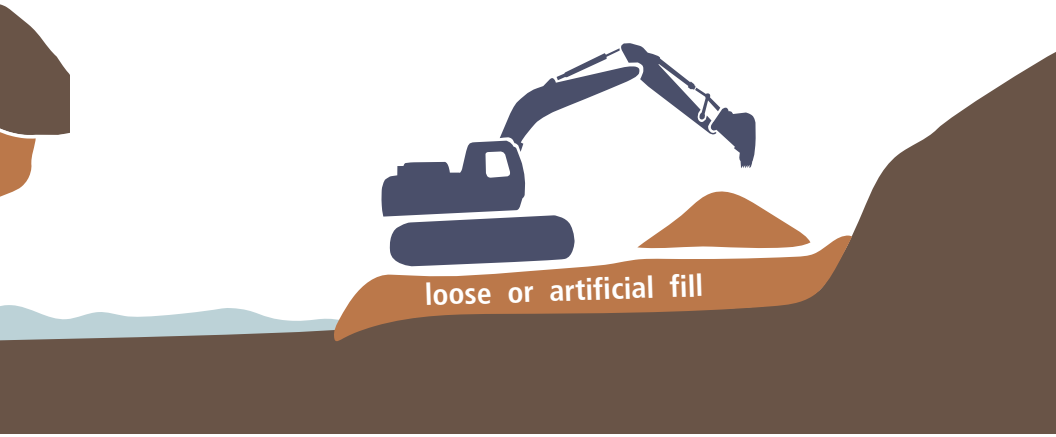
Ground shaking can also cause landslides and ground ruptures. Homes built on slopes or bluffs are at risk for earthquake-induced landslides. This is especially true if soils are saturated from rain.

Other ground failures can occur on gentle slopes due to soil liquefaction. Even small ground movements can disrupt utilities or make your home uninhabitable.



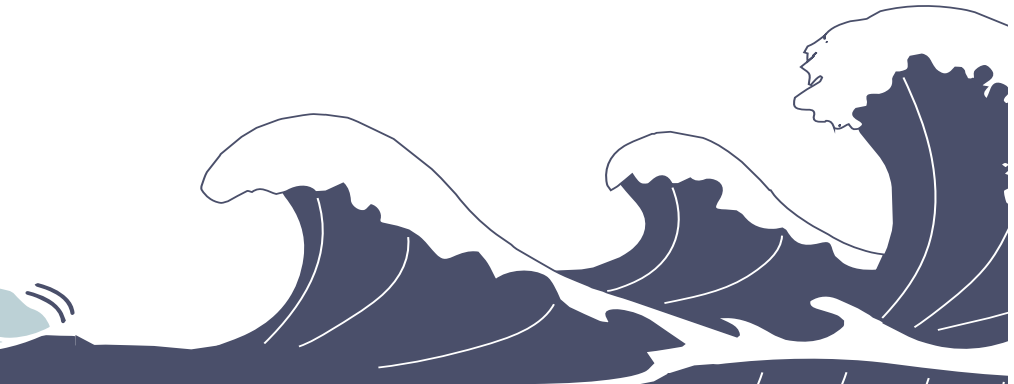
Find out what type of material sits beneath your home and its liquefaction potential. Check the Geologic Information Portal for maps showing liquefaction potential: https://geologyportal.dnr.wa.gov/#natural_hazards

Artificial fill, beach sand, dunes, river deposits, and relatively young sediment are especially susceptible to liquefaction.

