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Why Decks Fail – Design and New PA UCC Requirements to Improve Safety

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Description

- In this one hour workshop we will review past deck failures and explain the critical failure points in the design. Then we will review the current code requirements for residential deck design and construction. This will include reviewing the new prescriptive design requirements for joists, beams and post sizing. We will also review the design requirements for stairs and stair illumination. The newly adopted code requirements lay the groundwork for the design of a residential deck. Upon completion of this workshop, attendees will know where to find and apply the prescriptive design guidelines set forth in the IRC code books.




Objectives

- The learning objectives for this program are:**
 - Understand how decks can fail and cause harm to the occupants.
 - Provide an understanding of the deck requirements in the IRC and Pennsylvania's Uniform Construction Code.
 - Provide an overview of proper materials and construction methods
 - Provide background information on how to inspect for compliance with the IRC for occupant safety




Outline

- Review failures in decks
 - Ledger connection
 - Guardrails
- Review the **NEW** prescriptive requirements for Residential Deck Design and Construction



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Deck Failures



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Normal Deck Loading

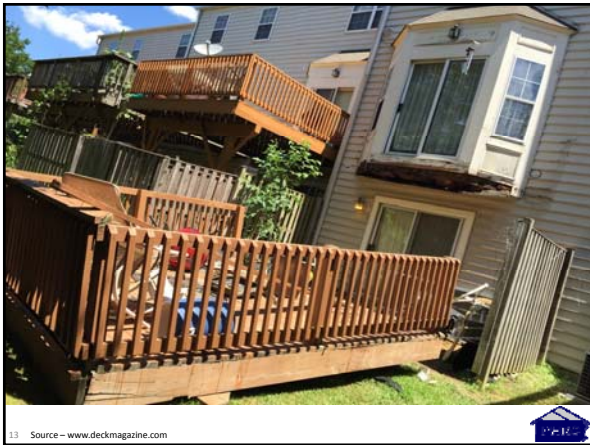


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Excessive Deck Loading



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13 Source - www.deckmagazine.com



14 Source - www.thatshouldhold.com













Injuries

- More injuries may be connected to deck failures than all other wood building components and loading cases combined!



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Guardrail Loading



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Guardrail failure

- Improper railing attachments resulted in a lady falling 14 feet to her death.



23 Photo courtesy of - Darin Clements



Post attachment

- Toe-nailed post?



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Compliant?



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Compliant?



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Structural Review

- It is much more than “just a deck”!

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And they are EVERYWHERE!



Is there a difference in design practice?

- House vs. Deck



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Structural Review – House vs. Deck

- Different structural systems
 - House – Platform frame
 - Deck - Post and beam
 - (Now covered by the IRC – See R507.1 Decks)
- Less structural redundancy
- Larger loads on members and connections
- Lower lateral stability

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Structural Review – House vs. Deck

- Increased exposure (wet service – UV)
 - Wood durability
 - Fasteners
- Uncertain (unexpected) service load during the life of the structure
- Design life expectancy
 - House = 50 years
 - Deck = ?
 - Deck Planks (wood) = 15 years
 - Deck Planks (composite) = 8-25 years
 - Structural Wood = 10-30 years
 - Fasteners (galvanized) = 10+ years
 - Fasteners (hot-dipped galvanized) = 35-60 years
 - Source – www.nachi.org
- Failure
 - House failure may not be catastrophic
 - Deck failure usually are

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New UCC Adopted Changes to Residential Deck Construction



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The Pennsylvania regulation related to Residential Construction codes changed effective December 31, 2015.



New Residential Deck Section in 2015 IRC

- **R507.1 Decks.** Wood-framed decks shall be in accordance with this section or Section R301 for materials and conditions not prescribed herein... (See text in 2015 IRC for remainder of unchanged section.)

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(i)
36 International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, Ill.



Decking Design Criteria

- **R507.4 Decking.** Maximum allowable spacing for joists supporting decking shall be in accordance with Table R507.4.

