

Rehabilitation Construction Basics

Part 6



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

1

Seismic Rehabilitation Basics

Introduction

- General rules
- Load path concepts
- Cripple wall sheathing
- Fasteners & connectors



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

2

While this seminar has focused on the big-picture concepts of seismic rehabilitation and rehabilitation design, details of installation are equally important to the improved performance of the dwelling.

This section gives a brief overview of important construction information for:
General rules

- Load path concepts
- Cripple wall sheathing
- Fasteners & connectors

General Rules: Safety On The Job Site

Working Conditions:

- Crawl spaces
- Demolition work
- Drilling wood/concrete
- Adhesive anchor use

Protection:

- Clothing
- Hard hats
- Gloves
- Respirators



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

3

Persons installing seismic rehabilitation work will be accessing and performing work in difficult access locations, which requires attention to safety. Installers must properly prepare for these difficult work conditions, including consideration of safe work methods and required protection.

General Rules: Use Prescribed Design

- Do not deviate without approval
- Don't change specified materials
- Don't change bracing length or location
- Don't change nail size or spacing
- If can't be installed as specified, call design professional
- Document all changes and communications



FEMA

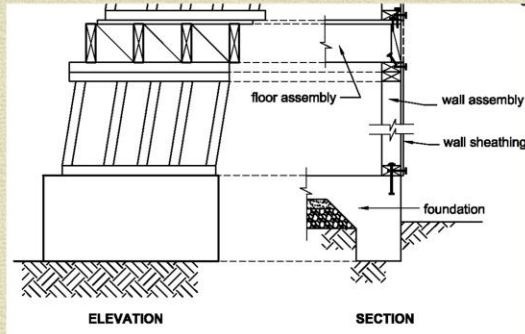
Residential Seismic Rehabilitation - CEBC Chapter A3

4

Once a rehabilitation design has been developed and approved by the building department, it is important that it be installed in substantial conformance with the approved plans. Revisions to the plans, if necessary, should also be approved. Specified materials, nails, connectors, etc should be used. Bracing length and location should not be changed except for very minor adjustments. Where specified work cannot be installed, additional guidance from an architect or engineer will likely be needed.

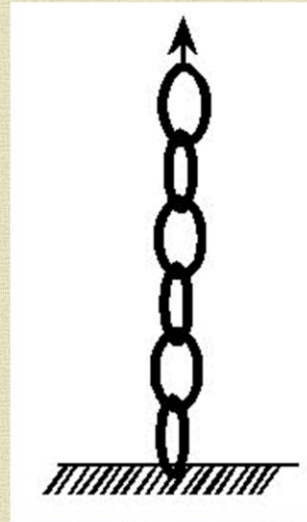
Load Path

Works like a chain being pulled. Weak or missing links hurt building performance.



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3



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

5

When seismic rehabilitation work is being installed, the concept of a load path provides important guidance on completeness of the rehabilitation measures installed. A load path works like a chain that is being pulled. Each link is a load path connection. A weak or missing link will prevent a building from performing as expected.

To have a complete load path for cripple wall rehabilitation, fastening or connections should be provided at every potential slip plane within the load path. The figure on the right illustrates potential weak links for cripple wall bracing. When cripple wall sheathing is added, it is important to have connections to get load in at the top of the wall, and to get load back out at the bottom of the wall. Where connection is not provided at a potential slip plane, the cripple wall bracing will not perform as intended. This condition should be corrected.

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

Cripple Wall Sheathing

- Use specified wood structural panel with proper grade stamps visible
 - OSB
 - Plywood
- 15/32-inch minimum thickness, no great benefit from greater thickness
- Exposure 1 or Exterior Exposure



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

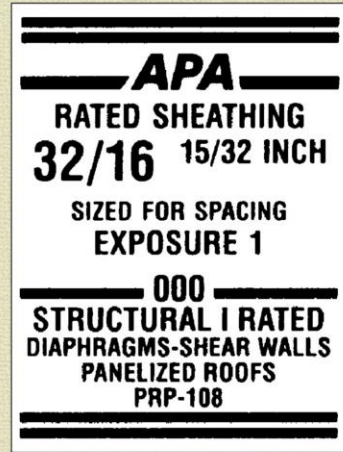
6

Cripple wall sheathing is an important component of the seismic rehabilitation work. Sheathing should have grade stamps that can be used to verify that the specified sheathing type is provided. It is important to verify:

- Sheathing is structural rated sheathing
- Sheathing is at least 15/32-inches thick
- Sheathing weather exposure rating is either exposure 1 or exterior exposure

Cripple Wall Sheathing

- Install in largest sheet size possible (may be controlled by crawlspace access)
- Provide 1/8-inch gap at sheathing panel ends and edges (allows for slight expansion with moisture increase)
- All sheathing edges to fall on existing wall framing or added blocking



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

7

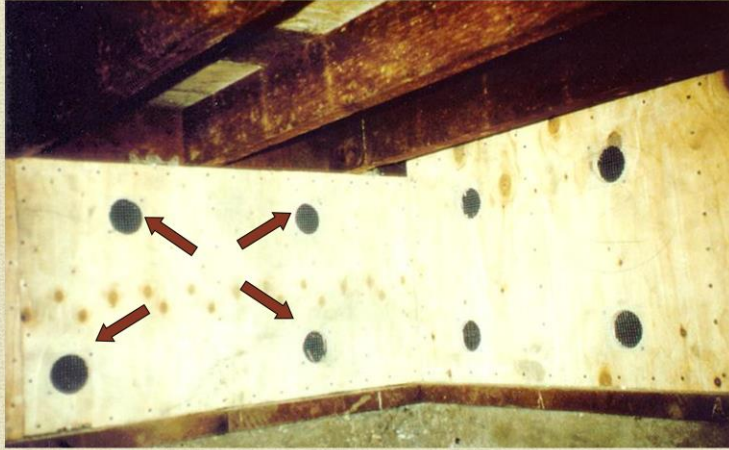
Installation should use the largest sheathing sheet size practical given access and restrictions of placement

Plywood is fabricated at a very low moisture content, and it is typical for the plywood to expand somewhat due to higher moisture content when installed. For this reason 1/8-inch gaps are required at sheathing ends and edges. It is recommended that these gaps be provided not only between abutting sheathing sheets, but also between panels and abutting framing.

All sheathing edges are required to fall on and be edge nailed (4-inches on center) to framing (studs, top plates, sill plates or blocking)

Cripple Wall Sheathing

Provide ventilation holes in each stud bay.



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

8

Ventilation holes should be provided in each stud bay. Because it is possible for moisture to enter the stud bays, the holes provide for air circulation that can allow moisture to dissipate rather than accumulating and causing decay.

Fasteners & Connectors

Sheathing nails:

- Use correct nail type
- Use correct nail size

COMPARISON OF COMMON VS. BOX NAILS					
Nail Size	Length, (inches)	Shank Diameter, (inches)		Allowable Lateral Load (pounds)	
		Common Nail	Box Nail	Common Nail	Box Nail
8d	2 ½	0.131	0.113	73	56
10d	3	0.148	0.128	87	63



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

9

It is important that the correct nail type and size be used for construction of seismic rehabilitation. Nails are typically specified by a combination of type and size (penny weight). Load capacities of nails are primarily related to shank diameter, and therefore vary based on both size and type – this can be seen in that table above where the diameter and capacity of 8d common nails vary from 8d box nails. If cripple wall sheathing were to be installed with box nails instead of common nails, the capacity would be less than required.

CEBC provisions require use of common nails. In some cases the common nails are required to be galvanized.