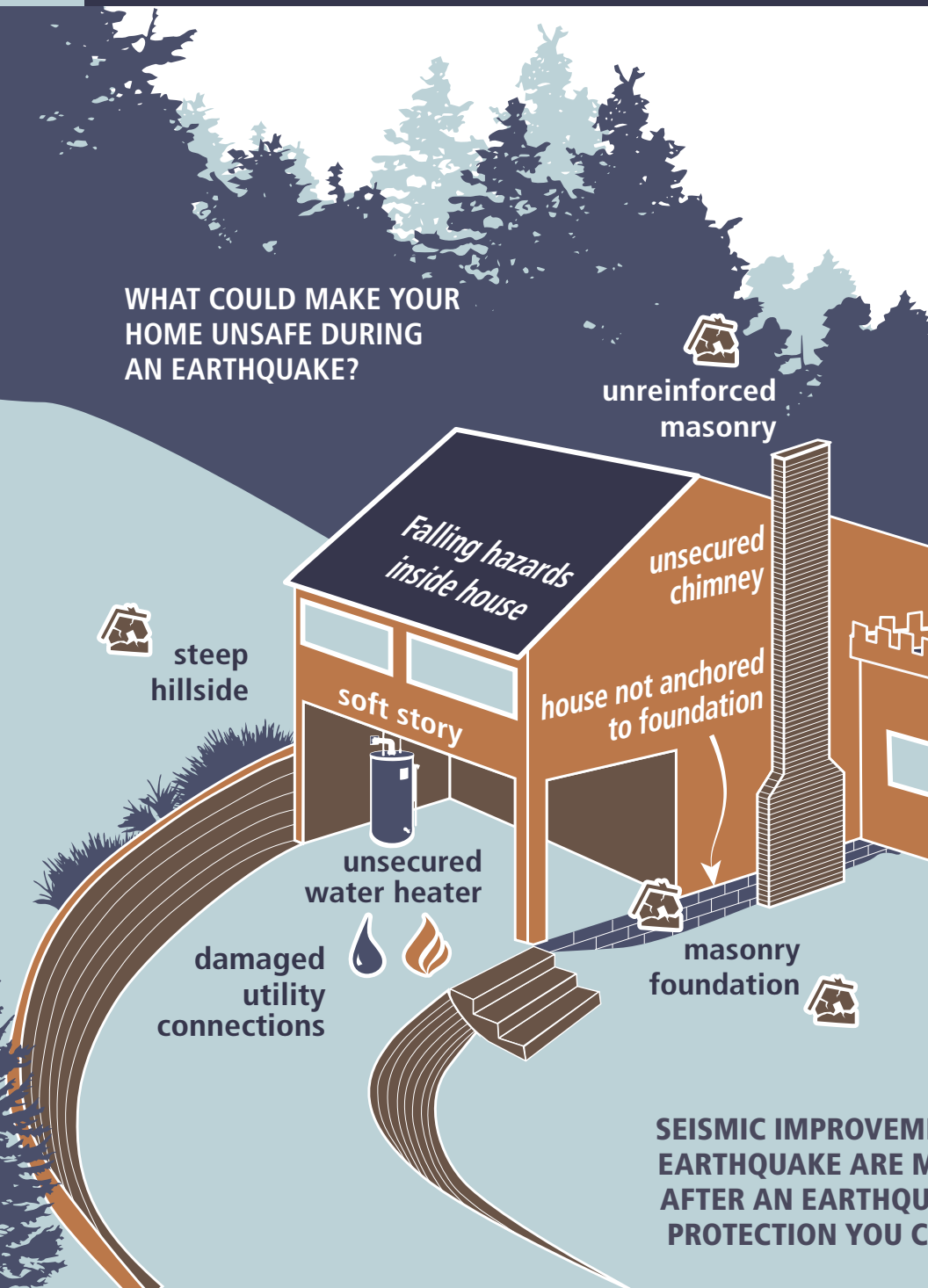


TsunamiS

Following a large earthquake, areas along the outer coast, the lower Columbia River, and Puget Sound are at risk for tsunamis. Local earthquakes can produce tsunamis within a short period of time. A distant earthquake will not produce ground shaking but may produce a tsunami. If you feel the ground shake, drop, cover, and hold on. If you are near the water, evacuate to higher ground or inland immediately once the shaking stops.

