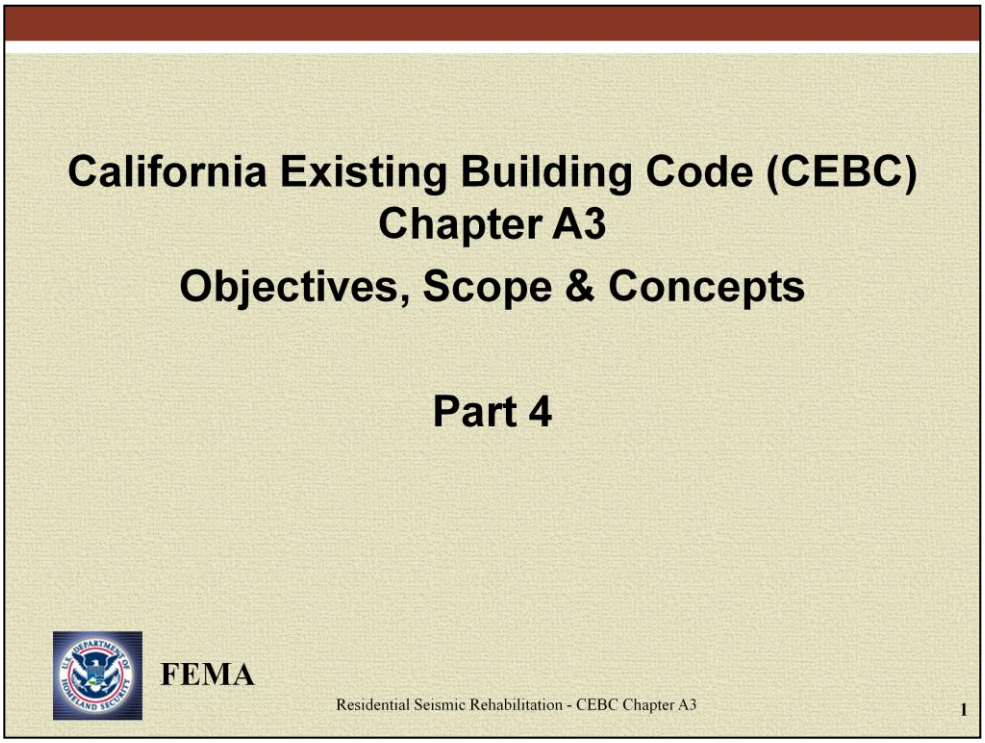
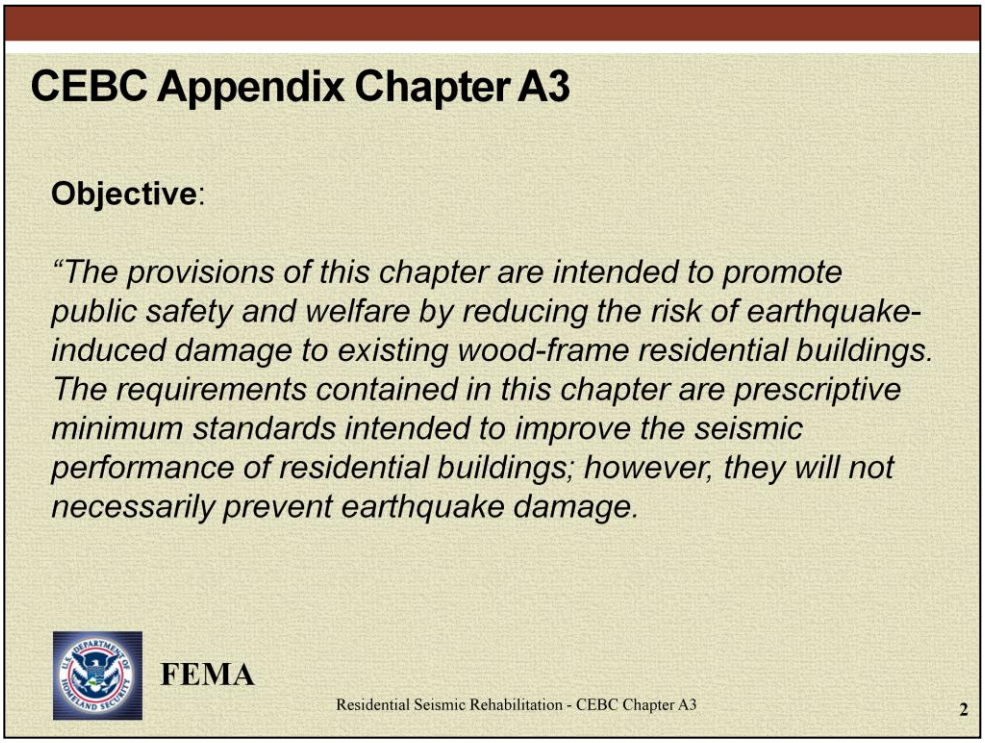
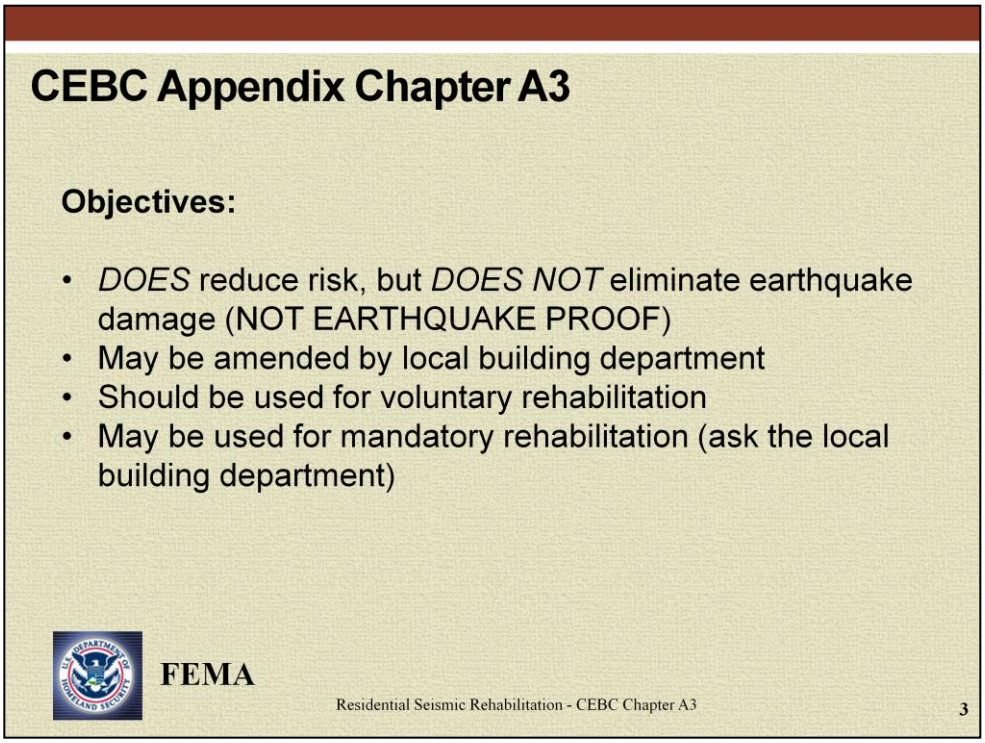


Part 4 introduces the objectives, scope and concepts of seismic rehabilitation using CEBC Appendix Chapter A3.



