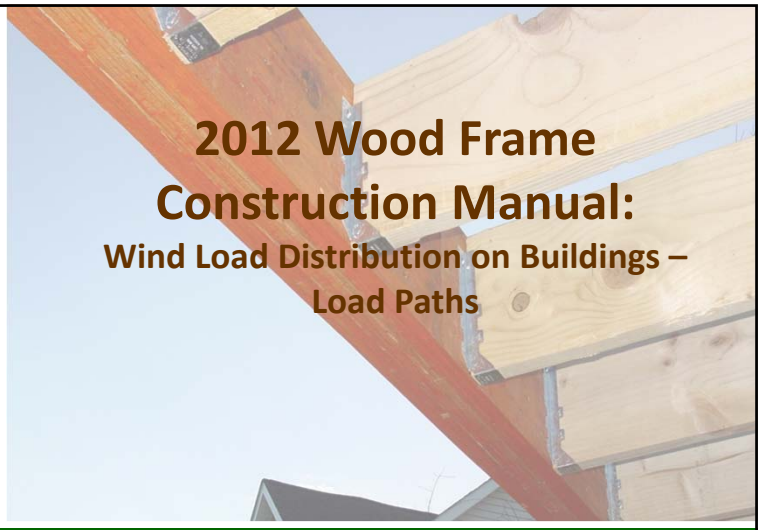

2012 Wood Frame Construction Manual:

Wind Load Distribution on Buildings – Load Paths

Presented by:
William L. Coulbourne, PE

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Learning Objectives

At the end of this program, participants will be knowledgeable of:

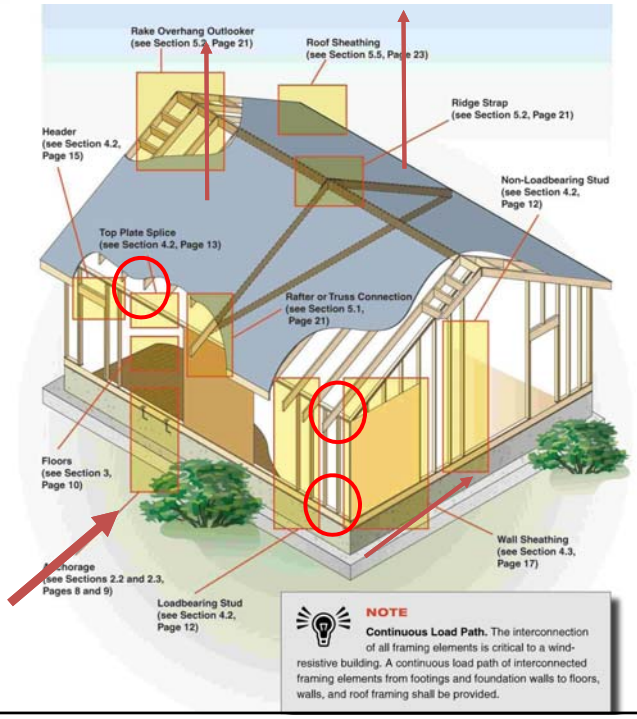
1. Be able to describe how loads are distributed to buildings both vertically and horizontally
2. Be able to describe several different load paths that are critical to improved building performance during high winds
3. Be able to recognize problems in building framing that might present construction challenges to framing continuous load paths
4. Be able to recognize construction defects that could potentially fail under high wind loads

WFCM

- **Basis for this webinar series is the 2012 Wood Frame Construction Manual (WFCM)**
- **Basis follows WFCM Prescriptive Provisions (Chapter 3).**
- **Prescriptive provisions are provided for:**
  - Connections
  - Floor systems
  - Wall systems
  - Roof systems
- **Provisions provide construction details and load tables**
- **WFCM also has engineering design in Chapter 2**

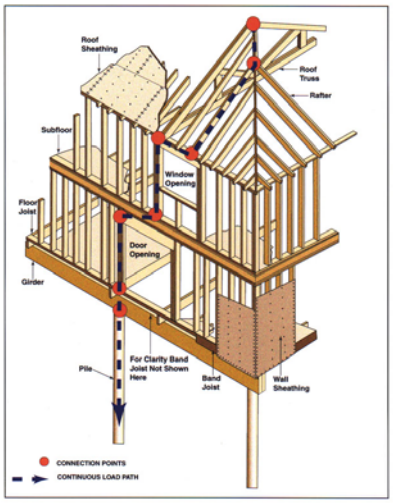
Agenda – Webinar 2

- **Vertical load paths**
  - Roofs
  - Floors
  - Walls
  - Foundations
- **Lateral load paths**
  - Shearwalls
  - Hold downs



Wind Loads and Load Paths

Load Path Example



- Load path must be continuous
- Continuity is created by connections
- Load path always ends in supporting soil
- A building has hundreds of load paths

