# Interior Wall Deep Dive: Fire Walls, Barriers, Partitions and Shaft Walls


PRESENTED BY:

CHELSEA DRENICK, PE, SE

WOODWORKS


JULY 25, 2023

Photo: Quality Contractor

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- Building Systems & Technologies

**River Edge**, Kitchen & Associates
photo courtesy of McAlvain Construction

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# **Questions?** Ask me anything.


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

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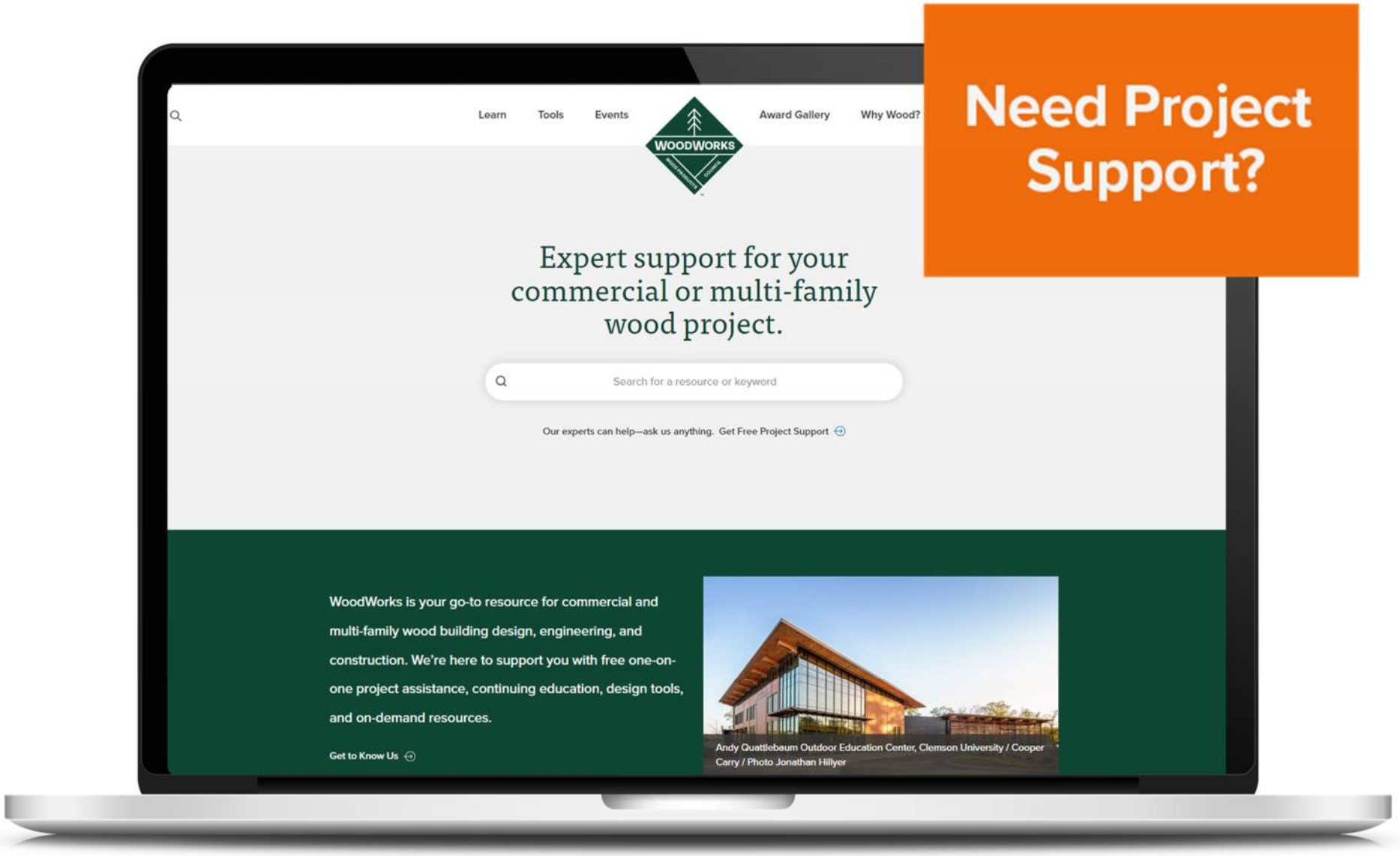

# Solutions Team

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Building Systems

- Light-Frame
- Mass Timber / CLT
- Off-Site / Panelized Construction
- Hybrid

Building Types

- Multi-Family / Mixed Use
- Education
- Office
- Commercial Low-Rise
- Industrial
- Civic / Recreational
- Institutional / Healthcare

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## Building Systems

- Mass Timber / CLT 24
- Light-Frame 9
- Panelized Construction 7
- Hybrid 5

## Building Types

- Multi-Family / Mixed-Use 16
- Education 10
- Office 10
- Commercial Low-Rise 9
- Civic / Recreational 6
- Industrial 6
- Institutional / Healthcare 6

## Project Roles

- Architect 14
- Developer/Owner 11
- Structural Engineer 10
- Contractor/Installer 6

## Resource Types

- Expert Tips 10
- Solution Papers 2
- Calculators 1
- Guides, Manuals & Inventories 1

## Regions

- National 20
- Midwest 5
- South 4
- West 4

acoustics

### Acoustics and Mass Timber: Room-to-Room Noise Control

This paper covers key aspects of mass timber acoustical design, including rules of thumb for optimal design, common assemblies, detailing strategies, and flanking paths. Companion to the Inventory of Mass Timber Acoustic Assemblies.

Solution Papers

### Designing Mass Timber Floor Assemblies for Acoustics

The growing availability and code acceptance of mass timber for construction has given designers a low-carbon alternative.

Expert Tips

### Impact of Wall Stud Size and Spacing on Fire and Acoustic Performance

Interior wall partitions in a wood-frame building—such as unit demising and corridor walls in a multi-family project—must meet several design objectives simultaneously. Two primary functions are fire resistance and acoustical separation. Having to cite two tested wall assemblies, one for fire-resistance endurance results and another for acoustic results, is common.

Expert Tips

### Firehouse 12

The continuous plywood shell that creates varying acoustic conditions within the performance space forms the exterior of the auditorium.

Award Winner

### Acoustical Considerations for Mixed-Use Wood-Frame Buildings

This paper will help you understand the effects of acoustics in the context of other performance areas, enabling you to more easily navigate the decisions and trade-offs required when evaluating assembly options.

Solution Papers

### Holes and Penetrations in Mass Timber Floor and Roof Panels

Guidance for the design of mass timber floor and roof panels with openings, including structural, fire resistance, and acoustic impacts, and tips for reinforcement.