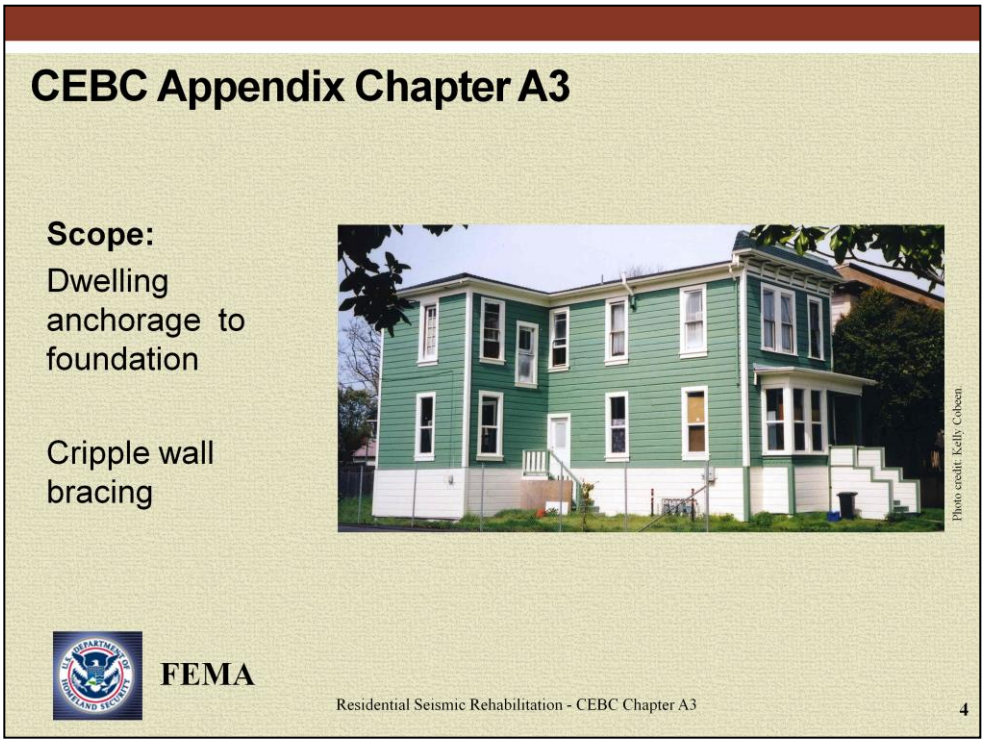
The objective of the CEBC Appendix Chapter A3 provisions is to REDUCE seismic risk by addressing an identified vulnerability. Reducing risk does not mean that NO damage will occur.



It should be emphasized that this rehabilitation is intended to REDUCE risk, but will not necessarily ELIMINATE damage.

Check with the local building department to see if they have amended the local building code provisions or have adopted local ordinances or rehabilitation measures that are applicable.

Use of CEBC Appendix Chapter A3 is primarily intended for voluntary seismic rehabilitation. Use of the provisions may also be determined appropriate by the building official, when mandatory seismic rehabilitation is required.



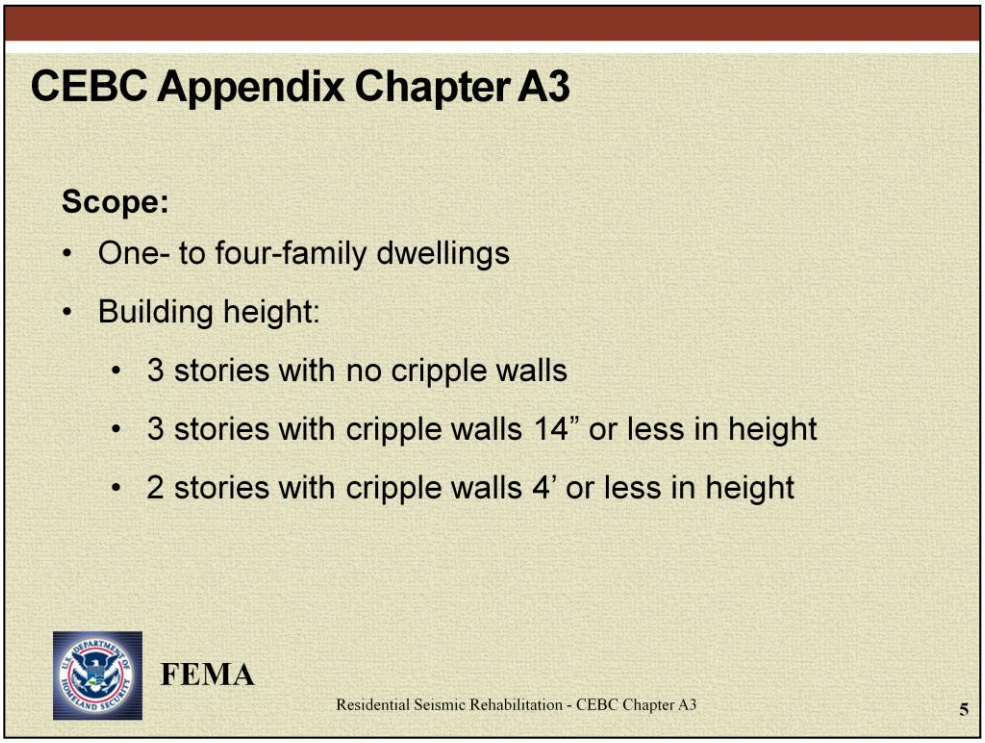
CEBC Appendix Chapter A3 addresses:

Vulnerability A - anchorage of wood frame dwellings and

Vulnerability B - cripple wall bracing, where applicable.

In this photo, of a Victorian era home, the white painted cripple walls stand out nicely, highlighting the portion of the building that will be rehabilitated.

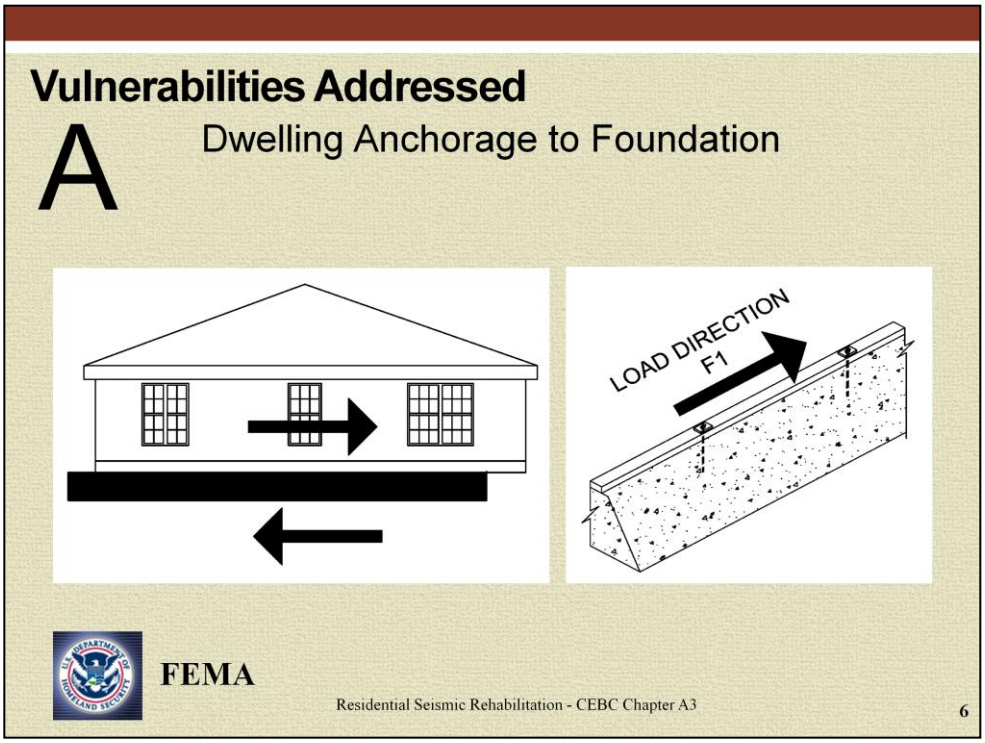
Photo credit: Kelly Cobeen.



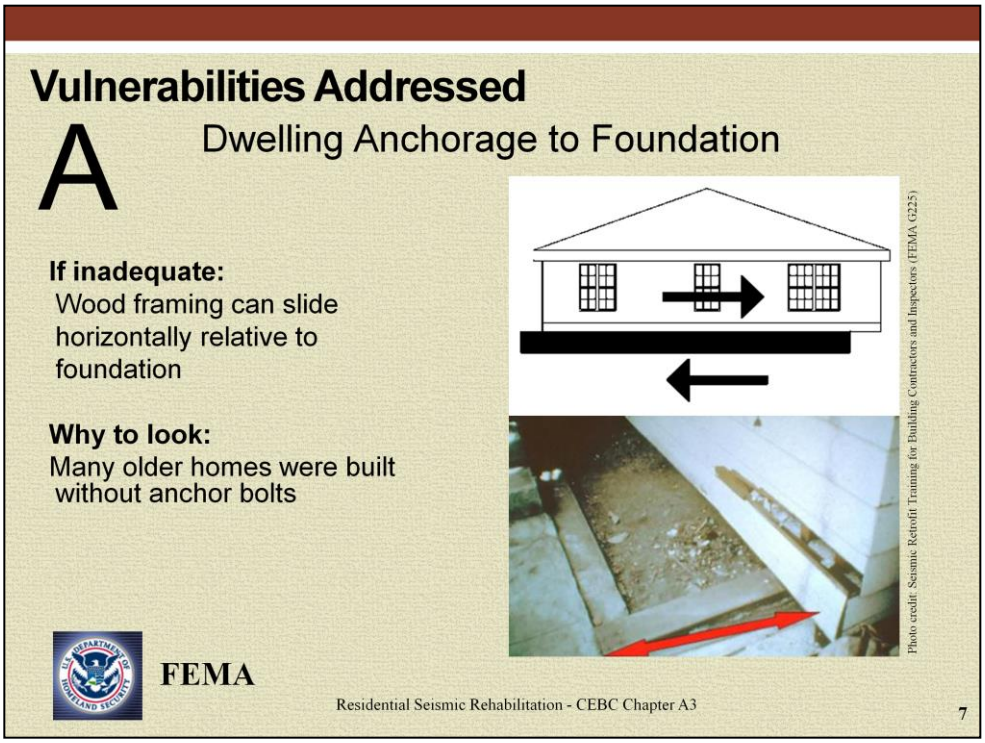
CEBC Appendix Chapter A3 addresses:

-One- to four-family dwellings. Residential buildings with 5 or more units require an engineered rehabilitation design due to greater weight and complexity.

