

Part 3

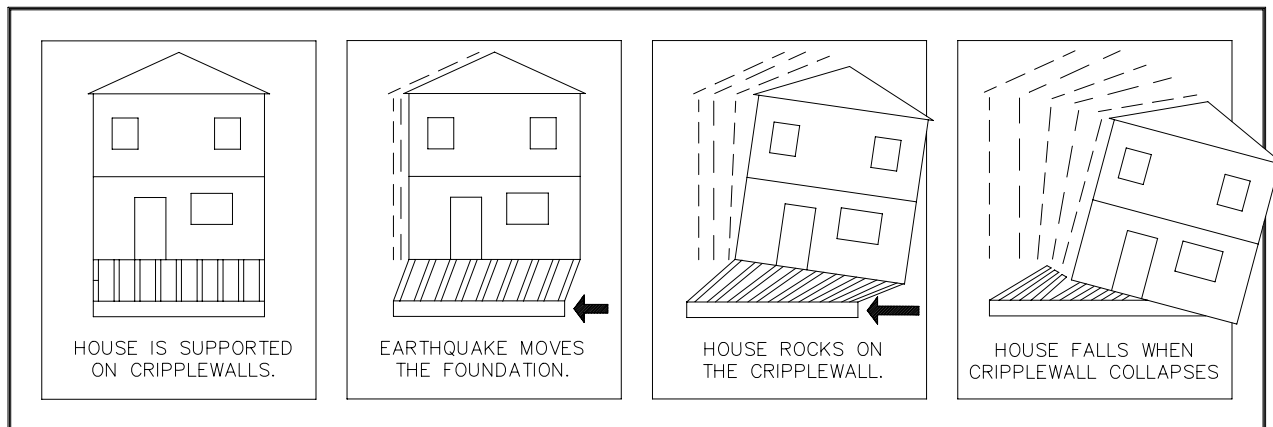
Understanding Your Retrofit



If you have a home built before 1945 it probably has a structural weakness called a cripple wall. This is a wall between the foundation and your floor.



A typical cripple wall seen from the outside
Photo courtesy Summerfield Inspections, Berkeley



A cripple wall will collapse during a large earthquake if it is not retrofitted with a shear wall.



This house in Watsonville fell off its foundation because the cripple walls collapsed in the 1989 Loma Prieta earthquake. This would not have happened if the cripple walls had been retrofitted.



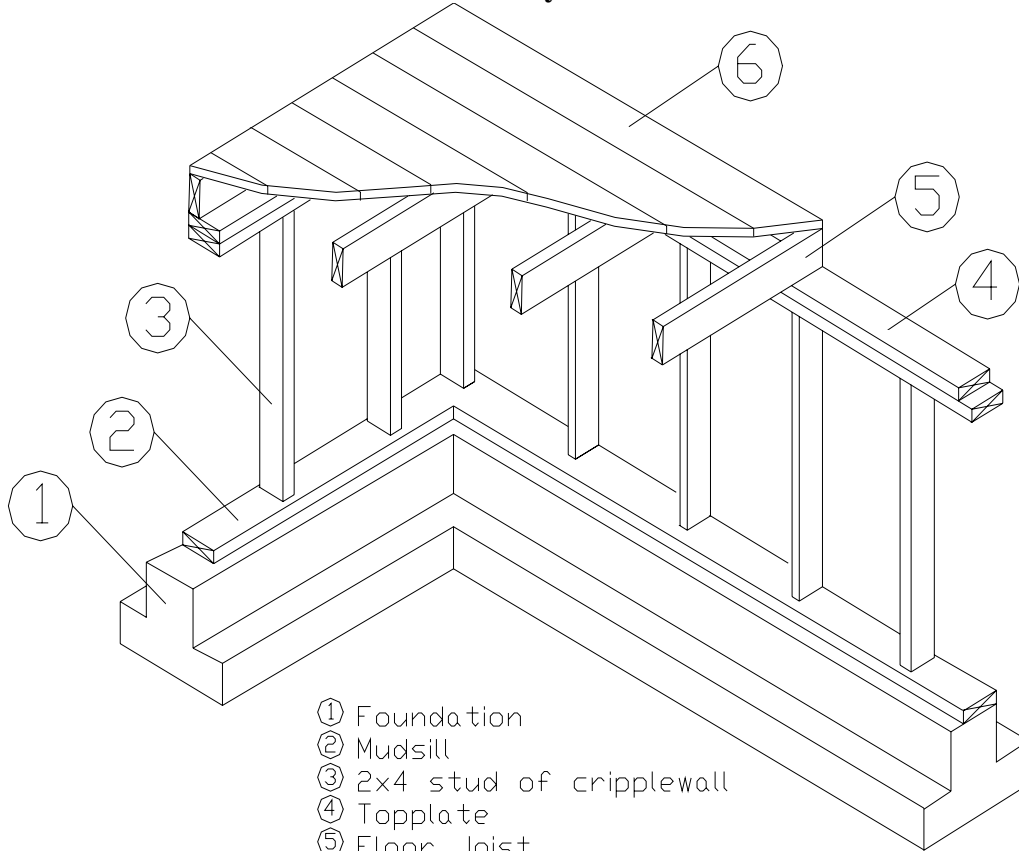
Example 1: Cripple wall failure; notice the location of the steps relative to the floor.



