

Shaft Wall Solutions for Wood-Frame Structures



Marc Rivard, SE, PE
Momo Sun, PE
Terry Pattillo, AIA

Shaft Walls

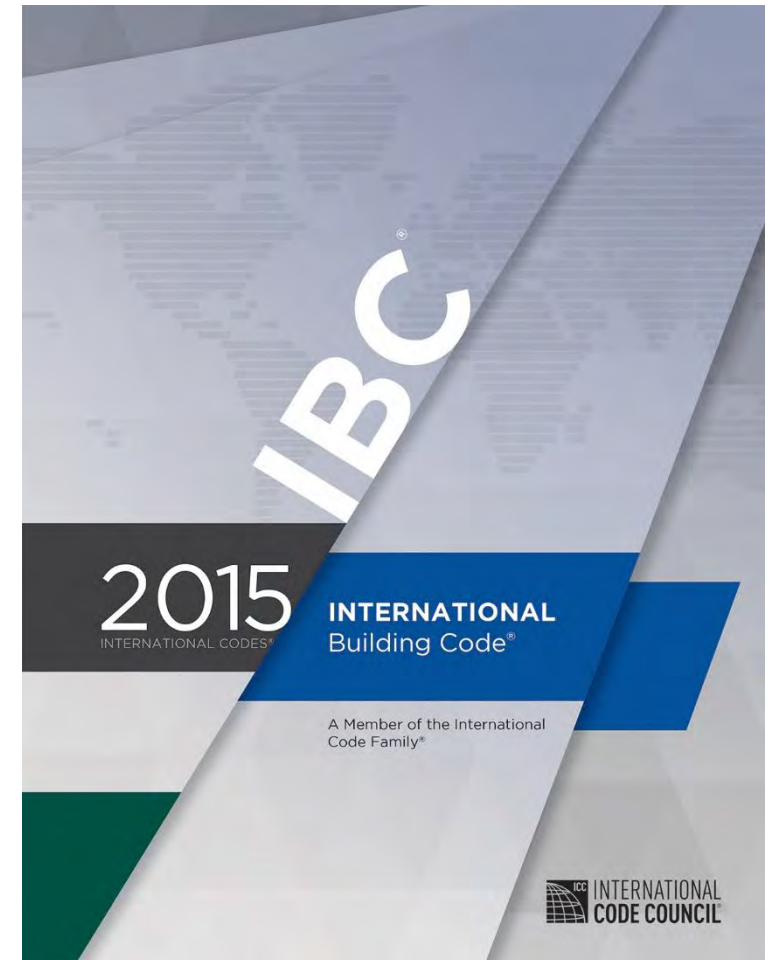


Shaft Walls

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

Types of Shafts:

- Elevator
- Stair
- Mechanical



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.

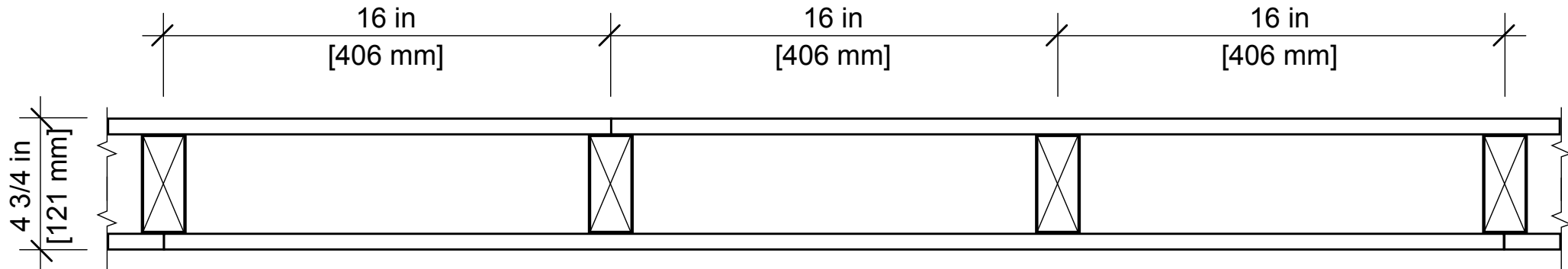
- IBC 713.2: Shaft Walls shall be constructed as Fire Barriers
- Many shaft wall provisions contained in IBC Section 707 – Fire Barriers

Defining Shaft Wall Requirements

Shaft Wall Hourly Ratings:

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

SECTION 707 FIRE BARRIERS

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 and V

Shaft Wall Materials

Type III Construction:

Any material permitted by code for all interior elements

Fire-retardant treated wood for exterior walls

Type IV Construction:

Heavy/mass timber members (or any wood wall min. 1 hr) for all interior elements

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 | Type V |
|-----------------------------|---------------------------------|--|---------------------------------|
| Interior Shaft Walls | Any code permitted wood framing | Heavy timber or any code permitted wood framing (min. 1 hr rated required) | Any code permitted wood framing |
| Exterior Shaft Walls | Fire-retardant treated wood | Fire-retardant treated wood or CLT | Any code permitted wood framing |

Shaft Wall Materials

Light Frame Wood Shaft Walls

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



Shaft Wall Materials

Mass Timber Shaft Walls

- Cost
- Construction Schedule
- Can double as architectural feature
- Successful fire tests for 2 Hr mass timber shaft walls exist (exposed and protected)



Photo: Lendlease

Continuity Provisions

SECTION 713 SHAFT ENCLOSURES

713.5 Continuity.

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

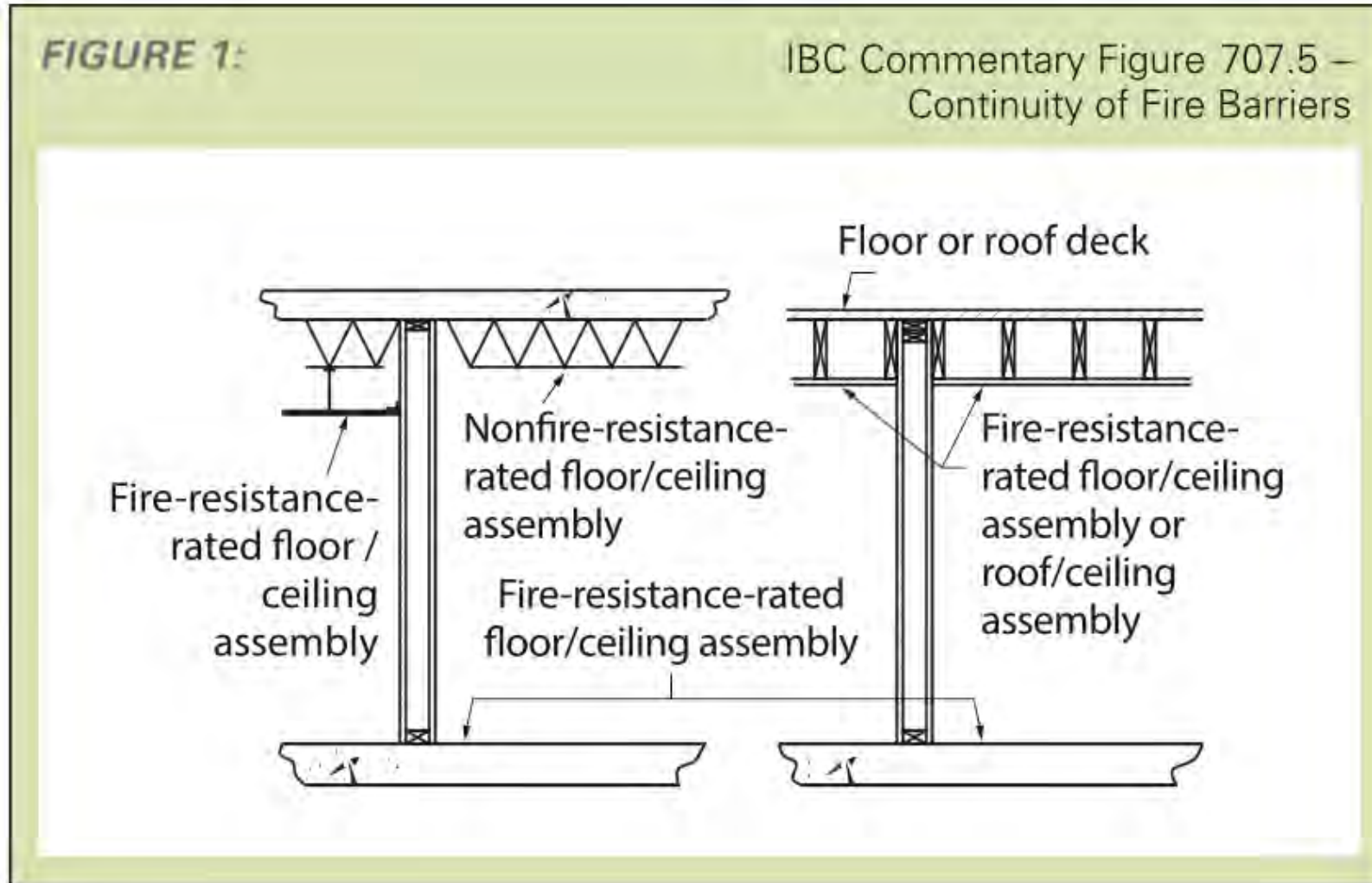
SECTION 707 FIRE BARRIERS

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?



Continuity Provisions



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

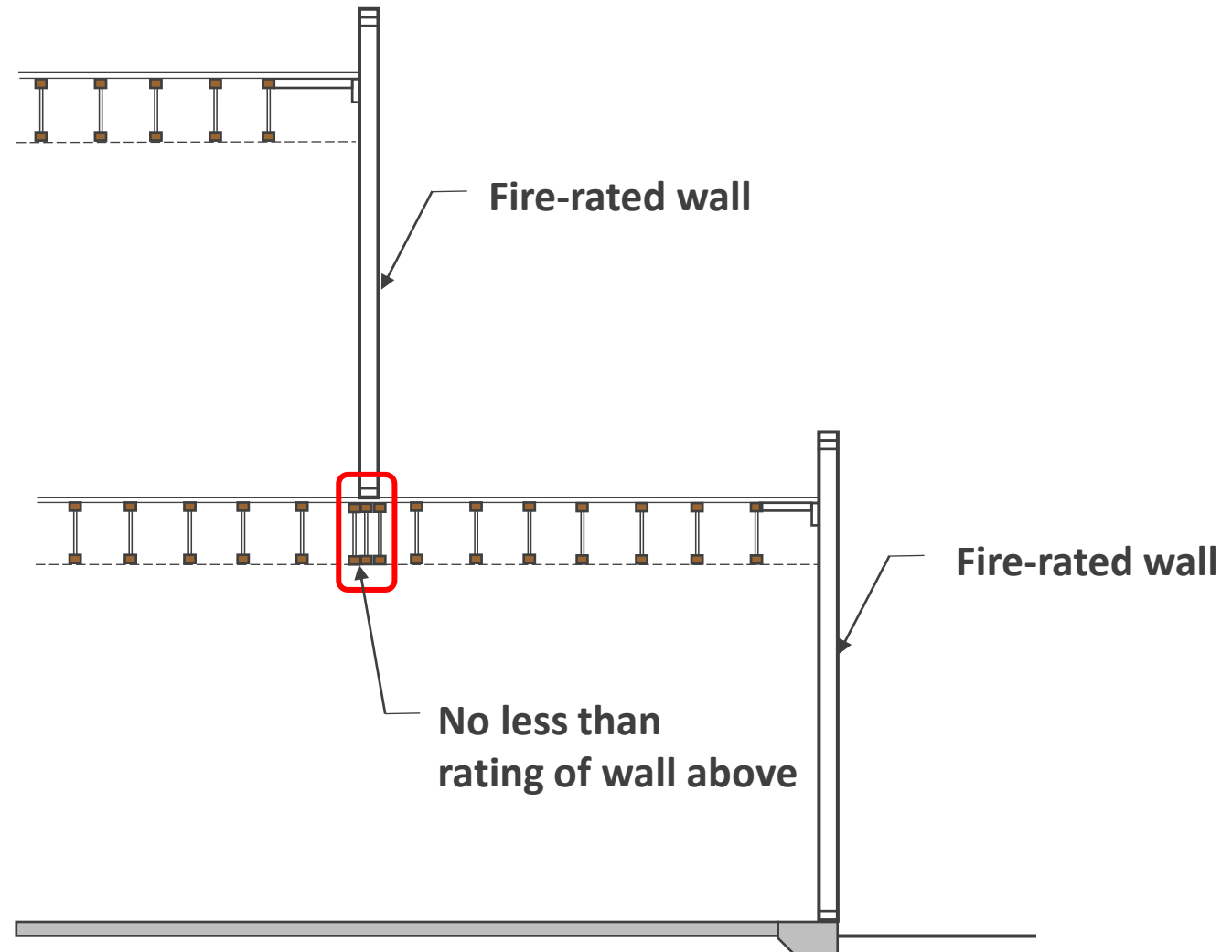
We'll cover some detailing options later...

