2021 IRC

Structural Concerns & Braced Walls

Chris Kimball, PE, SE, MCP, CBO
801.547.8133
chrisk@wc-3.com
www.wc-3.com

Course Objectives

- ***The intent of this course is to...***
  1. To gain a clear understanding of structural loads, load paths, and site conditions.
  2. To outline common framing and other structural errors in residential construction.
  3. To clearly define the braced wall provisions of the IRC.

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Seminar Format

1. Loads & Load Paths
2. Site Conditions
3. Structural Concerns
4. Trusses
5. Wall Bracing
6. Open Discussion

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PART 1

Loads & Load Paths

Habitat 67 - Montreal, Quebec

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Design Criteria (R301.1)

- *"…shall be constructed to safely support all loads, including dead loads, live loads, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code."*
- *"The construction… shall result in a system that provides a complete load path..."*

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Load Paths

- ***Newton's 3rd Law:***
  - "To every action there is an equal and opposite reaction."
- ***Load Path:***
  - How the loads are transferred from the point of origin to where they are resisted.

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Load Paths

- ***What causes vertical loads?***
  - Gravity
- ***What causes lateral loads?***
  - Wind
  - Seismic
- ***What resists these loads?***
  - Ground

7

Parts of Structure

- Connections, connections, connections
- Beams, columns, headers
- Diaphragms, shear walls, collectors
- Footings, foundations, soil

8

Not Part of Structure

- ❑ Interior partitions
- ❑ Drywall and other finishes
- ❑ Roofing, insulation, MEP

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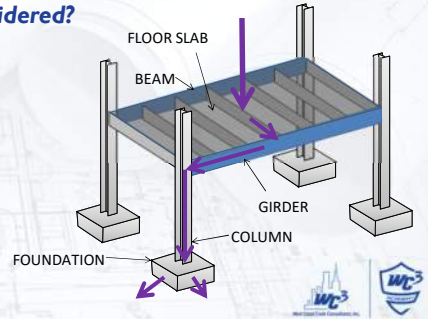
Gravity Load Path

- ❑ ***What loads need to be considered?***
  - Dead loads
  - Live loads
  - Snow loads
  - Soil loads
  - Hydrostatic loads
  - Rain loads
  - Flood loads



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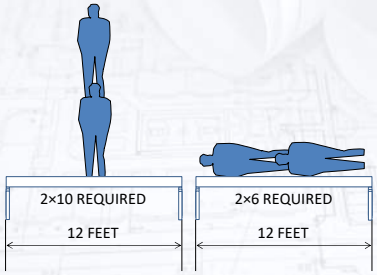
Gravity Load Path

- ❑ ***Concentrated vs. Uniform Loads***



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Gravity Load Path

- ❑ The load path is pretty easy to follow.
- ❑ What are some common problems?

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Lateral Load Path

- Not as easily understood
- What loads need to be considered?
  - Wind
  - Seismic

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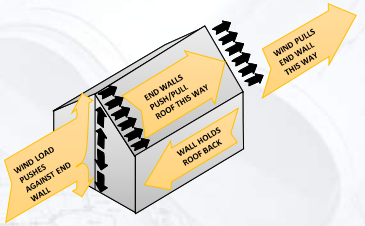
Lateral Load Path

- ***Wind:***
  - Wind acts against the sides of a building like the sail on a boat.
  - The majority of forces are transferred up into the roof/floor while the rest into the foundation.



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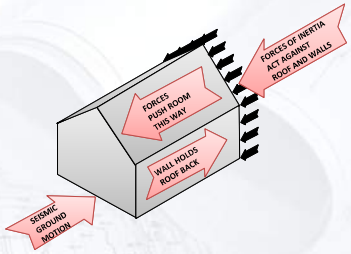
Lateral Load Path

- ***Seismic:***
  - Ground shaking causes the structure's mass to be accelerated back and forth.
  - Forces are developed where the structures mass is the largest.



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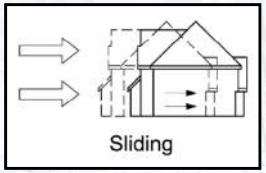
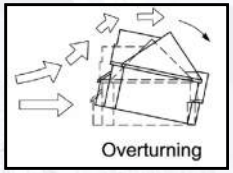
Lateral Load Path

- ***Structure & foundations must resist…***





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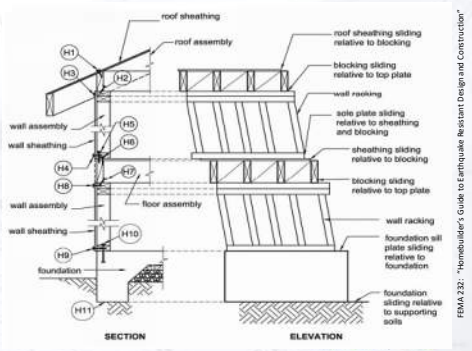
Lateral Load Path

- ***Sliding Load Path:***



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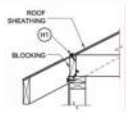
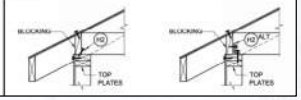
Lateral Load Path

- ***Sliding Load Path (cont.)***

H1	**Sheathing**[1] **Nailing**[2] 5/16" to ½" 8d common @ 6" 19/32" to 1" 8d common @ 6" 1⅛" to 1¼" 10d common @ 6" • Resists roof sheathing sliding with respect to blocking below. • Six-inch nail spacing applies to supported sheathing edges and blocking. Twelve-inch spacing applies at other panel supports. • Rafter blocking is not always required by *IRC*; however, sheathing should be nailed to blocking where blocking is provided.	
H2	Three 8d box (0.113"x2½") or three 8d common (0.131x2½") toenails each block. • Resists rafter blocking sliding with respect to wall top plate. • **Use of angle clips in lieu of toenails is a recommended above-code measure.** • Rafter blocking is not always required by *IRC*; however, it should be fastened where provided.	

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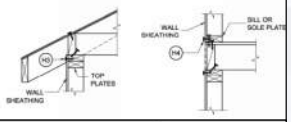
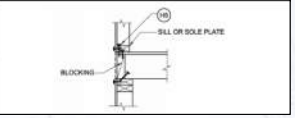
Lateral Load Path

- ***Sliding Load Path (cont.)***

H3 & H4	**Sheathing**[1] **Nailing**[2] 5/16" to ½" 6d common @ 6" 19/32" to 1" 8d common @ 6" 1⅛" to 1¼" 10d common @ 6" • Provides wall racking resistance. • Six-inch nail spacing applies to sheathing edges. Twelve-inch spacing applies at other studs.	
H5	**At Braced Wall Panels** Three 16d box (0.135"x3½") or three 16d sinker (0.148x3¼") face nails each 16 inches on center (space evenly). **Between Braced Wall Panels** One 16d box (0.135"x3½") or one 16d sinker (0.148x3¼") face nail at 16 inches on center. • Resists wall sole plate sliding with respect to sheathing and blocking or rim joist below.	

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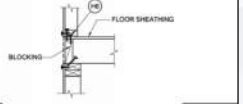
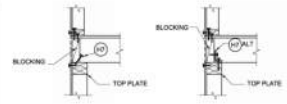
Lateral Load Path

- ***Sliding Load Path (cont.)***

H6	**Sheathing**[1] **Nailing**[2] 5/16" to ½" 6d common @ 6" 19/32" to 1" 8d common @ 6" 1⅛" to 1¼" 10d common @ 6" • Resists floor sheathing sliding with respect to blocking below. • Six-inch nail spacing applies to supported sheathing edges and blocking. Twelve-inch spacing applies at other panel supports.	
H7	Three 8d box (0.113"x2½") or three 8d common (0.131x2½") toenails each block. • Resists joist blocking sliding with respect to wall top plate. • **Use of angle clips in lieu of toenails is a recommended above-code measure.**	

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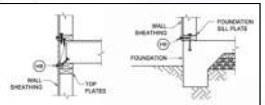
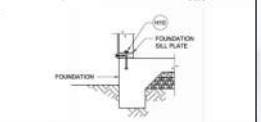
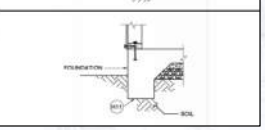
Lateral Load Path

H8 & H9	**Sheathing[2]** **Nailing[3]** 5/16" to ½" 6d common @ 6" 19/32" to 1" 8d common @ 6" 1 1/8" to 1 1/4" 10d common @ 6" • Provides wall racking resistance. • Six-inch nail spacing applies to sheathing edges. Twelve-inch spacing applies at other studs.	
H10	Anchor bolts in accordance with *IBC* Sections R403.1.6 and R403.1.6.1. Steel plate washers in accordance with R602.11.1. Requirements vary by SDC. See Chapter 4 of this guide for further discussion. • Resists foundation sill plate sliding with respect to slab-on-grade or other foundation.	
H11	Foundation embedment in accordance with *IBC* Section 403.1.4 provides for development of lateral bearing and friction, which permits transfer of loads between the foundation and supporting soil. • Resists foundation sliding relative to soil (grade).	

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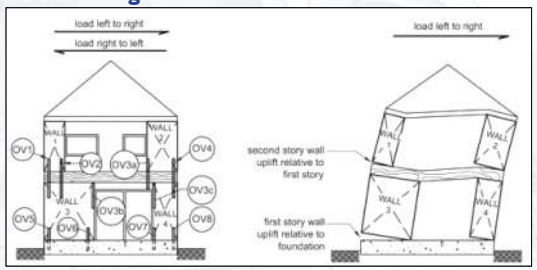
Lateral Load Path

- ***Overturning Load Path:***



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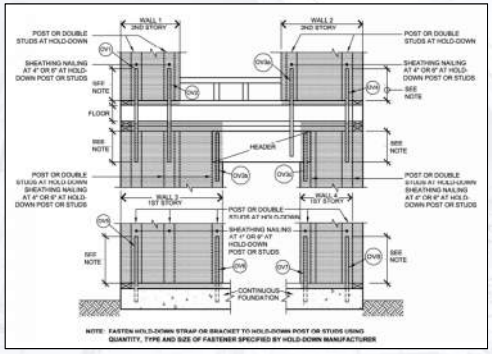
Lateral Load Path



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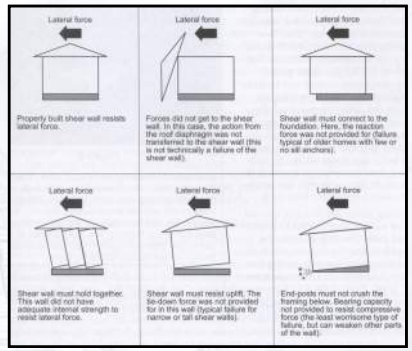
Lateral Load Path

- ***How important are the connections?***



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Lateral Load Path

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Lateral Load Path

- ❑ Special attention should be paid to structural irregularities.
- ❑ The ideal structure would have no irregularities.

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PART 2
Site Conditions

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Geotechnical Report

- ❑ ***Is a geotechnical report required per IRC?***
  - R106.1 – *"Submittal documents consisting of construction documents, and other data…"*
  - R401.2 – Fill soils that support footings and foundations
  - R401.4 – Where expansive soils, compressible soils, shifting soils or other questionable soil characteristics are likely present.
  - Table R401.4.1, Footnote 'b' – Where allowable bearing capacity of less than 1,500psf is likely present
  - IBC 1803 notes any project in SDC "C" or above
  - When can this requirement be waived?

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Geotechnical Report

- ***IBC 1803.6:*** ***Report should provide…***
  - A plot showing locations of borings
  - Complete record of soil borings
  - Record of soil profile
  - Elevation of water table
  - Recommendations for…
    - Foundation type
    - Bearing capacity
    - Mitigation measures for expansive soils
  - Expected total & differential settlement
  - Compacted fill properties

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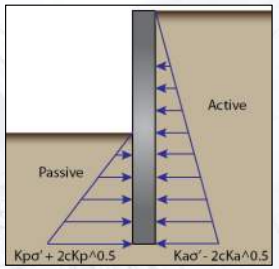
Geotechnical Report

- ***Additional items for SDC 'D' or above…***
  - Seismic lateral earth pressure → 6-feet
  - Potential for liquefaction
  - Assessment of liquefaction consequences
  - Liquefaction mitigation measures



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Geotechnical Report

- ***Will deep foundations be used?***
  - This includes specialty piles such as rammed aggregate piers, helical piers, drilled piers, micropiles, pin piles, etc.
  - This is often decided after the geotechnical report has been completed.

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Geotechnical Report

- ***Deep Foundations (IBC 1803.5.5):***
  - Recommended deep foundation types
  - Recommended center-to-center spacing
  - Driving criteria
  - Installation procedures
  - Field inspection & reporting procedures
  - Load test requirements
  - Reductions for group action

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Geotechnical Report

- ***Is it okay to assume Soil Site Class 'D'?***
  - 'D' = stiff soil
  - 'E' = soft clay
  - 'F' = liquefiable/collapsible

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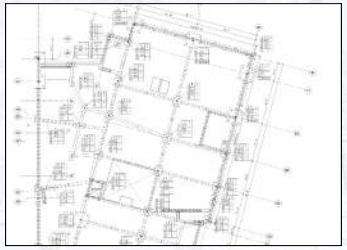
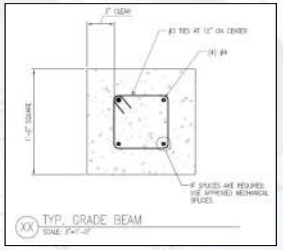
Geotechnical Report

- ***IBC 1809.13:*** Site Class E & F soils in high seismic regions require all footings to have "seismic ties".





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Sloped Lots

- ***Footings on Slopes:*** **Steeper than 1V:3H**
  - IRC Figure R403.1.7.1
  - or…
  - Ascending Slopes (R403.1.7.1) → steeper than 1V:1H
  - Descending Slopes (R403.1.7.2) → steeper than 1V:1H
  - or...
  - Alternate setbacks & clearances allowed by the Building Official (R403.1.7.4)

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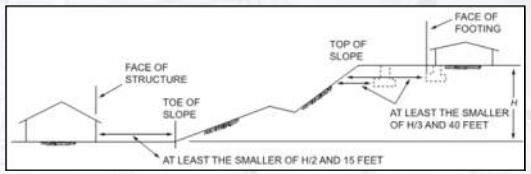
Sloped Lots

- ***Footings on Slopes (cont.)***
  - IRC Figure R403.1.7.1
  - Descending: H/3, but not greater than 40-feet
  - Ascending: H/2, but not greater than 15-feet



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Sloped Lots

- ***Footings on Slopes (cont.)***
  - Ascending Slopes (R403.1.7.1)

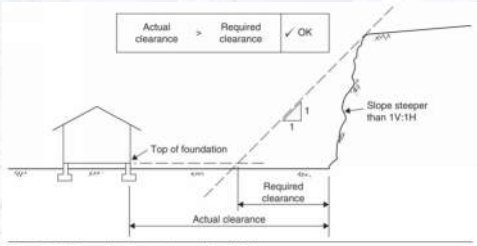

Figure 8.10 Ascending slopes steeper than 1V:1H.

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Sloped Lots

- ***Footings on Slopes (cont.)***
  - Descending Slopes (R403.1.7.2)

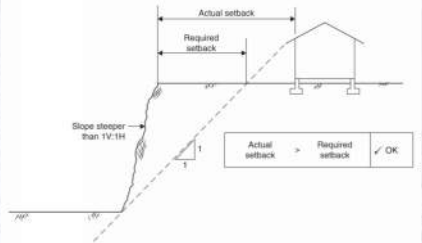

Figure 8.11 Descending slopes steeper than 1V:1H.

