



Shaft Wall Solutions for Wood-Frame Structures



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



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

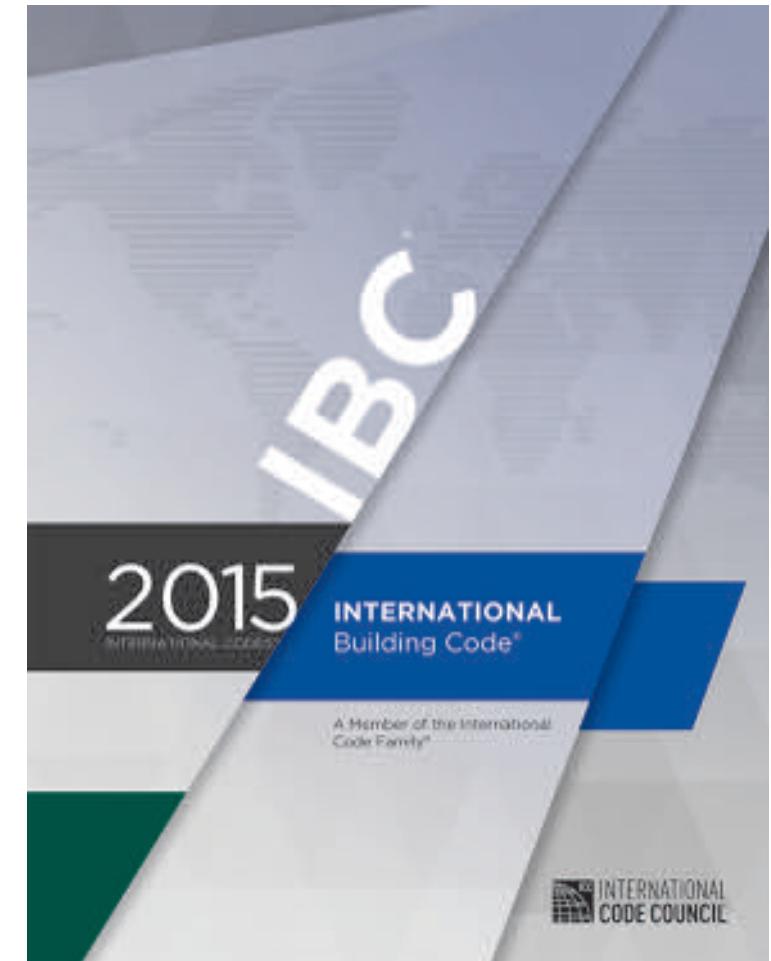
1. Review fire resistance-rated code provisions relevant to wood shaft wall design.
2. Introduce shaft wall assembly types, evaluating their applicability to elevator, stair and mechanical shafts.
3. Provide detailing options that establish fire resistance continuity at framing intersections.
4. Recognize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

Shaft 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



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 Materials

Light Frame Wood Shaft Walls

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



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

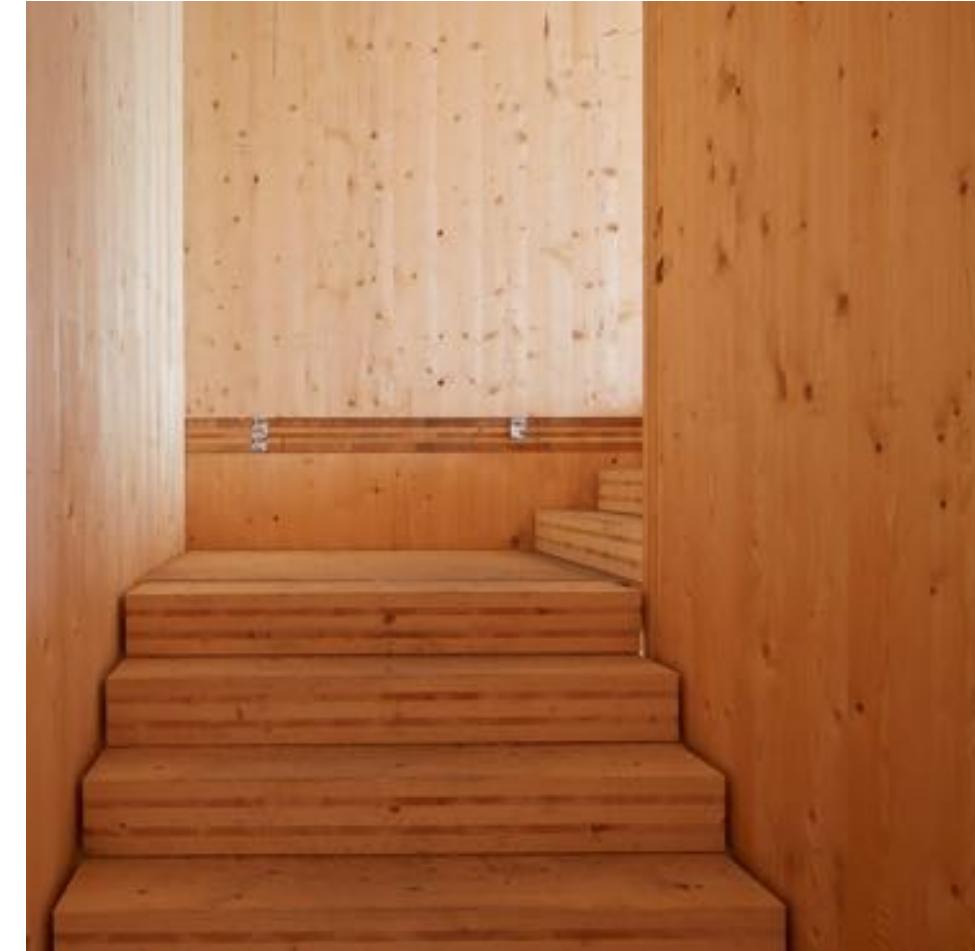


Photo: Will Pryce

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)



Photo: Lendlease

Shaft Wall Design Topics - Agenda

1. Wall Definition
2. Materials
3. Continuity
4. Supporting Construction
5. Joints & Penetrations
6. Exterior Walls
7. Assemblies
8. Floor to Shaft Wall Intersections
9. Stair, Elevator & Mechanical Shafts – Differences
10. Non-Wood Shaft Walls

Defining Shaft Wall Requirements

IBC defines 5 different types of fire-resistance rated walls:

- **Light Frame Bearing Walls (IBC 704.4.1)**
- **Exterior Walls (IBC 705)**
- **Fire Walls (IBC 706)**
- **Fire Barriers (IBC 707)**
- **Fire Partitions (IBC 708)**



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 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
- 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 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

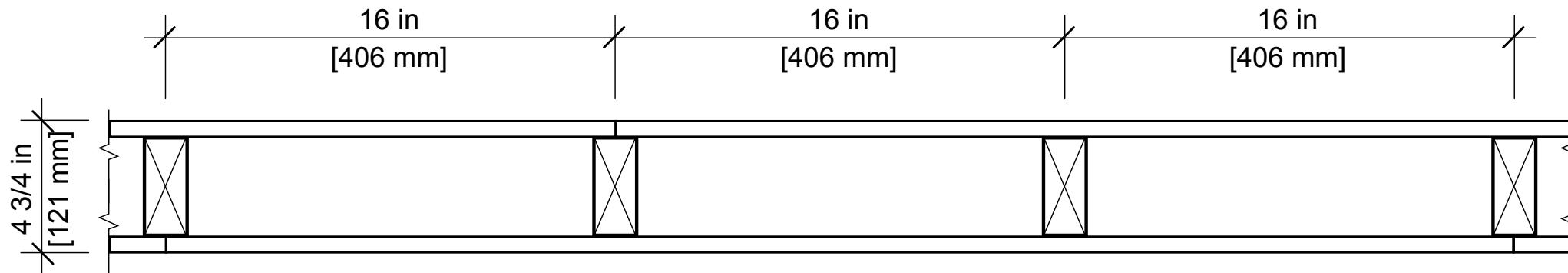
Info on unique fire rating requirements of exterior shaft walls to come in a bit...

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



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

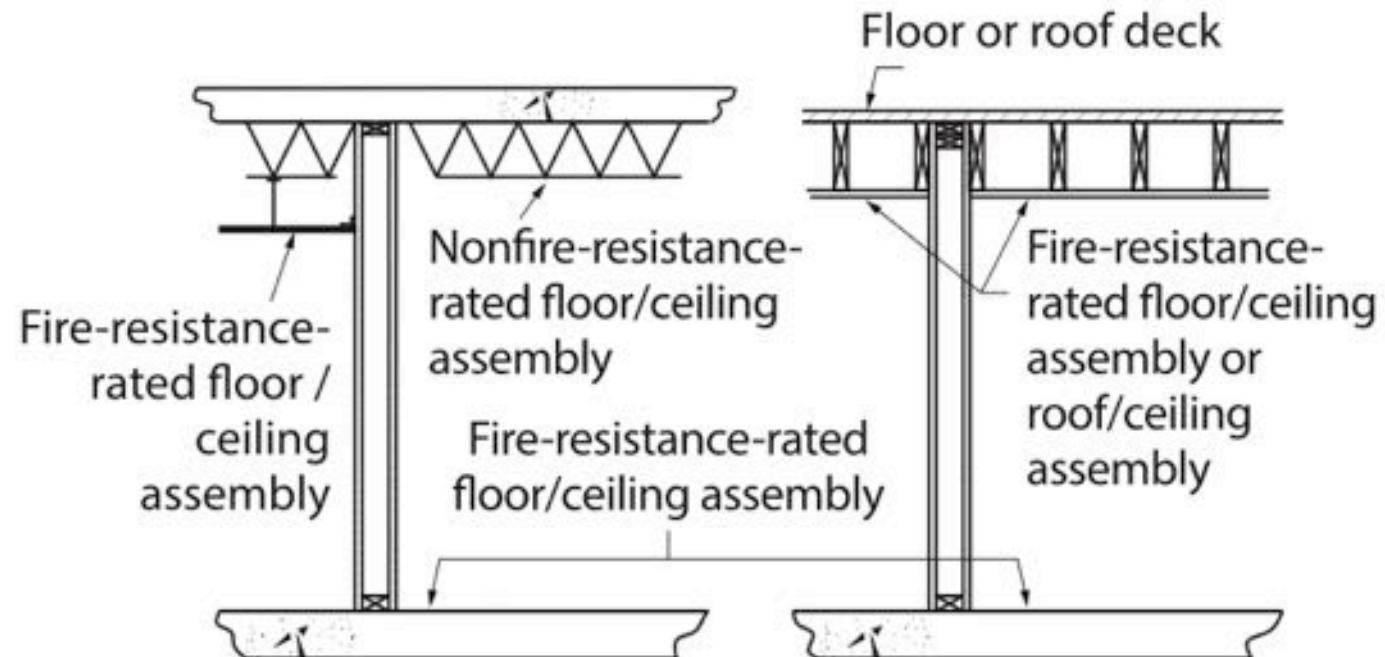
Fire barriers shall extend from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto. Such fire barriers shall be continuous through concealed space such as the space above a suspended ceiling. 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



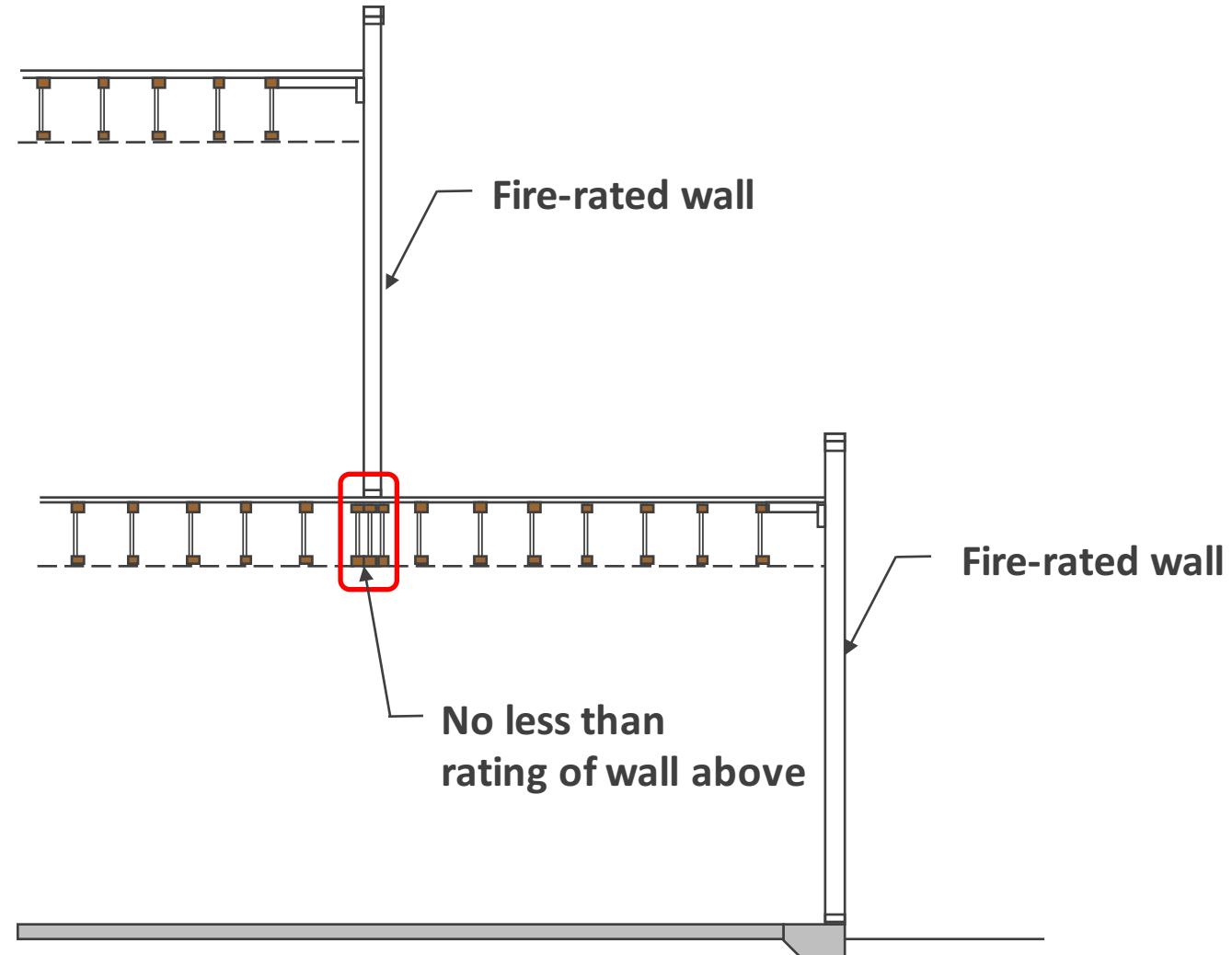
Fire barriers, including shaft walls, must extend from top of sheathing to underside of sheathing. Sheathing does not obstruct continuity.