Expert Tips

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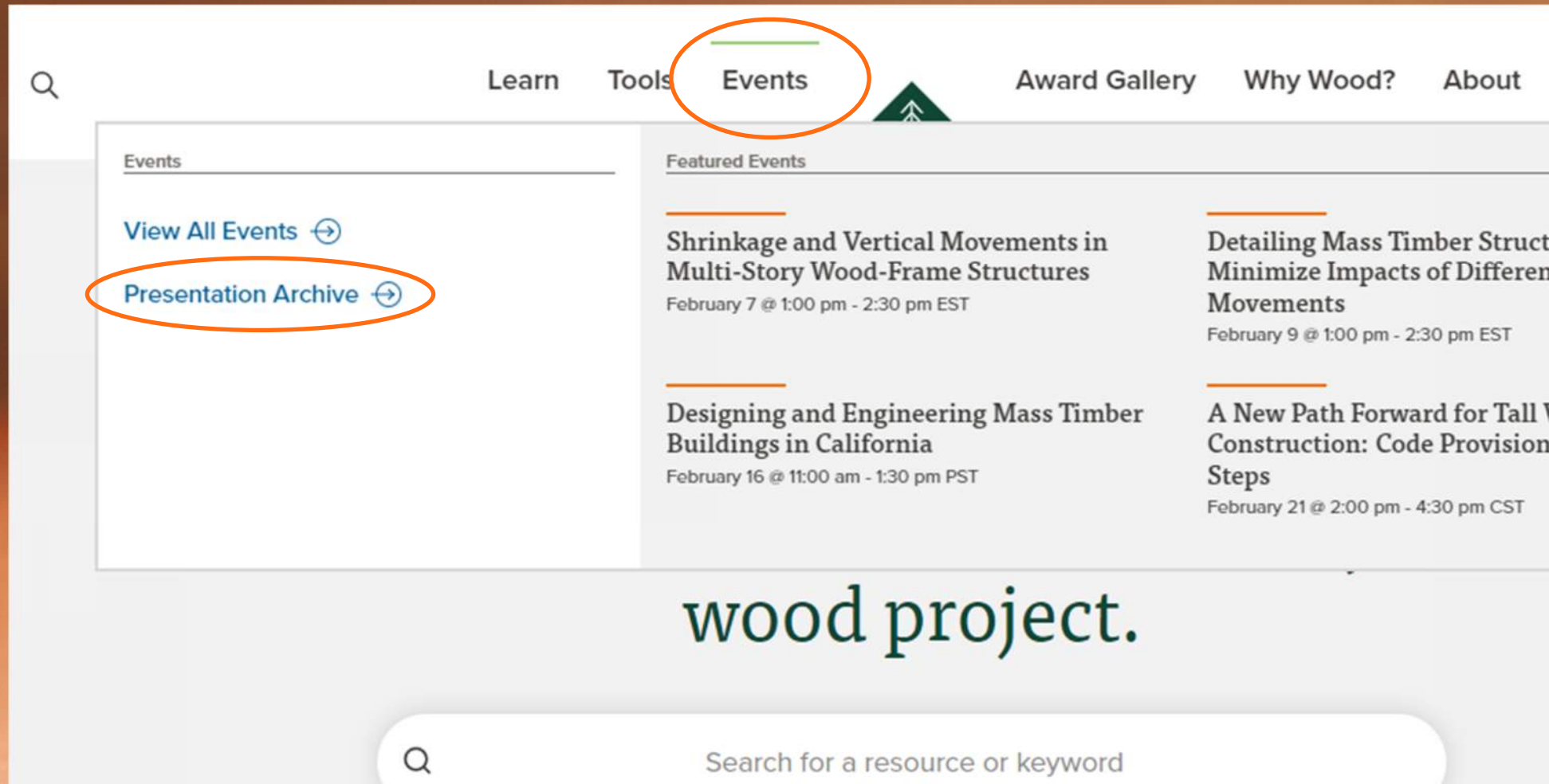
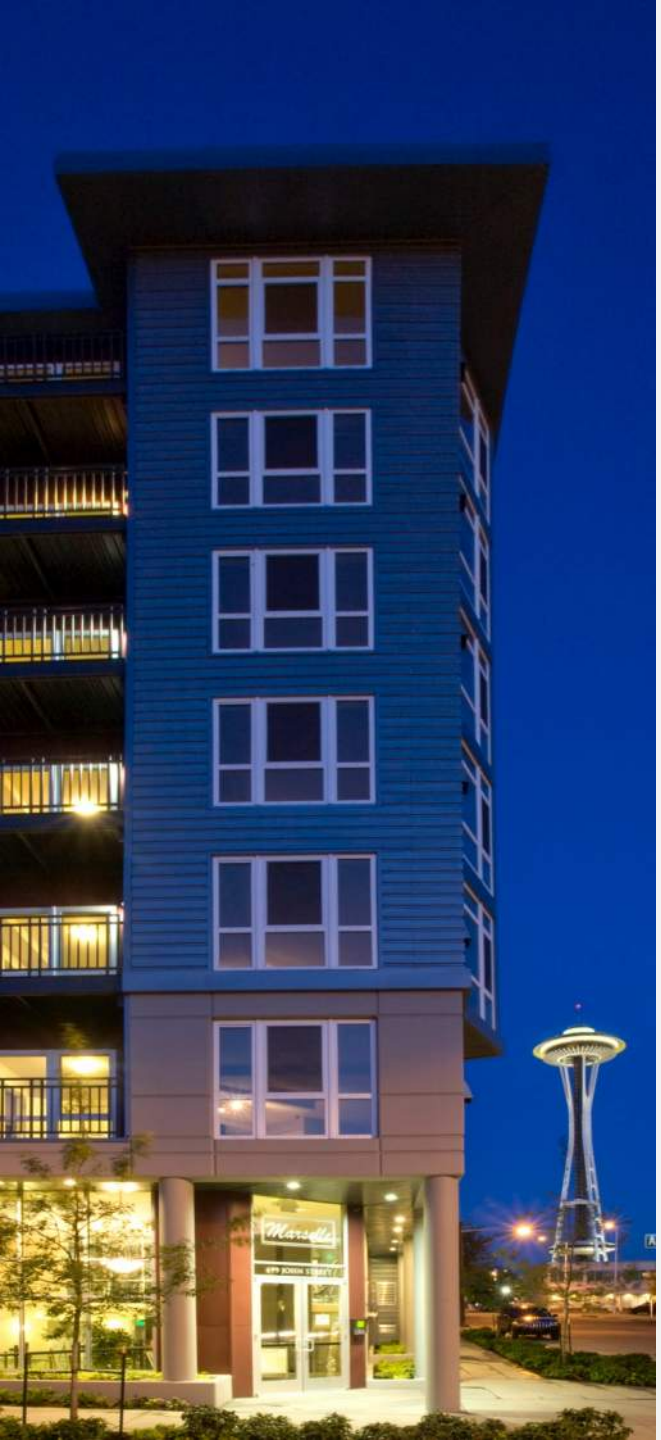


# Agenda

## Interior Wall Deep Dive: Fire Walls, Barriers, Partitions and Shaft Walls

| | |
|---|---|
| 11:00 – 11:05 am | Welcome and Introduction |
| 11:05 – 12:05 pm | ***Fire-Resistant Design and Detailing: Firewalls, Fire Barriers and Fire Partitions*** |
| 12:05 – 12:10 pm | *5-minute break* |
| 12:10 – 1:10 pm | ***Shaft Wall Solutions for Wood-Frame Structures*** |
| 1:10 – 1:30 pm | Q&A |



# Fire Resistant Design and Detailing

## For Light-Frame Wood Construction

### Fire Walls, Fire Barriers & Fire Partitions

Chelsea Drenick, PE, SE

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This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

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

# Course Description

With an increase in wood-frame buildings, more designers are seeking information on code-compliant and constructible detailing. Many are unsure of the code's requirements for details, specifically at the intersection of rated assemblies and where structure and fire protection meet. This presentation will focus interior fire rated assemblies such as firewalls, fire barriers and fire partitions. Discussion will include issues of fire-resistance rating continuity, allowable uses of wood framing in rated assemblies, and allowable penetrations.

# Learning Objectives

1. Review methods for determining fire-resistance ratings.

2. Discuss detailing aspects of fire resistance for fire walls, fire barriers and fire partitions including material and assembly options, continuity, structural stability, and penetrations.