-The scope limits both the number of stories and the height of cripple walls. Buildings with more stories and taller cripple walls require an engineered rehabilitation design.



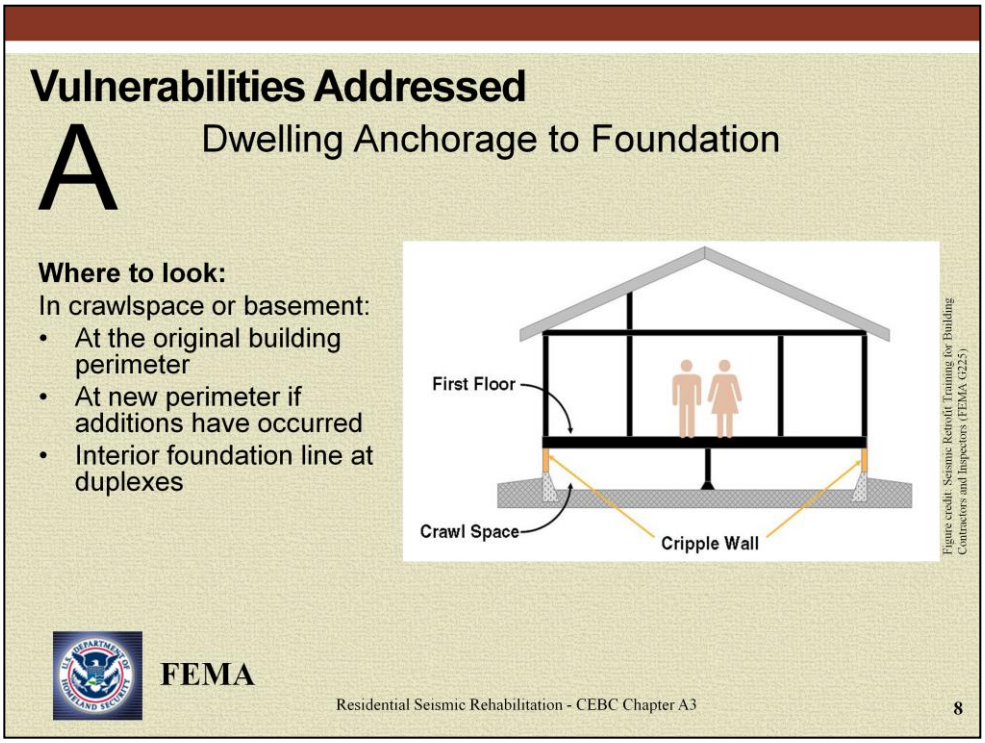
Foundation anchorage (Item A) will be discussed first. The purpose of anchorage to the foundation is to keep the dwelling from sliding horizontally on top of the foundation. F1 is the direction of the seismic load being considered. F1 is the load along the length of the foundation and wall.



Dwellings that slide off of their foundations due to lack of anchorage to the foundation have been very commonly seen in moderate to major earthquakes. Rehabilitation of anchorage provides a very large earthquake bracing improvement at a very small cost.

Many older buildings were constructed without anchor bolts, or have too few or inadequately installed bolts. On the west coast anchor bolts became common in approximately the 1950's. This date may vary locally and regionally.

Photo credit: Seismic Retrofit Training for Building Contractors and Inspectors (FEMA G225)

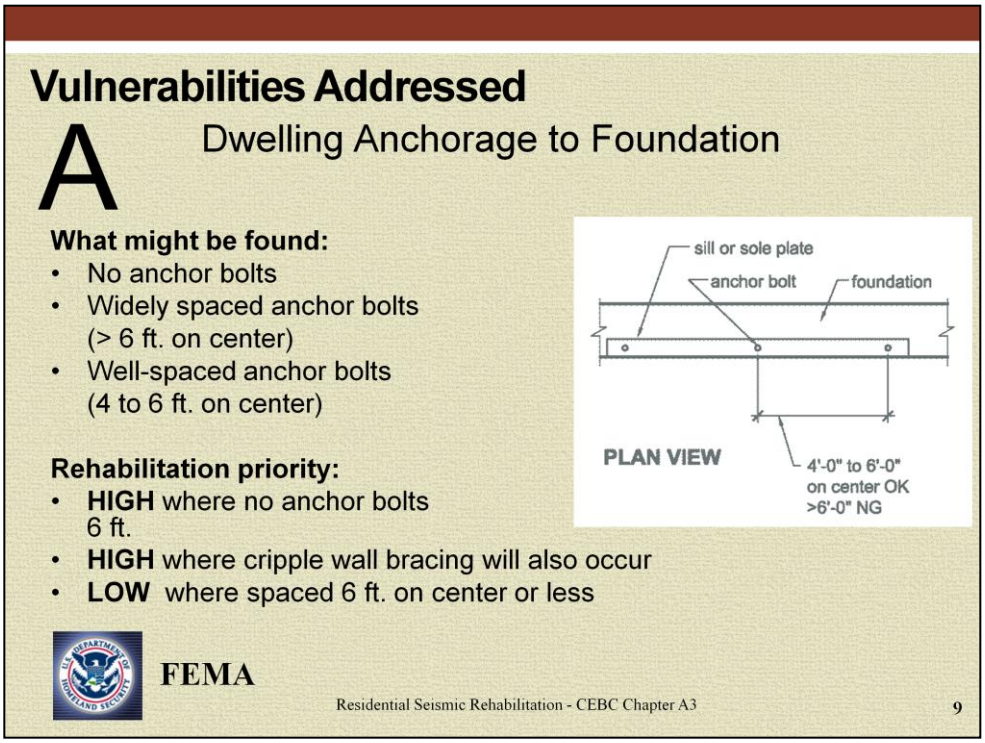


In dwellings with a crawlspace or basement, enter the crawlspace and look at the building perimeter. Anchor bolts should be provided from the wood framing to the foundation around the building perimeter.

If additions have occurred, anchor bolts should be provided at both the original and new building perimeters.

At multi-family dwellings, anchor bolts should generally occur at the interior foundation line separating the units.