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



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.

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

714.3.1.1 Fire-resistance-rated assemblies.

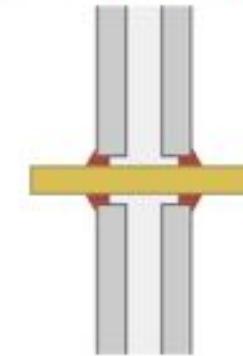
Penetrations shall be installed as tested in an approved fire resistance rated assembly.

OR

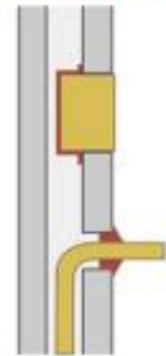
714.3.1.2 Through-penetration firestop system.

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.

Through Penetration



Membrane Penetration



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

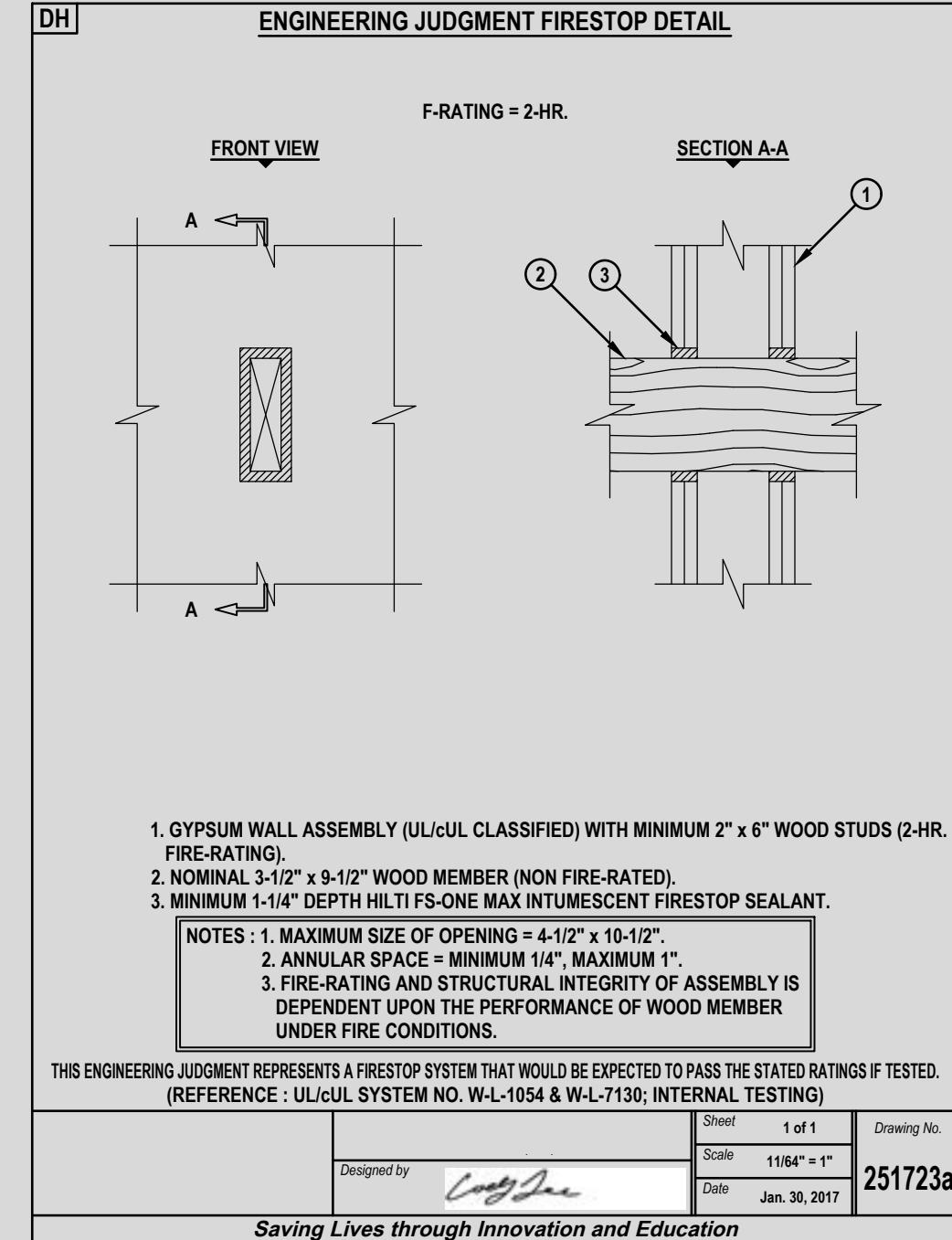
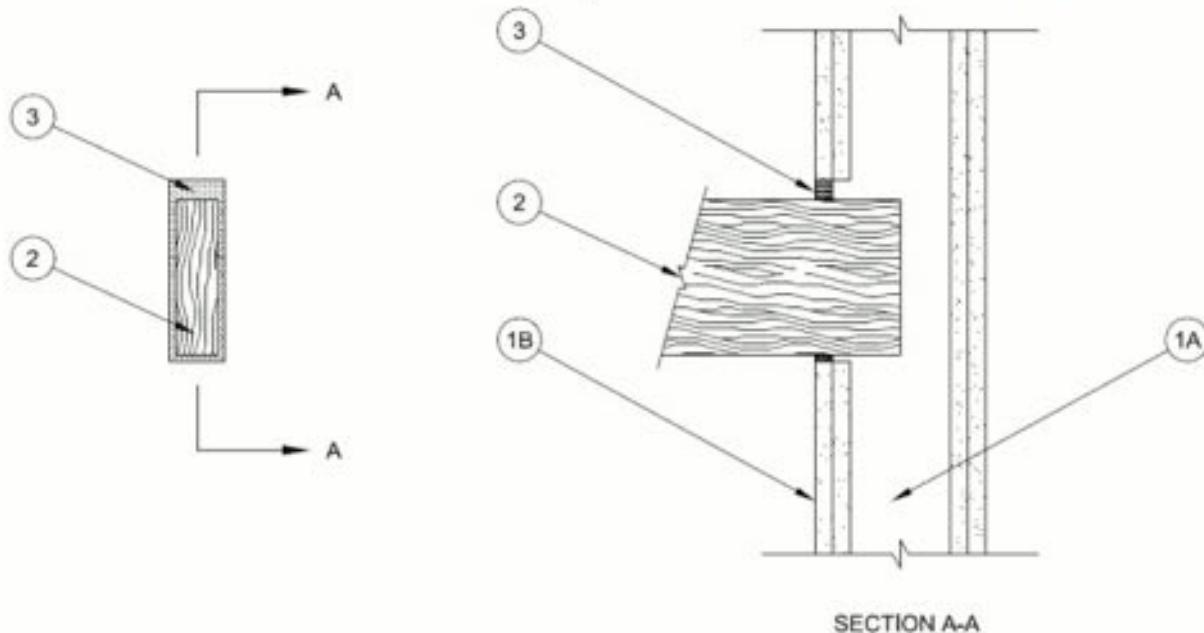
- Some firestopping systems available as tested configurations for wood conditions
- Most manufacturers can provide engineering judgement details / certification statements for this condition

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)



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

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 Exterior ^{e,f} Interior	3	2	1	0	2	2	2	1	0
Nonbearing walls and partitions Exterior	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions Interior ^d	See Table 602								
Floor construction and associated secondary members (see Section 202)	0	0	0	0	0	0	See Section 602.4.6	0	0
Roof construction and associated secondary members (see Section 202)	1 ^b / ₂	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 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

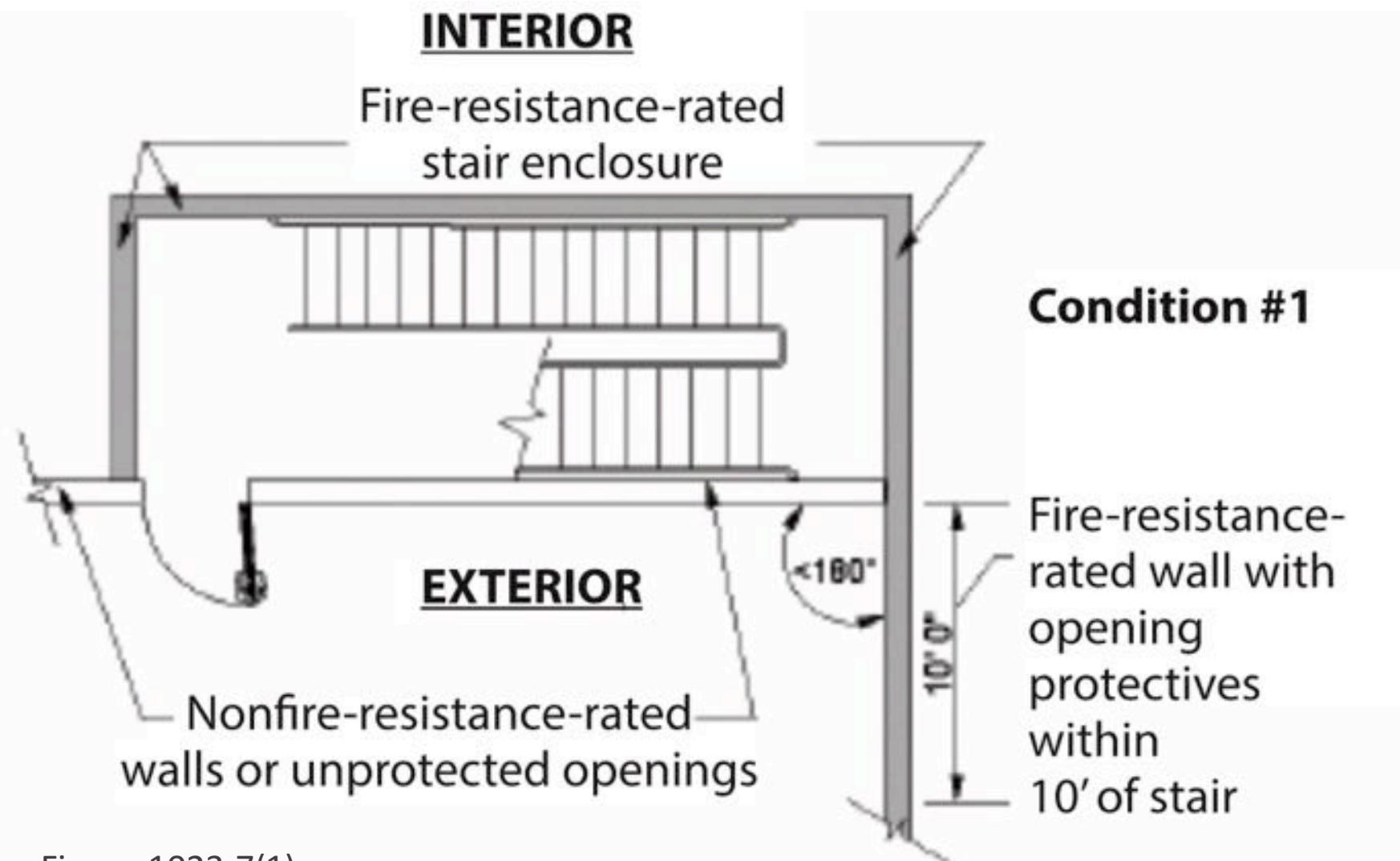


Shaft Walls that are also Exterior Walls

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.

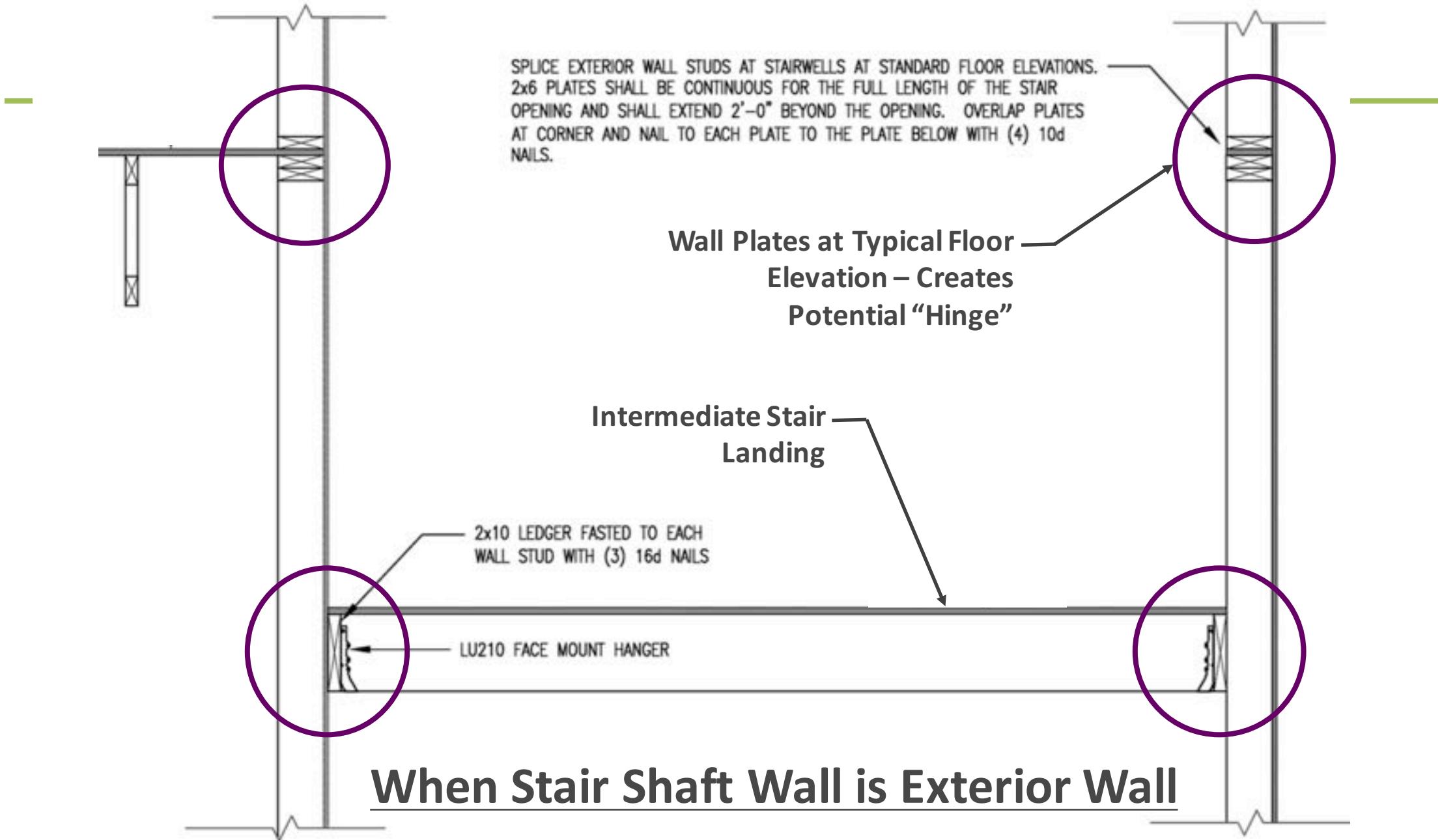
Shaft Walls that are also Exterior Walls



