

## Residential Seismic Rehabilitation Using California Existing Building Code Appendix Chapter A3



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This training has been developed from FEMA P-593, funded by the Federal Emergency Management Agency (FEMA), and developed by the Applied Technology Council (ATC).

This version of the training has been modified for use in California, and in particular for the use of California Existing Building Code (CEBC) Chapter A3, as published in the CEBC 2010 Edition.

# **Introduction, Importance of Seismic Rehabilitation**

## **Part 1**



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The importance of Seismic Rehabilitation.

## Conduct of Course

The course is divided into six parts. There is a short quiz at the end of each part. Completion of the course requires listening to all six parts and completing the six quizzes.



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## Background

The State of California has adopted, effective January 1, 2011, California Existing Building Code (CEBC) Appendix Chapter A3: *Prescriptive Provisions for Seismic Strengthening of Cripple Walls and Sill Plate Anchorage of Light, Wood-Frame Residential Buildings*



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## Background

These are not mandatory provisions, triggered by the code, but provisions available to those implementing voluntary seismic rehabilitation

It is intended that they provide a measurable target for seismic rehabilitation work



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## Training Objective

Prepare contractors to implement the residential seismic rehabilitation (strengthening) provisions of California Existing Building Code (CEBC) Appendix Chapter A3

Inform other interested persons regarding residential seismic rehabilitation



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A primary objective of this training is to prepare contractors to implement the residential seismic rehabilitation provisions of CEBC Appendix Chapter A3.

Another objective is to inform persons potentially involved in residential rehabilitation, including architects, engineers, and building officials.

## Training Scope

Focus: One- to four-family wood-frame dwellings



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This training focuses on the behavior and types of seismic vulnerabilities that can be seen in one- to four-family detached dwellings.

Some of these vulnerabilities can also be found in multi-family dwellings and in other wood-frame buildings. The basic concepts of seismic rehabilitation apply to these other buildings, too, but the details of code requirements and implementation may differ, due to the increased building complexity. A design professional is required for seismic rehabilitation of wood-frame multi-family dwellings and commercial buildings, due to increased building complexity.



## Training Outline

- Part 1: Introduction & Importance of Rehabilitation
- Part 2: Earthquake Basics & Common Seismic Vulnerabilities
- Part 3: Building Code Requirements for Seismic Rehabilitation
- Part 4: CEBC Chapter A3 Objectives, Scope and Concepts
- Part 5: Development of CEBC Chapter A3 Seismic Rehabilitation Plans
- Part 6: Rehabilitation Construction Basics



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Parts 1& 2 of this course will cover information on the importance of rehabilitation, basic information on earthquake effects on dwellings and description of seismic vulnerabilities commonly seen in dwellings. It is hoped that this will inform the contractor and aid the contractor in communication of this information to homeowners.

Part 3 will cover building code requirements applicable to either voluntary or mandatory seismic rehabilitation.

Parts 4 through 6 will cover implementation of CEBC Chapter A3 provisions including scope and concepts, development of rehabilitation plans, and basics of rehabilitation construction.



## Terminology

### **Seismic rehabilitation:**

- Modifications intended to improve the seismic (earthquake) safety and performance of a structure
- Also called seismic strengthening/retrofit/upgrade



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It is useful to define a series of terms that will be used throughout this presentation.

The term “seismic rehabilitation” will be used in this presentation to describe modifications to dwellings, which are intended to improve the safety and performance of a dwelling during an earthquake.

Other commonly used terms are “seismic strengthening,” “seismic retrofit” and “seismic upgrade.” In common usage, all of these terms mean the same thing.

## Terminology

### **Mandatory seismic rehabilitation:**

Mandated because of:

- Local ordinance
- Additions or alterations being made to a dwelling

### **Voluntary seismic rehabilitation:**

- Not mandated



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Seismic rehabilitation is sometimes mandated, because of a local ordinance or because an addition or alteration to a dwelling triggers seismic rehabilitation requirements of the building code. When this is the case, it is likely that both the type and the minimum required extent of rehabilitation work to be done will be defined.

Any seismic rehabilitation work that is not specifically triggered by building codes or local ordinances is classified as a voluntary seismic rehabilitation. Homeowners generally have significant flexibility in selecting the type and extent of work to be done for voluntary seismic rehabilitation, with the primary restriction that work performed should not make the dwelling more vulnerable to earthquake damage.

## Terminology

### **Prescriptive construction:**

Uses code-specified rules of proportioning, rather than calculations made by an architect or engineer

- Prescriptive new construction
- Prescriptive rehabilitation methods



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Two primary approaches are available for design:

-*Prescriptive construction* uses rules of proportioning that are published in codes or design standards.