Example 2: Cripple wall failure where the floor shifted to the right..

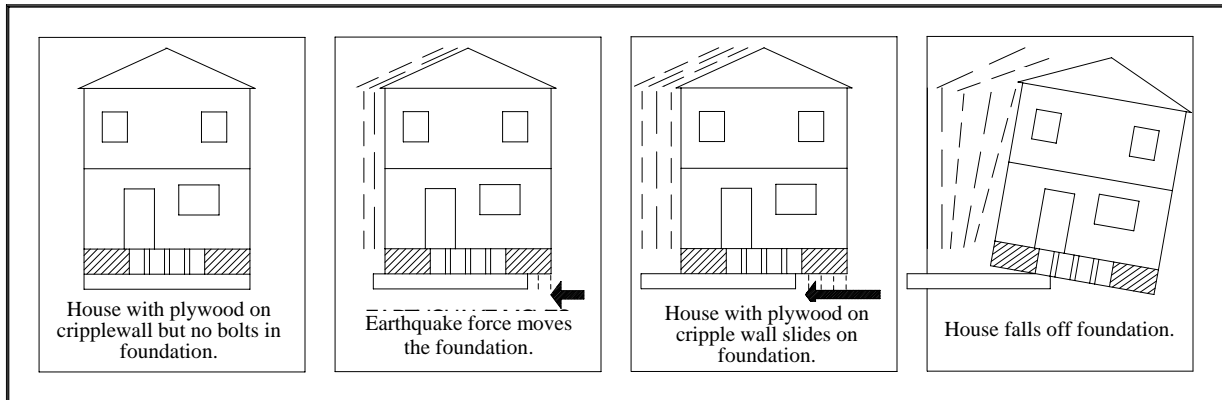
The house on the left has fallen from its foundation but is otherwise intact. This house in Ferndale California suffered extensive interior damage and needed to be torn down. This damage would have been avoided if it had been retrofitted.

Glossary of useful terms

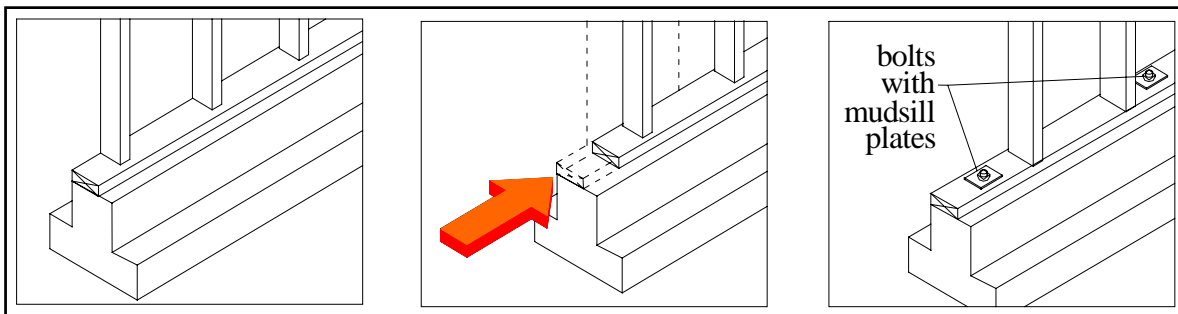


- ① Foundation
- ② Mudsill
- ③ 2x4 stud of cripplewall
- ④ Topplate
- ⑤ Floor Joist
- ⑥ Floor you walk on

Bolt House to Foundation



This is what happens when a house is not bolted to the foundation.



The arrow represents the earthquake force moving the bottom of the cripple wall. The third frame shows the bolts that prevent this movement.