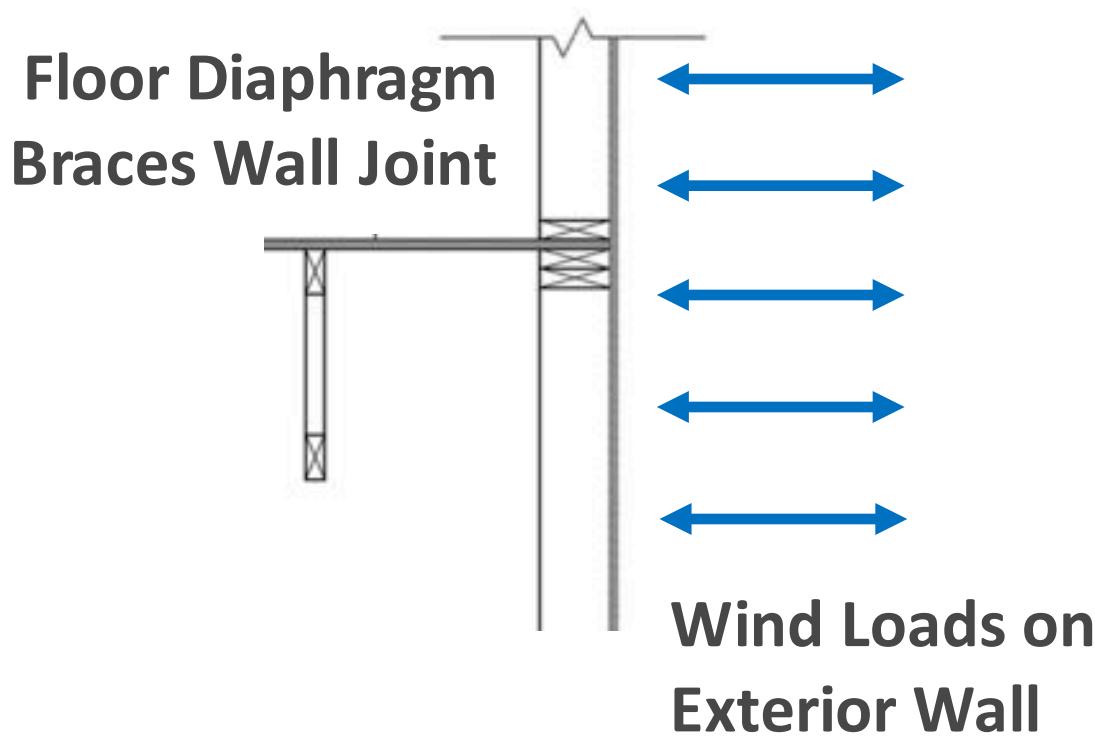
Shaft Walls that are also Exterior Walls

Structural Considerations

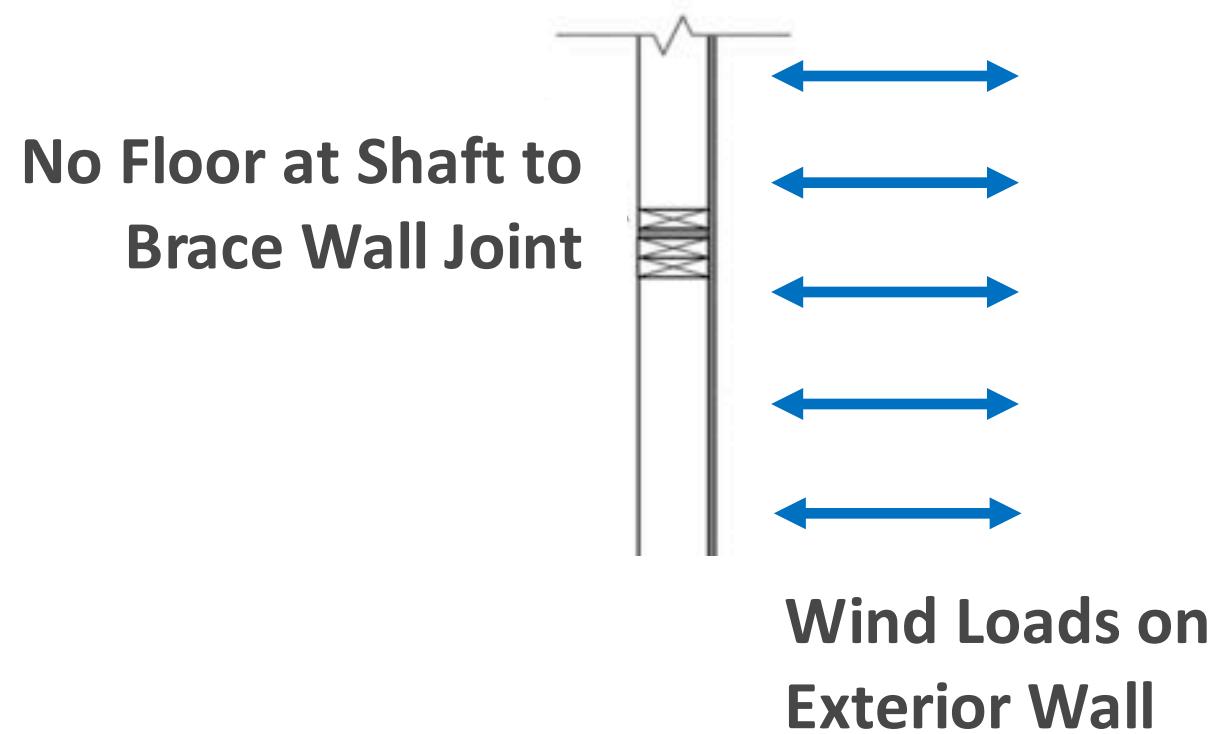




Shaft Walls that are also Exterior Walls

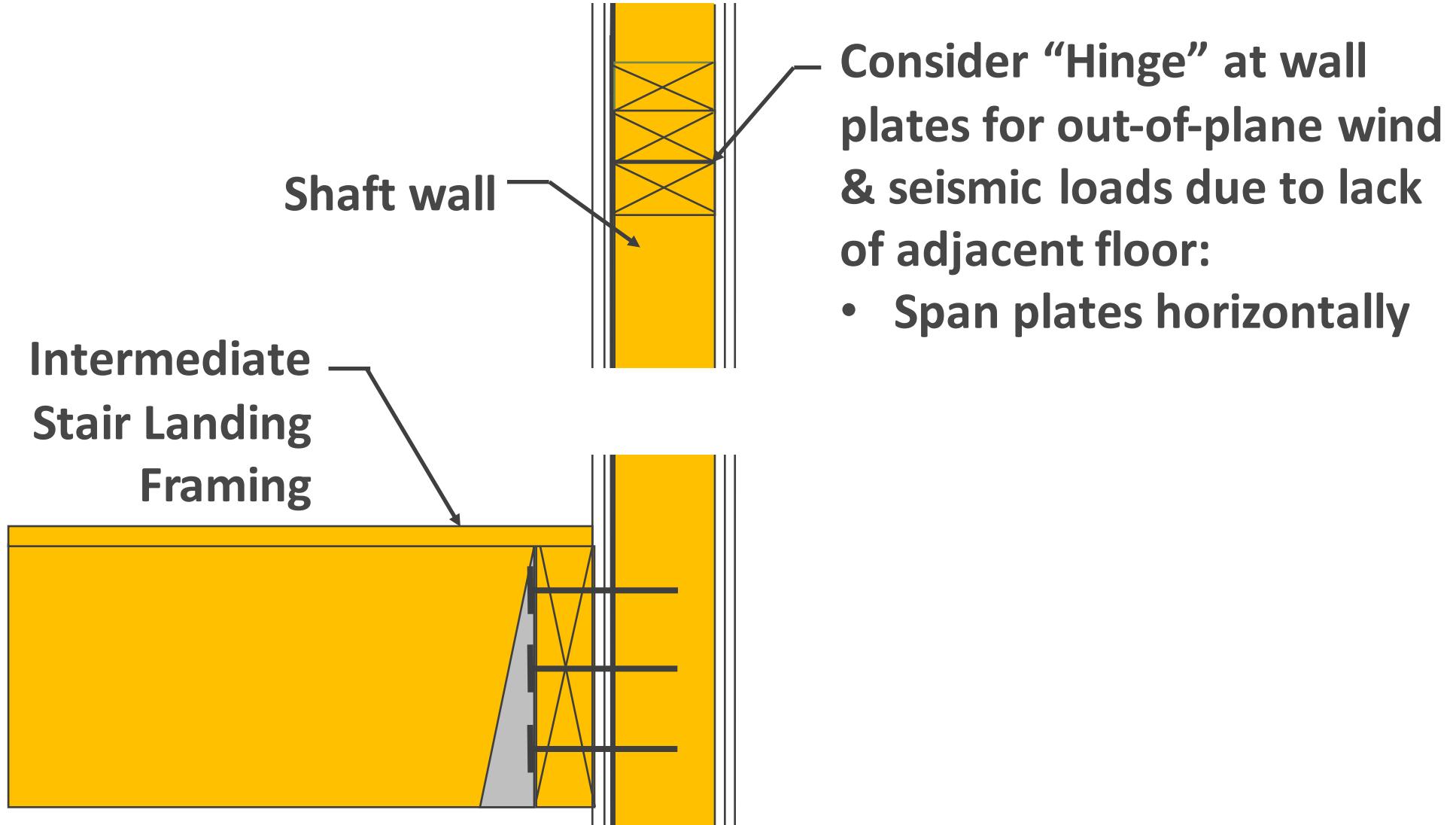


Typical Exterior Wall Condition

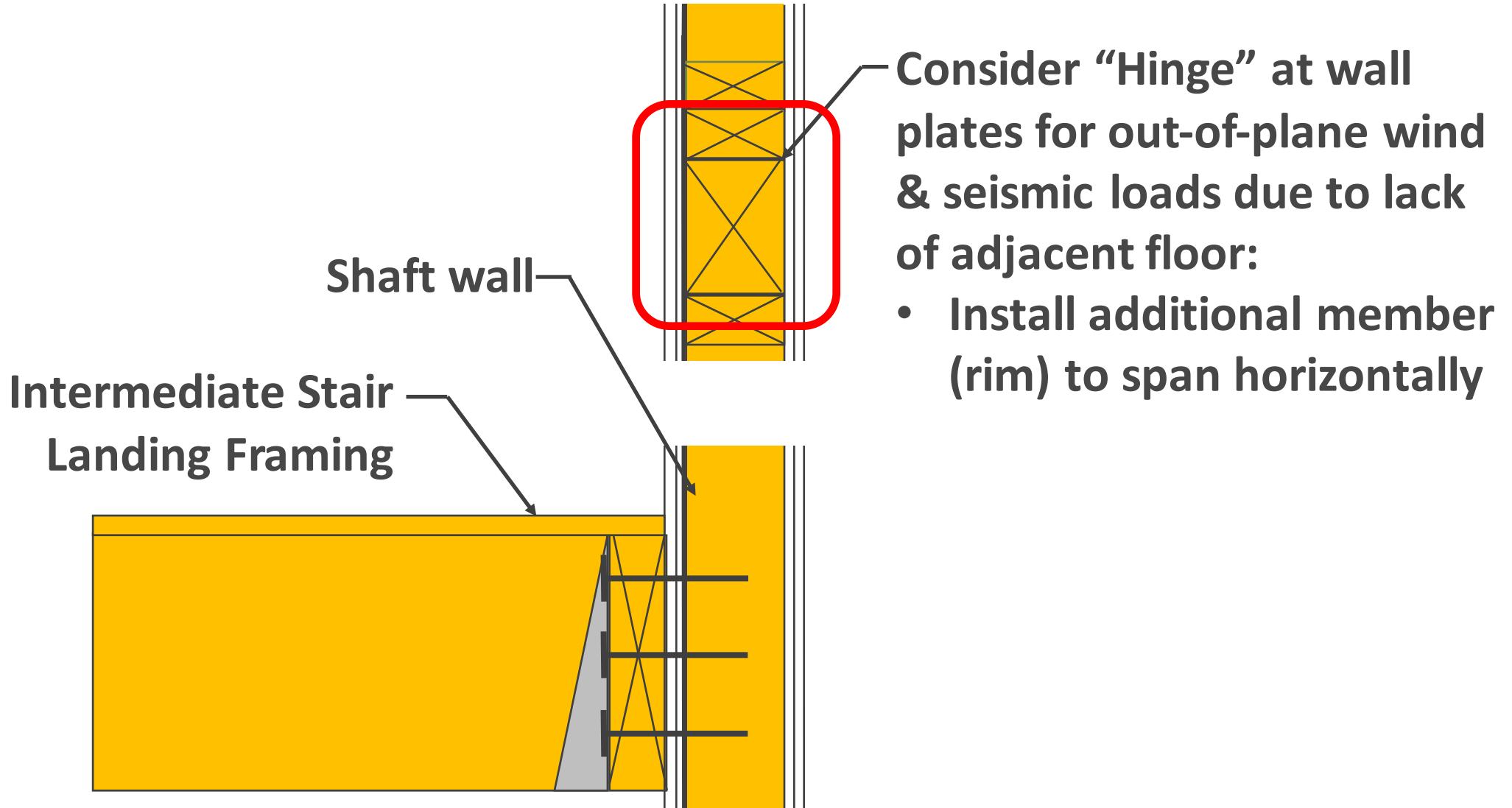


Exterior Wall That is Shaft Wall

Shaft Walls that are also Exterior Walls



Shaft Walls that are also Exterior Walls





Shaft Wall Assemblies

Assembly selection considerations

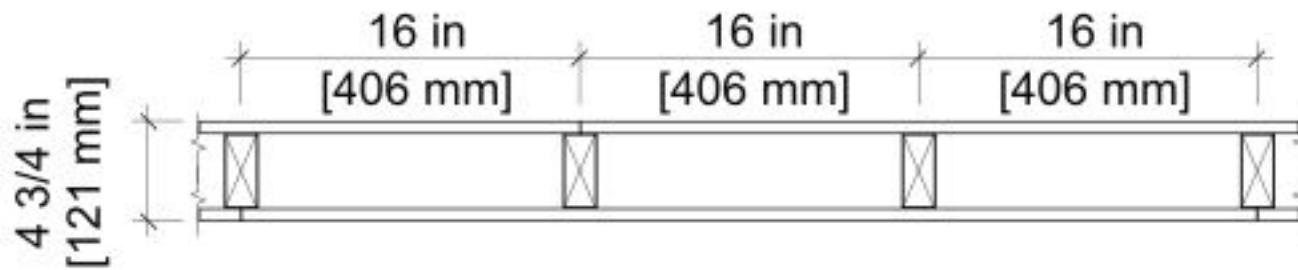
- Fire resistance rating requirement (1 hr or 2 hr)
- Size and height of shaft
- Structural needs (gravity & lateral loads)
- Acoustics
- Space available for wall (allowed thickness)