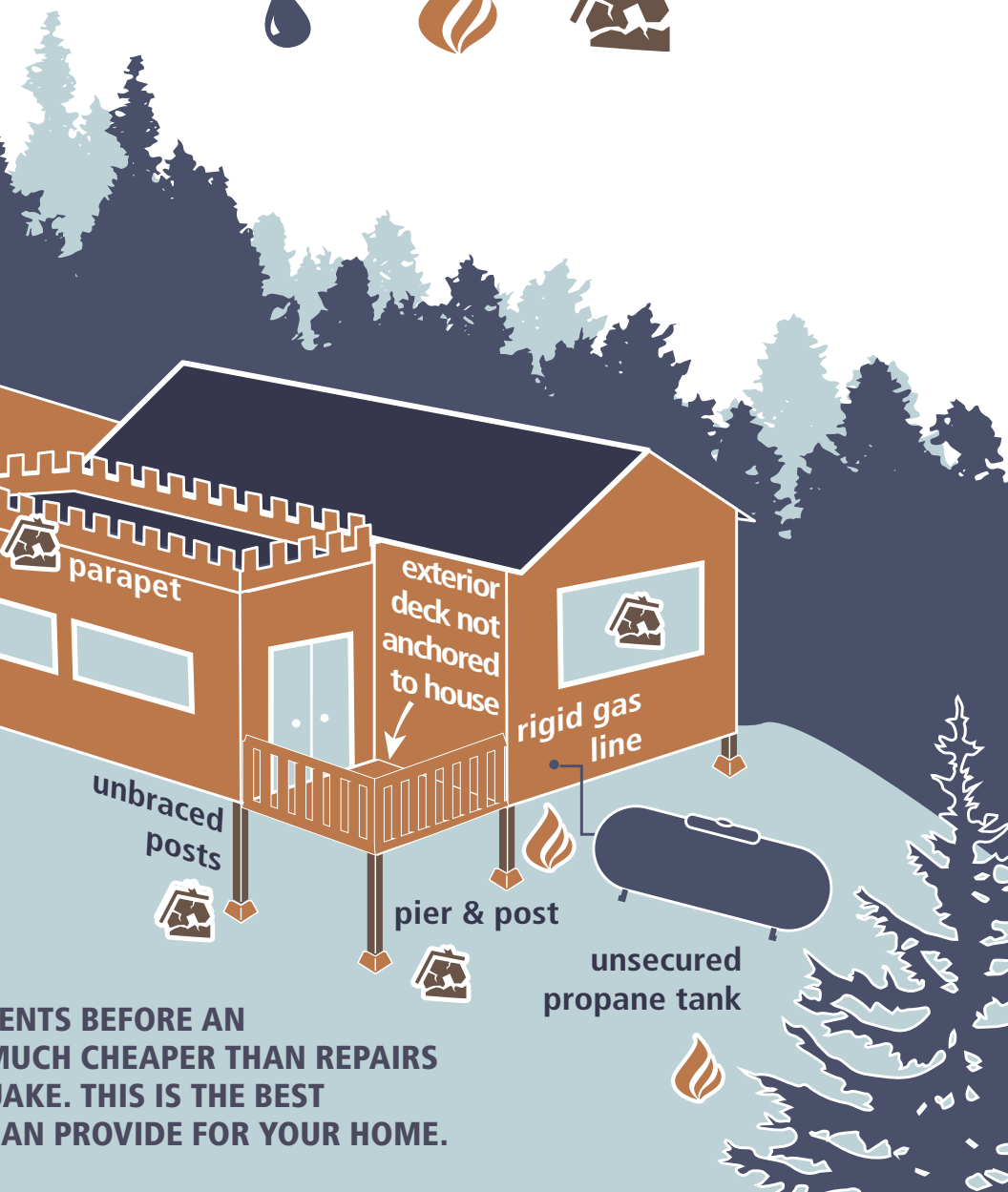


WHAT COULD MAKE YOUR HOME UNSAFE DURING AN EARTHQUAKE?



**SEISMIC IMPROVEMENTS
AFTER AN EARTHQUAKE
PROTECTION YOU CAN**

UNREINFORCED CONSTRUCTION WILL NOT FARE WELL DURING AN EARTHQUAKE, POSSIBLY CAUSING FLOODING, FIRE, OR STRUCTURAL DAMAGE.



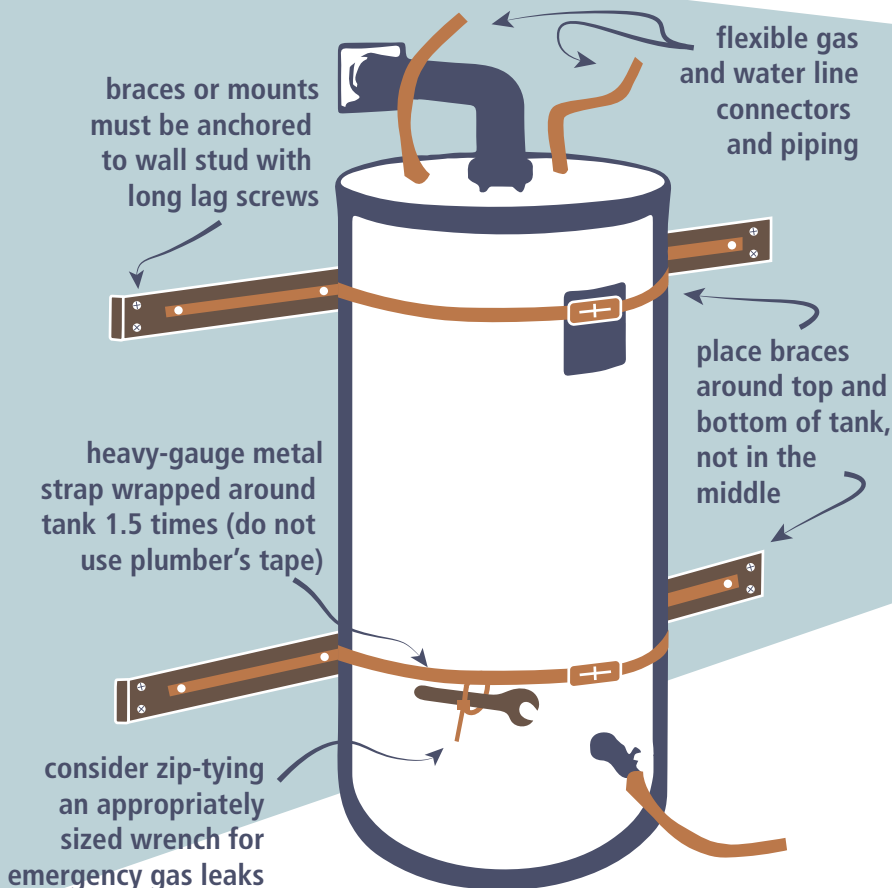
PREVENTIONS BEFORE AN EARTHQUAKE ARE MUCH CHEAPER THAN REPAIRS AFTER AN EARTHQUAKE. THIS IS THE BEST WAY TO PROVIDE FOR YOUR HOME.

WATER HEATERS**WEAKNESS:**

Your free-standing and unsecured water heater is one of the most unstable appliances in your home. During ground shaking it is apt to topple, causing broken gas and water lines, flooding, and (or) fire.

**REINFORCEMENT:**

Ensure your water heater stays put with a water-heater bracing kit, available at your local hardware store. Or build your own. **Make sure all family members know how to turn gas and water off** in the event of a leak. A heater that remains upright can be a potable water source should utilities be interrupted.