Structural engineers in Southern California discovered that bolts bent in earthquakes and that this split the mudsill. These same engineers discovered that plate washers as shown below prevent this from happening.



Bolt with plate washer



Bolt with plate washer passing through mudsill and into foundation.

Install Mudsill Plates



These engineers also discovered that mudsills often split because when the earthquake force pushed on the mudsill against the bolt, the wood was much softer than the bolt or the concrete. They developed a special type of washer called a mudsill plate that not only helps with spitting, but also increases bolt strength by 59% to 200%. Bay Area Retrofit is the only company that uses these special washers.



Mudsill Plate

Install Foundation Anchors

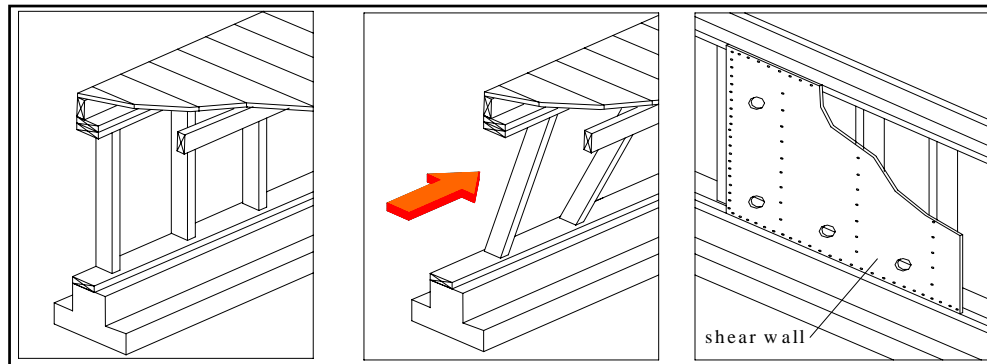
Sometimes there is no room to install a bolt because the distance from the mudsill to the floor you walk on is too short for a concrete drill. In these cases a foundation anchor is bolted to the side of the concrete and the side of the mudsill.

Foundation anchors, as shown in the photo below, are used to attach the mudsill to the concrete foundation. They are stronger than a standard bolt.



