Detailing Considerations for Offsite Building Components

Taylor Landry, PE, MLSE

Technical Director, WoodWorks

Outline

- Offsite Construction Basics
- Implementing Various Levels of Off-Site Building Components
- Detailing considerations
  - Structural considerations
  - Architectural considerations
- Regulation and Inspection
- Modular/Prefabricated Construction Resources



Photo: Zeta Design+Build

Off-Site Construction Basics

The Off-Site Continuum

Site-Built

- Conventional wood-frame construction with dimensional lumber
- Entirely built on site
- Requires each step to be completed before the next can begin

Prefabricated Components

- Wood products such as dimensional lumber and/or structural wood panels are used to form pre-assembled components
- Examples include trusses, I-Joists, SIPs
- Constructed at off-site facilities

Panelized Systems

- Prefabricated components are assembled into larger panels or complete assemblies off-site
- Examples include wall panels or floor/roof cassettes
- Can be assembled while other work is being done

Modular Construction

- Components are assembled at an off-site location into modular structures
- Modules include interior finishes as well as MEP
- Typically 80% - 95% complete before being shipped to site
- Inspected at the factory

Motivators for Off-Site Construction

- **Optimization**

- **Potential Motivators:**
  - Labor Shortages
  - Increased quality
  - Speed of installation (schedule savings)
  - Improved Site Safety
  - Reduced Waste



Image: WordClouds.com

Choosing Levels of Prefabrication

Walls

- Site Framed Wood Stud Walls
- Panelized Wood Stud Walls
- Mass Timber
- Other

Floor

- Dimensional Lumber
- Engineered Wood Products (I-Joist, LVL)
- Pre-Engineered Wood Floor Trusses
- Mass Timber
- Other

Roof

- Dimensional Lumber
- Engineered Wood Products (I-Joist, LVL)
- Pre-Engineered Wood Roof Trusses
- Mass Timber
- Other

Shafts

- Site Framed Wood Stud Walls
- Panelized Wood Stud Walls
- Mass Timber
- Other

- Light Frame Modular
- Mass Timber Modular

Panelized Construction

Floor or Roof Cassettes:

- Typically trusses
- Typically single span conditions, grouped together in 8’-10’ wide cassettes



Photo: Davis Frame

Wall Panels:

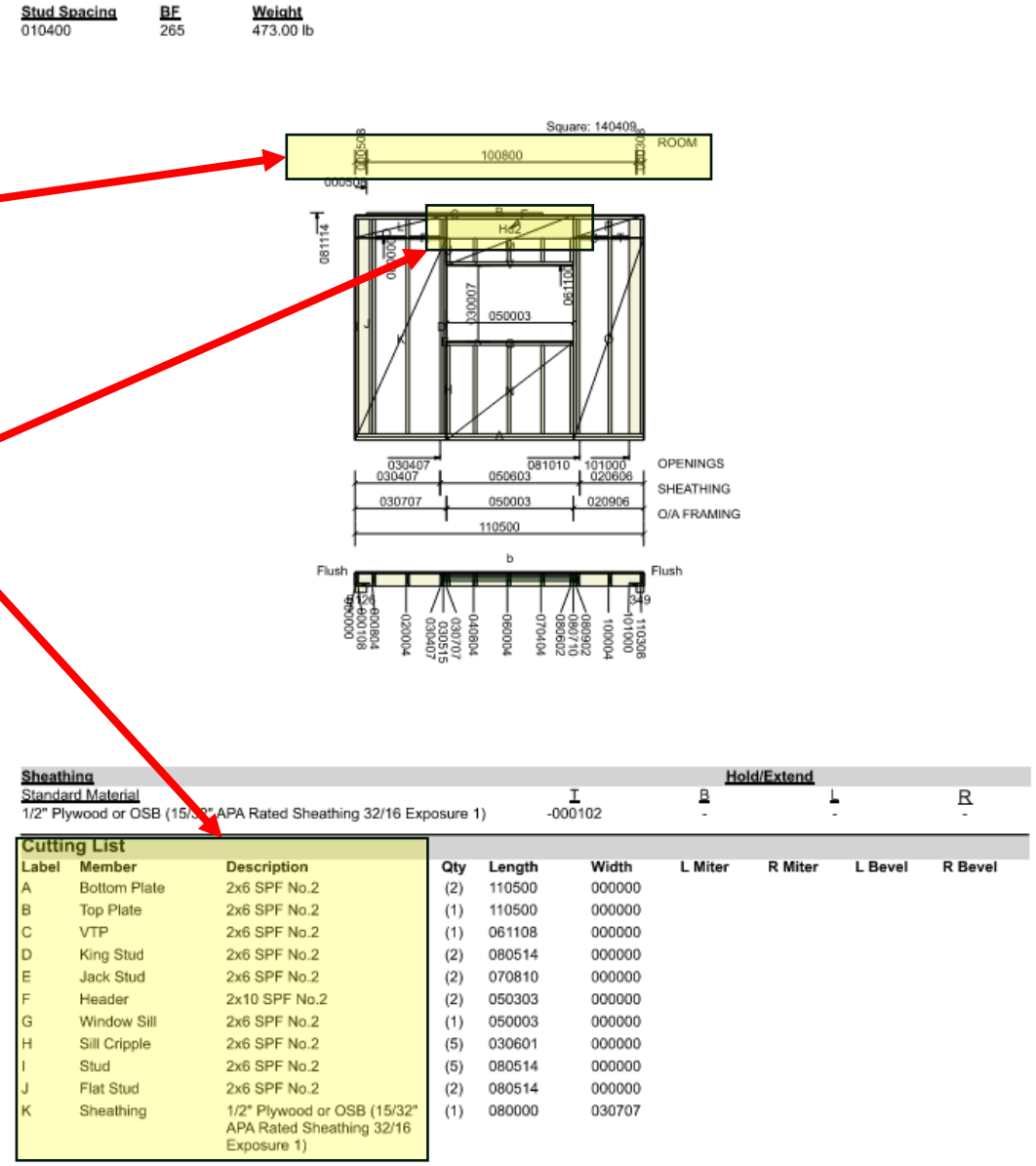
- Stud walls framed in a factory setting (manual or robotic)
- Fully sheathed, partial sheathing, no sheathing
- Can be integrated with other trades



Photo: Blueprint Robotics

Reading Wall Shop Drawings

- Dimensions given in Feet-Inches-16ths of an inch
  - Ex. 12’-2 ¼” = 12-02-04
- Verify species, member sizes, sheathing thickness
- Check fastener spacing and type at shear walls
- Posts or load transfer mechanisms
- Check any misc. blocking (kitchens, bathrooms)
- Potentially added scope for design team compared to site-framed buildings



Stud Spacing	BF	Weight
010400	265	473.00 lb

Square: 140409

ROOM

100800

OPENINGS

SHEATHING

O/A FRAMING

110500

Flush

Flush

Sheathing			Hold/Extend			
Standard Material			T	B	L	R
1/2" Plywood or OSB (15/32" APA Rated Sheathing 32/16 Exposure 1)			-000102	-	-	-

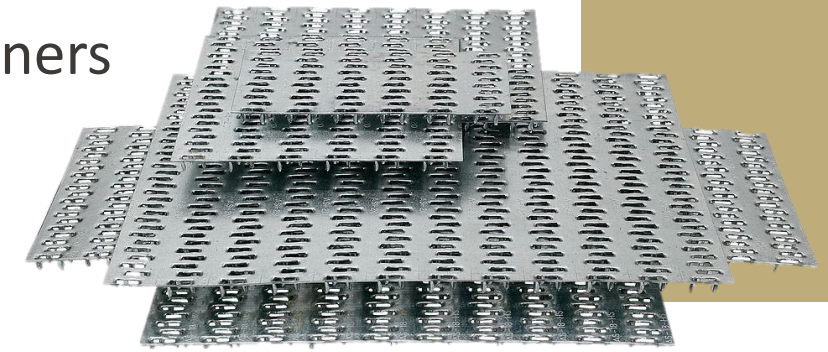
Cutting List

Label	Member	Description	Qty	Length	Width	L Miter	R Miter	L Bevel	R Bevel
A	Bottom Plate	2x6 SPF No.2	(2)	110500	000000				
B	Top Plate	2x6 SPF No.2	(1)	110500	000000				
C	VTP	2x6 SPF No.2	(1)	061108	000000				
D	King Stud	2x6 SPF No.2	(2)	080514	000000				
E	Jack Stud	2x6 SPF No.2	(2)	070810	000000				
F	Header	2x10 SPF No.2	(2)	050303	000000				
G	Window Sill	2x6 SPF No.2	(1)	050003	000000				
H	Sill Cripple	2x6 SPF No.2	(5)	030601	000000				
I	Stud	2x6 SPF No.2	(5)	080514	000000				
J	Flat Stud	2x6 SPF No.2	(2)	080514	000000				
K	Sheathing	1/2" Plywood or OSB (15/32" APA Rated Sheathing 32/16 Exposure 1)	(1)	080000	030707				

Image courtesy of MiTek

Pre-Engineered Trusses

- Typically connected with proprietary metal plates & delegated design
- Can achieve long spans
  - Truss Bracing requirements for spans greater than 60’ (IBC 2303.4.1.3)
- Flexibility to create unique roof profiles and ceiling lines
- Collaborate with Truss designers early



