# Shaft Wall Solutions for Wood-Frame Structures

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Photo: Avesta Housing

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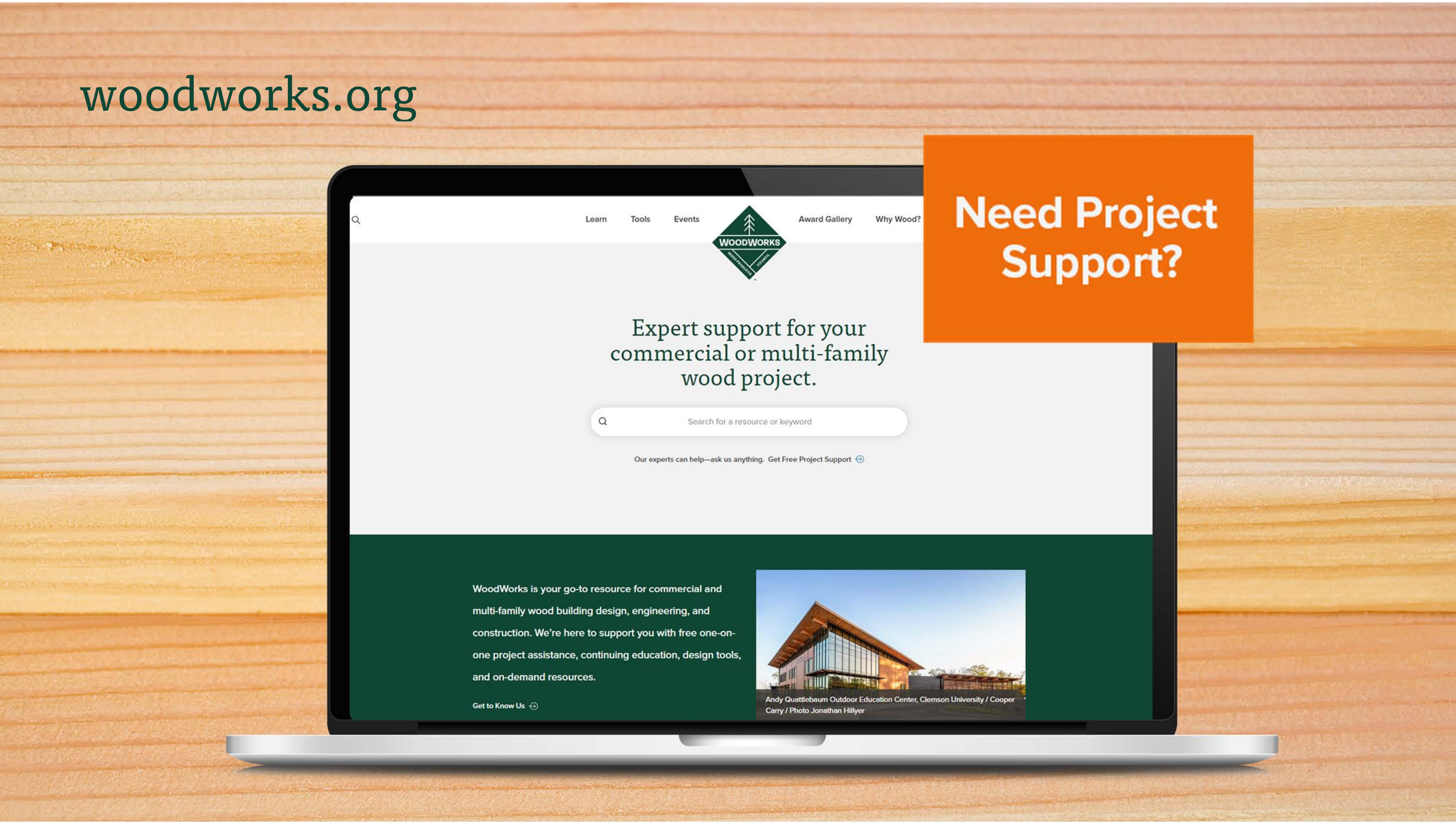
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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

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# Course Description

It is fairly common for light wood-frame commercial and multi-family buildings to include another material for the shaft construction. However, many designers and contractors have come to realize that wood-frame shaft walls are a code-compliant means of reducing cost and shortening construction schedule. In this presentation, detailing for elevator, stair and mechanical shafts will be reviewed along with relevant code provisions. Discussion will focus on fire resistance-rated design parameters but will also include other architectural and structural considerations related to shaft walls.

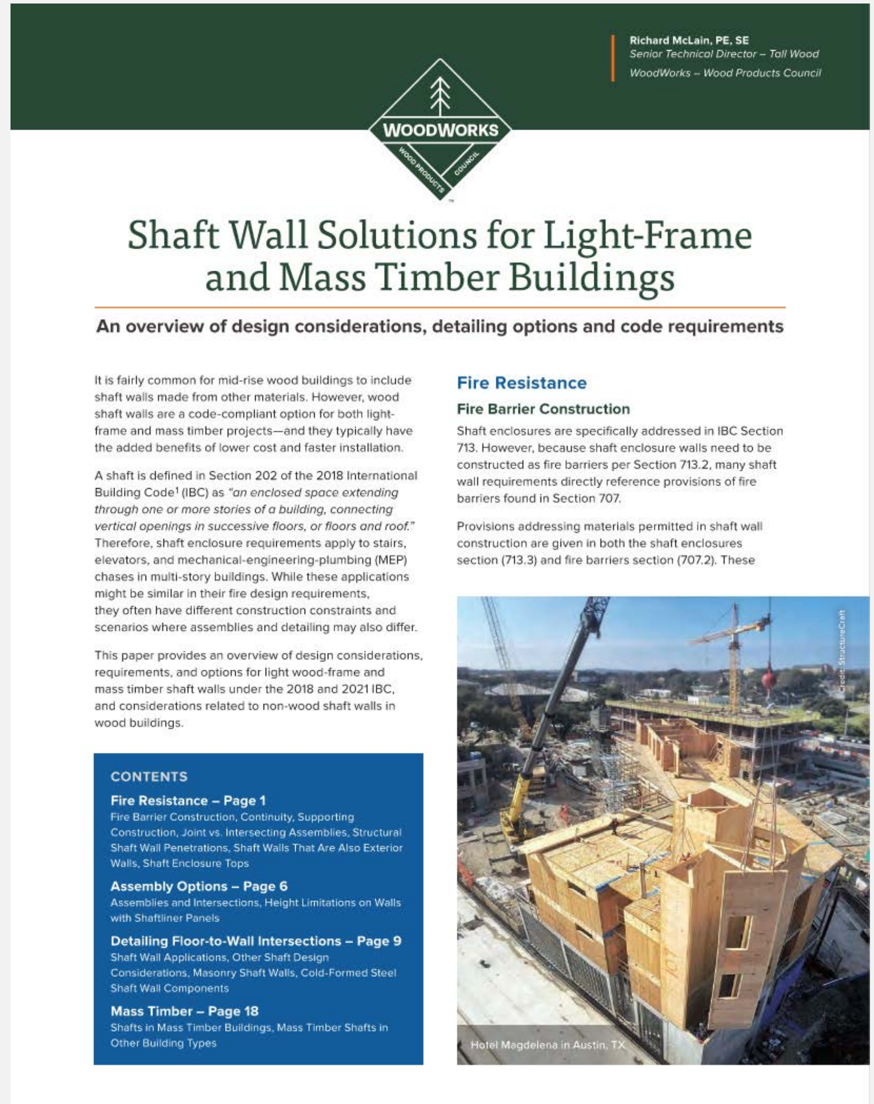
# Learning Objectives

1. Review fire resistance-rated code provisions relevant to wood shaft wall design.
2. Introduce shaft wall assembly types, evaluating their applicability to elevator, stair and mechanical shafts.
3. Provide detailing options that establish fire resistance continuity at framing intersections.
4. Recognize structural design considerations for stair and elevator shafts.

# Shaft Wall Resource

Code provisions, detailing options, project examples and more for light-frame wood and mass timber shaft walls

Free resource at **woodworks.org**



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# Shaft Wall Solutions for Light-Frame and Mass Timber Buildings

**An overview of design considerations, detailing options and code requirements**

It is fairly common for mid-rise wood buildings to include shaft walls made from other materials. However, wood shaft walls are a code-compliant option for both light-frame and mass timber projects—and they typically have the added benefits of lower cost and faster installation.

A shaft is defined in Section 202 of the 2018 International Building Code[1] (IBC) as *"an enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and roof."* Therefore, shaft enclosure requirements apply to stairs, elevators, and mechanical-engineering-plumbing (MEP) chases in multi-story buildings. While these applications might be similar in their fire design requirements, they often have different construction constraints and scenarios where assemblies and detailing may also differ.

This paper provides an overview of design considerations, requirements, and options for light wood-frame and mass timber shaft walls under the 2018 and 2021 IBC, and considerations related to non-wood shaft walls in wood buildings.

CONTENTS



## Fire Resistance

### Fire Barrier Construction

Shaft enclosures are specifically addressed in IBC Section 713. However, because shaft enclosure walls need to be constructed as fire barriers per Section 713.2, many shaft wall requirements directly reference provisions of fire barriers found in Section 707.

Provisions addressing materials permitted in shaft wall construction are given in both the shaft enclosures section (713.3) and fire barriers section (707.2). These

Hotel Magdelena in Austin, TX

# Shaft Walls


Mass Timber
Photo: Quality Contractors

Steel Studs, Wood Studs

Photo: WoodWorks

Shaftliner Panels

Photo: Georgia Pacific

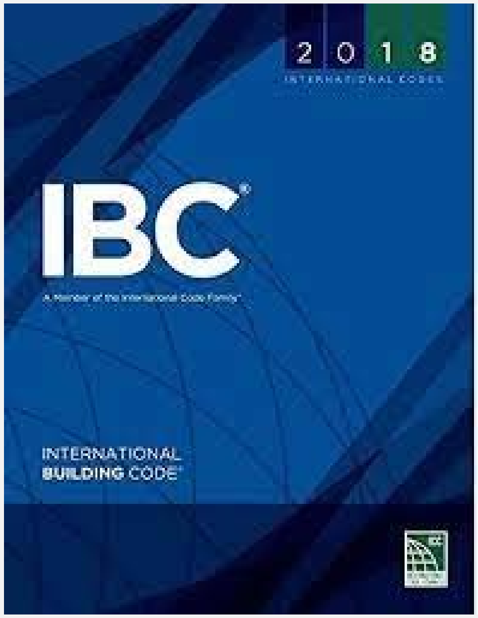
Masonry
Photo: WoodWorks

# Shaft Walls

**Shaft Walls Form Shaft Enclosures**

"The purpose of shafts is to confine a fire to the floor of origin and to prevent the fire or the products of the fire (smoke, heat and hot gases) from spreading to other levels."

*Source: IBC Commentary to Section 713.1*



# Types of Shaft Walls


Photo: Jeff Morrow

Types of Shafts:

- Elevator
- Stair
- Mechanical

Code requirements apply to any/all shaft enclosures. Some points of shaft wall construction and detailing apply to all types of shafts. Some are unique to each type of shaft.

More on the differences later…

# Shaft Wall Design Topics - Agenda

- Wall Definition
- Materials
- Continuity
- Supporting Construction
- Joints & Penetrations
- Exterior Walls
- Assemblies
- Floor to Shaft Wall Intersections
- Stair, Elevator & Mechanical Shafts – Differences
- Non-Wood Shaft Walls

# Defining Shaft Wall Requirements

IBC defines 4 different types of fire-resistance rated walls:

- Exterior Walls (IBC 705)
- Fire Walls (IBC 706)
- Fire Barriers (IBC 707)
- Fire Partitions (IBC 708)

Credit: WoodWorks

# Defining Shaft Wall Requirements

Code requirements for shaft enclosures contained in IBC Section 713:

**SECTION 713**
**SHAFT ENCLOSURES**

**713.1 General.** The provisions of this section shall apply to shafts required to protect openings and penetrations through floor/ceiling and roof/ceiling assemblies. *Interior exit stairways* and *ramps* shall be enclosed in accordance with Section 1023.

- IBC 713.2: Shaft Walls shall be constructed as **Fire Barriers**
- Many shaft wall provisions contained in *IBC Section 707: Fire Barriers*

# 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

707.2 Materials.

*Fire barriers shall be of materials permitted by the building type of construction.*

» Wood-framed shaft walls permitted for any shaft walls in construction types III, IV-HT and V
» FRT wood-framed shaft walls may be used for non-bearing shaft walls in construction types I and II (pending AHJ interpretation)

# Shaft Wall Materials

**Type III Construction:**

- Any material permitted by code for all interior elements
- Fire-retardant treated wood for exterior walls

**Type IV-HT Construction:**

- Heavy/mass timber members for all interior elements
- Any wall with 1-hr min for all interior walls/partitions
- Fire retardant treated wood or CLT for exterior walls

**Type V Construction:**

- Any material permitted by code for all interior and exterior elements

# 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 |

Info on unique fire rating requirements of exterior shaft walls to come in a bit…

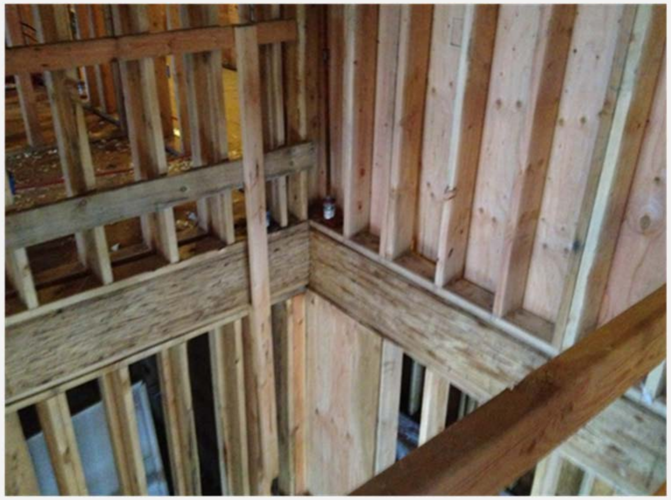
# Shaft Wall Materials

Light Frame Wood Shaft Walls:

» Cost

» Construction Schedule

» Material Compatibility
(movement & lateral load resistance)



Credit: WoodWorks

# Shaft Wall Savings – Case Study

Switch to Wood Framed Shaft Walls Saves Project $176,000

- Gala at Oakcrest, Euless, TX
- 4 Story, 135,000 sf multi-family building
- 2 Elevator Shafts, 3 Stair Shafts, all originally designed in masonry – project was otherwise all wood framed
- Initial estimates were total of $266,000 for all 5 shafts
- Team switched to wood shafts, cut $176,000 from cost and at least 3 weeks from schedule

*Source: Gardner Capital Construction, project General Contractor & Developer*

# Shaft Wall Materials

Photo: StructureCraft

Photo: Jeff Morrow

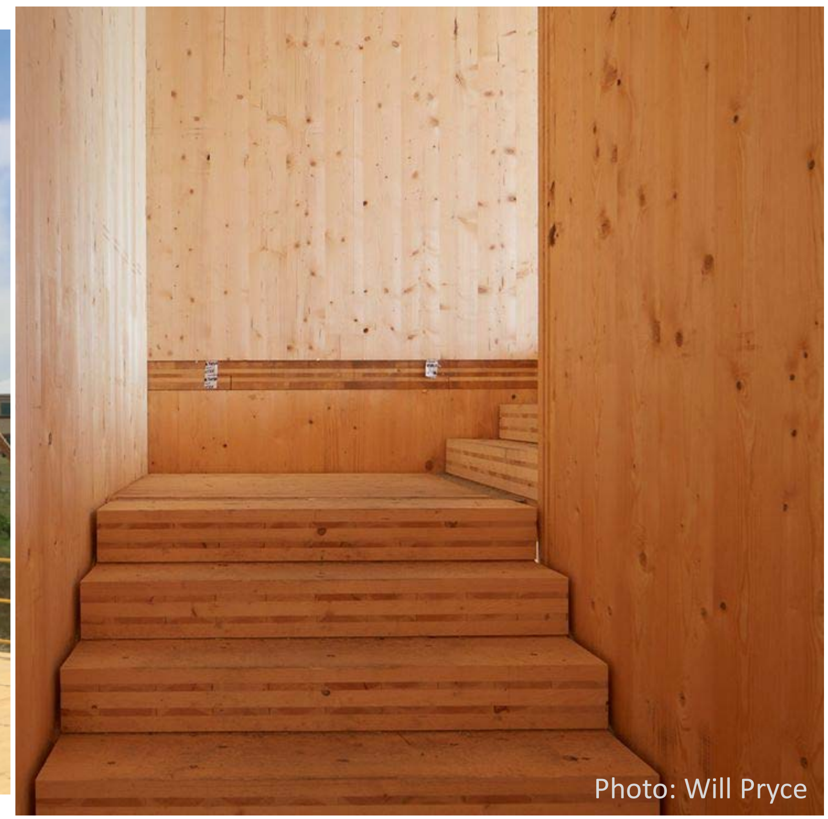


Photo: Will Pryce

# Shaft Wall Materials

Mass Timber Shaft Walls

- Cost
- Construction Schedule
- Material Compatibility (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)

**There is no restriction on combustible material within shaft walls or fire barriers in Types III, IV-HT or V construction.**

# Continuity Provisions

**Section 713: Shaft Enclosures**

*713.5 Continuity.*

Shaft enclosures shall have continuity in accordance with 707.5 for fire barriers.

**Section 707: Fire Barriers**

*707.5 Continuity.*

Fire barriers shall extend from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto. Such fire barriers shall be continuous though concealed space such as the space above a suspended ceiling. Joints and voids at intersections shall comply with Sections 707.8 and 707.9.

# Continuity Provisions

What do these continuity provisions look like?

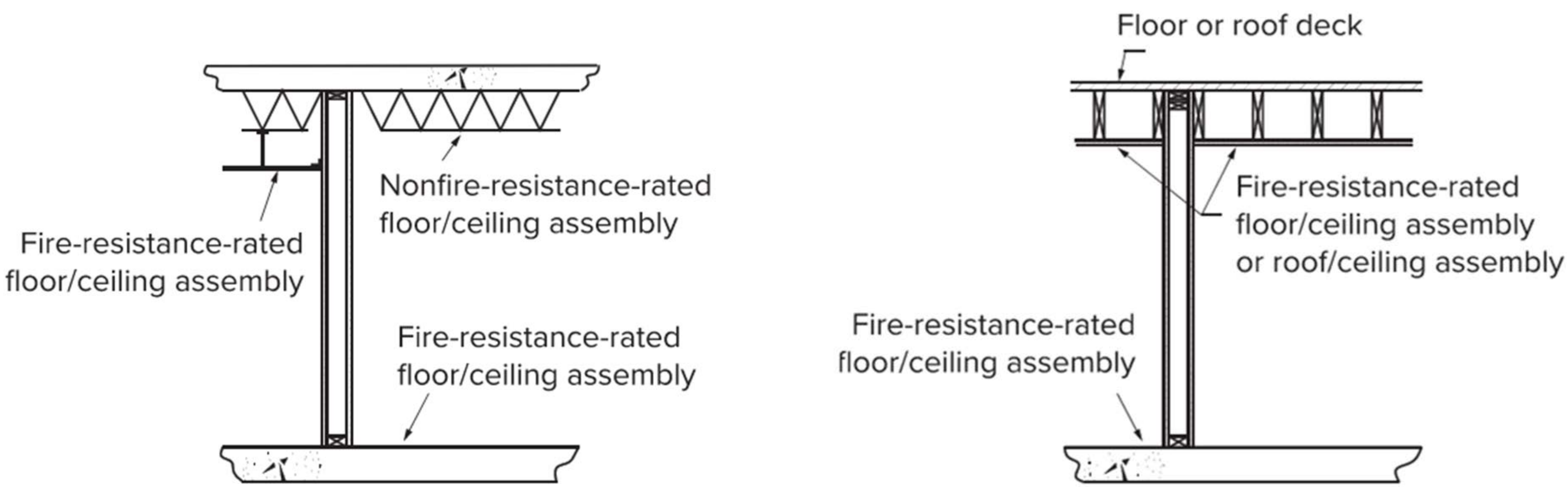



**FIGURE 1:** IBC Commentary Figure 707.5 – Continuity of fire barriers

# Continuity Provisions


Common Detailing Method: Fire Barrier & membrane extend to underside of floor deck above

**Fire barriers, including shaft walls, must extend from top of sheathing to underside of sheathing. Sheathing does not obstruct continuity.**

# Continuity Provisions

**How do we achieve these requirements?**

Continuity: The general requirements in 707.5 were not written with platform construction in mind. They were attempting to preclude large open concealed spaces to provide a continuous barrier between one portion of the building and another

Many jurisdictions have recognized that continuity of the fire barrier's fire protection can be maintained even if the wall framing does not extend to the underside of the decking above

We'll cover some detailing options later…

# Continuity Provisions

The continuity of the fire barrier’s fire protection can be maintained even if the wall framing does not extend to the underside of the decking above

Photo: WoodWorks

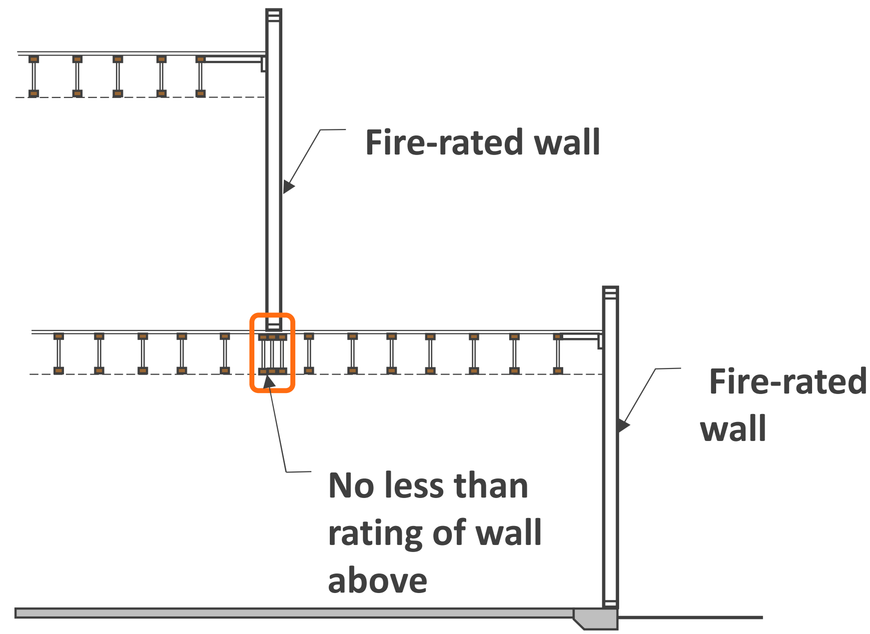
# Supporting Construction Provisions

**Section 707: Fire Barriers**

*707.5.1 Supporting Construction:*

The supporting construction for a fire barrier shall be protected to afford the required fire-resistance rating of the fire barrier supported.