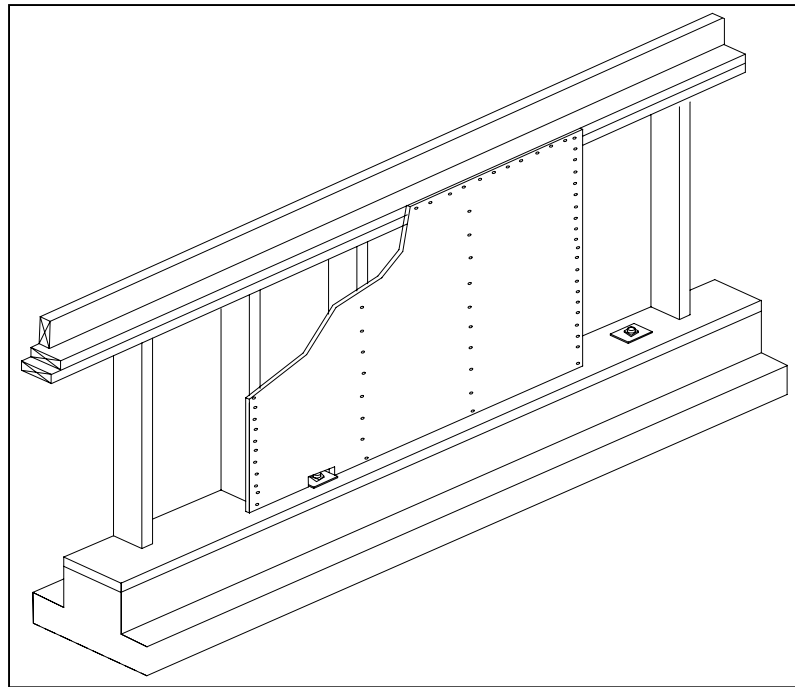
Foundation Anchor

Install Plywood

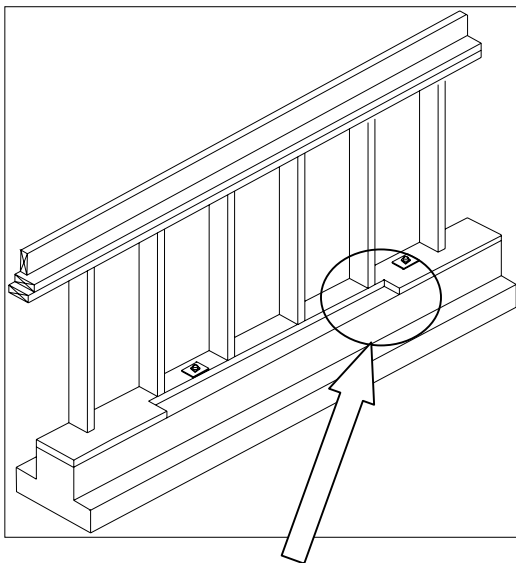


The red arrow in the center drawing shows how earthquake forces push on the cripple wall, causing it to collapse. The last drawing shows how we install plywood to prevent it from collapsing. Even though this drawing makes plywood installation look very simple, entire manuals and even books have been written on this subject

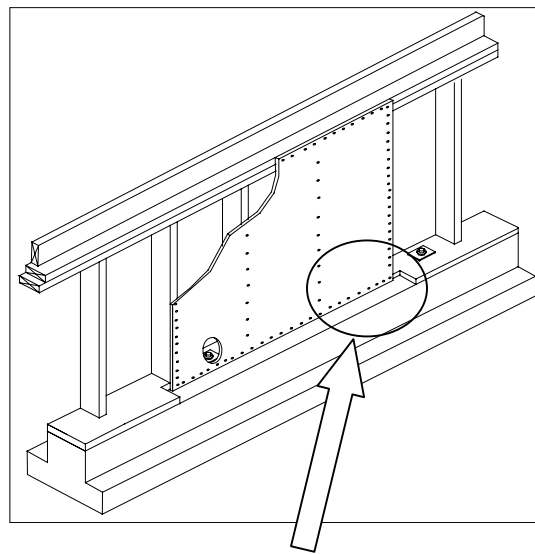
Use the flush cut method



Your home is built with mudsills that are 6 inches wide supporting 4 inch wide two by fours. As shown above, unless a modification is made, the plywood will sit on top of the mudsill where it will not be connected to the bolts. One method is the flush cut method. This is the method Bay Area Retrofit uses and is the only company in the Bay Area that does so

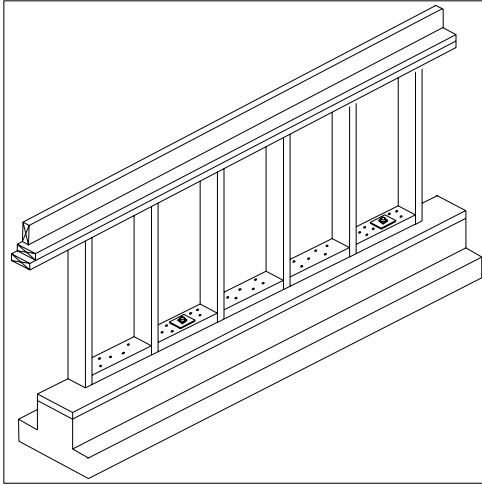


Mudsill is cut flush with the 2 by 4s

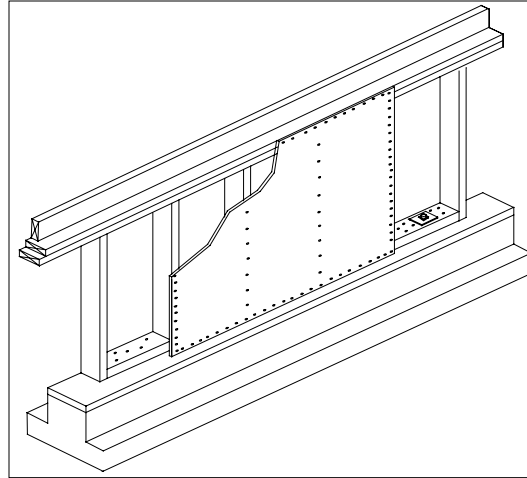


Plywood is nailed to the bolted mudsill.

Another method is to install wooden blocks between the 2 by 4s and then nail the plywood to the blocks.