Supporting Construction Provisions

IBC 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.

i.e. shaft walls that are not continuous to lowest level



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 / a floor assembly intersecting a shaft wall constitute a joint? In wood-frame construction, typically, no.

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?

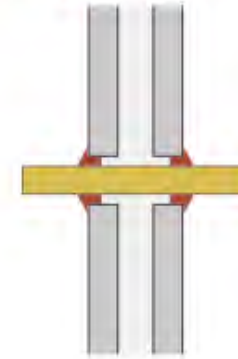
- Main Floor Joists to Shaft Wall Connection
- Stair framing to Shaft Wall Connection



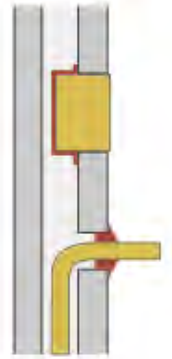
Penetrations in Shaft Walls

SECTION 714 PENETRATIONS

Through Penetration



Membrane Penetration



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

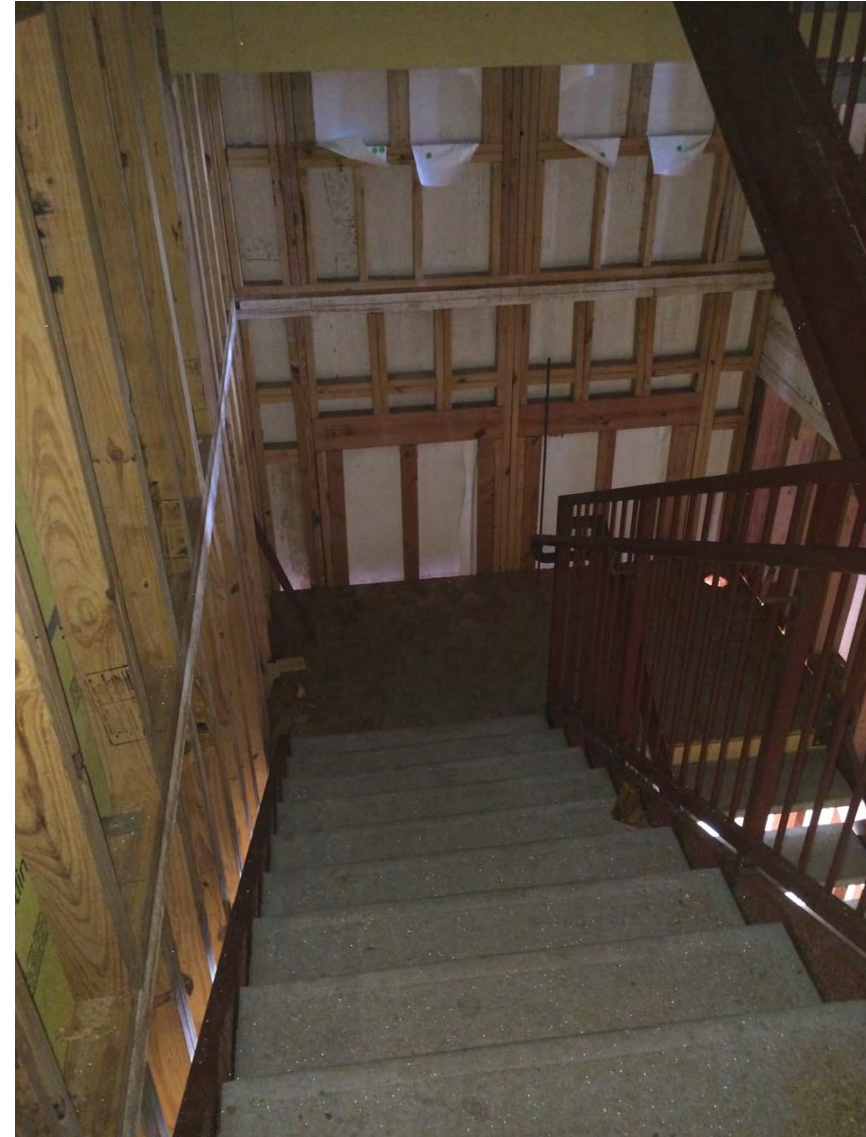


Penetrations in Shaft Walls

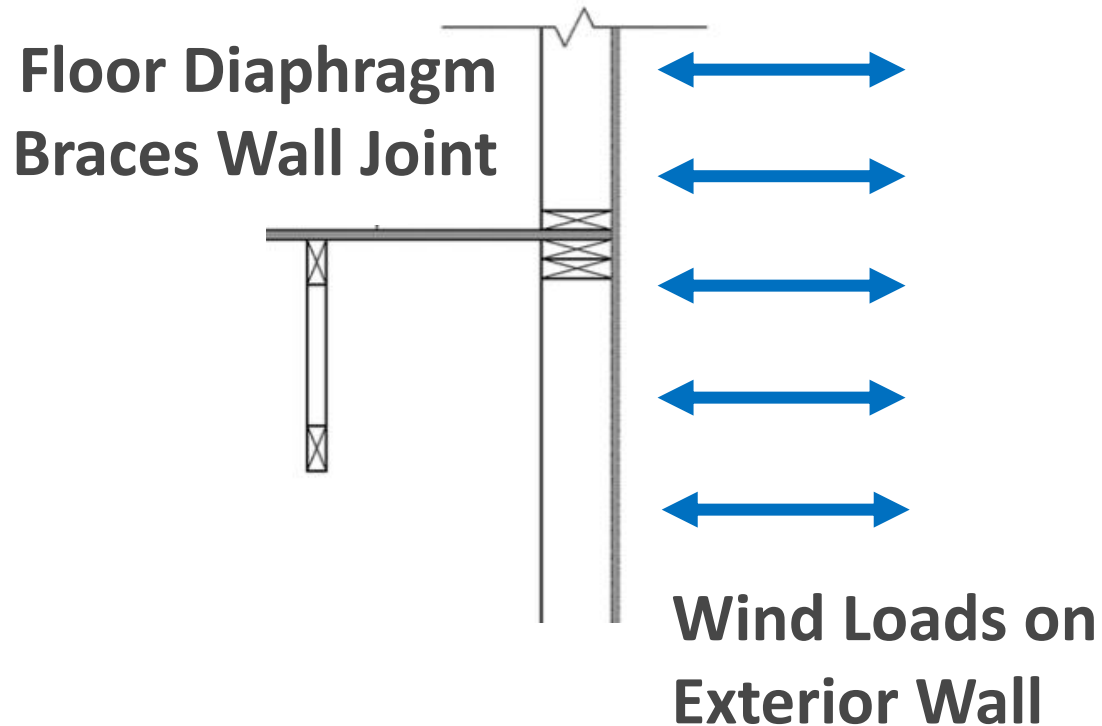


Stair landing beam shaft wall structural penetration prior to firestop system installation

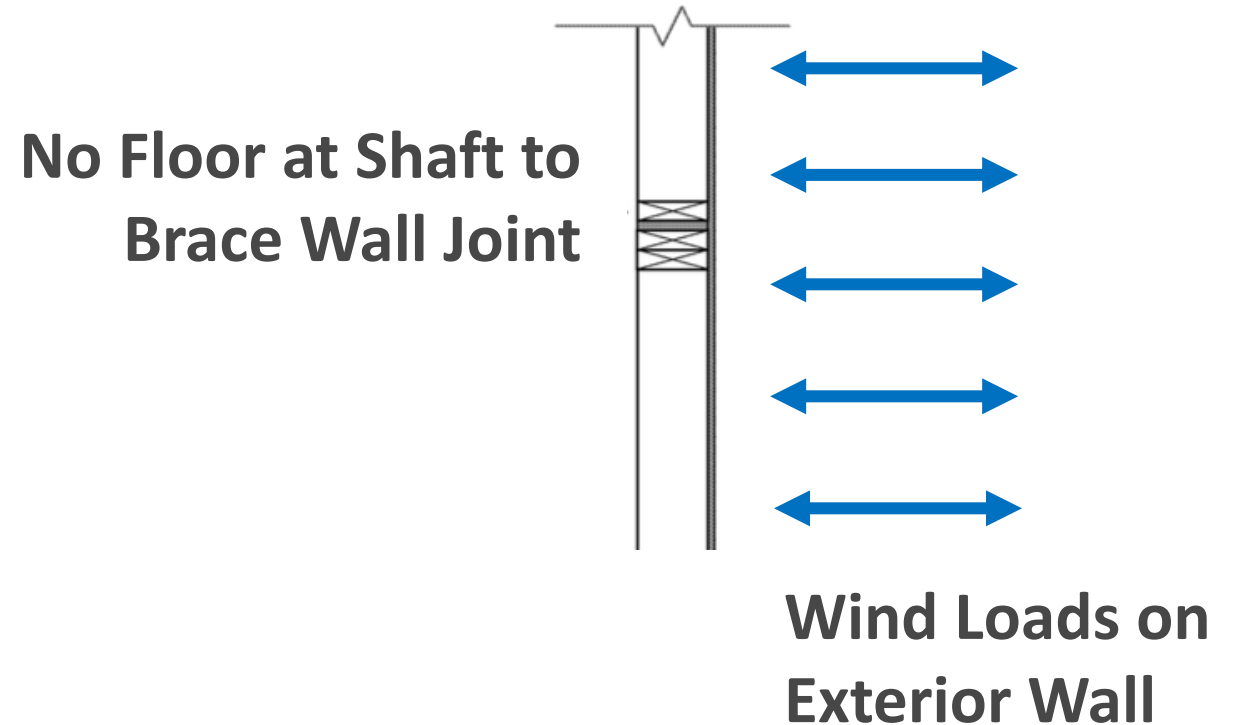
Shaft Walls that are also Exterior Walls