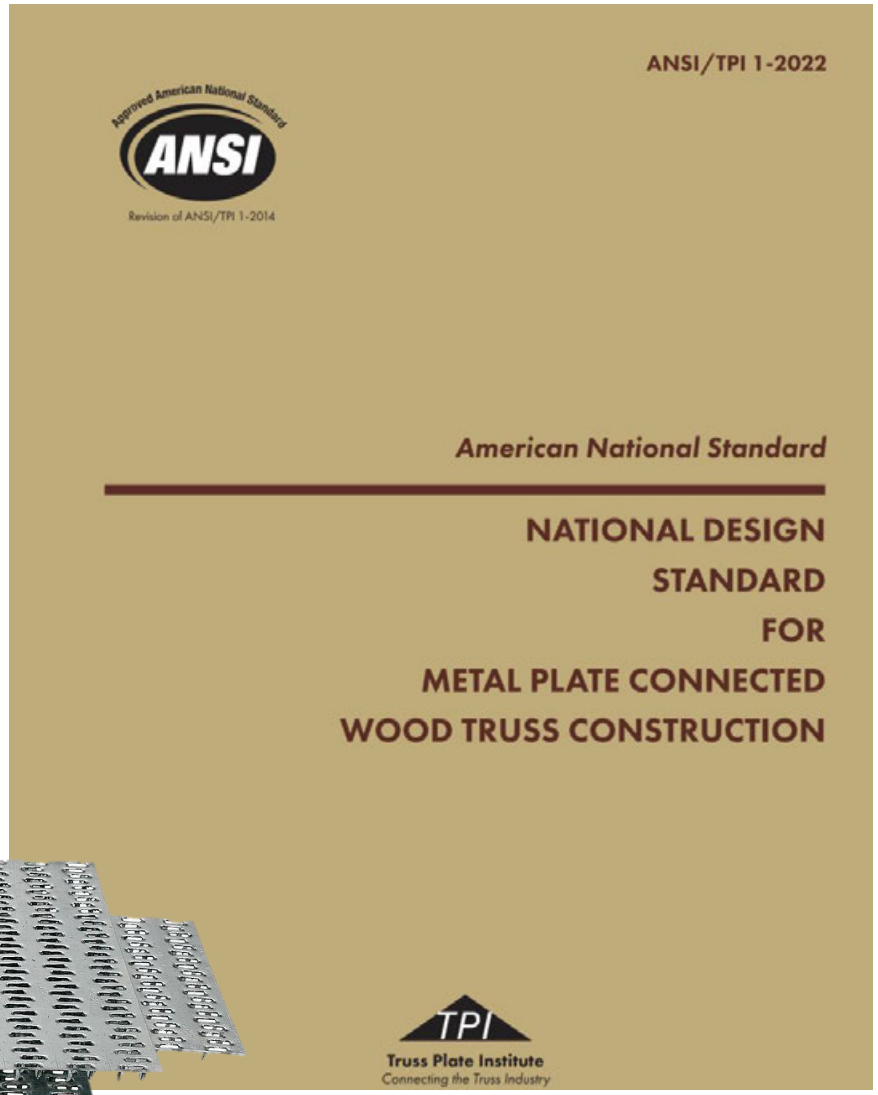


Image: Simpson Strong-Tie

Code Check – IBC 2303.4.1.1

2303.4.1.1 Truss design drawings. P

The written, graphic and pictorial depiction of each individual truss shall be provided to the *building official* for approval prior to installation. Truss design drawings shall be provided with the shipment of trusses delivered to the job site. Truss design drawings shall include, at a minimum, the following information:

1. Slope or depth, span and spacing.
2. Location of all joints and support locations.
3. Number of plies if greater than one.
4. Required bearing widths.
5. Design *loads* as applicable, including:
   - 5.1. Top chord *live load*.
   - 5.2. Top chord *dead load*.
   - 5.3. Bottom chord *live load*.
   - 5.4. Bottom chord *dead load*.
   - 5.5. Additional *loads* and locations.
   - 5.6. Environmental design criteria and *loads* (such as wind, rain, snow, seismic).
6. Other lateral *loads*, including *drag strutloads*.
7. Adjustments to wood member and metal connector plate design value for conditions of use.
8. Maximum reaction force and direction, including maximum uplift reaction forces where applicable.
9. Joint connection type and description, such as size and thickness or gage, and the dimensioned location of each joint connector except where symmetrically located relative to the joint interface.
10. Size, species and grade for each wood member.
11. Truss-to-truss connections and truss field assembly requirements.
12. Calculated span-to-deflection ratio and maximum vertical and horizontal deflection for live and total *load* as applicable.
13. Maximum axial tension and compression forces in the truss members.
14. Required permanent *individual truss member* restraint location and the method and details of restraint and diagonal bracing to be used in accordance with Section 2303.4.1.2.

Reading Truss Shop Drawings

- Dimensions given in Feet-Inches-16ths of an inch
  - Ex. 12’-2 ¼” = 12-2-4
- Verify Loading Criteria Matches what is Specified
- Stress Ratios & Deflections
  - Check Horizontal deflections for vaulted conditions
- Check reactions – bearing & uplift
- Read the note blocks!

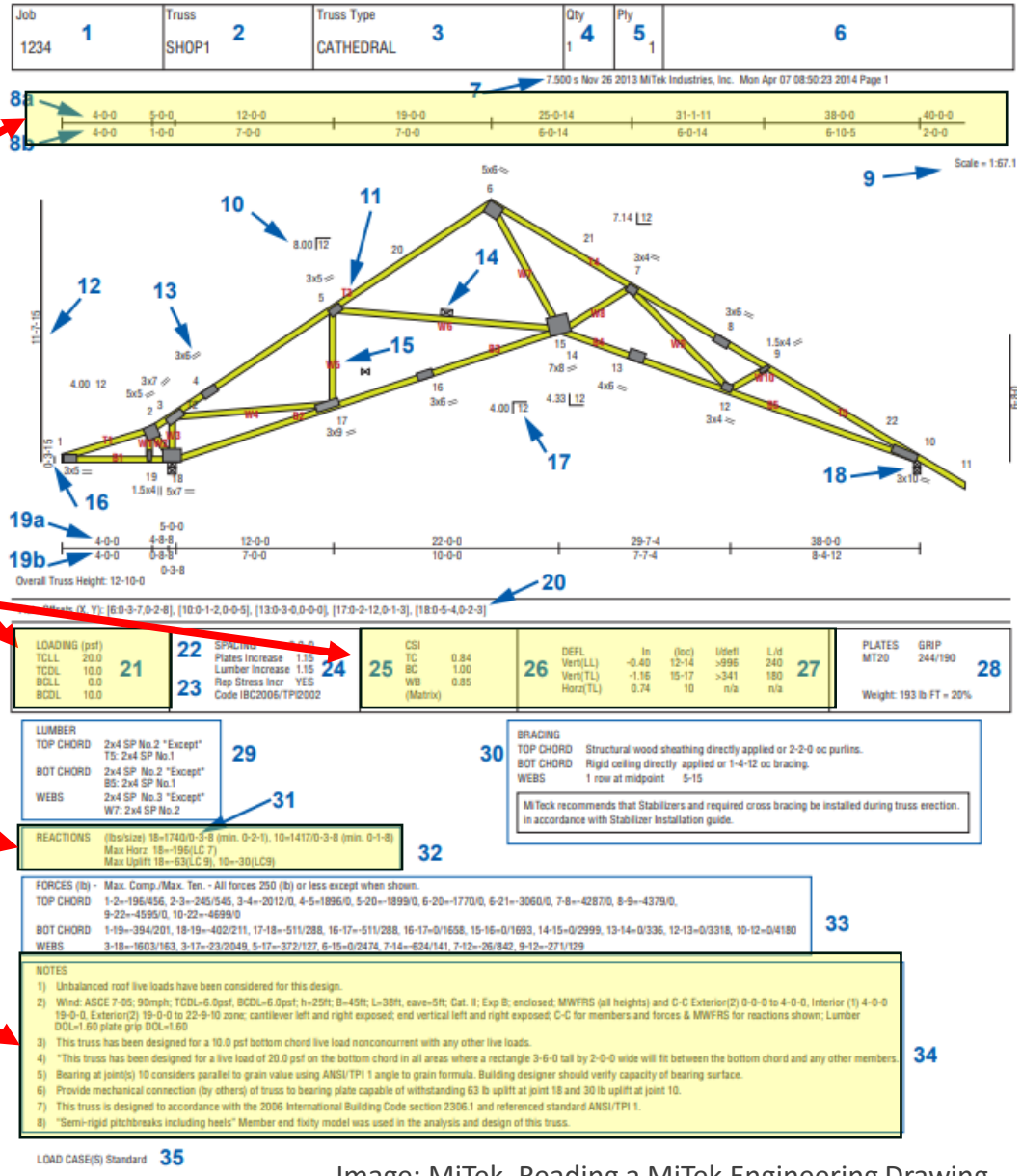


Image: MiTek, Reading a MiTek Engineering Drawing

Deflections: Code vs. Expectations

TABLE 1604.3 DEFLECTION LIMITS[a, b, c, h, i]

CONSTRUCTION	*L* or L_r	*S* or *W*[f]	*D* + *L*[d, g]
Roof members:[e]			
Supporting plaster or stucco ceiling	l/360	l/360	l/240
Supporting nonplaster ceiling	l/240	l/240	l/180
Not supporting ceiling	l/180	l/180	l/120
Floor members	l/360	—	l/240

- Review finishes and client expectations for occupant comfort
- For a 26’ span: L/240 = 1.3” , L/360 = 0.87” , L/480 = 0.65”
- Keep ponding in mind
- L/480 common rule of thumb to limit vibrations (not required by code)