Source: FEMA

Design vs Construction Sequences

- Construction sequence
  - Build from bottom up
- Design premise
  - Design from the top down
- Load path discussion
  - Follows the design premise even though that is not what is observed in the field

Connections (WFCM 3.2)

- Lateral and shear forces
- Uplift
- Overturning
- Load path connections are needed for:
  - Roof to wall
  - Wall to floor
  - Wall to wall
  - Floor to sill
  - Sill to foundation

Roof Systems (WFCM 3.5)

- Roof framing
  - Open ceiling plans that eliminate collar ties or ceiling joists must have ridge beam
- Roof sheathing
  - Sheathing support must be fully supported by roof framing members
  - Sheathing edges must be supported by blocking or edge clips
- Roof diaphragm bracing
  - For wind speeds > 130 mph, must block and nail @ panel edges perpendicular to roof framing in first two bays

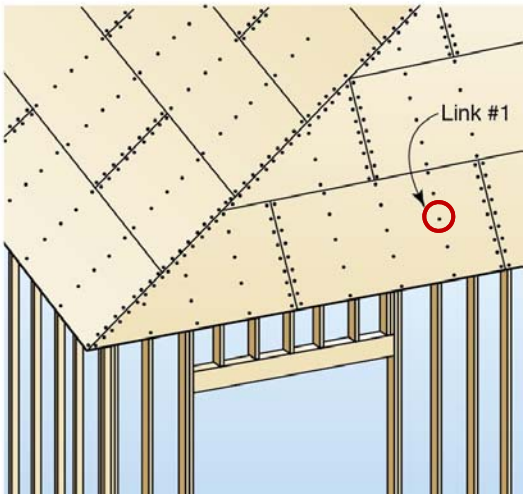
Roof Sheathing to Framing Connection

Nailed connection of roof sheathing to roof framing

Design considerations

❖Must have adequate strength to resist:

- Withdrawal of nail shank from roof framing
- "Head pull-through" (when sheathing pulls over head of fastener)



Source: FEMA

WFCM Roof Sheathing Requirements

Table 3.10 Roof Sheathing Attachment Requirements for Wind Loads **Exposure B**

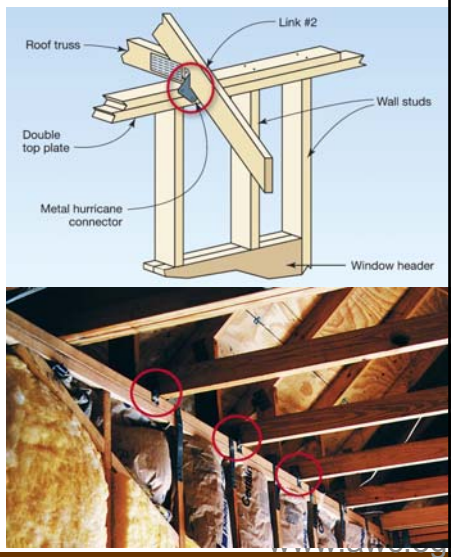
700-yr. Wind Speed 3-second gust (mph)			110		115		120		130		140		150		160		170		180		195	
			STRUCTURAL SHEATHING																			
			E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F	E	F
Sheathing Location[1]	Rafter/Truss Framing Specific Gravity, G	Rafter/Truss Spacing (in.)	Maximum Nail Spacing for 8d Common Nails or 10d Box Nails (inches, o.c.)[2]																			
Interior Zone	0.49	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12
		16	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12
		19.2	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12
		24	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12
	0.42	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12
		16	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12
		19.2	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12
		24	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	6	6	6
Perimeter Edge Zone	0.49	12	6	12	6	12	6	12	6	12	6	12	6	12	6	12	6	6	6	6	6	6
		16	6	12	6	12	6	12	6	12	6	12	6	6	6	6	6	6	6	6	6	6
		19.2	6	12	6	12	6	12	6	12	6	6	6	6	6	6	6	6	6	6	4	4
		24	6	12	6	12	6	6	6	6	6	6	6	6	6	6	4	4	4	4	4	4
	0.42	12	6	12	6	12	6	12	6	12	6	6	6	6	6	6	6	6	6	6	6	6
		16	6	12	6	12	6	12	6	6	6	6	6	6	6	6	6	6	4	4	4	4
		19.2	6	12	6	6	6	6	6	6	6	6	6	6	4	4	4	4	4	4	3	3
		24	6	6	6	6	6	6	6	6	4	4	4	4	4	4	4	4	3	3	3	3