3. Explore requirements for horizontal assemblies.

4. Understand requirements for individual encasement of beams and columns.

# Outline

- Review of Fire Resistance Methods
- Interior Fire Rated Wall Assemblies
  - Fire Walls
  - Fire Barriers
  - Fire Partitions/Corridors
- Horizontal Assemblies

Landing Apartments, Russell Scott Steedle & Capione Architects, photo Gregory Folkins

# Outline

- Review of Fire Resistance Methods
  - Interior Fire Rated Wall Assemblies
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    - Fire Partitions/Corridors
  - Horizontal Assemblies

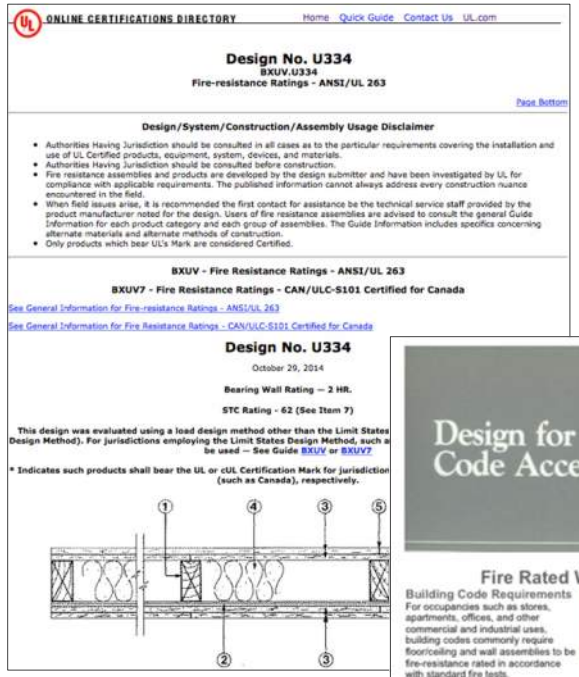
1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

# Fire Resistance Ratings –IBC 703.2

Fire resistance of elements, components or assemblies shall be based on testing (ASTM E119):

- UL Listings
- Gypsum Catalog
- Proprietary Manufacturer Tests
- Industry Documents: such as AWC's DCA3

OR…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Design No. U334
BXUV.U334
Fire-resistance Ratings - ANSI/UL 263

Design/System/Construction/Assembly Usage Disclaimer

- Authorities Having Jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of UL Certified products, equipment, system, devices, and materials.
- Authorities Having Jurisdiction should be consulted before construction.
- Fire resistance assemblies and products are developed by the design submitter and have been investigated by UL for compliance with applicable requirements. The published information cannot always address every construction nuance encountered in the field.
- When field issues arise, it is recommended the first contact for assistance be the technical service staff provided by the product manufacturer noted for the design. Users of fire resistance assemblies are advised to consult the general Guide Information for each product category and each group of assemblies. The Guide Information includes specifics concerning alternate materials and alternate methods of construction.
- Only products which bear UL's Mark are considered Certified.

BXUV - Fire Resistance Ratings - ANSI/UL 263

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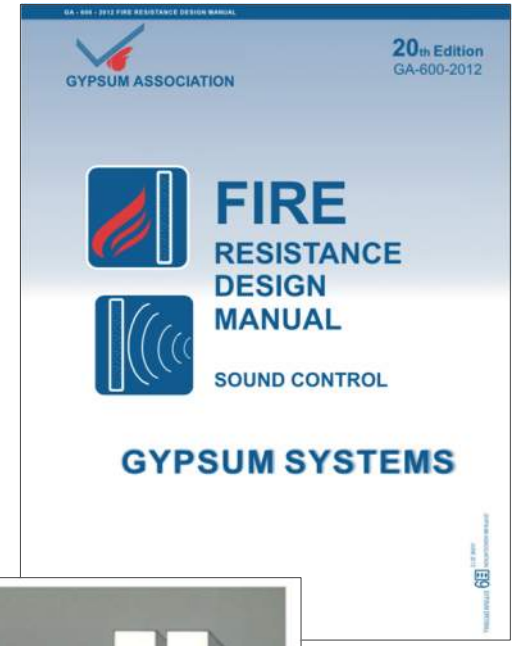
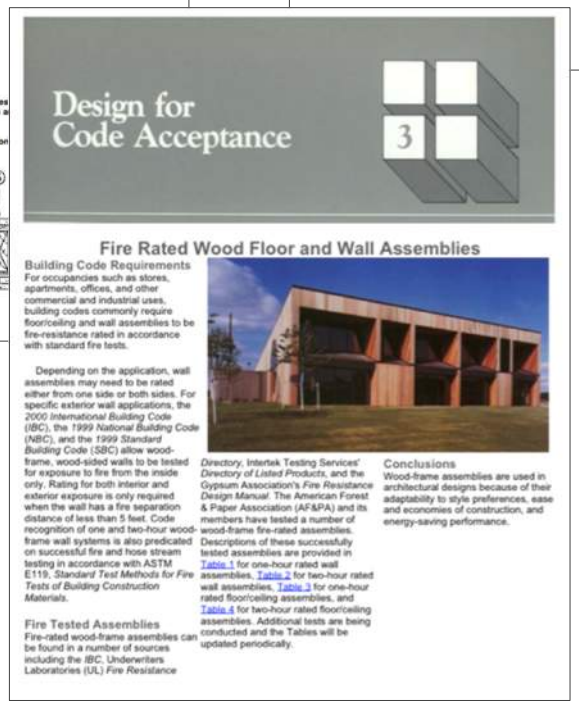
Design No. U334

October 29, 2014

Bearing Wall Rating — 2 HR.

STC Rating - 62 (See Item 7)





Design for Code Acceptance

3

Fire Rated Wood Floor and Wall Assemblies

Building Code Requirements

Fire Tested Assemblies

Conclusions

# Fire Resistance Ratings – IBC 703.2.2

Methods for determining fire resistance:

- Prescriptive designs per IBC 721.1

**TABLE 721.1(3)—continued**
**MINIMUM PROTECTION FOR FLOOR AND ROOF SYSTEMS[a, q]**

| FLOOR OR ROOF CONSTRUCTION | ITEM NUMBER | CEILING CONSTRUCTION | THICKNESS OF FLOOR OR ROOF SLAB (inches) | | | | MINIMUM THICKNESS OF CEILING (inches) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 4 hours | 3 hours | 2 hours | 1 hour | 4 hours | 3 hours | 2 hours | 1 hour |
| 28. Wood I-joist (minimum I-joist depth $9^1/_4$" with a minimum flange depth of $1^1/_2$" and a minimum flange cross-sectional area of 2.25 square inches; minimum web thickness of $^3/_8$") @ 24" o.c. Unfaced fiberglass insulation or mineral wool insulation is installed between the I-joists supported on the upper surface of the flange by stay wires spaced 12" o.c. | 28-1.1 | Base layer of $^5/_8$" Type C gypsum wallboard attached directly to I-joists with $1^5/_8$" Type S drywall screws spaced 12" o.c. with ends staggered. Minimum 0.0179" thick hat-shaped $^7/_8$-inch furring channel 16" o.c. (channels doubled at wallboard end joints), placed perpendicular to the joist and attached to each joist by $1^5/_8$" Type S drywall screws after the base layer of gypsum wallboard has been applied. The middle and face layers of $^5/_8$" Type C gypsum wallboard applied perpendicular to the channel with end joints staggered. The middle layer is fastened with 1" Type S drywall screws spaced 12" o.c. The face layer is applied parallel to the middle layer but with the edge joints offset 24" from those of the middle layer and fastened with $1^5/_8$" Type S drywall screws 8" o.c. The joints shall be taped and covered with joint compound. | — | — | — | Varies | — | — | $2^3/_4$ | — |

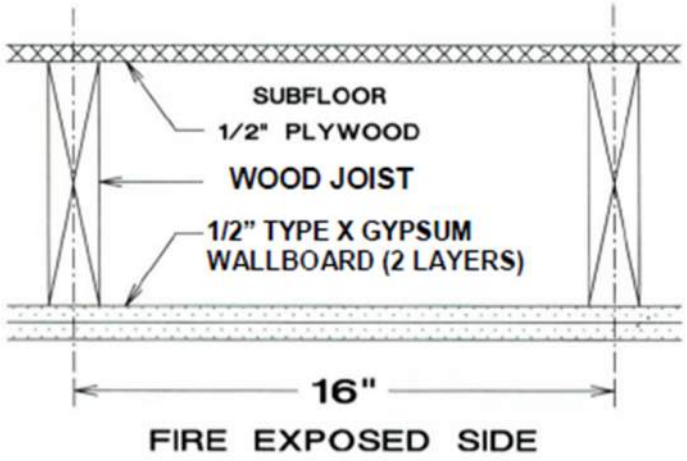
# Fire Resistance Ratings – IBC 703.2.2

Methods for determining fire resistance:

- Prescriptive designs per IBC 721.1
- Calculated Fire Resistance per IBC 722.6

**TABLE 722.6.2(1)**
**TIME ASSIGNED TO WALLBOARD MEMBRANES[a, b, c, d]**

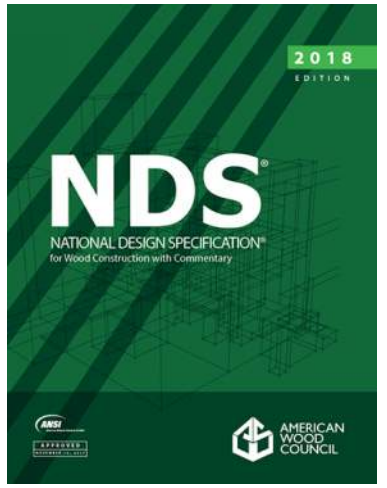
| DESCRIPTION OF FINISH | TIME[e](minutes) |
|---|---|
| 3/8-inch wood structural panel bonded with exterior glue | 5 |
| 15/32-inch wood structural panel bonded with exterior glue | 10 |
| 19/32-inch wood structural panel bonded with exterior glue | 15 |
| 3/8-inch gypsum wallboard | 10 |
| 1/2-inch gypsum wallboard | 15 |
| 5/8-inch gypsum wallboard | 30 |
| 1/2-inch Type X gypsum wallboard | 25 |
| 5/8-inch Type X gypsum wallboard | 40 |
| Double 3/8-inch gypsum wallboard | 25 |
| 1/2-inch + 3/8-inch gypsum wallboard | 35 |
| Double 1/2-inch gypsum wallboard | 40 |




| | | |
|---|---|---|
| 1/2 inch Type X Gypsum wallboard | = | 25 minutes |
| 1/2 inch Type X Gypsum wallboard | = | 25 minutes |
| Wood joists | = | 10 minutes |
| Combined Assembly Fire Resistance Rating | = | 60 minutes |

**Figure 2 Floor/Ceiling Assembly**

# Fire Resistance Ratings – IBC 703.2.2

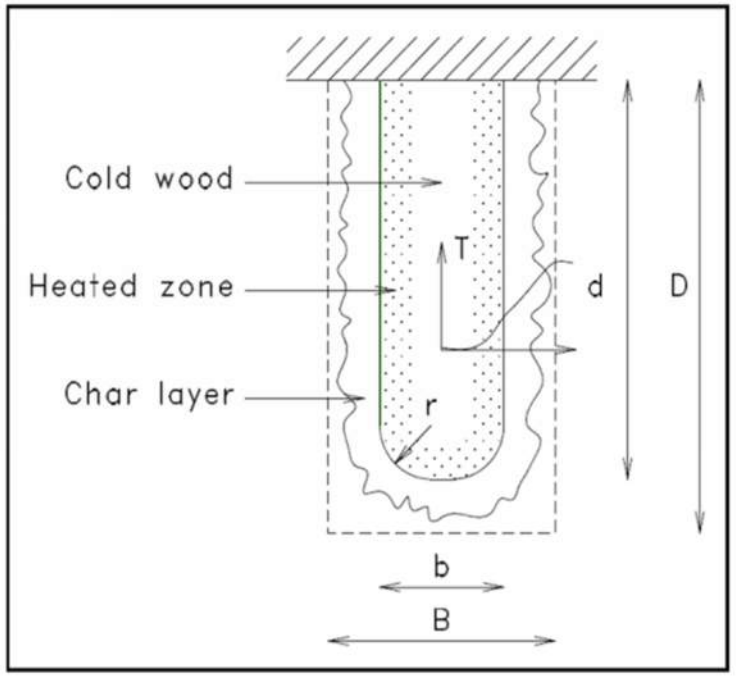



Methods for determining fire resistance:

- Prescriptive designs per IBC 721.1
- Calculated Fire Resistance per IBC 722.6
- Calculated Fire Resistance per IBC 722.1

**Table 16.2.1A Char Depth and Effective Char Depth (for $\beta_n$ = 1.5 in./hr.)**

| Required Fire Resistance (hr.) | Char Depth, $a_{char}$ (in.) | Effective Char Depth, $a_{eff}$ (in.) |
|---|---|---|
| 1-Hour | 1.5 | 1.8 |
| 1½-Hour | 2.1 | 2.5 |
| 2-Hour | 2.6 | 3.2 |



# Exposed Framing Fire Resistance

**IBC 703.2.2 Analytical methods** for determining fire resistance

Prescriptive designs per IBC 721.1

- **Calculations in accordance with IBC 722**
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Alternate protection methods as allowed by 104.11

**IBC 722** Calculated Fire Resistance

"…The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with **Chapter 16** of ANSI/AF&PA *National Design Specification for Wood Construction (**NDS**.)*"

**NDS Chapter 16** Fire Design of Wood Members

Limited to calculating fire resistance up to 2 hours.

Char rate varies based on endurance required, product type and lamination thickness. Equations and tables provided.

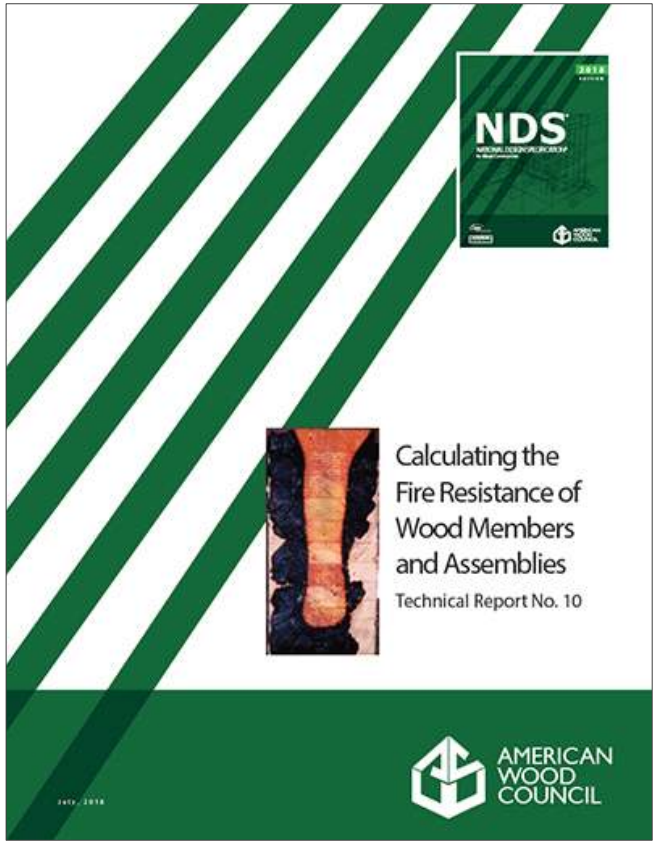
TR10 and NDS commentary are helpful in implementing permitted calculations.