Ex., shaft walls that are not continuous to lowest level



**The intent of a fire barrier is to provide fire confinement. If a fire barrier wall is supported directly by a wall below, the intersecting floor should not be considered a supporting element.**

# Joints in Shaft Walls

**Section 707: Fire Barriers**

*707.5 Continuity.*

Joints and voids at intersections shall comply with Sections 707.8 and 707.9.

*707.8 Joints.*

Joints made in or between fire barriers, and joints made at the intersection of fire barriers with underside of a fire resistance-rated floor or roof sheathing, slab or deck above, and the exterior vertical wall intersection shall comply with Section 715.

**Does floor sheathing or a floor assembly intersecting a shaft wall constitute a joint?**

**In wood-frame construction, typically, no.**

# Joints in Shaft Walls

**Section 202: Definitions**

*Joint.* The opening in or between adjacent assemblies that is created due to building tolerances, or is designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading.

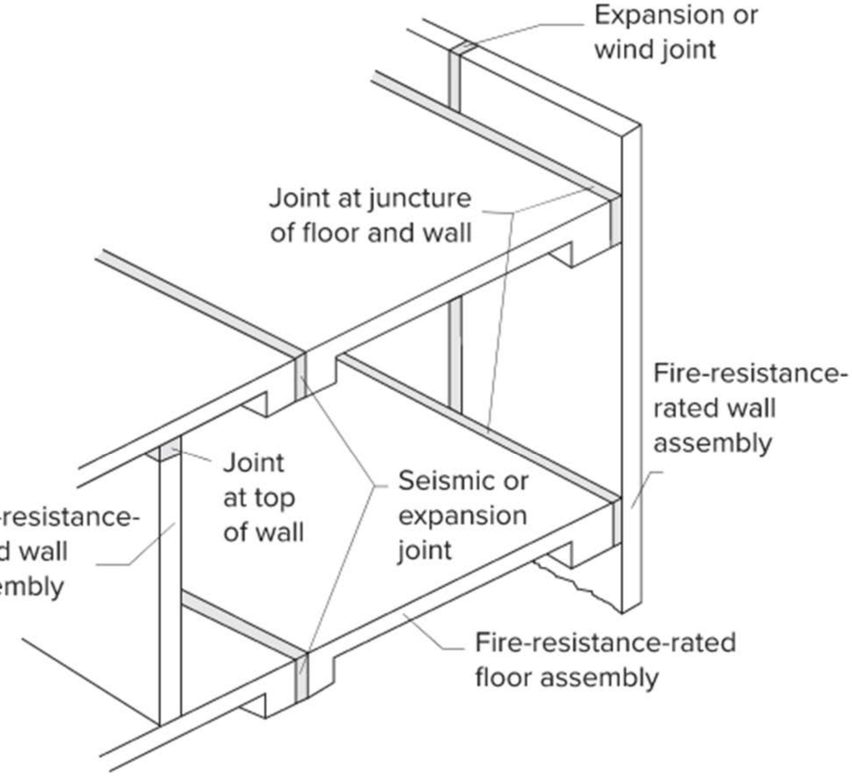



**FIGURE 2:** IBC Commentary Figure 715.1 – Examples of joint locations

**Assembly intersections that are in direct contact and securely attached are not considered joints.**

# Penetrations in Shaft Walls

**Section 713: Shaft Enclosures**

*713.8 Penetrations.*

Penetrations in shaft enclosure shall be protected in accordance with Section 714 as required for fire barriers. Structural elements such as beams or joists, where protected in accordance with Section 714 shall be permitted to penetrate a shaft enclosure.

**Section 707: Fire Barriers**

*707.7 Penetrations.*

Penetrations of fire barriers shall comply with Section 714.

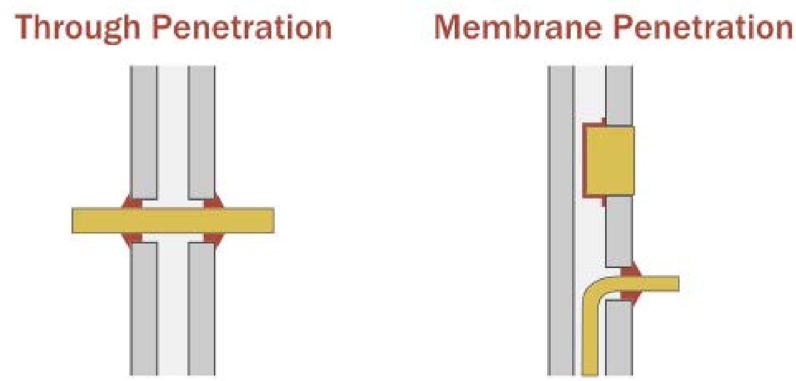
# Penetrations in Shaft Walls

Where are structural penetrations in shaft walls common?

- » Main Floor Joists to Shaft Wall Connection
- » Stair framing to Shaft Wall Connection

Credit: WoodWorks

# Penetrations in Shaft Walls




**Section 714: Penetrations**

*714.3.1.1 Fire-resistance-rated assemblies.*

Penetrations shall be installed as tested in an approved fire resistance rated assembly.

*or*

*714.3.1.2 Through-penetration firestop system.*
Through penetrations shall be protected by an approved penetration firestop system installed as tested in accordance with ASTM E814 or UL 1479, with a minimum positive pressure differential of .01 inch of water and shall have an F rating of not less than the required fire-resistance rating of the wall penetrated.

# Penetrations in Shaft Walls

To some, a new way of thinking:

Many are familiar with firestopping for MEP, but not structure, especially wood structure


Credit: STI

Credit: WoodWorks

# Penetrations in Shaft Walls


Stair landing beam shaft wall structural penetration prior to firestop system installation

Credit: WoodWorks

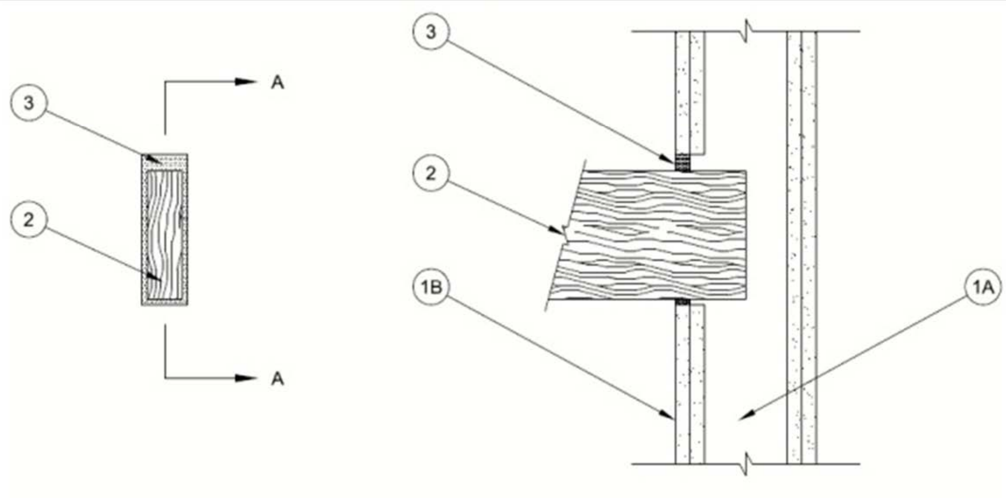
» Some firestopping systems available as tested configurations for wood conditions
» Most manufacturers can provide engineering judgement details, certification statements for this condition

# Penetrations in Shaft Walls

## System No. W-L-7244

August 24, 2016

| ANSI/UL1479 (ASTM E814) | CAN/ULC S115 |
|---|---|
| F Ratings — 1 and 2 Hr (See Item 1) | F Ratings — 1 and 2 Hr (See Item 1) |
| T Ratings — 1 and 2 Hr (See Item 1) | FT Ratings — 1 and 2 Hr (See Item 1) |
| | FH Ratings — 1 and 2 Hr (See Item 1) |
| | FTH Ratings — 1 and 2 Hr (See Item 1) |

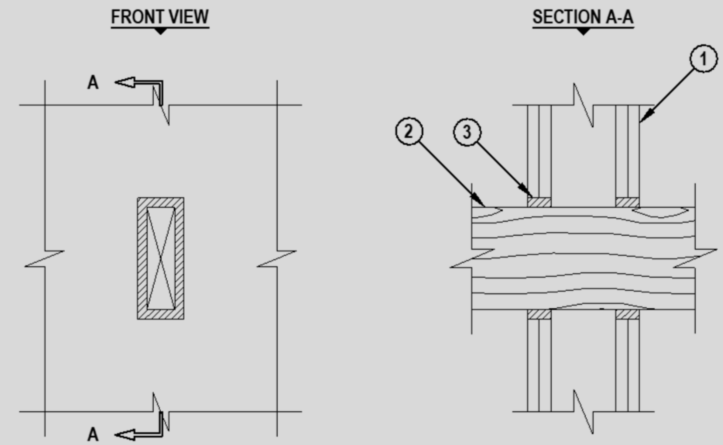



SECTION A-A

DH

ENGINEERING JUDGMENT FIRESTOP DETAIL

F-RATING = 2-HR.




1. GYPSUM WALL ASSEMBLY (UL/cUL CLASSIFIED) WITH MINIMUM 2" x 6" WOOD STUDS (2-HR. FIRE-RATING).
2. NOMINAL 3-1/2" x 9-1/2" WOOD MEMBER (NON FIRE-RATED).
3. MINIMUM 1-1/4" DEPTH HILTI FS-ONE MAX INTUMESCENT FIRESTOP SEALANT.

NOTES : 1. MAXIMUM SIZE OF OPENING = 4-1/2" x 10-1/2".
2. ANNULAR SPACE = MINIMUM 1/4", MAXIMUM 1".
3. FIRE-RATING AND STRUCTURAL INTEGRITY OF ASSEMBLY IS DEPENDENT UPON THE PERFORMANCE OF WOOD MEMBER UNDER FIRE CONDITIONS.

THIS ENGINEERING JUDGMENT REPRESENTS A FIRESTOP SYSTEM THAT WOULD BE EXPECTED TO PASS THE STATED RATINGS IF TESTED.
(REFERENCE : UL/cUL SYSTEM NO. W-L-1054 & W-L-7130; INTERNAL TESTING)

| | | |
|---|---|---|
| Designed by | Sheet 1 of 1 | Drawing No. |
| | Scale 11/64" = 1" | 251723a |
| | Date Jan. 30, 2017 | |

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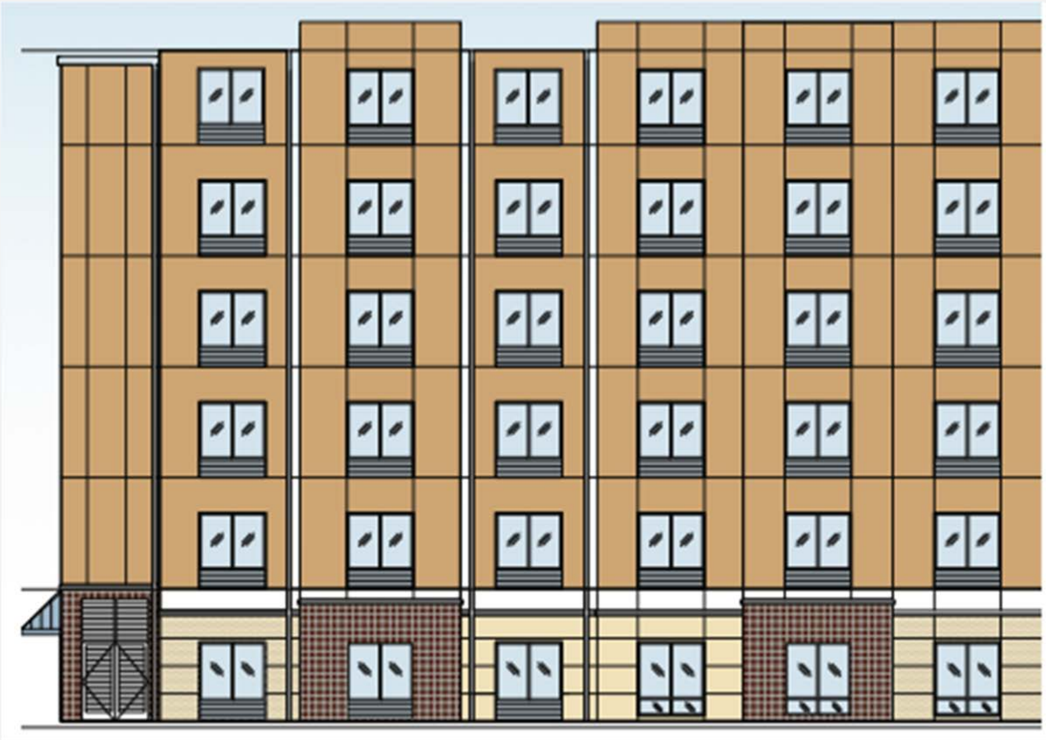
**Structural members are specifically called out as allowable penetrants in shaft enclosures.**

# Shaft Walls that are also Exterior Walls

Stair and elevator shaft enclosures are commonly placed along the exterior of the building

When a shaft wall also serves as the exterior wall of a building, unique provisions exist



# Shaft Walls that are also Exterior Walls

**Section 713: Shaft Enclosures**

*713.6 Exterior walls.*

Where exterior walls serve as a part of a required shaft enclosure, such walls shall comply with the requirements of Section 705 for exterior walls and the fire resistance-rated enclosure requirements shall not apply.

*Exception:* Exterior walls required to be fire-resistance rated in accordance with Section 1021.2 for exterior egress balconies, Section 1023.7 for interior exit stairways and ramps and Section 1027.6 for exterior exit stairways and ramps.

# Shaft Walls that are also Exterior Walls

Exterior bearing wall fire resistance rating per Table 601

**TABLE 601**
**FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)**

| BUILDING ELEMENT | TYPE I | | TYPE II | | TYPE III | | TYPE IV | TYPE V | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | HT | A | B |
| Primary structural frame[f] (see Section 202) | 3[a] | 2[a] | 1 | 0 | 1 | 0 | HT | 1 | 0 |
| Bearing walls<br>Exterior[e, f]<br>Interior | <br>3<br>3[a] | <br>2<br>2[a] | <br>1<br>1 | <br>0<br>0 | <br>2<br>1 | <br>2<br>0 | <br>2<br>1/HT | <br>1<br>1 | <br>0<br>0 |
| Nonbearing walls and partitions<br>Exterior | See Table 602 | | | | | | | | |
| Nonbearing walls and partitions<br>Interior[d] | 0 | 0 | 0 | 0 | 0 | 0 | See Section 602.4.6 | 0 | 0 |
| Floor construction and associated secondary members (see Section 202) | 2 | 2 | 1 | 0 | 1 | 0 | HT | 1 | 0 |
| Roof construction and associated secondary members (see Section 202) | $1^1/_2$[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | HT | 1[b,c] | 0 |

# Shaft Walls that are also Exterior Walls

Exterior non-bearing wall fire resistance rating per Table 602

**TABLE 602**
**FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, d, g]**

| FIRE SEPARATION DISTANCE = X (feet) | TYPE OF CONSTRUCTION | OCCUPANCY GROUP H[e] | OCCUPANCY GROUP F-1, M, S-1[f] | OCCUPANCY GROUP A, B, E, F-2, I, R, S-2, U[h] |
|---|---|---|---|---|
| $X < 5$[b] | All | 3 | 2 | 1 |
| $5 \le X < 10$ | IA<br>Others | 3<br>2 | 2<br>1 | 1<br>1 |
| $10 \le X < 30$ | IA, IB<br>IIB, VB<br>Others | 2<br>1<br>1 | 1<br>0<br>1 | 1[c]<br>0<br>1[c] |
| $X \ge 30$ | All | 0 | 0 | 0 |

# Shaft Walls that are also Exterior Walls

**Exterior Walls (IBC 705):**

- Materials as permitted for type of construction (same as fire barrier) – 705.4
- Fire resistance only required from inside if fire separation distance is > 10 ft – 705.5
- Possible to have exterior shaft wall that does not require a fire resistance rating