Figure credit: Seismic Retrofit Training for Building Contractors and Inspectors (FEMA G225)



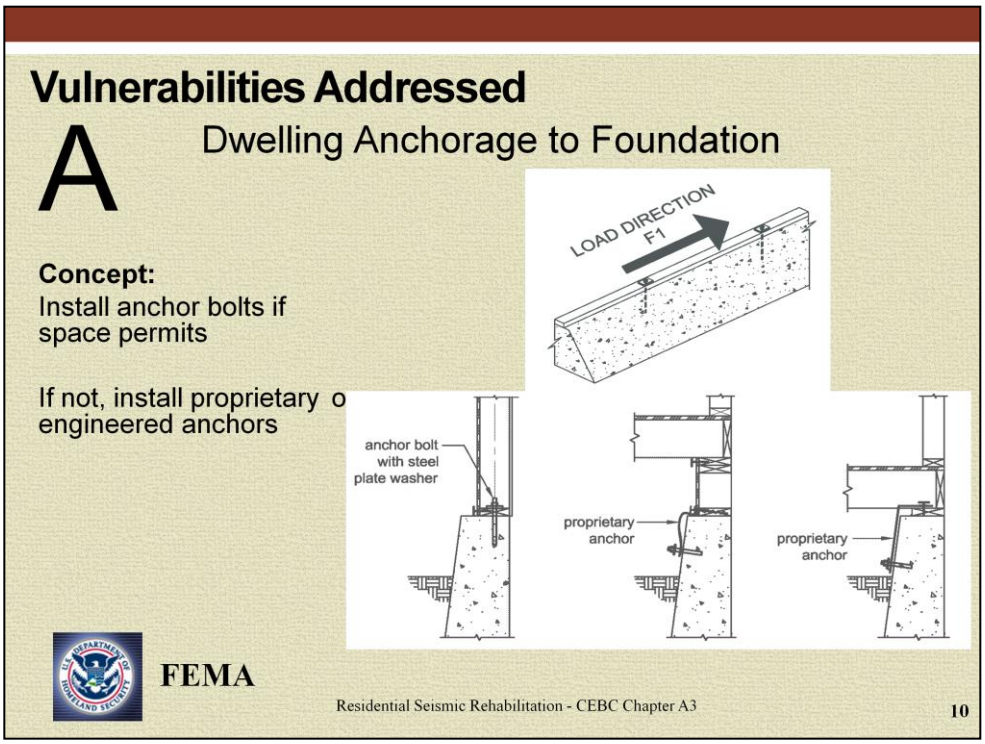
What might be found:

-No anchor bolts or anchor bolts spaced more than 6 feet on center – this is a HIGH priority for rehabilitation.

-Anchor bolts spaced 6 feet on center or less – this is a low priority for rehabilitation.

Where cripple wall bracing is provided, as discussed in Vulnerability B, it may be desirable to add more or bigger anchor bolts to meet the rehabilitation method requirements.

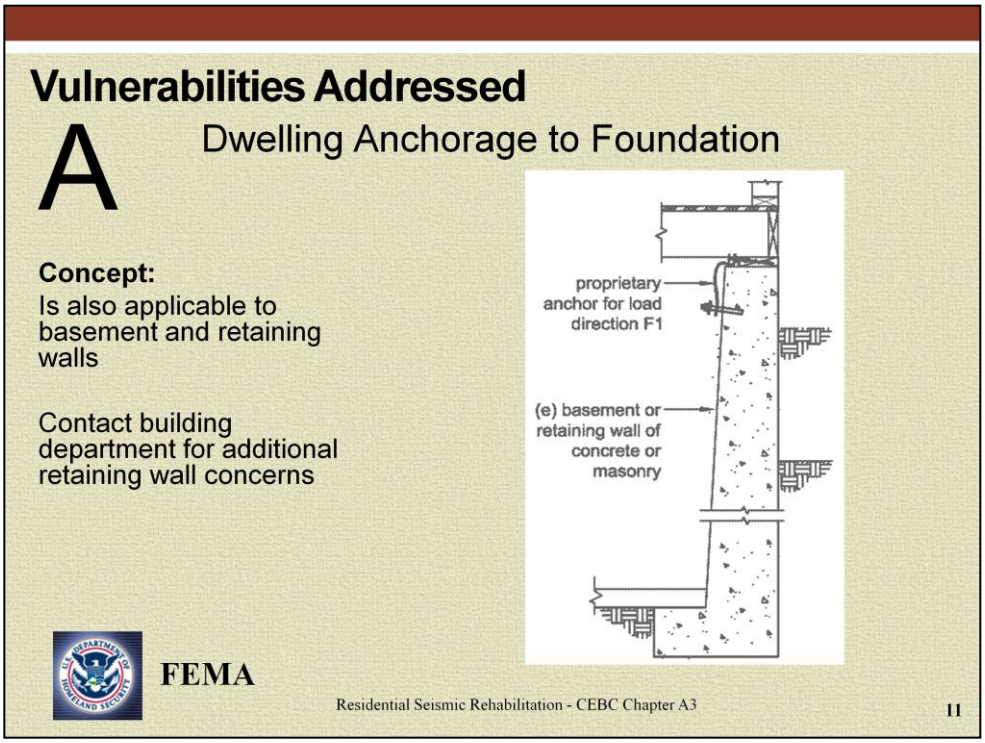
It is very common to see a light rust on anchor bolts in crawlspaces, and a light rust is not a concern. In some local communities rusting has occurred to such an extent that it jeopardizes the adequacy of the anchor bolts. Check with your local building department to see if this is a problem in your area, and whether rusting is to an extent that new anchor bolts ought to be added.



As mentioned in the introduction, the retrofit concept must be understood for the rehabilitation measure to be functional. The arrow labeled F1 shows the direction that the earthquake load is acting.

Anchor bolts can be installed where there is sufficient height for a rotary hammer and bit. Usually the cripple wall needs to be about 30 inches tall to allow this. A slight angle to the anchor bolt can help accommodate drilling. Up to seven degrees is generally considered acceptable. Steel plate washers 3” x 3” x 0.229” are required for anchor bolts. More information can be found in the notes to CEBC Figure A3-3.

Where drilling for anchor bolts is not possible, proprietary or custom engineered anchors must be used. The anchors chosen need to be rated for load direction F1 by the manufacturer or design. Devices intended for loading in other directions should not be used.

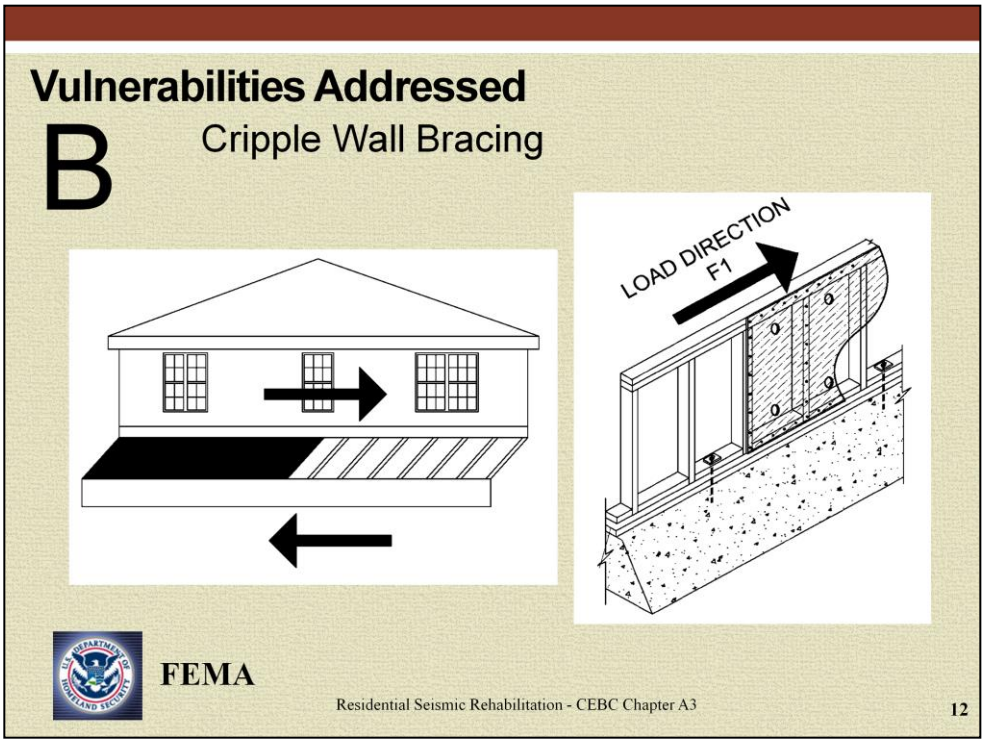


Several issues should be considered with basement and retaining walls.