Shaft Walls

Mass Timber



Photo: Quality Contractors

Steel Studs, Wood Studs

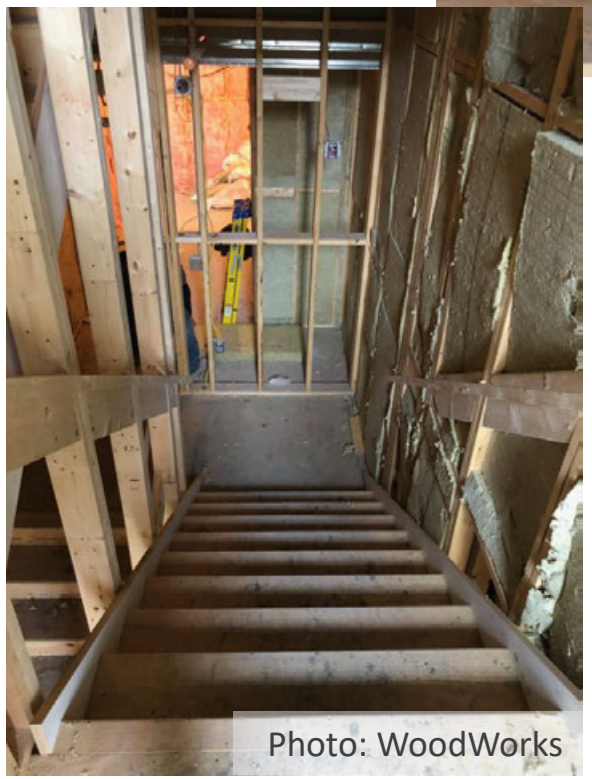


Photo: WoodWorks

Shaftliner Panels



Photo: Georgia Pacific

Masonry



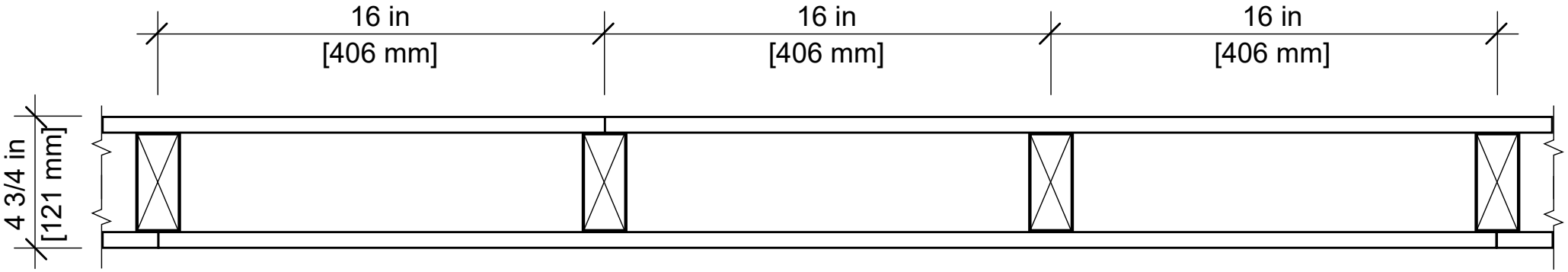
Photo: WoodWorks

Shaft Wall Hourly Rating

Section 713: Shaft Enclosures

713.4: Fire-Resistance Rating

- 2 hours when connecting 4 stories or more
- 1 hour when connecting less than 4 stories
- Number of connected stories includes basement but not mezzanine
- Fire rating of shaft walls shall not be less than floor assembly penetrated, but need not exceed 2 hours



Shaft Wall Materials

	Type III	Type IV-HT	Type V
Interior Shaft Walls	Any code-permitted wood framing	Heavy timber or any code-permitted, 1-hr wood framing	Any code-permitted wood framing
Exterior Shaft Walls	Fire-retardant treated wood	Fire-retardant treated wood or CLT	Any code-permitted wood framing

- Type IVB & Type IVC: CLT permitted with non-combustible covering

Light Frame Wood Shaft Walls

- Cost
- Construction Schedule
- Material Compatibility
  (uniform movement & lateral load resistance)





Credit: WoodWorks

Mass Timber Shaft Walls

- Cost
- Construction Schedule
- Material Compatibility (uniform movement & lateral load resistance)
- Can double as architectural feature
- Similar to tilt up or continuous wall applications
- Successful fire tests for 2 Hr mass timber shaft walls exist (exposed and protected)



Photo: Avesta Housing

Masonry Shaft Walls

- Commonly used for stair and elevator cores
- Can be utilized for lateral loads
- Labor intensive
- May require additional weather protection



Photos: WoodWorks

Masonry Shaft Walls



Photos: WoodWorks

~ 3 Weeks per Shaft

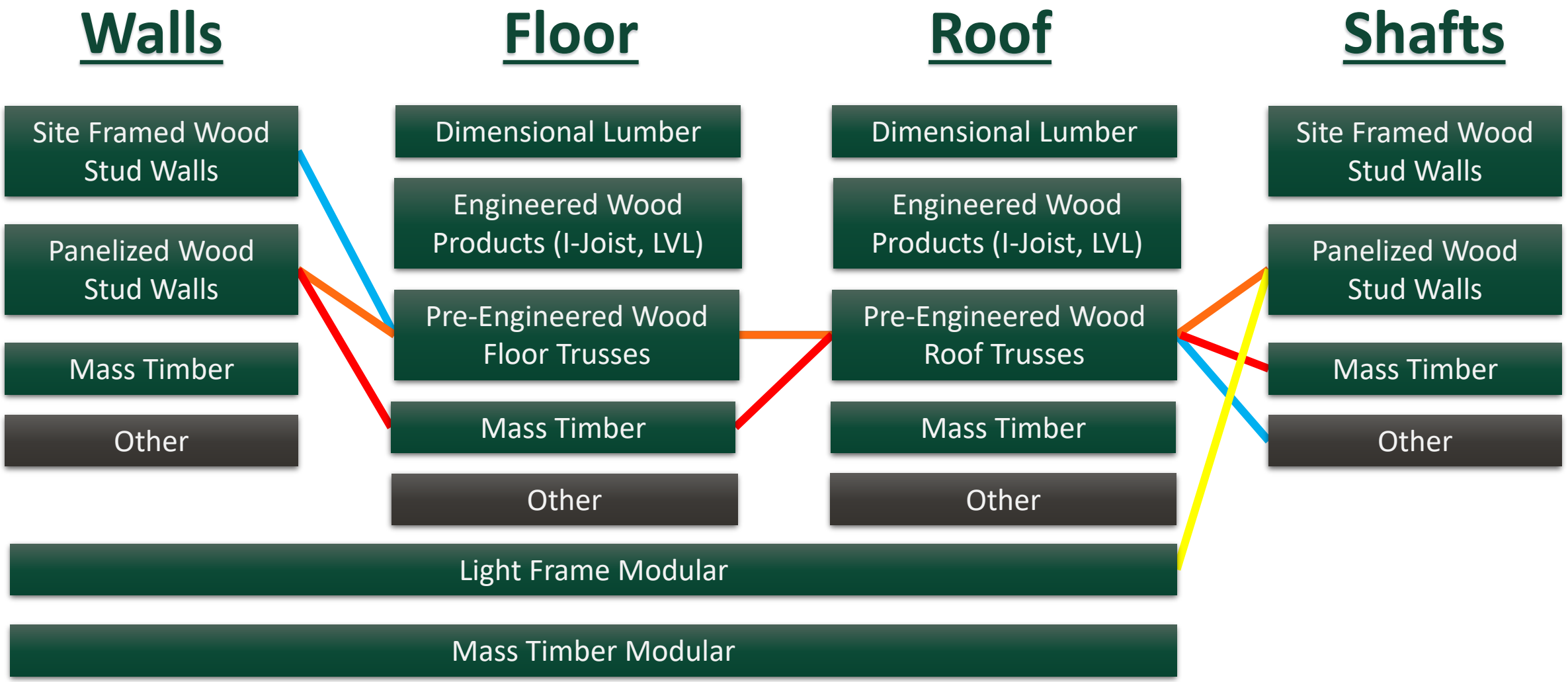
Mass Timber Shaft Walls





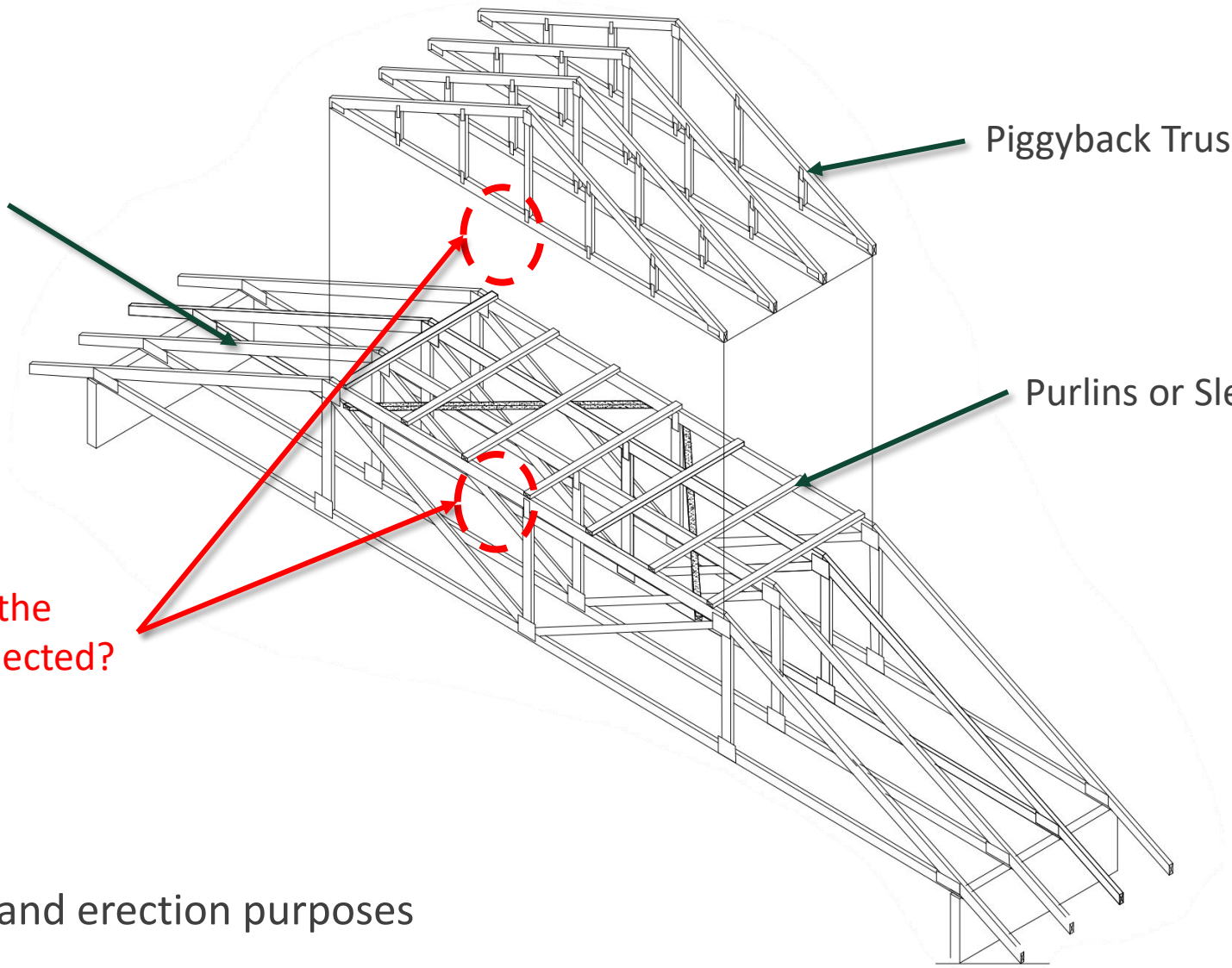
Image & video: Residences at 566 Columbus / J. Garland Enterprises / Bargmann Hendrie + Archetype / Photo Jogo Corporation