MATERIAL TYPE AND NOMINAL SIZE	MAXIMUM ON-CENTER JOIST SPACING	
	Perpendicular to joist	Diagonal to joist ^a
1 1/4-inch-thick wood	16 inches	12 inches
2-inch-thick wood	24 inches	16 inches
Plastic Composite	In accordance with Section R507.3	In accordance with Section R507.3

a. Maximum angle of 45 degrees from perpendicular for wood deck boards

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(K) – section
PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(S) - table

37 International Code Council (ICC). (2014). *2015 International Residential Code*, Country Club Hill, Ill.



Design Criteria for Composite Decking

Text adopted through reference in Table R507.4

- **Portions of R507.3.1 Labeling.** ...includes the maximum allowable span determined in accordance with ASTM D7032.
- **Portions of R507.3.5 Installation of plastic composites.** Plastic composite deck boards, stair treads, guards and handrails shall be installed in accordance with this code and the manufacturer's instructions.
- Section R507.3 is adopted by reference only to the extent that it provides the maximum on-center joist spacing for plastic composite decking.
- Subsections of R507.3 are adopted as referenced by the language of R507.3 only to the extent that it provides the maximum on-center joist spacing for plastic composite decking.
- Requirement that plastic composite components be installed with the manufacturer's instructions is adopted by reference as it relates to the maximum on-center joist spacing for plastic composite decking.

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Deck Joist Design Criteria

- **R507.5 Deck joists.** Maximum allowable spans for wood deck joists, as shown in Figure R507.5, shall be in accordance with Table R507.5. Deck joists shall be permitted to cantilever not greater than one-fourth of the actual, adjacent joist span.

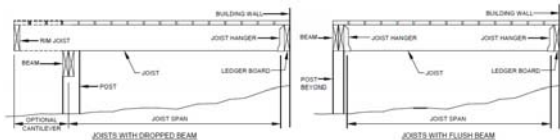


Figure R507.5
Typical Deck Joist Spans

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(L) – new section
PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(W) – new figure

39 International Code Council (ICC). (2014). *2015 International Residential Code*, Country Club Hill, Ill.



Deck Joist Span Table

**TABLE R507.5
DECK JOIST SPANS FOR COMMON LUMBER SPECIES¹ (ft. - in.)**

SPECIES ²	SIZE	SPACING OF DECK JOISTS WITH NO CANTILEVER ³			SPACING OF DECK JOISTS WITH CANTILEVERS ³		
		(inches)			(inches)		
		12	16	24	12	16	24
Southern Pine	2 X 6	9-11	9-0	7-7	6-8	6-8	6-8
	2 X 8	13-1	11-10	9-8	10-1	10-1	9-8
	2 X 10	16-2	14-0	11-5	14-6	14-0	11-5
	2 X 12	18-0	16-6	13-6	18-0	16-6	13-6
Douglas fir-larch ⁴ , hem-fir ⁴ , spruce-pine-fir ⁴	2 X 6	9-6	8-8	7-2	6-3	6-3	6-3
	2 X 8	12-6	11-1	9-1	9-5	9-5	9-1
	2 X 10	15-8	13-7	11-1	13-7	13-7	11-1
	2 X 12	18-0	15-9	12-10	18-0	15-9	12-10
Rosewood, western cedars, ponderosa pine ⁴ , red pine ⁴	2 X 6	8-10	8-0	7-0	5-7	5-7	5-7
	2 X 8	11-8	10-7	8-8	8-6	8-6	8-6
	2 X 10	14-11	13-0	10-7	12-3	13-3	10-7
	2 X 12	17-5	15-1	12-4	16-5	15-1	12-4

¹ No. 2 grade with wet service factor.
² Ground snow load, live load = 40 psf, dead load = 10psf, U/C = 360.
³ Ground snow load, live load = 40 psf, dead load = 10psf, U/C = 360 at main span, U/C = 180 at cantilever with a 220-pound load applied to end.
⁴ Includes incising factor.
⁵ Northern species with no incising factor.
⁶ Cantilevered spans not exceeding the normal depth of the joist are permitted.

