

# Earthquake Strengthening of Cripple Walls in Wood-Frame Dwellings



FEMA

## SOUTH NAPA EARTHQUAKE RECOVERY ADVISORY

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### Purpose and Intended Audience

Wood-frame dwellings generally perform well in earthquakes since they are lightweight and constructed of relatively flexible materials. Notable exceptions to this good performance are dwellings that are not properly anchored (bolted) to their foundations and dwellings with flexible wood foundation walls, known as cripple walls, that are inadequately braced. The August 24, 2014, South Napa earthquake reinforced these past observations by causing extensive damage to homes with inadequate anchorage and with inadequate cripple-wall bracing, particularly in taller walls.

Damage to cripple walls can be significant and costly to repair. In addition, the damaged home is usually identified as unsafe to occupy (that is, “red tagged”) until repair work can be performed. As a result, the residents will be displaced and in need of alternate living arrangements, adding additional expenses to the cost of repairing the damaged home.

Relatively simple and inexpensive measures can be undertaken by homeowners to mitigate the vulnerabilities of cripple walls. These measures include installing new anchor bolts to provide a better attachment between a dwelling and its foundation system, and adding plywood sheathing to cripple walls at the perimeter of the crawl space to strengthen the walls and provide better bracing.

To improve vulnerable cripple walls in a wide variety of homes and reduce the number of homes damaged in the next earthquake, the Federal Emergency Management Agency (FEMA) is issuing this Recovery Advisory and an accompanying prescriptive “Plan Set” that can be used as a template for reducing these vulnerabilities throughout California and the United States. This Plan Set provides a pre-engineered retrofit with step-by-step instructions describing how a contractor or homeowner customizes these plans to the specific geometry of their dwelling. Thus, the FEMA Plan Set facilitates the development of earthquake strengthening (retrofit) plans for submittal to the local building department, or the authority having jurisdiction, and for use during construction.

### Key Issues:

1. Wood-frame dwellings with cripple walls below the first floor that are not adequately braced, and dwellings not adequately anchored (bolted) to their foundations, can sustain significant damage in earthquakes.
2. This FEMA Recovery Advisory and Plan Set are applicable to dwellings with a crawl space and cripple walls up to seven feet (7'-0”) in height, among other limitations.
3. The earthquake strengthening measures illustrated in the FEMA Plan Set can be adapted to a one- or two-family dwelling and are intended to reduce—not eliminate—the risk of earthquake-related damage.
4. Even when dwellings have earthquake vulnerabilities in addition to inadequately braced cripple walls or inadequately anchored foundations, the earthquake strengthening of cripple walls and anchorage are still recommended in order to improve the earthquake performance of a dwelling.



**Figure 1: Damaged cripple wall at the crawl-space level, braced on the outside to stabilize the dwelling and prevent collapse**

## This Recovery Advisory Addresses:

- The issues involved in the earthquake strengthening of cripple walls in one- or two-family, wood-frame dwellings. This first part of the Recovery Advisory is intended to enable homeowners to determine whether their homes may have the vulnerable conditions addressed in this Advisory and whether the home is within the scope of the second part of this Advisory.
- The earthquake strengthening of a dwelling through specific measures in the accompanying part of this Recovery Advisory, *Earthquake Strengthening of Cripple Walls in Wood-Frame Dwellings: FEMA Plan Set*, for contractors and interested homeowners. This second part of the Recovery Advisory provides specific, pre-engineered details for the earthquake strengthening of dwellings so that the work can be done without the aid of a licensed design professional (in most cases), reducing the cost of the retrofit.

This Recovery Advisory does not address the repair of cripple walls damaged in the South Napa earthquake, and it does not provide a comprehensive evaluation and retrofit of all seismic vulnerabilities in your home.

## What is the FEMA Plan Set?

The FEMA Plan Set is a prescriptive, pre-engineered set of retrofit plans, which can be adapted to your home. The Plan Set allows a general contractor or homeowner to draw the layout of your home and specify the work required for earthquake strengthening. It is intended to contain all of the necessary supplemental technical information and guidance in the preparation of a complete set of plans for submittal to the local building department and for use during construction.

The earthquake strengthening work specified in the FEMA Plan Set meets the intent of the 2012 *International Existing Building Code* (IEBC), Chapter A3, and the 2013 *California Existing Building Code* (CEBC).