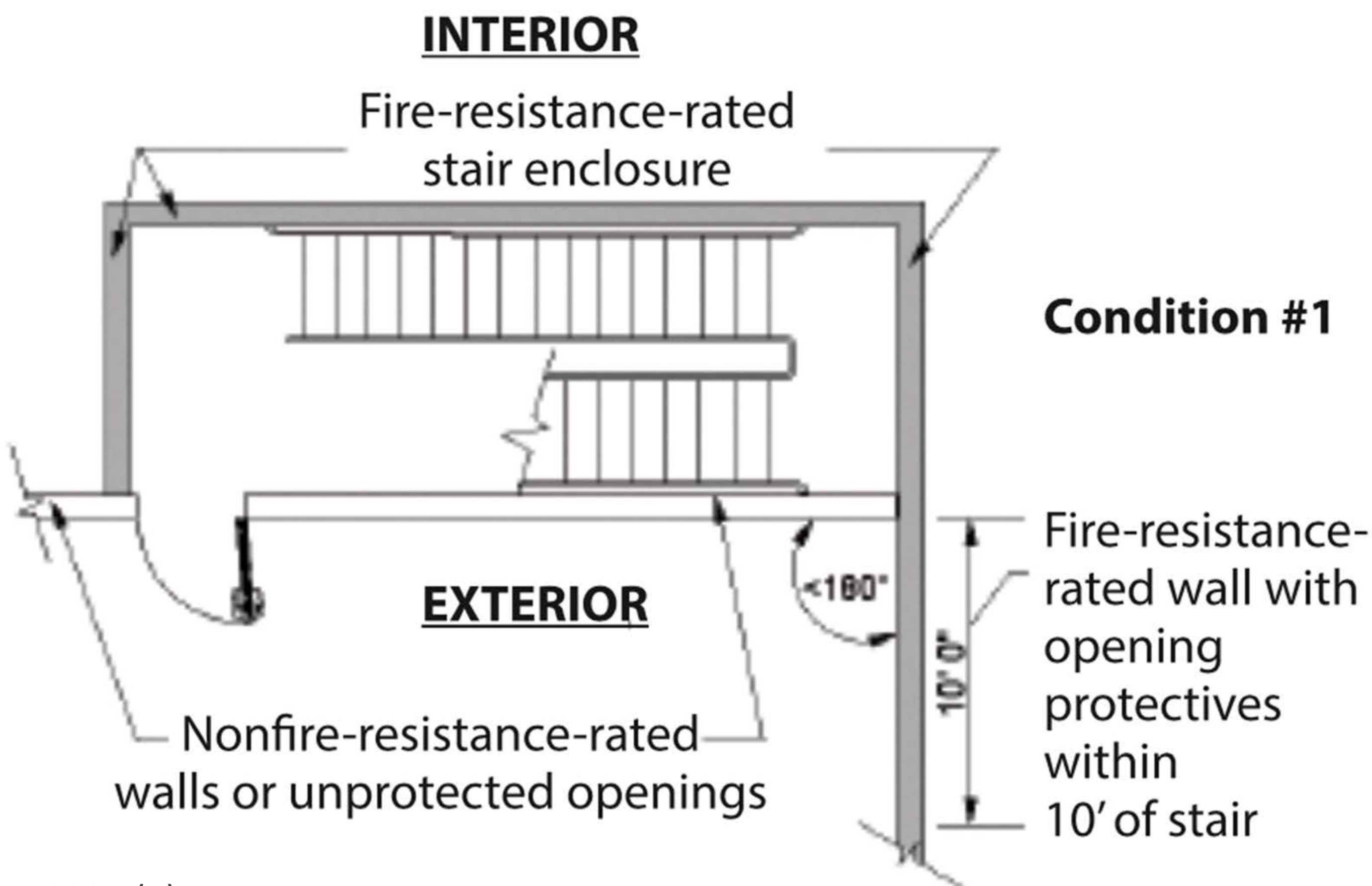
Photo: WoodWorks

# Shaft Walls that are also Exterior Walls

**1023.7 Interior exit stairway and ramp exterior walls.**

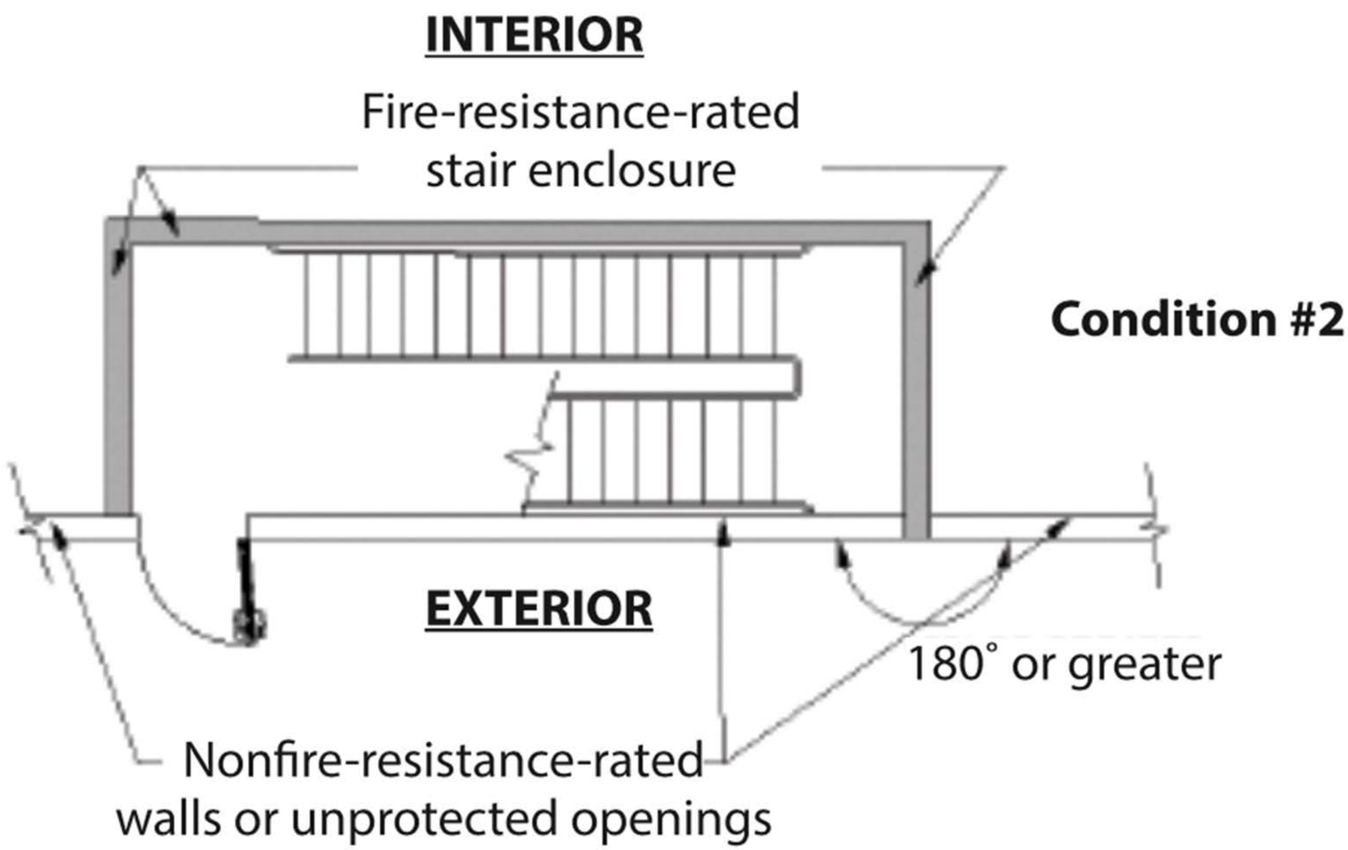
Exterior walls of the interior exit stairway or ramp shall comply with the requirements of Section 705 for exterior walls. Where nonrated walls or unprotected openings enclose the exterior of the stairway or ramps and the walls or openings are exposed by other parts of the building at an angle of less than 180 degrees (3.14 rad), the building exterior walls within 10 feet (3048 mm) horizontally of a nonrated wall or unprotected opening shall have a fire-resistance rating of not less than 1 hour. Openings within such exterior walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour. This construction shall extend vertically from the ground to a point 10 feet (3048 mm) above the topmost landing of the stairway or ramp, or to the roof line, whichever is lower.

# Shaft Walls that are also Exterior Walls



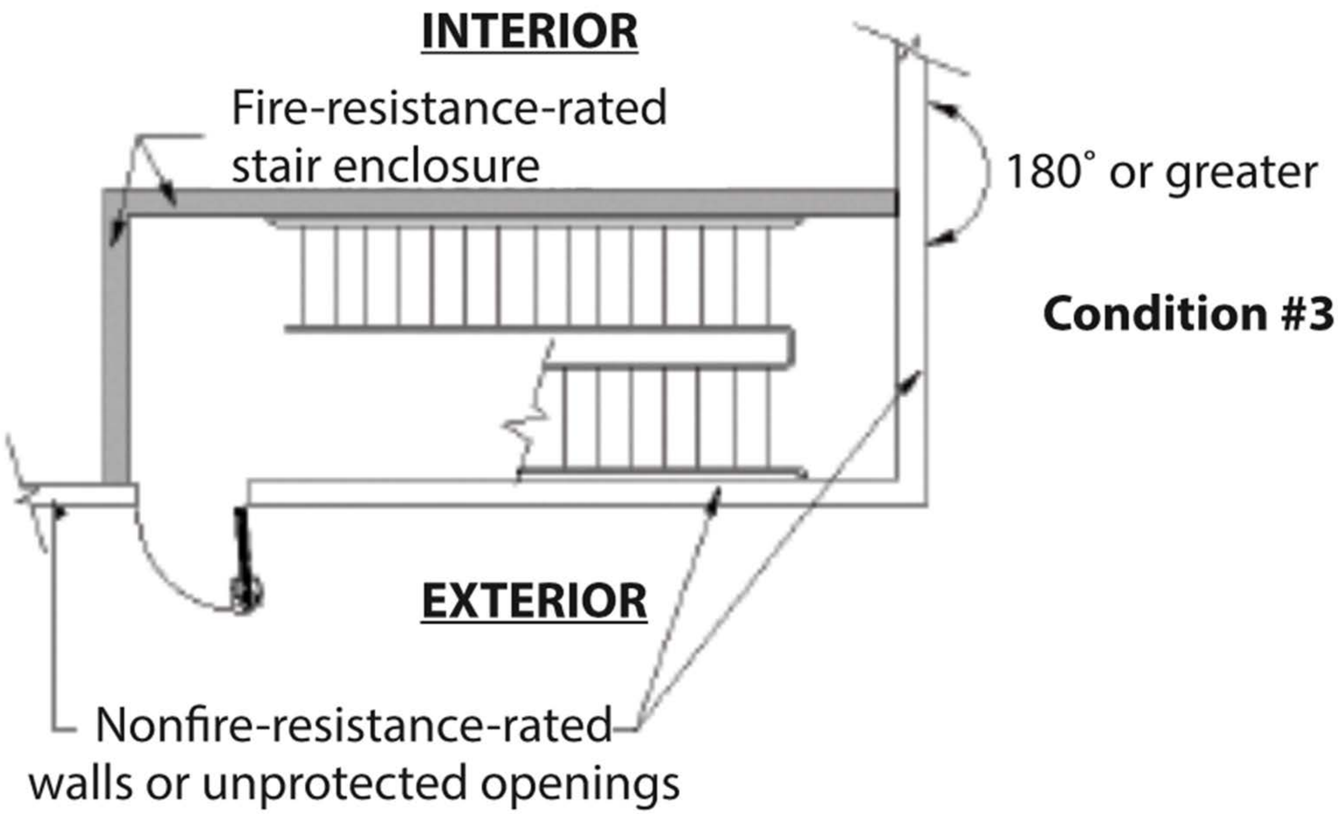

Source: IBC Commentary Figure 1023.7(1)

# Shaft Walls that are also Exterior Walls



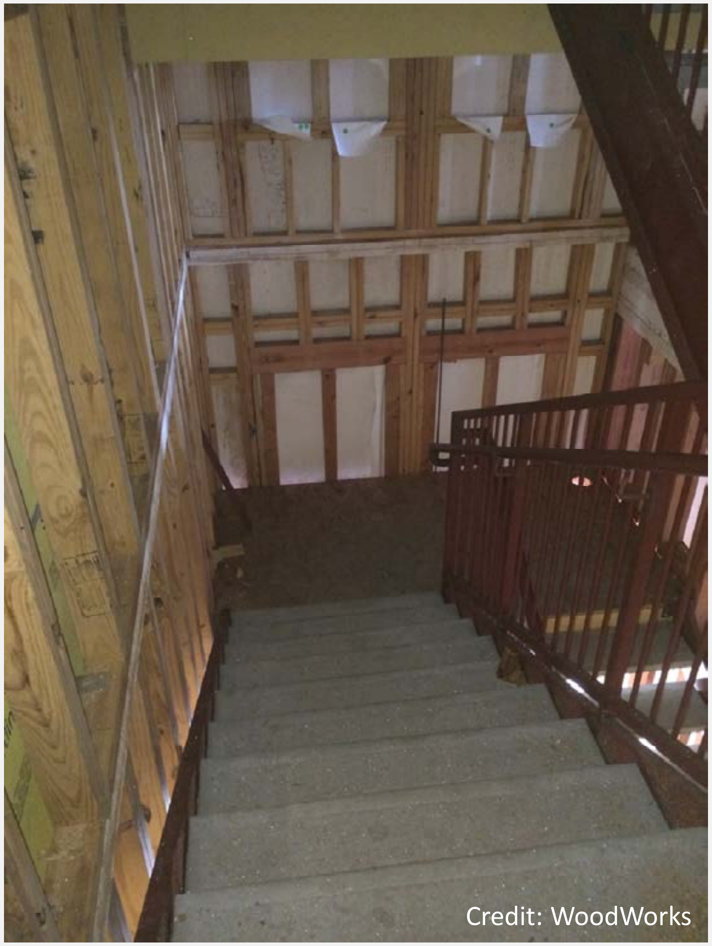

Source: IBC Commentary Figure 1023.7(1)

# Shaft Walls that are also Exterior Walls

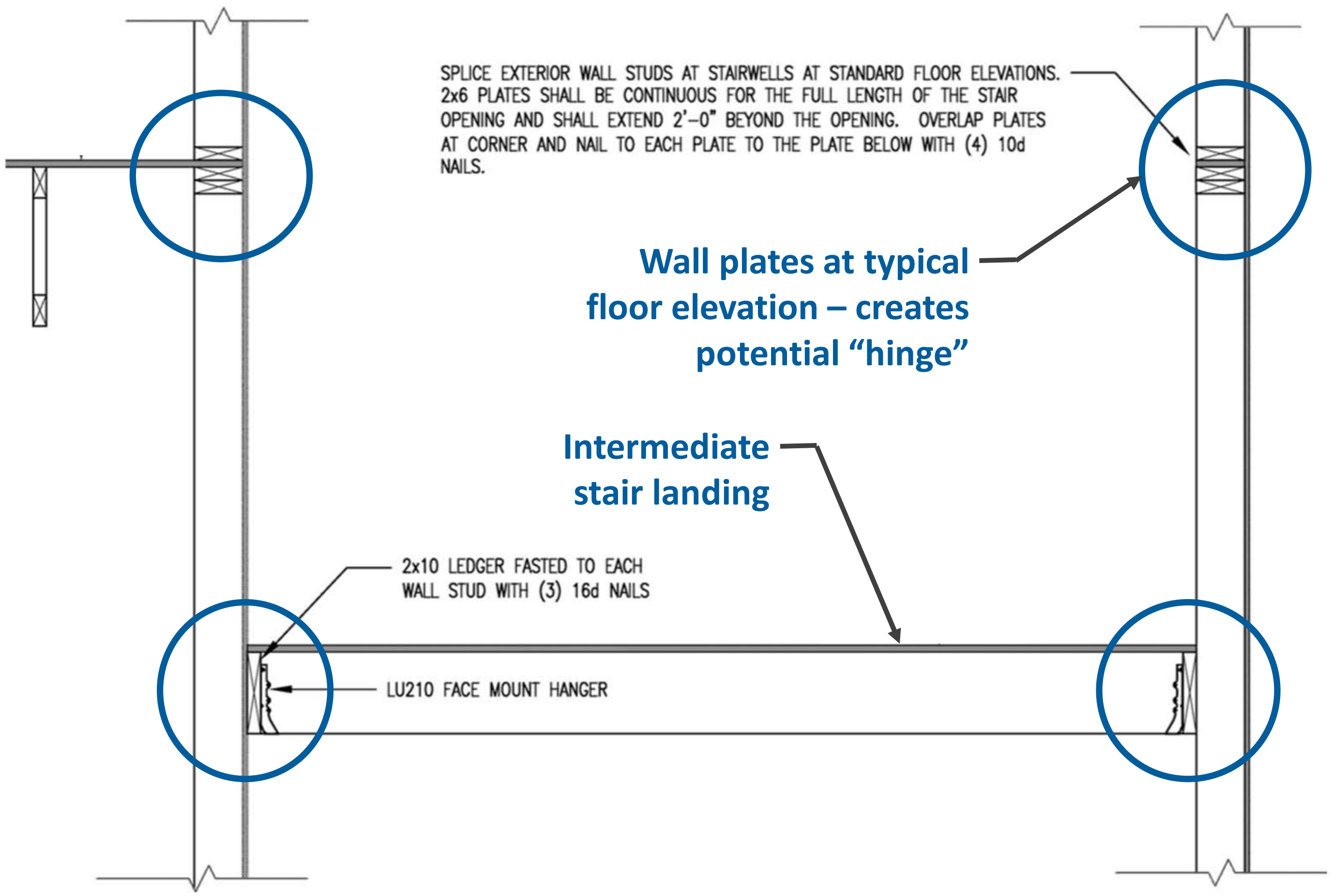



Source: IBC Commentary Figure 1023.7(1)

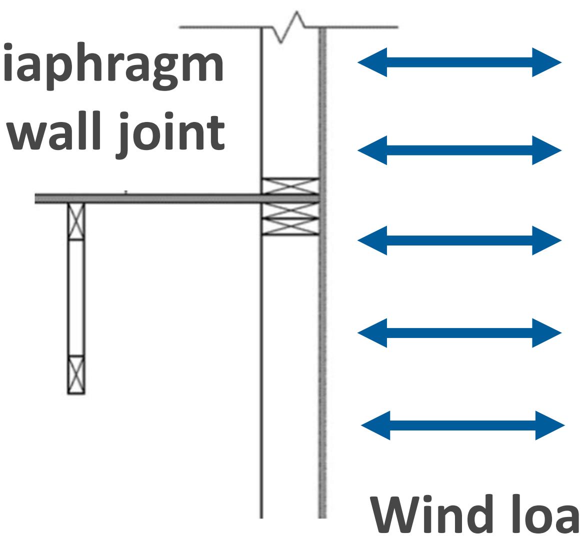
# Shaft Walls that are also Exterior Walls

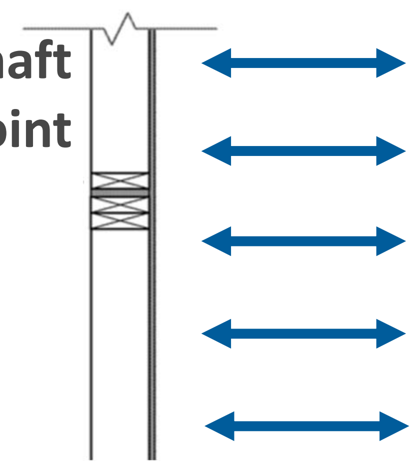
# When Stair Shaft Wall is Exterior Wall



# Shaft Walls that are also Exterior Walls




<u>Typical Exterior Wall</u>



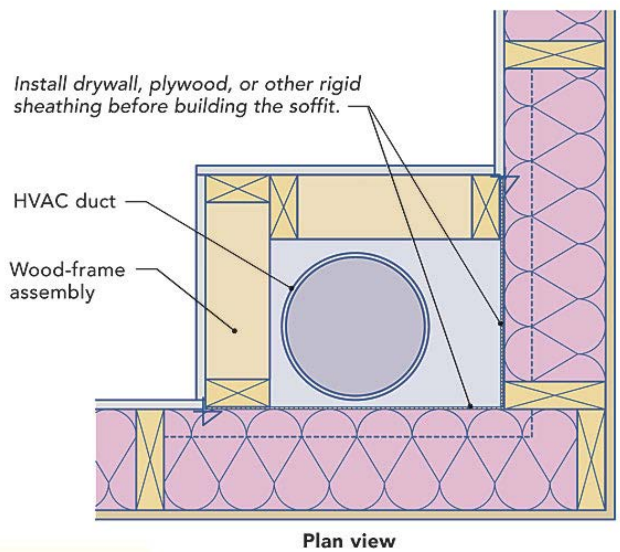

<u>Exterior Wall that is Shaft Wall</u>

# Stair, Elevator & MEP Shafts

Main Differences & Unique Design Constraints:

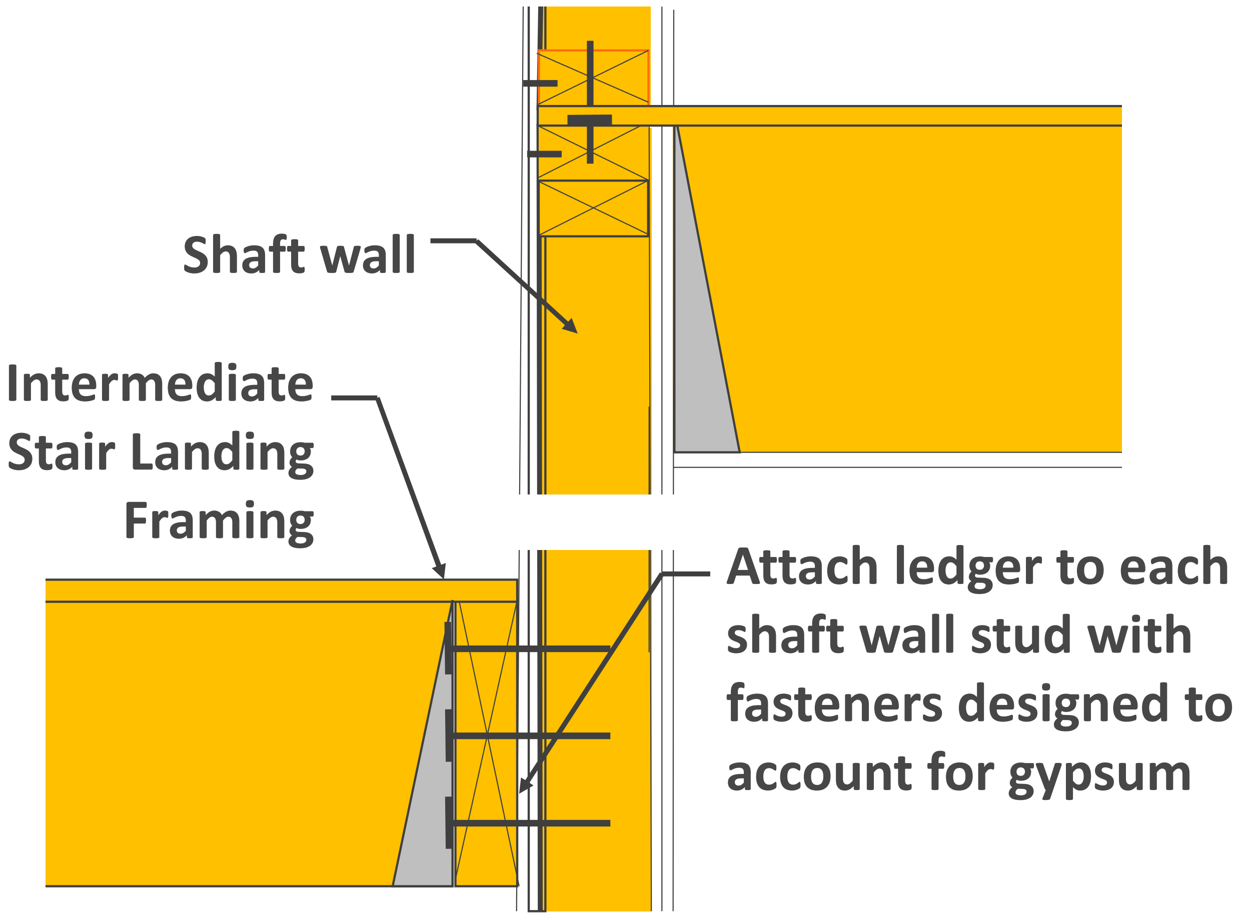
- Stair Shafts – Stair Framing
- Elevator Shafts – Rail supports
- MEP Shafts – Small Size