PROPANE TANKS

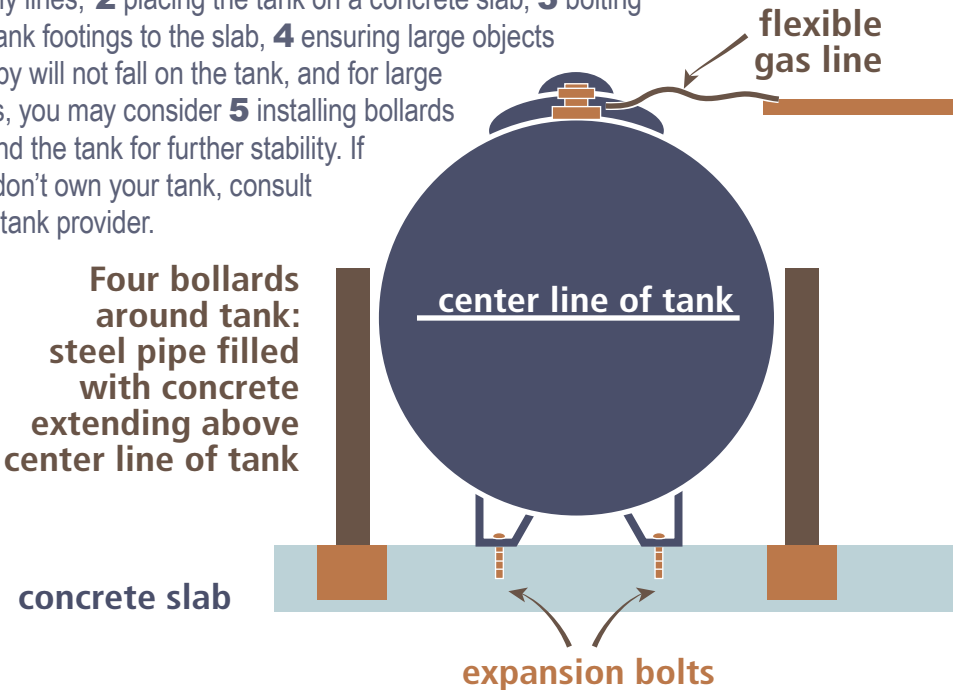
WEAKNESS:

During an earthquake, unsecured propane tanks with rigid supply lines may tip over and break their connections, causing fire. You might want to purchase and install an automatic gas shut-off valve.



REINFORCEMENT:

Keep your propane tank stable and connected by: **1** using flexible gas supply lines, **2** placing the tank on a concrete slab, **3** bolting the tank footings to the slab, **4** ensuring large objects nearby will not fall on the tank, and for large tanks, you may consider **5** installing bollards around the tank for further stability. If you don't own your tank, consult your tank provider.



WOOD STOVES**WEAKNESS:**

Another cause of fire after earthquakes are free-standing wood stoves that are not anchored to the ground.

**REINFORCEMENT:**

There are several inexpensive ways to make your wood stove more secure:

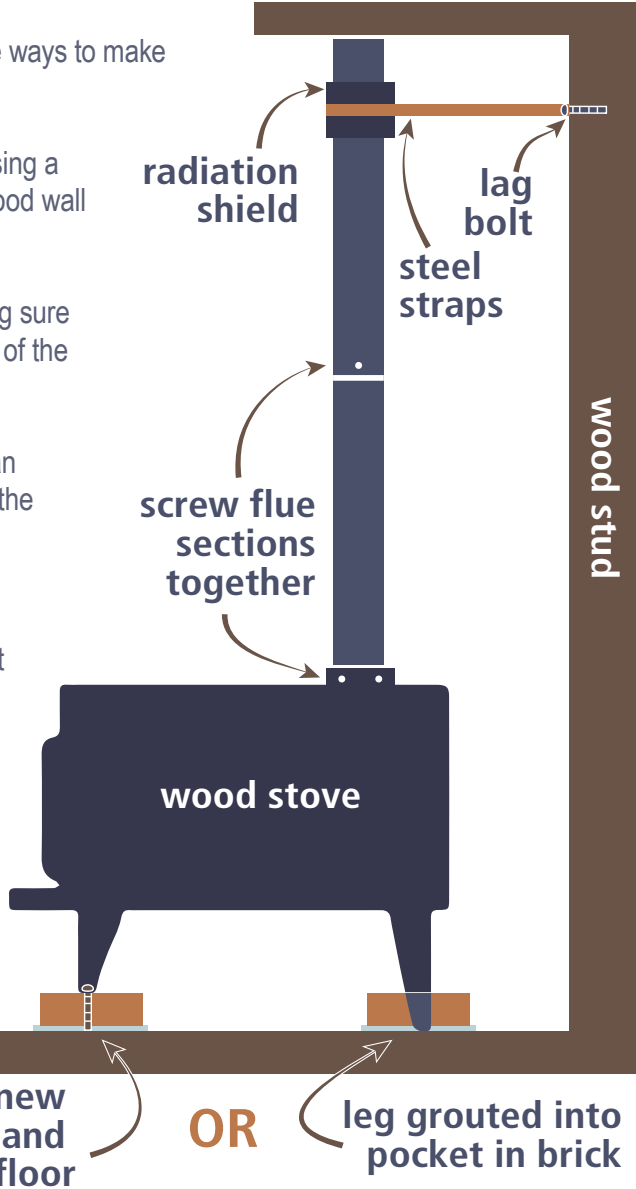
1 secure straps to the flue using a radiation shield and affix to wood wall stud with lag bolt,

2 attach flue sections, making sure not to penetrate the inner wall of the pipe, and either

3 bolt legs of stove through an added brick that is grouted to the floor,

OR

4 anchor the legs using grout placed in a pocket in brick.