Blocks nailed between 2 by 4s



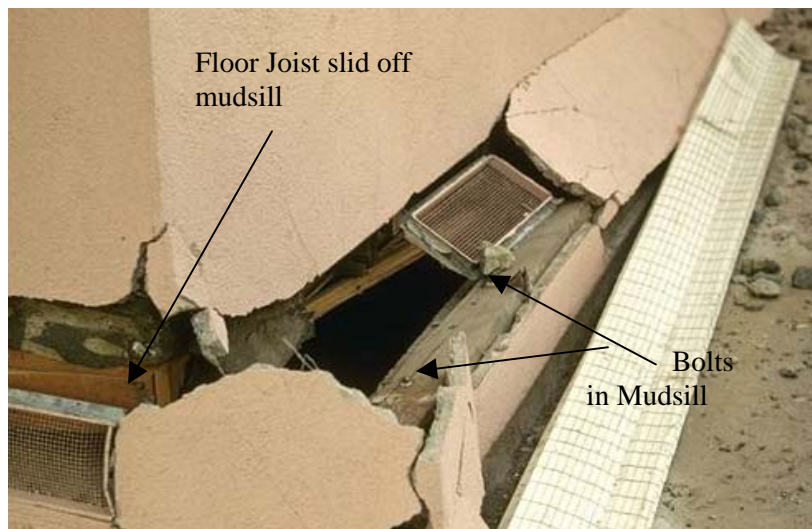
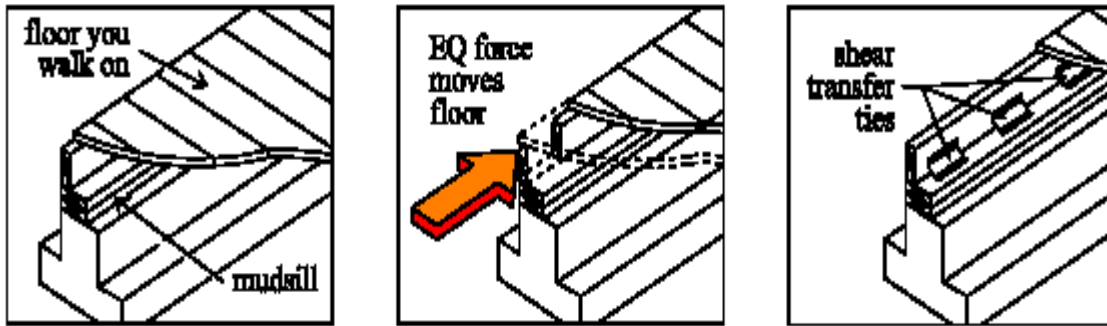
Plywood nailed to the blocks

This method often splits the blocks.



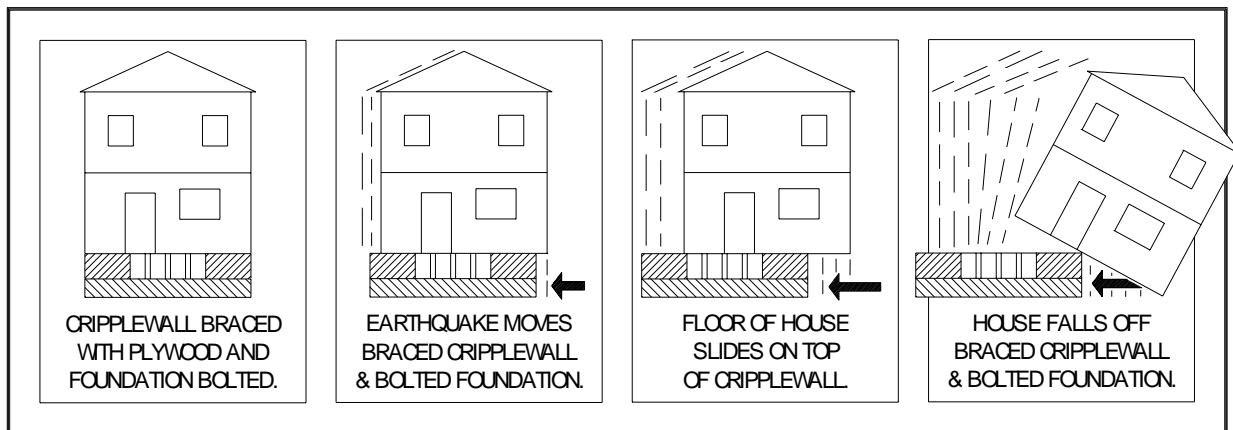
We never use nailed wood blocks. This method has only been tested once and was found to produce shear walls that are half as strong as shear walls built using the flush cut method.

Install Shear Transfer Ties to Connect Floor to Mudsill



A house without a cripple wall and no shear transfer ties.