Credit: WoodWorks




Credit: WoodWorks

# Stair Shafts



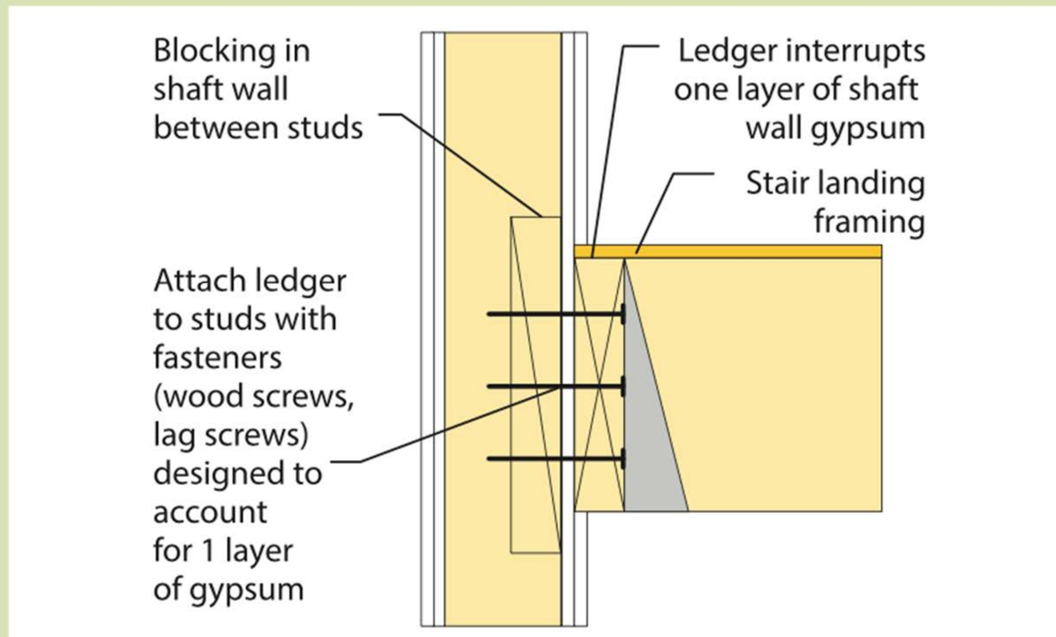

Credit: WoodWorks

# Stairway Shaft Enclosures & Framing

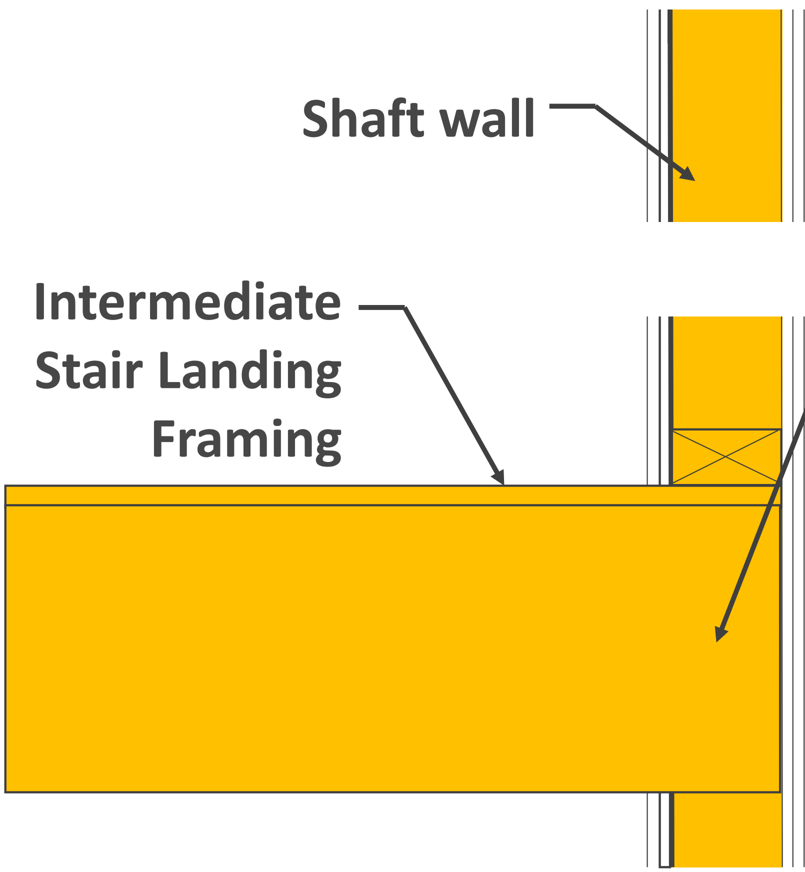

# Stair Shafts

- Wood blocking in wall used to achieve 1-hr of continuity
- Alternatively – interrupt both gypsum layers and use 2 layers of blocking in wall
- Key to attach ledger to studs, not blocking

**FIGURE 15:** Stair Framing to Shaft Wall Attachment with Blocking in Lieu of One Continuous Gypsum Layer



# Stair Shafts

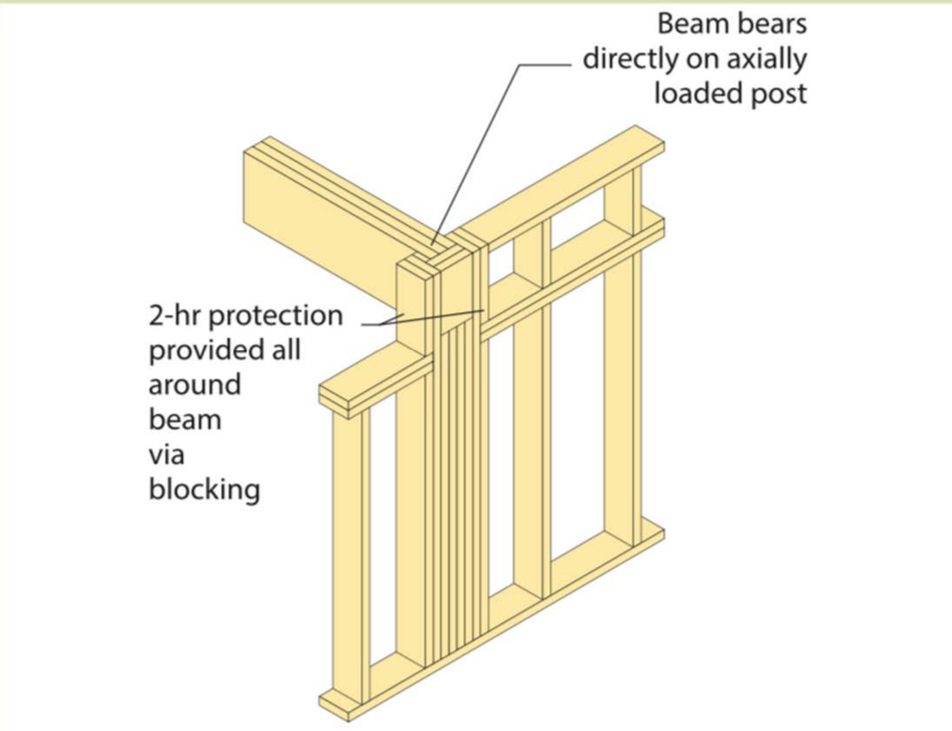



**Intermediate Landing Beam Extends into Shaft Wall – Oversize to Provide 2 Hour Fire Protection Using Calculated Char Rates**

- Membranes on both side of wall provide fire resistance via their approved assembly
- At floor cavity beam oversized to provide 2-hr char protection

# Stair Shafts

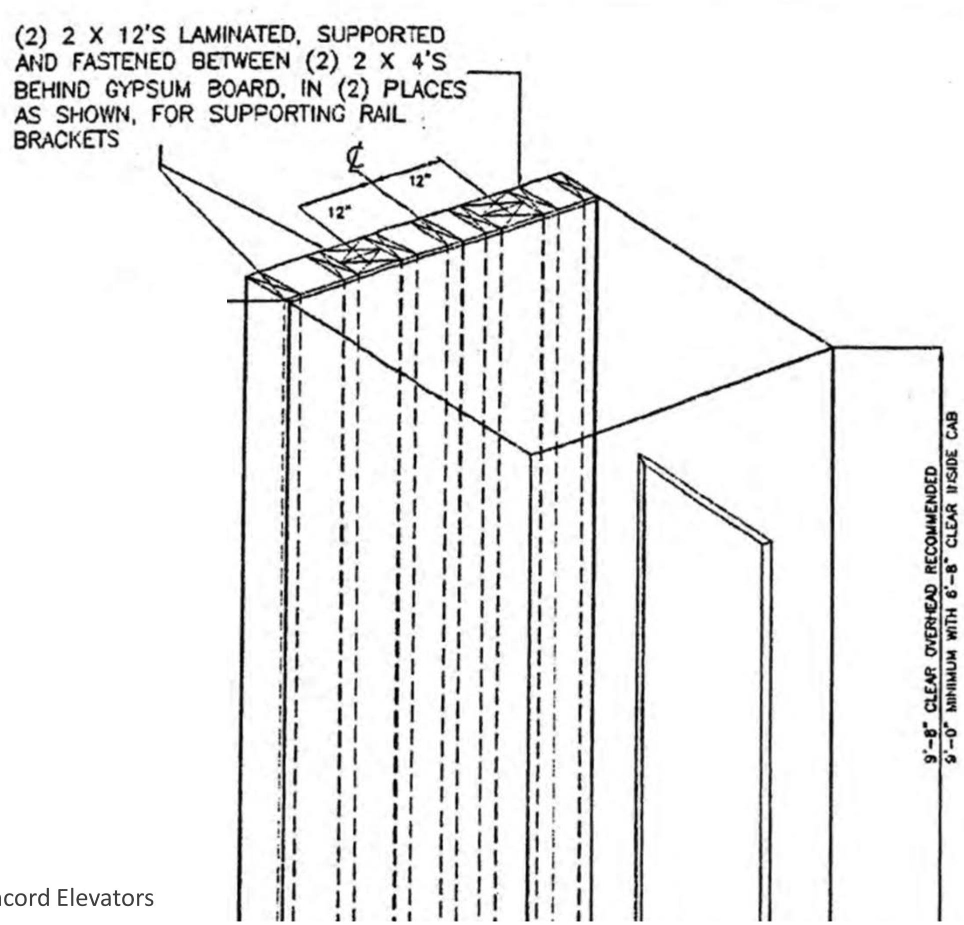
***FIGURE 16:*** Stair Framing Beam in Protect Pocket in Shaft Wall

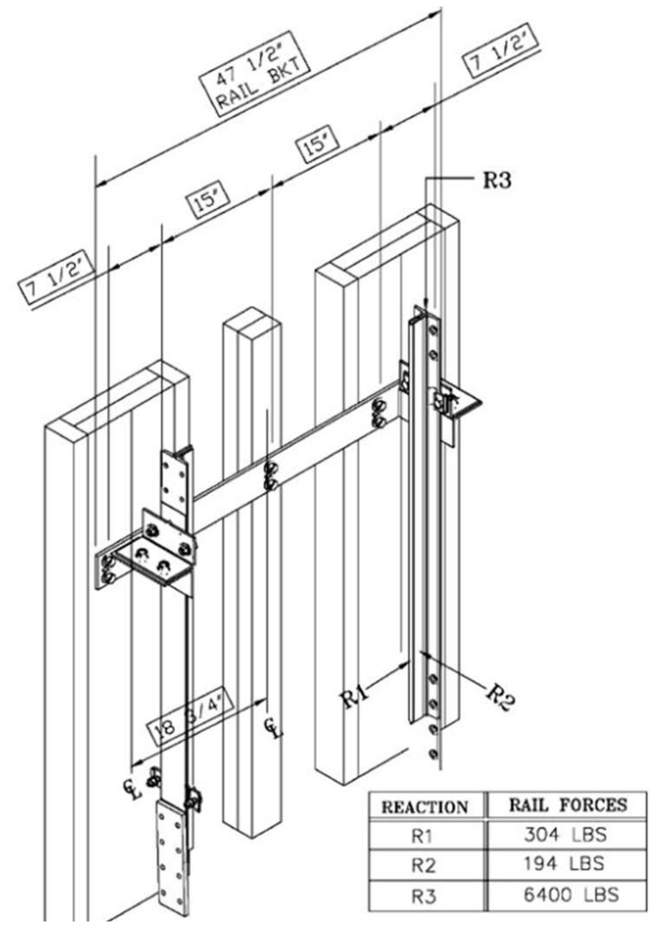



# Elevator Shafts

Credit: WoodWorks

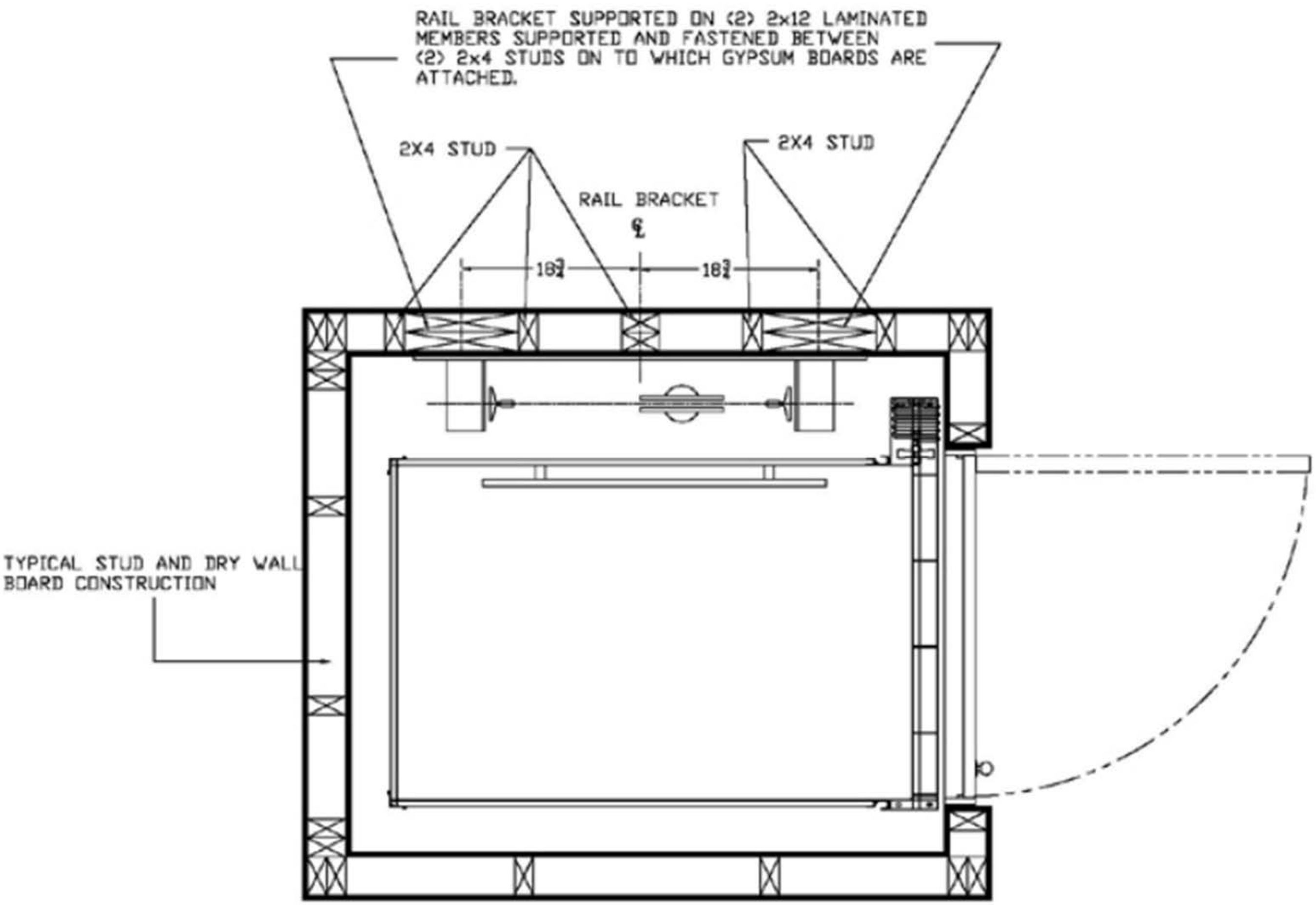
# Elevator Shafts




Credit: Concord Elevators

# Elevator Shafts




Credit: Concord Elevators

# Elevator Shafts

Credit: WoodWorks

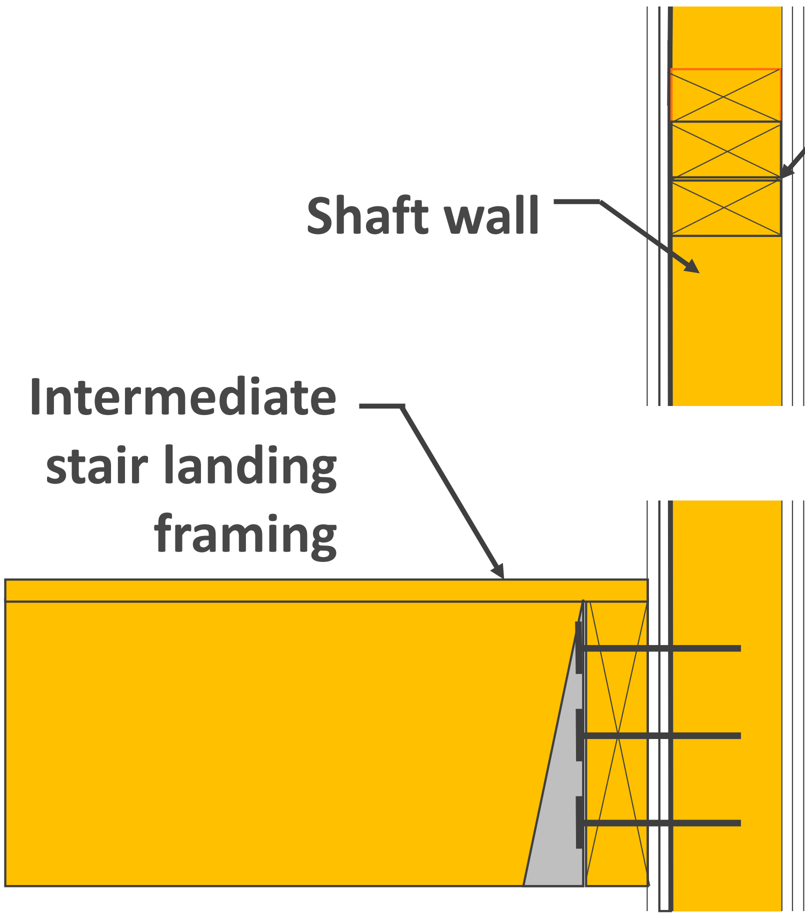
- Elevator hoist beam can be wood
- Material compatibility
- Construction schedule & sequencing
- Consult elevator manufacturer for details, forces, location information

# MEP Shafts


Credit: WoodWorks

- Size of MEP shaft may require a solution with one or more sides being shaftliner panels
- Ability to get inside shaft to finish gypsum panels often the controlling factor in wall assembly selection

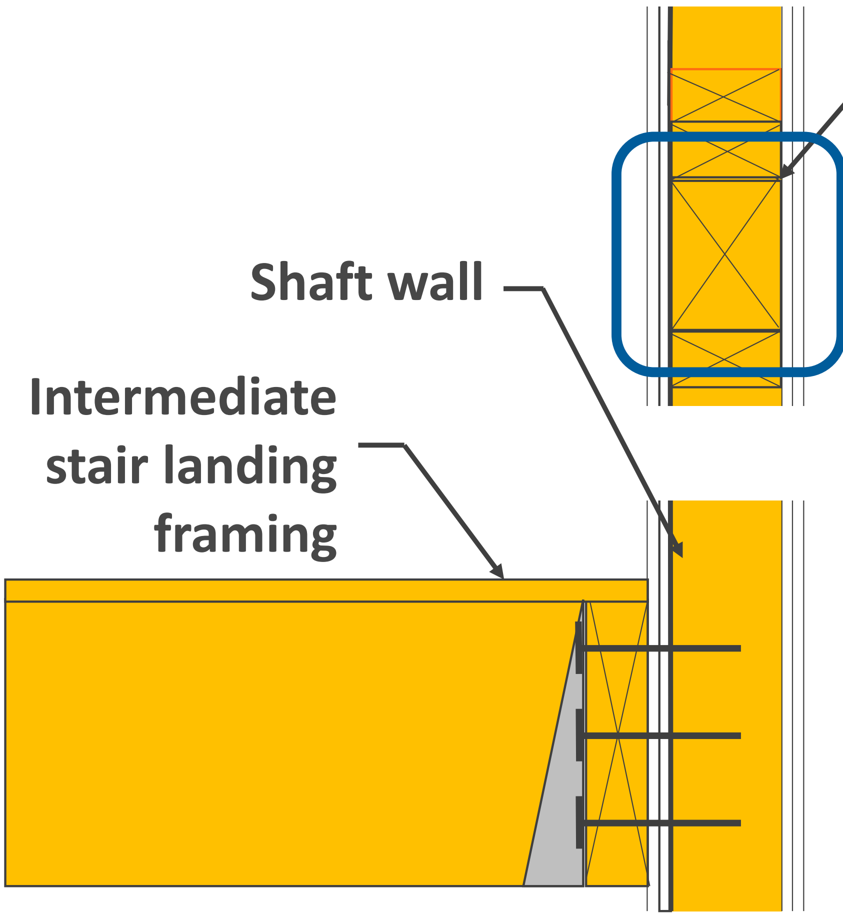
# Shaft Walls that are also Exterior Walls