The retrofit work described in this Recovery Advisory is focused only on the area below the first floor of a dwelling and only includes the strengthening of cripple walls and anchorage of the dwelling to its foundation. Your home may have other vulnerable areas and other structural deficiencies that may sustain significant damage in a future earthquake. **Even when vulnerable areas are improved, your home will not be “earthquake proof”: moderate and major earthquakes may damage your home despite any strengthening work.** Earthquake strengthening is expected to reduce this damage so that a homeowner may continue occupying the dwelling when any damage is repaired.



**Figure 2: Strengthened cripple wall in a crawl space, undamaged in the South Napa earthquake (Photo courtesy of ZFA Structural Engineers)**

## Is the Plan Set applicable to your home?

The FEMA Plan Set included in this Recovery Advisory is intended to be appropriate for a variety of dwellings. However, your home must meet a series of requirements, which are based on assumptions underlying the Plan Set. Sheet S0 of the FEMA Plan Set lists questions for you to answer, under the heading “Eligibility for Use.” If you can answer “yes” to all of these questions, the Plan Set should be applicable to your home.

The configuration of your home may require that you consult a licensed engineer or architect in order to modify the prescriptive information in the Plan Set. If only isolated locations in your home deviate from the conditions shown on the Plan Set, a licensed engineer or architect may be able to assist in a limited fashion by producing supplemental information for submittal to the building department. For example, a framing condition may be unique to your home and not directly covered by one of the pre-engineered details shown on the Plan Set.

If the FEMA Plan Set is not applicable to your home, a complete project-specific set of construction documents should be developed by a licensed engineer or architect. The project-specific documents may rely in part on the FEMA Plan Set but must be designed and signed by a licensed engineer or architect.

## How is the FEMA Plan Set used?

The adaptation of the FEMA Plan Set to a dwelling is performed by a licensed general contractor (recommended) or by the homeowner. Sheets S0 through S4 of the Plan Set should be filled out completely, including a scaled plan of the dwelling and reference to the applicable details in Sheets D1 through D7. Homeowners may consult with the local building department regarding any questions.

The licensed contractor or homeowner then submits the completed FEMA Plan Set to the local building department in order to receive a building permit. The building department may charge a fee to review the plans for conformance with the local building codes. This fee may also cover site inspection services by a representative of the building department to ensure that the proposed work has been constructed in accordance with the building permit.

**Building permits are always required when performing the work described in this Recovery Advisory.**

The building department may require Special Inspection, which is on-site testing by an outside, third-party inspector hired by the homeowner. Although the FEMA Plan Set identifies conditions requiring Special Inspection, which correspond to the use of tie downs or uplift anchors, the local building department decides what earthquake strengthening measures do and do not require Special Inspection.

The limited access and limited clearances found below most dwellings often make the implementation of earthquake strengthening work difficult. For these reasons, it is recommended that a licensed contractor, rather than a homeowner, perform the work. Since earthquake strengthening work is also specialized, homeowners should seek and engage general contractors who specialize in this type of work. Homeowners are encouraged to consult their state's contractor licensing board for guidance on hiring a contractor to provide construction work. Many states have laws regulating the types of licenses contractors must hold, insurance requirements, bonding requirements, and mechanics liens.

### Does your home need everything in the Plan Set?

The scope of work illustrated in the FEMA Plan Set is intended to provide a reasonable level of earthquake strengthening for cripple walls and foundation anchorage. These seismic improvements, however, are generally voluntary, meaning that the improvements may not be required by the local building department. The configuration of a dwelling or an obstruction in a dwelling may not allow the installation of all work prescribed by the Plan Set, or the installation may be too costly to perform. Although not recommended, a homeowner could choose to install less plywood bracing along wall lines or install fewer anchor bolts or metal connector plates, as long as the retrofit work is voluntary and the existing conditions warrant such an approach. If a decision is made to reduce the scope of the seismic improvement, the strengthening should be implemented as symmetrically as possible around the crawl space. A licensed engineer or architect should be consulted if there is uncertainty in a reduction of scope.