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(T)
⁴⁰ International Code Council (ICC). (2014). *2015 International Residential Code*, Country Club Hill, Ill.

Protection Against Rotation

- R507.5.1 Lateral restraint at supports.** Joist ends and bearing locations shall be provided with lateral restraint to prevent rotation. Where lateral restraint is provided by joist hangers or blocking between joists, their depth shall equal not less than 60 percent of the joist depth. Where lateral restraint is provided by rim joists, they shall be secured to the end of each joist with not less than (3)10d nails or (3) No. 10 x 3 inch long wood screws.

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(M)
⁴¹ International Code Council (ICC). (2014). *2015 International Residential Code*, Country Club Hill, Ill.

Deck Beam Design Criteria

- R507.6 Deck Beams.** Maximum allowable spans for wood deck beams, as shown in Figure R507.6, shall be in accordance with Table R507.6. Beam plies shall be fastened with two rows of 10d nails minimum at 19 inches on center along each edge. Beams shall be permitted to cantilever at each end up to one-fourth of the actual beam span. Splices of multispans beams shall be located at interior post locations.

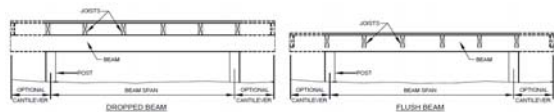


Figure R507.6
Typical Deck Beam Spans

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(N) – new section
PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(X) – new figure
⁴² International Code Council (ICC). (2014). *2015 International Residential Code*, Country Club Hill, Ill.

Deck Beam Span Table

TABLE R507.6
DECK BEAM SPAN LENGTHS^{a, b} (ft. - in.)

SPECIES ^c	SIZE	DECK JOIST SPAN LESS THAN OR EQUAL TO: ^d (feet)						
		6	8	10	12	14	16	18
Southern pine	2 - 2 X 6	6-1	5-11	5-4	4-10	4-6	4-3	4-0
	2 - 2 X 8	9-9	7-7	6-9	6-2	5-9	5-4	5-0
	2 - 2 X 10	10-4	9-0	8-0	7-4	6-9	6-4	6-0
	2 - 2 X 12	12-2	10-7	9-5	8-7	8-0	7-6	7-0
	3 - 2 X 6	8-2	7-5	6-8	6-1	5-8	5-3	5-0
	3 - 2 X 8	10-10	9-6	8-6	7-9	7-2	6-8	6-4
Douglas fir-larch ^e , hem-fir ^e , spruce-pine-fir ^e , redwood, western cedar, ponderosa pine ^e , redpine ^e	3 X 6 or 2 - 2 X 6	5-5	4-8	4-2	3-10	3-6	3-1	2-9
	3 X 8 or 2 - 2 X 8	6-10	5-11	5-4	4-10	4-6	4-1	3-8
	3 X 10 or 2 - 2 X 10	9-4	7-9	6-6	5-11	5-6	5-1	4-8
	3 X 12 or 2 - 2 X 12	9-8	8-5	7-6	6-10	6-4	5-11	5-7
	4 X 6	6-5	5-6	4-11	4-6	4-2	3-11	3-8
	4 X 8	8-5	7-9	6-6	5-11	5-6	5-2	4-9
	4 X 10	9-11	8-7	7-8	7-0	6-6	6-1	5-8
	4 X 12	11-5	9-11	8-10	8-1	7-6	7-0	6-7
	3 - 2 X 6	7-4	6-8	6-0	5-6	5-1	4-9	4-6
	3 - 2 X 8	9-8	8-6	7-7	6-11	6-5	6-0	5-8
	3 - 2 X 10	12-0	10-5	9-4	8-6	7-10	7-4	6-11
	3 - 2 X 12	13-11	12-1	10-9	9-10	9-1	8-6	8-1

^a Ground snow load, live load + 40 psf dead load + 10 psf U.L. + 30 psf min. snow U.L. + 100 psf live load with a 200-pound load applied to end.
^b Beams supporting deck joists from one side only.
^c No. 2 grade, wet service factor.
^d Beam depth shall be greater than or equal to depth of joist with which beam is installed.
^e Includes timing factor.
 International Code Council (ICC), (2014). 2015 International Residential Code, Country Club Hill, Ill.