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Geologic Hazards

- ***Are their other geologic hazards at your site?***

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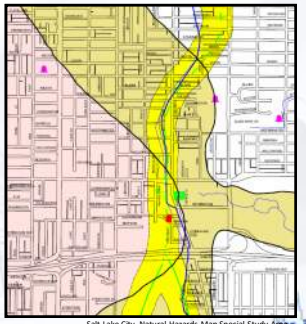
Geologic Hazards

- ***Seismic Hazard Maps:***
  - Liquefaction:
    - High
    - Moderate
    - Low
    - Very Low
  - Active Faults
    - Require "Special Surface Fault Rupture Hazard Study"



Salt Lake City, Natural-Hazards Map Special-Study Area

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Flood Hazards

- ***Flooding:***
  - National Flood Insurance Program (NFIP)
  - Flood Insurance Rate Maps (FIRM)
  - Flood Hazard Area (FHA) → Zones A & V
  - Base Flood Elevation (BFE) → "100-year flood"
  - Regulatory Floodway → area reserved to discharge base flood without increasing water surface elevation

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Flood Hazards

- ***Flooding (cont.)***
  - FHA → Flood-resistant construction per IRC R322
  - Floodway → design per ASCE 24.

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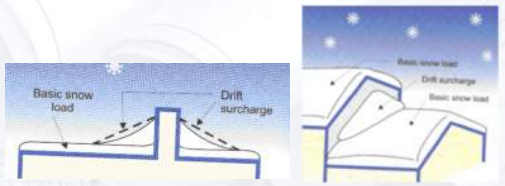
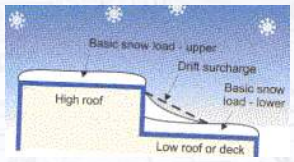
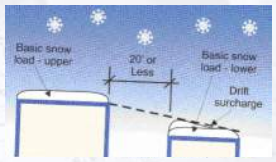
Special Snow Loads

- ***Snow Drift:***
  - Exceptions:
    - Projection ***< 15 feet***
    - P_f ***< 20psf***







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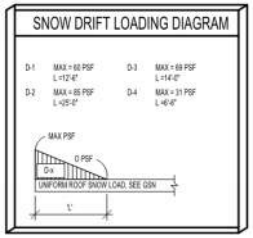
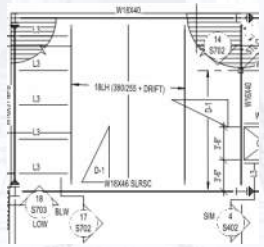
Special Snow Loads

- ***Snow Drift:***
  - What to look for on the plans…





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Special Snow Loads

- ***Unbalanced Snow:***
  - Essentially equal to ground snow load if rafter length is ***< 20 feet***.

Special Snow Loads

- ***Sliding Snow:***

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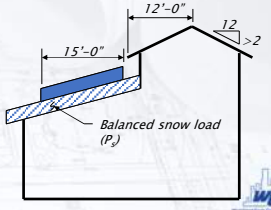
Special Snow Loads

- ***Sliding Snow:***
  - Slippery: > ¼:12 pitch
  - Non-slippery: > 2:12 pitch
  - W = ridge-to-eave
  - Distribute onto lower roof 15'
  - Sliding load: (0.4*Pf*W)/15'
- ***Example:***
  - Assume Pf = 30psf
  - Sliding load ≈ 10psf



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Special Snow Loads

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Wind Exposure

- ***Three exposures outlined in the IRC***
- ***Exposure B:*** Urban & suburban areas with closely spaced obstructions having the size of single-family dwellings.

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Wind Exposure

- ***Exposure C:*** Open terrain with scattered obstructions typically < 30-feet in height
- ***Exposure D:*** Flat, unobstructed areas exposed to wind flowing over open water for a distance of at least 1 mile.

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Seismic Hazard

- ***Seismic Design Category***
  - Figure R301.2.2.1
  - Table R301.2.2.1.1, or
  - IBC Methodology

TABLE R301.2.2.1.1
SEISMIC DESIGN CATEGORY DETERMINATION

CALCULATED S_{DS}	SEISMIC DESIGN CATEGORY
$S_{DS} < 0.17g$	A
$0.17g \le S_{DS} < 0.33g$	B
$0.33g \le S_{DS} < 0.50g$	C
$0.50g \le S_{DS} < 0.67g$	D_2
$0.67g \le S_{DS} < 0.83g$	D_1
$0.83g \le S_{DS} < 1.25g$	D_0
$1.25g \le S_{DS}$	E

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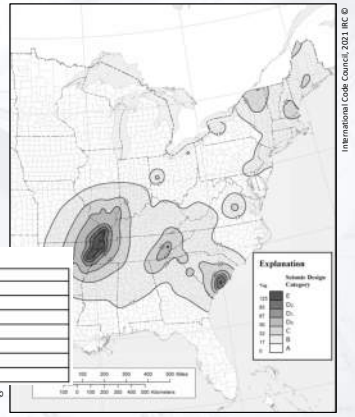

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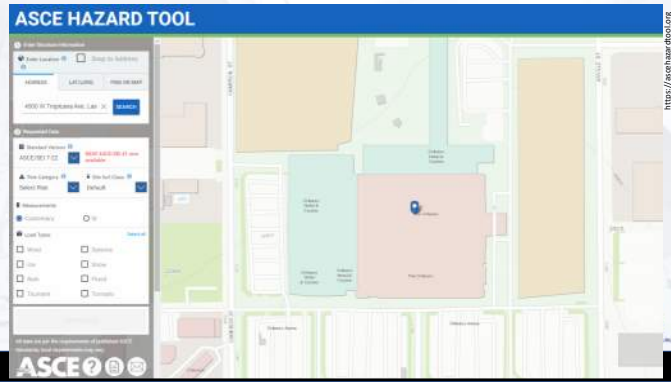
Seismic Hazard

- ***How many of you verify ground motions?***
  - Multiple options, such as …
    - ATC Hazards by Location (seismic, wind, snow, tornado)
    - SEAOC Seismic Design Map Tool (seismic only)
    - ASCE 7 Hazard Tool (seismic, wind, rain, flood, ice, snow & tsunami
  - The others are fading out with the introduction of ASCE 7-22.
  - For that reason, we will use the ***ASCE 7 Hazard Tool*** as an example.

https://ascehazardtool.org

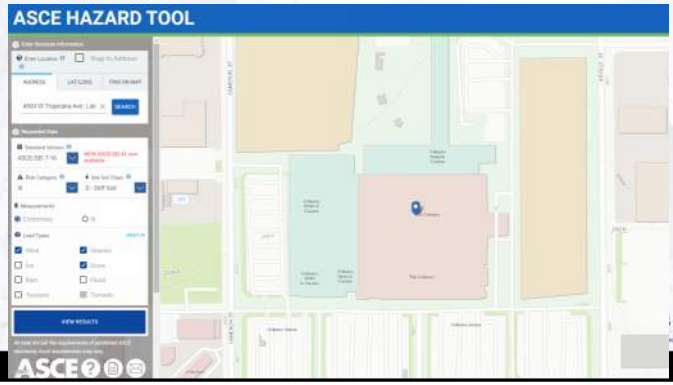
52

Seismic Hazard



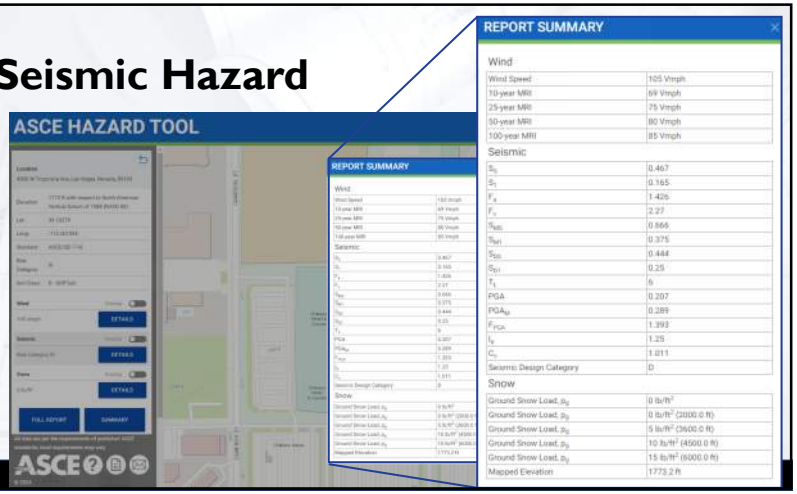
53

Seismic Hazard



54

Seismic Hazard

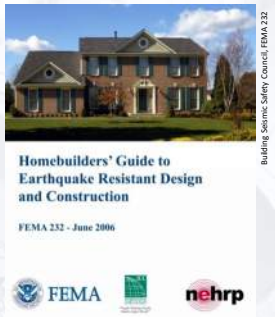


PART 3
Structural Concerns

56

Introduction

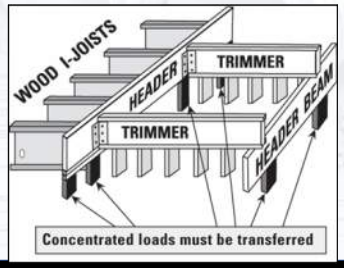
- ***Multiple topics based upon…***
  - Survey of licensed S.E.'s
  - FEMA 232, *"Homebuilders' Guide to Earthquake-Resistant Design and Construction"*
  - APA's *"Top 10 Framing Errors"*
  - Multiple APA Publications



57

Incomplete Load Path

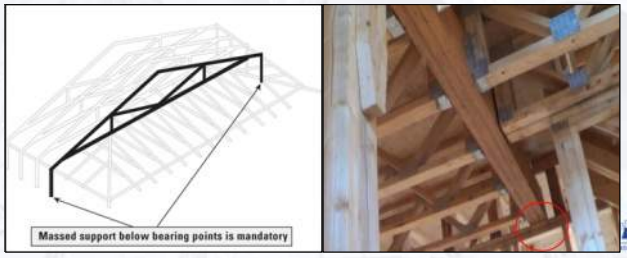
- ***Gravity Load Path:***
  - Verify that loads have a path to the foundation.



58

Incomplete Load Path

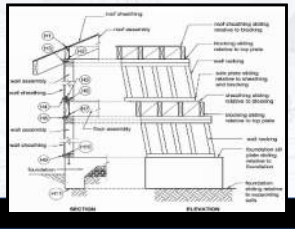
- ***Gravity Load Path (cont.)***
  - Example: Girder Truss support



59

Incomplete Load Path

- ***Lateral Load Path:***
  - Follow loads through members & connections from the roof to the foundation.
  - Forces will concentrate at the end of the path provided.



60

Incomplete Load Path

- ***Lateral Load Path (cont.)***
  - Example: Interior shearwalls

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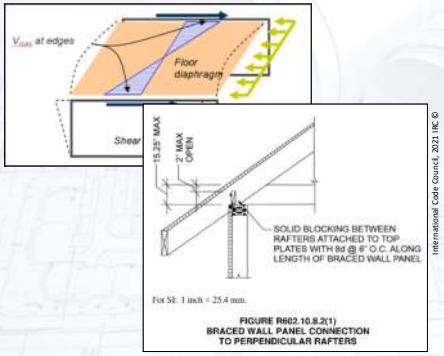
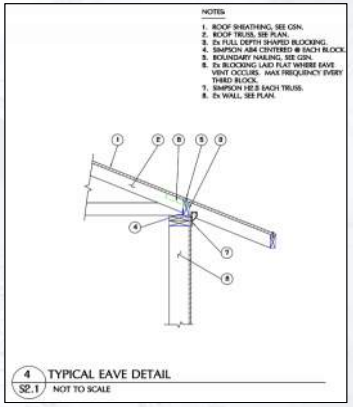
Eave Blocking





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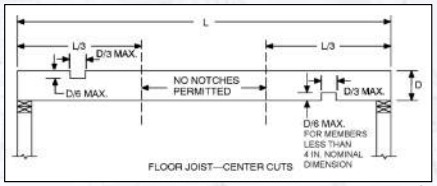
Notches / Holes

- ***Dimension Lumber joists and beams shall…***
  - Not exceed 1/6 of member depth
  - Not be longer than 1/3 member depth
  - Not be located in middle 1/3 of span



International Code Council, Figure R502.8, 2021 IRC ©

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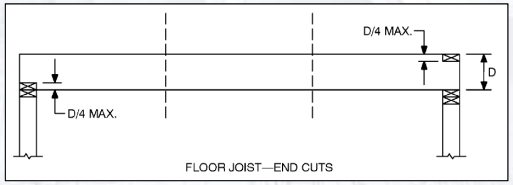
Notches / Holes

- ***Notches at the ends shall be ≤ 1/4 of the member depth.***



International Code Council, Figure R502.8, 2021 IRC ©

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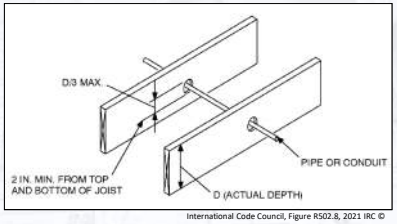
Notches / Holes

- ***Diameter of holes bored or cut into joists and beams shall…***
  - Not exceed 1/3 of member depth
  - Not be closer than 2" from bottom of member or any other hole or notch



International Code Council, Figure R502.8, 2021 IRC ©

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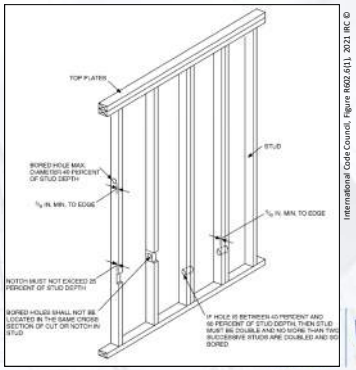
Notches / Holes

- ***Notches:***
  - Exterior ≤ 25% width
  - Bearing ≤ 25% width
  - Partition ≤ 40% width
- ***Holes:***
  - Edge ≥ 5/8"
  - Ø ≤ 40% width (single)
  - Ø ≤ 60% width (double)



International Code Council, Figure R602.6(1), 2021 IRC ©

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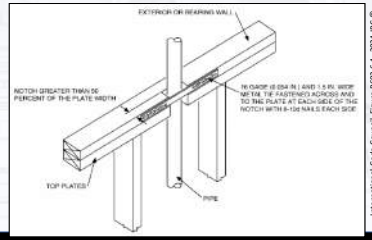
Notches / Holes

- ***If > 50% of top plate width is notched/drilled…***
  - Provide a 1.5" wide x 16ga. galvanized metal tie
  - Fasten to either side w/ (8) 10d nails



International Code Council, Figure R802.6.1, 2021 IRC ©

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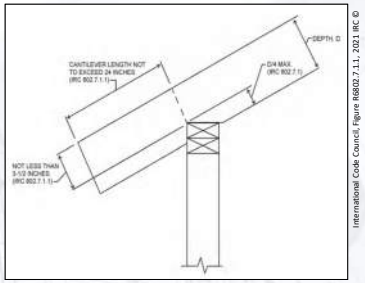
Notches / Holes

- ***Cantilevered Rafters:***
  - No more than 1/4 the depth, but not less than 3.5"
  - 24-inch maximum cantilever



International Code Council, Figure R802.7.1.1, 2021 IRC ©

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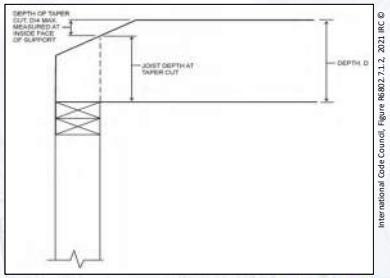
Notches / Holes

- ***Tapered Ceiling Joists:***
  - No more than 1/4 joist depth at inside face of support



International Code Council, Figure R802.7.1.2, 2021 IRC ©

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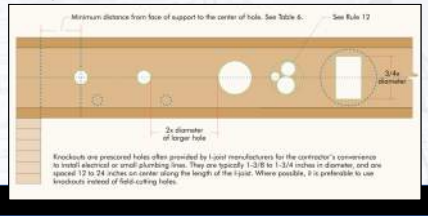
Notches / Holes

- ***Notches & Holes:***
  - I-Joists: APA – Form No. Z725F
  - Notch in Top Flange: Weyerhauser TB-818
  - Holes Near Bearing: Weyerhauser TB-817
  - Rafter Cuts: Weyerhauser TB-805



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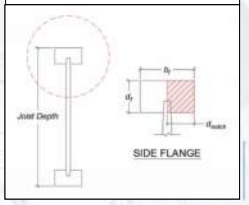
Notches / Holes

- ***I-Joists: Weyerhauser TB-818***
  - Original joists are properly designed
  - Adjacent joists are undamaged
  - Uniform loads
  - 1 side-flange notch

TJI® JOIST FLANGE DIMENSIONS

Product	b_f	d_f
TJI® 110	1 ¾"	1 ¼" - 1 ⅜"
TJI® 210	2 5/16"	1 ¼" - 1 ⅜"
TJI® 230	2 5/16"	1 ¼" - 1 ⅜"
TJI® 360	2 5/16"	1 ⅜"
TJI® 560	3 ½"	1 ⅜"



Weyerhauser, Technical Bulletin, TB-818©

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Notches / Holes

- ***I-Joists: Weyerhauser TB-817***

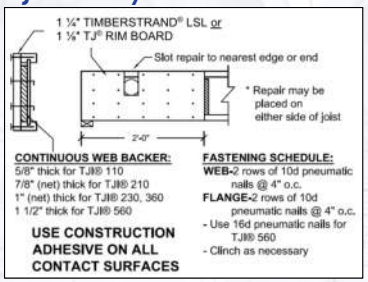

TABLE 1: MAXIMUM JOIST SPANS[1][2][3][4]

Joist Depth	Max Hole Diameter	TJI® Joist Series	Max o.c. Spacing	Max Joist Span (40 PSF Live) 10 PSF (Dead)	Max Joist Span (40 PSF Live) 20 PSF (Dead)
9½"	3"	110, 210, 230, & 360	16"	16'-6"	15'-3"
			24"	13'-8"	12'-5"
11⅞"	4½"	110, 210, 230, & 360	16"	18'-11"	17'-3"
			24"	15'-5"	14'-0"
		560	16"	26'-3"	26'-3"
			24"	21'-10"	20'-11"
14"	5¼"	110, 210, 230, & 360	16"	20'-6"	18'-9"
			24"	16'-9"	14'-9"
		560	16"	29'-9"	29'-9"
			24"	24'-3"	20'-11"
16"	6⅛"	210, 230, & 360	16"	24'-1"	22'-0"
			24"	19'-8"	16'-2"
		560	16"	32'-11"	31'-6"
			24"	25'-2"	20'-11"

(1) Span table and repair detail shown applies to holes placed in the first 12" from end bearing of joist.