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

2-Hour Single wall

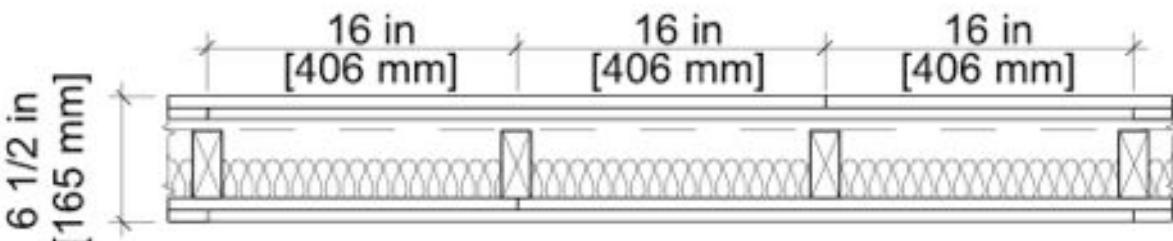
- UL U301
- UL U334
- IBC 2012 Table 721.1(2) Item Number 14-1.5
- IBC 2012 Table 721.1(2) Item Number 15-1.16

2-Hour Double Wall

- UL U342
- UL U370
- GA WP 3820

FIGURE 5:

UL U334



2-Hour Wall with Shaftliner

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

Shaft Wall Assemblies with Shaftliner

Shaftliner Unique Considerations

- Common for “party walls” in townhouse construction
- Many tested assemblies available for 1 hr and 2 hr applications
- May allow installation from one side only – useful in small MEP shafts where finishing from inside isn’t possible
- Some have height limitations, both per story and overall system
- Not structural, require back-up wood wall



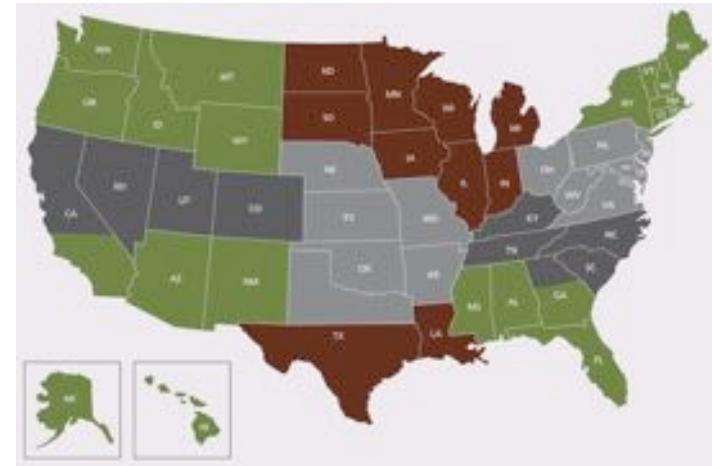
Credit: ClarkDietrich

Floor to Shaft Wall Detailing

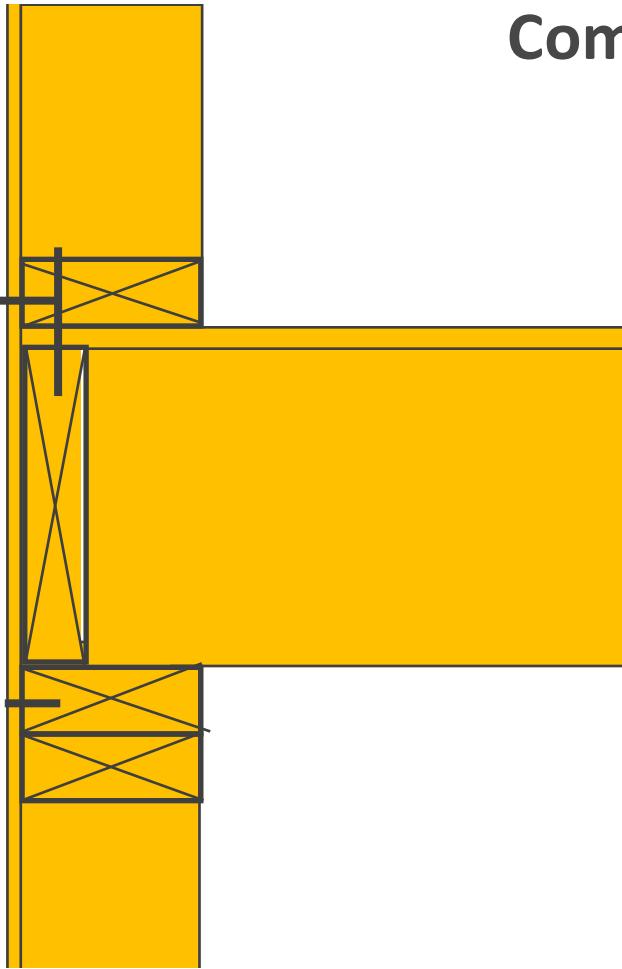
After shaft wall assembly is selected, need to consider how it will interface with floors and roof it intersects

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, providing rationale, other insight

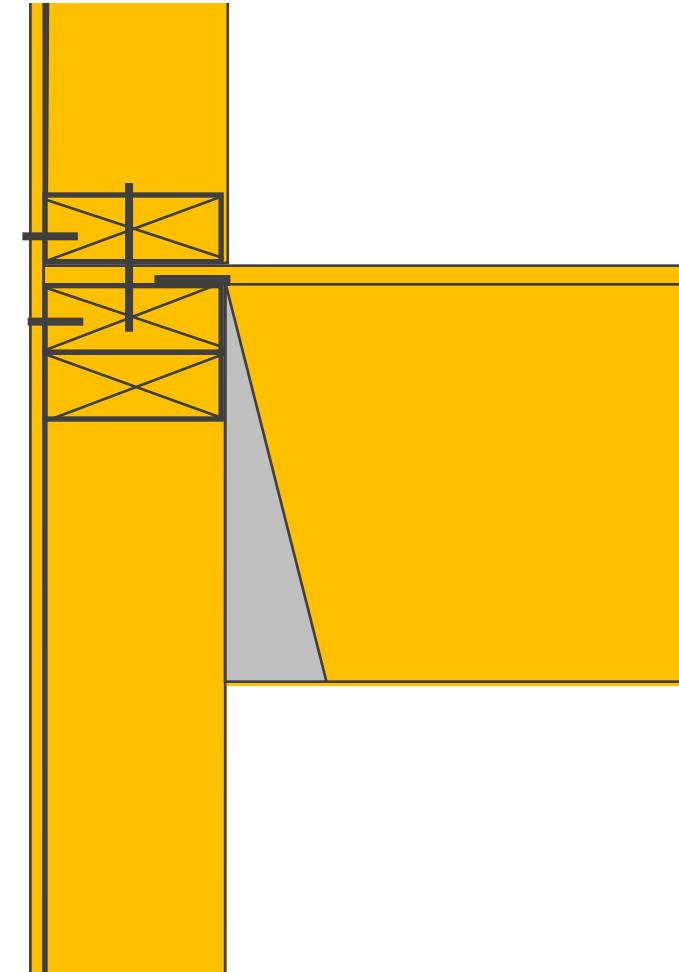


Floor to Shaft Wall Detailing



Platform Framing

Common Details

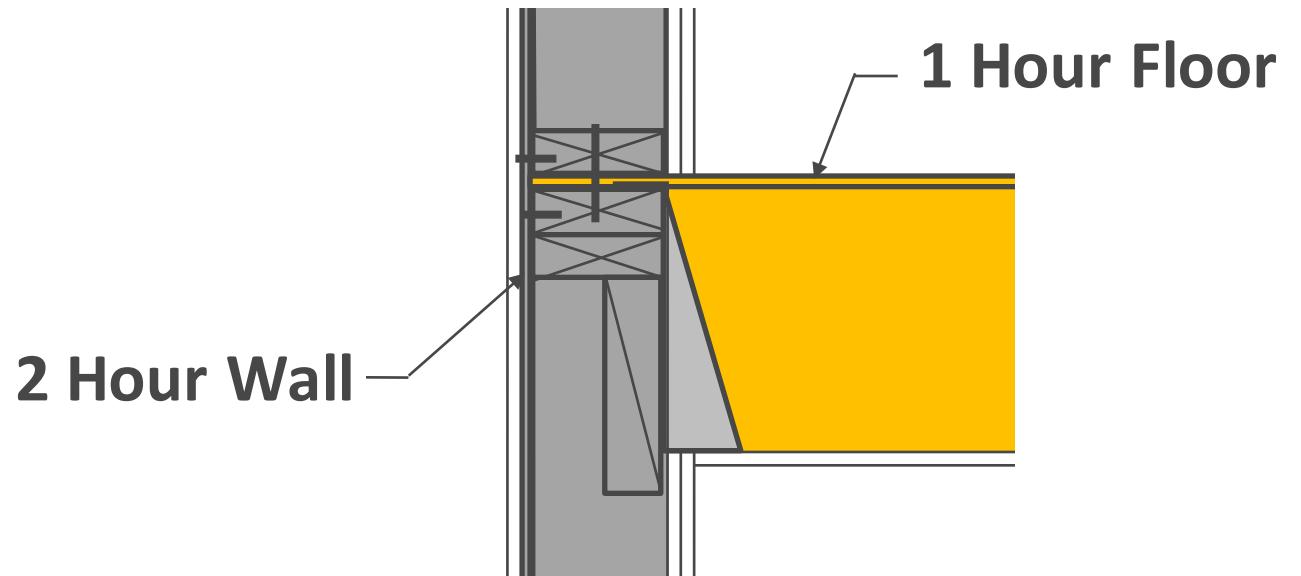
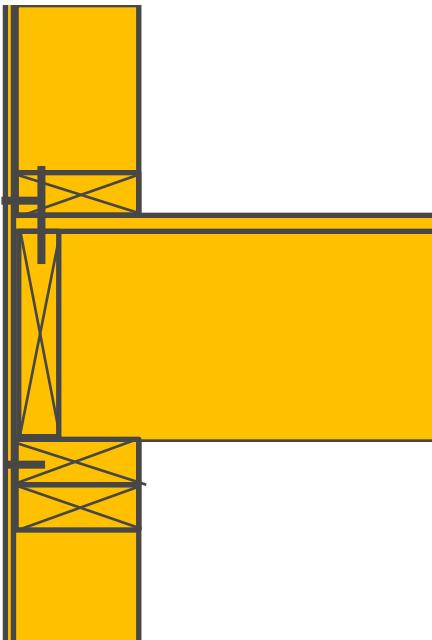