-*Engineered construction* uses calculations of demand, or load, and capacity as a basis for design.

The terms “prescriptive” and “engineered” construction apply both to new construction and to seismic rehabilitation work.

CEBC Chapter A3 is a prescriptive rehabilitation method; for dwellings that fall within the described scope, involvement of an engineer or architect is generally not required.



## Why is seismic rehabilitation important?

- Protect occupant life and safety
- Reduce structural damage
- Home likelier to remain habitable
- May facilitate resale



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Seismic rehabilitation is important, because a modest investment made prior to an earthquake can have a large payoff after an earthquake, including:

- Increased safety for occupants, when vulnerable configurations are present
- Reduced structural damage although some damage must be expected
- Increased likelihood of the dwelling being habitable after an earthquake, so that occupants do not have to seek emergency shelter
- In high seismic areas, rehabilitation may also increase home resale value



## Why is seismic rehabilitation important?



Photo credit: Ron Gallagher



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This dwelling's cripple walls collapsed, allowing the dwelling to fall off its foundations. This hazard can be reduced.

A cripple wall is a short wall that rests on the foundation and supports the floor and exterior walls. If the cripple wall is not braced, it can shift during an earthquake. When this occurs, there is a greater likelihood that the structure will be severely damaged and that you and others will be injured.

Photo credit: Ron Gallagher

## Why is seismic rehabilitation important?



Photo credit: Ron Gallagher



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This chimney collapse broke through the porch roof. This earthquake hazard can be reduced.

Photo credit: Ron Gallagher

## Why is seismic rehabilitation important?



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This open-front dwelling collapsed in the 1989 Loma Prieta earthquake, in part because it did not have any bracing walls at the building front. This hazard can be reduced.

Photo credit: Ron Gallagher



## Why is seismic rehabilitation important?



Photo credit: City of Los Angeles Department of Building and Safety.



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This hillside dwelling collapsed during the 1994 Northridge Earthquake. This hazard can be reduced.

Photo credit: City of Los Angeles Department of Building and Safety.



## Why is seismic rehabilitation important?

Seismic rehabilitation could have saved this home

- Approx. rehabilitation cost = \$10,000
- Approx. replacement cost = \$300,000



Photo credit FEMA.



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As a specific illustration of the benefits of seismic rehabilitation:

-In this photo, the main house had a cripple wall collapse, while the porch floor did not. Because the house roof and gable end walls were supported on both the porch and the main building, very significant damage occurred. This house would likely require demolition and reconstruction, at an estimated cost of \$300,000, while rehabilitation is estimated as costing approximately \$10,000. (The cost estimates are in 2009 dollars.)

-The home is not habitable in the condition shown, but it might have been habitable, post-earthquake, if seismic rehabilitation had been performed.

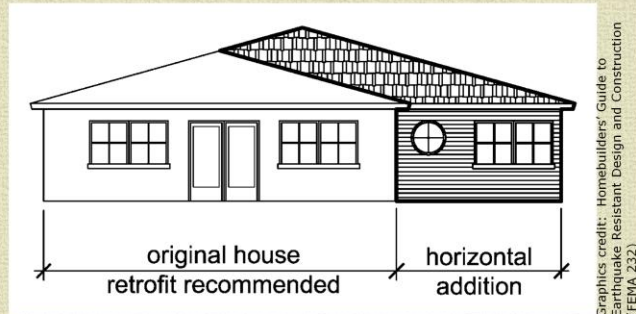
-While not all examples of earthquake damage will be this extreme, the cost ratios of reconstruction to rehabilitation are generally high in areas of high seismic hazard.

-Rehabilitation may reduce likelihood of injury to occupants.

Photo credit FEMA.

## When should seismic rehabilitation work be done?

- Anytime, as a stand-alone project
- During remodel, addition, or renovation



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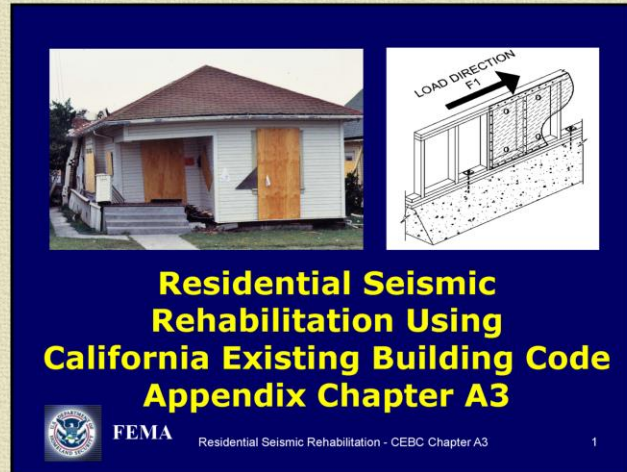
Seismic rehabilitation can always be undertaken as a stand-alone project. Any time is a good time to improve seismic safety.