Weyerhauser, Technical Bulletin, TB-817©

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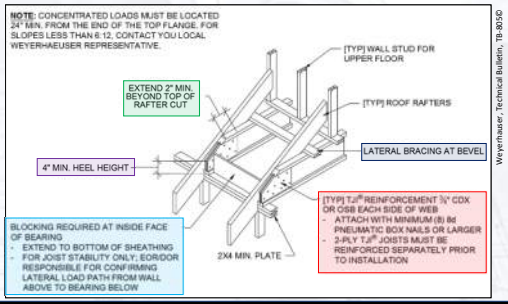
Notches / Holes

- *I-Joists: Weyerhauser TB-805*



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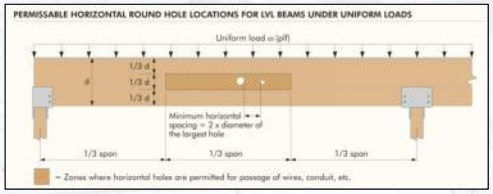
Notches / Holes

- *Notches & Holes:*
  - LVL's: APA – Form No. EWS G535A
  - GLB's: APA – Form No. EWS S560H



The Engineered Wood Association, Form No. EWS G535A©

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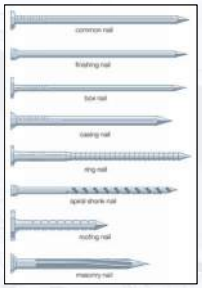
Improper Fasteners

- Model Codes have specified *"common"* nails for more than 40 years.
- Most gun nails are box nails (also cooler & sinker)
- 8d common → *0.131 shank*
- 8d box → *0.113 shank*
- ≈ *15% reduction* in shank



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Improper Fasteners

48 pages
(A bit overwhelming!)

- *ESR-1539 – International Staple, Nail and Tool Association*

TABLE 9—ALLOWABLE SHEAR FOR WIND OR SEISMIC LOADING FOR WOOD STRUCTURAL PANEL SHEAR WALLS WITH FRAMING OF DOUGLAS FIR-LARCH OR SOUTHERN PINE AND RATED SHEATHING (plf)[1,2,3,4,5,6,7,8,9,10,11]

NOMINAL NAIL DIAMETER (inch) or STAPLE GAGE (Nails must be smooth and must be carbon steel (bright or galvanized))	MINIMUM NOMINAL FASTENER LENGTH (inches)		SEISMIC				WIND			
	Panels Applied Directly to Framing	Panels Applied Over ½ inch or ⁹⁄₁₆ inch Gypsum Sheathing	Fastener Spacing at Panel Edges (inches)				Fastener Spacing at Panel Edges (inches)			
			6	4	3	2	6	4	3	2
			⅜-inch Nominal Panel Thickness							
0.148	2	—	220	320	410	530	305	445	575	740
	—	2½	260	380	490	640	365	530	685	895
0.135	2	—	220	320	410	530	305	445	575	740
	—	2½	230	335	430	560	320	465	600	785
0.131 8D common	1¾	—	220	320	410	530	305	445	575	740
	—	2¼	200	300	390	510	280	420	545	715
0.120	1¾	—	185	270	345	450	260	375	485	625
	—	2½	170	255	330	430	235	355	460	605
0.113 8D box	1½	—	200	300	390	510	280	420	545	715
	—	2⅛	150	225	295	385	210	315	410	540
14, 15, 16 Gage	1½	—	140	210	280	360	195	295	390	505
14, 15, 16 Gage	—	2	140	210	280	360	195	295	390	505

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Improper Fasteners

TABLE 11—FASTENING SCHEDULE–WALL FRAMING

CONNECTION DESCRIPTION	MINIMUM FASTENING REQUIREMENTS PRESCRIBED IN THE CODE								ALTERNATIVE FASTENING REQUIREMENTS			
	2012 IBC Table 2304.9.1 / 2012 IRC Table R602.3(1)		2015 IBC Table 2304.10.1 / 2015 IRC Table R602.3(1)		2018 IBC Table 2304.10.1 / 2018 IRC Table R602.3(1)		2021 IBC[1] Table 2304.10.2 / 2021 IRC[1] Table R602.3(1)		All nails are carbon steel.[2]			
	#	Nail Size [Type (inch)]	#	Nail Size [Type (inch)]	#	Nail Size [Type (inch)]	#	Nail Size [Type (inch)]	#	Nail Size [Type (inch)]	#	Nail Size [Type (inch)]
Stud-to-stud (double studs) **not at braced walls**	IBC Connection 9		IBC Connection 8		IBC Connection 8		IBC Connection 8		@ 24" o.c.		@ 16" o.c.	
	@ 24" o.c.		@ 24" o.c.		@ 24" o.c.		@ 24" o.c.		1	16d com (3½ x .162)	1	12d com (3¼ x .148)
	1	16d box (3½ x .135)	1	16d com (3½ x .162)	1	16d com (3½ x .162)	1	16d com (3½ x .162)			1	10d com (3 x .148)
	@ 8" o.c.		@ 16" o.c.		@ 16" o.c.		@ 16" o.c.				1	16d box (3½ x .135)
	1	3 x .131	1	3 x .131	1	3 x .131	1	3 x .131			1	3¼ x .131
			1	10d box (3 x .128)	1	10d box (3 x .128)	1	10d box (3 x .128)			1	3 x .131
	IRC Connection 12		IRC Connection 8		IRC Connection 8		IRC Connection 8				@ 8" o.c.	
	@ 24" o.c.		@ 24" o.c.		@ 24" o.c.		@ 24" o.c.				1	8d com (2½ x .131)
	1	10d box (3 x .128)	1	16d com (3½ x .162)	1	16d com (3½ x .162)	1	16d com (3½ x .162)			1	3¼ x .120
			@ 16" o.c.		@ 16" o.c.		@ 16" o.c.				1	3 x .120
			1	3 x .131	1	3 x .131	1	3 x .131				
			1	10d box (3 x .128)	1	10d box (3 x .128)	1	10d box (3 x .128)				
Stud-to-stud and abutting studs at intersecting wall corners at **braced walls**			IBC Connection 9		IBC Connection 9		IBC Connection 9		@ 16" o.c.		@ 12" o.c.	
			@ 16" o.c.		@ 16" o.c.		@ 16" o.c.		1	16d com (3½ x .162)	1	12d com (3¼ x .148)
			1	16d com (3½ x .162)	1	16d com (3½ x .162)	1	16d com (3½ x .162)			1	10d com (3 x .148)
			@ 12" o.c.		@ 12" o.c.		@ 12" o.c.				1	16d box (3½ x .135)
			1	16d box (3½ x .135)	1	16d box (3½ x .135)	1	16d box (3½ x .135)			1	3¼ x .131
			1	3 x .131	1	3 x .131	1	3 x .131			1	3 x .131
			IRC Connection 9		IRC Connection 9		IRC Connection 9				@ 8" o.c.	
			@ 16" o.c.		@ 16" o.c.		@ 16" o.c.				1	3¼ x .120
			1	16d com (3½ x .162)	1	16d com (3½ x .162)	1	16d com (3½ x .162)			1	3 x .120
			@ 12" o.c.		@ 12" o.c.		@ 12" o.c.					
			1	16d box (3½ x .135)	1	16d box (3½ x .135)	1	16d box (3½ x .135)				
			1	3 x .131	1	3 x .131	1	3 x .131				

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Improper Fasteners

- ***APA TT-087B:***
  - Using ESR-1539 and NDS equations → 25% reduction in capacity
  - SDPWS lists "common or hot-dip galvanized box"
  - *"Available test results suggest similar shear wall performance between walls constructed with 8d common and 8d box nails."*

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Overdriven Fasteners

- ***IBC 2304.10.2:***
  - Nails "*…shall be driven so that their head or crown is flush with the surface of the sheathing.*"

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Overdriven Fasteners

- ***APA TT-012C:***
  - Reduction in capacity is not required if…
    - If all are overdriven ≤ ***1/16"*** in dry conditions
    - If ≤ ***20%*** of edge fasteners are overdriven ≤ ***1/8"***
    - If panels used are ***thicker*** than required

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Overdriven Fasteners

- ***APA TT-012B:***
  - If > 20% are overdriven by > 1/16", or…
  - If any are overdriven by > 1/8", then…
  - ***One*** additional fastener must be driven ***for each two*** overdriven.
  - If nails were originally used and are spaced too close for additional nails, approved staples should be used to reduce the potential for splitting.

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Shear Walls

- ***Braced Walls:***
  - All framing members and blocking shall be ≥ 2x
  - 8d common at 6"o.c. edge nailing and 12"o.c. field nailing
- ***Engineered Shear Walls:***
  - All panels shall have 2x blocking
    - 3x required when edge nailing is 2"o.c., or…
    - 10d nails and 3"o.c., or…
    - Panels applied to each face and are not offset

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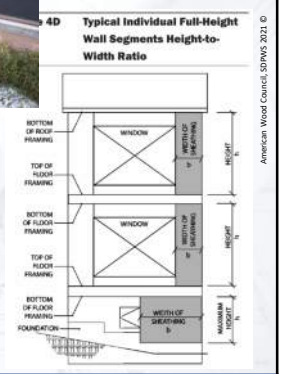
Shear Walls

- ***Shear Walls (cont.)***
  - Allowable aspect ratios
    - Without reduction → 2:1
    - With reduction → 3.5:1 (e.g. 8'-0" x 2'-3")
  - Example: 9-foot wall
    - 2:1 → 4.5 feet
    - 3.5:1 → 2.57 feet
    - 43% reduction in capacity!
  - Look for shear wall widths that have been changed in the field!



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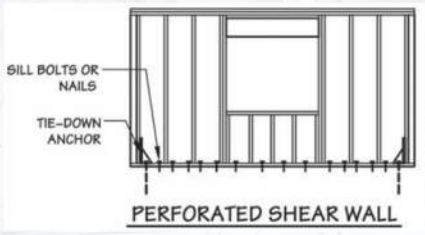
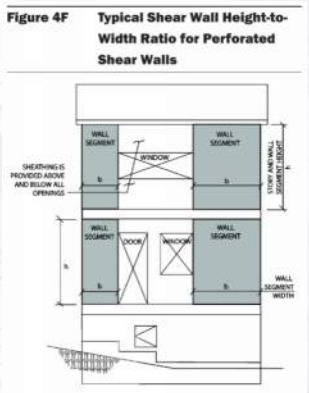
Shear Walls

- ***Shear Walls (cont.)***
  - Perforated Shear Walls





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Shear Walls

- ***Shear Walls (cont.)***
  - Perforated Shear Walls

Table 4.3.5.6 Shear Capacity Adjustment Factor, C_o[1]

Percent Full-Height Sheathing (A_{ffo}/A_{wall})	Percentage Wall Area Openings (A_o / A_{wall})									
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
	Shear Capacity Ratio, C_o									
10%	1.00	1.00	1.00	1.00	0.77	0.63	0.53	0.45	0.40	0.36
20%	1.00	1.00	1.00	0.91	0.71	0.59	0.50	0.43	0.38	-
30%	1.00	1.00	1.00	0.83	0.67	0.56	0.48	0.42	-	-
40%	1.00	1.00	1.00	0.77	0.63	0.53	0.45	-	-	-
50%	1.00	1.00	0.91	0.71	0.59	0.50	-	-	-	-
60%	1.00	1.00	0.83	0.67	0.56	-	-	-	-	-
70%	1.00	1.00	0.77	0.63	-	-	-	-	-	-
80%	1.00	0.91	0.71	-	-	-	-	-	-	-
90%	1.00	0.83	-	-	-	-	-	-	-	-
100%	1.00	-	-	-	-	-	-	-	-	-

American Wood Council, SDPWS 2021 ©

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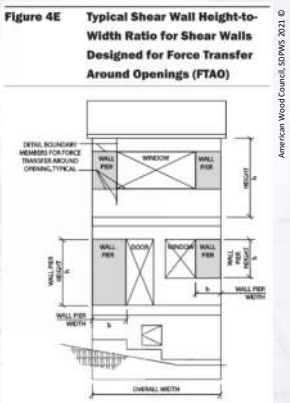
Shear Walls

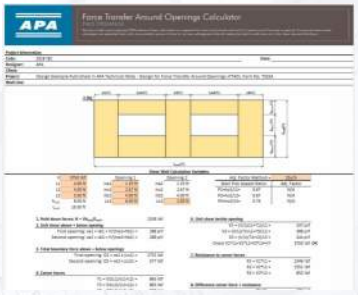
- ***Shear Walls (cont.)***
  - Force-Transfer Shear Walls



86

Shear Walls

- ***Shear Walls (cont.)***
  - Force-Transfer Shear Walls
    - Design & Detailing:
      - Each wall pier ≥ 2-feet
      - Full-height segment at each end
      - No out-of-plane offsets
      - Collectors shall be full length
    - Requires rational analysis
    - Must define blocking, straps and holdowns



Engineered Wood Association (APA), FTAO Calculator ©

87

Holdown Straps

- ***Case 1: Improper locations***
  - Engineered specified retrofit anchor required.

88

Holdown Straps

- ***Case 2: Spalling at embed straps***
  - If ***< 1"***, load capacity is not affected.
  - If ***< 4"***, holdown capacity is reduced by 10%. ???
  - If ***> 4"***, Engineered retrofit holdown is required.

89

Holdown Straps

- ***Case 3: Offsets***
  - Creates slack in the line.
  - Only a 5/8" offset is permitted.
  - If over sheathing, slightly notching the panel edge will keep strap from bulging and wall movement to a minimum.
  - More than a single 90° bend is not allowed.

90

Holdown Straps

- ***Case 4: Holdowns at Rim Joists***
  - Is proper holdown being used at rim joists?
  - The holdown will need to be replaced.

91

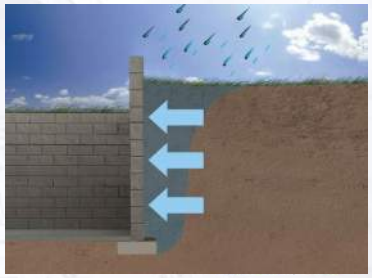
Holdown Straps

- ***Case 5: Improper Holdown Used***
  - Plans often state "Simpson xxx, or approved equal"
  - Is the replacement holdown equivalent?
  - Has the replacement holdown been approved by the EOR?
  - Does it have a current ICC-ES, IAPMO, or other report?