Combining Varying Levels of Prefabrication



Detailing Considerations: Pre-Engineered Trusses

Piggyback Roof Trusses



- Used for shipping and erection purposes

Image: MiTek, Standard Piggyback Truss Connection Detail

Piggyback Roof Trusses

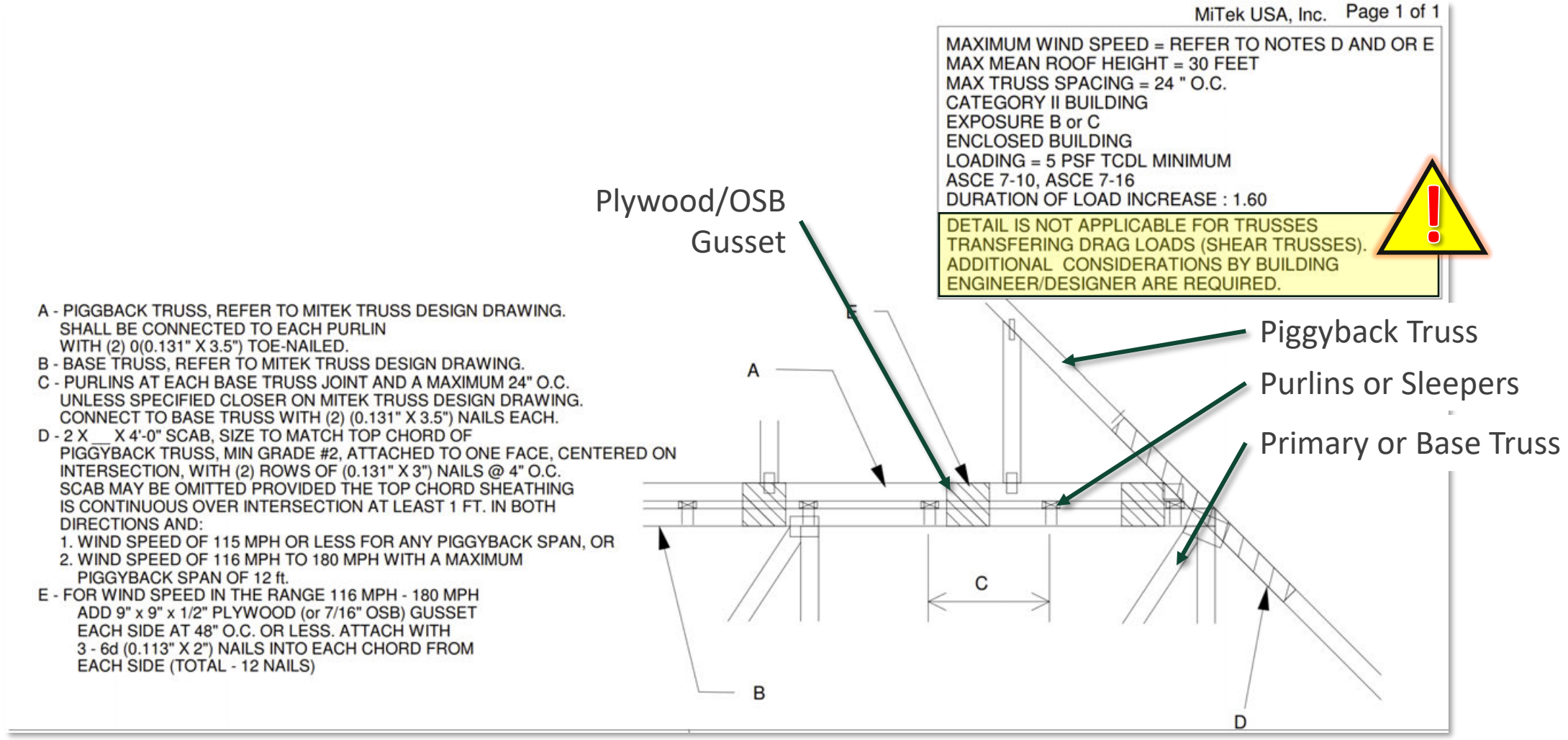


Image: MiTek, Standard Piggyback Truss Connection Detail

Truss Bearing Errors

- ***"Required bearing size at joint(s)…greater than input bearing size"***
- Not abundantly clear in the shop drawings, often buried in footnotes of calculation sheet
  - TIP: Ctrl+F "*Bearing*" to quickly highlight & identify these conditions
- Ways to resolve bearing issues:
  - Back-check the bearing condition
  - Bearing Block(s) – small blocks shipped loose, not the best solution
  - Bearing enhancers – proprietary connections that increase truss bearing area

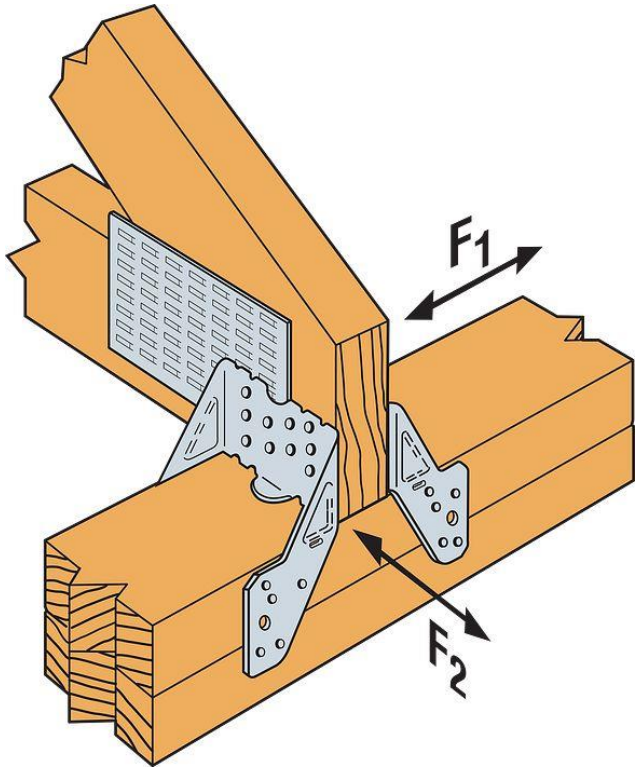


Image: Simpson StrongTie, Truss Bearing Enhancer

Rooftop Components

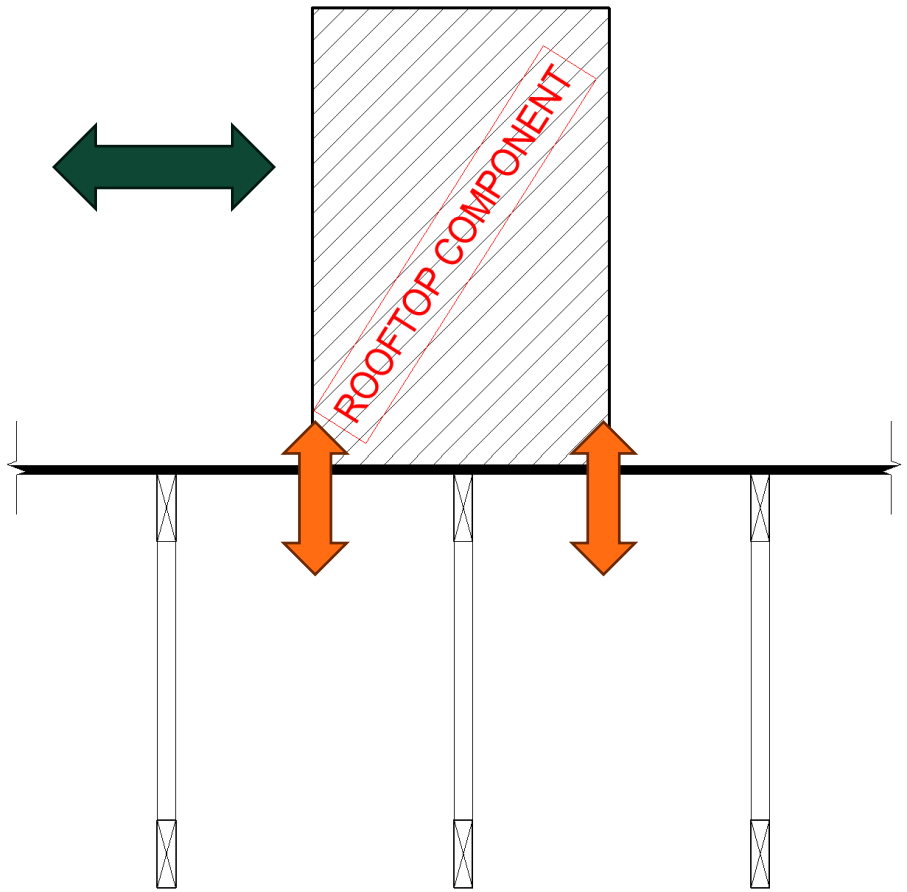




Photos: Istock

Rooftop Components

- ***Cupolas, Steeples, Faux Chimneys, Equipment Screens***
- How are they anchored to the structure?
  - Large overturning force
  - Can have heavy finishes (brick/stone veneer)
- Coordinate this with truss designer and provide additional design loads and any special detailing requirements
- Excessive deflections can lead to water infiltration