Semi-balloon Framing

Floor to Shaft Wall Detailing

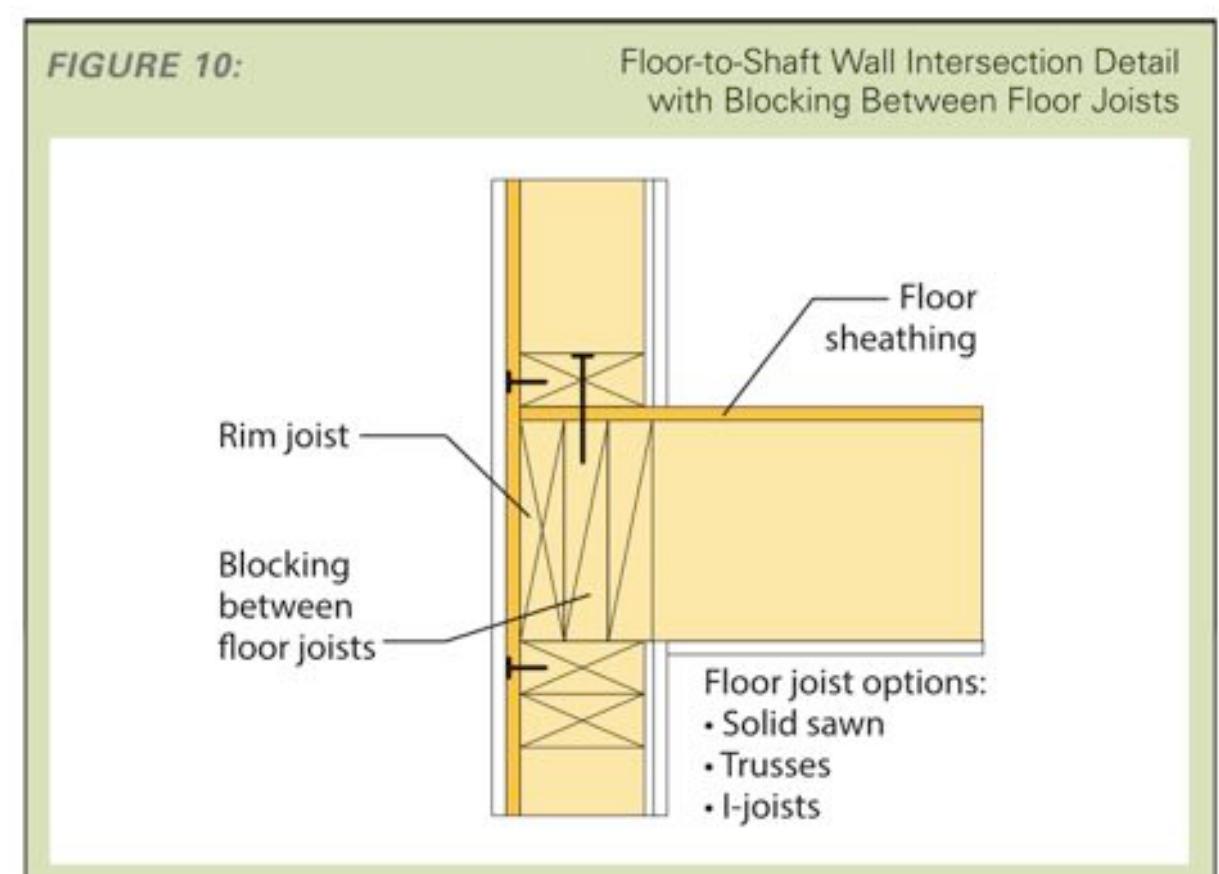
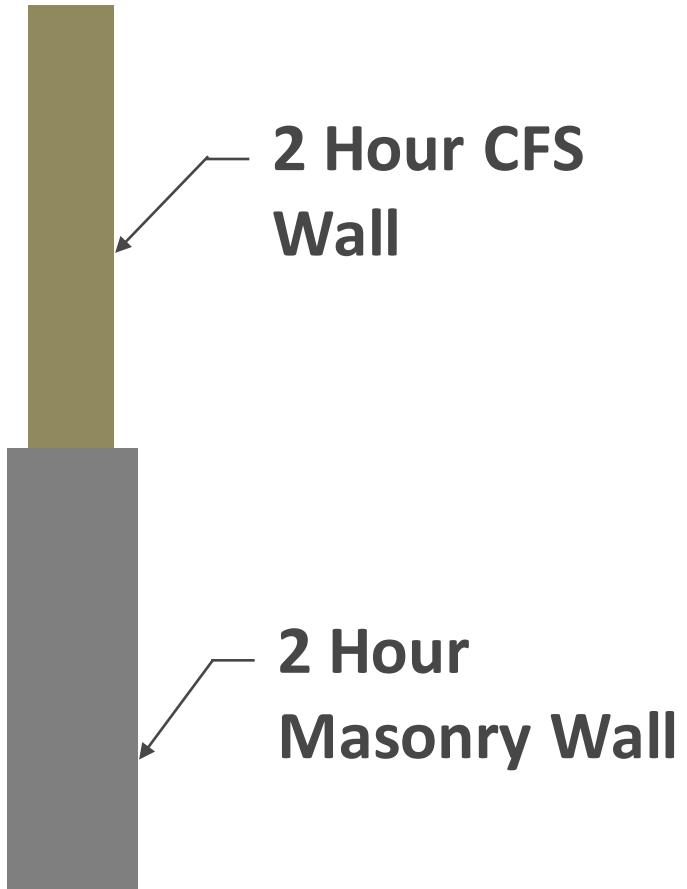
Supporting Construction: In platform and semi-balloon frame construction, if we have a 2 hour shaft wall and a 1 hour floor, how do we achieve this?

- 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"



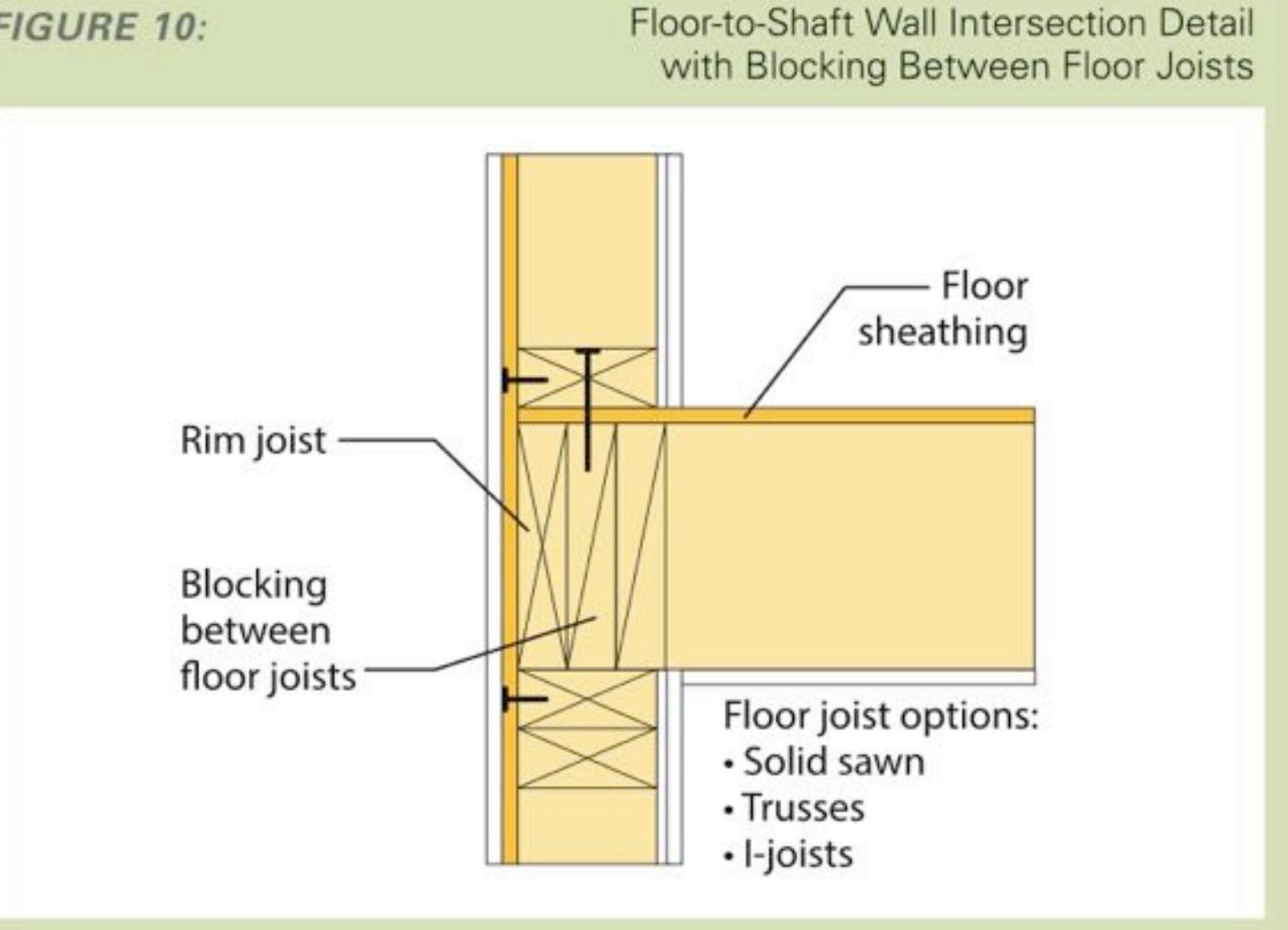
Floor to Shaft Wall Detailing

Concept of stacking different rated assemblies isn't new



Floor to Shaft Wall Detailing

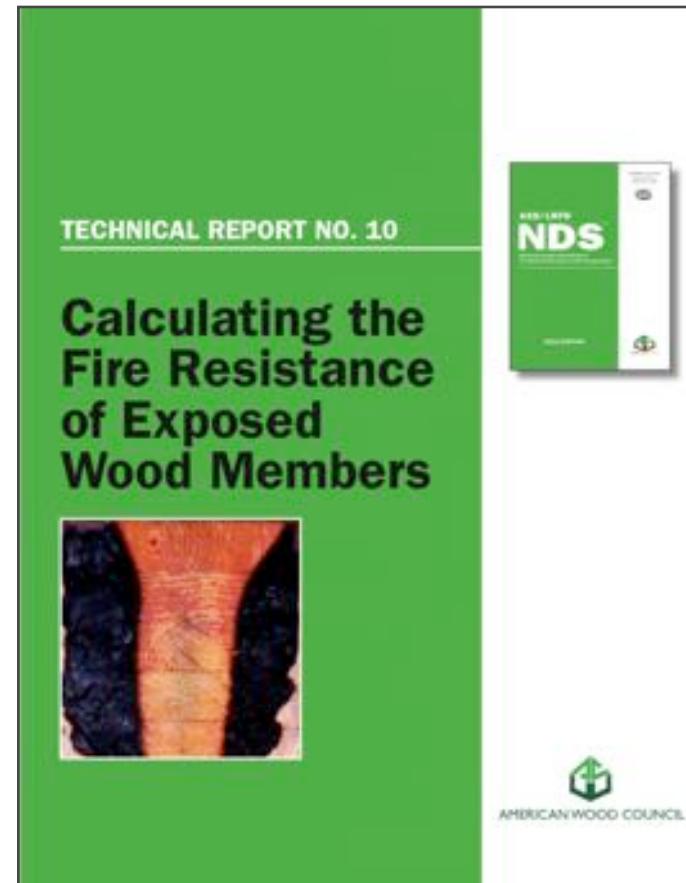
FIGURE 10:



- 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

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)



Calculated Fire Resistance of Wood

For solid sawn, glulam and SCL wood members,
nominal char rate = 1.5"/hr.