92

Foundation Walls

- ***IRC R404.1.1: Walls must be engineered if…***
  - Subject to hydrostatic pressure from ground water, or…
  - Support > 4 feet of unbalanced backfill and do not have permanent lateral support



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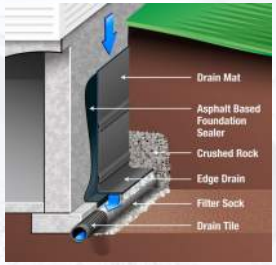
Foundation Walls

- ***Inadequate Foundation Drainage***
  - **IRC R405.1:** *"Drains shall be provided around concrete or masonry foundations that retain earth and enclose habitable or usable spaces located below grade."*
    - Exception: Well-drained ground



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Foundation Walls

- ***Inadequate Foundation Drainage (cont.)***
  - Foundation Drain ***(R405.1):***
    - At or below top of footing or below the bottom of the slab
    - Gravel drain:
      - 12" beyond outside edge of footing
      - Top at least 6" above footing
      - Cover with approved filter material
      - Perforated pipe w/ filter membrane
      - Pipe placed on at least 2" gravel
      - Surround pipe with 6" of gravel

95

Foundation Walls

- ***Inadequate Foundation Drainage (cont.)***
  - Foundation Drain (cont.):
    - Must discharge by gravity or mechanical means into an approved drainage system.

96

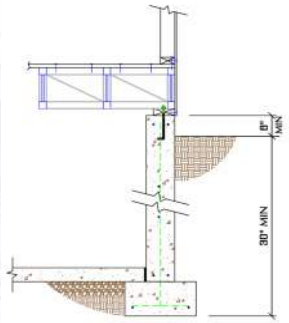
Foundation Walls

- ***Are foundation walls restrained?***
  - **Prescriptive Tables** include this footnote: *"Where walls retain more than 4 feet or more of unbalanced backfill, they shall be laterally supported at the top and bottom before backfilling."*
  - **R404.1.3.2:** *"Concrete foundation walls shall be laterally supported at the top and bottom."*

97

Foundation Walls

- ***Are foundation walls restrained? (cont.)***
  - How is a foundation wall considered restrained?
  - Are walkout basements restrained?



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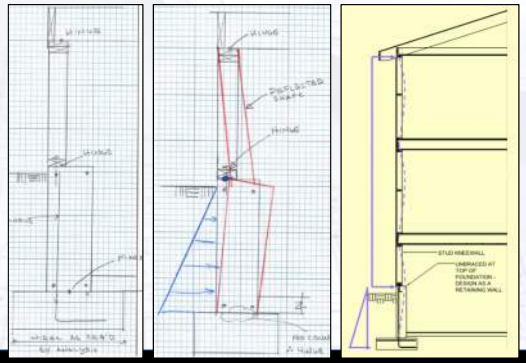
Foundation Walls



99

Concrete Piers

- ***Vertical Reinforcement (IBC 1810.3.9.4.2):***
  - SDC 'D or above'
  - At least 4 vertical bars
  - ρ_{min} = 0.005

ρ = 0.005
#4 ≤ 14"Ø
#5 ≤ 17"Ø
#6 ≤ 21"Ø
#7 ≤ 24"Ø

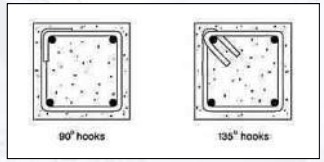
Concrete Piers

- ***Enclosed Ties (IBC 1810.3.9.4.2)***
  - #3 bar if ≤ 20"Ø
  - Otherwise #4 bar
  - Spacing shall be least of…
    - $12d_b$ vertical bar;
    - 1/2 least dimension of compression member; and…
    - 12 inches

#4 vert → 6"
#5 vert → 7.5"
#6 vert → 9"
#7 vert → 10.5"

Concrete Piers

- ***Seismic Hooks (IBC 1810.3.2.1.1)***
  - Required in SDC 'C' or above
  - ACI 318:
    - Bend not less than 135°
    - 6db extension (i.e. #4 bar → 3")



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Concrete Piers

- ***Exceptions (IBC 1810.3.9.4)***
  - Not required in R-3 of 2-stories or less when…
  - Element is not subject to lateral loads, or…
  - Only supports posts from decks and patios and the calculated lateral does not exceed ***200#***
  - In these cases a ***single #4 vertical*** bar must be provided without ties or spirals

Deep Foundations

- ***Caisson Footings (IBC 1810.3.5)***
  - Common for areas with expansive or collapsible soils
  - Cased:
    - "Permanent"
    - 8"Ø minimum
    - 1" concrete cover
  - Uncased:
    - 12"Ø minimum
    - Length ≤ 30*Ø
    - 2.5" concrete cover

104

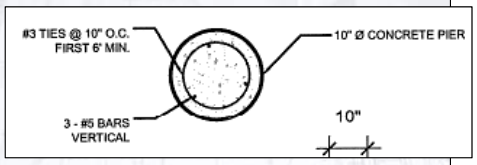
Deep Foundations

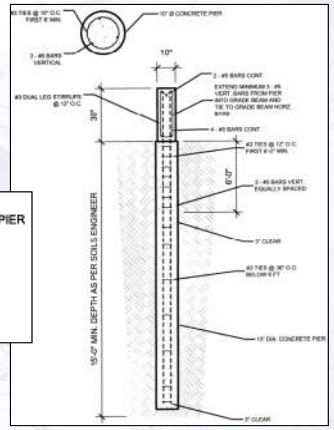
- ***Caisson Footings (cont.)***
  - Minimum of 4 vertical bars
  - Enclosed seismic hooks w/ spacing of…
    - 12 longitudinal d_b
    - 1/2 least dimension of element
    - 12 inches
  - Reinforced length is greatest of…
    - One-half element length;
    - 10-feet;
    - Three times least element dimension

105

Deep Foundations

- ***What is wrong with this detail?***





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Sill Plate Anchorage

- ***IBC §1905.1.8:***
  - In-plane shear strength to comply with the NDS
  - Maximum 5/8-inch diameter
  - Minimum 7-inch embedment
  - Min. concrete edge distance of 1-3/4”
  - Placed w/in 15ø of end of concrete foundation
  - 2x, 3x sill plates or 33-mil to 68-mil tracks

107

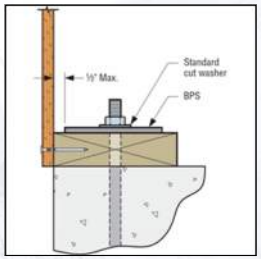
Sill Plate Anchorage

- ***IRC R403.1.6:***
  - 1/2” diameter min.
  - 7” embedment min.
  - Placed in middle third of plate
  - 2 per plate min.
  - Max 12” from end
  - Min. 7db from end

108

Sill Plate Anchorage

- ***IRC R403.1.6.1 - SDC 'D':***
  - 3"x3"x0.229" plate washers are required
  - 2021 SDPWS requires the edge of the square plate washer to extend within 1/2-inch of the sheathed edge.



109

Post-Installed Anchors

- ***Post-Installed Anchors:***
  - Expansion, epoxy, screw, etc.
  - Must be approved for proposed application
  - Special inspection is often required!!!

110

Upside-down Glulams

- If glulams are cambered the top will be marked.
- If the critical tension laminations are on the bottom than this builds deflection into the structure.

111

Rock Walls

- Slope protection, not a retaining wall
- Why should we worry about these walls?

112

Rock Walls

- **1/20/2013** – A 63-year-old St. George woman was sent to hospital with a broken jaw and sternum from a runaway boulder.

113

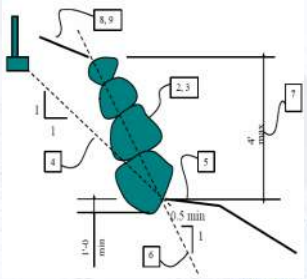
Rock Walls

- ***5/14/2010:*** An article stated that *"…a building inspector could have, and should have, detected and prevented the disaster at any stage, but didn't."*

114

Rock Walls

- What should we be looking for in a rock wall submittal?
- ***Prescriptive Handouts:***
  - Seattle, WA
  - Sparks, NV
  - Southern Nevada B.O.A.
  - FHWA



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Rock Walls

- ***Standard Items:***
  - Dimensioned site plan
  - Cross section of wall (rock size for each lift, maximum height, backfill, drainage, slope of ground, batter, and embedment)
  - If > 4-feet: Structural Analysis & Soils Report
  - Base rock must be embedded 12-inches
  - Minimum batter of 1H:4V (i.e. 15%)
  - Graded so water cannot flow over top
  - …

116

Rock Walls

- ***Standard Items (cont.):***
  - Lower half should consist of 4-man or larger rocks with upper half being progressively smaller with minimum 2-mand rocks.
  - Void spaces shall be "chinked" or tightly filled
  - Landscape materials cannot have detrimental effect

APPROXIMATE ROCK SIZES		
Size	*Weight*	*Volume*
1-man	58 - 210 lbs.	*0.4 - 1.3 cubic ft.*
2-man	265 - 580 lbs.	*1.6 - 3.6 cubic ft.*
3-man	760 - 1,830 lbs.	*4.7 - 11.2 cubic ft.*
4-man	3,000 - 4,000 lbs.	*18.4 - 24.5 cubic ft.*
5-man	5,000 lbs.	*30.7 cubic ft.*
6-man	7,000 lbs.	*42.9 cubic ft.*

117

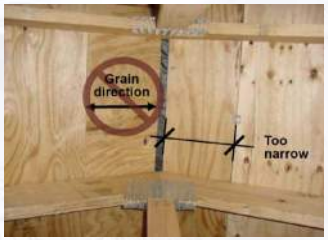
Rock Walls

- ***Standard Items (cont.):***
  - Shall not exceed 16-feet
  - If > 10-feet: MSE or slope stability analysis
  - Setback for terraced walls = height of lower wall
  - ***No surcharge loads***
  - Special Inspections are required

118

Narrow Sheathing

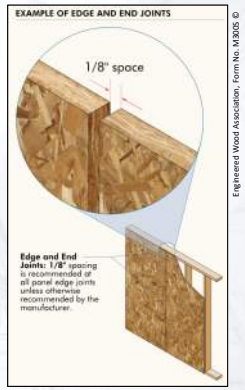
- ***APA Publication R275:***
  - > 16"-24" → block lower edge or provide 2 clips
  - ≥ 12"-16" → block lower edge
  - < 12" → block upper and lower edges



119

Gaps in Sheathing

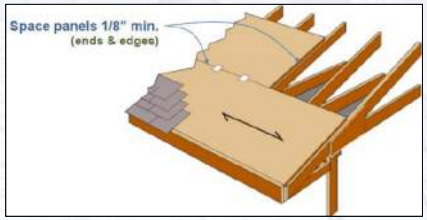
- APA recommends a minimum 1/8" gap between sheathing panels



120

Gaps in Sheathing

- ***APA's spacing hint:***
  - Use 10d box nail to gauge 1/8-inch spacing between panels.
  - Spacer-type panel clips may be used for roof sheathing applications.



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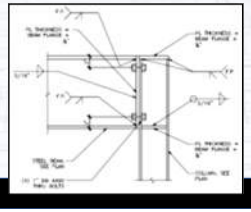
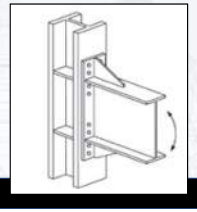
Steel Moment Frames

- ***Many residential designers do not understand how to design and detail a steel moment frame.***
  - Ordinary Moment Frame (OMF) → R = 3.5
  - Special Moment Frame (SMF) → R = 8.0
  - Wood Shearwalls → R = 6.5 (OMF = 54% capacity)

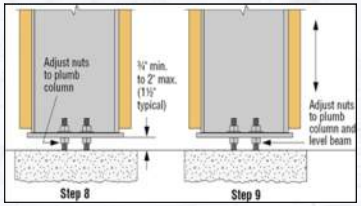


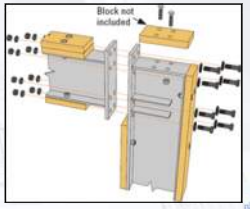


122

Steel Moment Frames

- The design within the wall line of the OMF → R = 3.5
- Several Prefabricated Moment Frames (i.e. Simpson Strong Frame®)





123

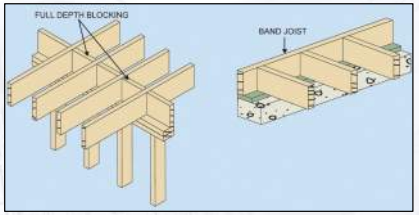
Steel Moment Frames

- ***IAPMO ER-164:***
  - Calculations by Simpson Strong-Tie are to be submitted to the code official.
  - Calculations by the EOR must be provided showing that the design loads do not exceed those allowed in ER-164.
  - Special inspections are required unless conventional construction has been met.

124

Full-Depth Blocking

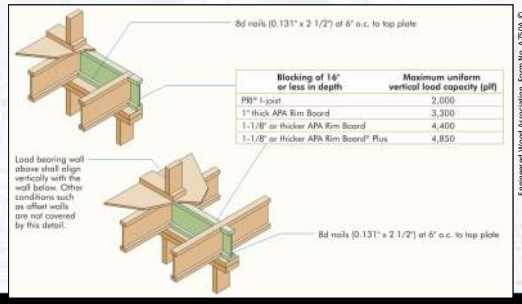
- ***Shall be provided at…***
  - Ends of joists
  - Intermediate supports (SDC D_0, D_1 and D_2 only)
  - At 8-feet on center (> 2"x12" dimension lumber)



125

Full-Depth Blocking

- ***Same for I-joists…***



126

APA I-Joist Blocking

- ***Web Stiffeners:***
  - Where web is in jeopardy of buckling out-of-plane
  - Heavy loads that cause web to knife through flange
  - Support hanger does not extend to top flange

STIFFENER SIZE REQUIREMENTS	
APA PRI Flange Width (in.)	Web Stiffener Size Each Side of Web (in.)
1-1/2	15/32 x 2-5/16 minimum width
1-3/4	19/32 x 2-5/16 minimum width
2-5/16	1 x 2-5/16 minimum width
2-1/2	1 x 2-5/16 minimum width
3-1/2	1-1/2 x 2-5/16 minimum width

Engineered Wood Association, Form No. A745C ©

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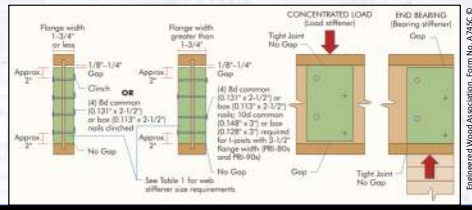
APA I-Joist Blocking

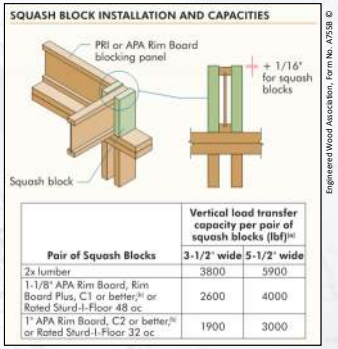
- ***Web Stiffeners (cont.)***
  - Bearing stiffeners: Located at the reactions when required
  - Load stiffeners: Located between supports where significant point loads are applied to top flange



128

APA I-Joist Blocking

- ***Squash Blocks:***
  - Purpose is to carry a point load that would otherwise be carried by the joist.

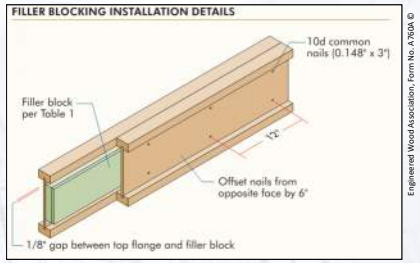


Pair of Squash Blocks	Vertical load transfer capacity per pair of squash blocks (lbf)[a]	
	3-1/2" wide	5-1/2" wide
2x lumber	3800	5900
1-1/8" APA Rim Board, Rim Board Plus, C1 or better,[b] or Rated Sturd-I-Floor 48 oc	2600	4000
1" APA Rim Board, C2 or better,[b] or Rated Sturd-I-Floor 32 oc	1900	3000

129

APA I-Joist Blocking

- ***Filler Blocks:***
  - Used to fill space between a pair of I-joists acting as a single bending member.
  - Helps to transfer load from one member to the next.
  - Must be placed the full length of the I-joist.