TALL AND HEAVY EQUIPMENT

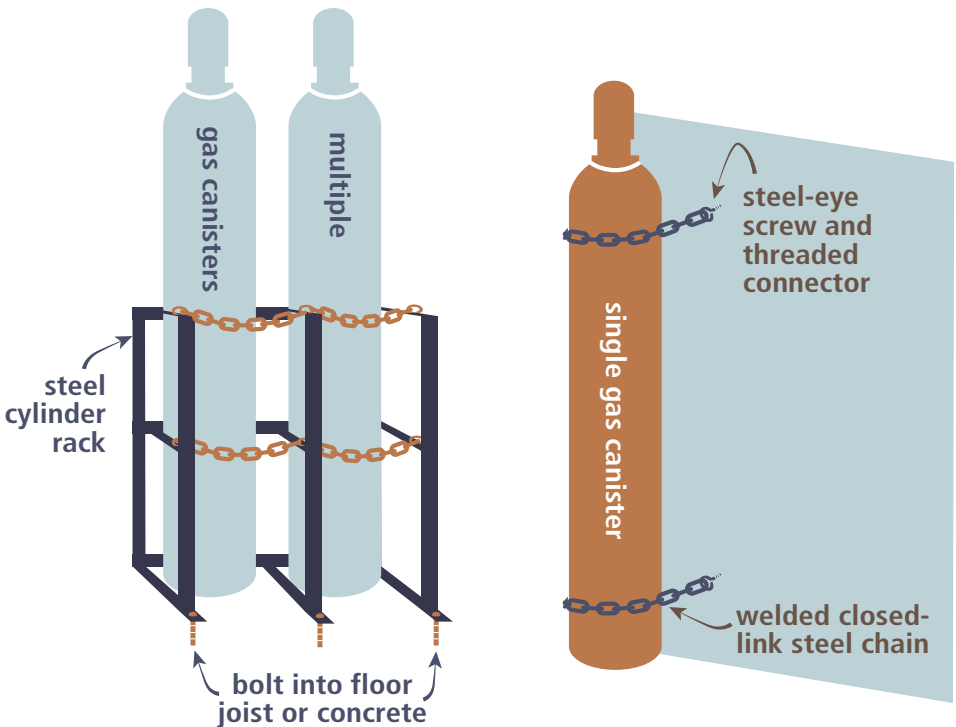
WEAKNESS:

Unsecured tall, heavy equipment such as compressed gas cylinders may topple or become projectiles during an earthquake. These can also be punctured causing explosions and fires.



REINFORCEMENT:

To secure one gas cylinder, use steel eye screws, connectors, and chain to hold the cylinder against a wall, making sure to connect to a wall stud. This type of fastening is insufficient to secure two or more cylinders. Instead, use a prefabricated gas cylinder rack that will hold several cylinders and ensure that it is bolted to the floor and wall, if possible.



SMALLER ITEMS: FURNITURE AND VALUABLES**WEAKNESS:**

Damage or injury from unsecured belongings, especially those that may fall from inside cabinets/shelves.

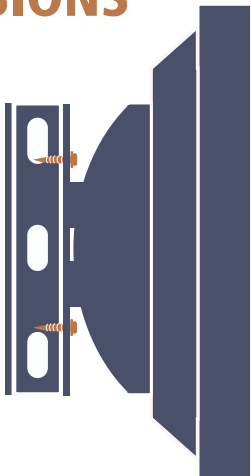
REINFORCEMENT:

Many items in the home can be secured to prevent toppling during an earthquake, which may block exits or cause injury. Securing these items also prevents them from breaking and needing to be replaced. The following methods are possible solutions using materials that can be obtained at your local hardware store.