Shaft Walls that are also Exterior Walls

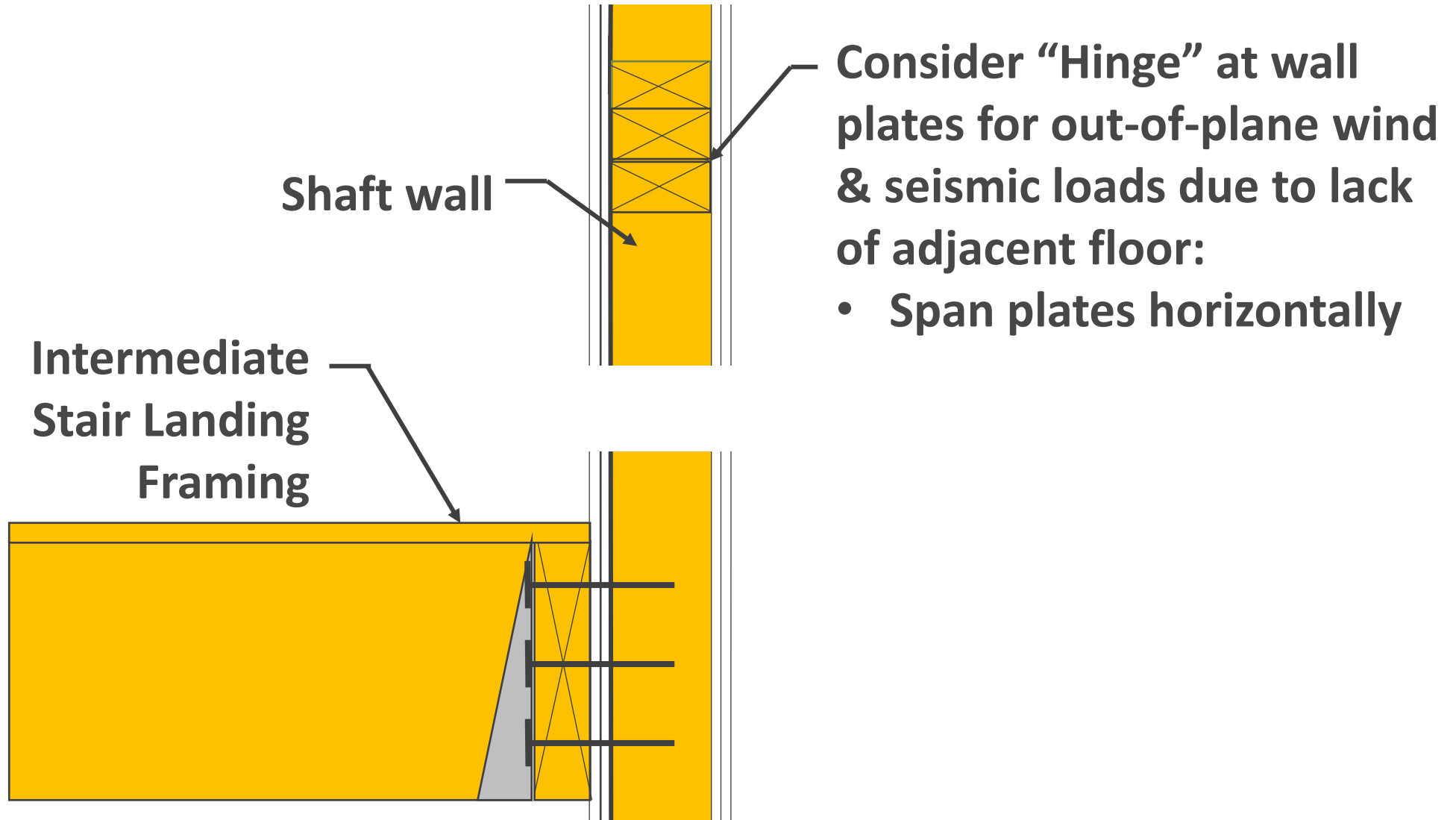


Typical Exterior Wall Condition

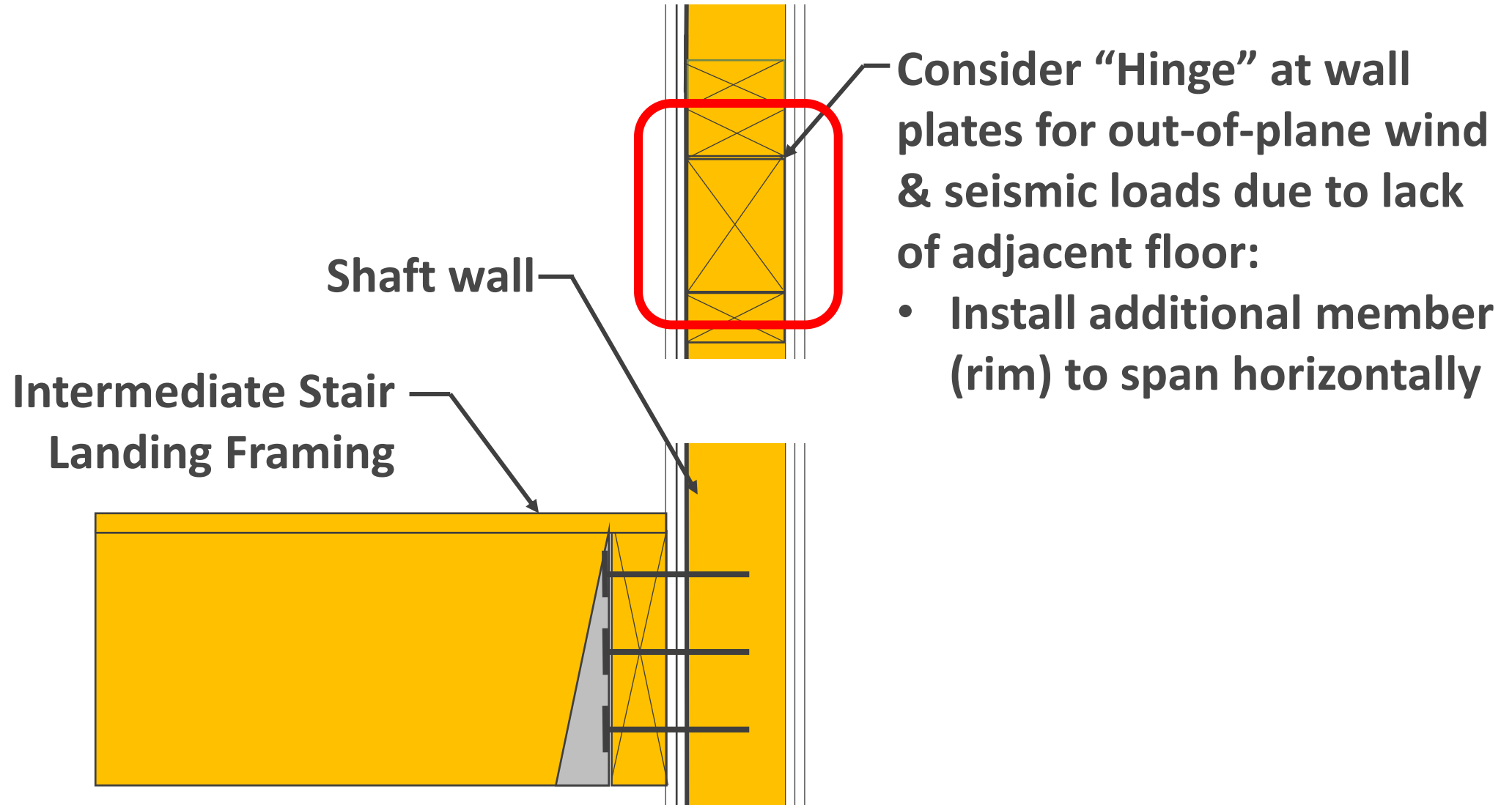


Exterior Wall That is Shaft Wall

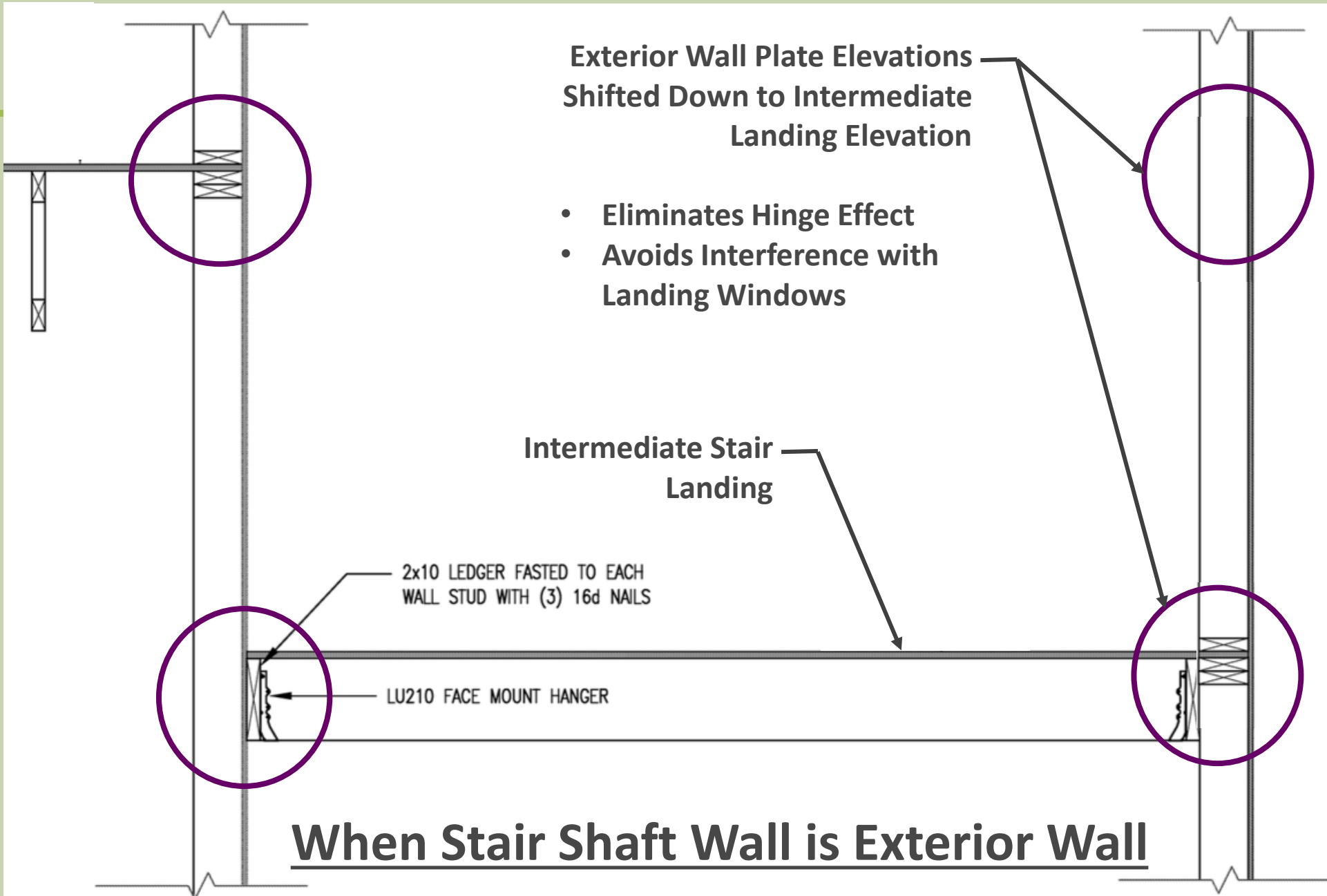
Shaft Walls that are also Exterior Walls



Shaft Walls that are also Exterior Walls







Shaft Wall Assemblies

Assembly selection considerations

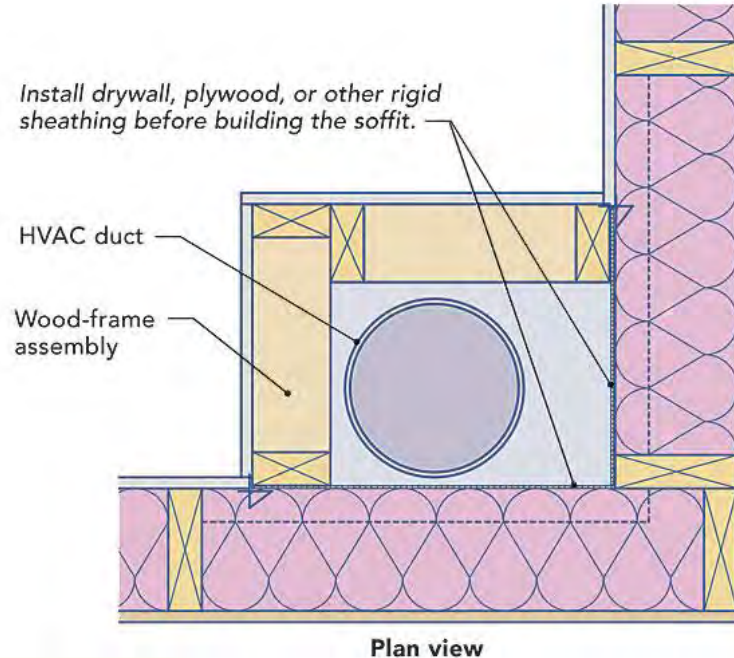
- Fire resistance rating requirement (1 hr or 2 hr)
- Size and height of shaft
- Structural needs (gravity & lateral loads)
- Acoustics
- Space available for wall (allowed thickness)