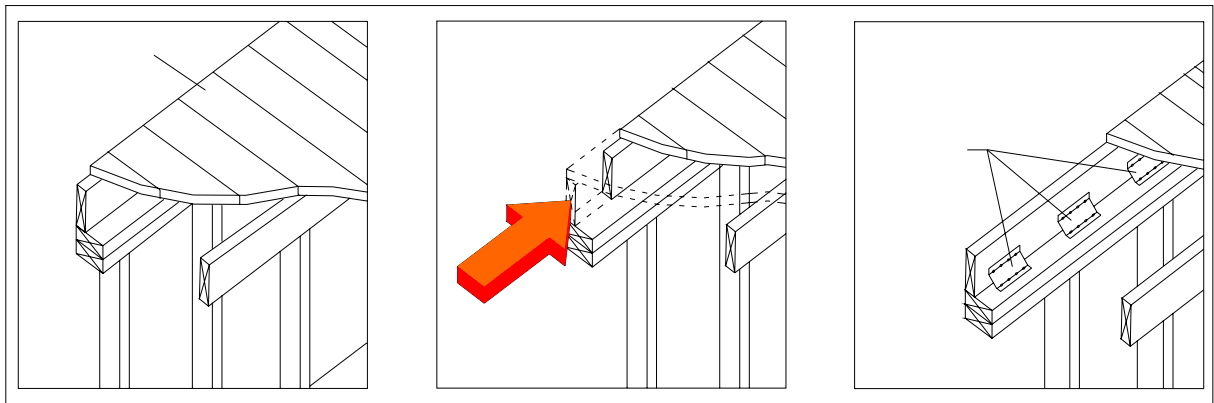
Install Shear Transfer Ties to Connect Floor Joists to Cripple Wall.