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Miscellaneous Items

- ***Decks***
  - IBC 1604.8.3: Positively attached for vertical & lateral loads
  - AWC DCA 6
- ***Post Frame Buildings***
  - AWC DCA 5
- ***Log Structures***
  - ICC 400

131

PART 4
Trusses

132

Truss Package

- Inconsistencies are common between the initial design and the truss package.
- What are some common issues that arise?
- When do you review the truss package?

133

Truss Package

- ***Deferred Submittal (IBC 107.3.4.1)***
  - Required for structural components in which the structural design has not been submitted.
  - Must be allowed by jurisdiction.
  - Must be listed on the construction documents.
  - Prior to submittal to the city, designs must be submitted to, and approved by, the EOR.
  - None of the deferred submittal items shall be installed until submittal is approved by the AHJ.

134

Truss Package

- ***What is included? (IBC 2303.4.1.1)***
  - Design per ANSI/TPI 1
  - Placement diagram & individual truss drawings
  - Design professional → where required
  - Permanent individual truss member restraint (PITMR)
    - Who is responsible for specifying?

135

Truss Package

- ***Truss Design Drawings*** *(IRC R502.11.4 & IBC 2303.4.1.1)*
  - Slope/depth, span and spacing;
  - Locations of all joints;
  - Required bearing widths;
  - Design loads;
  - Adjustments for conditions of use;
  - Each reaction force and direction;
  - Joint connector type, size, etc.;
  - Lumber size, species & grade of wood; …

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Truss Package

- ***Truss Design Drawings (cont.)***
  - Truss connections (truss-to-girder, ply-to-ply, splices);
  - Calculated and allowable deflections;
  - Maximum axial and tension forces;
  - Permanent bracing locations, methods & details

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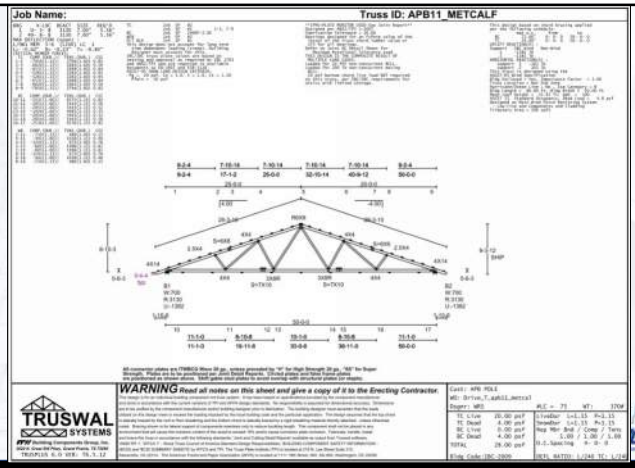

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Truss Bracing

- Trusses require lateral support to perform in the manner they are intended.
- Very narrow in relation to their depth and span.
- ***Bracing…***
  - Prevents out-of-plane buckling
  - Maintains spacing
  - Resists and transfers lateral loads

139

Truss Bracing

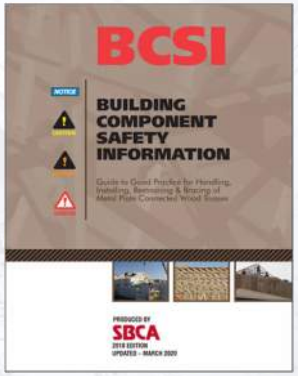
Let's Test Our Knowledge!

- Who is required to specify the truss bracing?
- What is the difference between temporary and permanent truss bracing?
- How is the permanent truss bracing typically accomplished?

140

Truss Bracing

- ***IRC R502.11.2***
  - Shall be specified on construction documents.
  - In the absence of providing → *BCSI Good to Good Practice for Handling, Installing & Bracing of Metal Plate Connected Wood Trusses*



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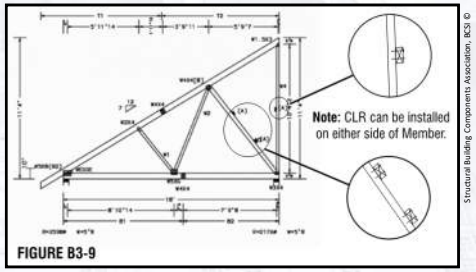
Truss Bracing

- ***Locations shown on individual truss drawings***



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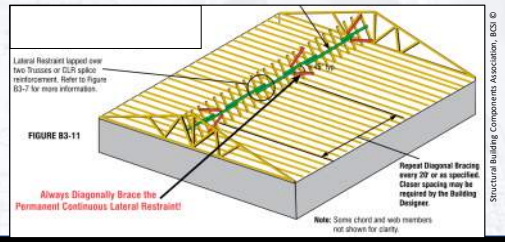
Truss Bracing

- ***IBC 2303.4.1.2:*** Clarifies what is already required
  - Member restraint (PITMR) in "green"
  - Diagonal bracing (PITMDB) at each PITMR in "red"



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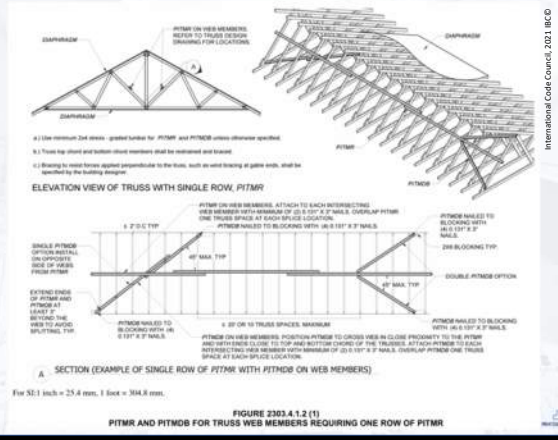
Truss Bracing

- ***IBC 2303.4.1.2 (cont.)***
  - When the truss plans call for PITMR, it must be provided by one of following…
  - PITMR & PITMDB shall be provided using standard industry lateral restraint and diagonal bracing details per TPI, accepted engineering practice, or Figures 2303.4.1.2(1), (3), and (5).
  - Buckling reinforcement is added to individual truss per truss drawings, or per Figures 2303.4.1.2 (2) and (4).
  - Project-specific PITMR and PITMDB design by EOR.

ADDED

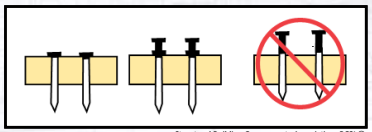
144



145

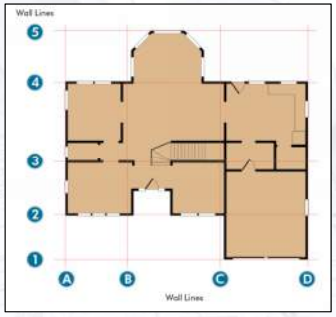
Truss Bracing

- ***Bracing Installation:***
  - Minimum size member → 2x4
  - Continuous bracing to overlap 2-feet.
  - Use at least two 10d, 12d, or 16d nails into each truss
  - Nails to be flush or double-headed for easy removal



146

PART 5
Wall Bracing

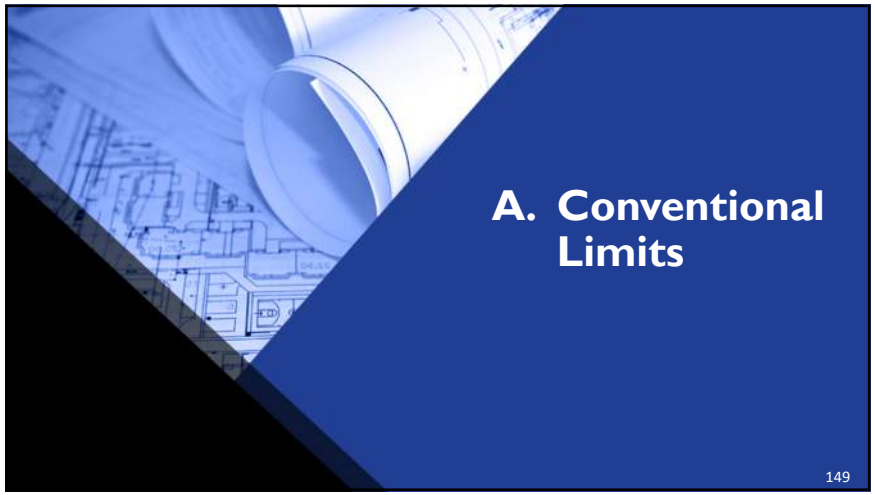


147

Items to Cover

A. Conventional Limits
B. Wall Bracing (Chapter 6)
C. Examples
D. Load Paths
E. Miscellaneous

148



A. Conventional Limits

- Prescriptive (i.e. "Cookbook") method.
- Provided in IRC, IBC Section 2308, WFCM, ICC 400 & AISI S230
- Several limitations, especially in high-seismic or high-wind regions

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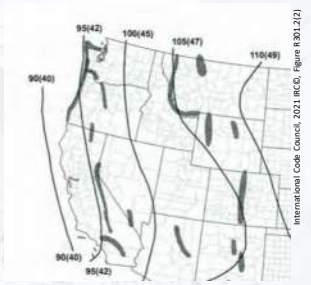
A. Conventional Limits

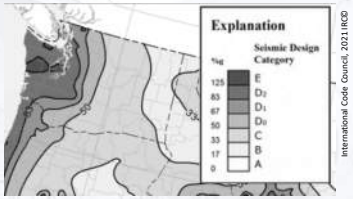
- ***Wind Limitations (R301.2.1.1):***
  - Figure R301.2(5)B: **> 140mph**
  - Vancouver, WA: 125mph, Exp. B
  - Clark County, WA: 135mph, Exp. B



151

A. Conventional Limits

- ***Seismic Provisions (R301.2.2):***
  - Applies to Seismic Design Categories D_0, D_1, & D_2.
  - Also applies to townhomes in SDC 'C'.
  - SDC 'E' shall comply with the IBC.



152

A. Conventional Limits

- ***Snow Loads (R301.2.3):***
  - Ground Snow Load (P_g) ≤ 70psf
  - Vancouver, WA: 25psf (20psf if < 150ft MSL)
  - Clark County, WA: 30psf


Residential Structural Design Information

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A. Conventional Limits

- ***Other Limitations:***
  - Floodplain Construction (R301.2.4)
  - Weight limitations for concrete, masonry & metal stud
  - In SDC 'D_0' or greater…
    - ≤ 3 stories
    - ≤ 2 stories if Structurally Insulated Panels (SIP)
    - Anchored masonry veneer (R702.1 and R703)
    - Masonry chimneys (Chapter 10)

154

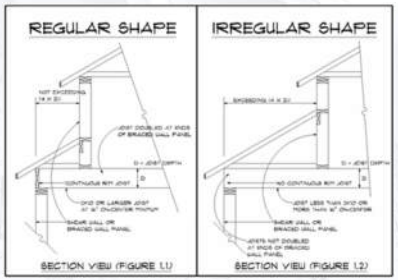
A. Conventional Limits

- ***Irregular Buildings (R301.2.2.2.6)***

155

A. Conventional Limits

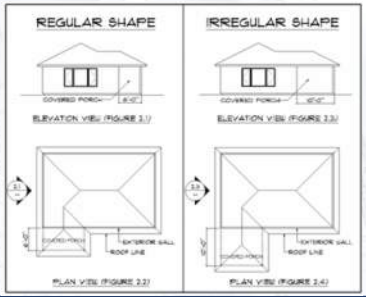
- ***Item #1:*** **Out-of-plane offsets**



156

A. Conventional Limits

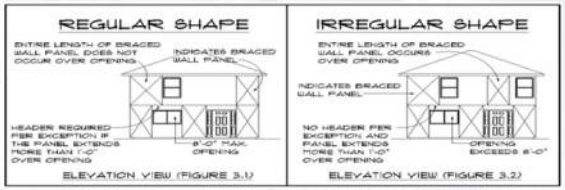
- ***Item #2:*** **Floors or roofs without lateral support on all sides.**



157

A. Conventional Limits

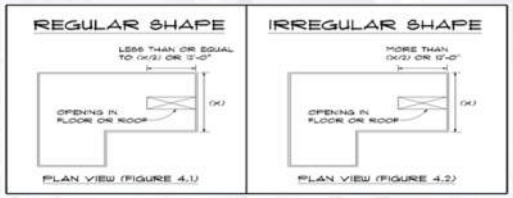
- ***Item #3:*** **End of braced wall segment occurring more than 1-foot over an opening below.**



158

A. Conventional Limits

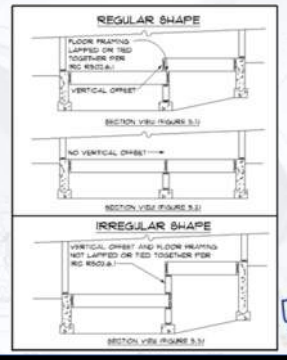
- ***Item #4:*** **Diaphragm openings exceeding either 12-feet or 50% of the least floor/roof dimension.**



159

A. Conventional Limits

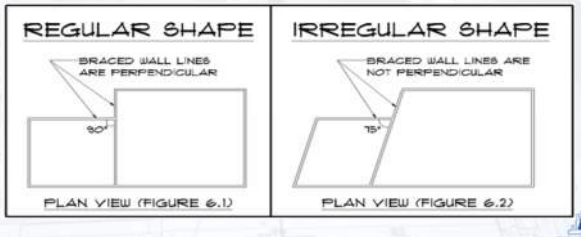
- ***Item #5:*** **Floor levels with vertical offsets.**
  - Exceptions:
    - Framing must be supported directly by continuous foundations at the perimeter.
    - Floor framing must be lapped or tied together as required by R502.6.1. (i.e., 3" lap and (3)10d face nails, or equivalent)



160

A. Conventional Limits

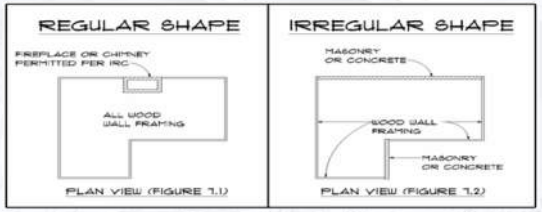
- ***Item #6:*** **Braced wall lines that do not occur in two perpendicular directions.**



161

A. Conventional Limits)

- ***Item #7:*** **Above grade masonry or concrete**



162

A. Conventional Limits)

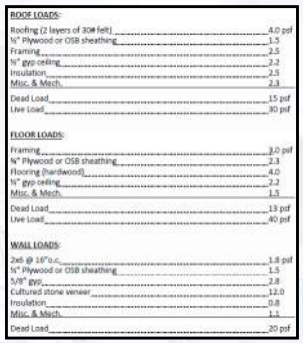
- ***Item #8:*** **Hillside** ***– New to 2021 IRC!***
  - All the following must apply…
    - Grade > 1V:5H, and…
    - Tallest cripple wall > 7-feet, and…
    - Of the total plan area below the lowest framed floor, whether open or enclosed, less than 50 percent is living space having interior wall finishes conforming to Section R702.