# Exposed Framing Fire Resistance

**Table 16.2.1A Char Depth and Effective Char Depth (for $\beta_n$ = 1.5 in./hr.)**

| Required Fire Resistance (hr.) | Char Depth, $a_{char}$ (in.) | Effective Char Depth, $a_{eff}$ (in.) |
|---|---|---|
| 1-Hour | 1.5 | 1.8 |
| 1½-Hour | 2.1 | 2.5 |
| 2-Hour | 2.6 | 3.2 |

Source: 2018 NDS Chapter 16

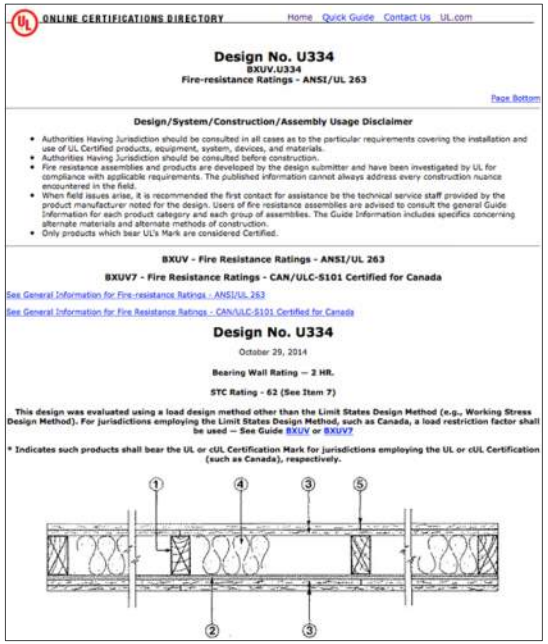



https://awc.org/codes-standards/publications/tr10

# Fire Resistance Ratings – IBC 703.2

Methods for determining fire resistance:

- Prescriptive designs per IBC 721.1
- Calculated Fire Resistance per IBC 722
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Fire-resistance designs certified by an approved agency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- Only products which bear UL's Mark are considered Certified.

**BXUV - Fire Resistance Ratings - ANSI/UL 263**

**BXUV7 - Fire Resistance Ratings - CAN/ULC-S101 Certified for Canada**

See General Information for Fire-resistance Ratings - ANSI/UL 263

See General Information for Fire Resistance Ratings - CAN/ULC-S101 Certified for Canada

**Design No. U334**

October 29, 2014

**Bearing Wall Rating — 2 HR.**

**STC Rating - 62 (See Item 7)**

**This design was evaluated using a load design method other than the Limit States Design Method (e.g., Working Stress Design Method). For jurisdictions employing the Limit States Design Method, such as Canada, a load restriction factor shall be used — See Guide BXUV or BXUV7**

*** Indicates such products shall bear the UL or cUL Certification Mark for jurisdictions employing the UL or cUL Certification (such as Canada), respectively.**





Design for Code Acceptance

3

Fire Rated Wood Floor and Wall 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.

Depending on the application, wall assemblies may need to be rated either from one side or both sides. For specific exterior wall applications, the *2000 International Building Code* (*IBC*), the *1999 National Building Code* (*NBC*), and the *1999 Standard Building Code* (*SBC*) allow wood-frame, wood-sided walls to be tested for exposure to fire from the inside only. Rating for both interior and exterior exposure is only required when the wall has a fire separation distance of less than 5 feet. Code recognition of one and two-hour wood-frame wall systems is also predicated on successful fire and hose stream testing in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction Materials*.

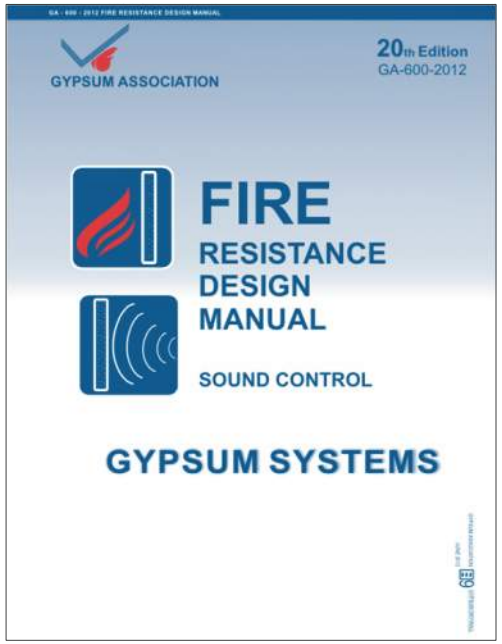
Fire Tested Assemblies

Fire-rated wood-frame assemblies can be found in a number of sources including the *IBC*, Underwriters Laboratories (UL) *Fire Resistance Directory*, Intertek Testing Services' *Directory of Listed Products*, and the Gypsum Association's *Fire Resistance Design Manual*. The American Forest & Paper Association (AF&PA) and its members have tested a number of wood-frame fire-rated assemblies. Descriptions of these successfully tested assemblies are provided in Table 1 for one-hour rated wall assemblies, Table 2 for two-hour rated wall assemblies, Table 3 for one-hour rated floor/ceiling assemblies, and Table 4 for two-hour rated floor/ceiling assemblies. Additional tests are being conducted and the Tables will be updated periodically.



Conclusions

Wood-frame assemblies are used in architectural designs because of their adaptability to style preferences, ease and economies of construction, and energy-saving performance.



# Outline

- Review of Fire Resistance Methods
- Interior Fire Rated Wall Assemblies
  - Fire Walls
  - Fire Barriers
  - Fire Partitions/Corridors
- Horizontal Assemblies

1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

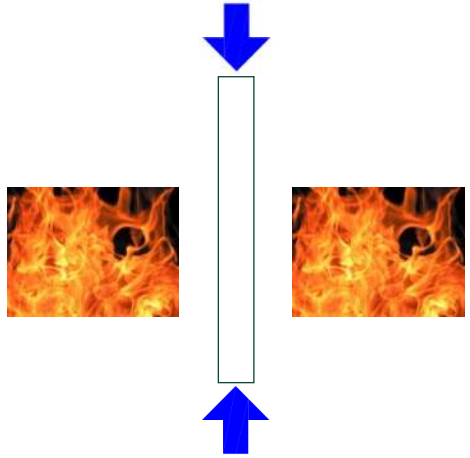
# Fire-Resistance Rated Wall Assemblies

**Fire-Resistance Rating**: The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.

**Tested under a standardized test fire exposure for a given duration to:**

1. Prevent the passage of flame and temperature rise from one side to the other
2. Continue to provide vertical structural support when exposed to fire and elevated temperatures

**Fire Confinement**



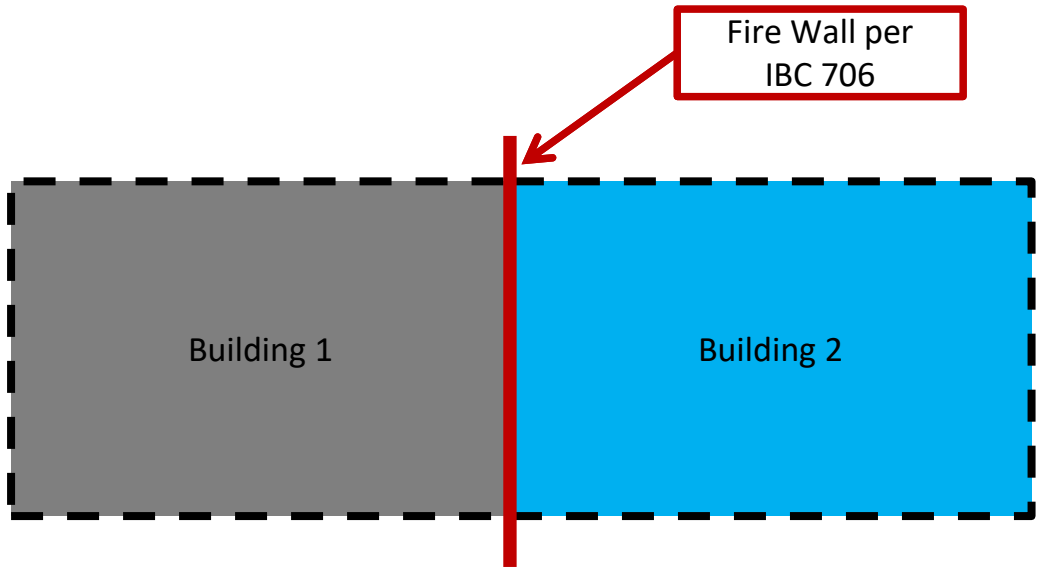
**Structural Performance**

# Interior Fire-Rated Walls: Differences

| Fire walls | Fire Barrier | Fire Partition: |
| --- | --- | --- |
| • Building Separation<br>• Openings are protected and limited<br>• Continuous from foundation to/through roof and exterior wall to/through exterior wall<br>• Structural stability | • Shafts; Occupancy Separation<br>• Openings are protected and limited<br>• Continuous from floor through concealed space at each level | • Dwelling Unit Separation; Corridors<br>• Openings are protected<br>• May terminate at a fire rated floor/ceiling/roof assembly |

# Fire Walls – IBC 706

Each portion of a building separated by one or more fire walls shall be considered a separate building.