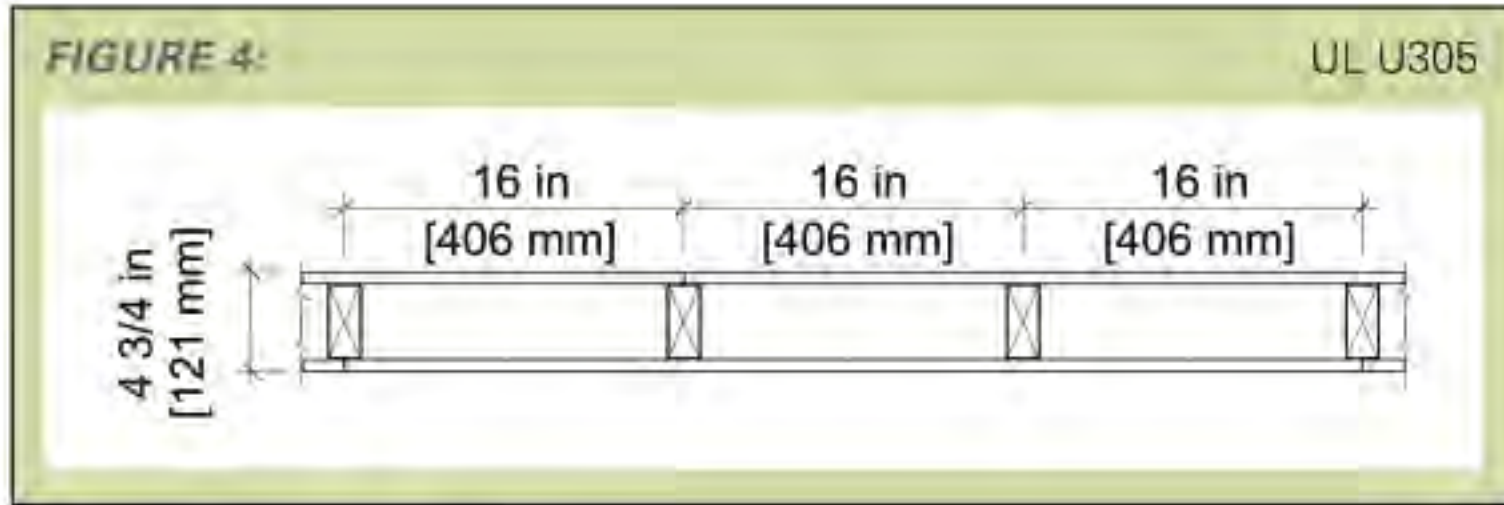
Stair, Elevator & MEP Shafts

Main Differences & Unique Design Constraints

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



Shaft Wall Assemblies



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

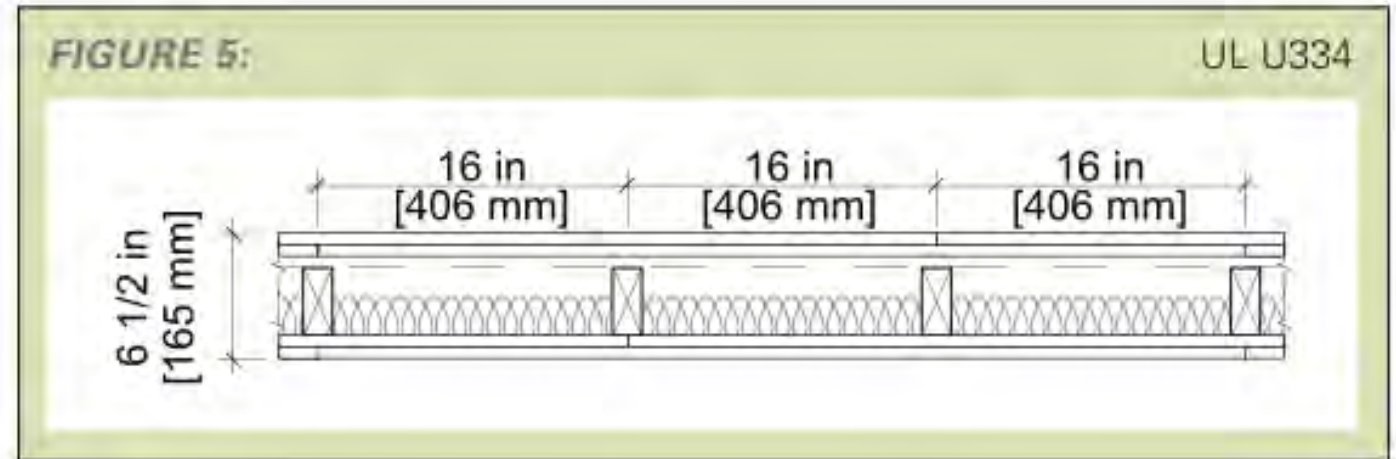
Shaft Wall Assemblies

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



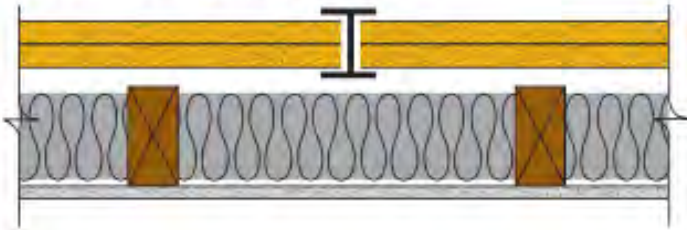
2-Hour Wall with Shaftliner

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

Shaft Wall Assemblies W/Shaftliner

2-Hour Fire Rating

Design Reference: UL U373, ULC W312,
WHI GP/WA 120-03, cUL U373



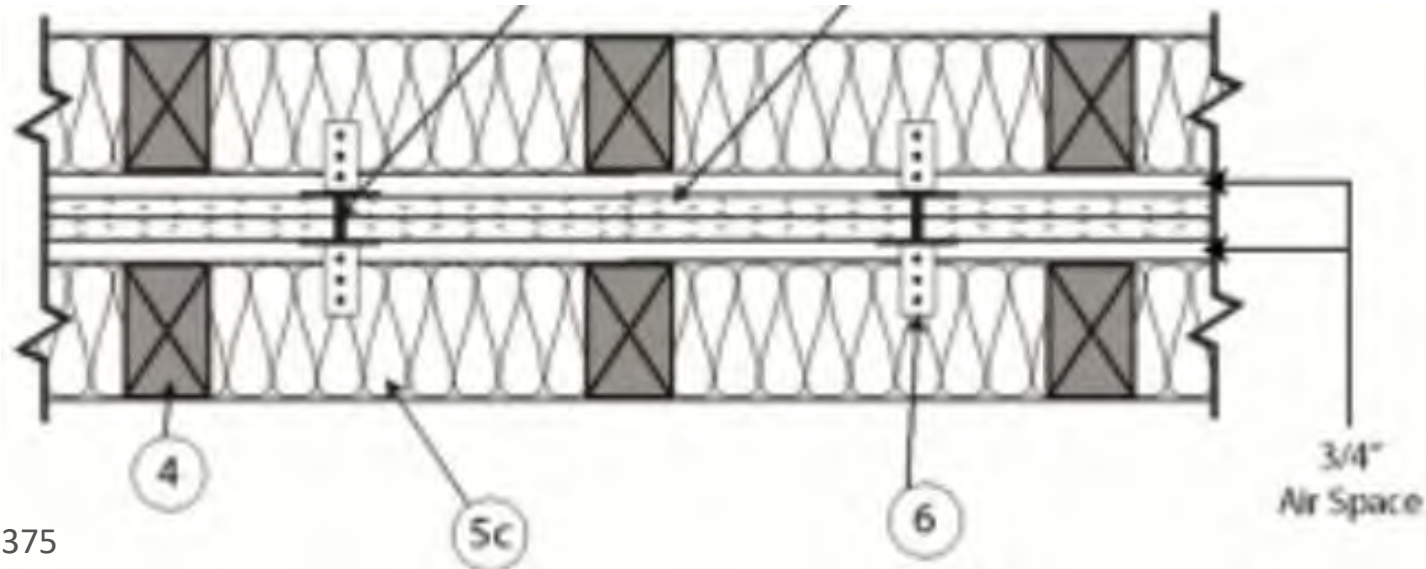
Source: Georgia Pacific

59 STC Sound Trans.

Test Reference: RAL TL 10-290

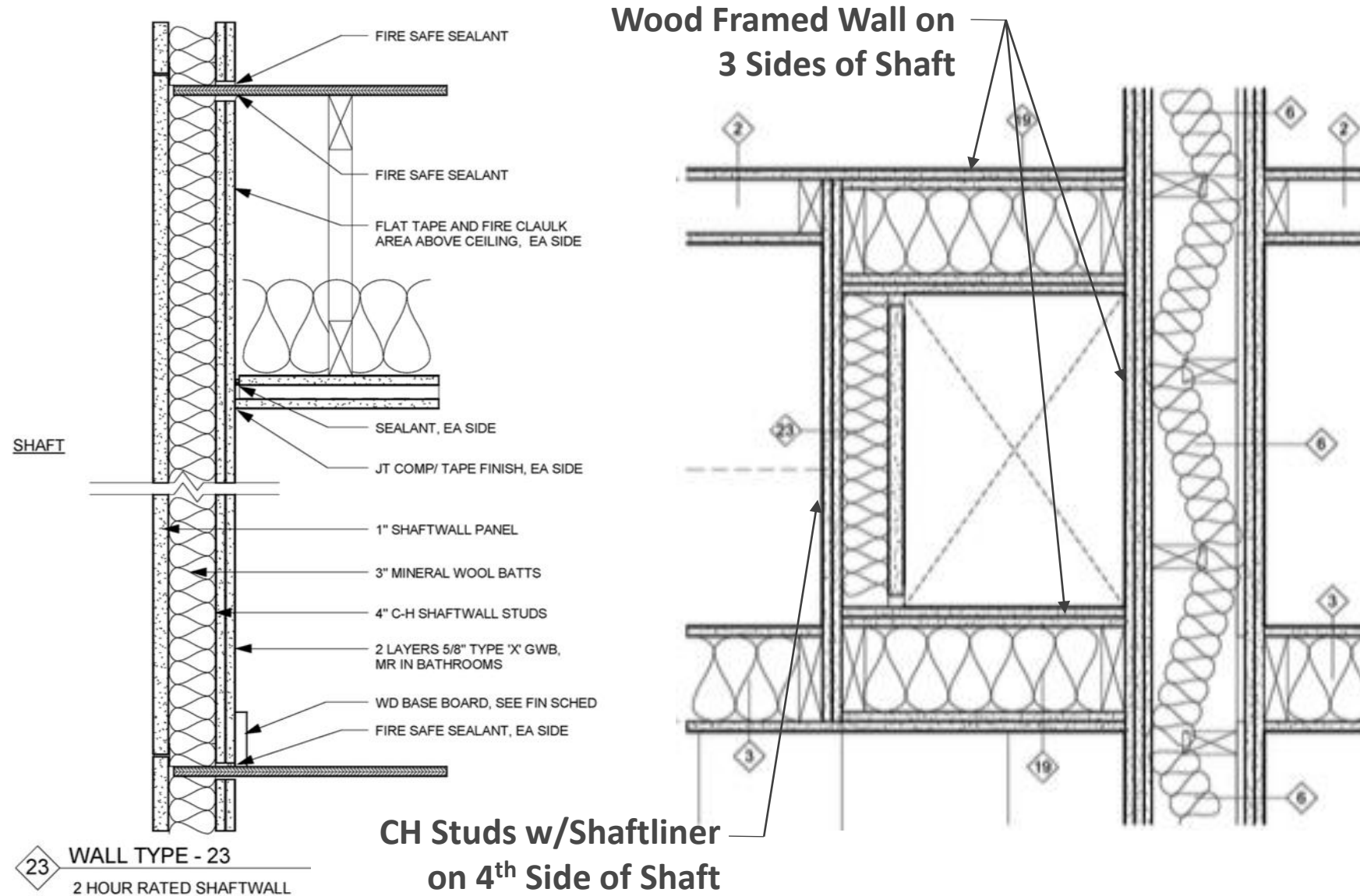
Two layers 1" (25.4 mm) DensGlass Shaftliner inserted in H-Studs 24" (610 mm) o.c. Min. 3/4" (19 mm) air space between liner panels and adjacent wood or metal framing.

Sound Tested with 2"x 4" stud wall with 1/2" (12.7 mm) ToughRock® wallboard or DensArmor Plus® interior panels and 3-1/2" (89 mm) fiberglass insulation in stud space.