Fasteners & Connectors

Sheathing nails:

- Make sure nail is fully embedded in framing
- Make sure nails do not split framing, replace framing if split



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

10

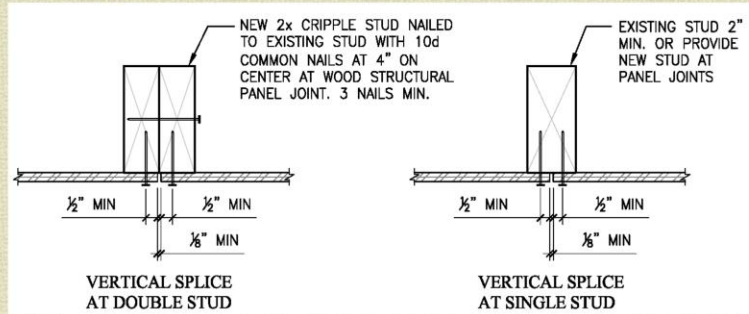
It is important that:

- Nails are embedded in the framing. Nails not embedded (shiners) as seen in this photograph have no capacity.
- Nails do not split framing. Nails in split framing do not have any capacity. Split framing must be replaced. Where splitting is possible, nail holes should be predrilled to 75% of the nail shank diameter.

Fasteners & Connectors

Sheathing nails:

- Use prescribed detail where sheathing panels abut



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

11

Abutting panel edges must either fall on a single common framing member or two framing members, properly interconnected as shown in this CEBC Chapter A3 figure.

Fasteners & Connectors

Sheathing nails:

- Do not over-drive nails (add one nail for each over-driven)
- Maintain 3/8" minimum distance from center of nail to edge of sheathing



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

12

Nails are considered to be over-driven when the face of the sheathing is fractured by the sheathing nails. Many of the nails in the above photo are over-driven. Properly adjusted nail guns will not over-drive nails. Where nails are over-driven, the capacity is significantly affected and additional nails must be provided.

A 3/8-inch distance is required between the center of the nails and the edge of the sheathing. This distance was not maintained for a number of nails in this photo. Nails with less edge distance will fail prematurely under earthquake loading, so additional nails must be provided. It is good practice to increase the edge distance to 1/2-inch in locations where this is possible, as this will result in better performing sheathing.

Fasteners & Connectors

Edge nail – 4" o.c.:

- upper top plate
- sill or sole plate
- blocking for individual panel edges
- blocking for opening reinforcement

Field nail – 12" o.c.:

- studs between the panel edges



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

13

Sheathing edge nailing at four inches on center is required at:

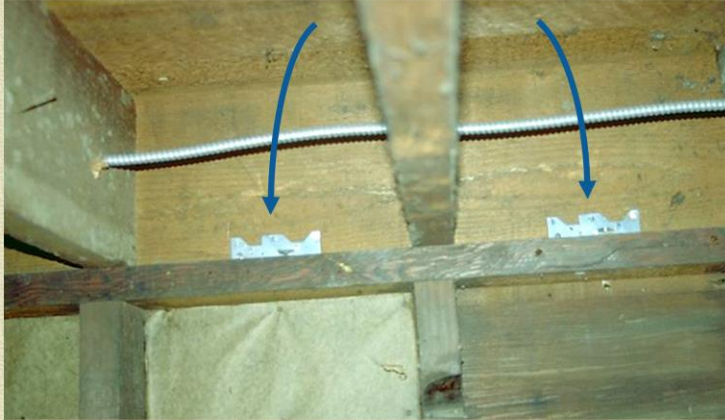
- The upper top plate of the cripple wall
- The sill plate, sole plate of blocking at the bottom of the cripple wall
- All panel edges
- Edges at openings in the sheathing

In short, any sheathing edge should be nailed at 4-inches on center

In addition, sheathing should be field nailed to studs that do not fall at panel edges. This nailing controls out-of-plane buckling of the sheathing.

Fasteners & Connectors

Connecting the Top Plate with Framing Clips



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

14

This photo shows framing clips connecting floor framing to cripple wall top plates.

Fasteners & Connectors

Palm Nailer



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

15

In locations with limited access, use of a palm nailer is helpful for installing required connectors.

Fasteners & Connectors

Steel Plate Washers



FEMA

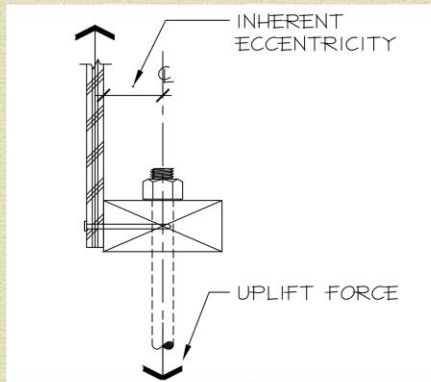
Residential Seismic Rehabilitation - CEBC Chapter A3

16

Square steel plate washers are required on all new anchor bolts and recommended on existing bolts where it is possible to install them.