163

A. Conventional Limits

- ***Weights of Materials:***
  - Roofs ≤ 15psf *
  - Floors ≤ 10psf
  - Exterior Walls ≤ 15psf
  - Interior Walls ≤ 10psf

* → 25psf allowed if…
  - 20% braced wall increase for 1-story or top story, and…
  - 10% braced wall increase for other stories
  - See Table R602.10.3(4)



164

A. Conventional Limits

- ***Engineered Design (R301.1.3):***
  - *"When a building of otherwise conventional construction contains structural elements exceeding the limits of… (the IRC), these elements shall be designed in accordance with accepted engineering practice."*

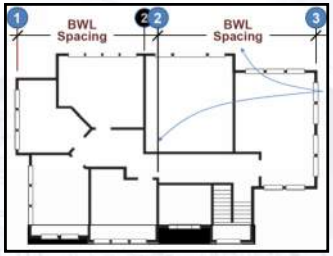
165

B. Wall Bracing
(IRC Chapter 6)

166

B. Wall Bracing

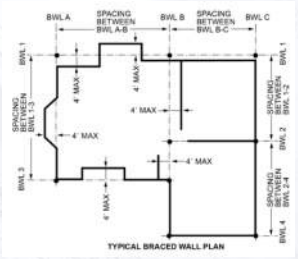
- ***Terminology:***
  - Wall Bracing
  - Braced Wall Line (**BWL**)
  - Braced Wall Panel (**BWP**)
  - Length
  - Spacing



167

B. Wall Bracing

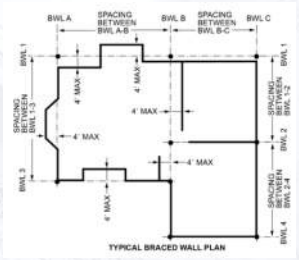
- ***Braced Wall Line (IRC R202):***
  - *"A straight line through the building plan that represents the location of the lateral resistance provided by the wall bracing."*
- ***BWL shown on plans! (IRC R602.10.1):***
  - *"The braced wall lines shall be designated as straight lines in the building plan placed in accordance with this section."*



168

B. Wall Bracing

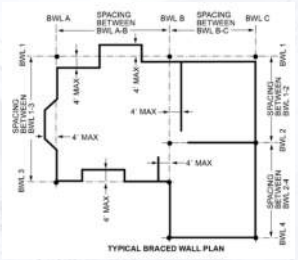
- ***BWL Length (IRC R602.10.1.1):***
  - Equals the distance between its ends
  - *"The end of a BWL shall be the intersection with a perpendicular BWL, an angled BWL… or an exterior wall."*



169

B. Wall Bracing

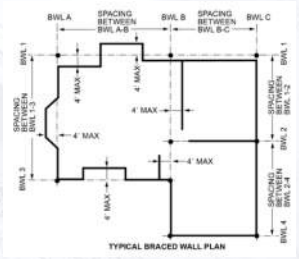
- ***BWL Locations & Permitted Offsets (IRC R602.10.1.2):***
  - BWP can be offset up to **4-feet** on either side of BWL
  - ≤ **2/3** of BWP length can be placed to either side of BWL ***(New to 2021 IRC)***



170

B. Wall Bracing

- ***BWL Spacing (IRC R602.10.1.3):***
  - Wind (100 mph to < 140mph) ≤ **60-feet**
  - SDC A – C → Use Wind Bracing *(except for townhomes)*
  - SDC D ≤ **25-feet**



171

B. Wall Bracing

- ***BWL Spacing (IRC R602.10.1.3):***
  - BWL Spacing:

>25 feet and ≤ 30 feet: **1.2**
>30 feet and ≤ 35 feet: **1.4**

TABLE R602.10.1.3
BRACED WALL LINE SPACING

APPLICATION	CONDITION	BUILDING TYPE	BRACED WALL LINE SPACING CRITERIA	
			Maximum Spacing	Exception to Maximum Spacing
Wind bracing	Ultimate design wind speed < 140 mph	Detached, townhouse	60 feet	None
Seismic bracing	SDC A – C	Detached	Use wind bracing	
	SDC A – B	Townhouse	Use wind bracing	
	SDC C	Townhouse	35 feet	Up to 50 feet when length of required bracing per Table R602.10.3(3) is adjusted in accordance with Table R602.10.3(4).
	SDC D_0, D_1, D_2	Detached, townhouses, one- and two-story only	25 feet	Up to 35 feet to allow for a single room not to exceed 900 square feet. Spacing of all other braced wall lines shall not exceed 25 feet.
	SDC D_0, D_1, D_2	Detached, townhouse	25 feet	Up to 35 feet when length of required bracing per Table R602.10.3(3) is adjusted in accordance with Table R602.10.3(4).

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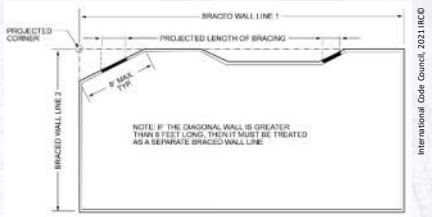
B. Wall Bracing

- ***Angled Walls (IRC R602.10.1.4):***
  - Maximum diagonal length of 8-feet
  - If > 8-feet, shall be considered a separate BWL



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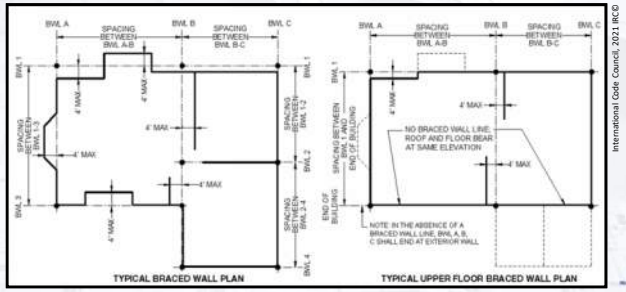
B. Wall Bracing

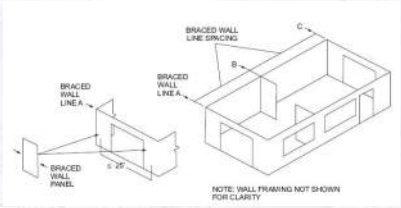
- ***Braced Wall Lines (cont.):***



174

B. Wall Bracing

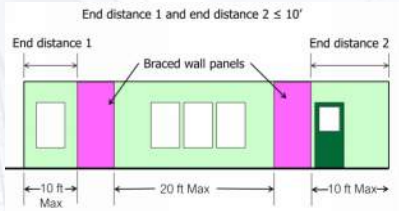
- ***Braced Wall Panel (IRC R202):***
  - *"A full-height section of wall constructed to resist in-plane shear loads through interaction of framing members, sheathing material and anchors. The panel's length meets the requirements of its particular bracing method and contributes toward the total amount of bracing required along its braced wall line in accordance with Section R602.10.1."*



175

B. Wall Bracing

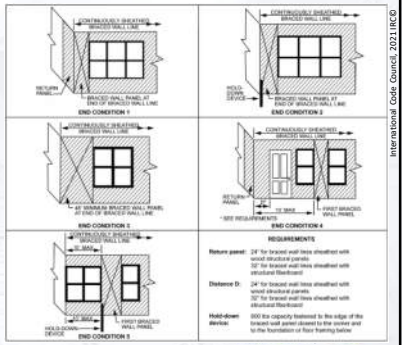
- ***Braced Wall Panels (R602.10.2):***
  - Shall be…
    - Full-height sections
    - No vertical/horizontal offsets
    - Placed along BWL
  - Location:
    - Spacing ≤ 20-feet
    - w/in 10-feet from each end



176

B. Wall Bracing

- ***Braced Wall Panels (R602.10.2):***
  - Location *(cont.)*:
    - SDC D_0, D_1, & D_2 → 10-feet from end
      - 2-foot panel on each side
      - 1,800# holdown



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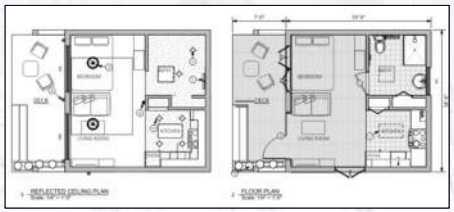
B. Wall Bracing

- ***BWP – Min. Number (R602.10.2.3):***
  - BWL ≤ 16-feet → 2 BWP of any length or one 4-foot BWP
  - BWL > 16-feet → 2 BWP
  - Floors or roofs not laterally supported by braced walls: ***6 feet max.***



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B. Wall Bracing

FIGURE R602.10.2.2
LOCATION OF BRACED WALL PANELS

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B. Wall Bracing

- ***Required Length of Bracing (R602.10.3):***
  - Min. Length of BWP on ***each*** BWL
- ***Only Table R602.10.3(1)*** *Wind*
  - SDC A and B – All structures
  - SDC C – Detached structures (acc. or 1 family)
  - Modified by Table R602.10.3(2)
- ***Both Table R602.10.3(1) and R602.10.3(3)*** *Wind and Seismic*
  - SDC C – Townhouses
  - SDC D – All structures
  - Modified by Table R602.10.3(2) and R602.10.3(4)

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B. Wall Bracing

- ***Braced Wall Panels (R602.10.4):***
  - Intermittent Bracing (12 methods)
  - Continuous Sheathing (4 methods)


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B. Wall Bracing

- ***Intermittent Bracing (Table R602.10.4):***

TABLE R602.10.4
BRACING METHODS

METHODS, MATERIAL	MINIMUM THICKNESS	FIGURE	CONNECTION CRITERIA[a] Fasteners	CONNECTION CRITERIA[a] Spacing
LIB Let-in-bracing	1 × 4 wood or approved metal straps at 45° to 60° angles for maximum 16" stud spacing		Wood: 2-8d common nails or 3-8d (2½" long x 0.113" dia.) nails	Wood: per stud and top and bottom plates
			Metal strap: per manufacturer	Metal: per manufacturer
DWB Diagonal wood boards	¾" (1" nominal) for maximum 24" stud spacing		2-8d (2½" long × 0.113" dia.) nails or 2 - 1¾" long staples	Per stud
WSP Wood structural panel (See Section R604)	⅜"		Exterior sheathing per Table R602.3(3)	6" edges 12" field
			Interior sheathing per Table R602.3(1) or R602.3(2)	Varies by fastener
BV-WSP[b] Wood structural panels with stone or masonry veneer (See Section R602.10.6.5)	⅜"	See Figure R602.10.6.5	8d common (2½" × 0.131) nails	4" at panel edges 12" at intermediate supports 4" at braced wall panel end posts

Methods

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B. Wall Bracing

- ***Continuous Bracing (Table R602.10.4):***

Continuous Sheathing Methods					
CS-WSP Continuously sheathed wood structural panel	⅜"		Exterior sheathing per Table R602.3(3)	6" edges 12" field
			Interior sheathing per Table R602.3(1) or R602.3(2)	Varies by fastener
CS-G[b,c] Continuously sheathed wood structural panel adjacent to garage openings	⅜"		See Method CS-WSP	See Method CS-WSP
CS-PF Continuously sheathed portal frame	7/16"		See Section R602.10.6.4	See Section R602.10.6.4
CS-SFB[d] Continuously sheathed structural fiberboard	½" or 25/32" for maximum 16" stud spacing		1½" long × 0.12" dia. (for ½" thick sheathing) 1¾" long × 0.12" dia. (for 25/32" thick sheathing) galvanized roofing nails	3" edges 6" field

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B. Wall Bracing

- ***Mixing (R602.10.4.1):***
  - From story to story → **Any method**
  - From BWL to BWL → **Intermittent only**
  - Not allowed **within a BWL** (SDC 'D_0' or above)

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B. Wall Bracing

- ***Braced Wall Panels (R602.10.5):***
  - Minimum Length:

TABLE R602.10.5
MINIMUM LENGTH OF BRACED WALL PANELS

METHOD (See Table R602.10.4)		MINIMUM LENGTH[a] (inches) Wall Height 8 feet	9 feet	10 feet	11 feet	12 feet	CONTRIBUTING LENGTH (inches)
DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP		48	48	48	53	58	Actual[b]
GB		48	48	48	53	58	Double sided = Actual Single sided = 0.5 × Actual
LIB		55	62	69	NP	NP	Actual[b]
ABW	SDC A, B and C, ultimate design wind speed < 140 mph	28	32	34	38	42	48
	SDC D_0, D_1 and D_2, ultimate design wind speed < 140 mph	32	32	34	NP	NP	

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B. Wall Bracing

Example: What is the minimum width of a continuous sheathed braced wall that is 10-feet tall and includes a single man door opening (i.e. height = 80")?

	Adjacent clear opening height (inches)						
CS-WSP, CS-SFB	≤ 64	24	27	30	33	36	Actual[b]
	68	26	27	30	33	36	
	72	27	27	30	33	36	
	76	30	29	30	33	36	
	80	32	30	30	33	36	
	84	35	32	32	33	36	
	88	38	35	33	33	36	
	92	43	37	35	35	36	
	96	48	41	38	36	36	
	100	—	44	40	38	38	
	104	—	49	43	40	39	
	108	—	54	46	43	41	
	112	—	—	50	45	43	
	116	—	—	55	48	45	
	120	—	—	60	52	48	
	124	—	—	—	56	51	
	128	—	—	—	61	54	
	132	—	—	—	66	58	
	136	—	—	—	—	62	
	140	—	—	—	—	66	
	144	—	—	—	—	72	

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B. Wall Bracing

- ***Braced Wall Panels (cont.):***

PFH	Supporting roof only	16	16	16	Note c	Note c	48
	Supporting one story and roof	24	24	24	Note c	Note c	
PFG		24	27	30	Note d	Note d	1.5 × Actual[b]
CS-PF	SDC A, B and C	16	18	20	Note e	Note e	1.5 × Actual[b]
	SDC D_0, D_1 and D_2	16	18	20	Note e	Note e	Actual[b]

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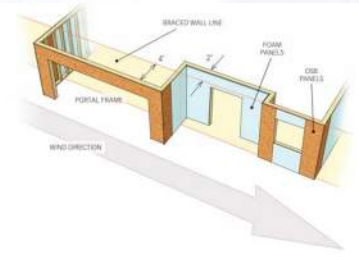
B. Wall Bracing

- ***Required Bracing (R602.10.3):***
  - Each wall line must be checked for wind & seismic
  - Exceptions:
    - SDC A and B → Wind only
    - SDC C – Detached structures (accessory or 1-family) → Wind only



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B. Wall Bracing

- ***8 Steps to Verifying Bracing:***
  - What bracing method is being used?
  - Braced length requirement – Wind
  - Apply wind adjustment factors.
  - Braced length requirement – Seismic
  - Apply seismic adjustment factors.
  - What braced wall length controls? (wind or seismic)
  - BWL locations & spacing
  - BWP locations & spacing

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C. Examples

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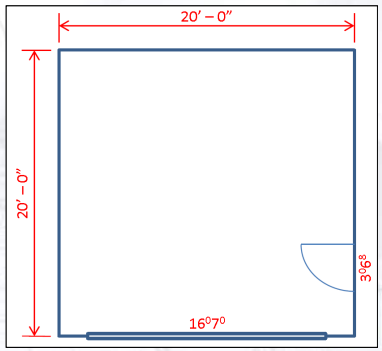
Example #1 – Detached Garage

- ***Given:***
  - 20'x20' footprint
  - 8' wall height
  - 4:12 roof pitch
  - Mfr. Trusses
  - WSP
  - Wind: 95mph, Exp. 'B'
  - SDC 'D_1'



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Example #1 – Detached Garage

- ***Step 1: What bracing method is being used?***

TABLE R602.10.4
BRACING METHODS

METHODS, MATERIAL	MINIMUM THICKNESS	FIGURE	CONNECTION CRITERIA[a]	
			Fasteners	Spacing
LIB Let-in-bracing	1 × 4 wood or approved metal straps at 45° to 60° angles for maximum 16" stud spacing		Wood: 2-8d common nails or 3-8d (2½" long x 0.113" dia.) nails	Wood: per stud and top and bottom plates
			Metal strap: per manufacturer	Metal: per manufacturer
DWB Diagonal wood boards	¾" (1" nominal) for maximum 24" stud spacing		2-8d (2½" long × 0.113" dia.) nails or 2 - 1¾" long staples	Per stud
WSP Wood structural panel (See Section R604)	⅜"		Exterior sheathing per Table R602.3(3)	6" edges 12" field
			Interior sheathing per Table R602.3(1) or R602.3(2)	Varies by fastener

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Example #1 – Detached Garage