Source: UL U375

Shaft Wall Assemblies W/Shaftliner



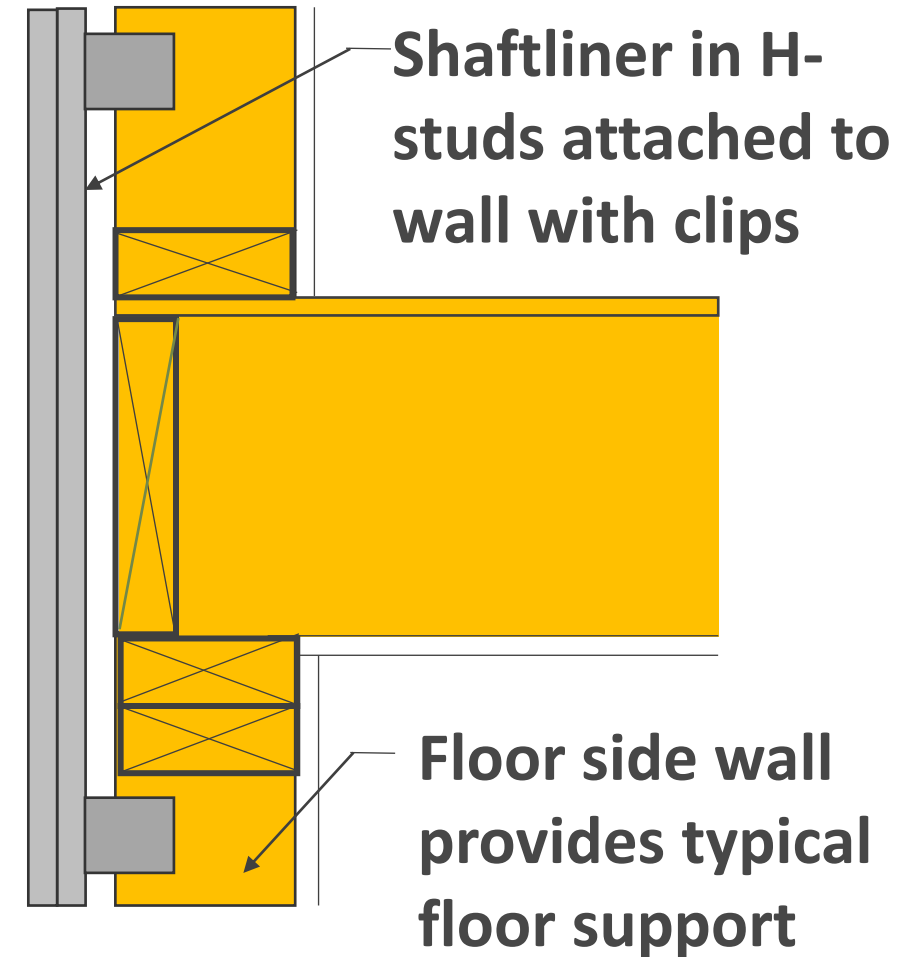
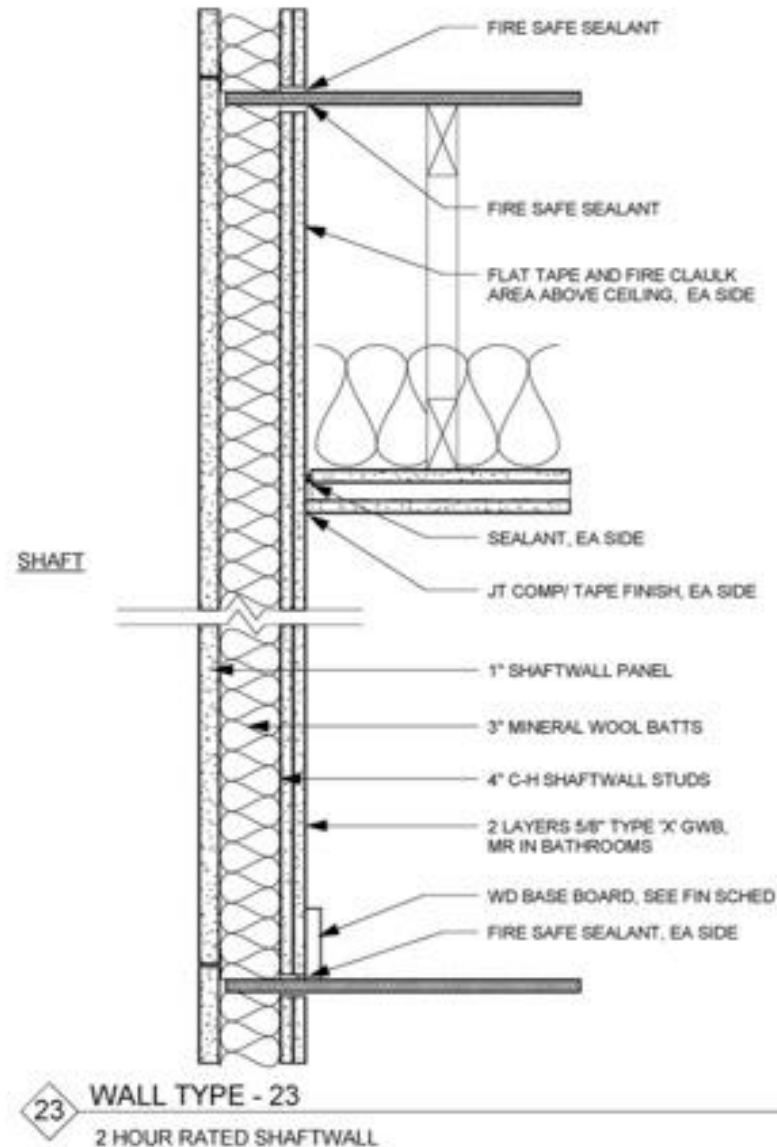
Shaft Wall Assemblies W/Shaftliner



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



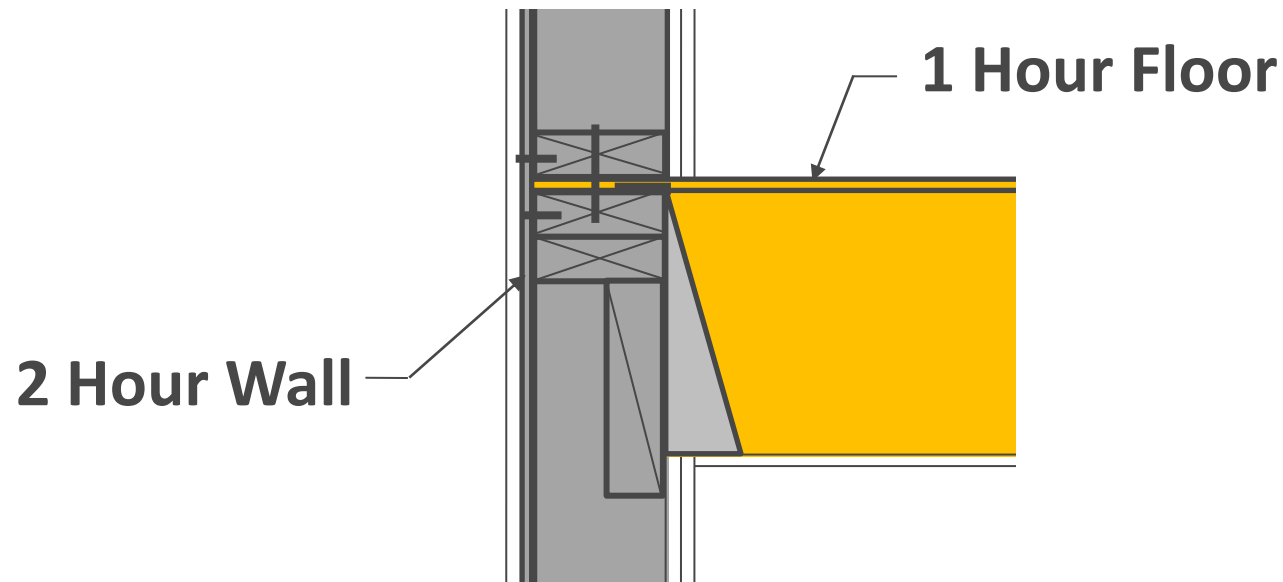
Floor to Shaft Wall Detailing



Floor to Shaft Wall Detailing

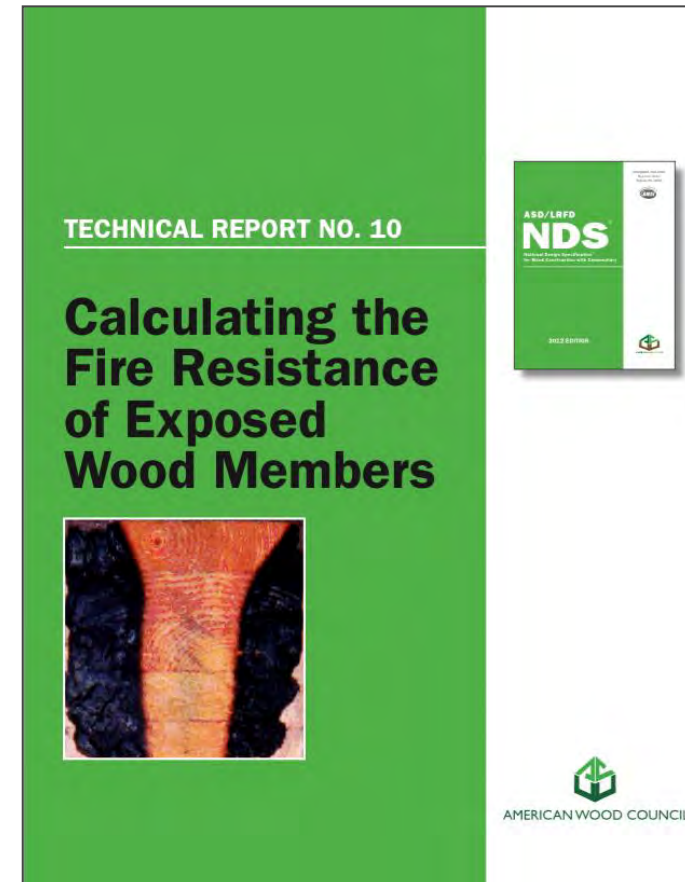
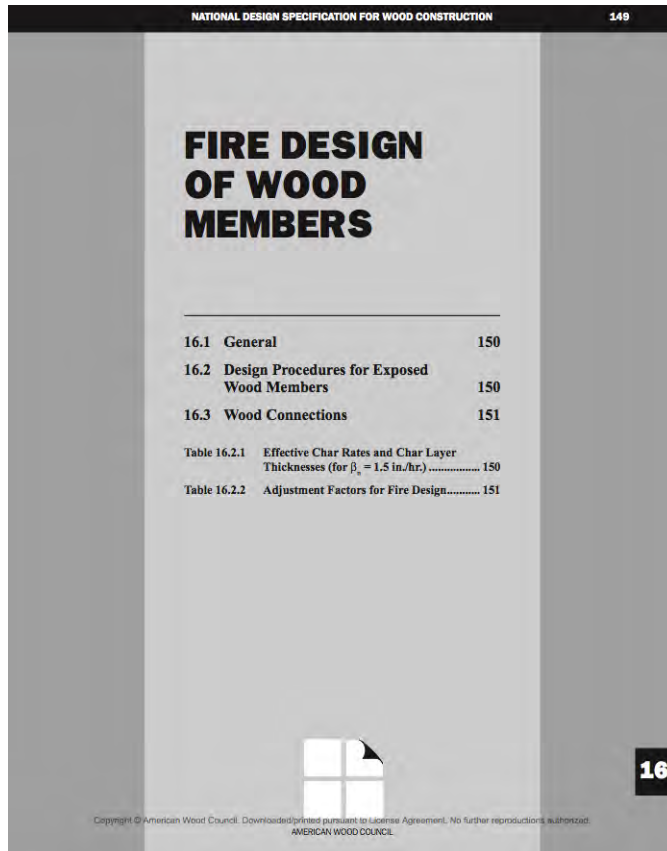
Supporting Construction: In platform and semi-balloon frame construction, if we have a 2 hour shaft wall and a 1 hour floor, how do we achieve this?