Roof Framing to Exterior Walls

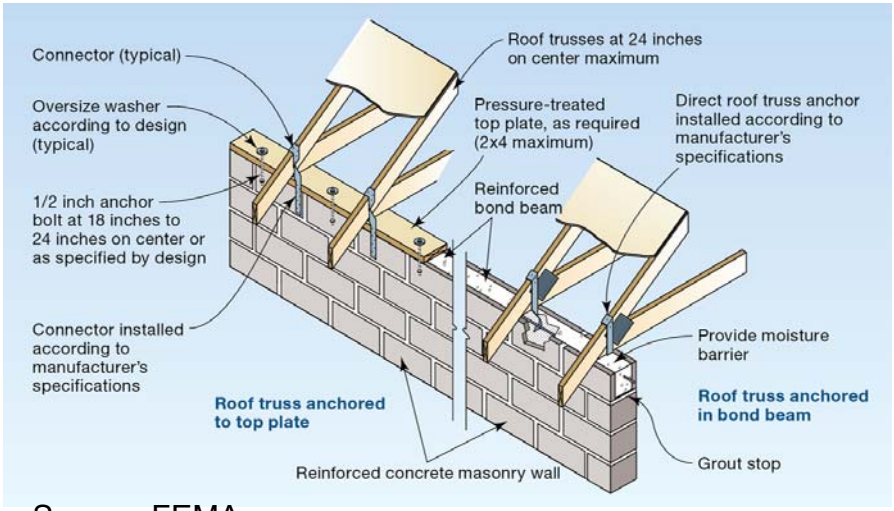
Connection between the roof framing member (truss or rafter) and top of the wall below for resistance to wind uplift – connectors must attach to both top plates

- ❖**Metal connectors are available → follow manufacturers' guidance**
- ❖**Fastener schedule should be called out in design plans**

Source: FEMA



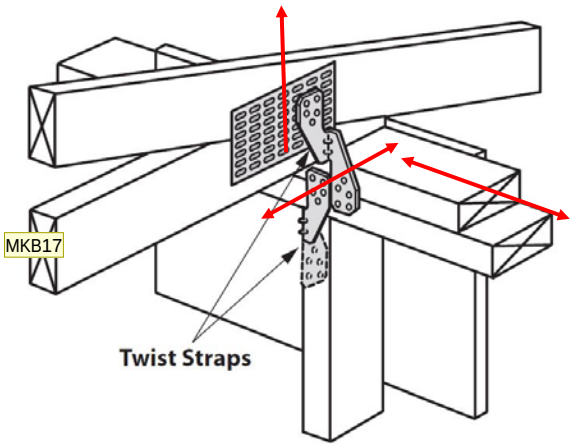
Roof Framing to Exterior Walls



Source: FEMA

Roof to Wall Connection

Figure 3.2k Roof to Top Plate Uplift Connection



Uplift Failure

Roof Diaphragm Blocking

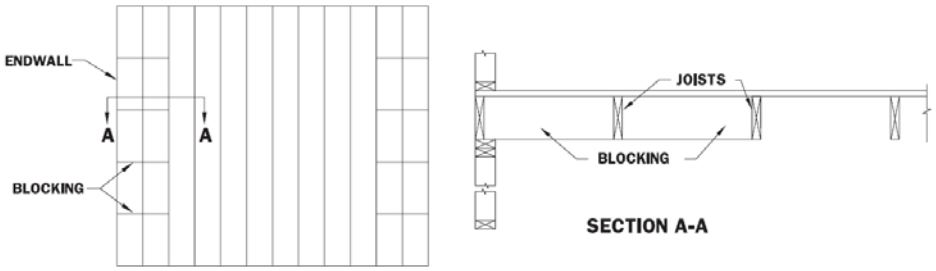
Source: Simpson Strong-Tie

Floor Systems (WFCM 3.3)

- **Floor joists**
  - Lateral stability requirements
  - Cantilever length restrictions
- **Floor sheathing**
- **Floor nailing**
  - 8d common nails, 6” oc. edge, 12” o.c. field
- **Floor diaphragm bracing**
  - For wind speeds > 130 mph, must block and nail @ panel edges perpendicular to floor framing in first two bays (see next slide)

Floor Bracing Detail

Figure 3.7b Floor Bracing Endwall



I-Joist Web Bracing

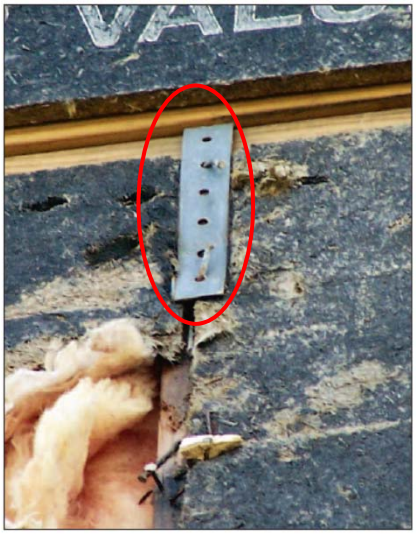
Wall Systems (WFCM 3.4)

- **Studs**
  - Limitations on wall heights
  - Requirements for attaching headers to studs to accommodate loads
  - Limitations on stud notching
- **Walls**
  - Double top plate splice requirements
  - Wall sheathing coverage and nailing is specified for shear walls
  - Holddowns are required at ends of shear walls to resist overturning