### Foundation Requirements

The FEMA Plan Set applies to existing dwellings with a continuous concrete perimeter foundation system with or without steel reinforcing. Since the Plan Set is prescriptive, existing foundation systems of stone, concrete masonry (CMU) or brick masonry are not addressed. Where an existing foundation system is constructed from something other than continuous concrete, the Plan Set is not applicable, and a licensed engineer or architect should be consulted. For the application of the proposed work, the existing foundation system is assumed to be in reasonably good condition. The Plan Set contains guidance on evaluating the existing concrete quality and additional specific requirements that must be met where tie downs or uplift anchors must be installed.



**Figure 3: Dwelling with damage to its cripple wall (top); failure of the cripple wall, resulting in the movement of the dwelling off its foundation (bottom) (Photo courtesy of ZFA Structural Engineers)**

## Strengthening Adjacent Garage Slabs-On-Grade

The FEMA Plan Set applies only to those portions of a dwelling that contain wood-frame cripple walls in the crawl space. Garages or other portions of the dwelling built on concrete slabs-on-grade are not within the scope of the Plan Set. Although not addressed here, portions of a dwelling supported by a concrete slab-on-grade could also have an inadequate connection between wood-frame walls and the slab-on-grade and thus be vulnerable to damage during earthquakes. If a homeowner suspects that a connection of this type may be inadequate, or cannot verify the presence of existing anchor bolts within accessible spaces such as a garage, the homeowner should consult with a licensed engineer or architect for recommendations.

## Project Participants

This Recovery Advisory was prepared by the Applied Technology Council (ATC) for the Federal Emergency Management Agency (Michael Mahoney, Project Officer). The Project Technical Committee was Colin Blaney (Chair), Thor Matteson, and David L. McCormick, assisted by a Working Group of Gayle Klink and Steve R. Patton. The Project Review Panel was Kelly Cobeen and Jeffrey E. Taner. Jon A. Heintz and Anna H. Olsen provided management and oversight for ATC.

## Resources and other Useful Links

- CBSC, **2013 California Existing Building Code**, California Code of Regulations, Title 24, Part 10, California Building Standards Commission, Sacramento, California.
- City of Los Angeles Department of Building and Safety, **Earthquake Hazard Reduction in Existing Wood Frame Residential Buildings with Weak Cripple Walls and Unbolted Sill Plates**, Standard Plan Number One, September 2009. [http://lads.org/LADBSWeb/LADBS\\_Forms/Publications/anchor\\_bolting.pdf](http://lads.org/LADBSWeb/LADBS_Forms/Publications/anchor_bolting.pdf)
- City of San Leandro, California, **Earthquake Retrofit Programs**, Last accessed April 2015. <http://www.sanleandro.org/depts/cd/bldg/retrofit/default.asp>
- City of Seattle, Washington, **Emergency Management: What Can I Do?**, Last accessed April 2015. <http://www.seattle.gov/emergency-management/what-can-i-do>
- Federal Emergency Management Agency, **FEMA P-50: Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings**, May 2012. <https://www.fema.gov/media-library/assets/documents/92229>
- Federal Emergency Management Agency, **FEMA P-50-1: Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings**, June 2012. <https://www.fema.gov/media-library/assets/documents/92229>
- ICC, **2012 International Existing Building Code**, Chapter A3, International Code Council, Washington, D.C.
- Project Impact Seattle, **Standard Earthquake Home Retrofit Plan Set**, January 2008. [http://www.seattle.gov/dpd/static/get\\_file/Earthquake%20Home%20Retrofit%20Planset\\_DPDD017407\\_LatestReleased.pdf](http://www.seattle.gov/dpd/static/get_file/Earthquake%20Home%20Retrofit%20Planset_DPDD017407_LatestReleased.pdf)
- Simpson Strong-Tie Company, Inc., **Seismic Retrofit for Residential Wood Frame Cripple Walls and Sill Plate Anchorage**, May 2012. <http://www.strongtie.com/literature/f-plans.html>
- Structural Engineers Association of Northern California, Association of Bay Area Governments, California Building Officials, Northern California Chapter of the Earthquake Engineering Research Institute, Tri-Chapter of the International Code Council, **Standard Plan A (2008): Residential Seismic Strengthening Plan**. <http://seaonc.org/free-publications>

For more information, see the FEMA Building Science Earthquake Program web site at <http://www.fema.gov/earthquake>  
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