- **Step 2: *Braced length requirement – Wind***

TABLE R602.10.3(1)
BRACING REQUIREMENTS BASED ON WIND SPEED

• EXPOSURE CATEGORY B • 30-FOOT MEAN ROOF HEIGHT • 10-FOOT WALL HEIGHT • 2 BRACED WALL LINES			MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a]			
Ultimate Design Wind Speed (mph)	Story Location	Braced Wall Line Spacing[f] (feet)	Method LIB[b]	Method GB	Methods DWB, WSP, SFB, PBS, PCP, HPS, BV-WSP, ABW, PFH, PFC, CS-SFB	Methods CS-WSP, CS-G, CS-PF
< 95 mph		10	2.5	2.5	1.5	1.5
		20	4.5	4.5	2.5	2.5
		30	6.5	6.5	4.0	3.5
		40	8.5	8.5	5.0	4.0
		50	10.5	10.5	6.0	5.0
		60	12.5	12.5	7.0	6.0

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Example #1 – Detached Garage

- **Step 3: *Apply Wind Adjustment Factors***

TABLE R602.10.3(2)
WIND ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

ITEM NUMBER	ADJUSTMENT BASED ON	STORY/SUPPORTING	CONDITION	ADJUSTMENT FACTOR[c,f] [multiply length from Table R602.10.3(1) by this factor]	APPLICABLE METHODS
1	Exposure category	One-story structure	B	1.00	
			C	1.20	
			D	1.50	
		Two-story structure	B	1.00	
			C	1.30	
			D	1.60	
2	Roof eave-to-ridge height	Roof only	≤ 5 feet	0.70	All methods
			10 feet	1.00	
			15 feet	1.30	
			20 feet	1.60	
		Roof + 1 floor	≤ 5 feet	0.85	
			10 feet	1.00	
			15 feet	1.15	
			20 feet	1.30	

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Example #1 – Detached Garage

- **Step 3: *Apply Wind Adjustment Factors* (cont.)**

TABLE R602.10.3(2)
WIND ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

ITEM NUMBER	ADJUSTMENT BASED ON	STORY/SUPPORTING	CONDITION	ADJUSTMENT FACTOR[c,f] [multiply length from Table R602.10.3(1) by this factor]	APPLICABLE METHODS
3	Story height (Section R301.3)	Any story	8 feet	0.90	
			9 feet	0.95	
			10 feet	1.00	
			11 feet	1.05	
			12 feet	1.10	
4	Number of braced wall lines (per plan direction)[f]	Any story	2	1.00	
			3	1.30	
			4	1.45	
			≥ 5	1.60	
6	Interior gypsum board finish (or equivalent)	Any story	Omitted from inside face of braced wall panels	1.40	DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS-G, CS-SFH

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Example #1 – Detached Garage

- **Step 3: *Apply Wind Adjustment Factors* (cont.)**

- Adjusted Braced Wall Length for Wind:

Exp. B, Wall Height, No Gypsum Board

- LW = 2.5'*1.0*0.7*0.9*1.0*1.4 = **2.2'/BWL**

Eave-to-Ridge Height, # Lines

How many BWP per BWL are required?

What is the minimum width of the BWPs?

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Example #1 – Detached Garage

- *Step 4: Braced length requirement - Seismic*

TABLE R602.10.3(3)—continued
BRACING REQUIREMENTS BASED ON SEISMIC DESIGN CATEGORY

• WALL HEIGHT = 10 FEET • 10 PSF FLOOR DEAD LOAD • 15 PSF ROOF/CEILING DEAD LOAD • BRACED WALL LINE SPACING ≤ 25 FEET			MINIMUM TOTAL LENGTH (FEET) OF BRACED WALL PANELS REQUIRED ALONG EACH BRACED WALL LINE[a, g]				
Seismic Design Category[h]	Story Location	Braced Wall Line Length (feet)[i]	Method LIB[e]	Method GB	Methods DWB, SFB, PBS, PCP, HPS, CS-SFB[g]	Methods WSP, ABW[c], PFH[c] and PFG[c, f]	Methods CS-WSP, CS-G, CS-PF
D_1		10	NP	3.0	3.0	2.0	1.7
		20	NP	6.0	6.0	4.0	3.4
		30	NP	9.0	9.0	6.0	5.1
		40	NP	12.0	12.0	8.0	6.8
		50	NP	15.0	15.0	10.0	8.5

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Example #1 – Detached Garage

- *Step 5: Apply Seismic Adjustment Factors*

TABLE R602.10.3(4)
SEISMIC ADJUSTMENT FACTORS TO THE REQUIRED LENGTH OF WALL BRACING

ITEM NUMBER	ADJUSTMENT BASED ON	STORY[a]	CONDITION	ADJUSTMENT FACTOR[a, b] (Multiply length from Table R602.10.3(3) by this factor)	APPLICABLE METHODS
1	Story height (Section 301.3)	Any story	≤ 10 feet	1.0	All methods
			> 10 feet and ≤ 12 feet	1.2	
2	Braced wall line spacing, townhouses in SDC C	Any story	≤ 35 feet	1.0	
			> 35 feet and ≤ 50 feet	1.43	
3	Braced wall line spacing, in SDC D_0, D_1, D_2	Any story	> 25 feet and ≤ 30 feet	1.2	
			> 30 feet and ≤ 35 feet	1.4	
4	Wall dead load	Any story	> 8 psf and < 15 psf	1.0	
			< 8psf	0.85	
5	Roof/ceiling dead load for wall supporting	1-, 2- or 3-story building	≤15 psf	1.0	
		2- or 3-story building	> 15 psf and ≤ 25 psf	1.1	
		1-story building or top story	> 15 psf and ≤ 25 psf	1.2	

N/A

N/A

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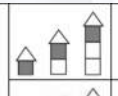
Example #1 – Detached Garage

- *Step 5: Apply Seismic Adjustment Factors (cont.)*

6	Walls with stone or masonry veneer, townhouses in SDC C[d, f]		1.0	All methods
			1.5	
			1.5	

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Example #1 – Detached Garage

- *Step 5: Apply Seismic Adjustment Factors (cont.)*

7	Walls with stone or masonry veneer, detached one- and two-family dwellings in SDC D_0 – D_2[d, f]	Any story	See Section R602.10.6.5.4		BV-WSP
8	Walls with stone or masonry veneer, detached one- and two-family dwellings in SDC D_0 – D_2[d, f]	First and second story of two-story dwelling	Limited brick veneer on second story. See Section R602.10.6.5.3.	1.2	WSP, CS-WSP
9	Interior gypsum board finish (or equivalent)	Any story	Omitted from inside face of braced wall panels	1.5	DWB, WSP, SFB, PBS, PCP, HPS, CS-WSP, CS-G, CS-SFB
10	Horizontal blocking	Any story	Horizontal blocking omitted	2.0	WSP, PBS, CS-WSP

N/A

N/A

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Example #1 – Detached Garage

- ***Step 5: Apply Seismic Adjustment Factors (cont.)***
  - Adjusted Braced Wall Length for Seismic:
  - LS = 4.0'*1.0*1.0*1.0*1.0*1.0*1.5*1.0 = ***6.0'/BWL***

Story Height, Wall DL, Veneer, Blocking

BWL Spacing, Roof DL, Interior Gypsum

How many BWP per BWL are required?

What is the minimum width of the BWPs?

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Example #1 – Detached Garage

- ***Step 6: What Bracing Length Controls?***
  - Wind: Adjusted Length = 4.9'/BWL
  - Seismic: Adjusted Length = 6.0'/BWL
  - → **6.0'/BWL**
  - ***While that is the calculated braced wall length, it does not control!***

How many BWP per BWL are required?

What is the minimum width of the BWPs?

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Example #1 – Detached Garage

- ***The last two steps (#7 & #8) are to verify the locations of the braced walls and their spacing.***

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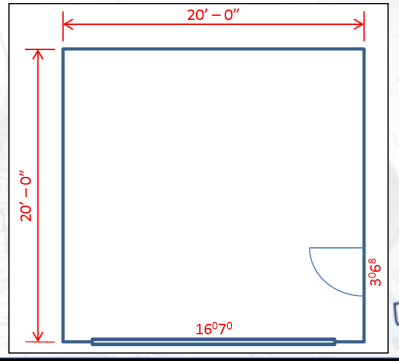
Example #1 – Detached Garage

- ***7.5'/BWL***
- ***Step 7:***
  BWL Locations & Spacing
- ***Step 8:***
  BWP Locations & Spacing



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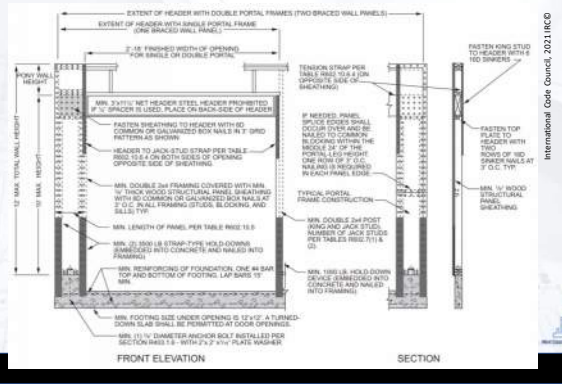
Example #1 – Detached Garage



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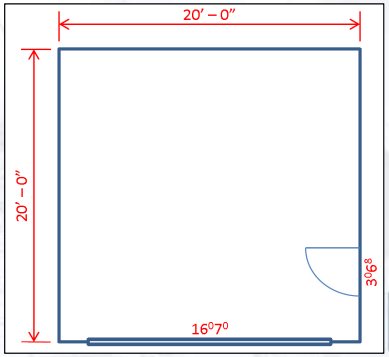
Example #1 – Double Garage

- ***Does this work using the WSP method?***
- ***Can it work using the CS-WSP method?***



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Wall Bracing Quiz

- What is the maximum offset of BWP along a BWL?
- What is the maximum spacing, edge to edge, between BWP's within a BWL?
- How far can a BWP be from the end of a BWL?
- What is the minimum width of a WSP BWP?
- What is the minimum width of a CS-WSP BWP?
- What is the maximum spacing between centers of BWL's?
- What alternate methods can allow for narrow BWP's which are equivalent to 4-feet of braced length?

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Wall Bracing

- ***8 Steps to Verifying Bracing:***
  - What bracing method is being used?
  - Braced length requirement – Wind
  - Apply wind adjustment factors.
  - Braced length requirement – Seismic
  - Apply seismic adjustment factors.
  - What braced wall length controls? (wind or seismic)
  - BWL locations & spacing
  - BWP locations & spacing

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Wall Bracing

- ***8 Steps to Verifying Bracing:***
  - ~~*What bracing method is being used?*~~
  - ~~*Braced length requirement – Wind*~~
  - ~~*Apply wind adjustment factors.*~~
  - ~~*Braced length requirement – Seismic*~~
  - ~~*Apply seismic adjustment factors.*~~
  - ~~*What braced wall length controls? (wind or seismic)*~~
  - BWL locations & spacing
  - BWP locations & spacing

Rule of Thumb: If 50% of a BWL consists of BWP's the amount of bracing provided is likely more than sufficient.

We need to pay attention to the details!

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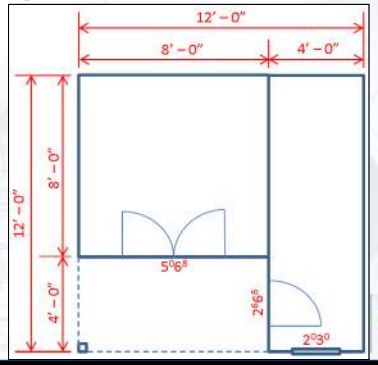
Example #2 – Simpson

- ***The Kimball Shed***
- ***Simpson's "Wall-Bracing Length Calculator"***

www.strongtie.com/webapps/bracedwall/#



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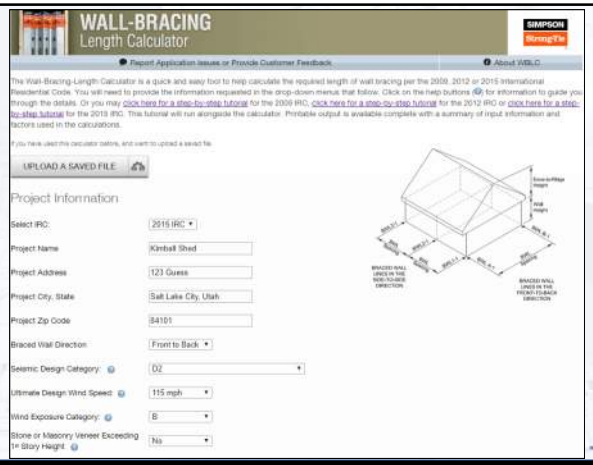

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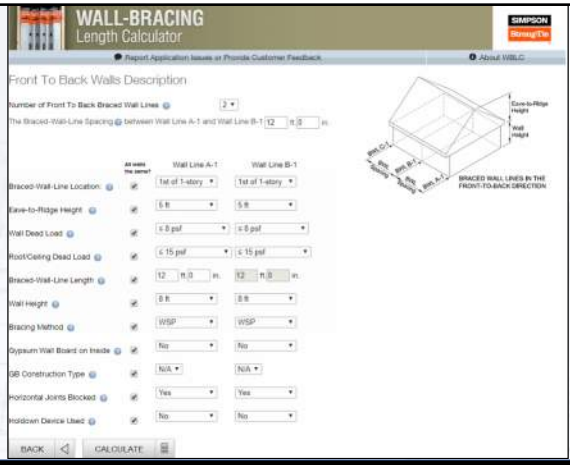

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WIND		
Tabulated Wind Bracing Amount	2.3 ft	2.3 ft
Exposure Height Factor	1	1
Eave-to-Ridge Height Factor	0.7	0.7
Wind Wall Height Factor	0.9	0.9
Number of BWL Factor	1	1
Holdown Factor	1	1
Blocked Joint Factor	1	1
Gypsum on Inside Factor	1.4	1.4
Wind GB Construction Factor	1	1
Required Wind Bracing Amount	2.03 ft	2.03 ft
SEISMIC		
Tabulated Seismic Bracing Amount	3 ft	3 ft
Seismic Wall Height Factor	1	1
BWL Spacing Factor	1	1
Blocked Joint Factor	1	1
Gypsum on Inside Factor	1.5	1.5
Seismic GB Construction Factor	1	1
Wall Dead Load Factor	0.85	0.85
Roof Dead Load Factor	1	1
Veneer Factor	1	1
Required Seismic Bracing Amount	3.83 ft	3.83 ft
RESULTS		
Length of Wall Bracing Required	3.83 ft	3.83 ft

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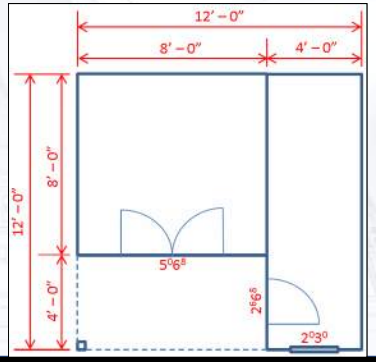
Example #2 – Simpson



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Example #3 – APA

- ***APA's calculator → great for designer's***
  www.apawood.org/calculator

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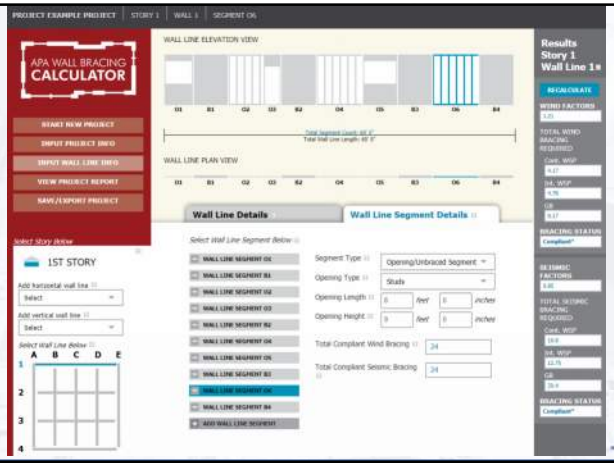
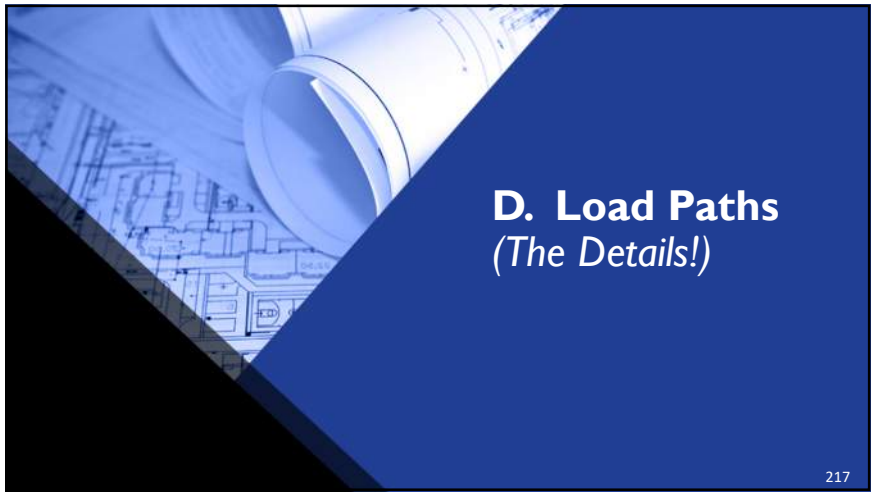
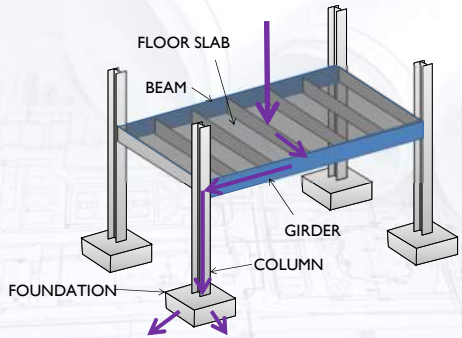