**Consider "hinge" at wall plates for out-of-plane wind & seismic loads due to lack of adjacent floor:**

- **Span plates horizontally**

# Shaft Walls that are also Exterior Walls

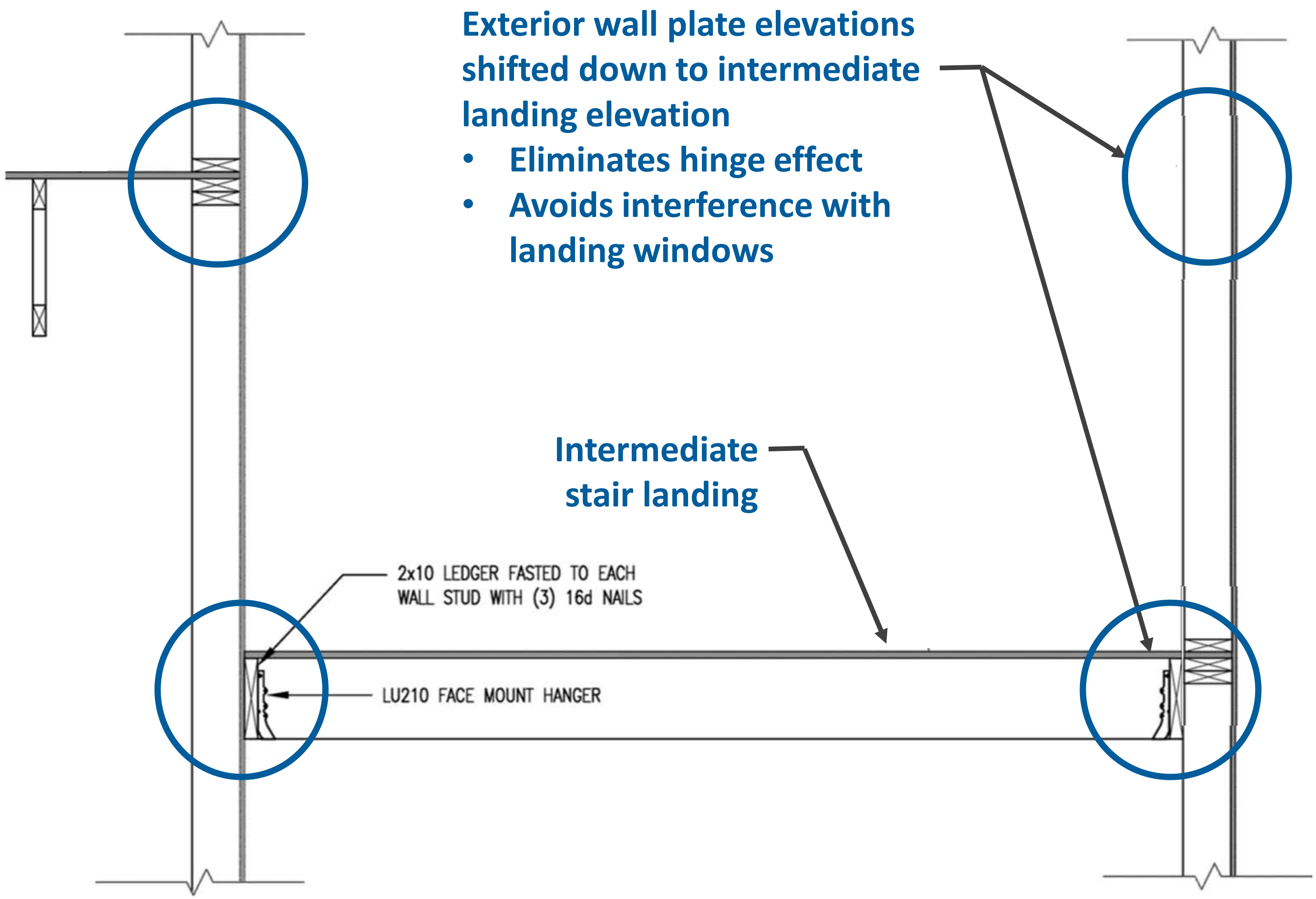



Consider "hinge" at wall plates for out-of-plane wind & seismic loads due to lack of adjacent floor:

- Install additional member (rim) to span horizontally

Credit: WoodWorks

# When Stair Shaft Wall is Exterior Wall



# Shaft Wall Assemblies

Assembly selection considerations:

- Fire resistance rating requirement (1-hr or 2-hr)
- Size and height of shaft
- Structural needs (gravity & lateral loads)
- Acoustics
- Space available for wall (allowed thickness)

Photo: WoodWorks

# Shaft Wall Assemblies

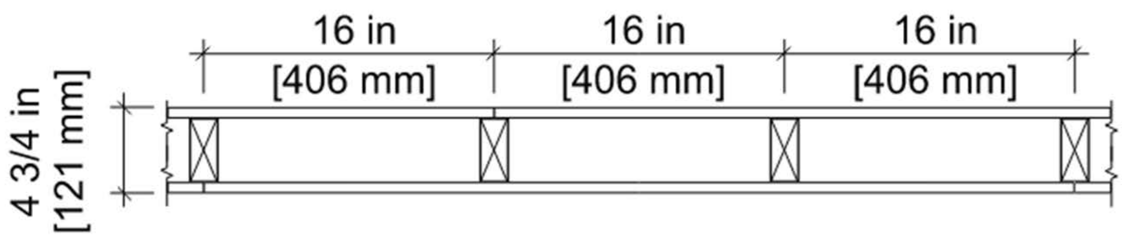



**FIGURE 4:** UL U305

**1-Hour Single Wall**

- UL U305
- GA WP 3510
- UL U311
- IBC 2012 Table 721.1(2), Item 14-1.3
- UL U332

**1-Hour Double Wall**

- UL U341

**1-Hour Wall with Shaftliner**

- UL V455
- UL V433

# Shaft Wall Assemblies

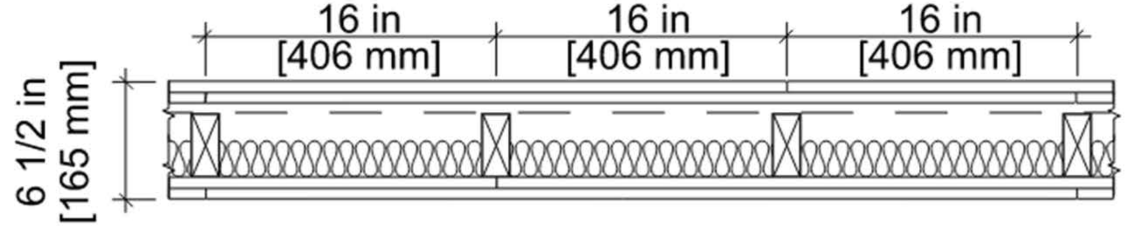



**FIGURE 5:** UL U334

**2-Hour Single wall**

- UL U301
- UL U334
- IBC 2012 Table 721.1(2) Item Number 14-1.5
- IBC 2012 Table 721.1(2) Item Number 15-1.16

**2-Hour Double Wall**

- UL U342
- UL U370
- GA WP 3820

**2-Hour Wall with Shaftliner**

- UL U336
- UL U373
- UL U375
- UL V455
- UL V433
- GA ASW 1000

# Shaftliner Systems - Benefits & Limitations

**Benefits**

» Allows installation from one side only – useful in small MEP shafts where finishing from inside isn't possible

**Limitations**

» Some have height limitations, both per story and overall system

» Not structural, requires back-up wood wall

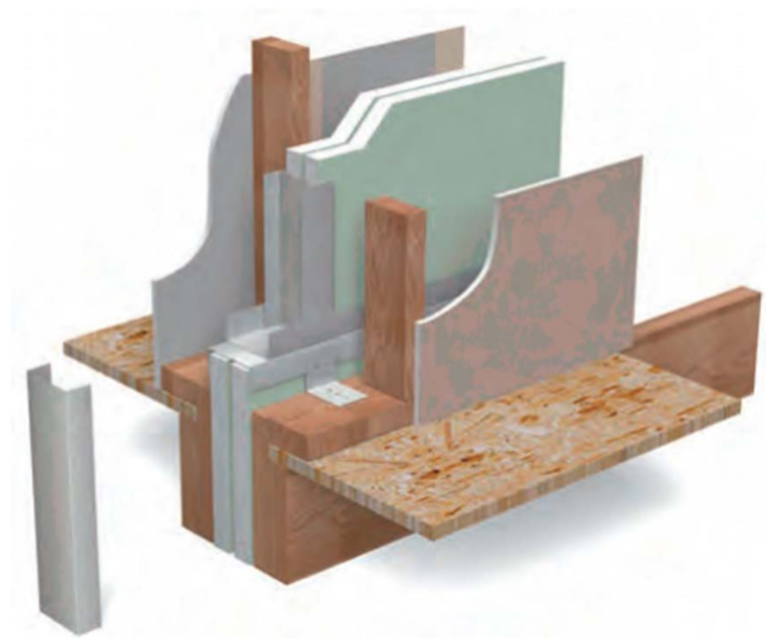
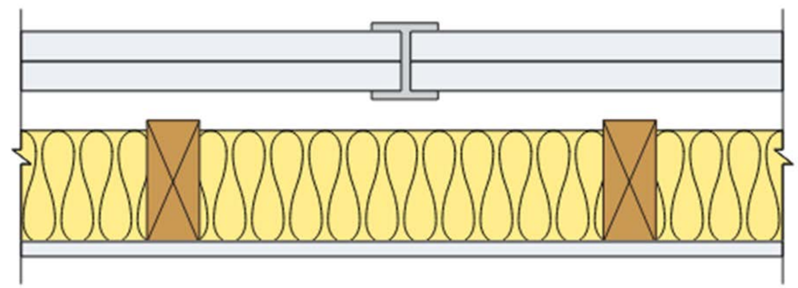


**FIGURE 6:** Shaftliner wall assembly with wood wall on each side *Credit: ClarkDietrich*

# Shaftliner Systems – Configuration Options

## H-Stud Option

Source: Clark Dietrich



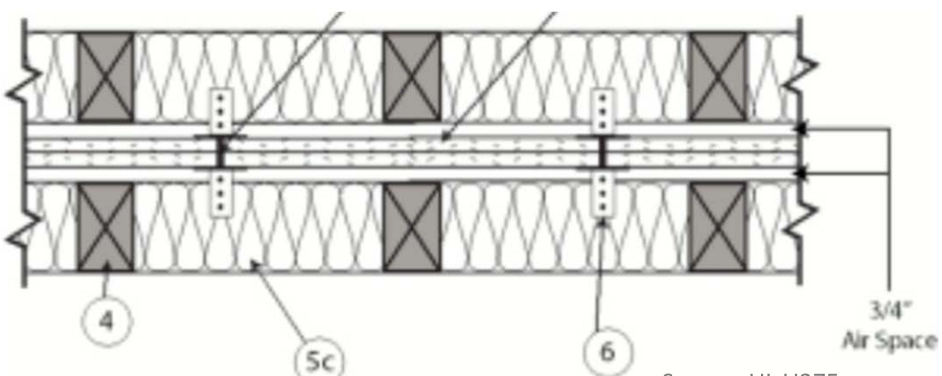
**59 STC Sound Transmission**

Test Reference: RAL TL 10-290

Two layers 1" (25.4 mm) shaftliner inserted in H-studs 24" (610 mm) o.c., min. 3/4" (19 mm) air spacing between liner panels and adjacent or wood metal framing

Sound tested with 2"x4" stud wall with 1/2" (12.7 mm) wallboard or interior panels and 3-1/2" (89 mm) fiberglass insulation in stud space

**FIGURE 8:** UL U373
*Credit: Georgia Pacific*

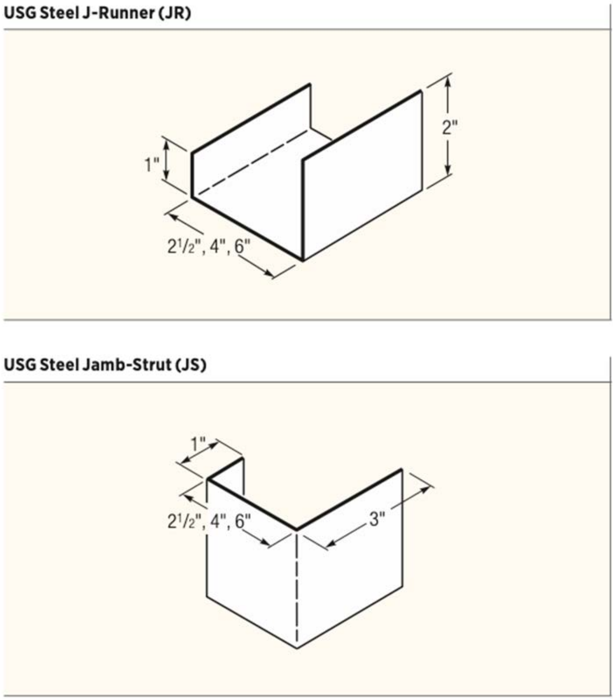



Source: UL U375

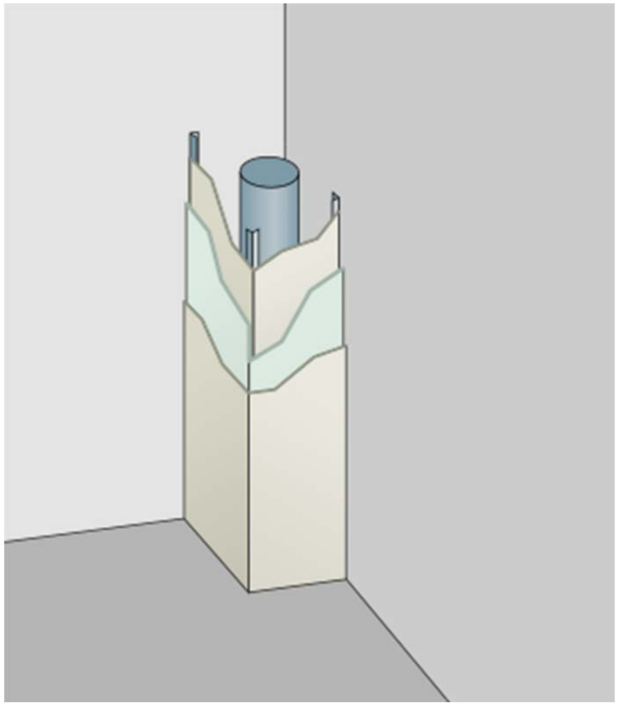
# Shaftliner Systems – Configuration Options

## H-Stud Option

Source: Clark Dietrich




Source: USG

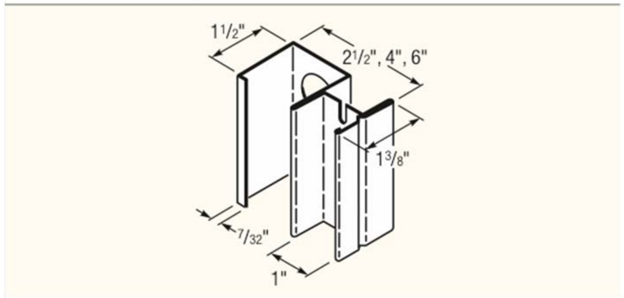


# Shaftliner Systems – Configuration Options

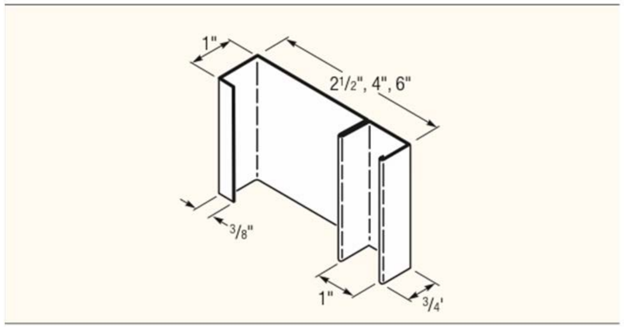
CH-Stud Option

Source: Clark Dietrich

USG Steel C-H Stud (CH)




USG Steel E-Stud (ES)




Source: USG

No wood backup wall



Source: Clark Dietrich

# Shaftliner Systems – Height Limits

Why do you need to support shaftliner panels?

- H-studs are non-structural
- Can only resist nominal horizontal pressures and self weight (but limited on self weight capacity)

# PERFORMANCE SELECTOR

## WALL SYSTEMS—LIMITING HEIGHTS TABLE

| | | | One-Hour Shaft Wall / Stairwell (U415 System A)[b] | | | | Two-Hour Shaft Wall (U415 System C)[b] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Stud Type and Size** | **Designation** | **Allowable Deflection** | **5** | **7.5** | **10** | **15** | **5** | **7.5** | **10** | **15** |
| 2-1/2" C-H Studs  | 212CH-18 | L/120 | 11' 5" | 10' 0" | 9' 1"[d] | 7' 11"[d] | — | — | — | — |
| | | L/240 | 10' 7" | 9' 3" | 8' 4"[d] | 7' 4"[d] | — | — | — | — |
| | | L/360 | 9' 4" | 8' 2" | 7' 5" | 6' 6" | — | — | — | — |
| | 212CH-34 | L/120 | 13' 5" | 11' 8" | 10' 8" | 9' 3" | — | — | — | — |
| | | L/240 | 12' 3" | 10' 9" | 9' 9" | 8' 6" | — | — | — | — |
| | | L/360 | 10' 10" | 9' 6" | 8' 7" | 7' 6" | — | — | — | — |
| 4" C-H Studs  | 400CH-18 | L/120 | 15' 2" | 12' 5" | 10' 9"[d] | 8' 9"[d] | 15' 2" | 12' 5" | 10' 9"[d] | 8' 9"[d] |
| | | L/240 | 14' 5" | 12' 5" | 10' 9"[d] | 8' 9"[d] | 14' 5" | 12' 5" | 10' 9"[d] | 8' 9"[d] |
| | | L/360 | 12' 9" | 11' 2" | 10' 1"[d] | 8' 9"[d] | 12' 9" | 11' 2" | 10' 1"[d] | 8' 9"[d] |
| | 400CH-34 | L/120 | 20' 5" | 17' 10" | 16' 2"[d] | 13' 4"[d] | 20' 5" | 17' 10" | 16' 2"[d] | 13' 4"[d] |
| | | L/240 | 17' 6" | 15' 3" | 13' 10" | 12' 1"[d] | 17' 6" | 15' 3" | 13' 10" | 12' 1"[d] |
| | | L/360 | 15' 3" | 13' 4" | 12' 1" | 10' 7"[d] | 15' 3" | 13' 4" | 12' 1" | 10' 7"[d] |

# Shaftliner Systems – Height Limits

Can also perform a structural analysis of the walls, especially when stacking multiple stories, to verify adequacy

| Allowable Moment, Shear and Effective Section Properties | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Section | Web A in | Flange B in | Stiffener C in | Design T in | Radius R in | Fy = 33 ksi, Fu = 45 ksi | | | | |
| | | | | | | May kip-in | Vax kips | Iye $in^4$ | Sye $in^3$ | Ae $in^2$ |
| **Web Depth 2.50" Lip 1.00"** | | | | | | | | | | |
| 250 J100-18 | 2.622 | 2.25 | 1.00 | 0.0188 | 0.0843 | 0.8999 | 0.247 | 0.0679 | 0.0455 | 0.0366 |
| 250 J100-27 | 2.636 | 2.25 | 1.00 | 0.0283 | 0.0796 | 1.5439 | 0.685 | 0.1123 | 0.0781 | 0.0754 |
| 250 J100-30 | 2.641 | 2.25 | 1.00 | 0.0312 | 0.0782 | 1.7646 | 0.832 | 0.1270 | 0.0893 | 0.0896 |
| 250 J100-33 | 2.646 | 2.25 | 1.00 | 0.0346 | 0.0764 | 2.0359 | 1.023 | 0.1448 | 0.1030 | 0.1073 |
| **Web Depth 2.50" Lip 2.00"** | | | | | | | | | | |
| 250 J200-18 | 2.622 | 2.25 | 2.00 | 0.0188 | 0.0843 | 0.8674 | 0.247 | 0.0792 | 0.0439 | 0.0369 |
| 250 J200-27 | 2.636 | 2.25 | 2.00 | 0.0283 | 0.0796 | 1.7070 | 0.685 | 0.1442 | 0.0864 | 0.0765 |
| 250 J200-30 | 2.641 | 2.25 | 2.00 | 0.0312 | 0.0782 | 1.9498 | 0.832 | 0.1634 | 0.0987 | 0.0910 |
| 250 J200-33 | 2.646 | 2.25 | 2.00 | 0.0346 | 0.0764 | 2.2482 | 1.023 | 0.1866 | 0.1138 | 0.1092 |
| **Web Depth 4.00" Lip 1.00"** | | | | | | | | | | |
| 400 J100-18 | 4.122 | 2.25 | 1.00 | 0.0188 | 0.0843 | 1.4271 | 0.152 | 0.1807 | 0.0722 | 0.0373 |
| 400 J100-27 | 4.136 | 2.25 | 1.00 | 0.0283 | 0.0796 | 3.0404 | 0.518 | 0.3395 | 0.1539 | 0.0780 |
| 400 J100-30 | 4.141 | 2.25 | 1.00 | 0.0312 | 0.0782 | 3.4461 | 0.695 | 0.3818 | 0.1744 | 0.0930 |
| 400 J100-33 | 4.146 | 2.25 | 1.00 | 0.0346 | 0.0764 | 3.9409 | 0.948 | 0.4326 | 0.1994 | 0.1121 |