Detailing Considerations: Wall Panels

Things to Look For

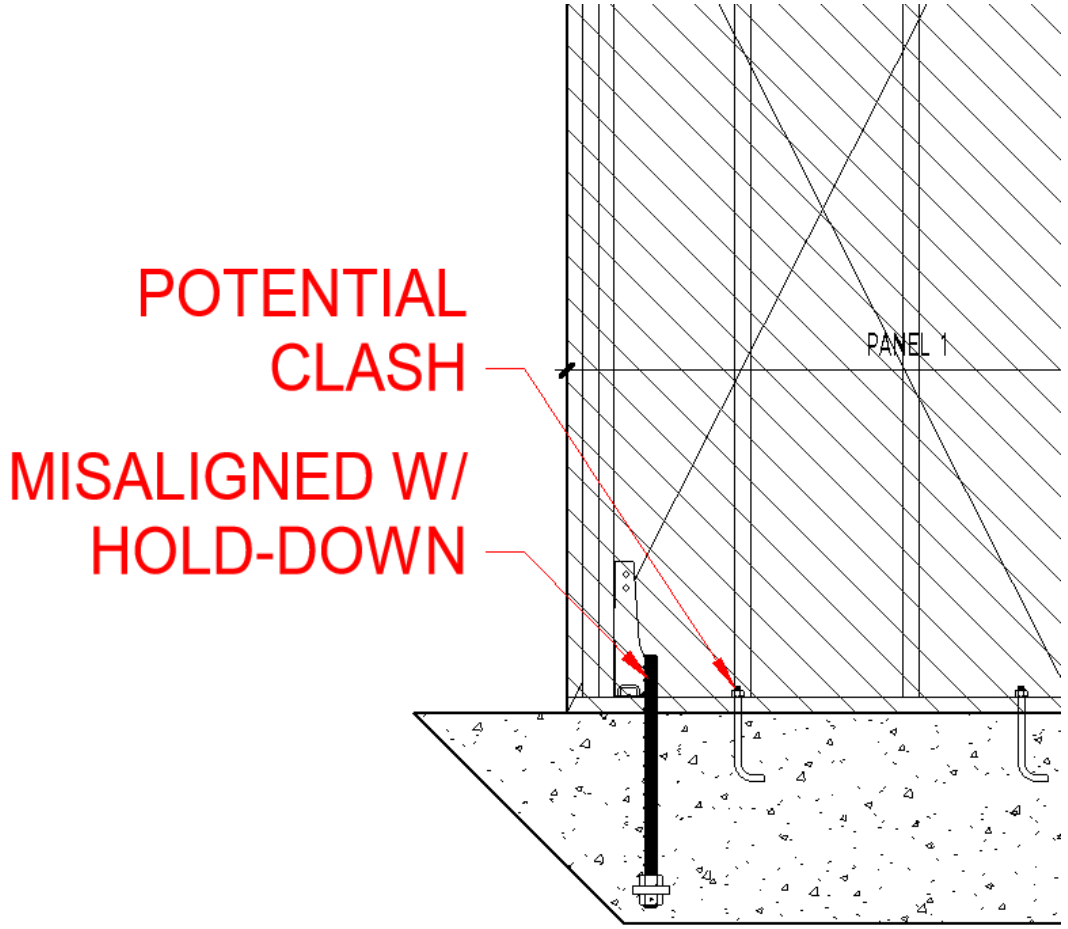
- “It’s really almost the same as framing on site”
  - Keyword: **almost**
- Shear wall nailing and sheathing thickness
- Stud pack/boundary post quantity & size
- Blocking – can be required for structural and non-structural purposes



Photo: Pacific Wall Systems

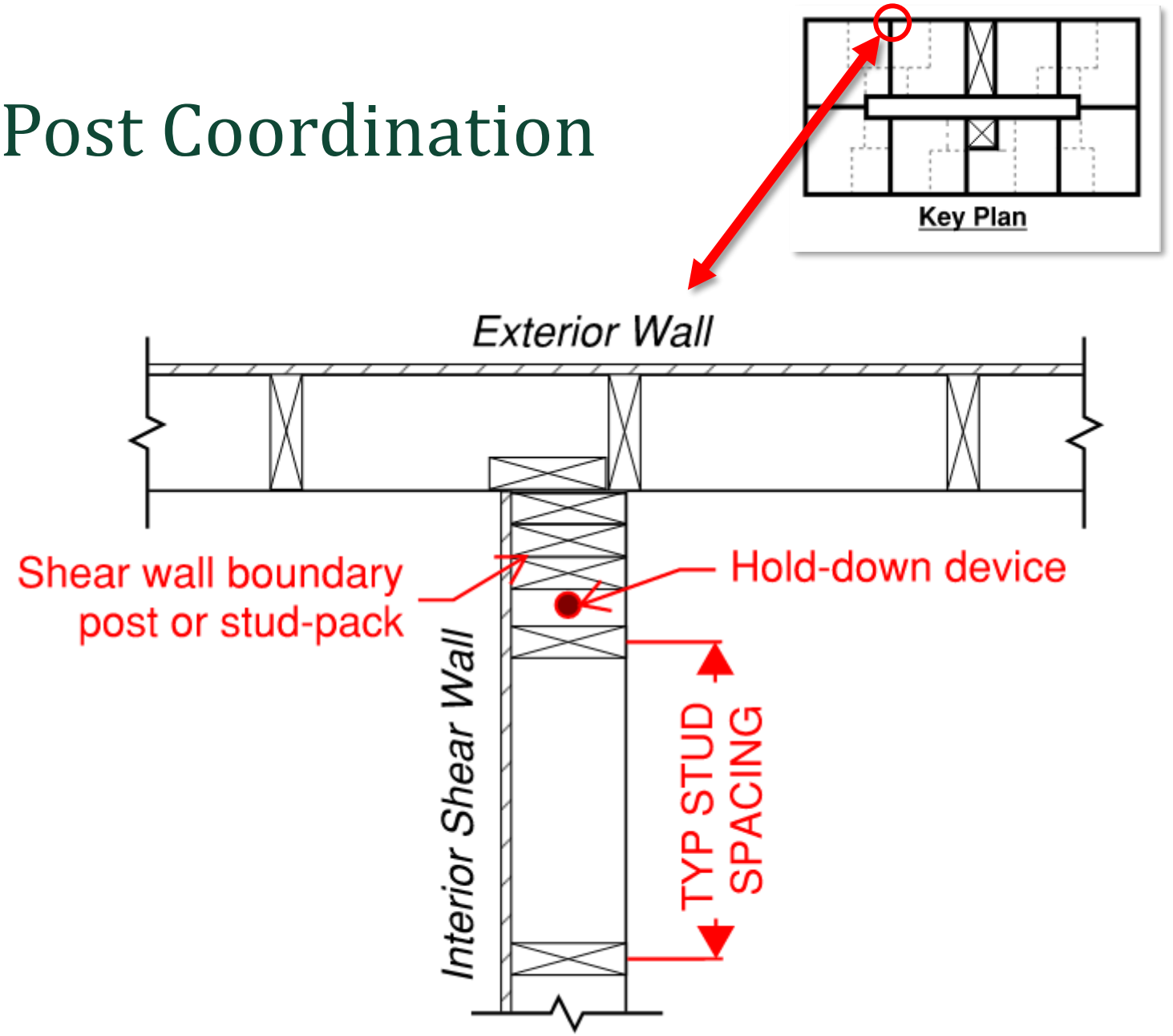
Panel to Foundation Connection

- Consider post-installed anchors if possible
- More involved coordination required for cast-in-place anchors
- Consider load path for shear wall locations
- Build in tolerance where possible

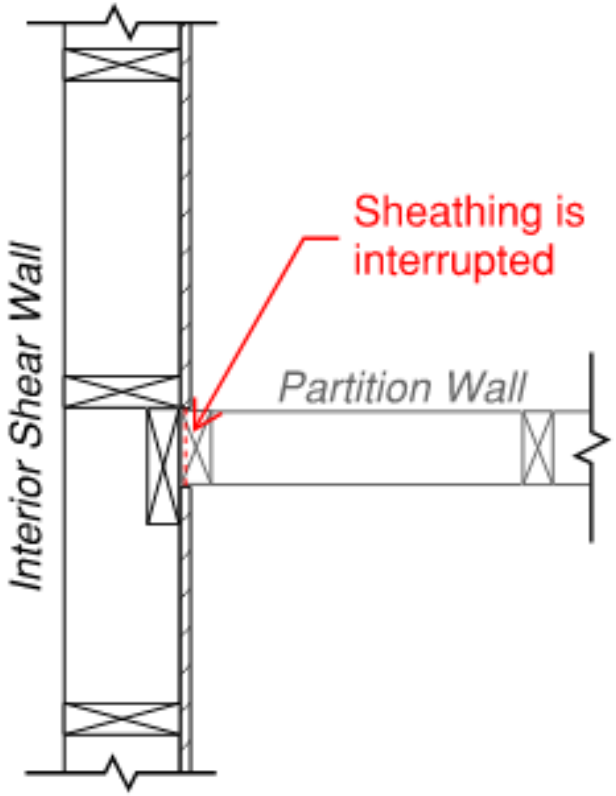


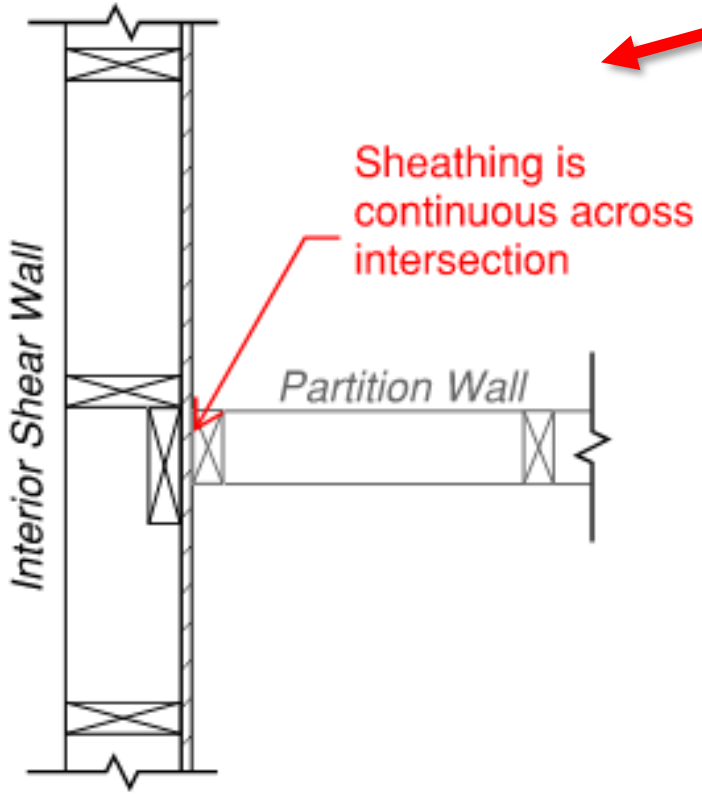
Shear Wall Boundary Post Coordination

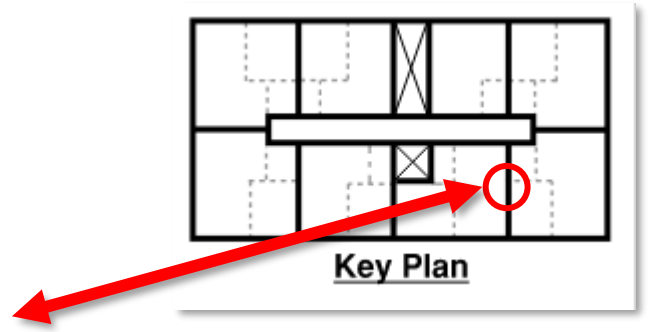
- Is the boundary post or stud-pack shown?
- Is there space for the hold down device and enough space to install it?
- Is the hold-down location coordinated with the foundation or podium?