Fasteners & Connectors

Steel Plate Washers



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

17

Foundation sill plates split when shear walls are loaded in plane, resulting in the sheathing being pulled up at one end of the wall. Where sheathing is pulled up, the uplift is resisted by the anchor bolts, but this causes bending of the sill plate in its weak direction, allowing splitting at very low load levels, as seen in the right photo. Steel plate washers help to limit or delay splitting of foundation sill plates.

Fasteners & Connectors

Mechanical Anchors



- Concrete must be in good shape.
- Minimum edge distance must be maintained.
- Use required torque and calibrated torque wrench.



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

18

Mechanical anchors (wedge anchors or expansion anchors) are one of the types of anchors permitted by CEBC for foundation sill plate anchorage to the foundation. When using mechanical anchors it is important that:

- Concrete is in good shape
- Minimum edge distances are maintained
- Manufacturer's installation instructions are followed, including required torque values

Fasteners & Connectors

Adhesive Anchor



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

19

Adhesive (epoxy) anchors are the other type of anchor allowed by CEBC Chapter A3. When installing adhesive anchors, strict attention to the manufacturer's installation instructions is vital to obtaining adequate anchor capacity.

Fasteners & Connectors

Adhesive Anchor



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

20

Very important in anchor installation is proper cleaning of the drilled hole, generally using both a wire brush and compressed air. Where not cleaned properly, adhesive anchors will fail at a small portion of the rated capacity.

Fasteners & Connectors

Adhesive Anchor



- Use all-thread rod
- Fill the hole with adhesive in accordance with instructions
- Install rod with washer and nut attached
- Cure before tightening



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

21

When installing the adhesive anchor, it is also important to:

- Use all-thread rod
- Fill the hole with adhesive in accordance with instructions
- Install rod with washer and nut attached
- Cure before tightening

Fasteners & Connectors

Split Sill Plate



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

22

With either mechanical or adhesive anchors, there are some common installation issues that need to be considered.

First, anchors installed in split plates have little to no capacity. Where this occurs, either additional anchor bolts need to be installed into sill plates that are not split, or the split sill plate needs to be replaced.

Fasteners & Connectors

Improper Countersinking



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

23

Counter sinking of anchor bolts greatly reduces the bolt capacity and does not allow proper installation of plate washers. Counter-sunk anchor bolts should not be counted towards the requirements of CEBC Chapter A3 unless specifically approved by an architect or engineer.

Fasteners & Connectors

Improper Edge Distance in Concrete



FEMA

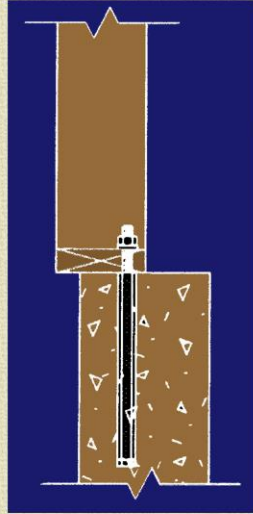
Residential Seismic Rehabilitation - CEBC Chapter A3

24

Bolts installed with inadequate distances between the center line of the bolt and edge of the concrete can fail prematurely, with failure sometimes occurring during installation, as seen in this photo.

Fasteners & Connectors

Misaligned Sill Plate Should be Adjusted



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

25

Misalignment of sill plates and foundation is sometimes found while installing rehabilitation work. Where the edge of studs and sill plates extend a small distance beyond the edge of the foundations, a wider sill plate should be installed so that the bolt center is at least one inch from the edge of the sill plate. Where the misalignment is larger, an architect or engineer should be consulted to evaluate the overall capacity of the wall support.

Rehabilitation Construction Basics

Part 6 Quiz



FEMA

Residential Seismic Rehabilitation - CEBC Chapter A3

26

You have completed part 6 of the education module.

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