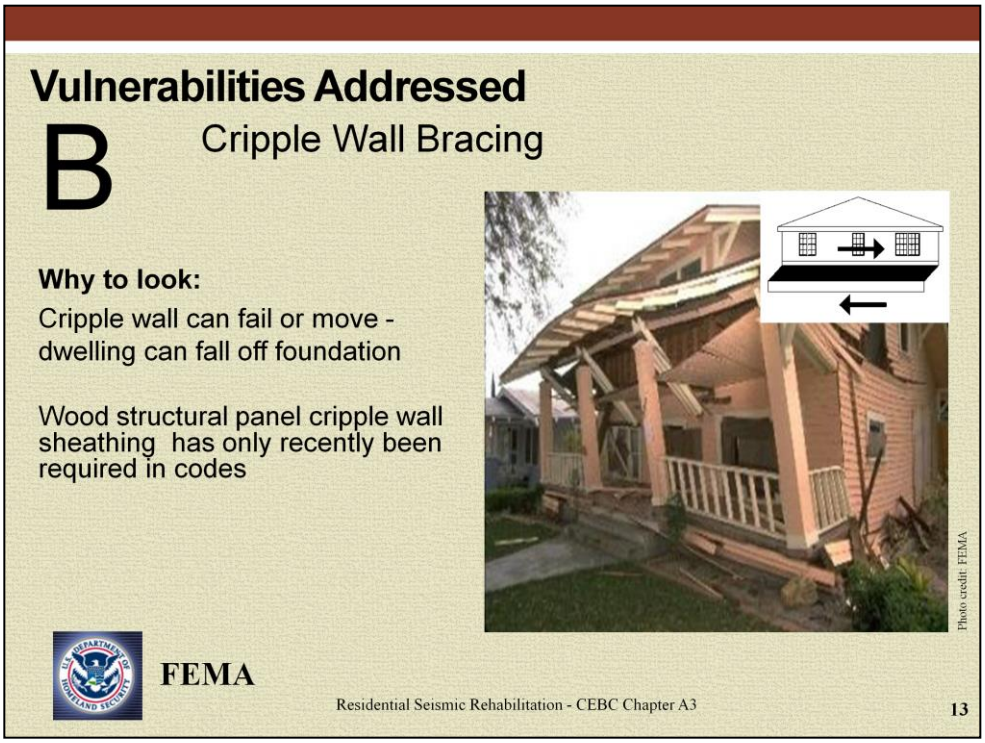
First, like any other interface between the wood-framed dwelling and the foundation, the wood dwelling should be bolted down to the basement or retaining wall. For this connection, all discussion regarding Vulnerability A rehabilitation is applicable. There is no difference between anchoring to a foundation stem wall and a basement retaining wall for seismic loads in the F1 direction.

Second, in some local areas there has been experience with inadequate strength of the basement retaining wall itself. This issue is not related to seismic loading, but rather the long term loading of the wall by the retained soils. Where this condition is possible, the local building department should be consulted.

Related to the second item, in some local areas there has been experience with the tops of retaining walls pushing inward perpendicular to the F1 direction. Again, this issue is not related to seismic loading, but rather the long term loading of the wall by the retained soils. Where this condition is possible, the local building department should be consulted.



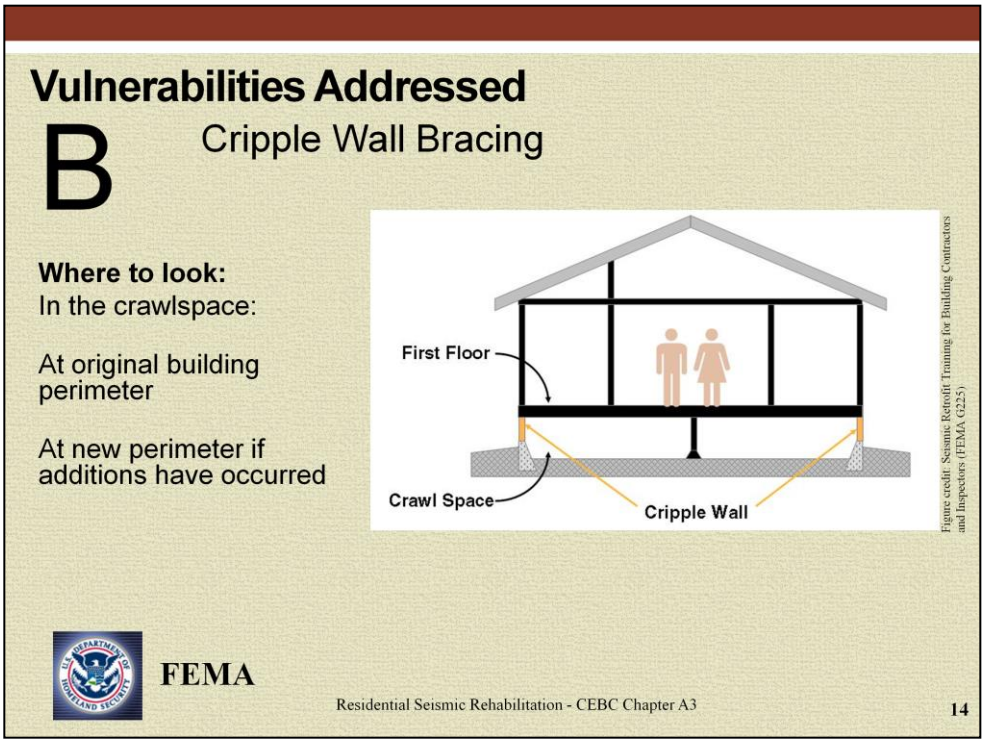
CEBC Chapter A3 rehabilitation design also addresses cripple wall bracing (Vulnerability B).



A cripple wall is a partial height wall that extends from the foundation to the first framed floor. Cripple walls generally enclose crawlspaces, but are also found in partial basements. Cripple wall failures have been very commonly seen in moderate to major earthquakes. Rehabilitation of cripple walls provides a very large earthquake bracing improvement at a small cost.

Building codes for new dwellings now require use of plywood or OSB sheathing for cripple wall bracing in areas of high seismic hazard; however this requirement is very recent and many existing buildings are braced with other materials that do not perform as well in earthquakes.

Photo credit: FEMA

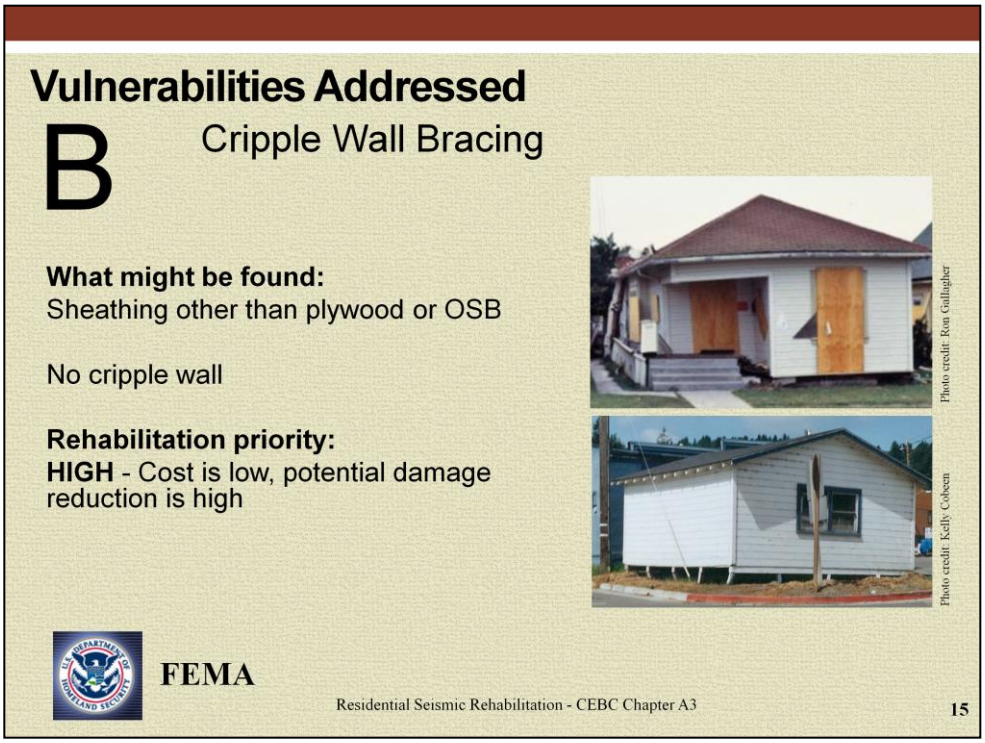


In dwellings with a crawlspace or basement, enter the crawlspace and look at the building perimeter. Plywood or OSB sheathing should be provided on approximately 40 to 100 percent of the perimeter cripple wall length, depending on the number of stories above and the weight of the existing construction.

At multi-family dwellings, cripple wall bracing should generally occur at the interior foundation line separating the units.