Joist Bearing Requirements

- R507.7 Deck joist and deck beam bearing.** The ends of each joist and beam shall have not less than 1 1/2 inches of bearing on wood or metal and not less than 3 inches on concrete or masonry for the entire width of the beam. Joist framing into the side of a ledger board or beam shall be supported by approved joist hangers. Joists bearing on a beam shall be connected to the beam to resist lateral displacement.

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(O)
 International Code Council (ICC), (2014). 2015 International Residential Code, Country Club Hill, Ill.

Deck Post to Beam Connection

- R507.7.1 Deck post to deck beam.** Deck beams shall be attached to deck posts in accordance with Figure R507.7.1, or by other equivalent means capable to resist lateral displacement. Manufactured post-to-beam connectors shall be sized for the post and beam sizes. All bolts shall have washers under the head and nut.
 - Exception:** Where deck beams bear directly on footings in accordance with Section R507.8.1

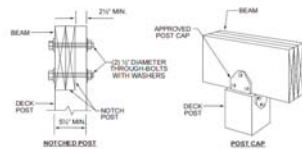


Figure R507.7.1
Deck Beam to Deck Post

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(P) – new section
 PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(V) – new figure
 International Code Council (ICC), (2014). 2015 International Residential Code, Country Club Hill, Ill.

Deck Post Design Criteria

- R507.8 Deck posts.** For single level wood-framed decks with beams sized in accordance with Table R507.6, deck post size shall be in accordance with Table R507.8.

TABLE R507.8
DECK POST HEIGHT^a

DECK POST SIZE	MAXIMUM HEIGHT ^a
4 X 4	8'
4 X 6	8'
6 X 6	14'

^a Measured to the underside of the beam.

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(Q) – new section
 PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(U) – new table
⁴⁶ International Code Council (ICC). (2014). *2015 International Residential Code, Country Club Hill, Ill.*



Deck Post Footing Detail

- R507.8.1 Deck post to deck footing.** Posts shall bear on footings in accordance with Section R403 and Figure R507.8.1. Posts shall be restrained to prevent lateral displacement at the bottom support. Such lateral restraint shall be provided by manufactured connectors installed in accordance with Section R507 and the manufacturers' instructions or a minimum post embedment of 12 inches (305 mm) in surrounding soils or concrete piers.

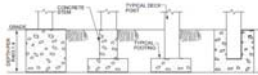


Figure R507.8.1
Typical Deck Posts to Deck Footings

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(R) – new section
 PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(Z) – new figure
⁴⁷ International Code Council (ICC). (2014). *2015 International Residential Code, Country Club Hill, Ill.*



Lateral Load Design

- R507.2.4 Deck lateral load connection.** The lateral load connection required by Section R507.1 shall be permitted to be in accordance with Figures R507.2.3(1) or R507.2.3(2). Where the lateral load connection is provided in accordance with Figure R507.2.3(1), hold-down tension devices shall be installed in not less than two locations per deck, within 24 inches of each end of the deck. Each device shall have an allowable stress design capacity of not less than 1500 pounds. Where the lateral load connections is provided in accordance with Figure R507.2.3(2), the hold-down tension devices shall be installed in not less than 4 locations per deck, and each device shall have an allowable stress design capacity of not less than 750 pounds.