- 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

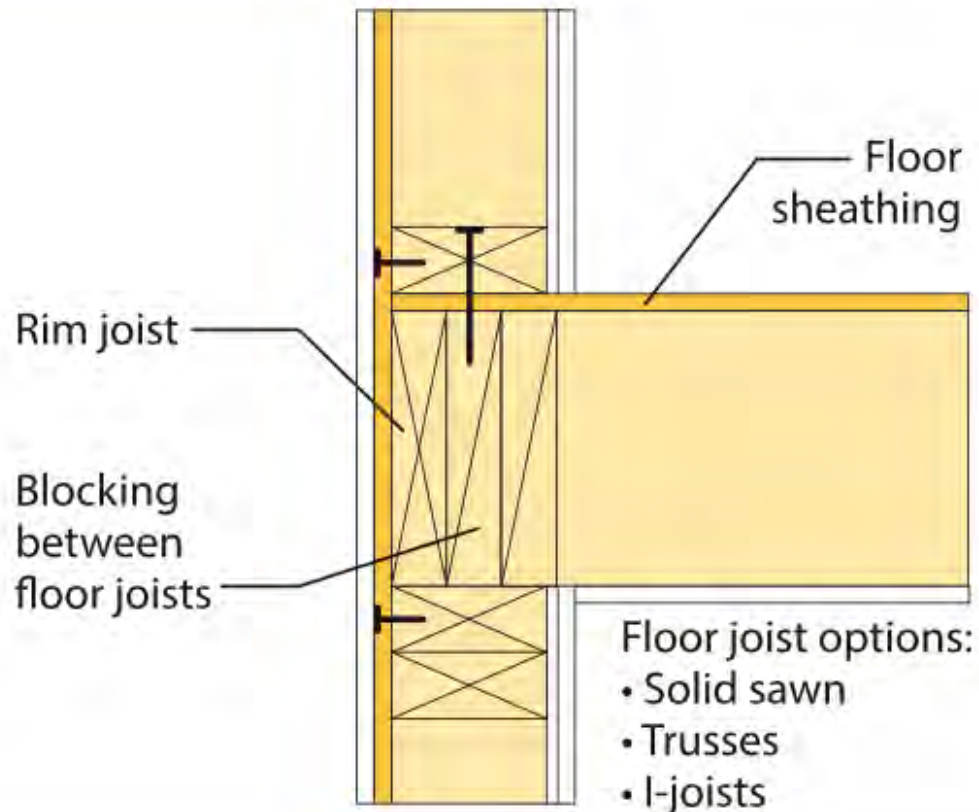
For Exposed Wood Members: IBC 722.1 References AWC's NDS Chapter 16 (AWC's TR 10 is a design aid to NDS Chapter 16)



Floor to Shaft Wall Detailing

FIGURE 10:

Floor-to-Shaft Wall Intersection Detail
with Blocking Between Floor Joists



- Fire-resistance rating still 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
- The combustibility of the material is not an issue; must meet the fire rating requirement

Exterior Walls – Intersecting Floors

AWC's DCA3 provides floor to wall intersection detailing options

Addresses both continuity provisions and requirements for FRT elements in exterior wall plane



Fire-Resistance-Rated Wood-Frame Wall and Floor/Ceiling Assemblies

Building Code Requirements

For occupancies such as stores, apartments, offices, and other commercial and industrial uses, building codes commonly require floor/ceiling and wall assemblies to be fire-resistance rated in accordance with standard fire tests. This document is intended to aid in the design of various wood-frame walls and wood-frame floor/ceiling assemblies, where such assemblies are required by code to be fire-resistance-rated.

Depending on the application, wall assemblies may need to be fire-resistance-rated for exposure from either one side or both sides. Exterior walls are required to be rated for both interior and exterior fire exposure where the wall has a fire separation distance of 10 feet or less. For exterior walls with a fire separation distance of greater than 10 feet, the required fire-resistance-rating applies only to exposure from the interior. The designer should note that some state and local building code amendments may require fire resistance rating for exposure from both sides of exterior walls, regardless of fire separation distance; however,

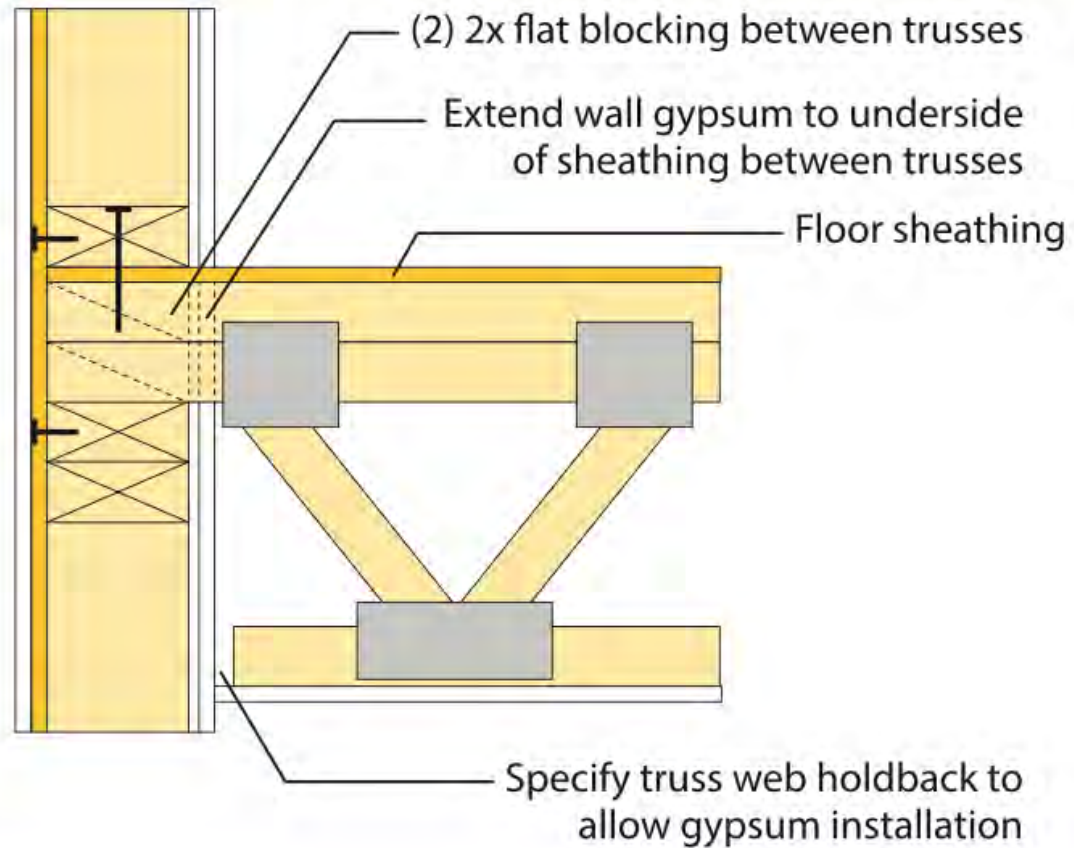
Fire Tested Assemblies

Fire-resistance-rated wood-frame assemblies can be found in a number of sources including the *International Building Code (IBC)*, Underwriters Laboratories (UL) *Fire Resistance Directory*, Intertek Testing Services' *Directory of Listed Products*, and the Gypsum Association's *Fire Resistance Design Manual (GA 600)*. The American Wood Council (AWC) and its members have tested a number of wood-frame fire-resistance-rated assemblies (see photos). Descriptions of successfully tested lumber wall assemblies are provided in [Table 1](#) for one-hour fire-resistance-rated wall assemblies and [Table 2](#) for two-hour fire-resistance-rated wall assemblies. Lumber shall be identified by the grade mark of a lumber grading or inspection agency that has been approved by an accreditation body that complies with the *American Softwood Lumber Standard (PS 20)*. The fire-resistance-rated assemblies described in this document, as well as those listed in other sources are not species- or grade-specific unless specifically noted as such.

Floor to Shaft Wall Detailing

FIGURE 11:

Floor-to-Shaft Wall Intersection Detail
with Gypsum Extending to Underside
of Sheathing between Trusses

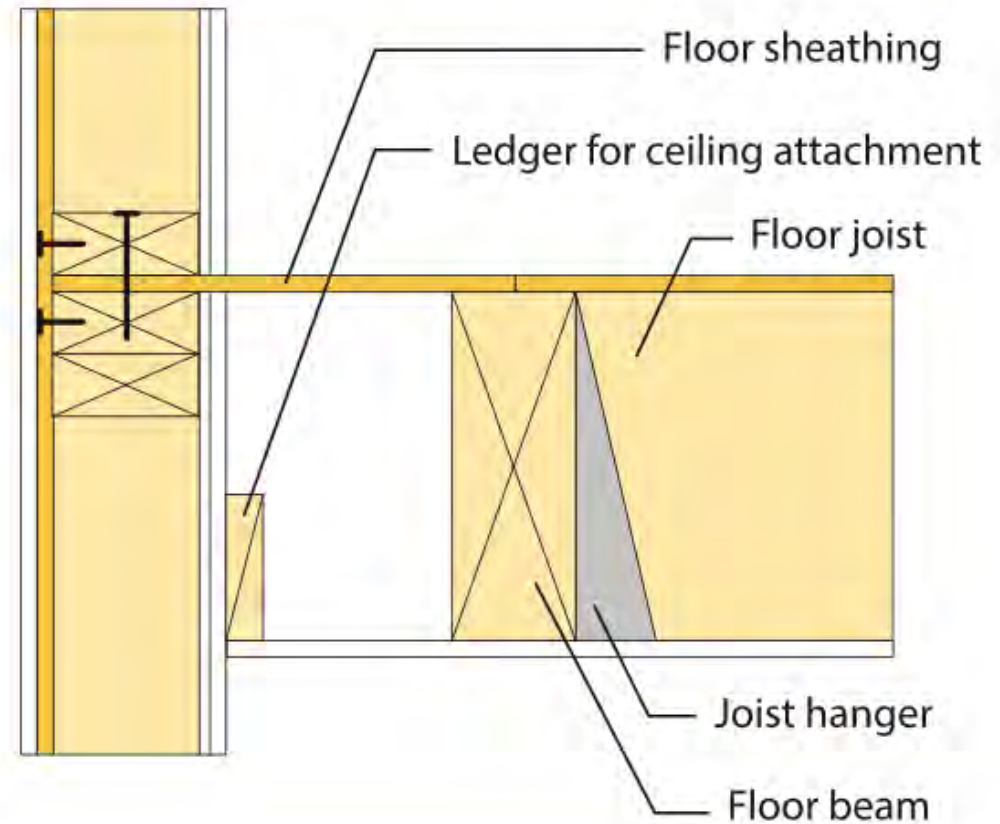


Floor to Shaft Wall Detailing



FIGURE 12:

Floor-to-Shaft Wall Intersection Detail with Supporting Beam Just Inboard of Wall

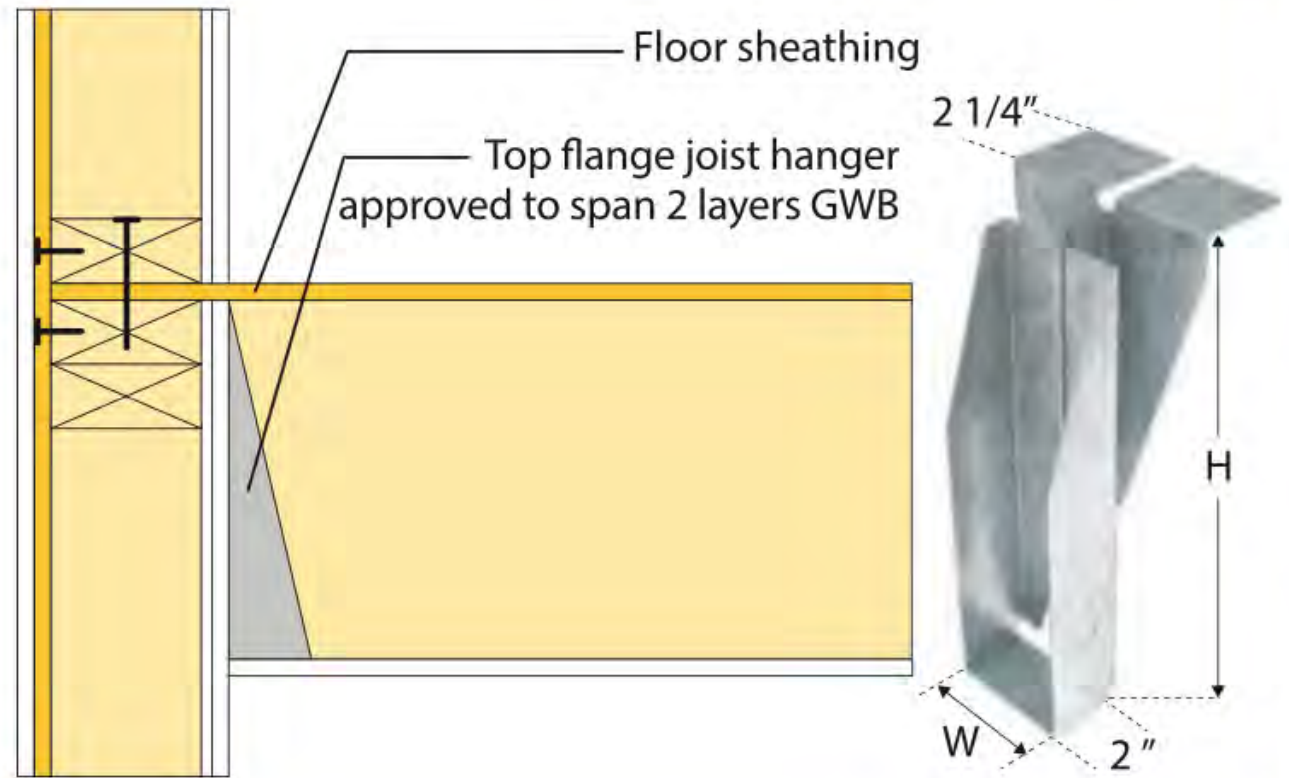


Floor to Shaft Wall Detailing

- 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 13:

Floor-to-Shaft Wall Intersection Detail with Hangers Designed to Span Over Gypsum

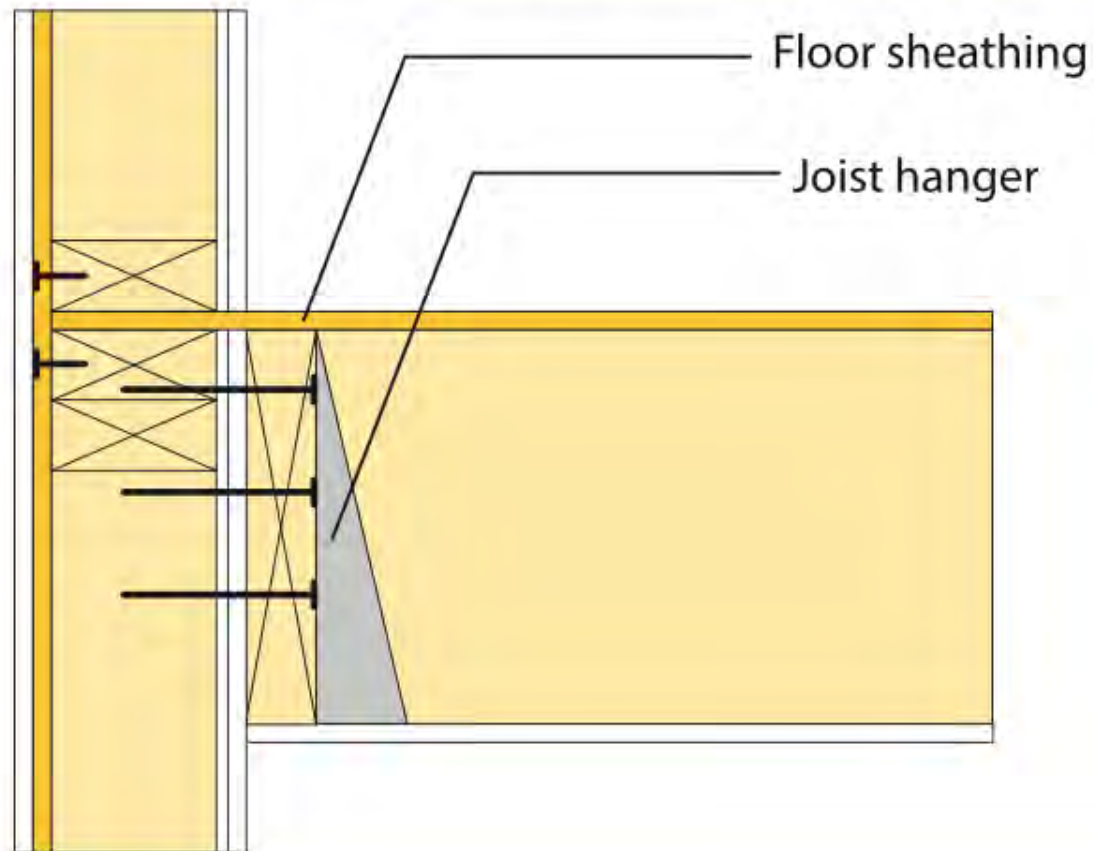


Right image credit: MiTek Builder Products

Floor to Shaft Wall Detailing

FIGURE 14:

Floor Framing Ledger Attached to Shaft Wall through Two Layers of Gypsum



- 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

Floor to Shaft Wall Detailing

FIGURE 20:

Mass Timber Floor Framing-to-Shaft
Wall Attachment

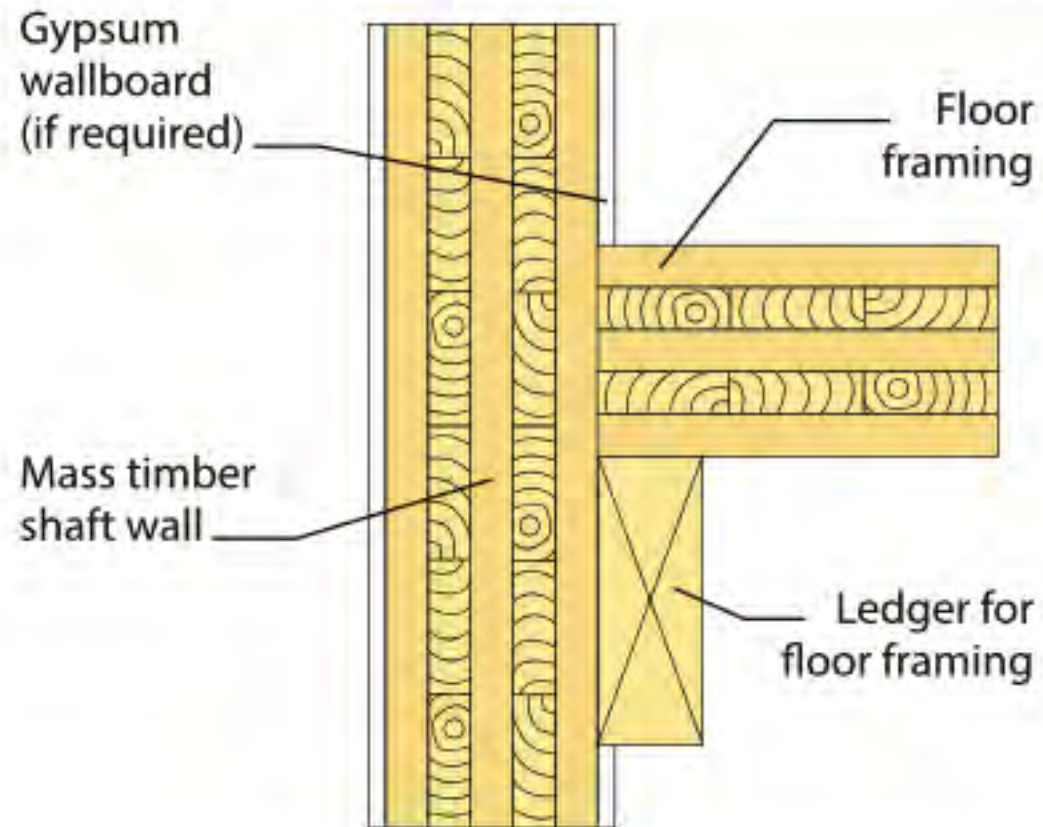
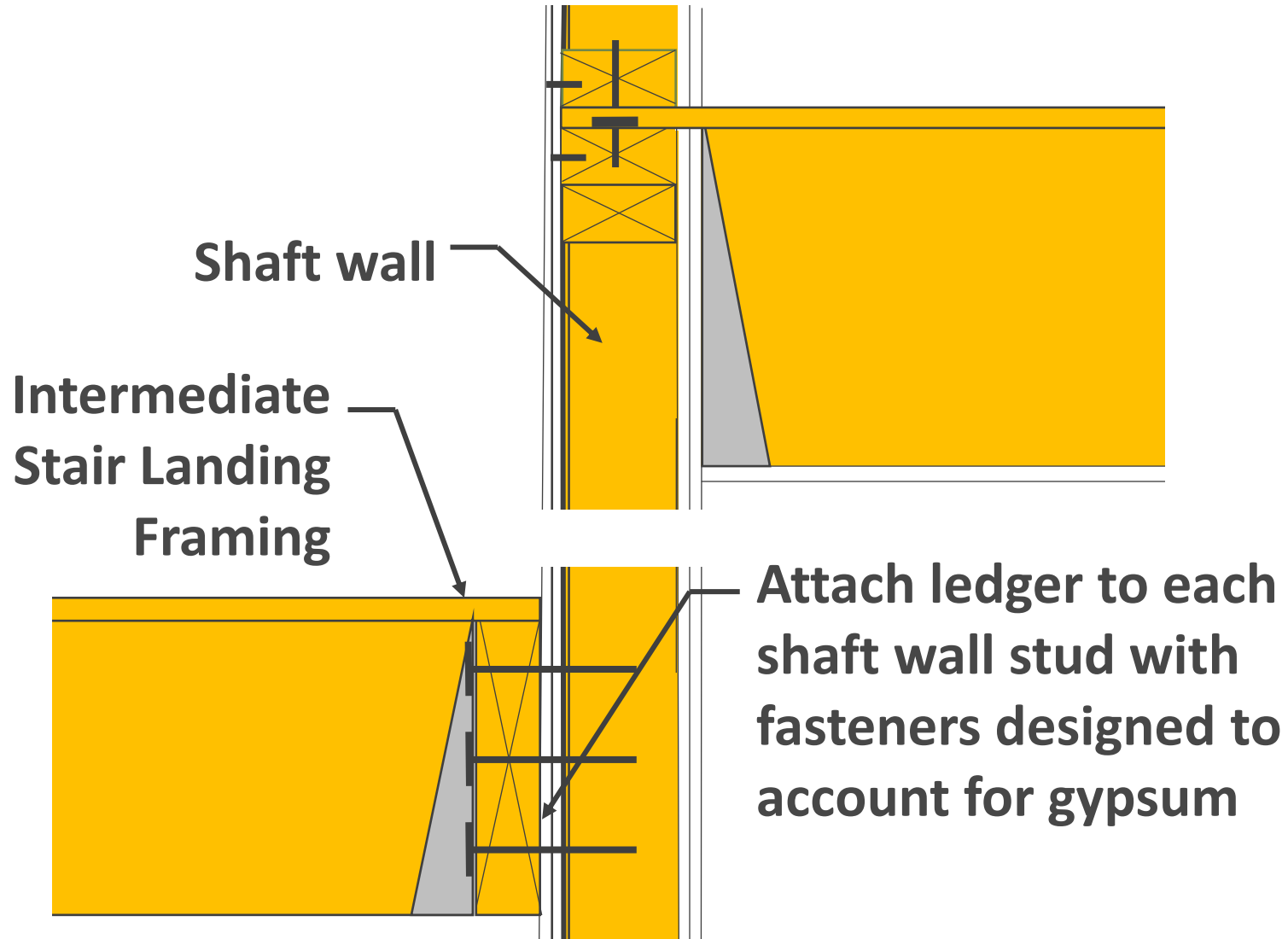