# Fire Walls – Ratings & Materials

**TABLE 706.4**
**FIRE WALL FIRE-RESISTANCE RATINGS**

| GROUP | FIRE-RESISTANCE RATING (hours) |
|---|---|
| A, B, E, H-4, I, R-1, R-2, U | 3[a] |
| F-1, H-3[b], H-5, M, S-1 | 3 |
| H-1, H-2 | 4[b] |
| F-2, S-2, R-3, R-4 | 2 |

a. In Type II or V construction, walls shall be permitted to have a 2-hour fire-resistance rating.

b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.6 and 415.7.

**IBC 706.3** – Fire walls shall be of any approved noncombustible materials.

**Exception:** Buildings of type V construction

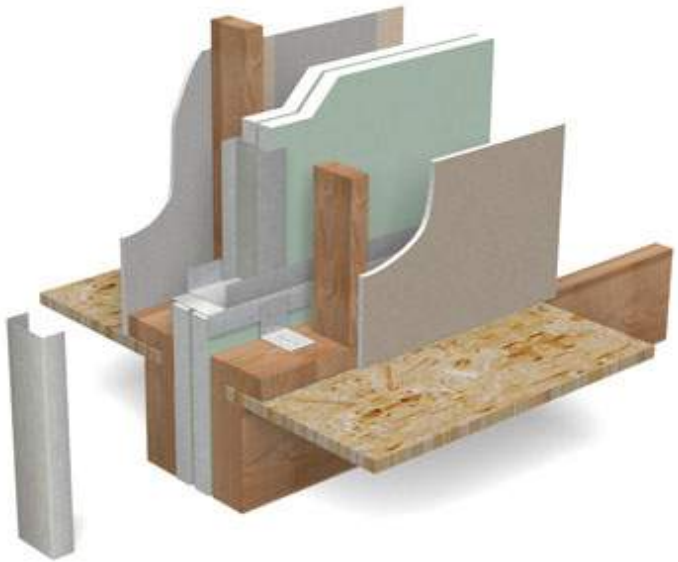
# Fire Walls – Ratings & Materials

Opportunity for Wood Framed Fire Walls:

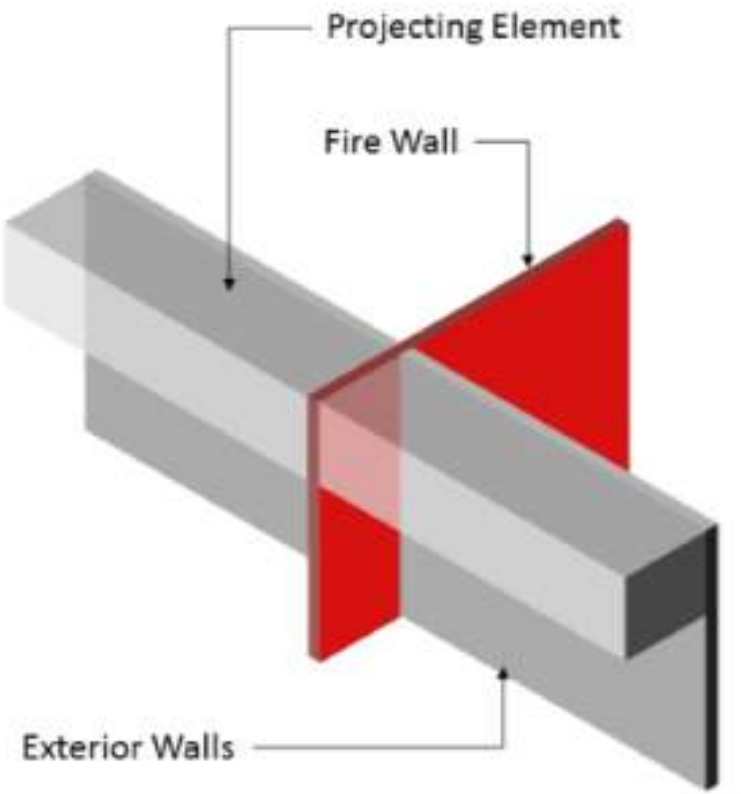
- Permitted in type V construction
- Fire Walls in type V construction of A, B, E, R and several other occupancies may be 2-hr

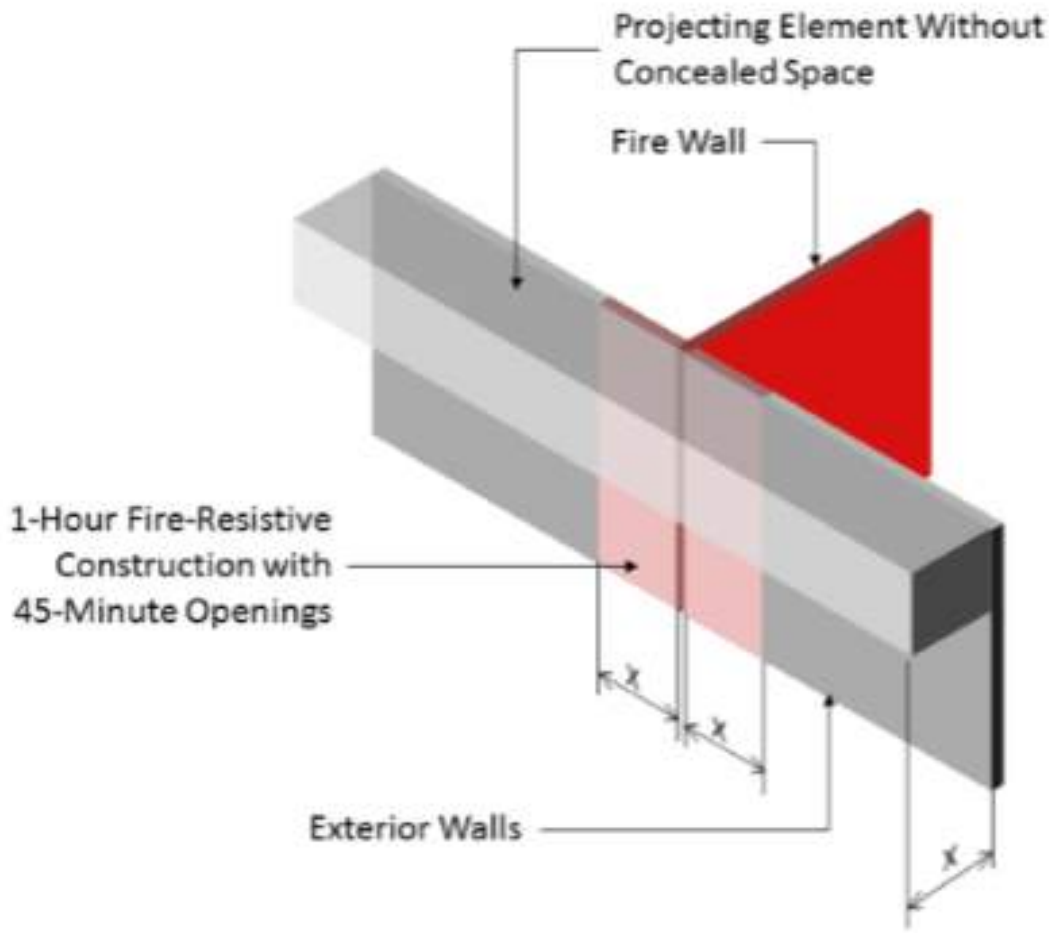
Fire Walls in type III and IV construction are required to be constructed of noncombustible materials