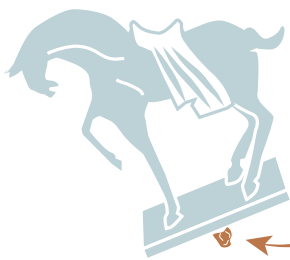
BOOKS
(also v
on refriger

TELEVISIONS

sheet
metal
screws
attached
to braced
wall
studs

**COMPUTERS**

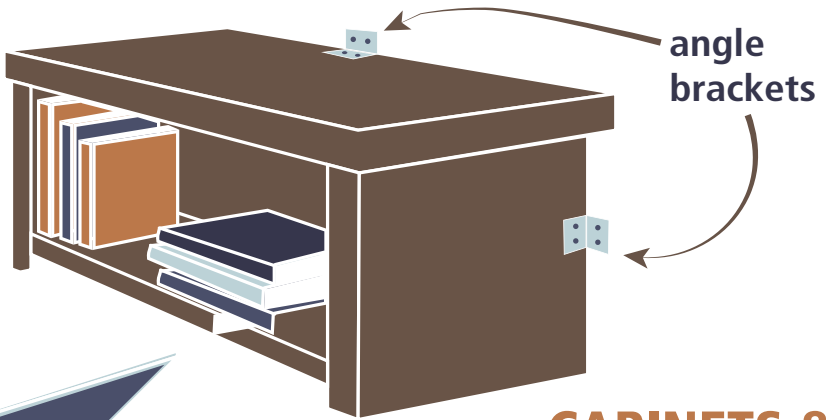
nylon
straps
buckles

**SMALL
OBJECTS**

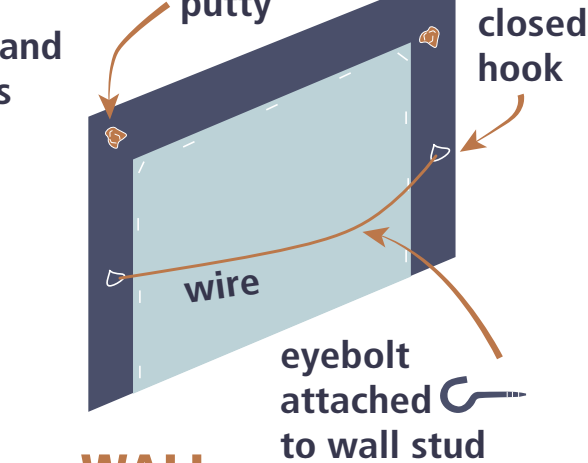
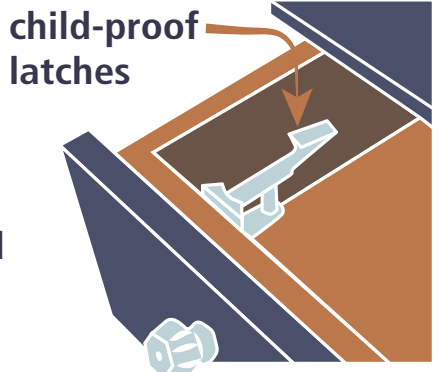
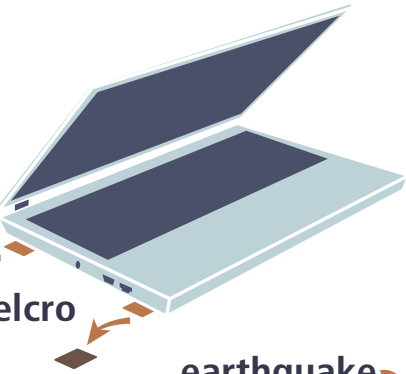
earthquake putty



CASES
(works
ators)



CABINETS & DRAWERS



WALL HANGINGS

rubber mats on shelves



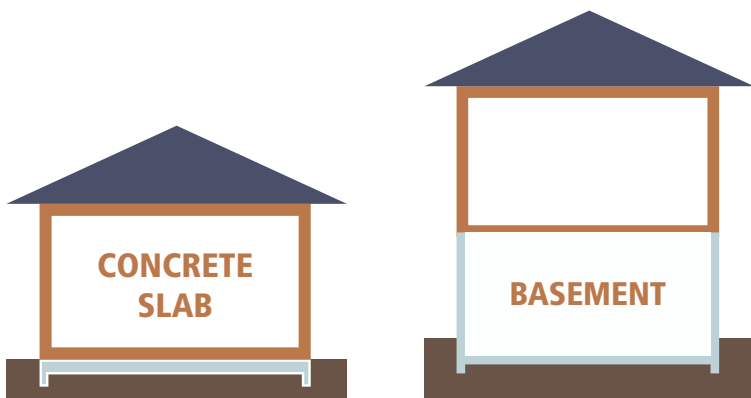
FOUNDATIONS

Foundations are the critical connection between your living space and the ground, and during an earthquake the type of foundation may determine if your home remains standing. For this reason, it's important to know exactly what kind of foundation you have beneath your home and what condition it is in.



CONCRETE SLABS AND BASEMENTS

Slab foundations and basements usually consist of a masonry or concrete structure upon which the house is directly placed. As long as the slab is in good condition (no cracks or sagging) and the house is adequately bolted or strapped to the slab, houses with these types of foundations **generally perform well during earthquakes**.



UNREINFORCED MASONRY

Foundations built from bricks, concrete blocks, or mortared stone **often fail during earthquakes**. Have a licensed engineer check to see if your masonry has been reinforced. Options for reinforcement include strengthening or replacing with a concrete foundation.

POST & PIER

Though not common, post and pier foundations are **extremely vulnerable to collapse during earthquakes** if not properly braced. Contact a professional engineer to evaluate your home if you have this type of foundation. Some homes may be made safer by bracing the posts and using pier bolts, but you may be better served by adding a brand new foundation.



CAISSONS

This type of foundation involves all or part of a house elevated above concrete piers embedded in the ground. If the piers reach bedrock, they pose little hazard. But if the piers rest in unconsolidated material, **earthquake movement may seriously compromise the structure of the home.**

Contact a professional engineer to evaluate your home if you have this type of foundation. Some homes may be made safer by bracing the posts.



SOFT STORIES

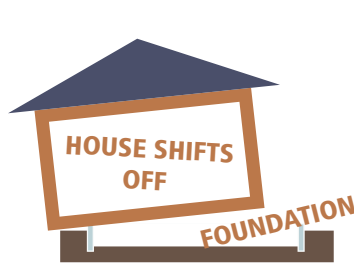
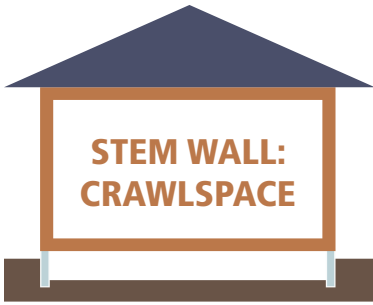
Soft stories are floors in a multi-story building that are largely unsupported by shear walls that prevent horizontal shaking. Garages, large bay windows, and wide doors are all good examples of this type of structural weakness. Houses with soft stories are **vulnerable to collapse.**

Soft stories may be made more rigid by structural reinforcement. Contact a professional engineer to evaluate the best retrofit method for your home's design and your budget.