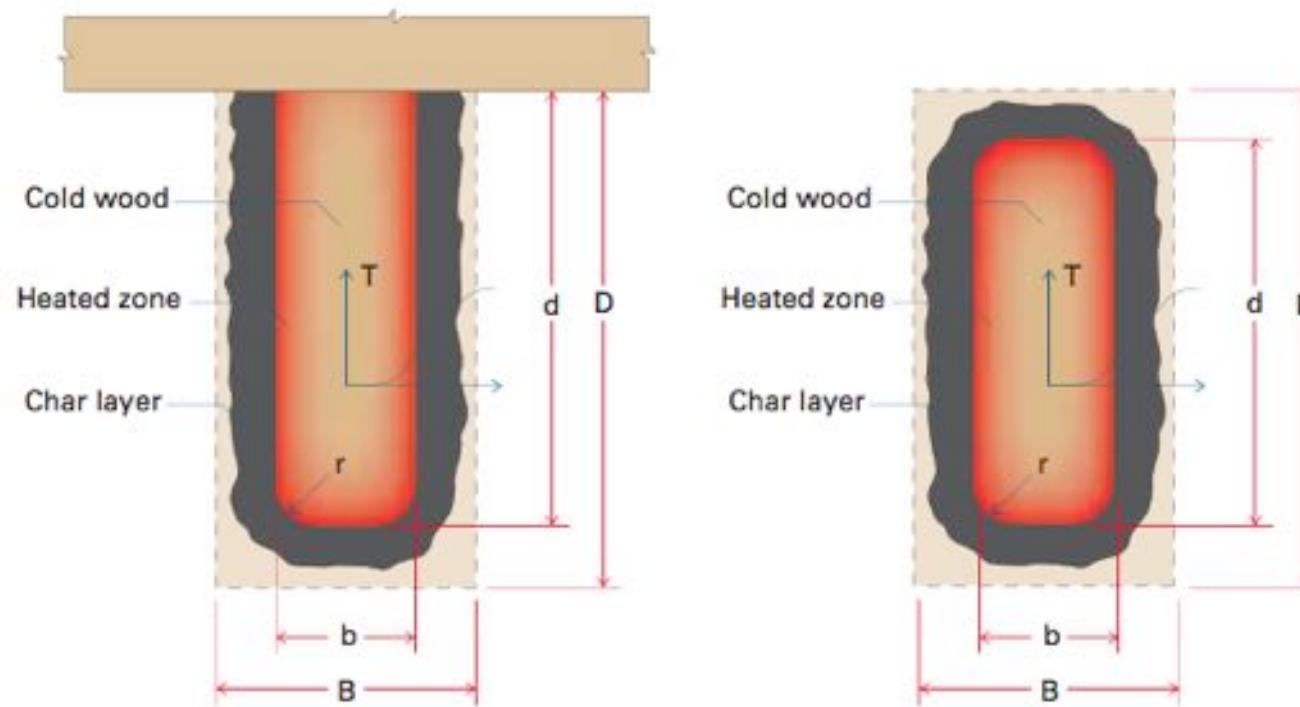


Figure 1-1 Reduction in member breadth and depth over time, t

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



United States
Department of
Agriculture

Forest Service

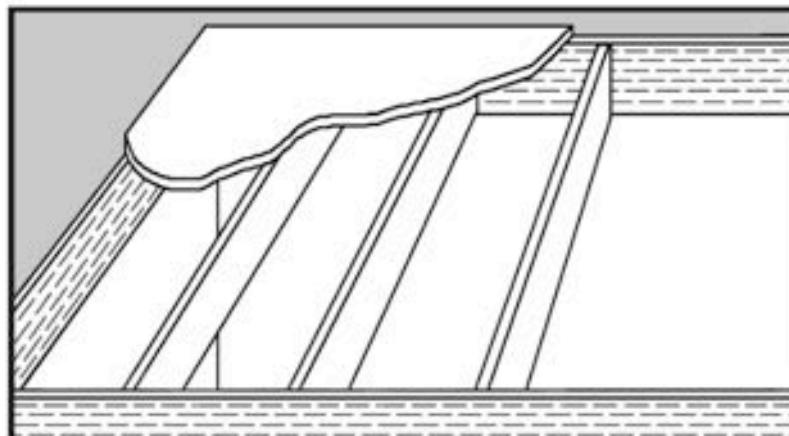
Forest
Products
Laboratory

Research
Paper
FPL-RP-610



Fire Resistance of Engineered Wood Rim Board Products

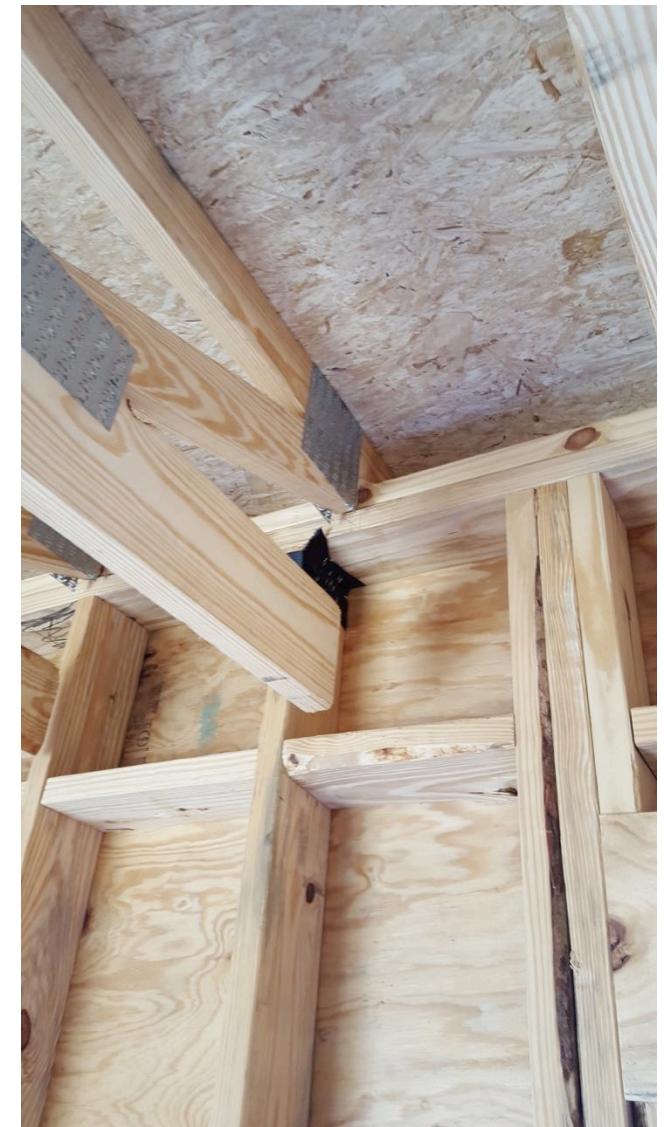
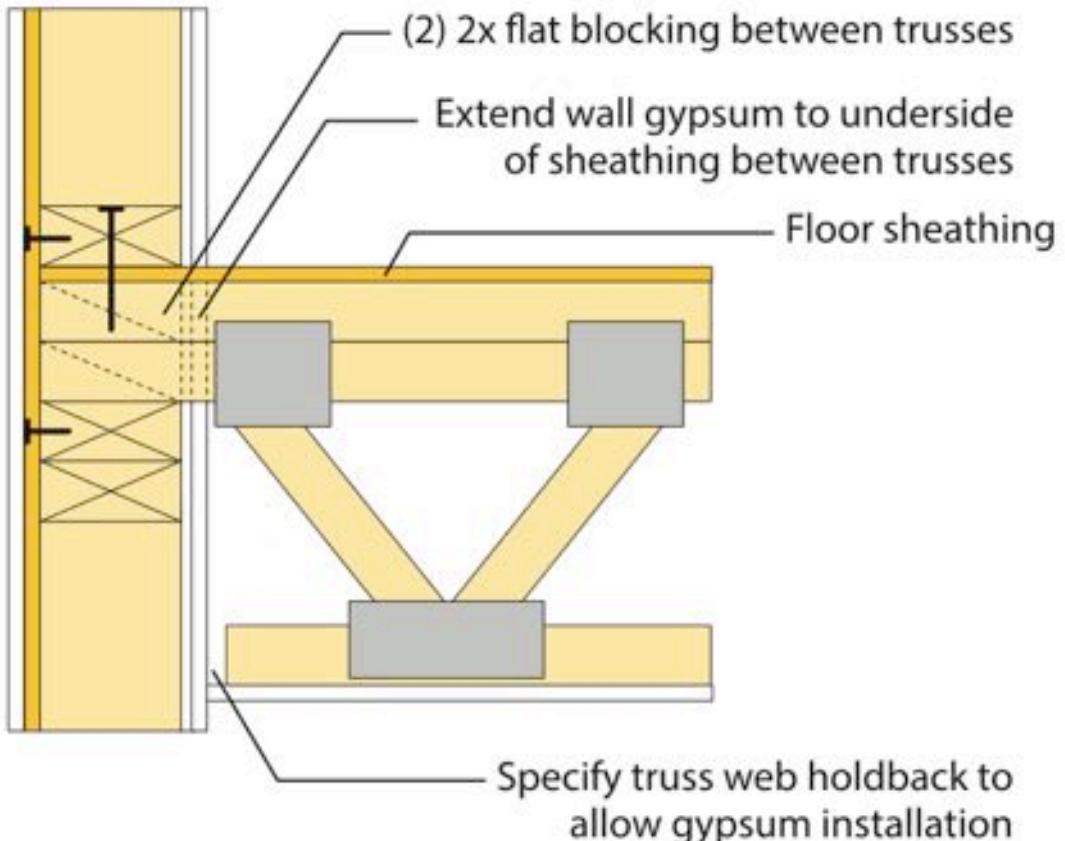
Robert H. White



Floor to Shaft Wall Detailing

FIGURE 11:

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

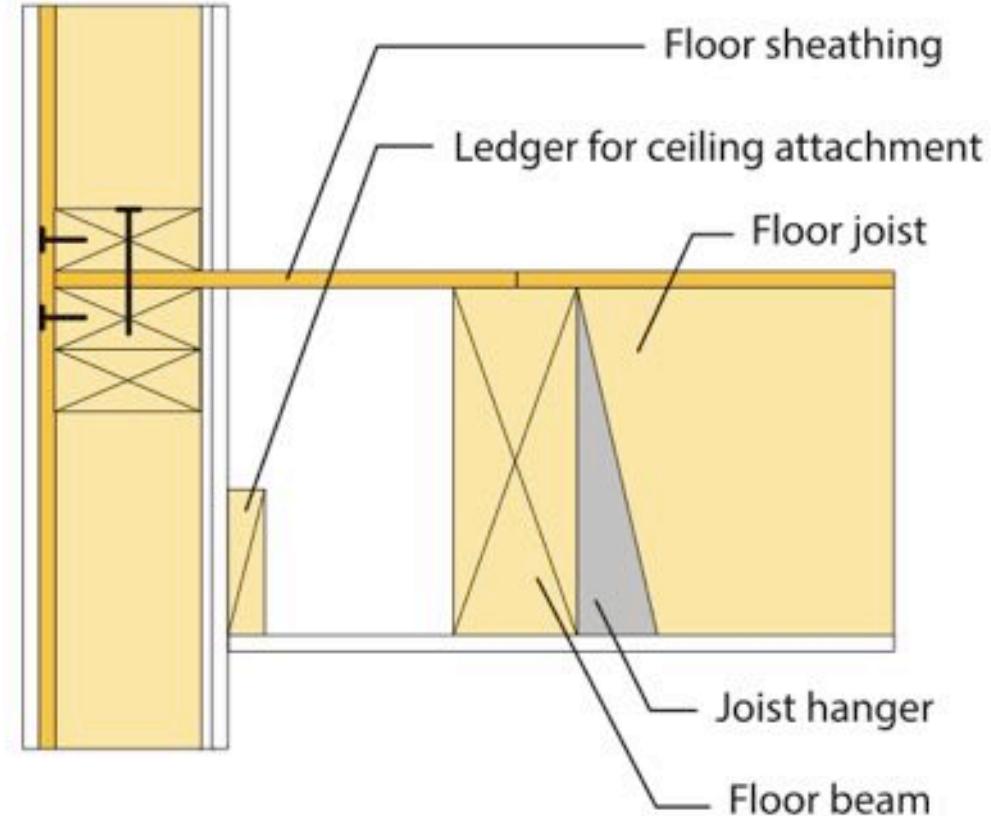


Floor to Shaft Wall Detailing



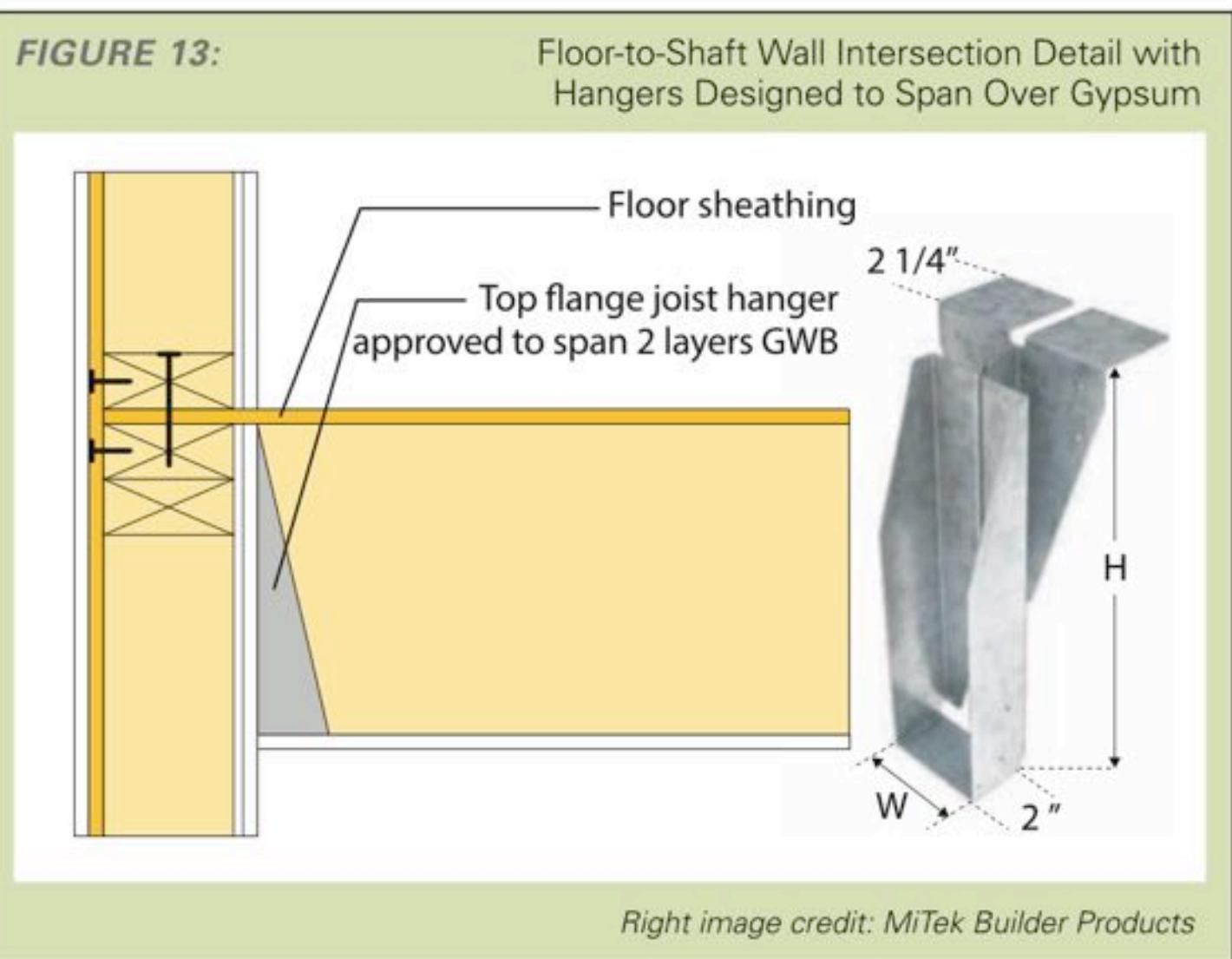
FIGURE 12:

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

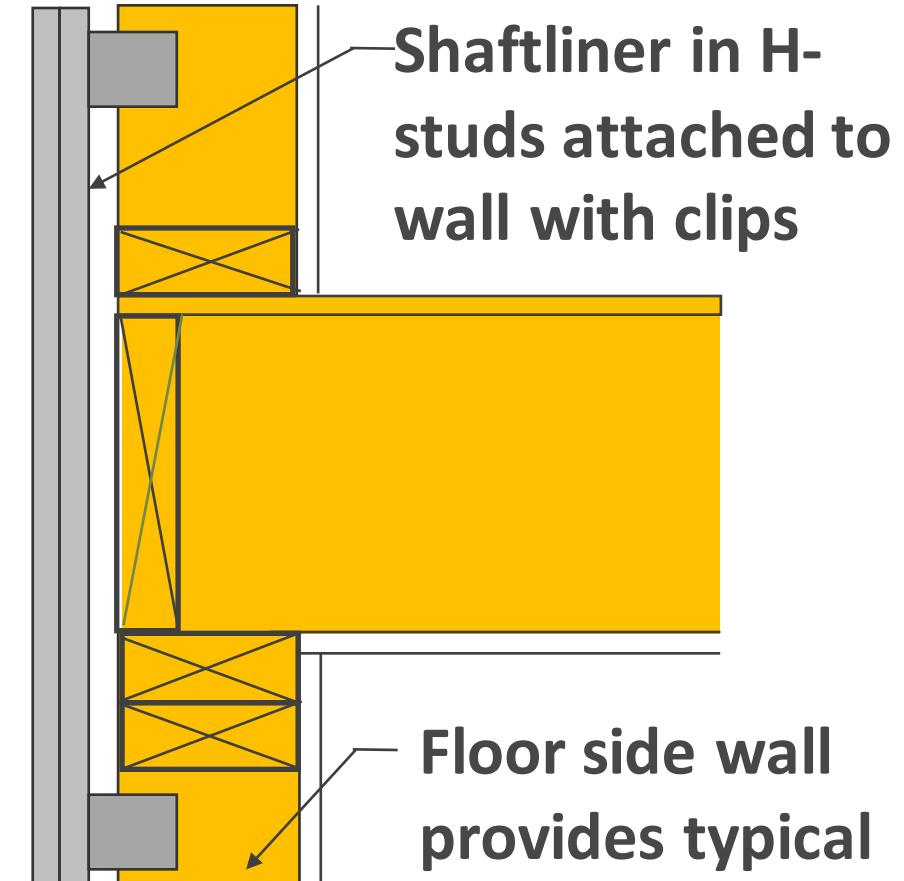
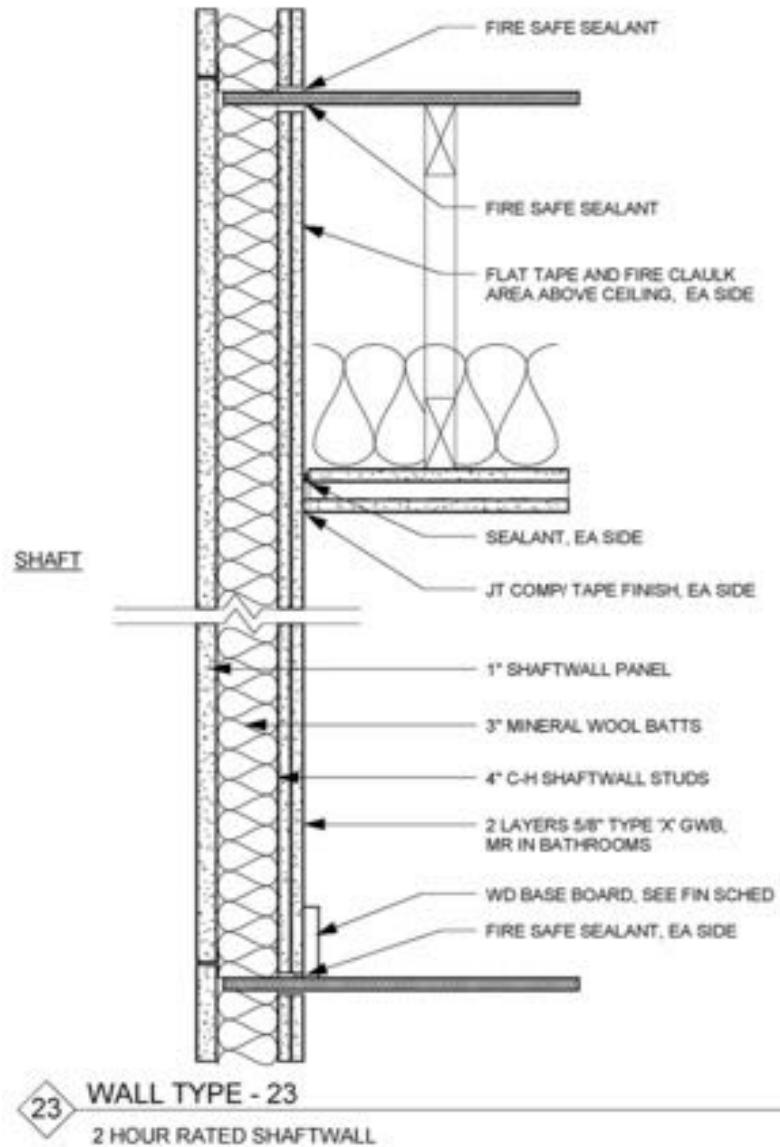