Seismic rehabilitation should be encouraged as part of addition or alteration projects. Each year homeowners invest a significant amount of money in remodels and additions, and they significantly extend the useful life of their houses through that investment. Seismic rehabilitation can be a small part of the overall construction project, can use the same contractor, and can help to protect the investment that is being made in the dwelling. Seismic rehabilitation work done within the livable space is more likely to be possible during remodel/addition/renovation work. Also, mandatory building code requirements may apply. (Part 4 of this training will discuss code requirements.)

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

## Training Handouts

Presentation slide handouts



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PDF files of this course are available for download. For these files and additional seismic rehabilitation information, see the “Additional Information” page. This information includes:

# Training Handouts

## Annotated resource list & CD's

### Seismic Rehabilitation Training for One & Two-Family Dwellings Annotated Bibliography

#### REFERENCES PROVIDED ON CD WITH TRAINING:

##### **Seismic Retrofit Training for Building Contractors & Inspectors (FEMA G225)**

This training addresses how to implement a seismic retrofit (rehabilitation) that has been designed by others, including how seismic retrofit measures work, how they are installed, and how to avoid typical installation errors. Details include selection and installation of sheathing, nailing, anchor bolts, and other connectors. Sections also address earthquake basics, nonstructural elements, and legal issues. Chapter 6 provides prescriptive guidance on retrofitting post and pier houses that is not available in other publications. This information will be of primary interest to persons installing, inspecting, or plan checking retrofit measures. Portions will be of interest to a broad audience including building owners, realtors, lenders, insurers, and attorneys.

**Provided information:** CD includes the power point training slides, a participant handbook and a trainer handbook

##### **Earthquake Safety Guide for Homeowners (FEMA 530)**

This publication introduces earthquake hazard in the United States, provides a series of easy to follow descriptions of common earthquake weaknesses in homes, how to identify them, solutions, and information resources. Other sections address natural gas safety, getting retrofit work done, geologic hazards, and what to do before, during and after an earthquake. This publication is an excellent starting point for homeowners, and will also be of interest to a broad audience.

**Provided information:** CD includes an electronic file of the FEMA 530 publication.



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FEMA publications available for download from their website. One useful document is FEMA 232, The Homebuilders' Guide to Earthquake Resistant Design and Construction.



# Training Handouts

## Potential Seismic Vulnerabilities card

Potential Seismic Vulnerabilities - One and Two-Family Wood Frame Dwellings

Item	Seismic Potential	Seismic Vulnerability	Why it's a problem	How to fix it	Seismic Hazard	Seismic Risk	Seismic Vulnerability	Seismic Risk	Seismic Vulnerability	Seismic Risk	Seismic Vulnerability	Seismic Risk	Seismic Vulnerability	Seismic Risk	Seismic Vulnerability	Seismic Risk	Seismic Vulnerability	Seismic Risk
A	Unreinforced masonry walls	Unreinforced masonry walls	Unreinforced masonry walls are vulnerable to seismic forces. They can crack, spall, and even fall out of the wall.	Reinforce masonry walls with steel reinforcement bars (rebar) and grout. Use proper construction techniques.	High	High	High	High	High	High	High	High	High	High	High	High	High	High
B	Soft-story condition	Soft-story condition	Soft-story condition occurs when the first floor is significantly weaker than the floors above. This can lead to collapse during an earthquake.	Strengthen the first floor by adding bracing, cross-bracing, or other structural elements. Increase the stiffness of the first floor.	High	High	High	High	High	High	High	High	High	High	High	High	High	High
C	Diaphragm weakness	Diaphragm weakness	Diaphragm weakness occurs when the floor diaphragm is not properly connected to the walls. This can lead to failure of the diaphragm during an earthquake.	Strengthen the diaphragm by adding bracing, cross-bracing, or other structural elements. Increase the stiffness of the diaphragm.	High	High	High	High	High	High	High	High	High	High	High	High	High	High
D	Unreinforced concrete walls	Unreinforced concrete walls	Unreinforced concrete walls are vulnerable to seismic forces. They can crack, spall, and even fall out of the wall.	Reinforce concrete walls with steel reinforcement bars (rebar) and grout. Use proper construction techniques.	High	High	High	High	High	High	High	High	High	High	High	High	High	High
E	Unreinforced brick walls	Unreinforced brick walls	Unreinforced brick walls are vulnerable to seismic forces. They can crack, spall, and even fall out of the wall.	Reinforce brick walls with steel reinforcement bars (rebar) and grout. Use proper construction techniques.	High	High	High	High	High	High	High	High	High	High	High	High	High	High

Seismic Rehabilitation Training for One- and Two-Family Dwellings



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A picture card summarizing seismic vulnerabilities.