- Opportunity for wood frame bearing walls on each side of fire wall to meet structural stability requirements

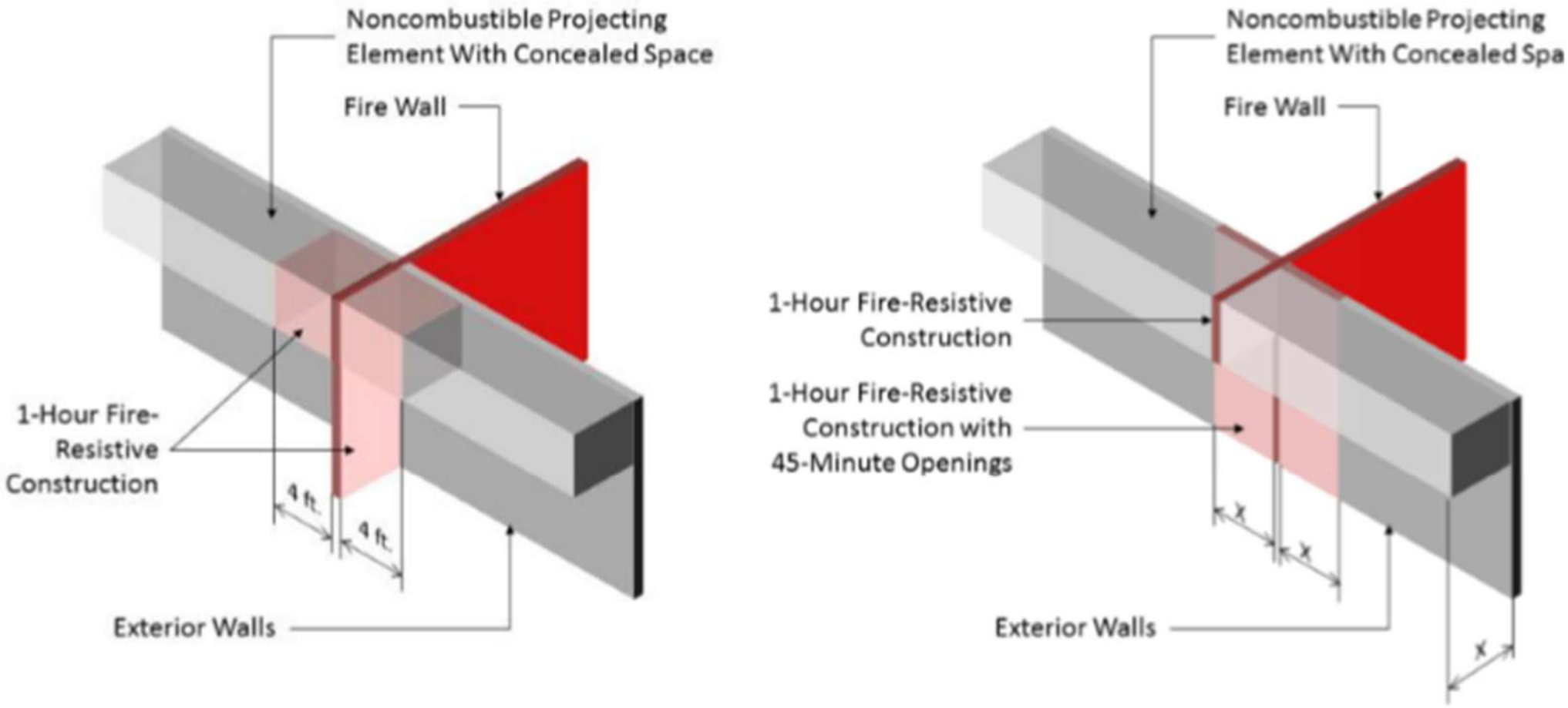


# Fire Walls – Horizontal Continuity

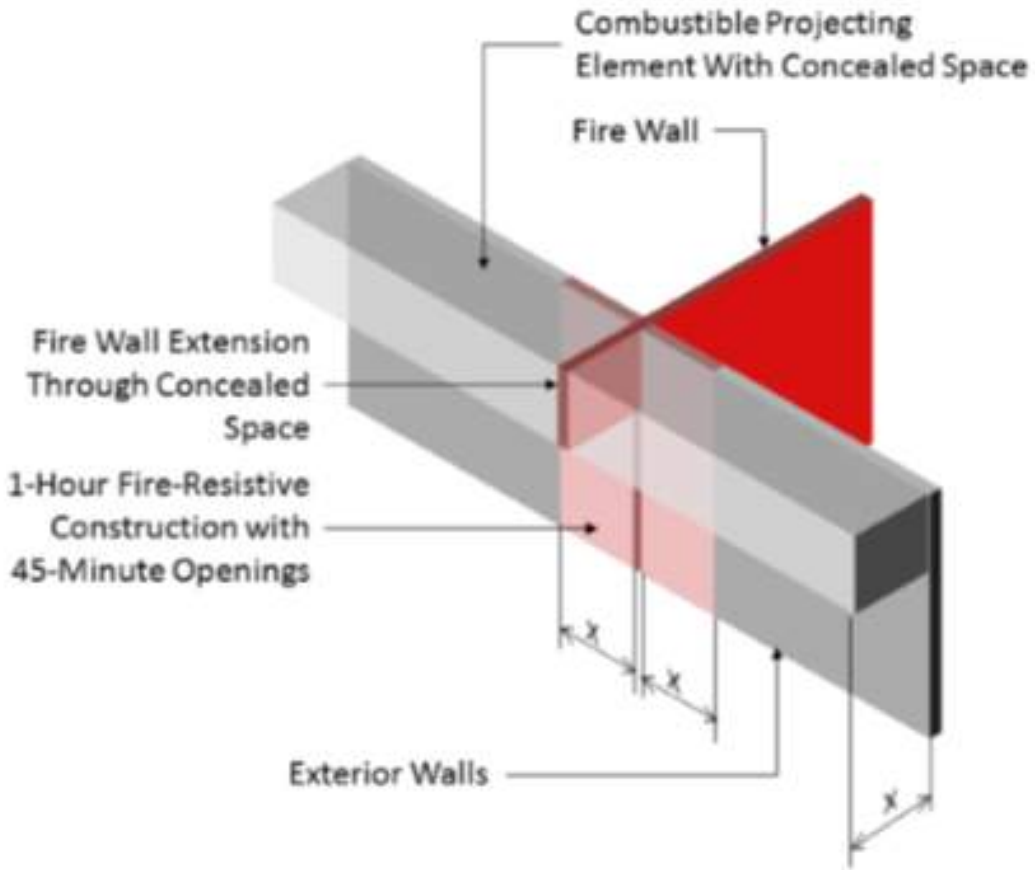


# Fire Walls – Horizontal Continuity

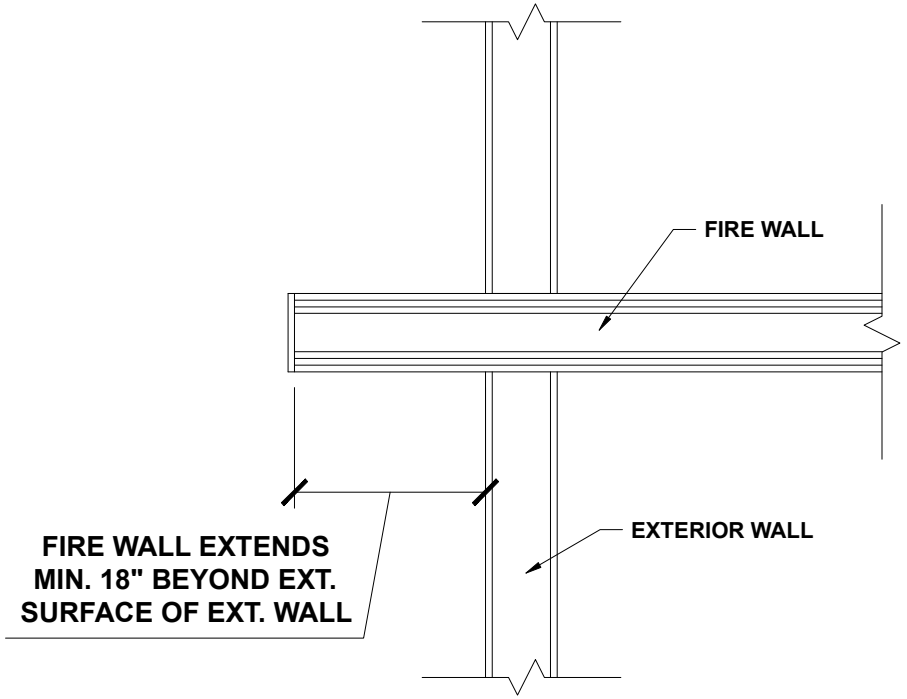


# Fire Walls – Horizontal Continuity



# Fire Walls - Horizontal Continuity

Fire walls are required to be continuous
from exterior wall to exterior wall

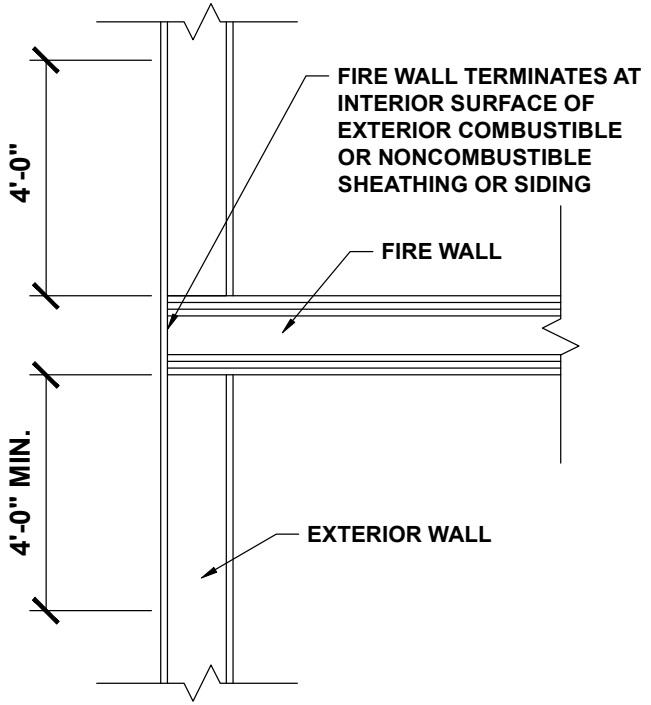



**FIRE WALL TO EXTERIOR WALL: OPTION 1**

# Fire Walls - Horizontal Continuity

**ALTERNATIVES:**

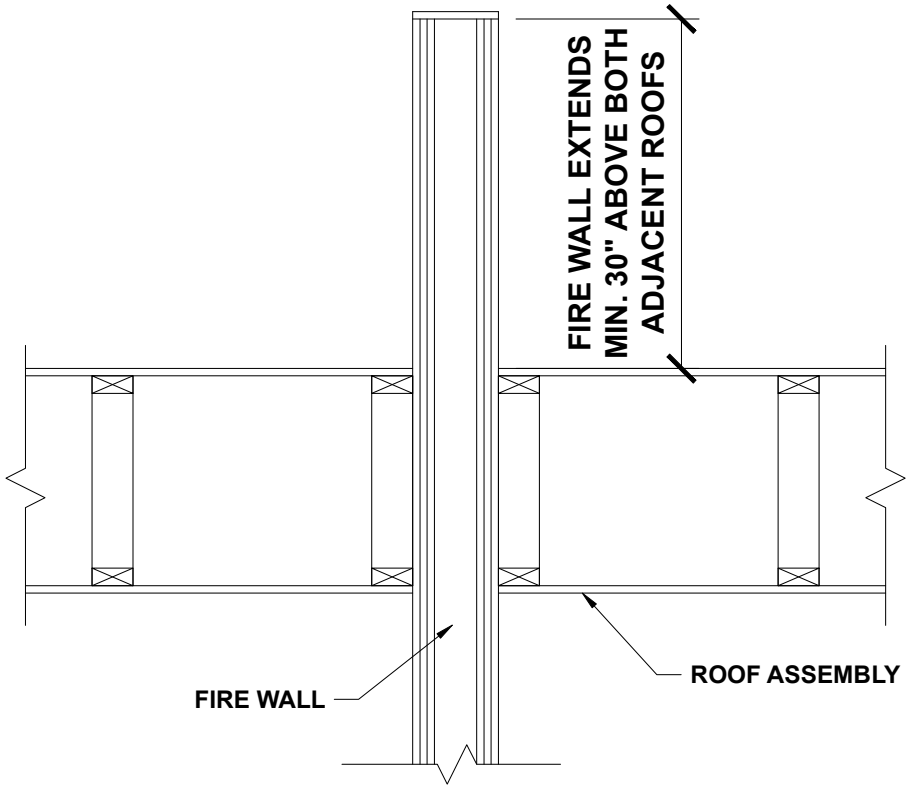