Floor to Shaft Wall Detailing

- 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



Floor to Shaft Wall Detailing



Floor side wall
provides typical
floor support

Floor to Shaft Wall Detailing

FIGURE 20:

Mass Timber Floor Framing-to-Shaft Wall Attachment

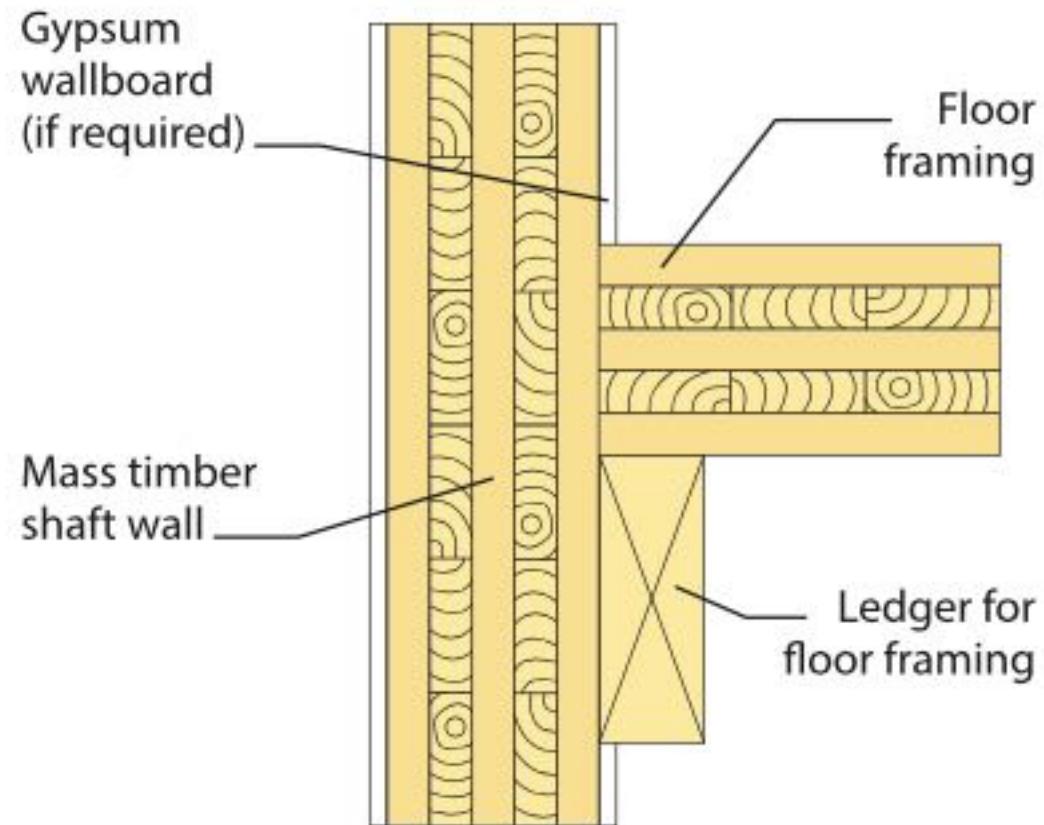
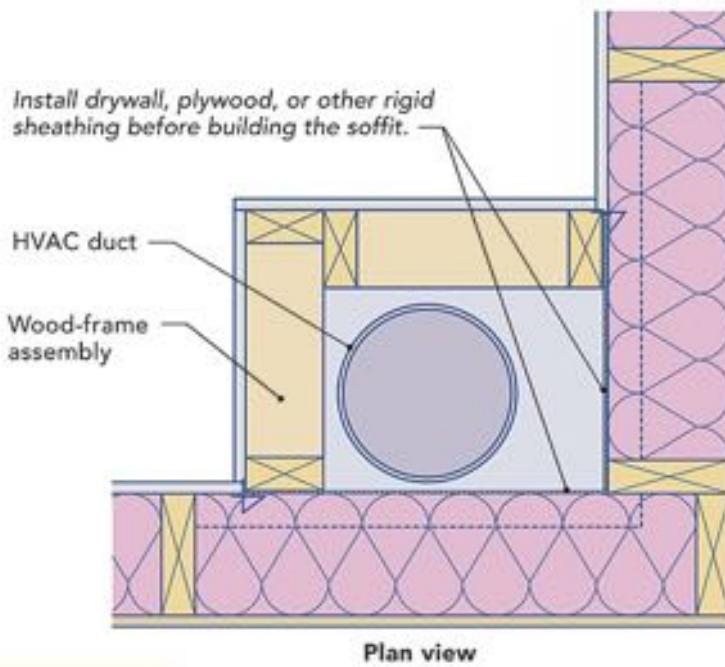


Photo: Alex Schreyer

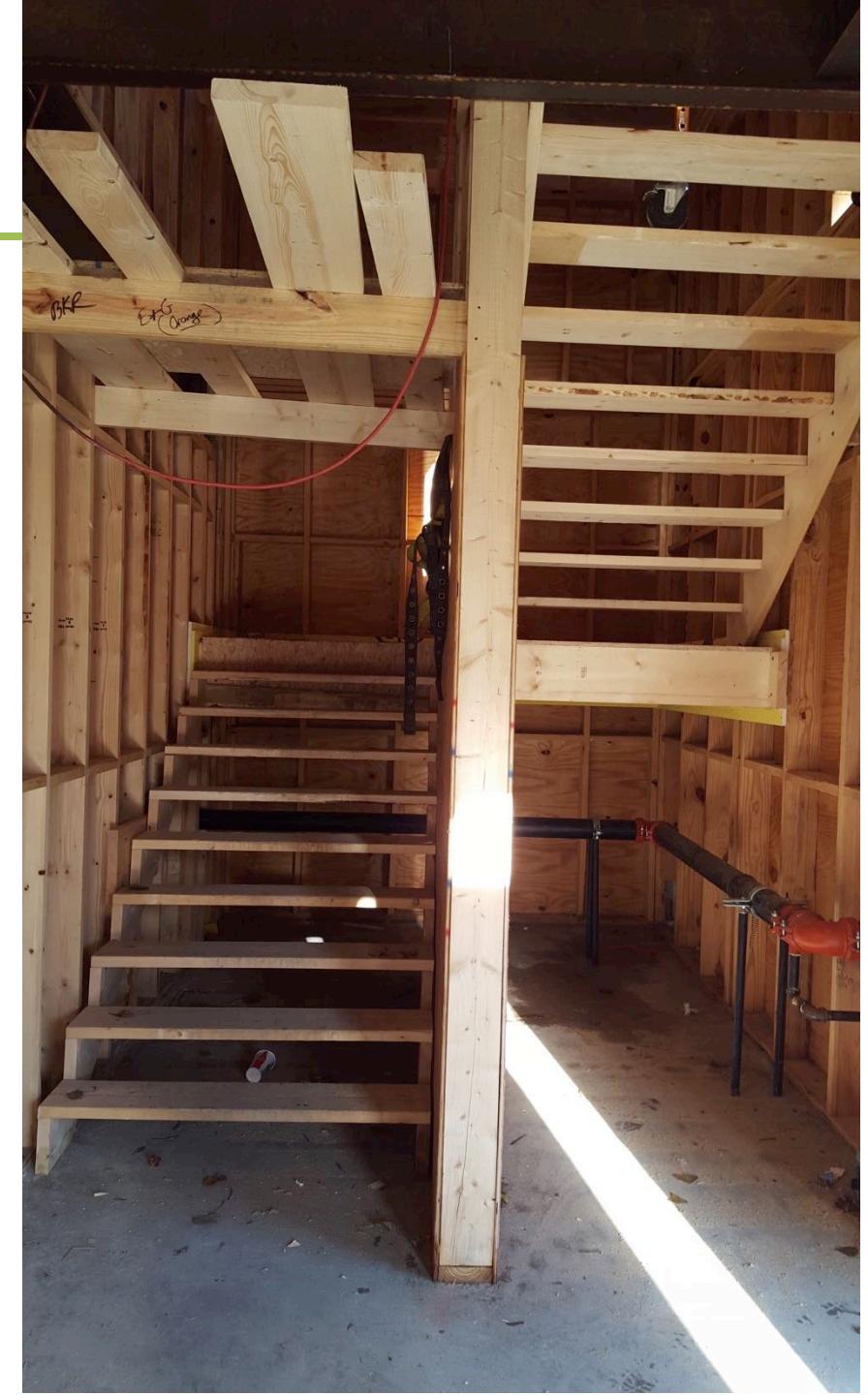
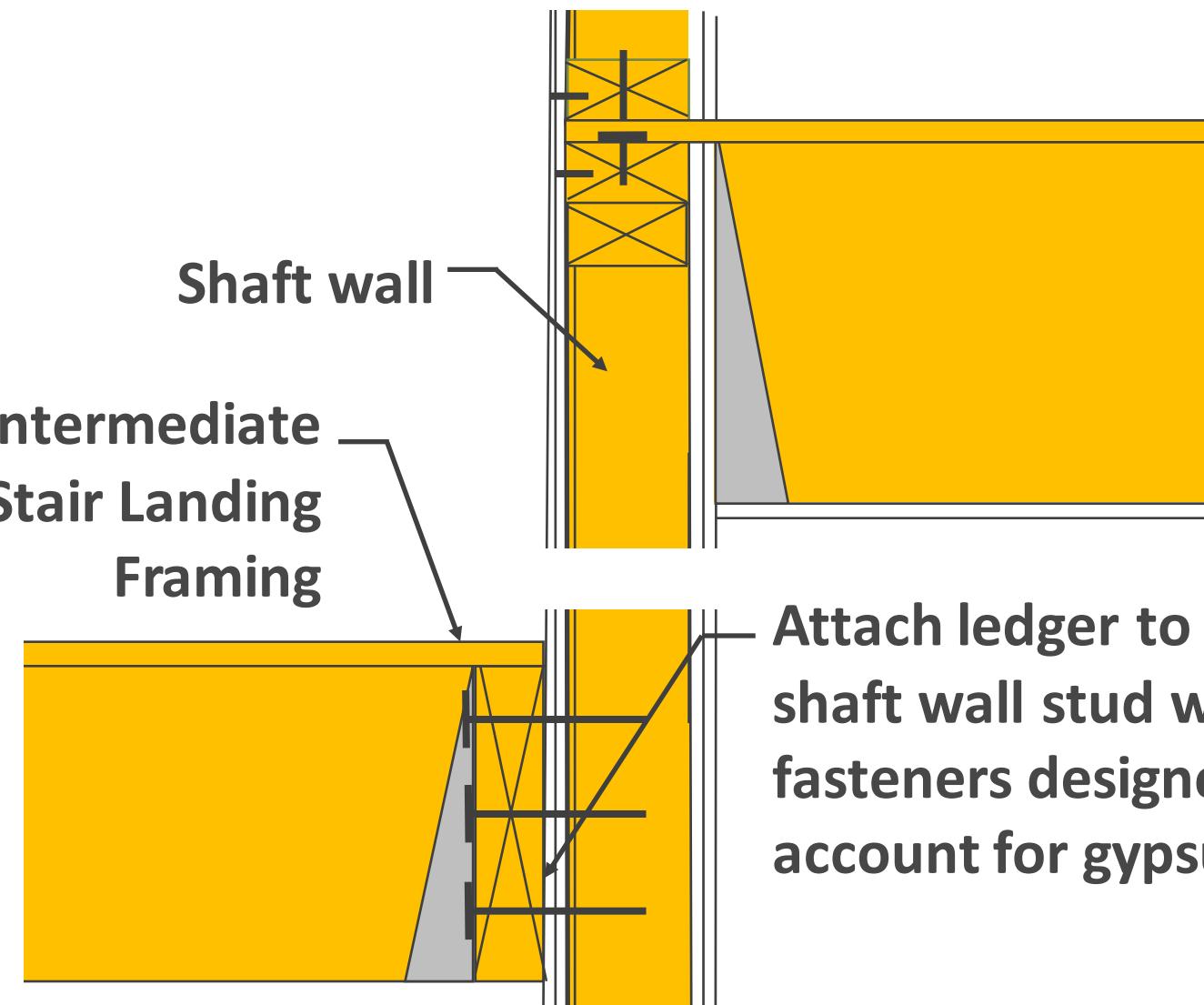
Stair, Elevator & MEP Shafts