more foundations on the next page

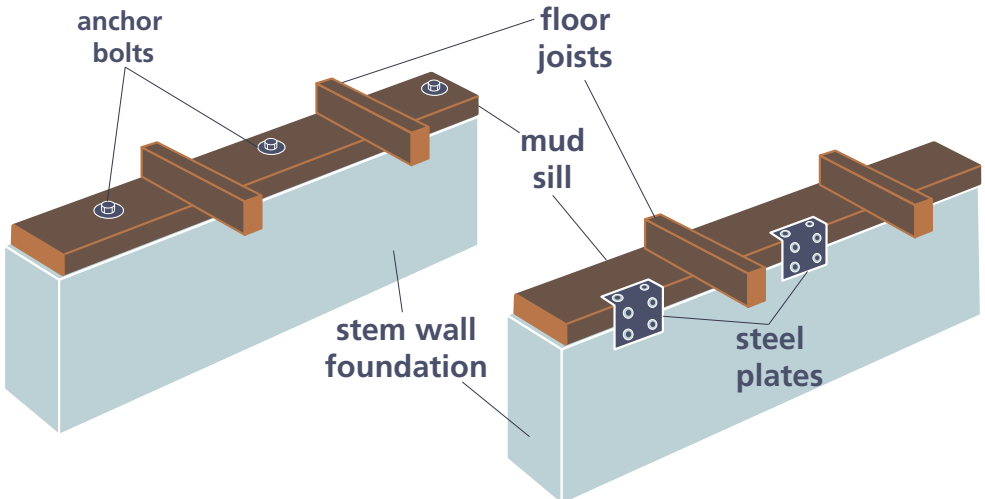
STEM WALLS

**WEAKNESS:**

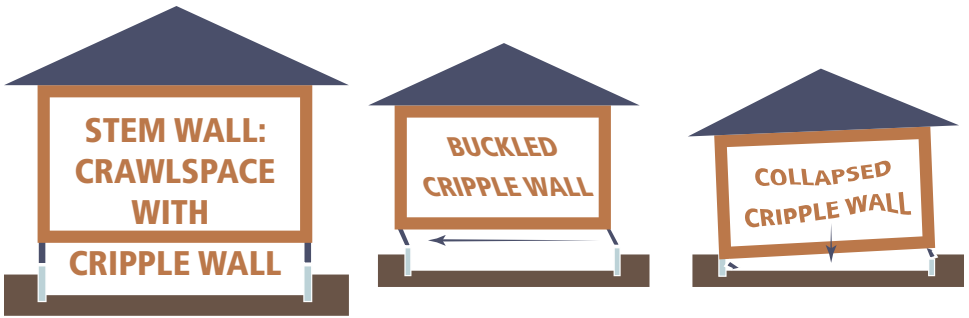
These foundations consist of short walls made of poured concrete on which the wood frame of the house rests. The only weakness of concern with these types of foundations is that the wood frame of the house must be bolted or anchored to the stem walls. Otherwise, during an earthquake, the house could shake right off its foundation. Many older houses are not bolted to their foundations.

REINFORCEMENT:

The good news is that a handy homeowner could retrofit this type of foundation on their own, and it's MUCH cheaper to have the stem wall anchored to the house than to have to replace the foundation after an earthquake moves it. It's possible to do these retrofits yourself, but a professional engineer and (or) contractor can navigate other issues inherent in older construction.



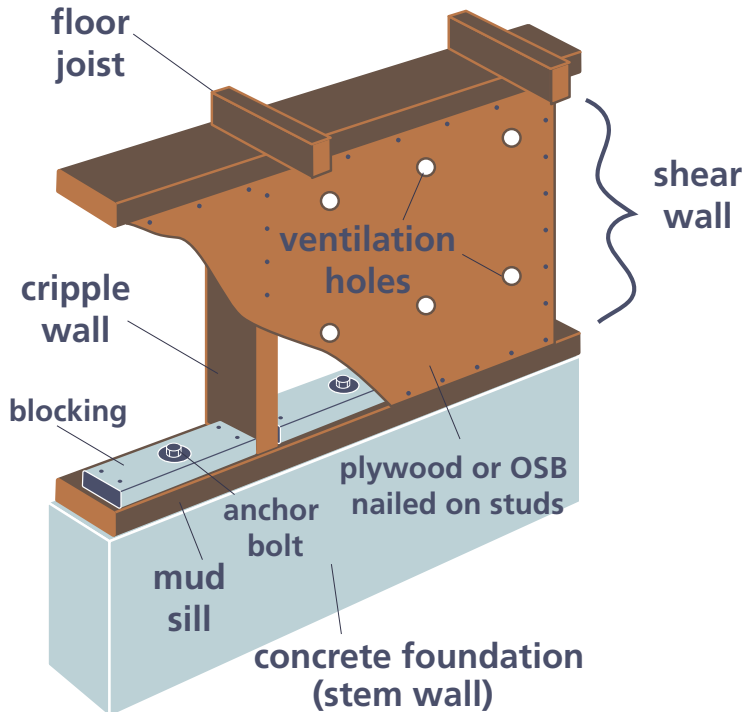
STEM WALLS WITH CRIPPLE WALLS

**WEAKNESS:**

Cripple walls are vertical wood frames that rest on the stem wall and lie beneath the floor of the house. These exterior foundations support the weight of the house. Without proper reinforcement, however, these walls buckle or collapse during horizontal shaking during earthquakes. Older houses may not have the required shear walls installed to protect against collapse.

REINFORCEMENT:

Reinforcing cripple walls involves installing plywood or Oriented Strand Board (OSB) shear walls. Reinforcement is likely too advanced for most homeowners. A professional engineer and (or) contractor with experience doing this type of work is recommended.



CHIMNEYS

WEAKNESS:

Unreinforced masonry chimneys may crumble or topple during an earthquake, posing a hazard to roofs, people, and nearby vehicles. These chimneys tend to break at the roofline or peel away from the house, and the likelihood of breakage increases with chimney height. Check the grout between the brick or stones by picking at it with a knife. It should not crumble.