# Shaftliner Systems – Height Limits

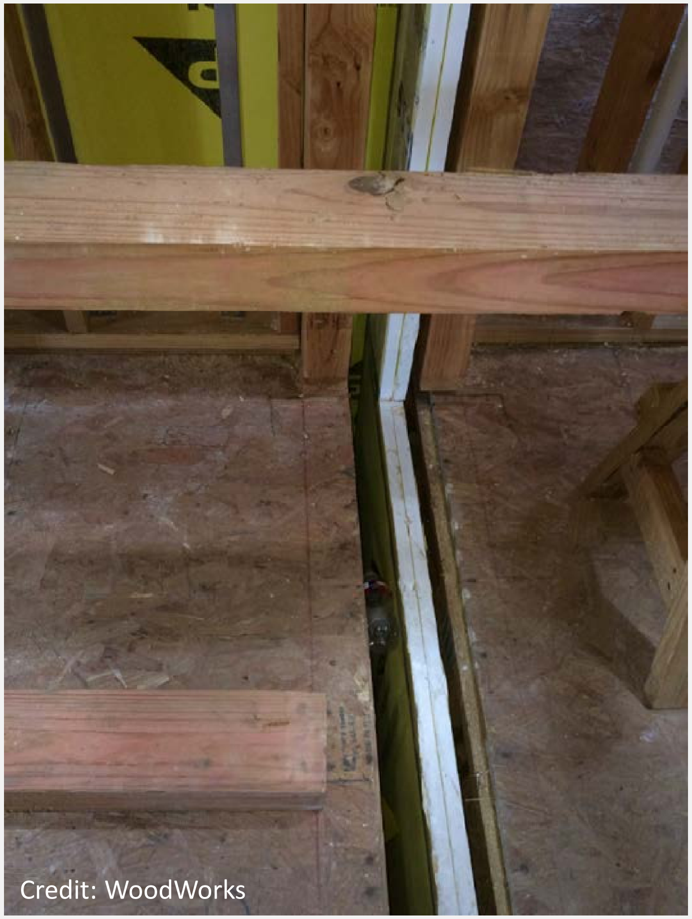
| Example Shaftliner Clip Attachment Schedule per UL U375 | | |
|---|---|---|
| System No. | System Height Limitation | Attachment Clip Schedule |
| 1 | 23 ft | 10 ft o.c. |
| 2 | 44 ft | Base to 20 ft: 5 ft o.c.<br>20 ft to 44 ft: 10 ft o.c. |
| 3 | 66 ft | Base to 22 ft: 3'-4" o.c.<br>22 ft to 42 ft: 5 ft o.c.<br>42 ft to 66 ft: 10 ft o.c. |

H-Stud

Source: Clark Dietrich

Attachment Clips: Aluminum or steel angles, usually 14 – 16 gauge, 2" wide with 2" to 2-1/2" long legs. Attaches to wall framing and H-studs

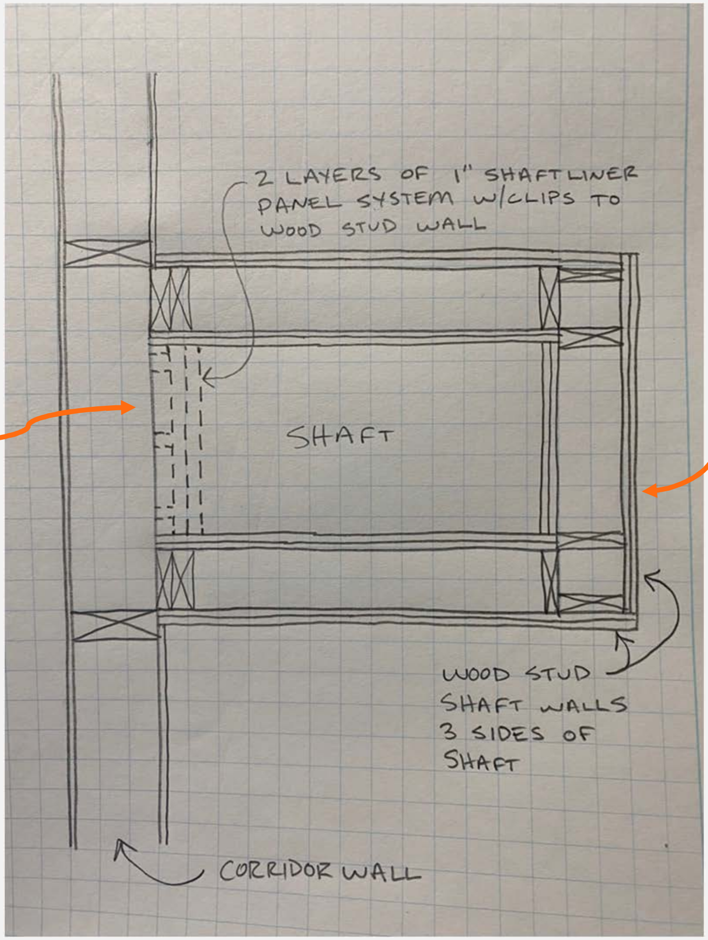
# Shaftliner Systems – Configuration Options




Can also utilize wood framed shaft walls on 3 sides and CH studs with shaftliner on 4th side

# Shaftliner Systems – Configuration Options

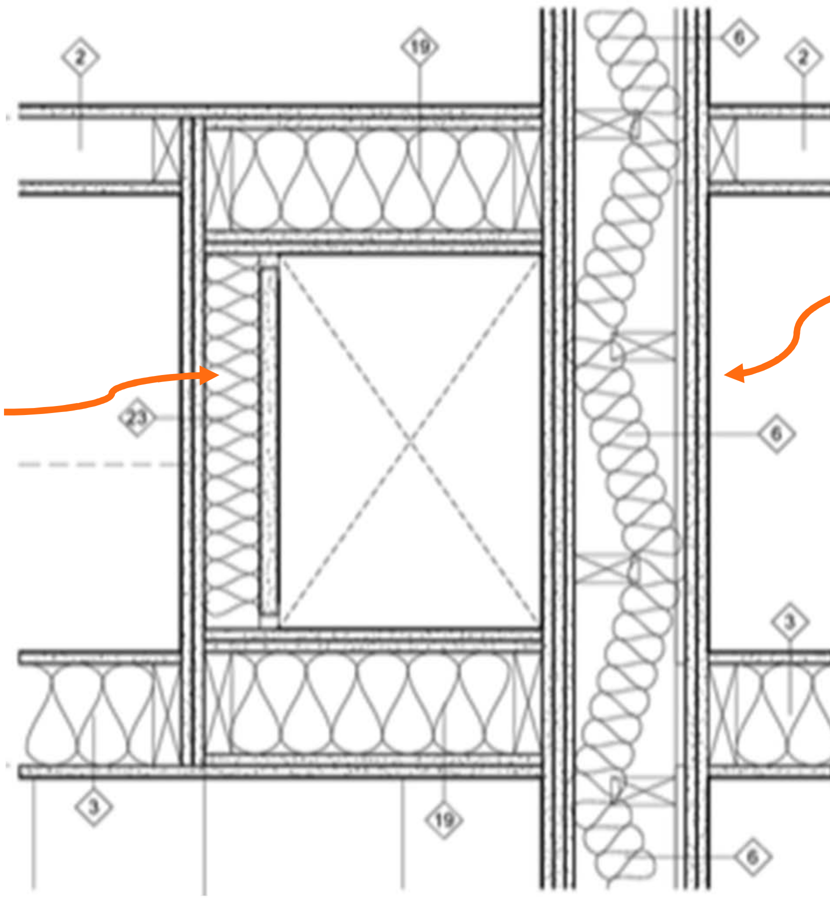
H-stud shaftliner with wood stud wall backup




3 sides of wood shaft walls installed first. If shaft is small enough, might suggest shaftliner system on more than one side

# Shaftliner Systems – Configuration Options

CH-stud shaftliner




3 sides of wood shaft walls installed first. If shaft is small enough, might suggest shaftliner system on more than one side

# Floor to Shaft Wall Detailing

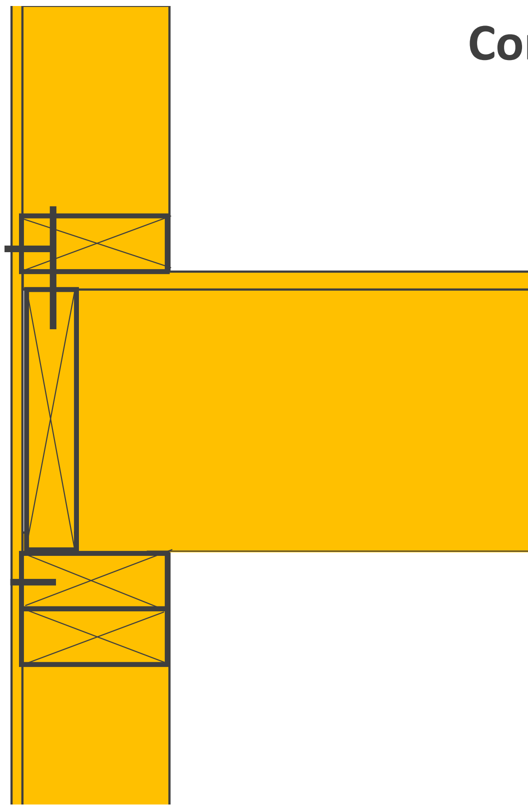
After shaft wall assembly is selected, need to consider how it will interface with floors and roof it intersects

Some key considerations are:

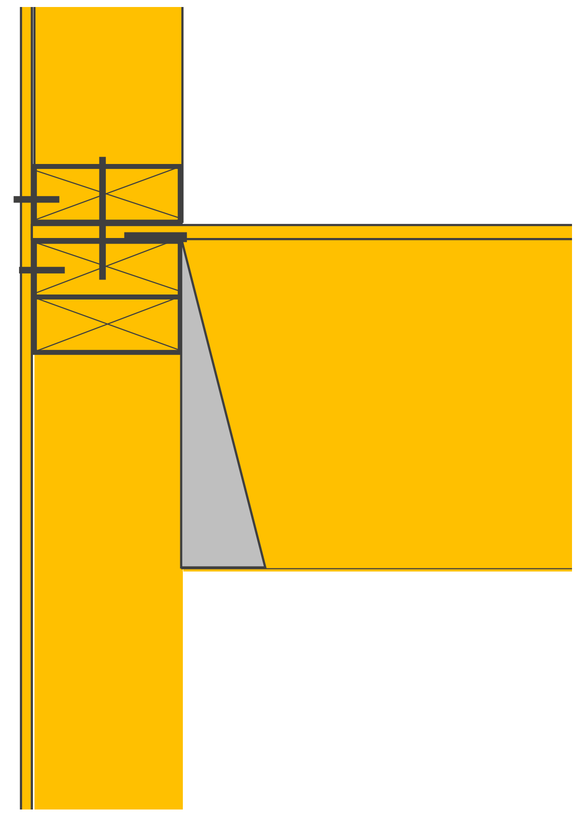

- Supporting Construction
- Continuity and Hourly Ratings
- Joints and Penetrations
- Depends on floor joist/truss type used, bearing condition
- No tested intersections exist; discuss desired detail and rationale with building official
- The following are just a few options - Contact local WoodWorks Regional Director for regional preferences, rationale, insight

# Floor to Shaft Wall Detailing

**Common Details**



**Platform Framing**

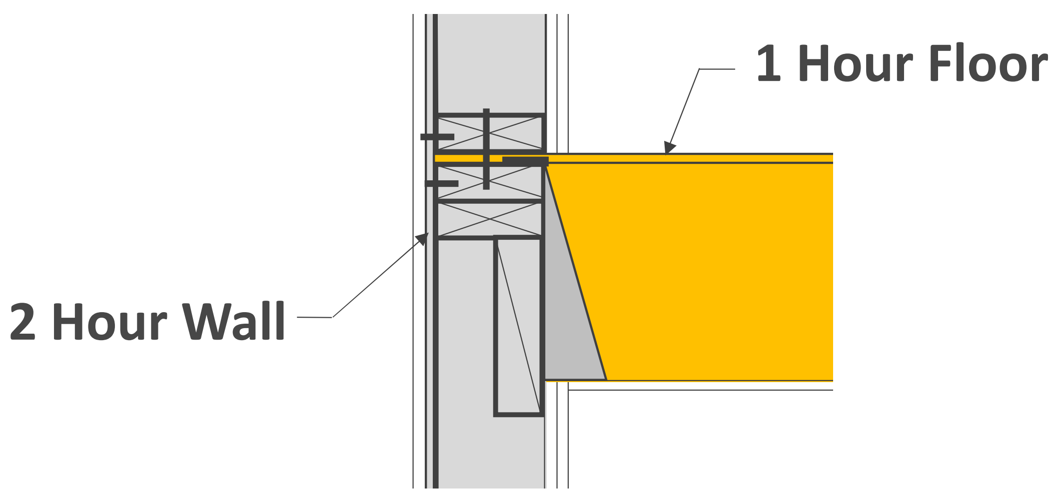


**Semi-Balloon Framing**

# Floor to Shaft Wall Detailing

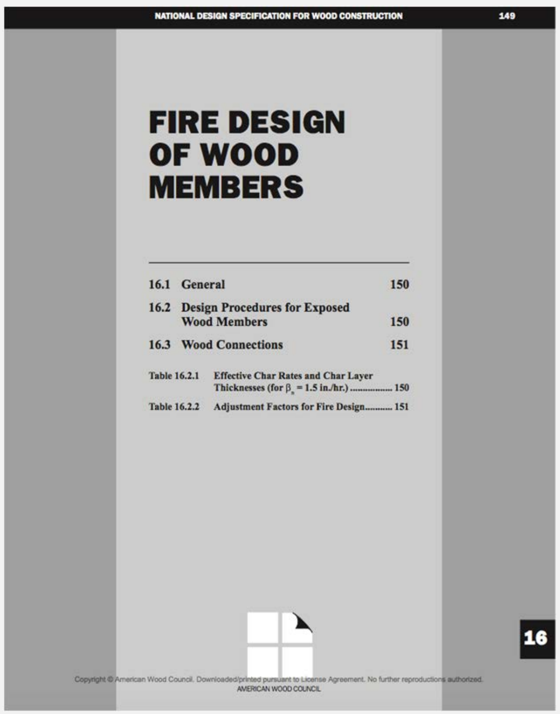
*Supporting Construction: In platform and semi-balloon frame construction, if we have a 2-hour shaft wall and a 1-hour floor, how do we achieve this?*

If we are able to demonstrate the wall's 2-hour continuity through the floor depth, should not need to consider the floor "supporting construction"



# Calculated Fire Resistance of Wood

For Exposed Wood Members: IBC 722.1 References AWC's NDS Chapter 16
(AWC's TR 10 is a design aid to NDS Chapter 16)

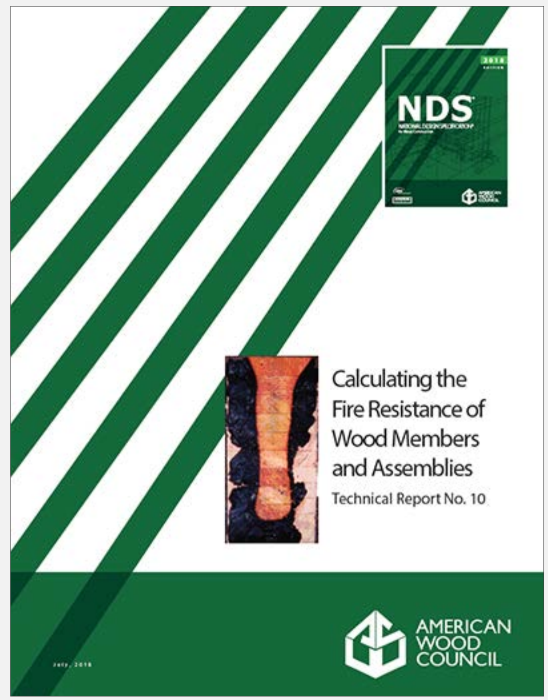

NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION 149

**FIRE DESIGN OF WOOD MEMBERS**



16





# Calculated Fire Resistance of Wood

Assumptions:

- Nominal assumed char rate = 1.5”/hr.
- Uses ultimate strength for design check

Structurally spanning members: reduced section checked for capacity vs. demand

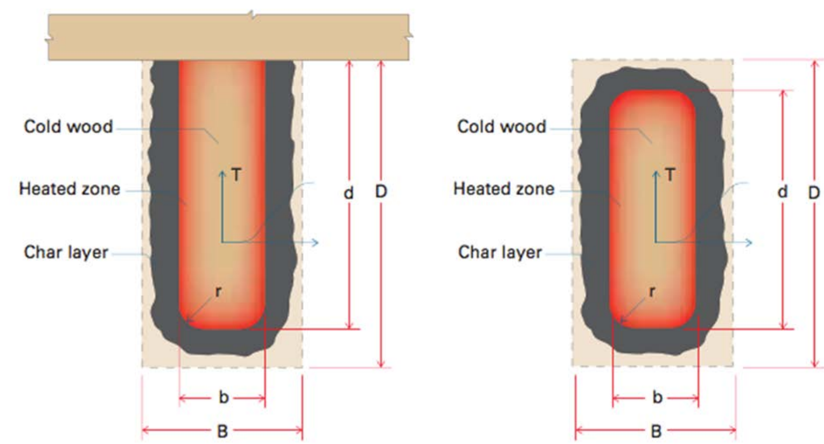
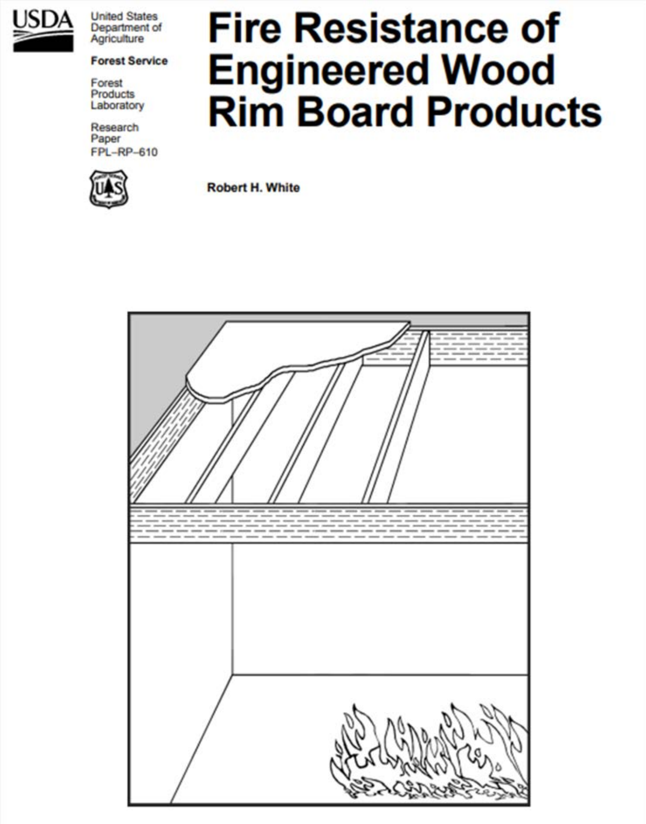



**Figure 1-1** Reduction in member breadth and depth over time, t

Source: AWC’s TR 10

# Calculated Fire Resistance of Wood

Report FPL-RP-610 from USDA FPL summarizes results from fire testing on rim boards.