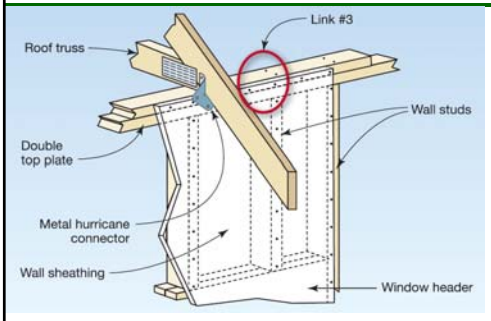
Inadequate Connections

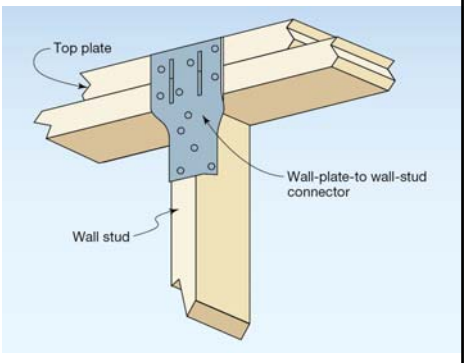
Source: FEMA

Inadequate Connection



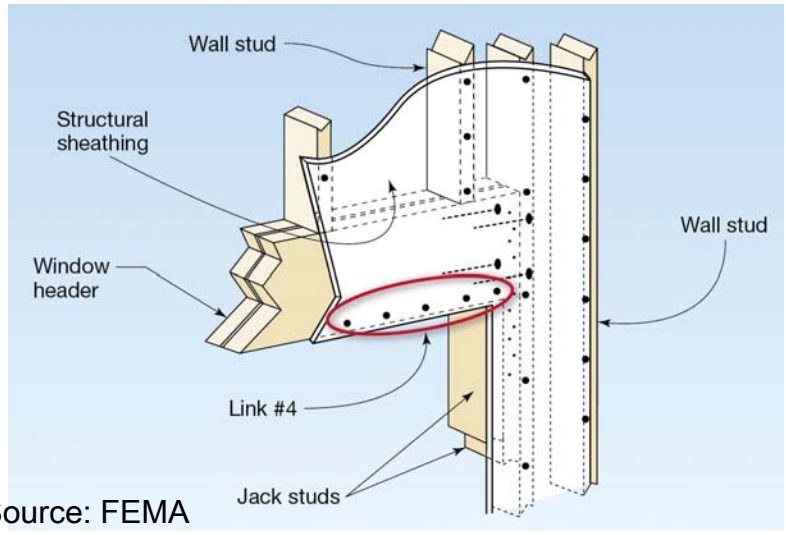
Top Wall Plate to Wall Studs





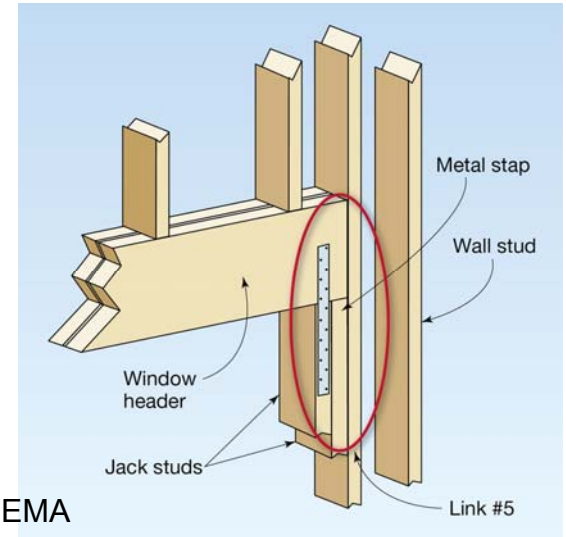
Source: FEMA

Wall Sheathing to Window Header



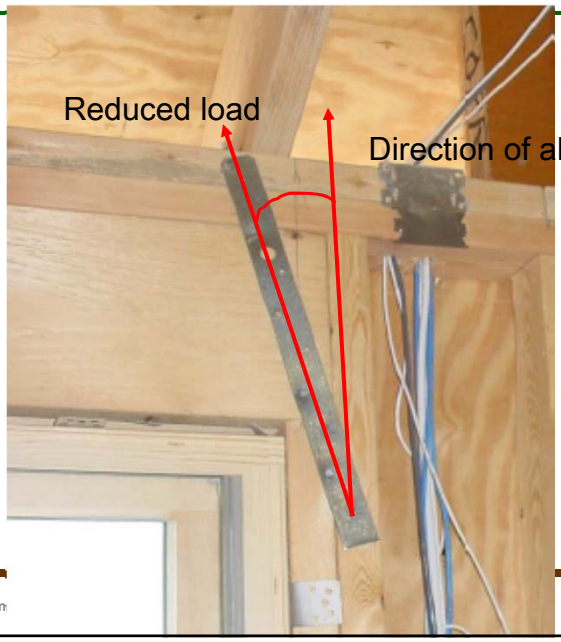