Figure credit: Seismic Retrofit Training for Building Contractors and Inspectors

(FEMA G225)

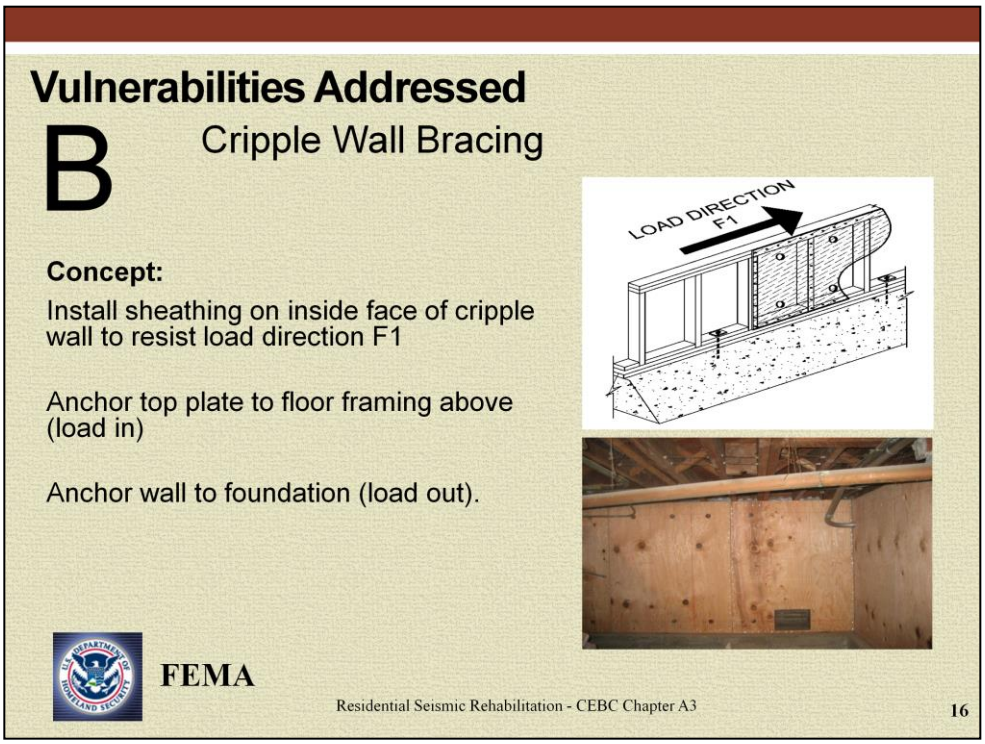


It is common to find finish materials only (for example stucco, siding boards, etc.) or finish materials over horizontal sheathing serving as bracing for cripple walls. These materials have not provided reliable bracing, due to the large loads and deformations imposed on cripple walls.

In some regions, posts and foundation piers occur instead of cripple walls. This "post and pier" system does not provide any path for loads between the dwelling and foundation, and is even more vulnerable than unbraced cripple walls.

Photo credit top: Ron Gallagher – dwelling with cripple wall failure

Photo credit bottom: Kelly Cobeen – cripple wall rehabilitation in older dwelling

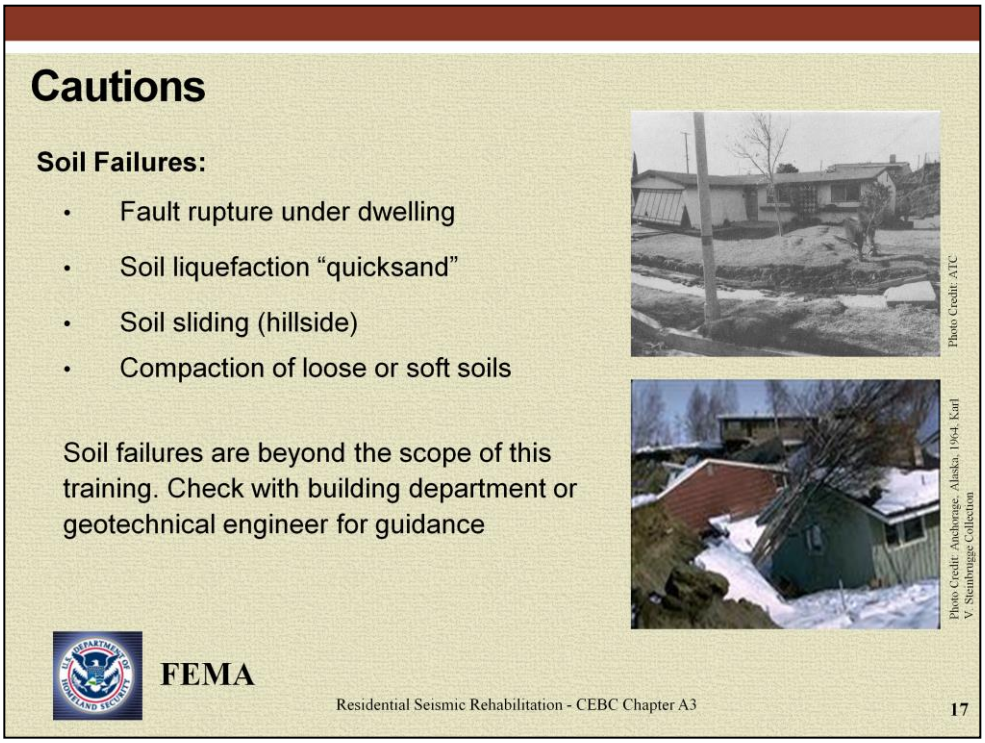


The arrow labeled F1 shows the direction of earthquake loading.

The seismic rehabilitation concept is to install plywood or OSB sheathing on the face of the cripple wall. The plywood or OSB is most often installed on the inside face of the cripple wall from the crawl space since there are generally no finish materials in the way. Installation on the exterior face is equally acceptable; finish materials must be removed and then reinstalled over the plywood or OSB.

Note that oriented strand board (OSB) is a commonly used alternative to traditionally used plywood.

In addition to the plywood or OSB, it is important to install connections from the top of the cripple wall to the framing above, and from the bottom of the cripple wall to the foundation.



A series of cautions and points of information regarding seismic rehabilitation follow. The first caution addresses potential soil failures that can include:
-fault rupture
-soil liquefaction
-soil sliding
-soil compaction

While only affecting a small portion of the building stock, the effect of a soil failure can be significant. In areas where soil failure is a possibility, the homeowner should be encouraged to pursue understanding the soil failure potential for their property.

Rehabilitation of vulnerable soils are of concern, but are beyond the scope of this training. The following gives some guidance:

- The California Governor's Office of Emergency Services (CalOES) website http://myhazards.calema.ca.gov can be used to identify potential soil failure hazards by inputting the California dwelling street address.

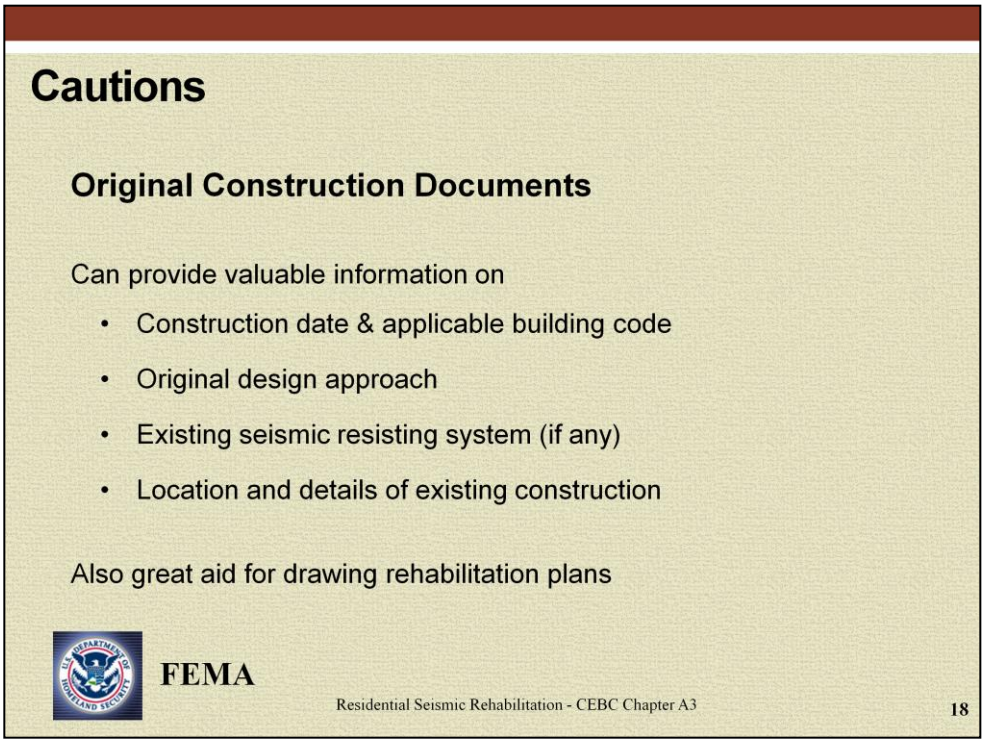
- Where potential soil hazards are identified, a geotechnical (or soils) engineer will often be needed to determine if and to what extent the specific site is affected and to recommend mitigation measures.