# Light Wood-Frame Shaft Walls in Light Wood-Frame Buildings

# Floor to Shaft Wall Detailing

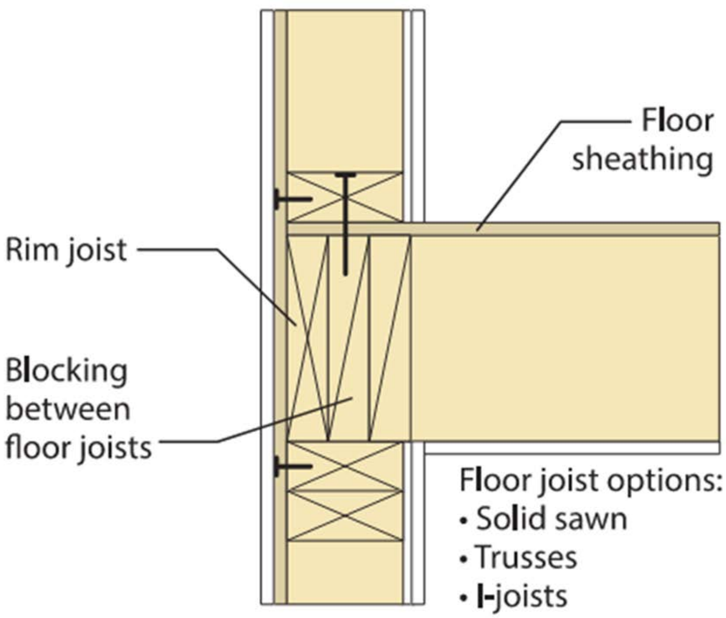



**FIGURE 11:** Floor-to-shaft wall intersection with blocking between floor joists

- Fire-resistance rating continues to the underside of the deck
- Assumes a tested assembly to the top of wall plate
- Above wall top plate, uses 703.3 allowance for fire-resistance calculations per 722
- 722 allows NDS Chapter 16 methods for fire resistance calculations for exposed wood
- Combustibility of the material is not an issue; must meet the fire rating requirement

# Floor to Shaft Wall Detailing

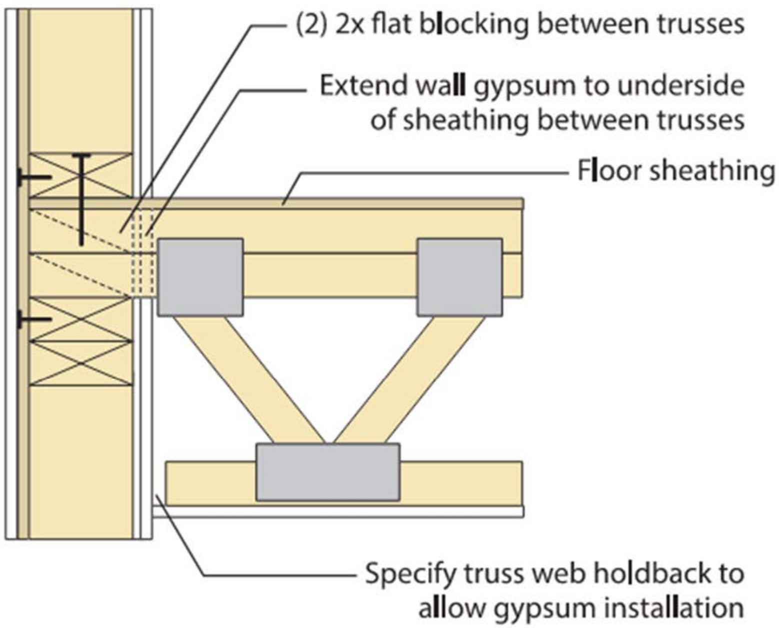



**FIGURE 12:** Floor-to-shaft wall intersection with gypsum extending to underside of sheathing between trusses

# Floor to Shaft Wall Detailing

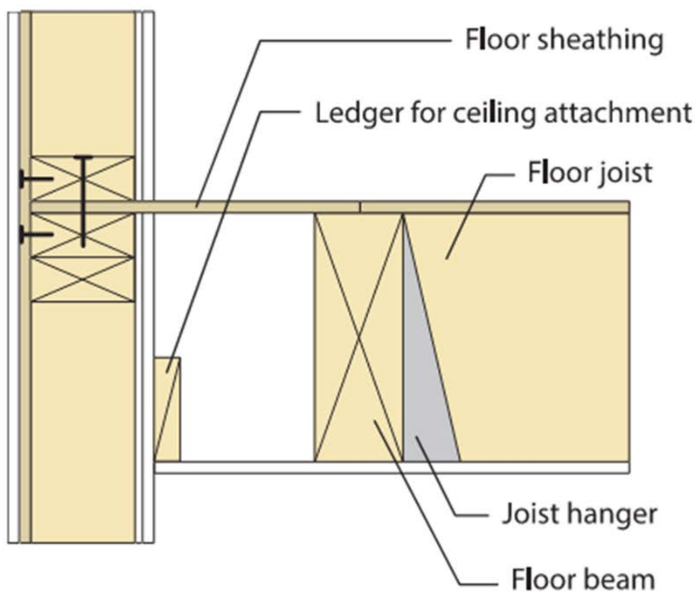



**FIGURE 13:** Floor-to-shaft wall intersection with supporting beam just inboard of wall

Credit: WoodWorks

# Floor to Shaft Wall Detailing

- Perhaps most conservative solution
- Cost and schedule are considerations
- Some require that wall gypsum be installed prior to hanger, some allow post-install
- Not uncommon in type III floor to exterior wall details – easy extension to shaft walls
- Several options on the market

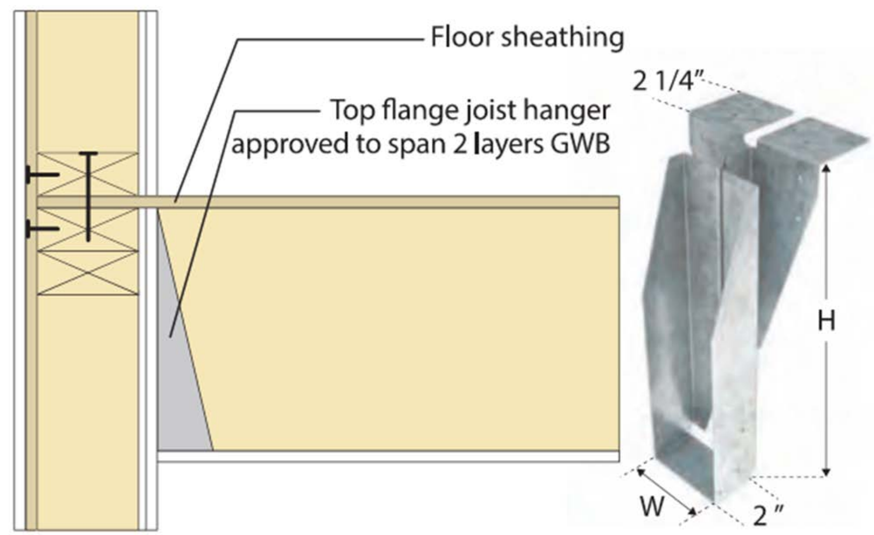



**FIGURE 14:** Floor-to-shaft wall intersection with hangers designed to span over gypsum
*Credit (image on the right): MiTek Builder Products*

# Floor to Shaft Wall Detailing

- Can be a challenge structurally to make fasteners work
- Scheduling and sequencing considerations
- Allows use of standard face mount hangers
- A common situation at stair shaft intermediate framing

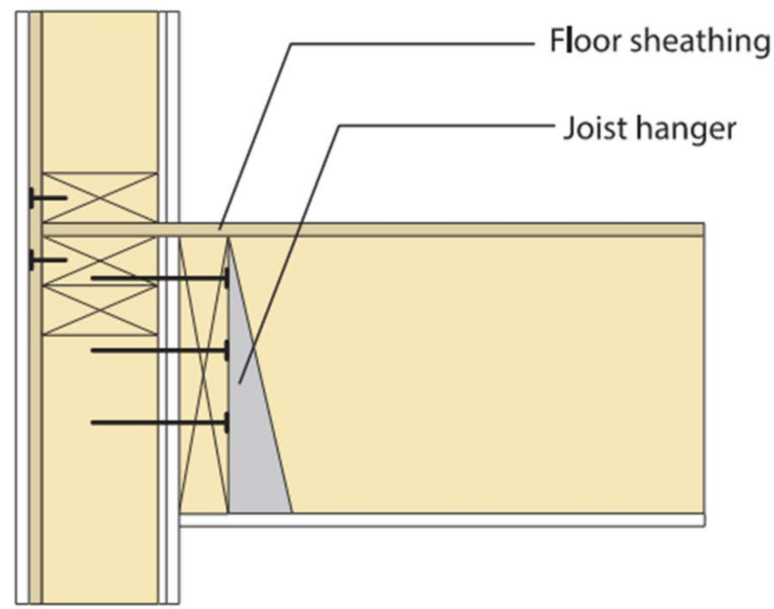
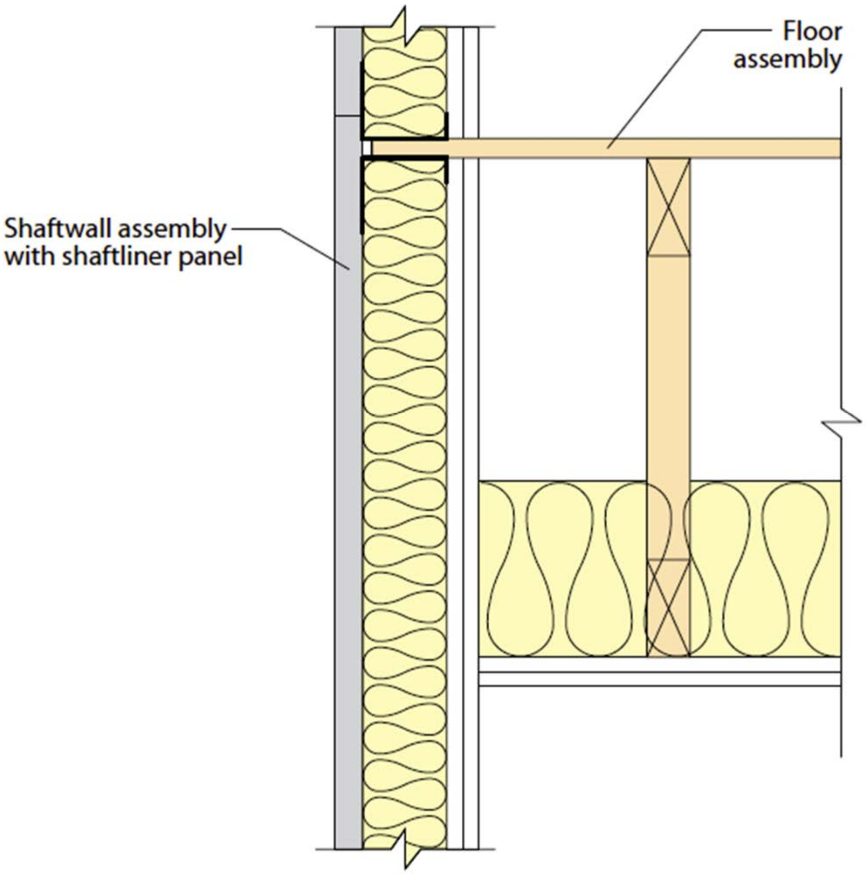
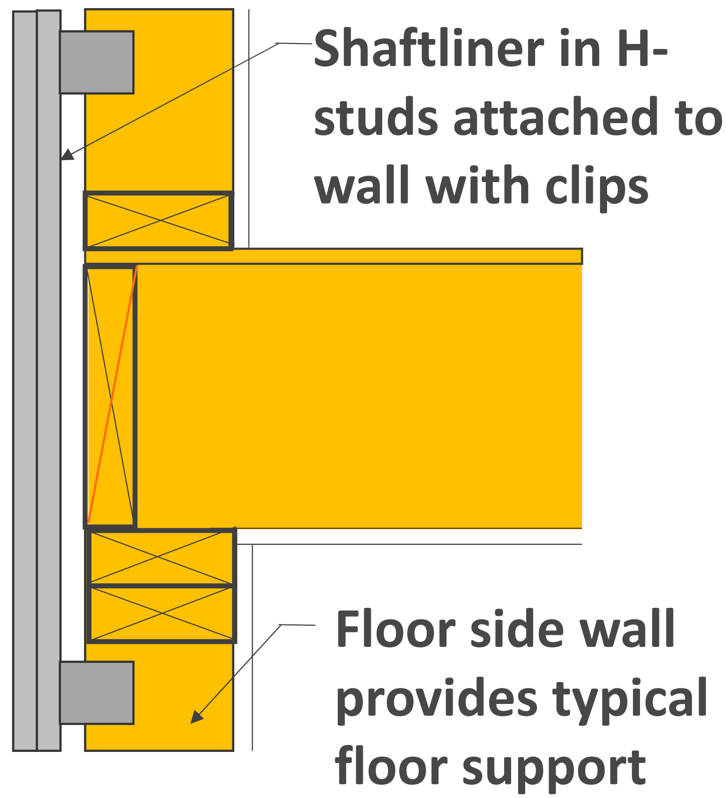



**FIGURE 15:** Floor framing ledger attached to shaft wall through two layers of gypsum

# Shaftliner Systems in Light Wood-Frame Buildings

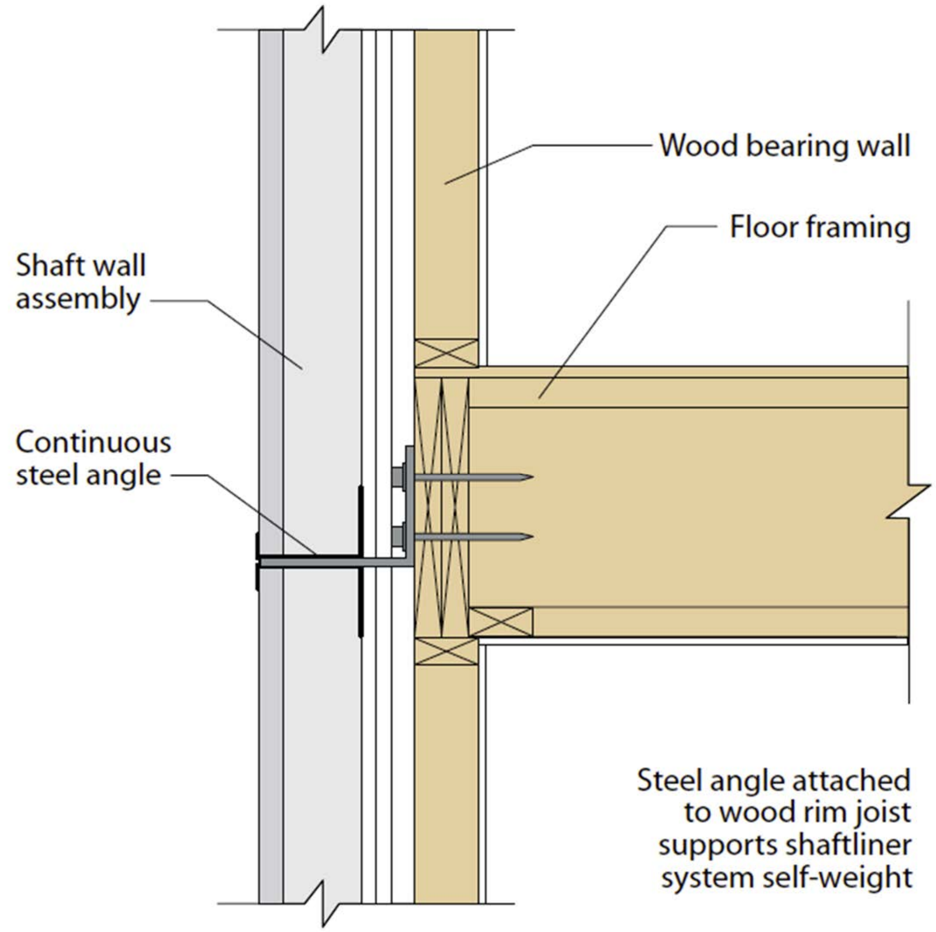
# Floor to Shaft Wall Detailing



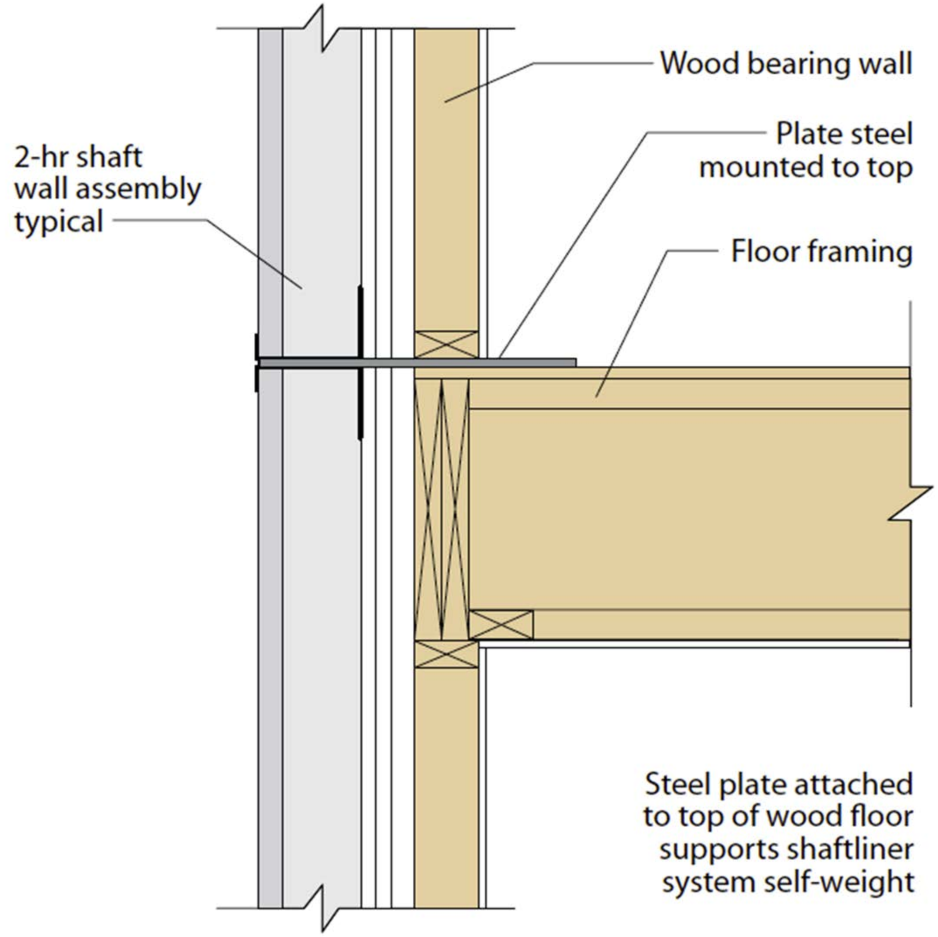
# Shaftliner Systems – Support Details

Steel angle attached to wood rim joist supports shaftliner system self-weight



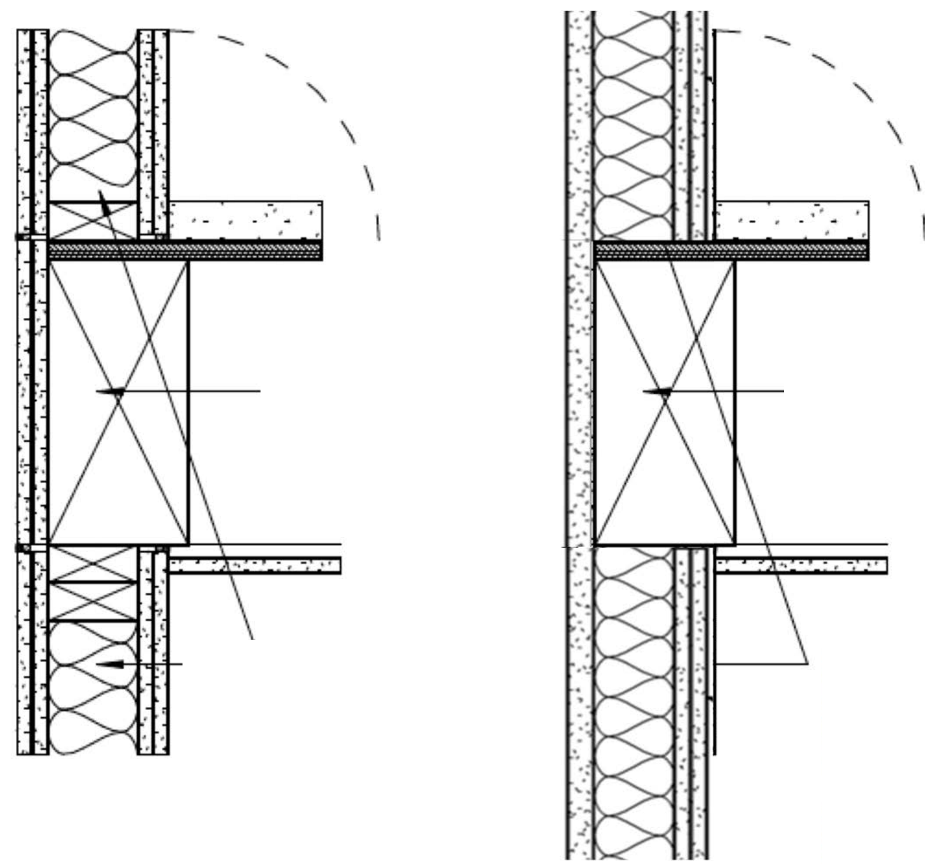
# Shaftliner Systems – Support Details

Steel plate attached to top of wood floor supports shaftliner system self-weight



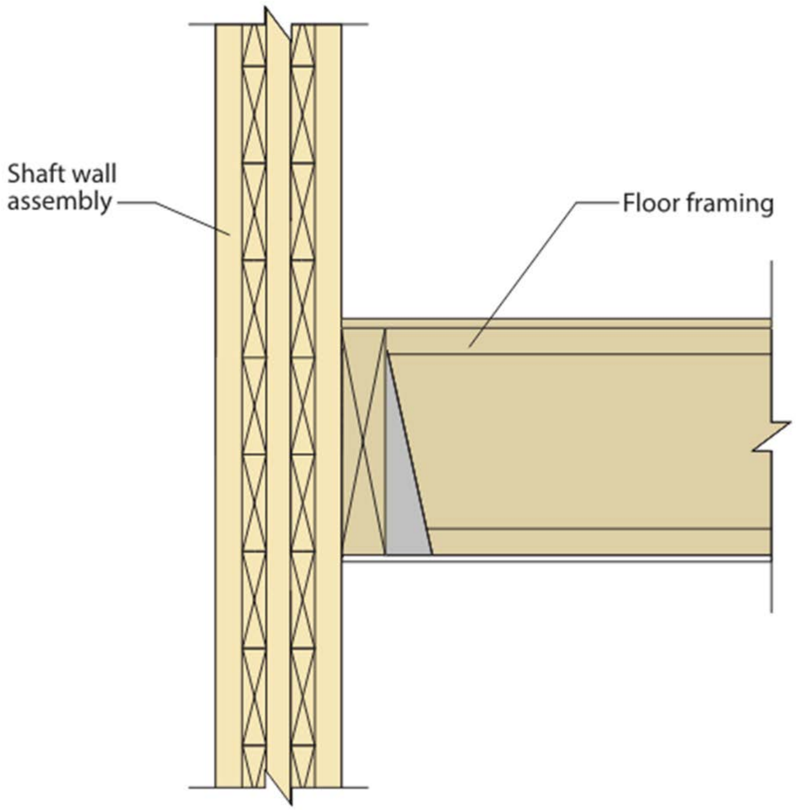
# Shaftliner Systems – Support Details

Shaftliner system self-weight supported on wood floor in platform framed condition