Main Differences & Unique Design Constraints

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



Stair Shafts

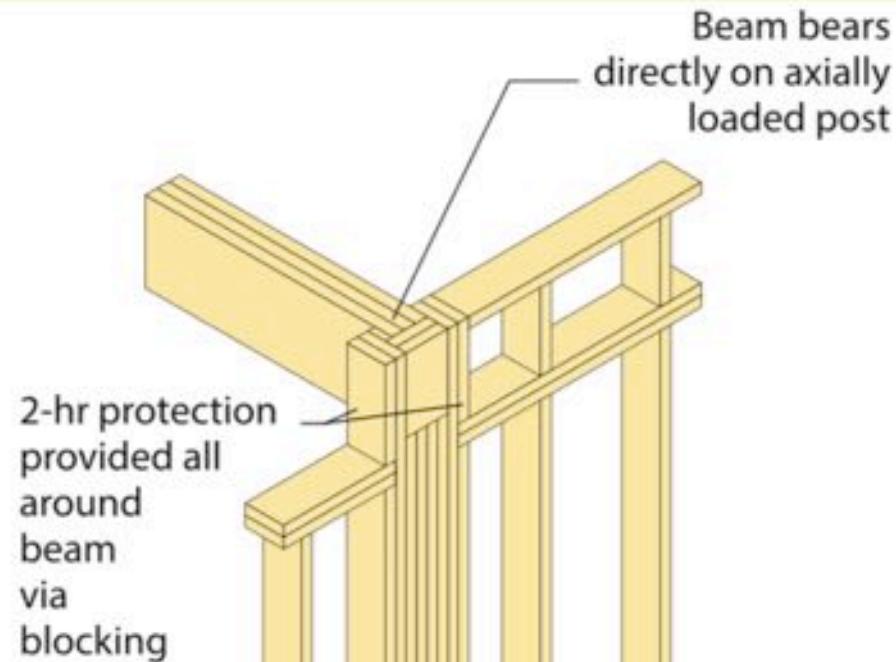




Stair Shafts

FIGURE 16:

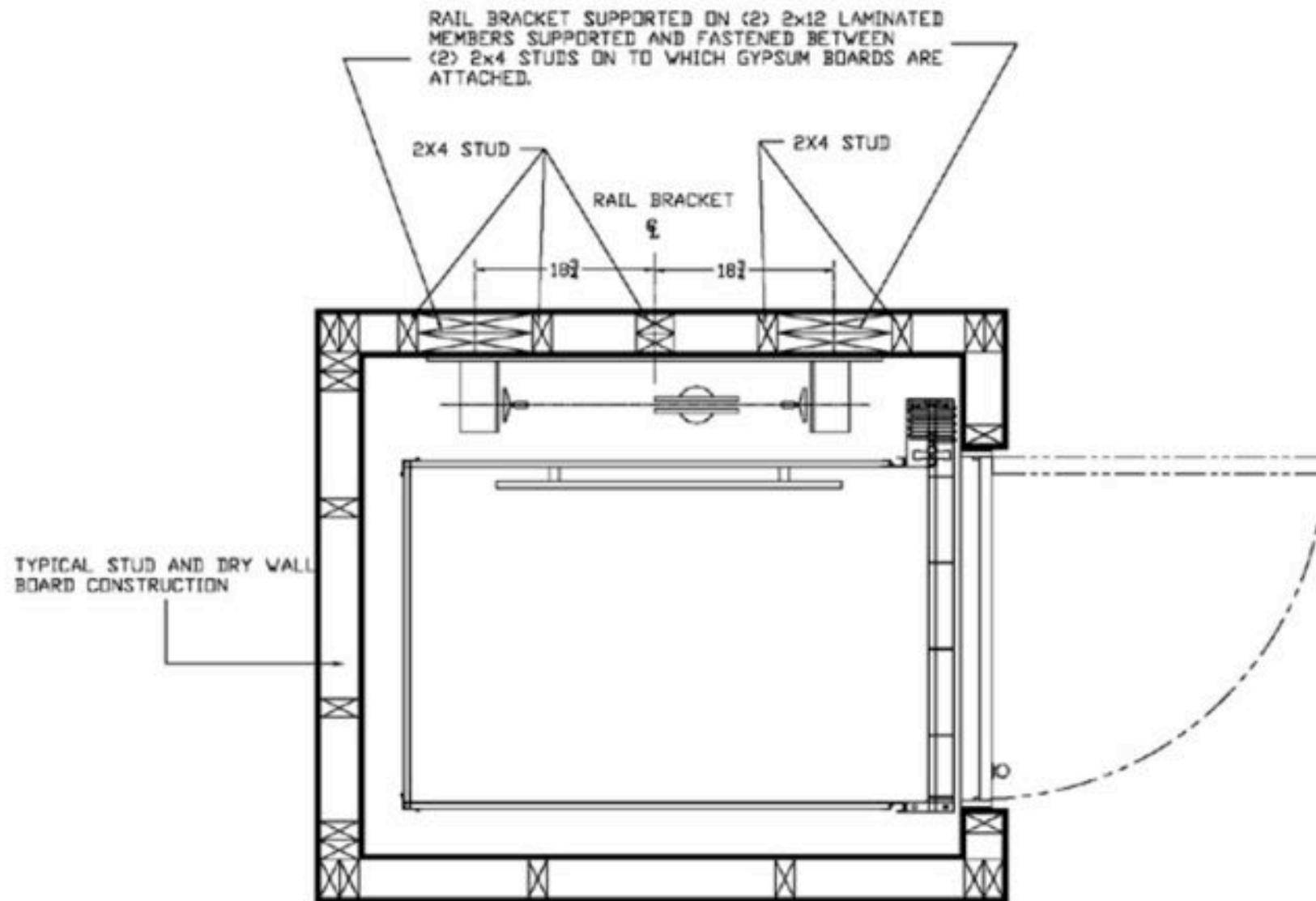
Stair Framing Beam in Protect Pocket in Shaft Wall



Elevator Shafts



Elevator Shafts



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



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 isolating masonry shaft walls, only tie wood floor to masonry shaft if/where required (i.e. at door threshold)

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	Structural System Limitations Including Structural Height, h _a (ft) Limits ^c					
			Overstrength Factor, Ω ₀ ^d	Deflection Amplification Factor, C _d ^b	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
16. Special reinforced masonry shear walls	14.4	5½	2½	4	NL	NL	160	160
17. Intermediate reinforced masonry shear walls	14.4	4	2½	4	NL	NL	NP	NP
18. Ordinary reinforced masonry shear walls	14.4	2	2½	2	NL	160	NP	NP

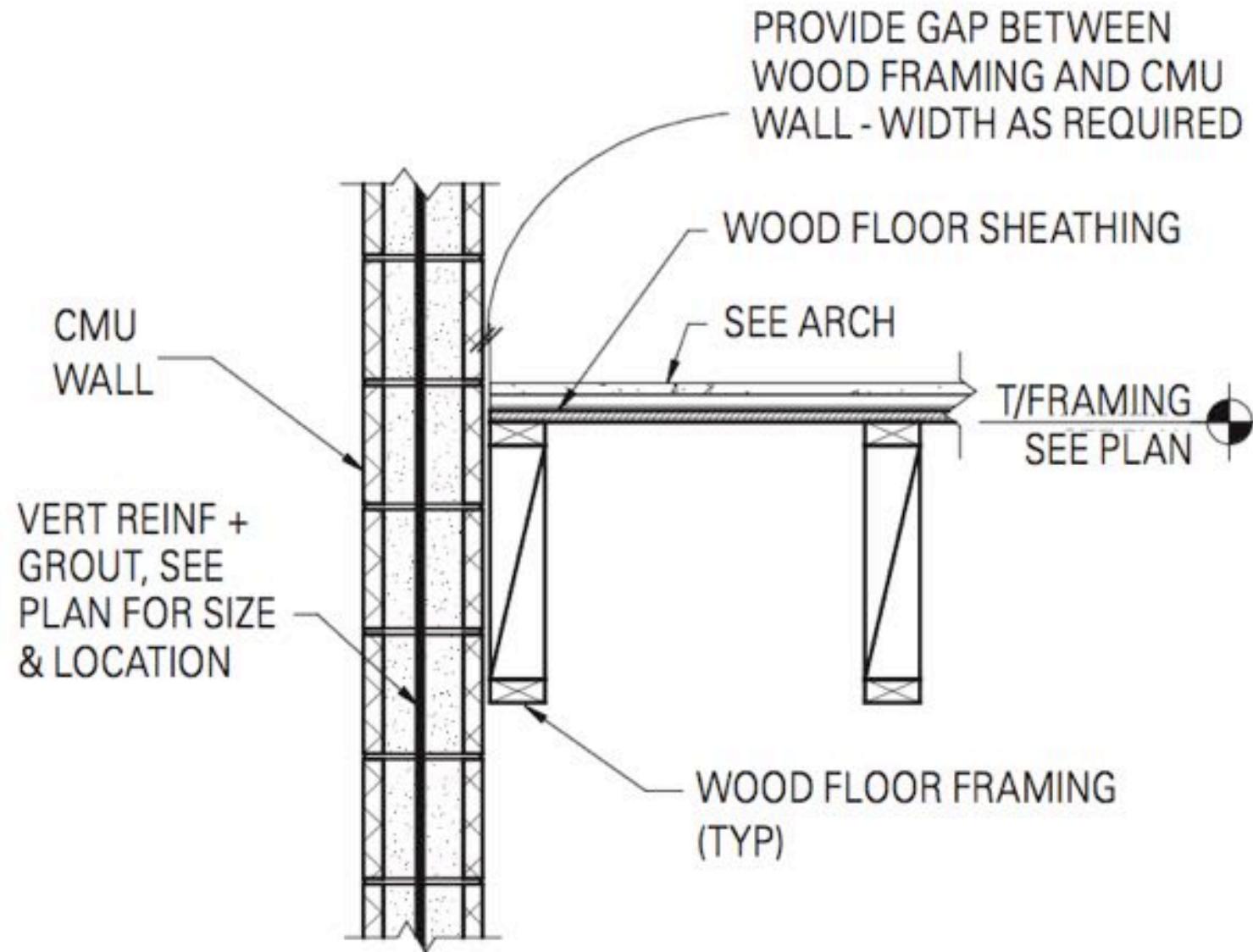
Source: ASCE 7-10

Mass Matters:

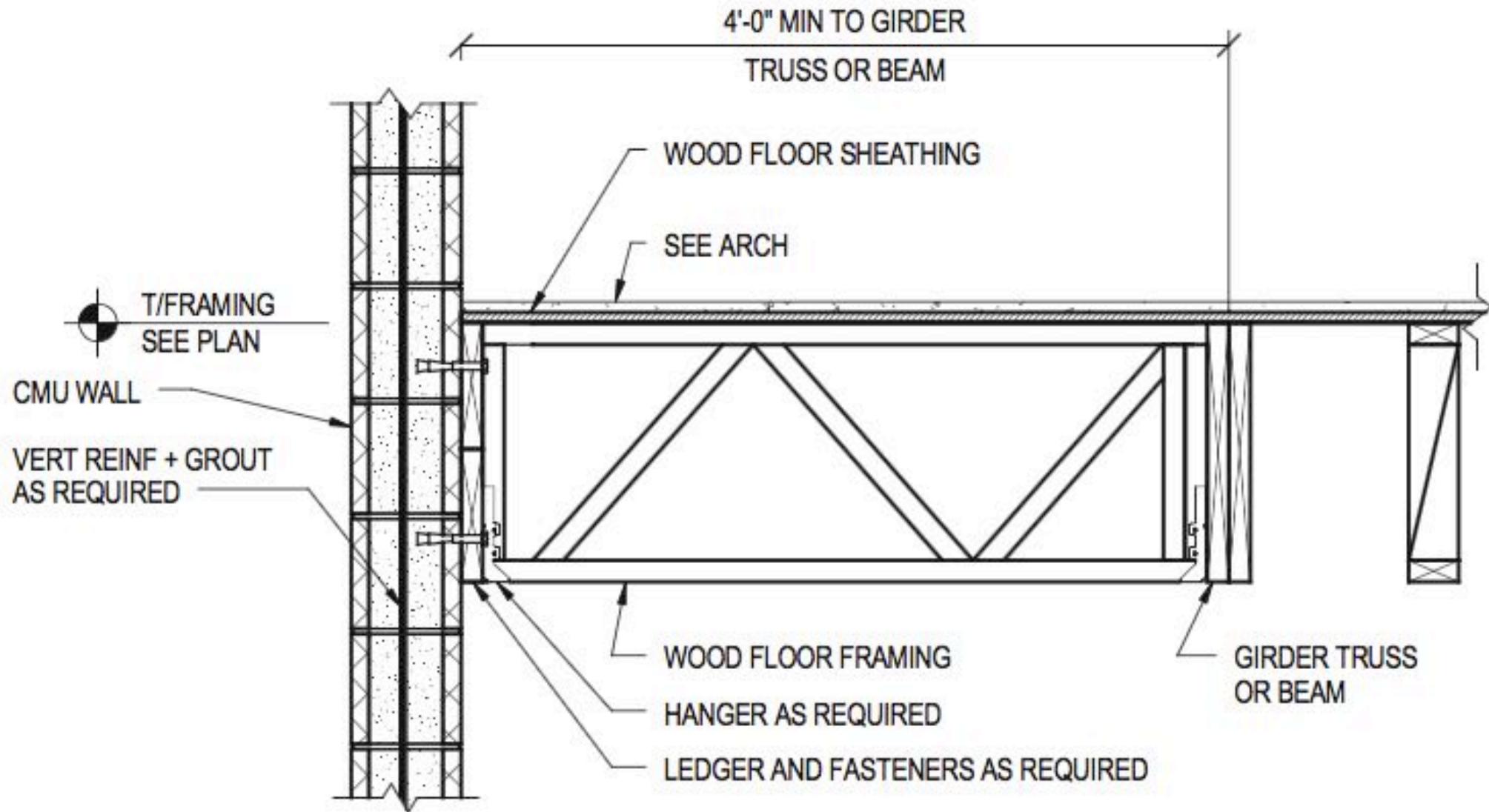
8" CMU Wall, grout & reinforcing @ 48" o.c.: 44 psf

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

Masonry Shaft Walls



Masonry Shaft Walls



Resource for Material Movement



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

Free resource at woodworks.org

Accommodating Shrinkage in Multi-Story Wood-Frame Structures

Richard McLain, MS, PE, SE, Technical Director, WoodWorks • Doug Steinle, 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.



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

Photo: Pollock 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.

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, AIA, PE, SE • Technical Director • WoodWorks



Wood shaft walls can reduce costs and shorten the construction schedule.

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

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