REINFORCEMENT:

- Replace masonry chimneys above the roofline with lighter metal flues that may be veneered to match the lower brickwork.
- Add plywood above the ceiling joists in the attic or layer additional plywood directly beneath the roof shingles near the chimney to prevent any collapsing brickwork from damaging the interior of the home.
- Reinforce the masonry with additional anchorage at each floor, roof, and ceiling to meet design standards.

PARAPETS

WEAKNESS: Parapets are low walls along the edges of roofs or balconies. Older unreinforced masonry designs are typically unbraced—during an earthquake they can fall apart, damaging the house and possibly causing injury.

REINFORCEMENT: The materials used to construct the parapet determine the method used to brace them. Contact a professional engineer to evaluate your parapet.



STEEP HILLSIDES

**WEAKNESS:**

Steep hillsides either uphill or downhill from your home may fail during an earthquake

REINFORCEMENT:

Retaining walls, groundwater control, or regrading can provide extra stability to soil and control excess water flow

See our [homeowner's guide to landslides](#) for more on slope stability. There are also numerous types of retaining walls (a few are shown below). Contact a professional engineer to design retaining walls to fit your slope and your budget.

counterfort wall



gravity wall



pile wall



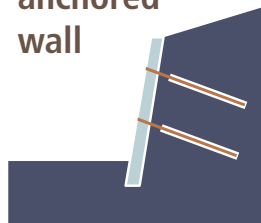
gabion wall



cantilevered wall



anchored wall



WHAT TO DO

BEFORE AN EARTHQUAKE

Prepare emergency kits for your home, automobile, and work



DURING AN EARTHQUAKE



**DROP TO THE FLOOR,
AWAY FROM OBJECTS
THAT MAY TOPPLE**



**TAKE COVER
BENEATH LARGE,
STURDY FURNITURE**



**HOLD ON UNTIL THE
SHAKING SUBSIDES**

There are instructions for what to do during an earthquake for persons with limited mobility: shakeout.org/graphics/index.html#dcho

If you are outside during an earthquake, move out into the open and avoid anything that might fall on you, including buildings, chimneys, trees, light posts, and power lines.

AFTER THE SHAKING SUBSIDES

- If you are near water, grab your go bag and move to high ground or inland immediately!
- Check yourself and others for injuries, and apply basic first-aid if needed
- Move away from unsafe areas
- Follow your family/business/agency/organization emergency plan/instructions
- Expect aftershocks

WHAT SHOULD I HAVE IN MY EMERGENCY KIT?

You should prepare an emergency kit with a two-week supply of necessary items for each member of your family, including pets. The kit should be adapted to your needs. Have a go-bag ready for immediate evacuation. Develop a plan with your family and practice it. Possible supplies include:

The infographic features a central dark blue circle labeled "EMERGENCY KIT" with a white outline of a person's head and shoulders. Surrounding this central hub are various icons representing emergency supplies, each with a text label. The items include: a fork, a cooking pot with a lid, and a spoon; a water bottle with "H₂O" on it; a first-aid kit, sunglasses, and a first-aid kit icon; a folder labeled "Important documents"; cash, a cell phone, and portable chargers; dental and personal hygiene items like soap, a toothbrush, and a roll of paper; plastic bags for storage and waste; clothes and shoes like a jacket and boots; a sleeping bag and tent; maps showing safe routes to high ground; pet food and supplies like a can of cat food and a bowl; baby supplies and diapers like a baby bottle, a pacifier, and a diaper; a radio, headlamp/flashlight, and batteries; matches, a pocket knife, duct tape, a whistle, and gloves.

Non-perishable food and cooking and eating utensils, including can opener

Water and a water purification kit

First-aid kit, medication, and glasses

Important documents

Cash, cell phone, and portable chargers

Dental and personal hygiene items

clothes and shoes

EMERGENCY KIT

Plastic bags for storage & waste

sleeping bag & tent

Maps showing safe routes to high ground

Pet food and supplies

Baby supplies and diapers

Radio, headlamp/flashlight, and batteries

matches

duct tape

pocket knife

whistle

gloves

For More Information

WASHINGTON GEOLOGICAL SURVEY

Earthquakes and Faults

<http://www.dnr.wa.gov/earthquake>

The geology beneath your home:

Geologic Information Portal

<https://www.dnr.wa.gov/geologyportal>

INSTITUTE FOR BUSINESS & HOME SAFETY

A Homeowner's Guide to Earthquake Retrofit

<http://www.disastersrus.org/emtools/earthquakes/earthquake.pdf>

CENTERS FOR DISEASE CONTROL & PREVENTION

Earthquakes

<https://www.cdc.gov/disasters/earthquakes/>

FEDERAL EMERGENCY MANAGEMENT AGENCY

Earthquake Safety at Home

<https://www.fema.gov/earthquake-safety-home>

READY.GOV

Earthquakes

<https://www.ready.gov/earthquakes>



WHO CAN I CONTACT FOR MORE INFORMATION?

WASHINGTON GEOLOGICAL SURVEY

360.902.1450

www.dnr.wa.gov/geology



WASHINGTON STATE DEPT OF

**NATURAL
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WASHINGTON
GEOLOGICAL SURVEY

WASHINGTON MILITARY DEPARTMENT

1.800.562.6108

<http://www.mil.wa.gov/earthquake>