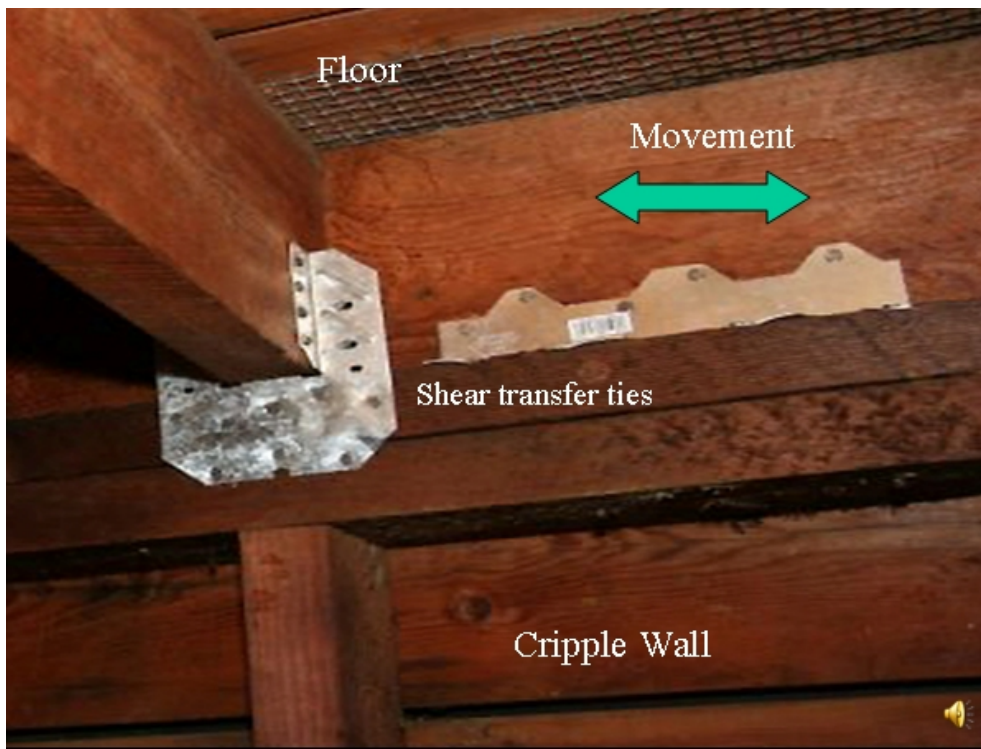
Floor you walk on

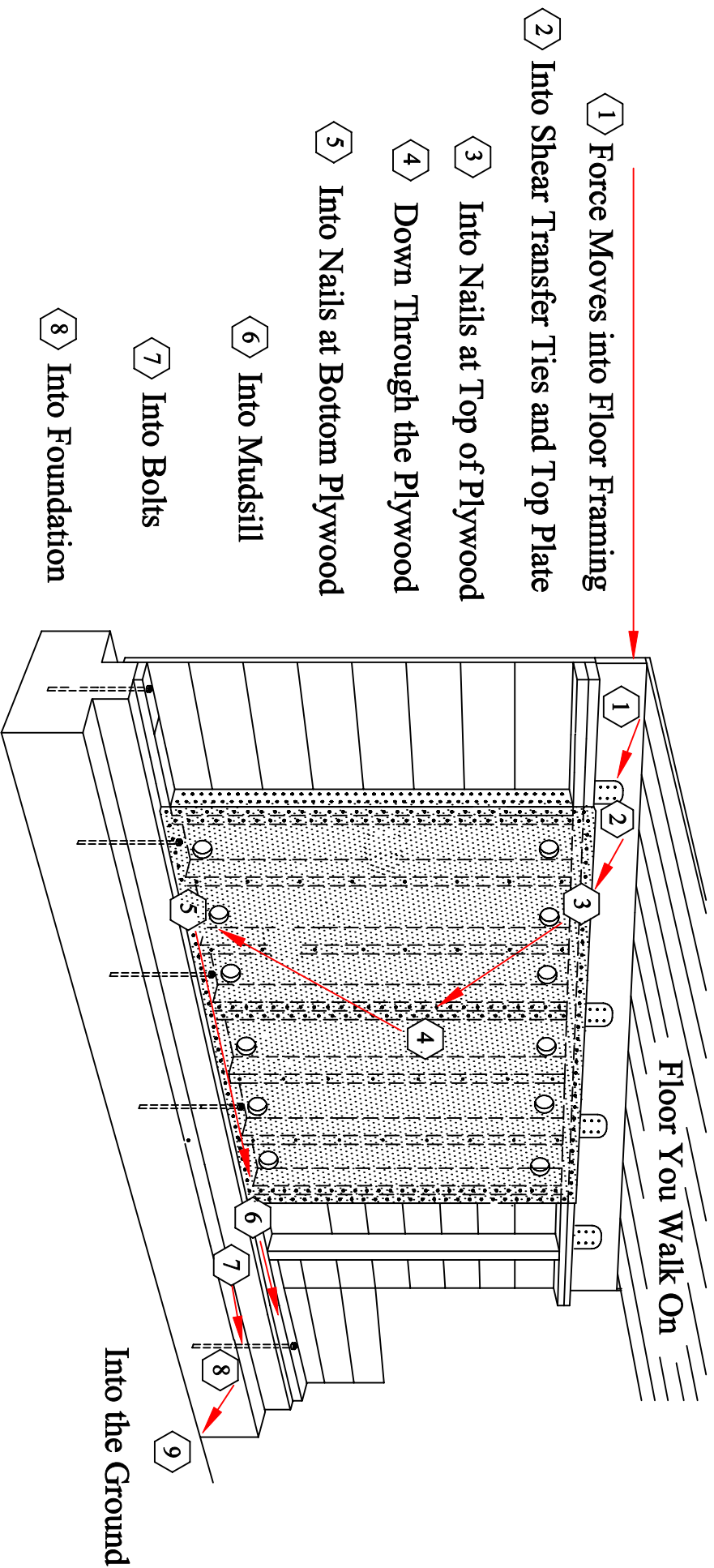
Earthquake Force

Shear Transfer Ties



Shear Transfer Ties are a special type of hardware designed to prevent the floor framing from moving on top of the cripple walls.