Partition Wall Intersections

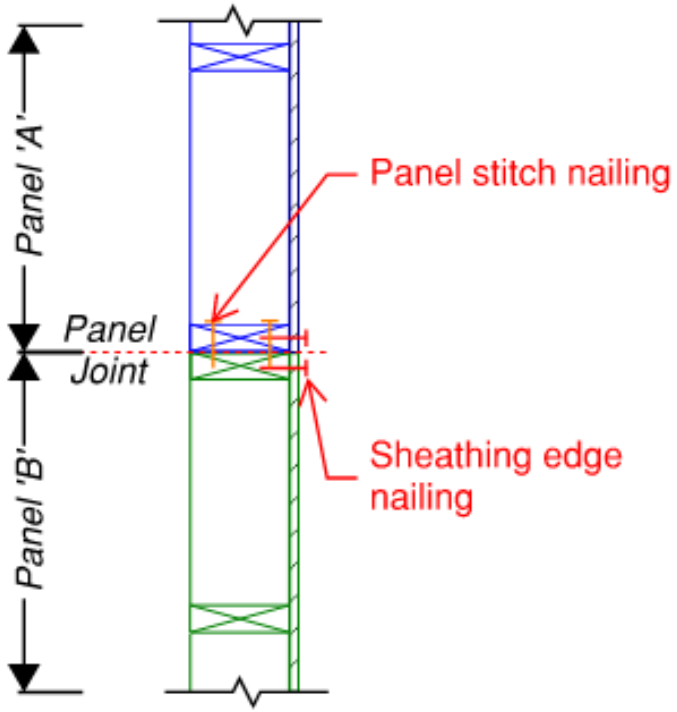


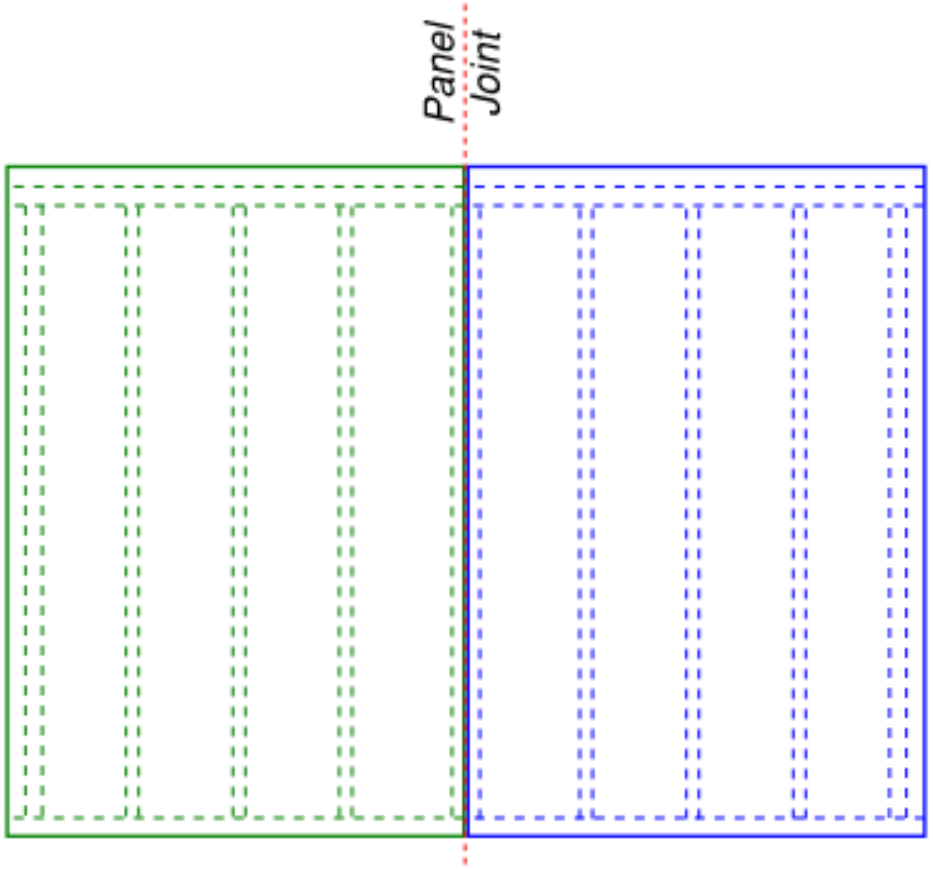




- Make sure sheathing is continuous at interior partition intersections

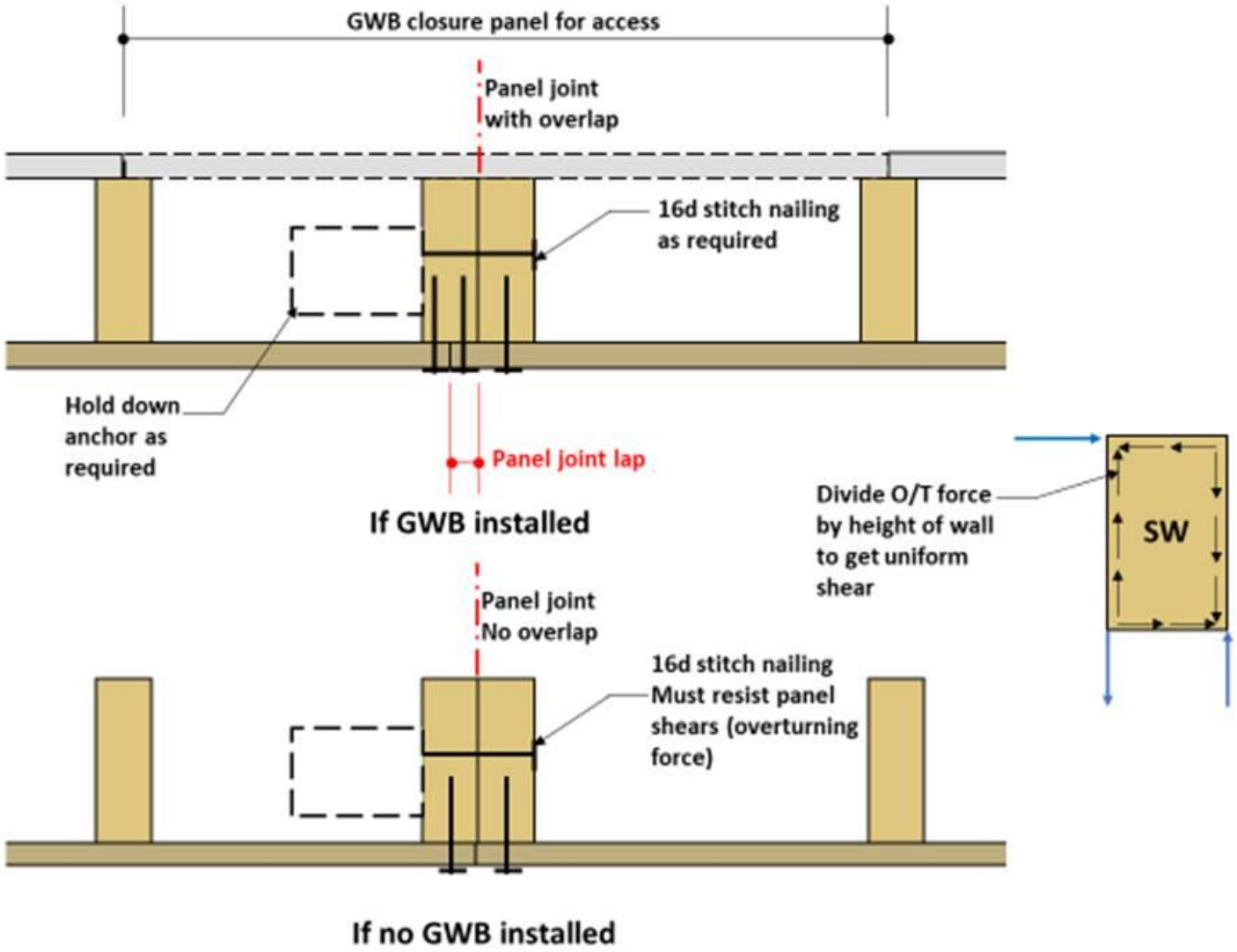
Panel Joints



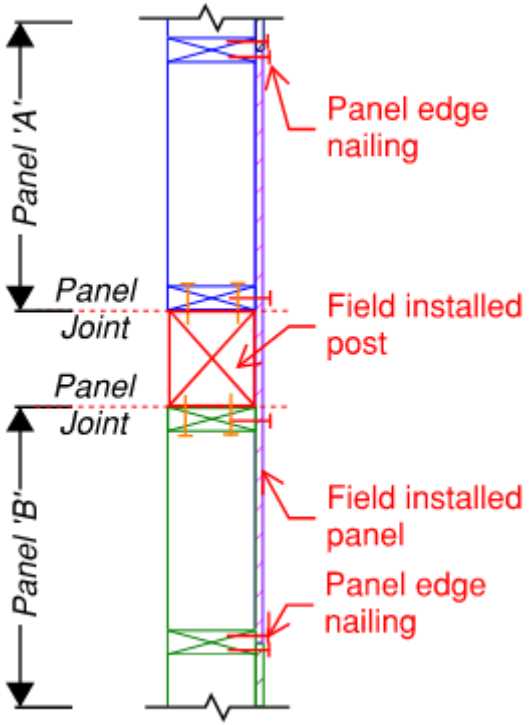


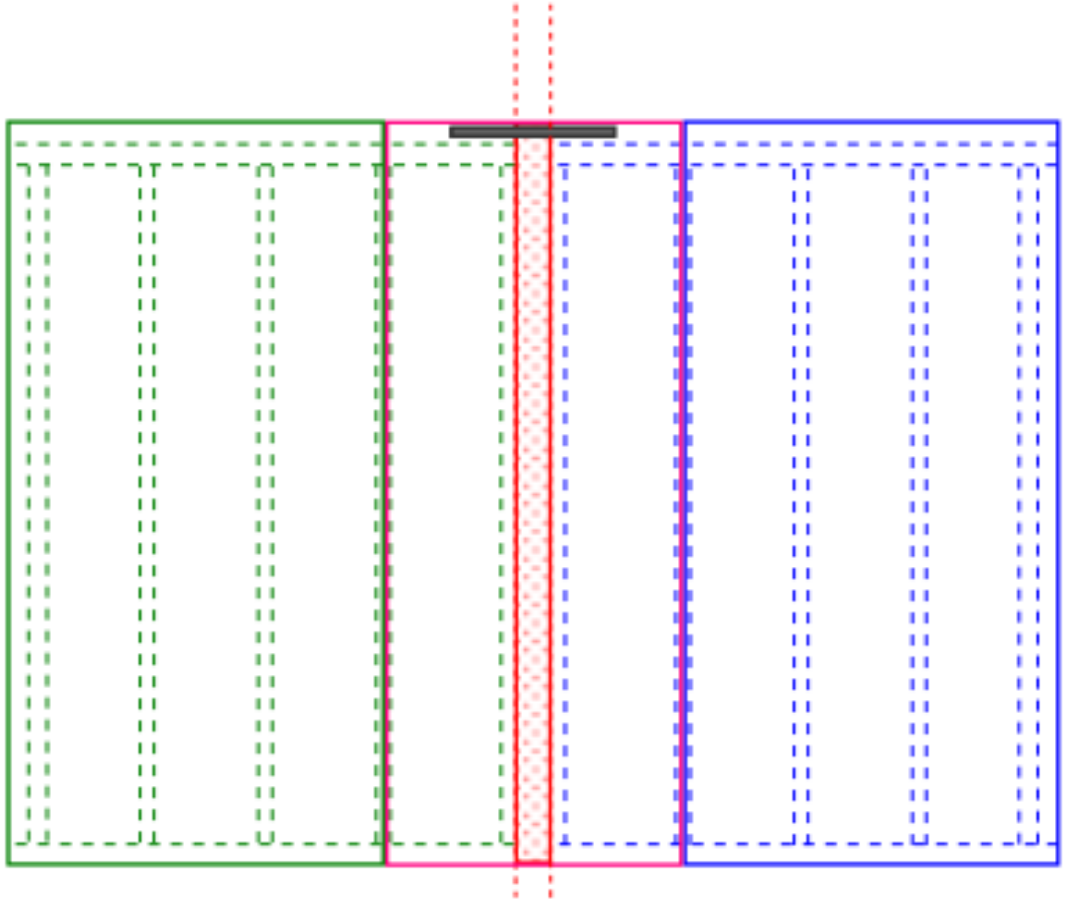
- Non-shear walls require prescriptive nailing (IBC Table 2304.10.2)
- Shear walls require special nailing typically

Panel Joints



Continuous Posts

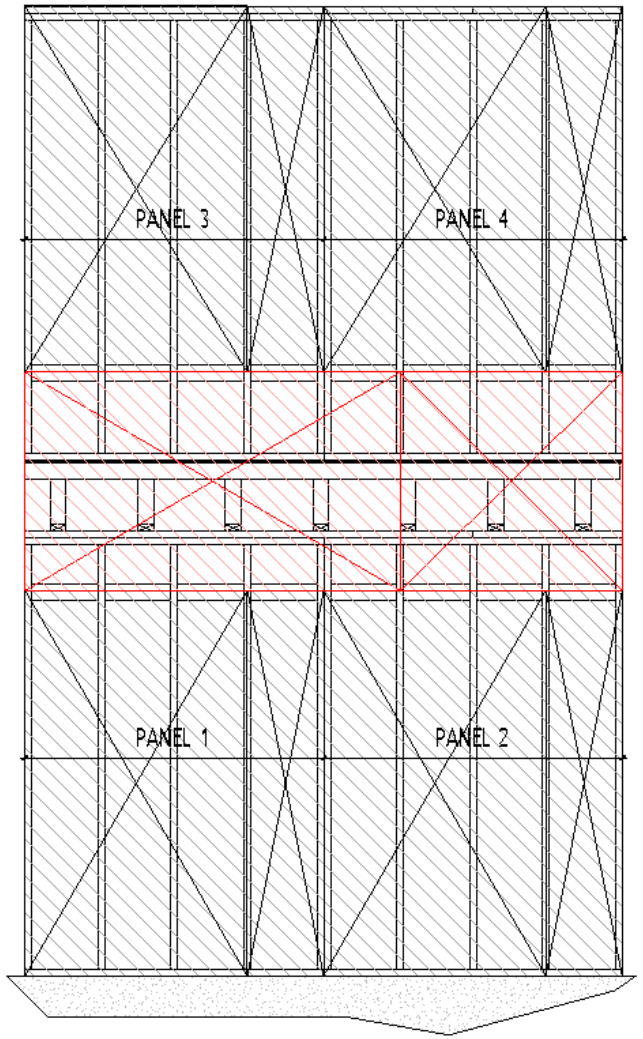