216



Gravity Load Path



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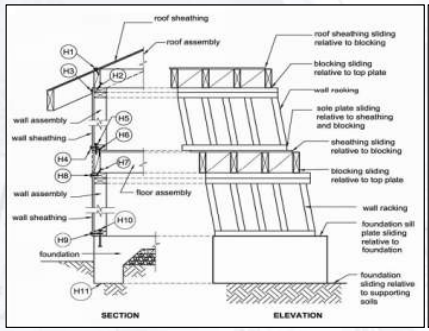
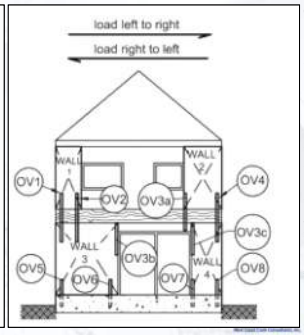
Lateral Load Path



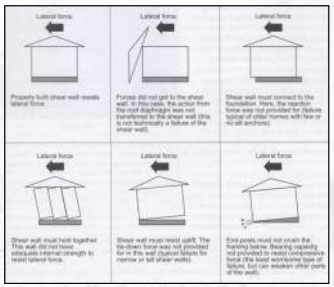


FEMA 232, "Homebuilder's Guide to Earthquake Resistant Design and Construction"

219

Lateral Load Path

- ***IRC R502.2.1:***
  - *"A load path for lateral forces shall be provided between floor framing and braced wall panels located above or below a floor…"*
- ***Connections, connections, connections!!!***



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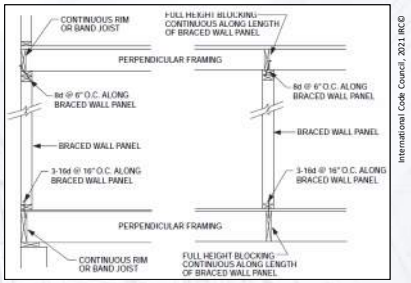
Lateral Load Path

- ***Braced Wall Connections (R602.10.8):***
  - Framing **perpendicular** to BWP
  - A rim joist, band joist, or blocking shall be provided along entire length of BWP.
  - Fastening shall be per Table R602.3(1)



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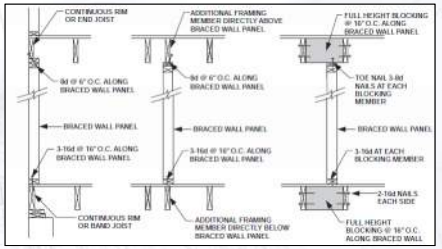
Lateral Load Path

- ***Braced Wall Connections:***
  - Framing **parallel** to BWP
  - A rim joist, end joist, or other parallel framing member shall be provided directly above and below the BWP.
  - Where not possible, full-depth blocking at 16"o.c. to the parallel framing members to each side of BWP.
  - Fastening shall be per Table R602.3(1) & Figure R602.10.8(2)



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Lateral Load Path

- ***Braced Wall Connections (R602.10.8):***
  - BWP to ***concrete or masonry*** → per **IRC R403.1.6**
  - Foundation anchorage *(IRC R403.1.6)*:
    - Sill plates treated against decay and termites
    - ***½"Ø*** anchor bolts having ***7"*** minimum embedment
    - Spaced ≤ 6-feet o.c.
    - Located in ***middle-third*** of plate
    - Two minimum per plate
    - Place within ***12"*** of end but not closer than ***7db***
    - Anchor bolts can be placed while concrete is still plastic → ***2021 IRC change***

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Lateral Load Path

- ***Braced Wall Connections (R602.10.8):***
  - Foundation anchorage – SDC C, D_0, D_1 & D_2
    - Only applies to townhouses in SDC C
    - ***3"x3"x0.229"*** plate washers for full length of BWL
    - Max. anchor spacing is ***4-feet*** for 2-story buildings
    - Stepped cripple walls → R602.10.10
      - Bracing is limited to WSP and CSP-WSP
      - BWP spacing 14-feet max. edge-to-edge
      - May require 4"o.c. edge nailing

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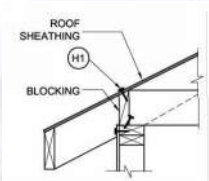
Lateral Load Path

- ***Connections to Roof Framing (R602.10.8.2):***
  - Top Plates:
    - Attached to rafters and trusses per IRC Table R602.3(1)
    - Top plate splice → (8) 16d common nails on each side
    - Blocking *(or band joist, rim, header joist, or truss)* shall be provided between rafters and roof trusses at BWP.
    - Not required over openings in continuous sheathed BWL.



FEMA 232: "Homebuilder's Guide to Earthquake Resistant Design and Construction"

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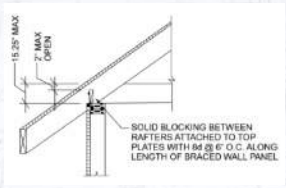
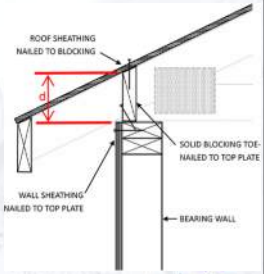
Lateral Load Path

- ***Connections to Roof Framing (R602.10.8.2):***
  - SDC A, B & C:
    - Blocking not required if d ≤ ***9.25-inches***
    - If ***> 9.25-inches*** and ***≤ 15.25-inches***, blocking may comply with Figure R602.10.8.2(1)





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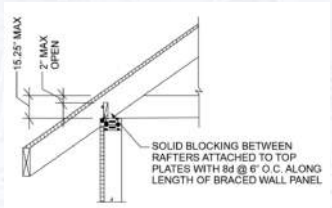
Lateral Load Path

- ***Connections to Roof Framing (R602.10.8.2):***
  - SDC D_0, D_1, & D_2:
    - If ***≤ 15.25-inches***, blocking may comply with Figure R602.10.8.2(1)



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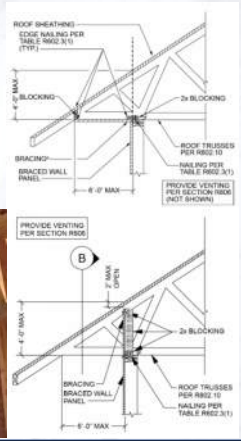
Lateral Load Path

- ***Connections to Roof Framing (R602.10.8.2):***
  - SDC D_0, D_1, & D_2 *(cont.)*:
    - If ***> 15.25-inches***, there are four options…
      1. Soffit blocking panels
      2. Vertical blocking panels
      3. Truss blocking
      4. Other acceptable methods



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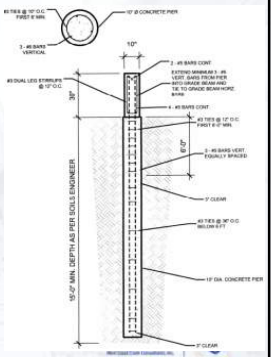
Lateral Load Path

- ***BWP Support (R602.10.9):***
  - Cantilevered floor joists → IRC R502.3.3
    - Shall not exceed nominal depth of joist
    - Alternate #1 → Table R502.3.3(1) – *dimension lumber only*
    - Alternate #2 → exterior balconies – *dimension lumber only*
  - Post- or pier-supported raised floor systems → engineered



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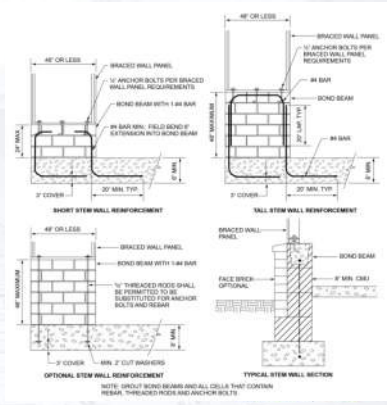
Lateral Load Path

- ***BWP Support (R602.10.9):***
  - Masonry stem walls ≤ 48" long → IRC Figure R602.10.9
  - Masonry stem walls > 48" → IRC R403.1
  - Concrete stem walls ≤ 48" long, and > 12" tall, and < 6" thick → IRC Figure R602.10.9



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Gravity & Lateral Load Paths

- ***Fastening - Table R602.3(1):***
  - #1: Blocking to top plate, toe nail (3-10d)
  - #6: Rafter or roof truss to plate, toe nail (3-16d)
  - #8: Built-up studs, face nail (10d @ 16"o.c.)
  - #9: Wall corners, face nail (16d @ 12"o.c.)

TABLE R602.3(1)
FASTENING SCHEDULE

ITEM	DESCRIPTION OF BUILDING ELEMENTS	NUMBER AND TYPE OF FASTENER[a, b, c]	SPACING AND LOCATION
	Roof		
1	Blocking between ceiling joists or rafters to top plate	4-8d box (2½" × 0.113"); or 3-8d common (2½" × 0.131"); or 3-10d box (3" × 0.128"); or 3-3" × 0.131" nails	Toe nail
2	Ceiling joists to top plate	4-8d box (2½" × 0.113"); or 3-8d common (2½" × 0.131"); or 3-10d box (3" × 0.128"); or 3-3" × 0.131" nails	Per joist, toe nail

International Code Council, 2018 IRC©

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E. Miscellaneous

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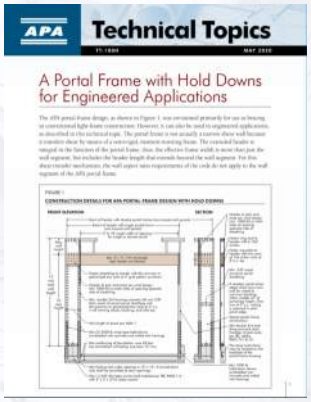
Portal Frame Options

- ***Intermittent Method:***
  - PFH → 16" is = 48" of WSP wall bracing
  - We also see these specified on engineered shear walls

TABLE 1

RECOMMENDED ALLOWABLE DESIGN VALUES FOR A SINGLE LEG OF AN APA PORTAL FRAME USED ON A RIGID-BASE FOUNDATION FOR WIND OR SEISMIC LOADING[a,b,c,d]

Minimum Portal Width (in.)	Maximum Portal Height (ft)	Allowable Design (ASD) Values per Frame Segment		
		Shear[e,f] (lbf)	Deflection (in.)	Load Factor
16	8	850	0.33	3.09
	10	625	0.44	2.97
24	8	1,675	0.38	2.88
	10	1,125	0.51	3.42

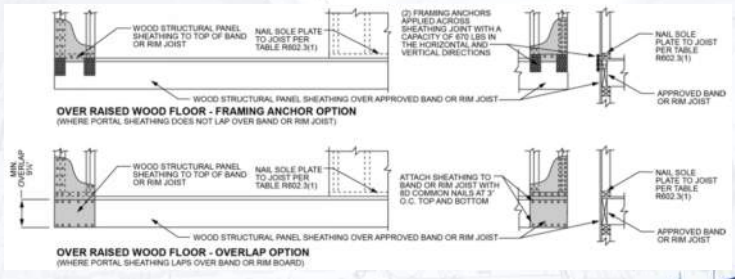

APA Technical Topics

A Portal Frame with Hold Downs for Engineered Applications

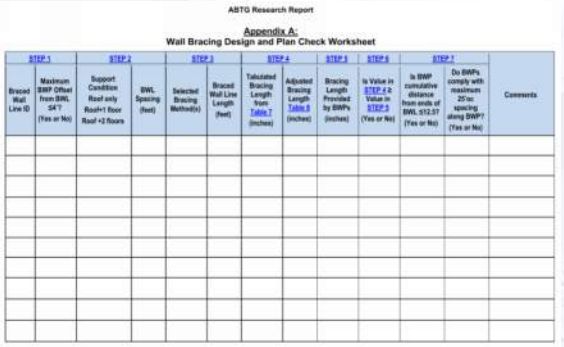
Portal Frame Options

- ***Continuous Sheathed Method:***
  - CS-PF
    - ***SDC A, B, C:*** 16" is = 1.5 x Actual length **(not = 48")**
    - ***SDC D_0, D_1, D_2:*** 16" is = Actual length **(not = 48")**
  - No foundation holdowns
  - Can be used at upper floors*
    - Not allowed for engineered design

Portal Frame Options



Plan Review Tools


ABTG Research Report

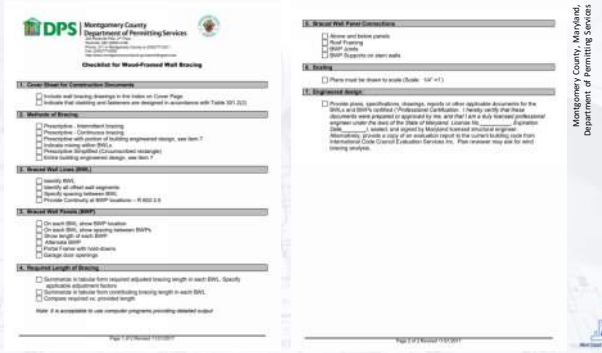
Appendix A:

Wall Bracing Design and Plan Check Worksheet

STEP 1		STEP 2		STEP 3		STEP 4		STEP 5	STEP 6	STEP 7		
Braced Wall Line ID	Maximum BWP Offset from BWL 54'? (Yes or No)	Support Condition Roof only Roof+1 floor Roof +2 floors	BWL Spacing (feet)	Selected Bracing Method(s)	Braced Wall Line Length (feet)	Tabulated Bracing Length from Table 7 (inches)	Adjusted Bracing Length Table 8 (inches)	Bracing Length Provided by BWPs (inches)	Is Value in STEP 4 ≥ Value in STEP 5 (Yes or No)	Is BWP cumulative distance from ends of BWL ≤12.5? (Yes or No)	Do BWPs comply with maximum 25'-0" spacing along BWL? (Yes or No)	Comments

Applied Building Technology, IRC Wall Bracing, Research Report No. 1601-01

Plan Review Tools


DPS | Montgomery County Department of Permitting Services

Checklist for Wood-Framed Wall Bracing

Montgomery County, Maryland, Department of Permitting Services

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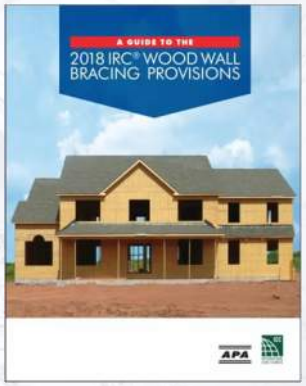
Other Resources

- ❑ APA/ICC Guide to Wall Bracing
- ❑ APA → ***apawood.org/wall-bracing***; Includes a 5-part webinar series on wall bracing with ICC and AIA CEUs



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PART 6
Open Discussion

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Any Questions?

Chris Kimball, SE, MCP, CBO
801.547.8133
chrisk@wc-3.com
http://www.wc-3.com

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