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(J)
⁴⁸ International Code Council (ICC). (2014). *2015 International Residential Code, Country Club Hill, Ill.*



Lateral Load Design Option #1

**Figure R507.2.3(1)
Deck Attachment for Lateral Loads
(Same as IRC 2009 figure)**

PA UCC Reference: Title 34, Chapter 403.21 (7)(iii)(V)
International Code Council (ICC), (2014). 2015 International Residential Code, Country Club Hill, Ill.

Lateral Load Design Option #2

NOTE: THIS DETAIL IS APPLICABLE WHERE FLOOR JOISTS ARE PARALLEL TO DECK JOISTS.

**Figure R507.2.3(2)
Deck Attachment for Lateral Loads**

PA UCC Reference: Title 34, Chapter 401.21 (7)(iii)(V)
International Code Council (ICC), (2014). 2015 International Residential Code, Country Club Hill, Ill.

Proprietary Installation Instructions

- Alternative connection detail examples (proprietary)**

Figure 4

DTT12 – 750-Pound Assembly
Condition 1 – Hold-downs Cannot Be Installed Flush with Wall Sheathing

Unlike some hold-downs, the DTT12 seat is not required to bear on sheathing or framing and can be installed away from the wall to account for non-structural siding, joist hanger interference or other conditions. Longer screw anchors may be required to ensure a minimum of 2" thread penetration by a fully threaded lag screw or Strong-Drive® SOWH Timber-Hex HDG screw into the wall framing.

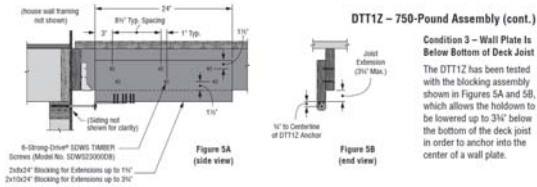
Condition 2 – Top of Wall Plate Does Not Align with Bottom of Deck Joist

The 2015 IRC detail shows a hold-down installed on the bottom of the joist. However, the DTT12 was tested and developed using 1½" fasteners into either the narrow edge or side face of a 2x member, allowing the DTT12 to be installed at any location along the depth of the joist.

Source: Simpson Strong-Tie Technical Bulletin
"Installation Options for Deck Lateral Load Connections"

Proprietary Installation Instructions

• Alternative connection detail examples (proprietary)

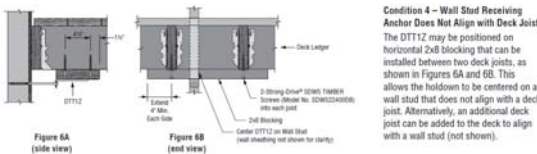


Source: Simpson Strong-Tie Technical Bulletin
 "Installation Options for Deck Lateral Load Connections"



Proprietary Installation Instructions

• Alternative connection detail examples (proprietary)

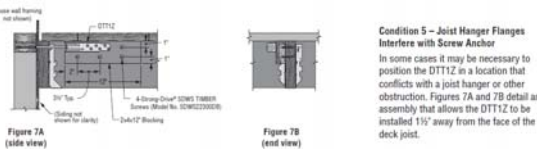


Source: Simpson Strong-Tie Technical Bulletin
 "Installation Options for Deck Lateral Load Connections"



Proprietary Installation Instructions

• Alternative connection detail examples (proprietary)

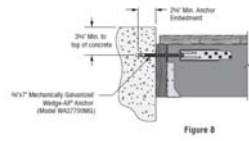


Source: Simpson Strong-Tie Technical Bulletin
 "Installation Options for Deck Lateral Load Connections"



Proprietary Installation Instructions

- Alternative connection detail examples (proprietary)



Condition 6 – Ledger Attaches to Concrete Foundation Wall
 As an alternative to using a Strong-Drive® SDWH Timber-Hex HDG screw or fully threaded 1/2" lag screw, the DTT12 may be anchored with a 1/2" mechanically galvanized Wedge-All® anchor (as shown in Figure 8) to achieve the 750-pound load requirement.