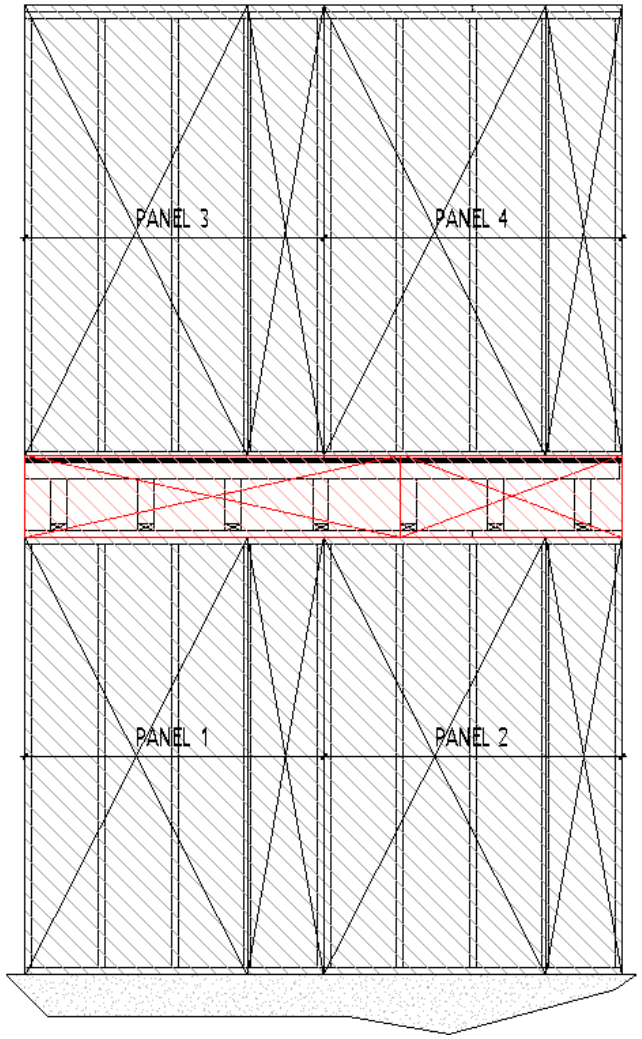


- Post shipped loose and field installed, strip of WSP installed connecting panels
- Consider load path for shear wall locations
- Consider fire rating implications

Floor-to-Floor Connection

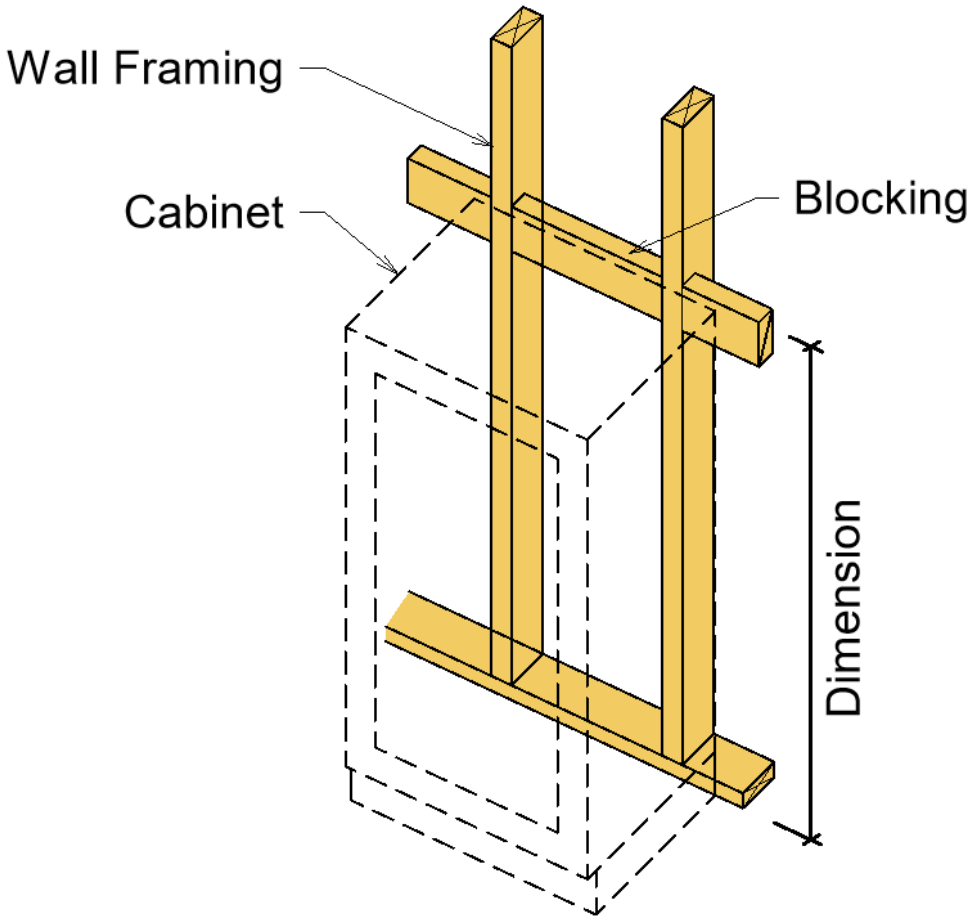
- Make sure your detailing matches what the shop drawings show
- Review with panelizer to discuss efficiencies that may be available
- Review compatibility of floor-to-floor hardware with panelizing process