Source: FEMA

Window Header to Exterior Wall

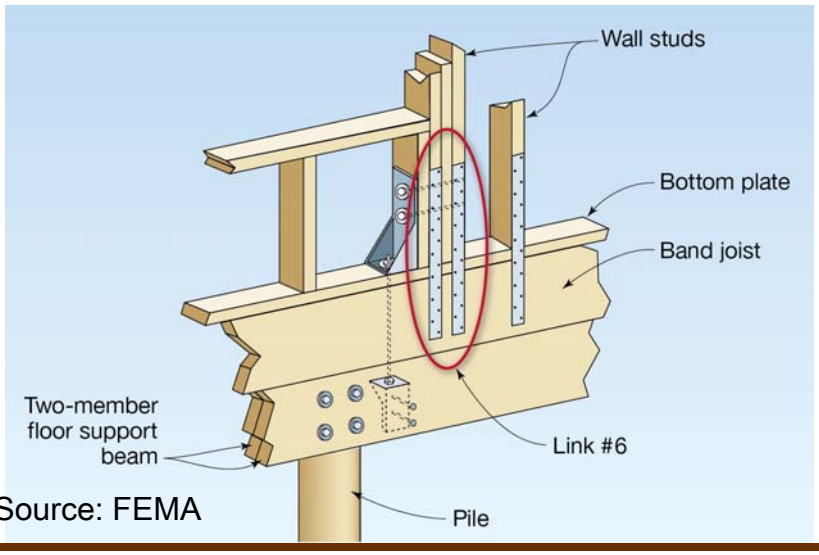


Source: FEMA

Reduced Strap Capacity

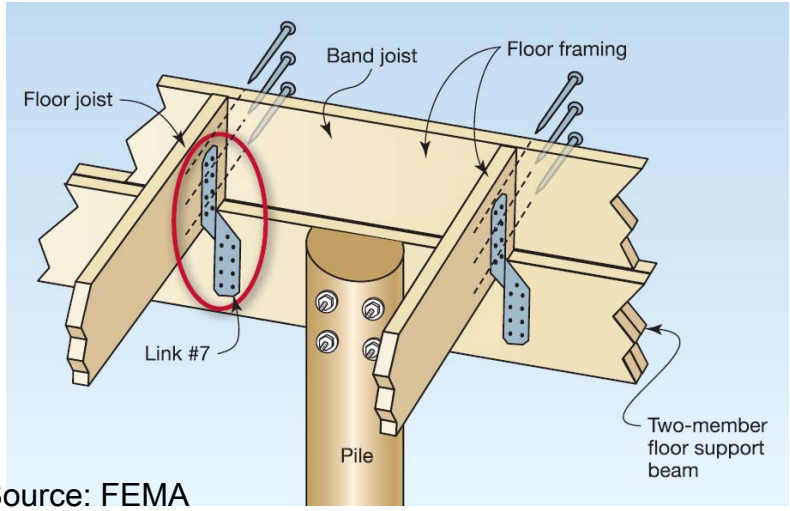


Wall to Floor Framing



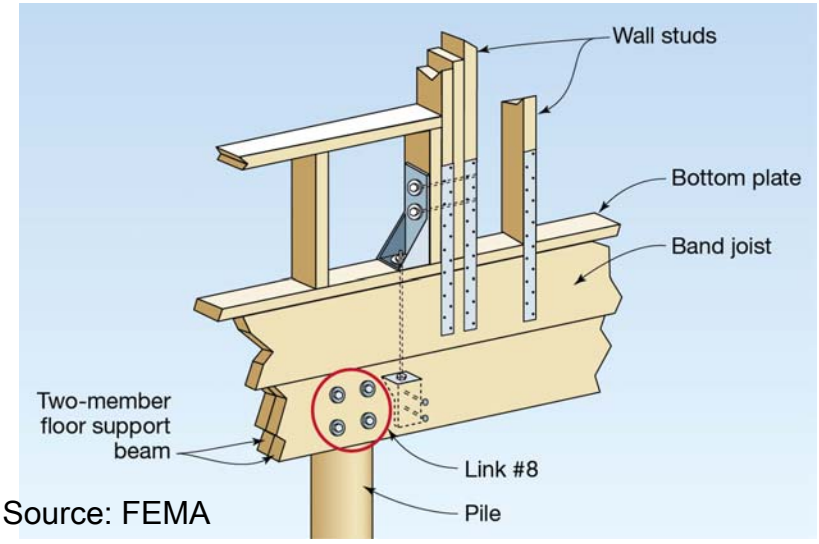
Source: FEMA

Floor Framing to Support Beam



Source: FEMA

Floor Support Beam to Foundation (Pile)