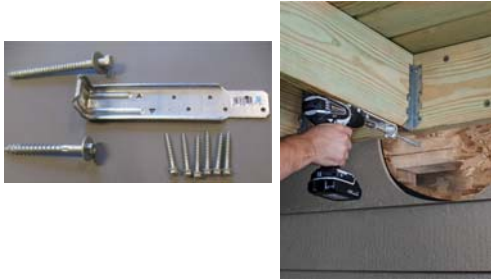
Figure 8

Source: Simpson Strong-Tie Technical Bulletin
 "Installation Options for Deck Lateral Load Connections"



Proprietary Installation Instructions

- Alternative connection detail examples (proprietary)



Source: Simpson Strong-Tie



Safety Consideration Not Changed by
 the New UCC Codes

Guardrails



Guardrail Loading

- **2009 IRC Table R301.5**
 - Guardrails and Handrails – 200 lb live load
 - Guardrail in-fill components – 50 lb live load
- **Single concentrated load applied in any direction at any pint along the top.**

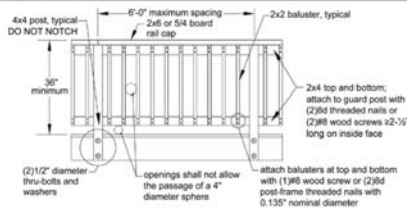
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Guardrail Design with DCA-6

- **Decks greater than 30" above grade require a guard**

Figure 24. Example Guard Detail



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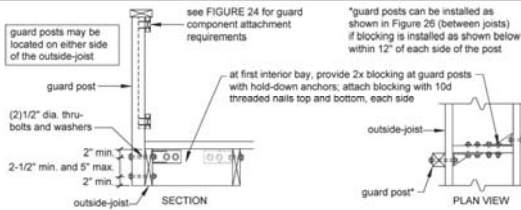
courtesy, American Wood Council, Leesburg, VA



Guardrail Requirements

- **Minimum 4x4 post**

Figure 25. Guard Post to Outside Joist Example



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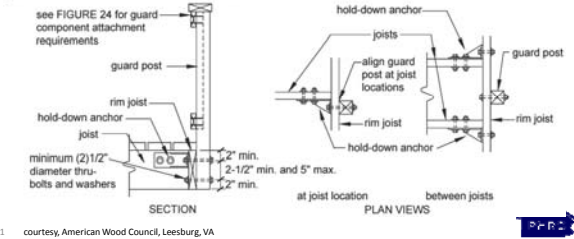
courtesy, American Wood Council, Leesburg, VA



Guardrail Requirements

- Guard post to rim joist

Figure 26. Guard Post to Rim Joist Example



Thoughts on Guards

- Never rely on nails in withdrawal.
- Guard rail post connection capacity:
 - Difficult to calculate (too many variables, large number of connections, requires 3 dimensional analysis)
 - relies on full assembly (weakest link)
 - is difficult to field verify (hip check is probably ~ 30lbs)
- Notched posts should not be allowed in most cases.
- Proprietary systems are all tested at required load + factor-of-safety.

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References

- International Code Council (ICC). (2008). 2009 International Residential Code, Country Club Hill, Ill.
- International Code Council (ICC). (2014). 2015 International Residential Code, Country Club Hill, Ill.
- PA Code Title 34, Chapter 401.21 (7)(iii)(A) – (BB)
- PA Code Title 34, Chapter 401.21 (9)(i) – (v)
- American Wood Council, DCA-6 09, Leesburg, VA
 - <http://www.awc.org/codes-standards/publications/dca6>

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Evaluations / Certificate / Questions?

This concludes The American Institute of Architects Continuing Education Systems Course



Link to Certificate:

<http://www.cvent.com/d/bfqvn3/4W>

This concludes the 2015-16 PHRC Webinar Series. The 2016-17 series will begin in September 2016.

Have a wonderful summer – See you in September!

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