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## Building code citations

### Building Code Requirements Applicable to Seismic Rehabilitation

#### Basis for *Voluntary* Seismic Rehabilitation

**International Building Code (IBC)** Section 3403.2.3.2 Exception: Alterations initiated for the purpose of increasing the strength or stiffness of the seismic force resisting system need not be designed for ASCE 7 forces provided:

- Capacity of existing elements not reduced
- Loads to existing elements not increased beyond their capacity
- New elements detailed and connected per IBC
- New or moved nonstructural per IBC
- Alterations do not create a structural irregularity
- A dangerous condition is not created

#### **International Residential Code (IRC)**

- Does not explicitly address voluntary seismic upgrade
- Appendix J Section AJ501.4 suggests use of the structural loads applicable at the time the building was constructed
- Structural members found to be dangerous or unsound are required to conform to current IRC
- Recommend deferring to IBC or IEBC direction

**International Existing Building Code (IEBC)** Section 707.7: Voluntary alterations for purposes of increasing lateral force resistance need not meet force requirements of the IBC provided an engineering analysis shows:

- Capacity of existing elements not reduced
- Loads to existing elements not increased beyond their capacity
- New elements detailed and connected per IBC
- New or moved nonstructural per IBC
- A dangerous condition is not created

Voluntary alterations in accordance with IEBC appendix chapters and referenced standards are permitted



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A list of applicable building code citations.

# Training Handouts

## Step by step guide: prescriptive rehabilitation plans

**DEVELOP PRESCRIPTIVE RETROFIT PLANS  
FOR CRIPPLE WALL BRACING & ANCHORAGE TO FOUNDATION**

**INTRODUCTION**

**Objective of provisions:** The provisions of IEBC Appendix Chapter A3 are intended to reduce hazard of earthquake-induced damage (IEBC A301.1). These provisions are not intended to eliminate earthquake damage. This is partial seismic upgrade of vulnerable configuration.

**Alternative prescriptive provisions:** Some local jurisdictions and regional groups have developed bolting and bracing provisions similar to the IEBC provisions, with modifications deemed appropriate for local use. The following information will be applicable in general concept, but may vary from local provisions in some details. Consult with building department regarding local revisions and resources.

**When this prescriptive design method should be used:**

- 1) When undertaking voluntary seismic retrofit
- 2) When otherwise deemed appropriate by the building official.

**STEP 1: VERIFY IEBC SCOPE LIMITATIONS ARE MET (IEBC A301.2)**  
(circle YES or NO)

**Building Configuration Scope**

YES	NO	One to four-family detached dwelling with crawlspace
YES	NO	No lateral resistance is from poles or columns embedded in the ground
YES	NO	Cripple walls do not exceed 4 ft in height (level and low-slope sites)
YES	NO	3 stories or less with no cripple walls, OR
		2 stories or less with cripple walls less than 14 inches, OR
		2 stories or less with cripple walls up to 4 ft high

If all answers YES then proceed. If any of the above are NO, consult with building official or design professional regarding applicability of these provisions.



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A step by step procedure for how to use IEBC prescriptive provisions for anchorage and cripple wall bracing.

## Following This Training

### To learn more about installation:

FEMA G225 training course,  
*“Seismic Retrofit Training for Building Contractors & Inspectors”*



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Anyone who is interested in the nuts and bolts of seismic rehabilitation installation may also want to take the FEMA G225 training course, “Seismic Retrofit Training For Building Contractors & Inspectors.”

That course addresses installation details of:

- Shear wall construction (sheathing, nails, etc.)
- Shear wall connections (anchor bolts, etc.)
- Post & pier foundation rehabilitation

Portions of the FEMA G225 training are incorporated into Part 6 of this training.



# **Introduction, Importance of Seismic Rehabilitation**

## **Part 1 Quiz**



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You have completed part 1 of the education module.  
Contractor's please return to the contractor dashboard to take a short quiz.