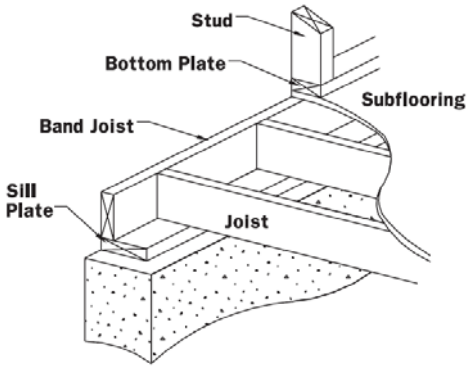
Source: FEMA

Wall to Foundation Connection

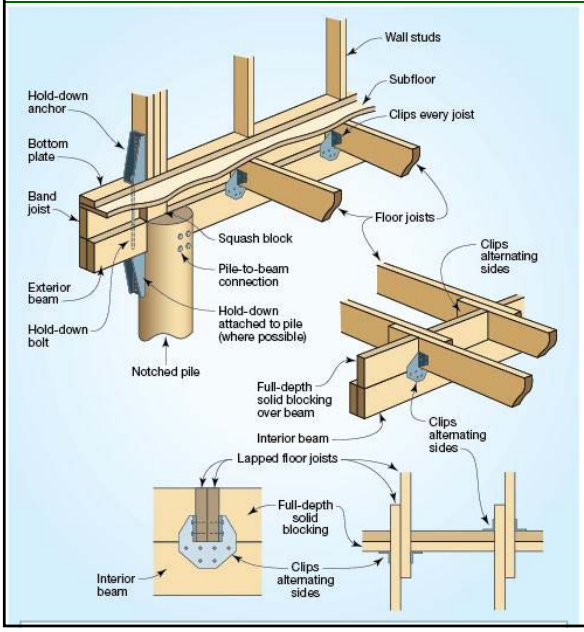
Many variations of wall to foundation connection:

1. Sill to foundation
2. Band joist acts like beam and spans across piers or piles
3. Cantilever over wall
4. Band joist behaves like ledger board

Figure 3.4e Joist Framing on a Foundation Sill Plate



Floor to Foundation Connection



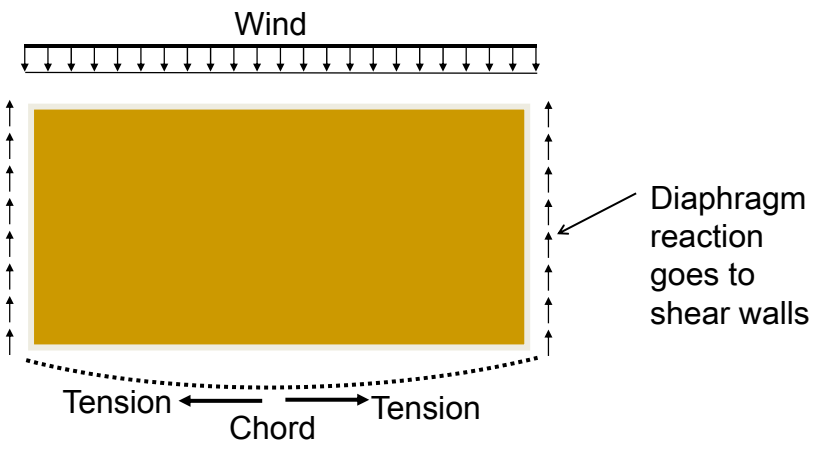
Source: FEMA

Sliding Failure

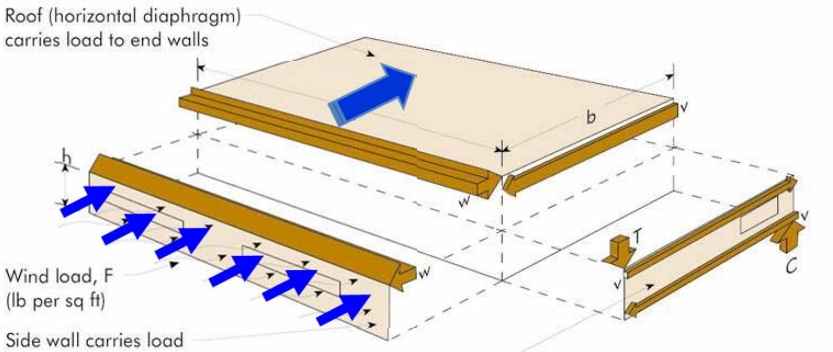
Diaphragms

- Boundary edges
- Blocking
- Layout of panels – horizontal or vertical

From Diaphragms to Shear Walls



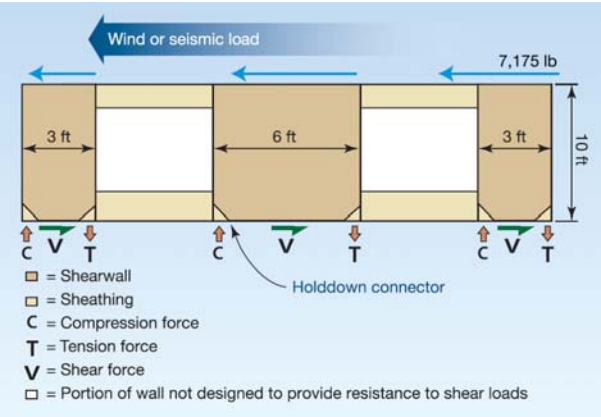
Distribution of Loads into Shear Walls



Shear Wall Methods

- Perforated
- Segmented
- Shear transfer around openings
- Wood structural panels used for shear and uplift
- Wind/Seismic Commentary (2008) and WFCM Section 3.4.4