- Seismic rehabilitation of the above-ground structure can generally proceed independent of soils issues.

- Soils failures can be very expensive, and in some cases economically prohibitive to mitigate. In cases where it is prohibitive to mitigate potential soil failure, it still may make sense to retrofit the above grade structure. Design professional input is recommended in this instance.

Top photo credit: ATC – dwelling with fault rupture below, San Fernando EQ

Bottom photo credit: Anchorage, Alaska, 1964, Karl V. Steinbrugge Collection, Courtesy of the National Information Service for Earthquake Engineering, EERC, University of California, Berkeley



It is suggested that a check be made for construction plans (and specifications and soils reports, if available) from initial construction and any subsequent remodels, additions, etc.

In most cases, original construction documents for dwellings will not be available, however it is always worth asking. For custom homes, the owners may have plan sets available. Most building departments will not have residential plans but some will. Building departments are more likely to have plans available for dwellings constructed as part of large subdivisions where the same plan was used many times.

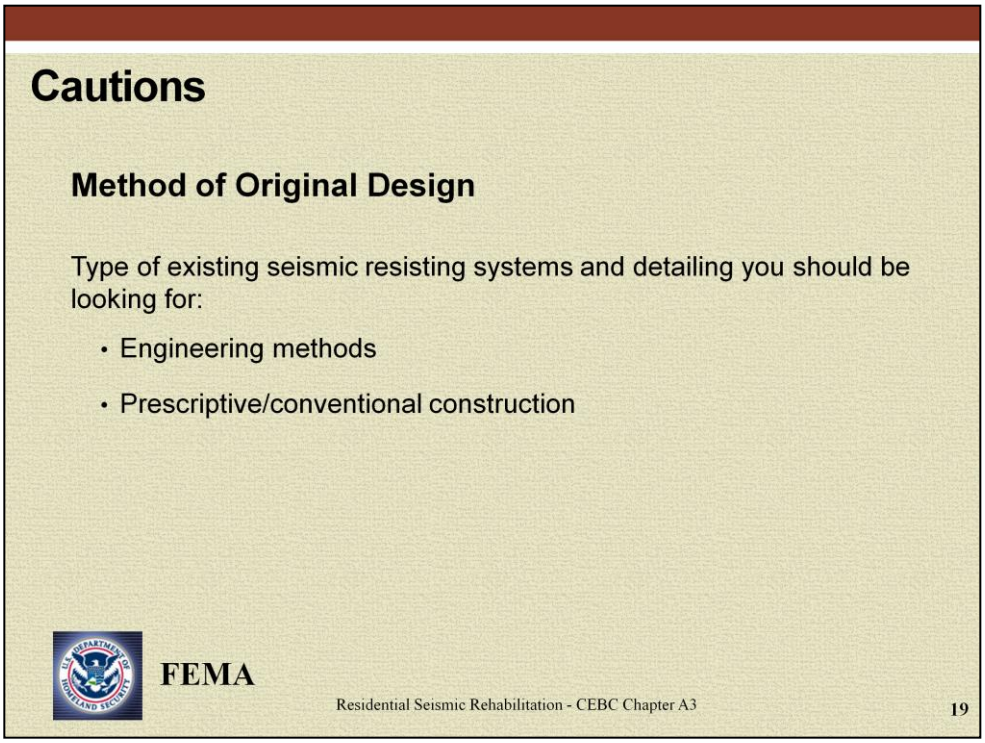
Where plans are available they provide clarity regarding:

-Construction date & building code and can provide significant information on likely design approach

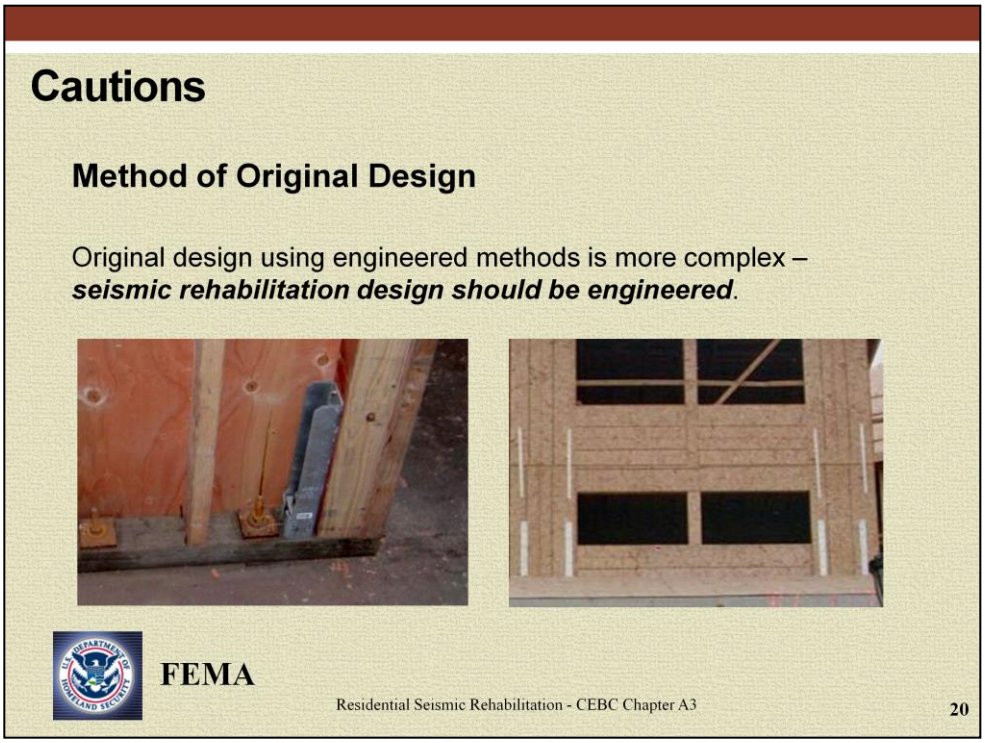
-Identification of prescriptive versus engineered design indicating the nature of the existing system

Existing plans also significantly reduce the effort needed for developing seismic

rehabilitation plans from scratch



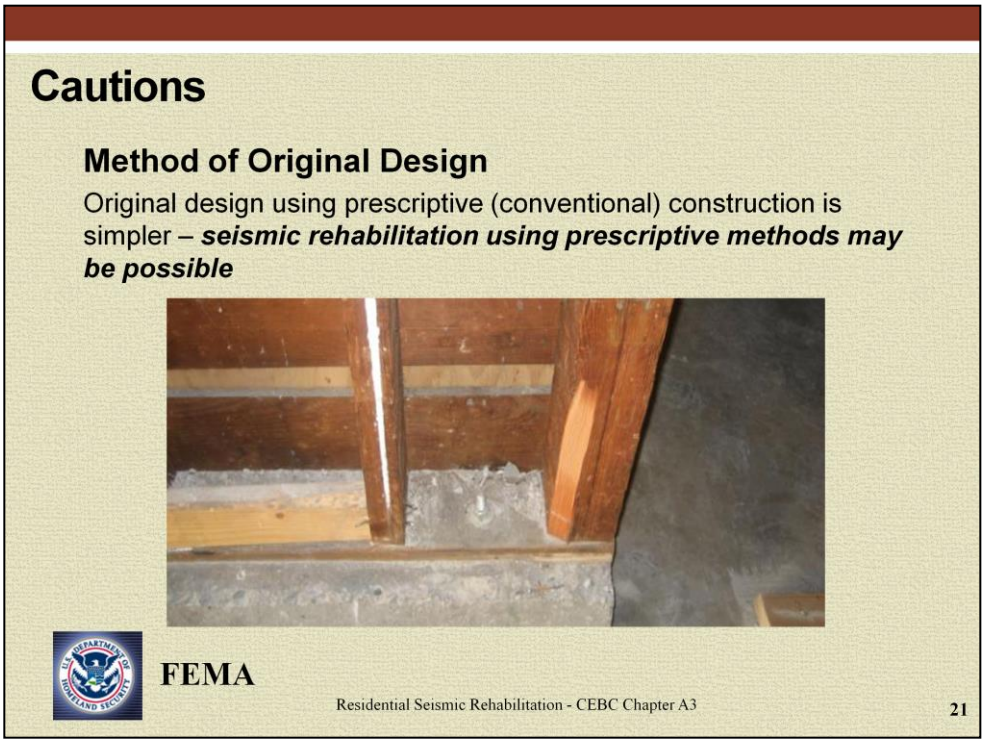
It is important to determine whether an existing dwelling has an engineered design of the seismic force-resisting system, or a conventional construction (or prescriptive) design.