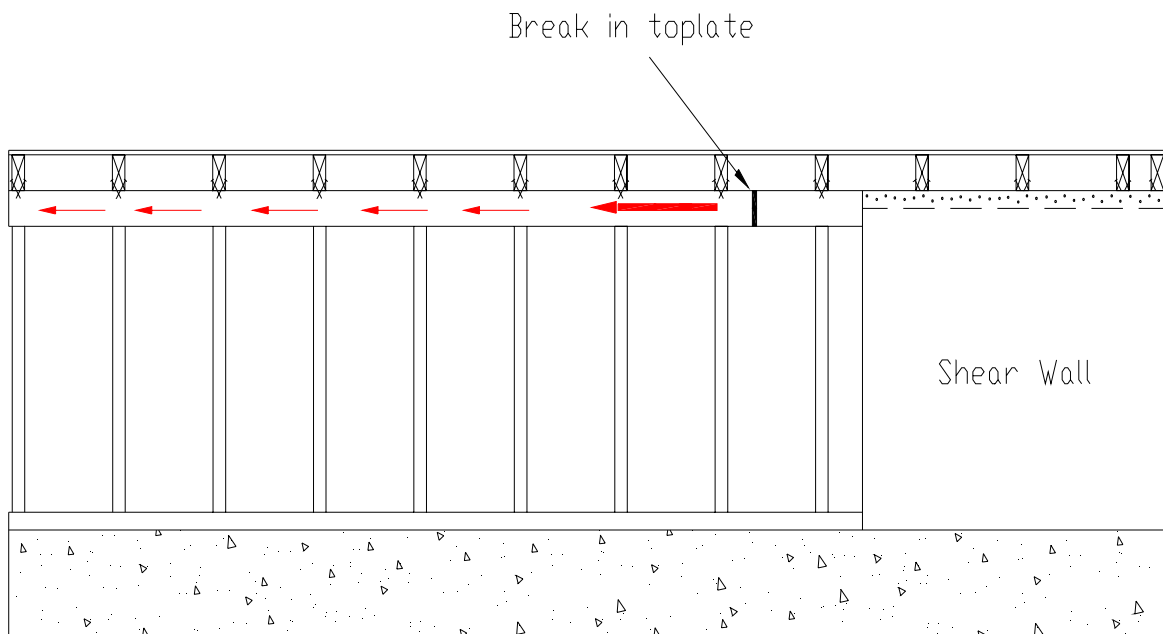




Load Path of Earthquake Forces

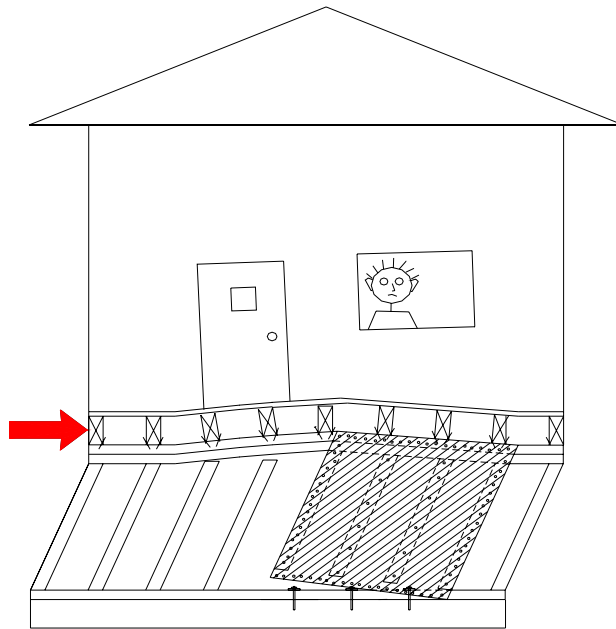
Connecting Breaks in Upper Top Plate

It is important to make sure any breaks in the top plate are spliced together. The red arrows represent earthquake forces pulling on the cripple wall and trying to pull the floor along with it. This movement would cause damage if it were not restrained by the shear walls. In order for these forces to make it into the shear wall, the Break in Topplate must be joined together with nails or a steel strap placed over it. In this way earthquake forces traveling through the top plate are transferred through the break in top plate and into the shear wall.



Install Hold Downs

A shear wall can tip over when an earthquake force shown by the red arrow pushes on the floor. This is especially true for tall shear walls. Hold downs prevent this from happening.



Shear walls on either side of a garage with overturning damage
Install Steel Cantilever Column



Living area above a garage



The garage used to be on the left

Garage Door Openings Represent a Serious Structural Weakness



Embedding a very rigid large steel beam into concrete and attaching it to the floor above the garage door opening addresses this weakness. These are known as moment columns



Does Retrofitting Really Work?



Notice the top of the stairs of this home relative to the position of the floor. This home fell six feet in a 7.1 earthquake in Ferndale California. None of the windows are cracked and the house is fully intact in every way except the damage to the interior was so extensive it needed to be torn down. The damage to this home would have been quite minimal if it had been retrofitted and not fallen off its foundation.

An actual laboratory test of retrofitting:

An architect owned two identical Santa Cruz homes. In 1989 he retrofitted one of them. Before retrofitting the other one the 7.1 Loma Prieta earthquake struck. The retrofitted one cost \$5,000 to repair for minor interior plaster cracks. The other one cost \$260,000 to repair because the cripple walls collapsed and it fell off its foundation.