Photo: Alex Schreyer

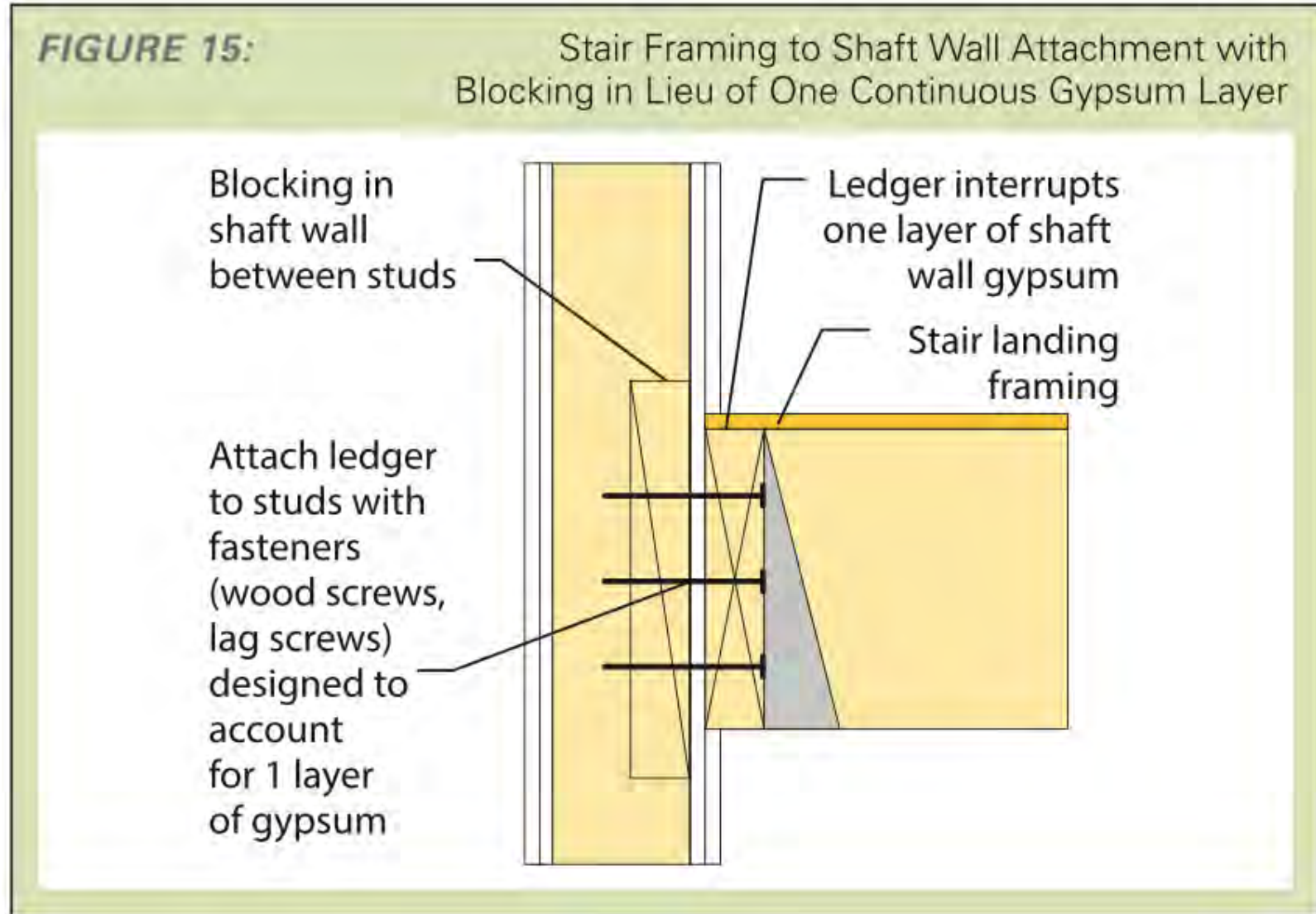
Stair Shafts



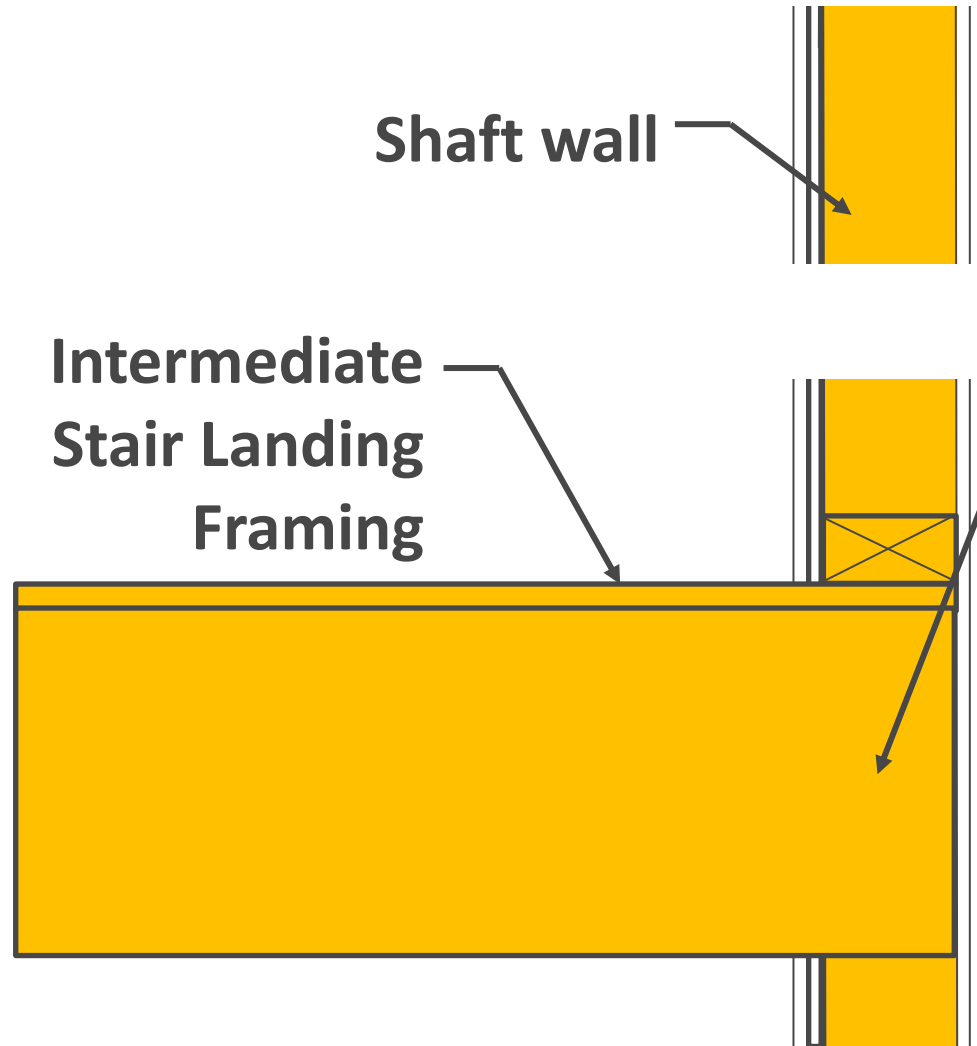


Stair Shafts

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



Stair Shafts



Shaft wall

Intermediate
Stair Landing
Framing

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

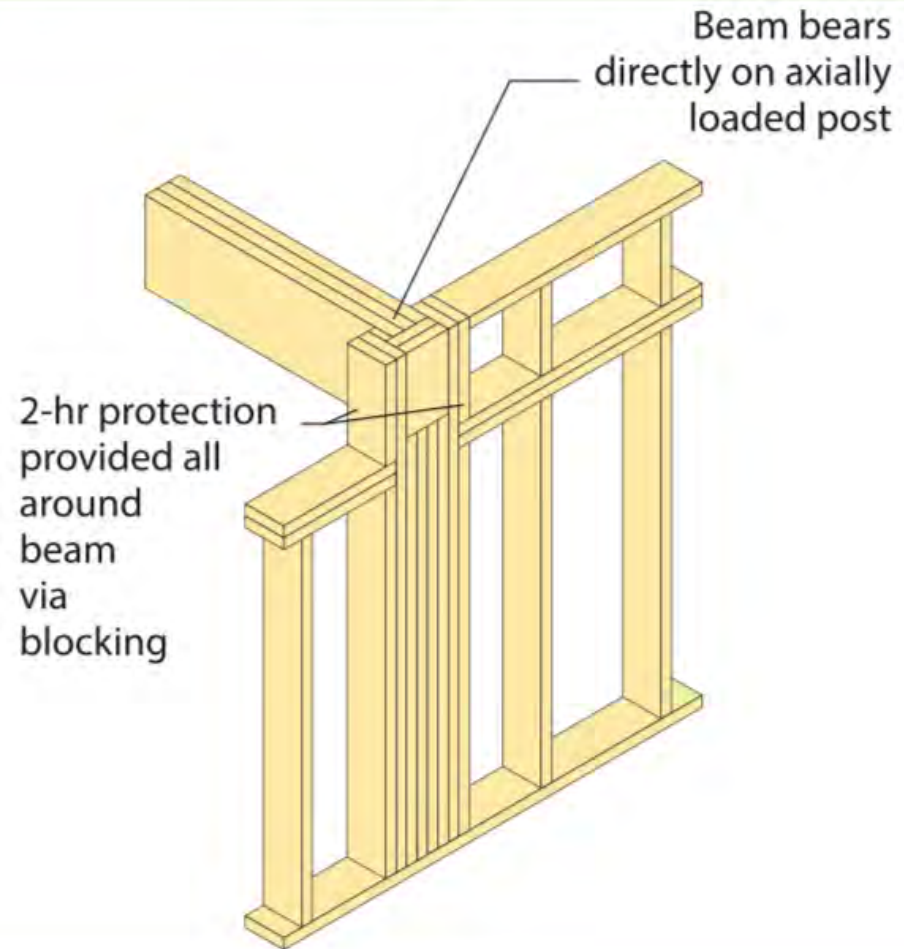
Rationale for detail approval:

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

Stair Shafts

FIGURE 16:

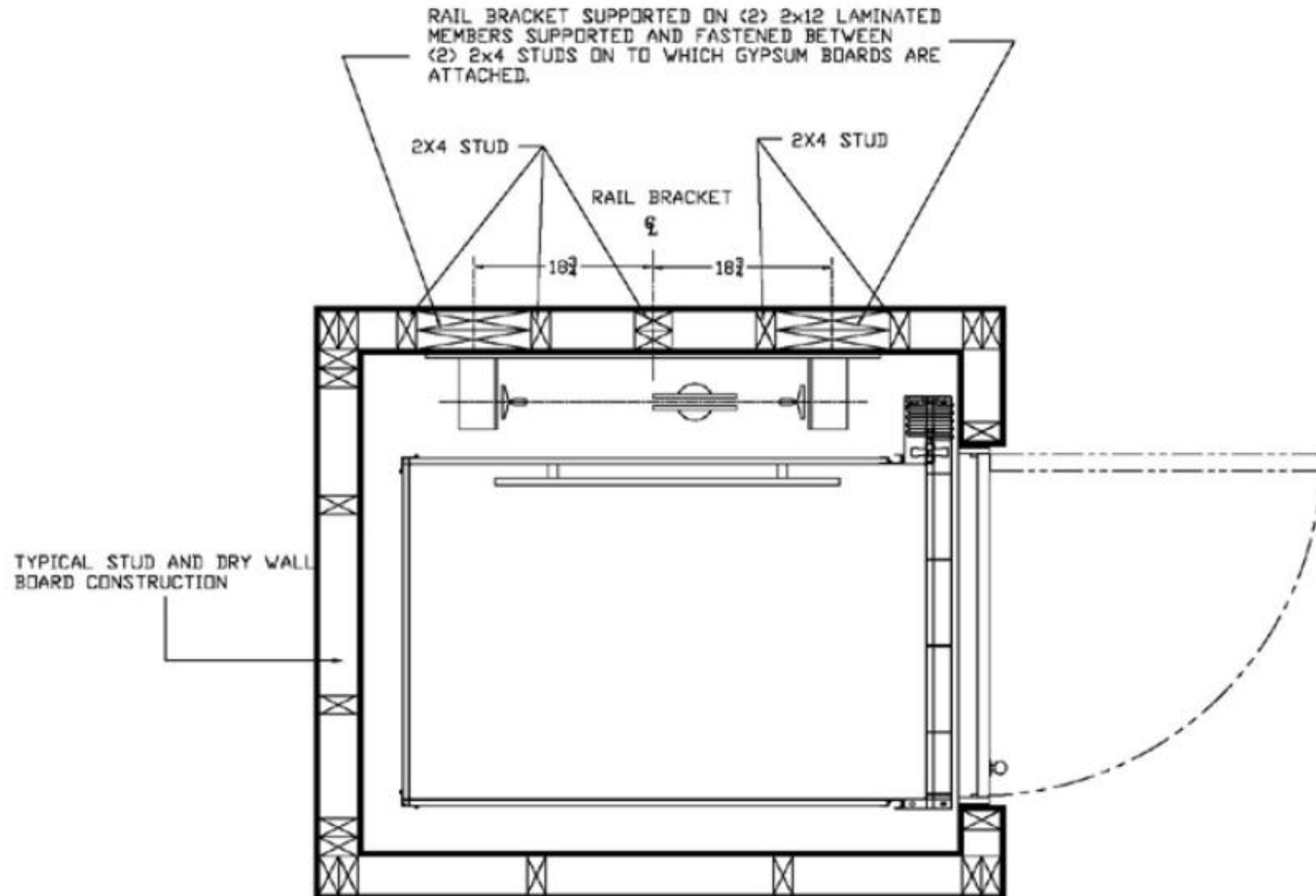
Stair Framing Beam in Protect Pocket in Shaft Wall



Elevator Shafts



Elevator Shafts



Elevator Shafts



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

MEP Shafts

- 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 Wall Resource

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

Free resource at woodworks.org

Shaft Wall Solutions For Wood-Frame Buildings

Richard McLain, MS, PE, SE • Technical Director • WoodWorks



It is fairly common for light wood-frame commercial and multi-family buildings to include shaft walls made from other materials. However, with the heavy use of wood structure in mid-rise construction, many designers and contractors have come to realize that wood-frame shaft walls are in fact a code-compliant means of reducing cost and shortening construction schedule.

A shaft is defined in Section 202 of the 2012 International Building Code (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 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 wood-frame shaft walls under the 2012 IBC. While some of the IBC-referenced section numbers may be different in different editions, none of the main shaft wall provisions have been modified in the 2015 IBC.

> QUESTIONS?

This concludes The American Institute
of Architects Continuing Education
Systems Course

Marc Rivard, SE, PE

Marc.Rivard@woodworks.org

WoodWorks