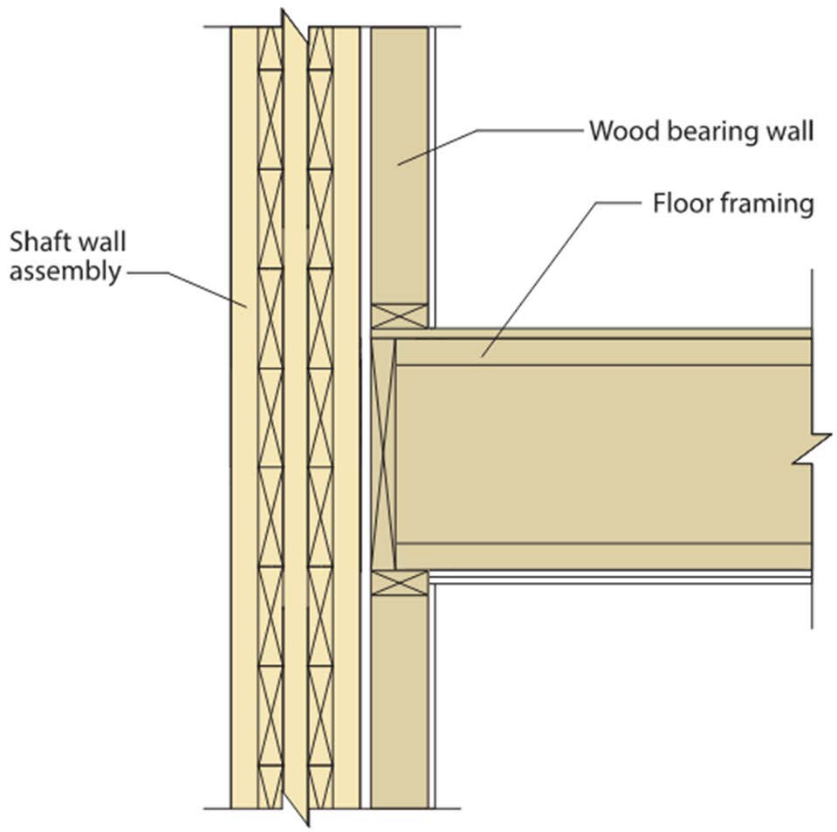


# Mass Timber Shafts in Light Wood-Frame Buildings

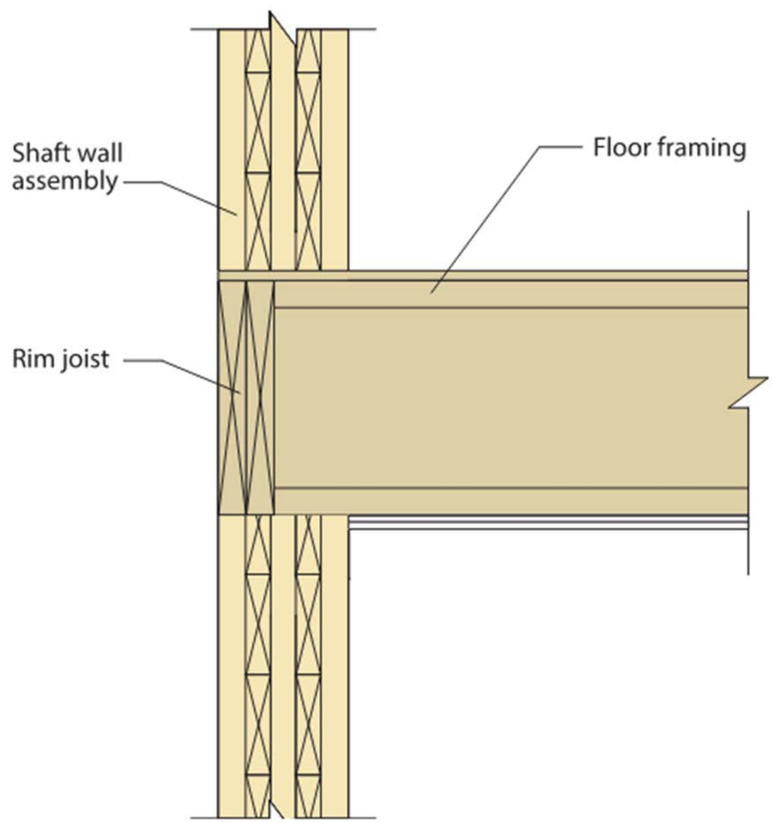
# Floor to Shaft Wall Detailing




# Floor to Shaft Wall Detailing



# Floor to Shaft Wall Detailing



# Other Shaft Wall Materials in Light Wood-Frame Buildings

# Non-Wood Shaft Walls

# Masonry Shaft Walls

Mixing masonry shaft walls with wood floor framing can create several issues:

- Masonry shaft walls often become part of building’s lateral force resisting system
- This increases seismic forces and adds mass
- Difference in stiffness between wood & masonry shear walls may need to be considered
- Differential shrinkage between wood and masonry needs to be considered
- Best practices include seismically isolating masonry shaft walls, only tie wood floor to masonry shaft if/where required (i.e., at door threshold)

AC0

# Masonry Shaft Walls

Table 12.2-1 Design Coefficients and Factors for Seismic Force-Resisting Systems

| Seismic Force-Resisting System | ASCE 7 Section Where Detailing Requirements Are Specified | Response Modification Coefficient, $R^a$ | Overstrength Factor, $\Omega_0^g$ | Deflection Amplification Factor, $C_d^b$ | Structural System Limitations Including Structural Height, $h_n$ (ft) Limits[c] — Seismic Design Category: B | C | $D^d$ | $E^d$ | $F^e$ |
|---|---|---|---|---|---|---|---|---|---|
| 15. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance | 14.5 | 6½ | 3 | 4 | NL | NL | 65 | 65 | 65 |
| 16. Special reinforced masonry shear walls | 14.4 | 5½ | 2½ | 4 | NL | NL | 160 | 160 | 100 |
| 17. Intermediate reinforced masonry shear walls | 14.4 | 4 | 2½ | 4 | NL | NL | NP | NP | NP |
| 18. Ordinary reinforced masonry shear walls | 14.4 | 2 | 2½ | 2 | NL | 160 | NP | NP | NP |

Source: ASCE 7-16

Mass Matters:

8” CMU Wall, grout & reinforcing @ 48” o.c.: **44 psf**

2x6 wood wall w/2-layers of 5/8” gypsum each side: **16 psf**

## Slide 108

**AC0** Is it worth mentioning this is also a potential consideration for mass timber shaft walls, which have low R values?
Ashley Cagle, 2022-11-29T22:26:57.271

**RM0 0** I think adding the mass of a mass timber shaft wall here would be a good idea. There could be a lot of extra material to cover if going into the structural differences of these wall types for lateral resistance, but just showing the basics of R value and mass would help illustrate the point
Ricky McLain, 2022-12-01T22:08:13.767

**AC0 1** See next slide. Is this okay? Kind of an interruption to the masonry discussion, but addressed in speaker notes.
Ashley Cagle, 2022-12-03T00:09:20.070

**RM0 2** I think it works. We should probably also point out the mass of the CLT sheaerwalls so that that could be compared to the masonry walls. Even if they are on different slides
Ricky McLain, 2022-12-03T10:17:03.834

# Mass Timber Shaft Walls

**Table 12.2-1 Design Coefficients and Factors for Seismic Force-Resisting Systems**

| Seismic Force-Resisting System | ASCE 7 Section Where Detailing Requirements Are Specified | Response Modification Coefficient, $R^a$ | Overstrength Factor, $\Omega_0^g$ | Deflection Amplification Factor, $C_d^b$ | Structural System Limitations Including Structural Height, $h_n$ (ft) Limits[c] — Seismic Design Category: B | C | $D^d$ | $E^d$ | $F^e$ |
|---|---|---|---|---|---|---|---|---|---|
| 15. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance | 14.5 | 6½ | 3 | 4 | NL | NL | 65 | 65 | 65 |
| 20. Cross-laminated timber shear walls | 14.5 | 3 | 3 | 3 | 65 | 65 | 65 | 65 | 65 |
| 21. Cross-laminated timber shear walls with shear resistance provided by high-aspect-ratio panels only | 14.5 | 4 | 3 | 4 | 65 | 65 | 65 | 65 | 65 |

Source: ASCE 7-22

Mass Matters:

5-ply CLT (6 7/8" thick): **16.5 psf – 21 psf**

# Masonry Shaft Walls

**12.2.3.3 *R*, $C_d$, and $\Omega_0$ Values for Horizontal Combinations.** The value of the response modification coefficient, $R$, used for design in the direction under consideration shall not be greater than the least value of $R$ for any of the systems utilized in that direction. The deflection amplification factor, $C_d$, and the overstrength factor, $\Omega_0$, shall be consistent with $R$ required in that direction.

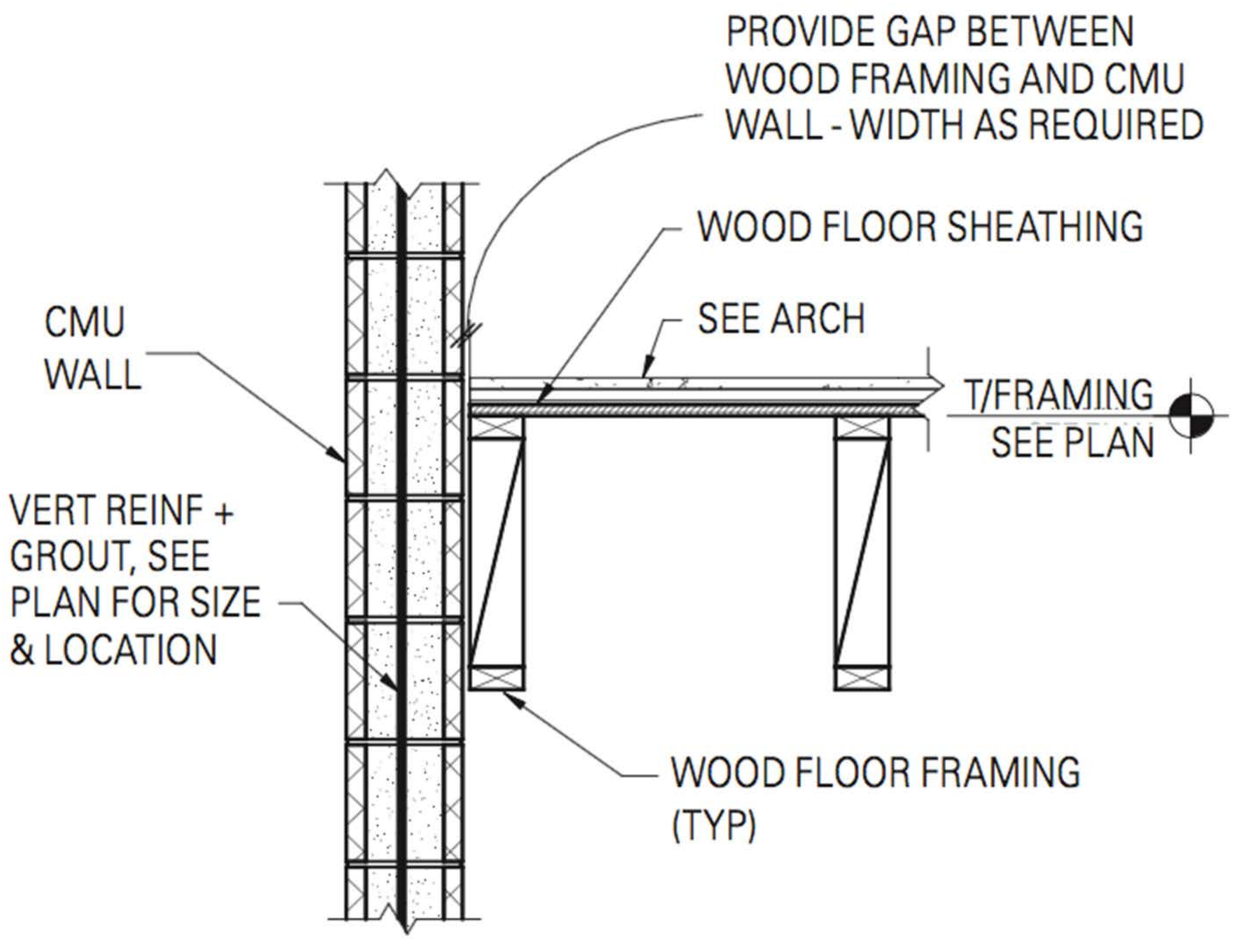
Source: ASCE 7-16

**4.1.5 Wood Members and Systems Resisting Seismic Forces Contributed by Masonry and Concrete Walls**

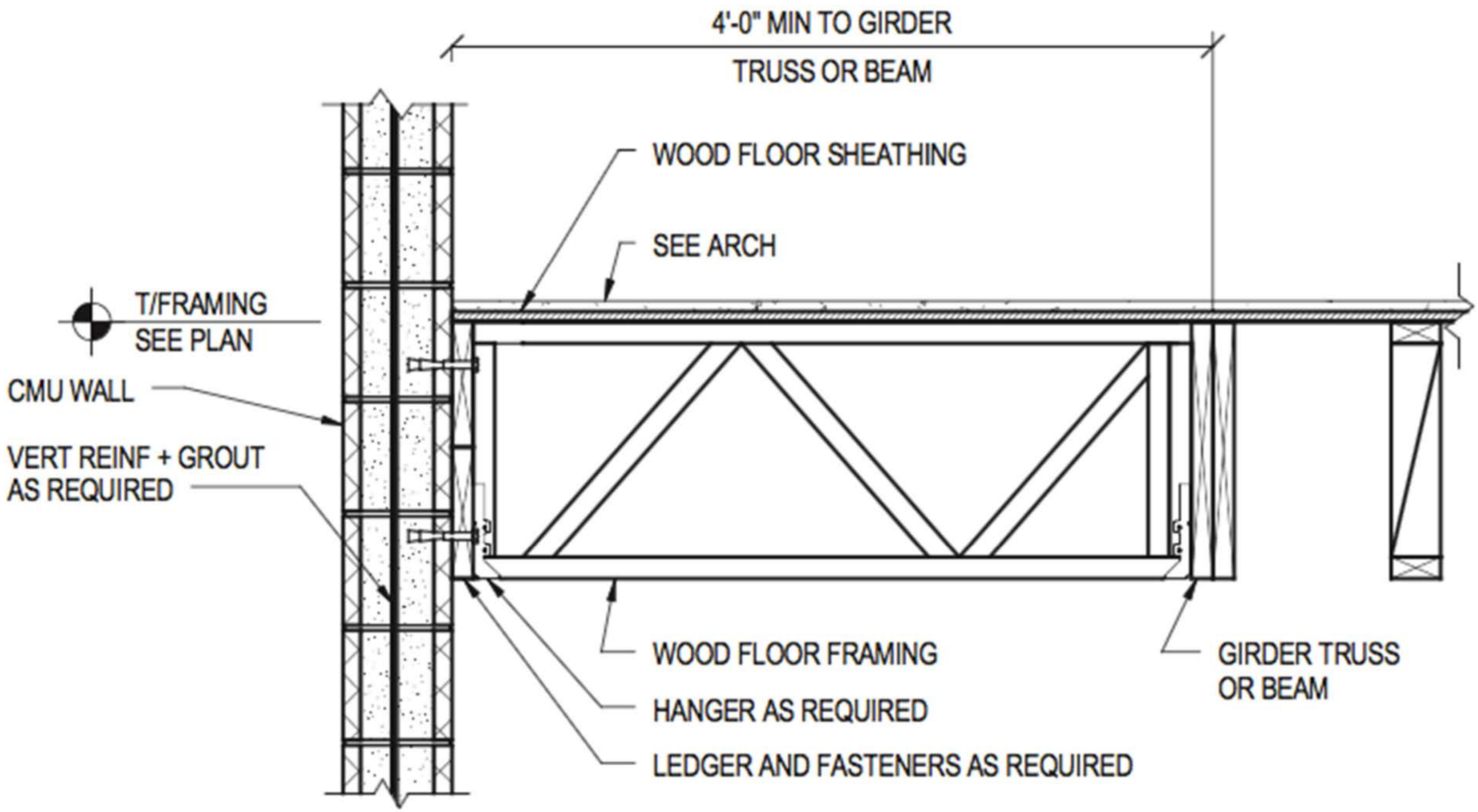
Wood-frame shear walls, wood-frame diaphragms, trusses, and other wood members and systems shall not be used to resist seismic forces contributed by masonry or concrete walls in structures over one story in height.

Source: SDPWS 2015

# Masonry Shaft Walls



# Masonry Shaft Walls



# Shrinkage & Movement Resource

Code provisions, detailing options, calculations and more for accommodating differential material movement in wood structures

Free resource at **woodworks.org**

WoodWorks™ WOOD PRODUCTS COUNCIL

## Accommodating Shrinkage in Multi-Story Wood-Frame Structures

*Richard McLain, MS, PE, SE, Technical Director, WoodWorks • Doug Steimle, PE, Principal, Schaefer*

In wood-frame buildings of three or more stories, cumulative shrinkage can be significant and have an impact on the function and performance of finishes, openings, mechanical/electrical/plumbing (MEP) systems, and structural connections. However, as more designers look to wood-frame construction to improve the cost and sustainability of their mid-rise projects, many have learned that accommodating wood shrinkage is actually very straightforward.

Wood is hygroscopic, meaning it has the ability to absorb and release moisture. As this occurs, it also has the potential to change dimensionally. Knowing how and where wood shrinks and swells helps designers detail their buildings to minimize related effects.

Wood shrinkage occurs perpendicular to grain, meaning that a solid sawn wood stud or floor joist will shrink in its cross-section dimensions (width and depth). Longitudinal shrinkage is negligible, meaning the length of a stud or floor joist will essentially remain unchanged. In multi-story buildings, wood shrinkage is therefore concentrated at the wall plates, floor and roof joists, and rim boards. Depending on the materials and details used at floor-to-wall and roof-to-wall intersections, shrinkage in light-frame wood construction can range from 0.05 inches to 0.5 inches per level.

This publication will describe procedures for estimating wood shrinkage and provide detailing options that minimize its effects on building performance.

### Wood Science & Shrinkage

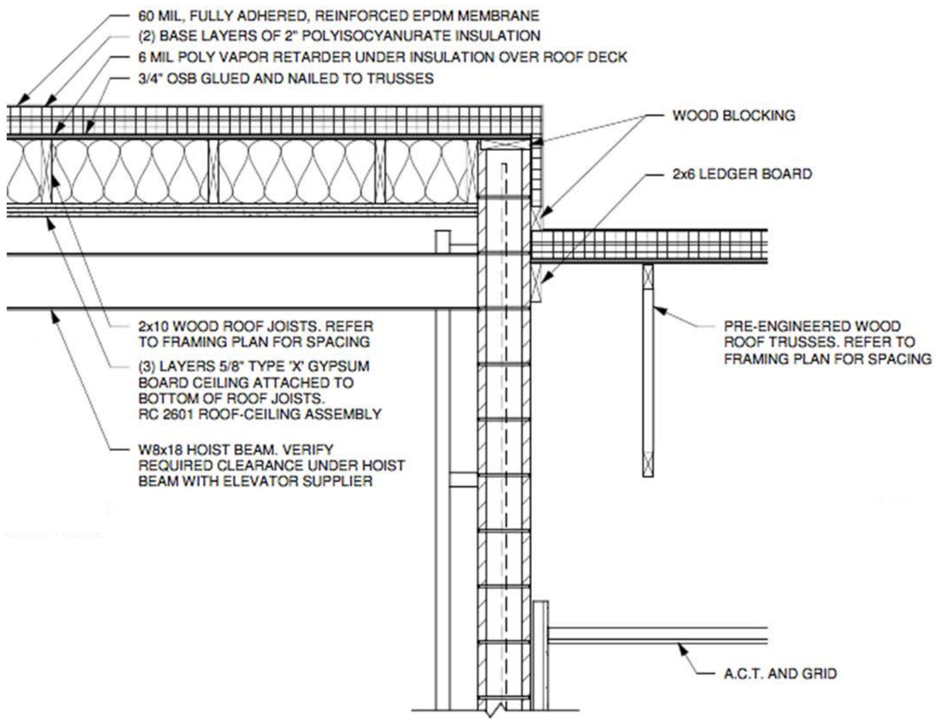
Understanding the cellular structure of wood allows us to understand how moisture and wood interact and identify the

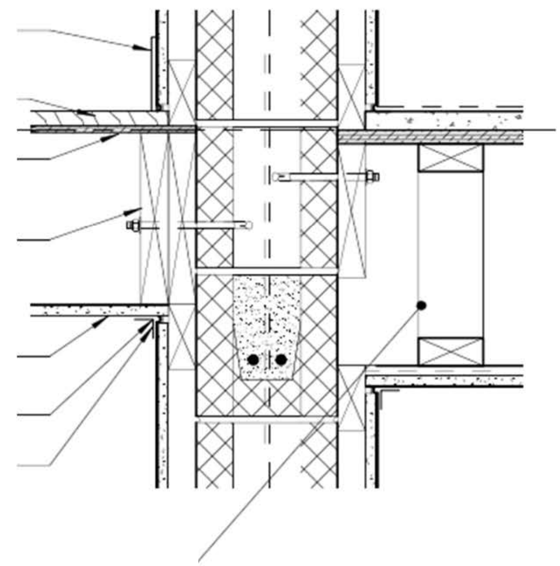
The Brooklyn Riverside
Jacksonville, Florida
Architect: Dwell Design Studio
Structural Engineer: M2 Structural Engineering

*Photo: Pollack Shores, Matrix Residential*

a longitudinal cell in the wood. Water can be free water stored in the straw cavity or bound water absorbed by the straw walls. At high moisture contents, water exists in both locations. As the wood dries, the free water is released from the cell cavities before the bound water is released from the cell walls. When wood has no free water and yet the cell wall is still saturated, it is said to be at its fiber saturation point (FSP). Imagine a sponge that has just been taken out of a bucket filled with water. As the sponge is lifted from the bucket, water comes out of the pores. When the sponge is

# Shaft Wall Material Choice



**Why do we introduce new materials for our shaft walls?**

**They can be framed with wood!**

# Questions?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901 East Sixth, Thoughtbarn-Delineate Studio,
Leap!Structures, photo Casey Dunn

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*Funding provided in part by the Softwood Lumber Board*