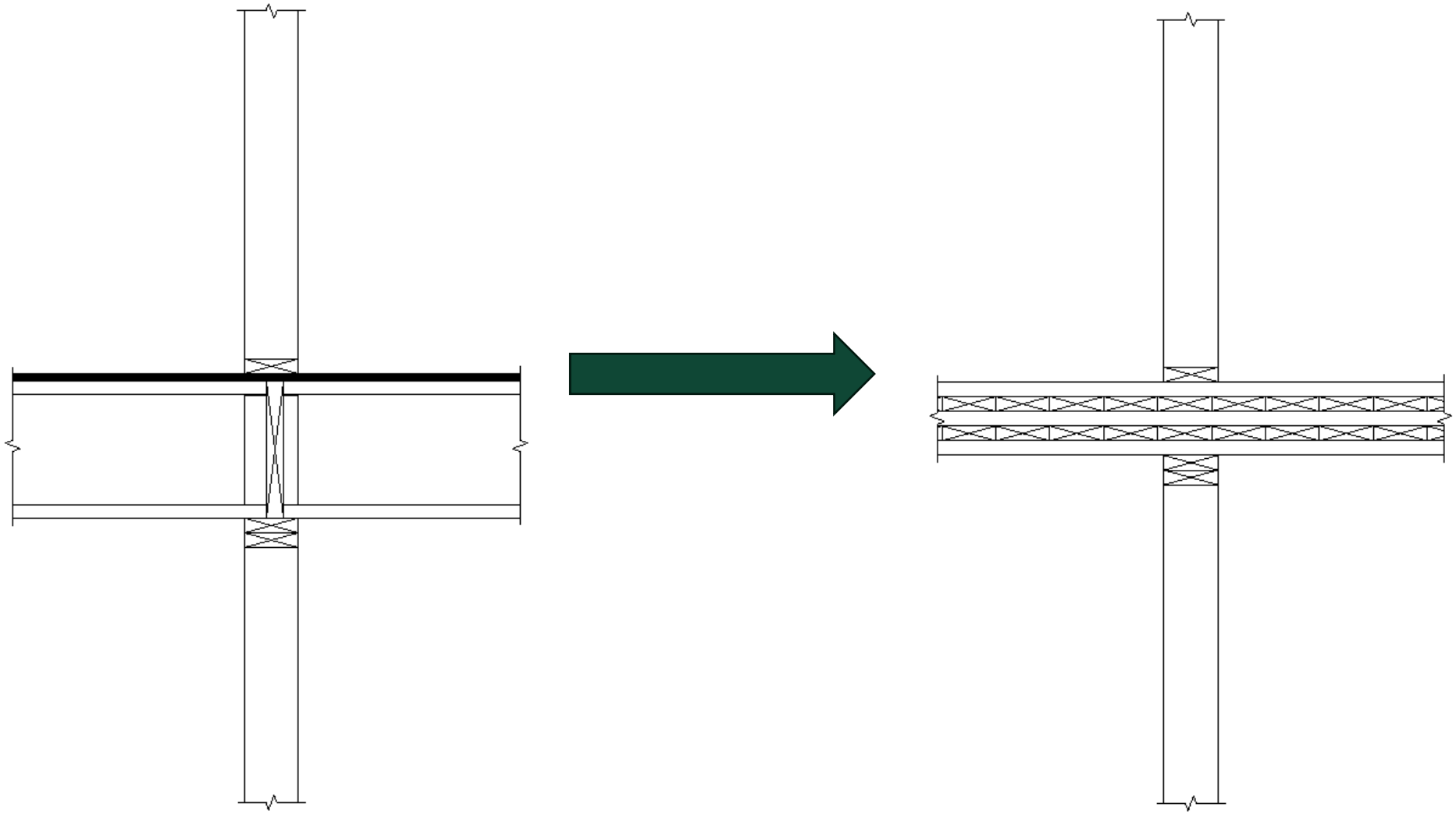


Miscellaneous Blocking

- Ensure your notes and or details convey blocking for wall mounted fixtures
  - Cabinets
  - Handrails/ADA Components
  - Fire-blocking (required >10’ height)
- Consider orientation for acoustics



Mass Timber Floor Panels on Light Framed Walls



Mass Timber Floor Panels on Light Framed Walls

- MT panel spans demising-to-demising
- Most efficient with panelized wall systems
- Slight gap a non-loadbearing partitions
- Panels screwed from underside of double top plate
  - Visible for inspection
  - Shorter screws
- Note the blocking orientation on the staggered stud wall



Photo: WoodWorks

Resources and Regulation for Off-Site Construction

Regulating Offsite Construction

- International Code Council and the Modular Building Institute
  - ICC/MBI Standard 1200
  - ICC/MBI Standard 1205
  - ICC G6-2023
- Regulating Off-Site Construction: Ensuring Code Compliance in a Factory-Built Environment
- Panelized products can typically be inspected on-site

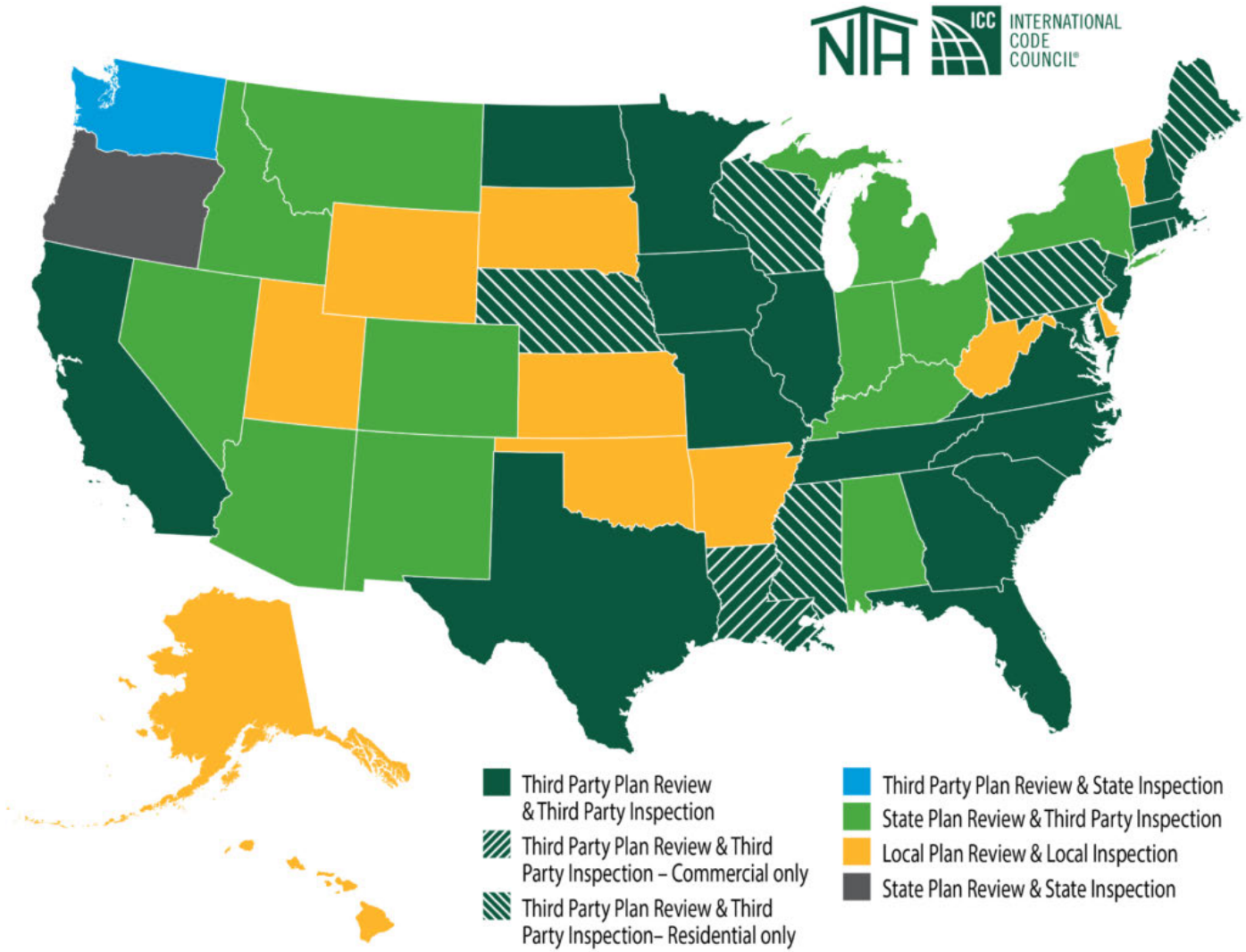


Image: International Code Council

Offsite Construction Resources

- Off-Site/Panelized Wood Construction – WoodWorks
- Shaft Wall Solutions for Light-Frame and Mass Timber Buildings
- Hybrid Design: Mass Timber Floor and Roof Panels Over Light-Frame Wood Walls
- Webinars on The Wood Institute
  - The Rise of Modular Construction in the US
  - Offsite Construction in Wood: Reinventing the Role of the Design Professional



Photo: Cubix North Park / Jackson|Main Architecture / photo NP Construction

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Taylor Landry

WoodWorks

Taylor.Landry@woodworks.org

Copyright Materials

This presentation is protected by US
and International Copyright laws.
Reproduction, distribution, display and use of
the presentation without written permission
of the speaker is prohibited.

© The Wood Products Council 2024

Funding provided in part by the Softwood Lumber Board

Disclaimer: The information in this presentation, including, without limitation, references to information contained in other publications or made available by other sources (collectively "information") should not be used or relied upon for any application without competent professional examination and verification of its accuracy, suitability, code compliance and applicability by a licensed engineer, architect or other professional. Neither the Wood Products Council nor its employees, consultants, nor any other individuals or entities who contributed to the information make any warranty, representative or guarantee, expressed or implied, that the information is suitable for any general or particular use, that it is compliant with applicable law, codes or ordinances, or that it is free from infringement of any patent(s), nor do they assume any legal liability or responsibility for the use, application of and/or reference to the information. Anyone making use of the information in any manner assumes all liability arising from such use.