Lateral and Uplift Loads on Shear Walls



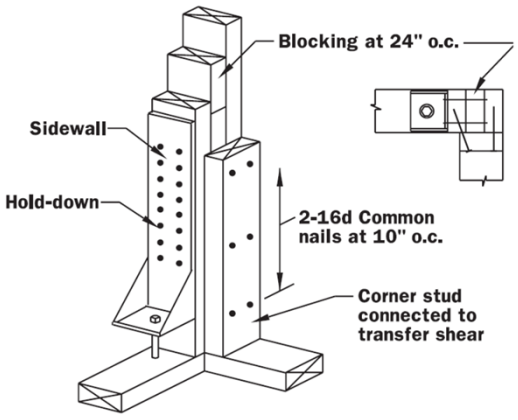
- The shear wall that includes connections designed to resist forces from wind acting perpendicular to the shear wall. This causes tension and compression in the shear wall connections
- Desirable to align shear wall ends with piles for more efficient load transfer

Source: FEMA

Uplift and Lateral Failure

Shear Wall Hold down

Figure 3.8a Corner Stud Hold-down Detail - 3 Studs With Blocking



Wall Sheathing for Shear and Uplift

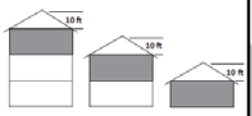
Table 3.4B Shear Walls Resisting Uplift and Shear[1] **Exposure B**

(Prescriptive Alternative to Table 3.4)

700-yr. Wind Speed 3-second gust (mph)				110	115	120	130	140	150	160	170	180	195
Wood Structural Panel Shear Wall Requirements		Top & Bottom of Panel Nailing Requirements		Maximum Roof Span (ft) [2, 3]									
Sheathing Thickness	Shear Wall Nailing	Rows of Nails	Nail Spacing (in)										
7/16" OSB or 15/32" plywood with species of plies having G≥0.49	8d Common Nails @ 4" panel edge spacing and 12" field edge spacing	1 [4]	4	-	-	-	-	-	-	-	-	-	-
			3	36	32	24	12	-	-	-	-	-	-
		2 [5]	6	36	32	24	12	-	-	-	-	-	-
			4	36	36	36	36	36	32	28	20	16	12
			3	36	36	36	36	36	36	36	36	32	24
7/16" OSB or 15/32" plywood with species of plies having G≥0.49	8d Common Nails @ 6" panel edge spacing and 12" field edge spacing	1 [4]	6	-	-	-	-	-	-	-	-	-	-
			4	36	32	24	12	-	-	-	-	-	-
			3	36	36	36	36	28	20	16	12	-	-
		2 [5]	6	36	36	36	36	28	20	16	12	-	-
			4	36	36	36	36	36	36	36	32	24	20
			3	36	36	36	36	36	36	36	36	36	32
15/32" OSB or plywood with species of plies having G≥0.49	10d Common Nails @ 6" panel edge spacing and 12" field edge spacing	1 [4]	6	-	-	-	-	-	-	-	-	-	-
			4	36	36	28	20	12	-	-	-	-	-
			3	36	36	36	36	36	24	20	16	12	-
		2 [5]	6	36	36	36	36	36	24	20	16	12	-
			4	36	36	36	36	36	36	36	36	32	24
			3	36	36	36	36	36	36	36	36	36	36

Segmented Shear Wall Sheathing

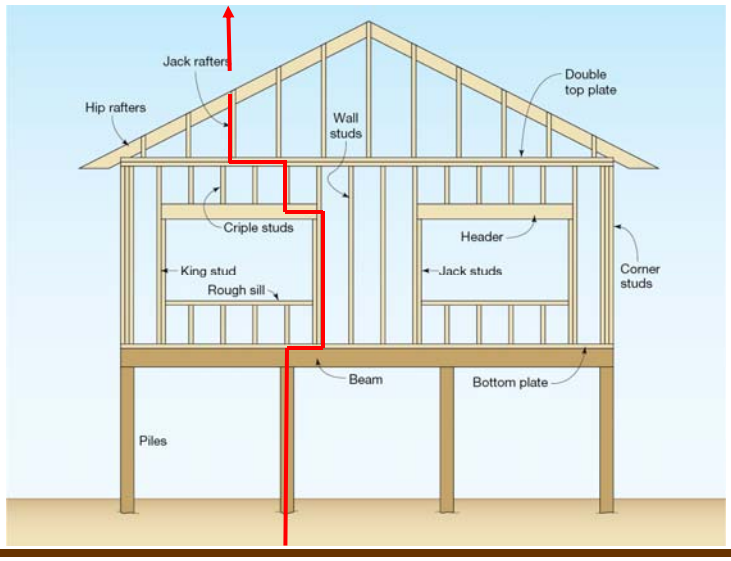
Table 3.17A Segmented Shear Wall Sheathing Requirements for Wind **Exposure B**