An “engineered design” or “design using engineering methods” uses a calculated approach to comparing seismic demand to available dwelling capacity. This will most often be done by a registered engineer or licensed architect.

Engineered design can often be identified by existing connection hardware such as tie-down devices, steel straps, and steel clip angles.

Dwellings that were originally designed by engineering methods should have an engineered design for seismic rehabilitation in order to ensure that rehabilitation is compatible with the original design.



Most dwellings will have been designed using conventional construction (prescriptive) design methods. Dwellings designed by this method will generally not have steel connection hardware, but just basic anchor bolts and nailed connections.

Rehabilitation design can generally use prescriptive methods when the original design used conventional construction.

Cautions

Previous Additions, Alterations, Repairs and Rehabilitation

- Look for varying construction style and detailing
- Look where older and newer portions meet
  - Often not well tied together
  - Often require non-standard retrofit details

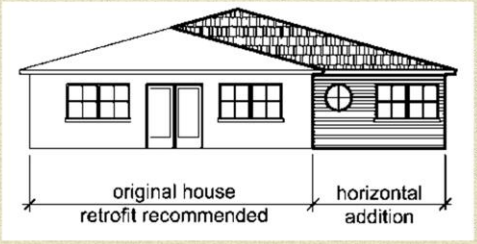


Figure credit: Homebuilders' Guide to Earthquake Resistant Design and Construction (FEMA 232)

FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

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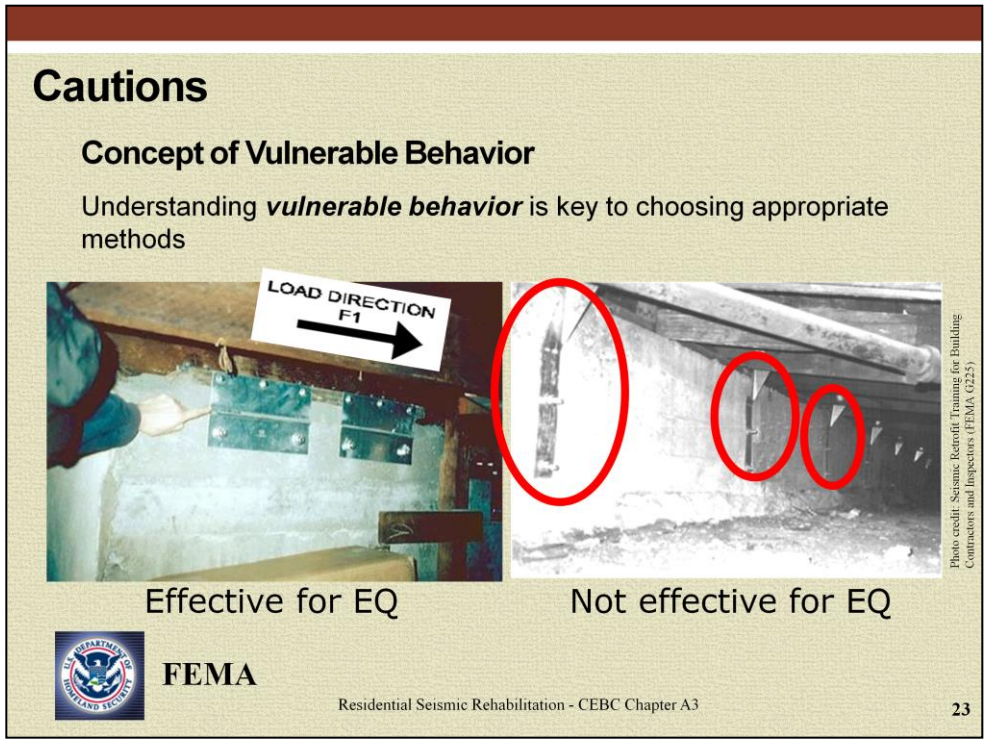
A very large portion of existing dwellings have had additions, alterations, repairs etc. it is important to identify these because non-standard seismic rehabilitation details may be required at these conditions

-Look for construction style and detailing that might vary in different portions of the dwelling

-Look for vulnerable characteristics particularly where older and newer portions meet – these are often not well tied together and may separate during an earthquake

Figure credit: Homebuilders' Guide to Earthquake Resistant Design and Construction (FEMA 232)



Understanding the vulnerable behavior concept is key to choosing appropriate seismic rehabilitation methods. For each potential vulnerability presented, the concept for seismic rehabilitation is also described on the vulnerability picture card. This is to help assure that seismic rehabilitation measures installed will indeed address the vulnerability.

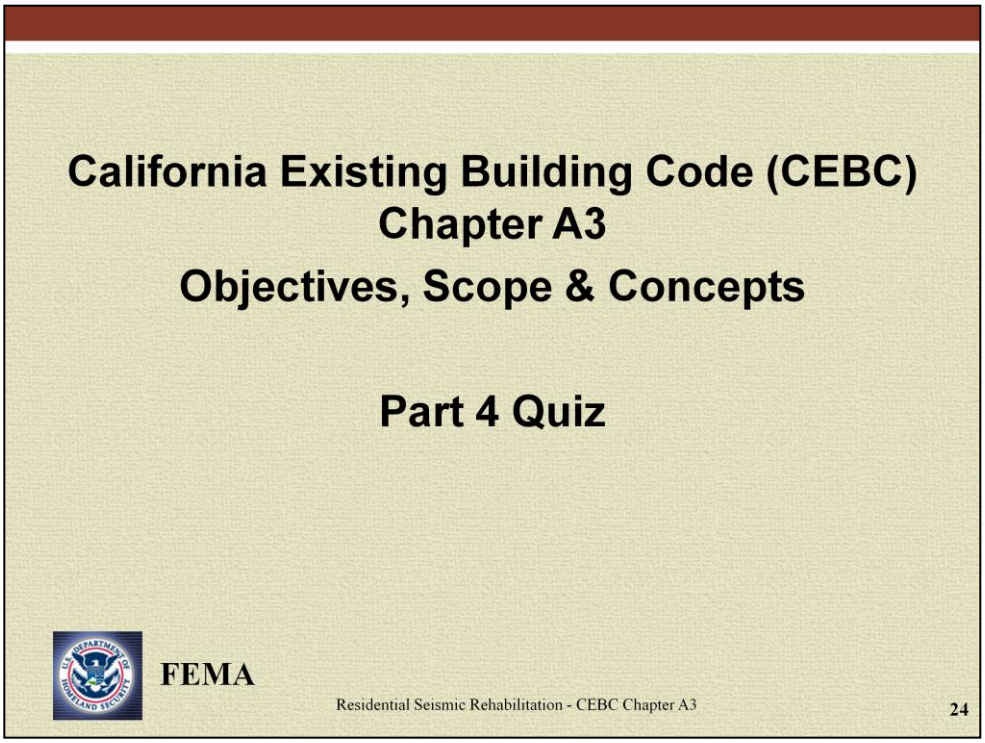
Recent seismic rehabilitation experience has illustrated that this is not always the case; as illustrated in the above photos. The intent of the pictured rehabilitation was to prevent the wood framing from sliding horizontally along the top of the concrete foundation wall, as shown by load direction F1.

-The photo on the left shows anchors that are designed to prevent this horizontal sliding; therefore this is an acceptable retrofit.

-The photo on the right shows anchors that are design to prevent the wood framing from being pulled vertically upwards (as might be required for high wind design); this is a highly ineffective retrofit for resisting horizontal sliding load F1.

If the vulnerable behavior concept was understood, this rehabilitation measure should not have been installed. When choosing anchorage devices from a manufacturer's catalogue, the selected device needs to have a reasonable load capacity in the F1 direction.

Photo credit: Seismic Retrofit Training for Building Contractors and Inspectors (FEMA G225)



You have completed part 4 of the educational module.

Contractor's please return to the contractor dashboard to take a short quiz.