700-yr. Wind Speed 3-second gust (mph)		110	115	120	130	140	150	160	170	180	195
Shear Wall Line Beneath	Building Dimension, L or W (ft)	Minimum Length of Full Height Sheathing on Exterior Shear Walls Perpendicular to Building Dimension, L or W (ft)[1,2,3,4,5]									
Roof & Ceiling 	12	1.8	2.0	2.2	2.5	2.9	3.4	3.8	4.3	4.9	5.7
	16	2.4	2.6	2.9	3.4	3.9	4.5	5.1	5.8	6.5	7.6
	20	3.0	3.3	3.6	4.2	4.9	5.6	6.4	7.2	8.1	9.5
	24	3.6	4.0	4.3	5.1	5.9	6.8	7.7	8.7	9.7	11.4
	28	4.2	4.6	5.0	5.9	6.9	7.9	9.0	10.1	11.4	13.3
	32	4.8	5.3	5.8	6.8	7.8	9.0	10.3	11.6	13.0	15.2
	36	5.5	6.0	6.5	7.6	8.8	10.1	11.5	13.0	14.6	17.1
	40	6.1	6.6	7.2	8.5	9.8	11.3	12.8	14.5	16.2	19.0
	50	7.6	8.3	9.0	10.6	12.3	14.1	16.0	18.1	20.3	23.8
	60	9.1	9.9	10.8	12.7	14.7	16.9	19.2	21.7	24.3	28.6
	70	10.6	11.6	12.6	14.8	17.2	19.7	22.4	25.3	28.4	33.3
	80	12.1	13.2	14.4	16.9	19.6	22.5	25.6	28.9	32.4	38.1

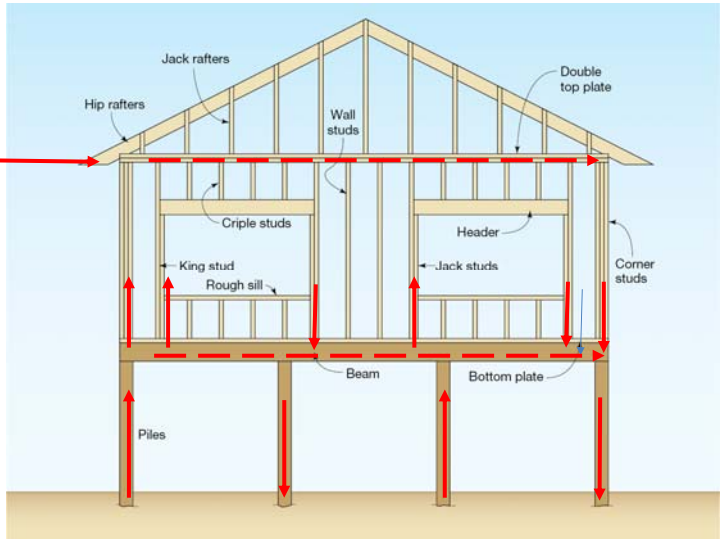
Moment Frames

Moment frames are used when there is not enough shear wall length or there are large openings in the walls.

Summary – Vertical Load Paths



Summary – Lateral Load Paths



Questions?

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info@awc.org

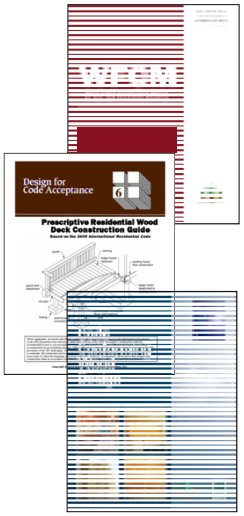
THANK YOU!

Follow up email with:

- SurveyMonkey, presentation links and info. on Certificates

Instructor: William L. Coulbourne, PE

- Sept. 4th 2012 WFCM: Wind Speed and Design Pressure Determination According to ASCE 7-10
- Sept. 11th 2012 WFCM: Wind Load Distribution on Buildings – Load Paths
- Sept. 18th 2012 WFCM: Connections
- Sept. 25th 2012 WFCM: Foundation Design to Resist Flood Loads and WFCM Calculated Wind Loads
- **NEW! Nov. 21st *Prescriptive Residential Wood Deck Construction Guide* (DCA 6)**
- **NEW! Jan. 16th AWC's Code Conforming Wood Design**
- http://www.awc.org



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