1. **EXTERIOR WALL RATED FOR 1 HR MIN. 4FT EACH SIDE (OPENING PROTECTION REQ'D)**
2. **NONCOMBUSTIBLE SHEATHING/SIDING EXTENDS MIN. 4FT EACH SIDE**
3. **BUILDING ON EACH SIDE OF THE FIRE WALL IS EQUIPPED THROUGHOUT WITH AN NFPA OR NFPA 13 SPRINKLER SYSTEM**




**FIRE WALL TO EXTERIOR WALL: OPTION 2**

# Fire Walls - Vertical Continuity

Fire walls are required to be continuous from foundation to roof

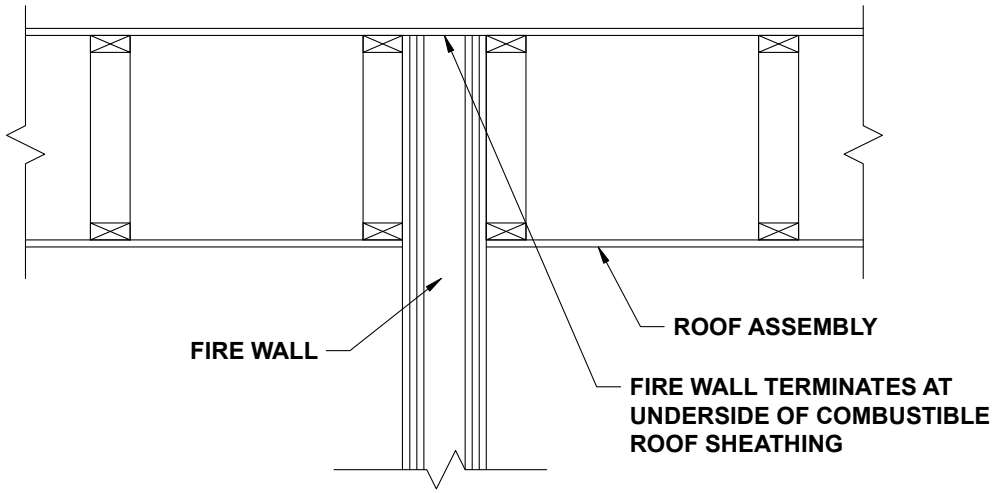



**FIRE WALL TO ROOF: OPTION 1**

# Fire Walls - Vertical Continuity

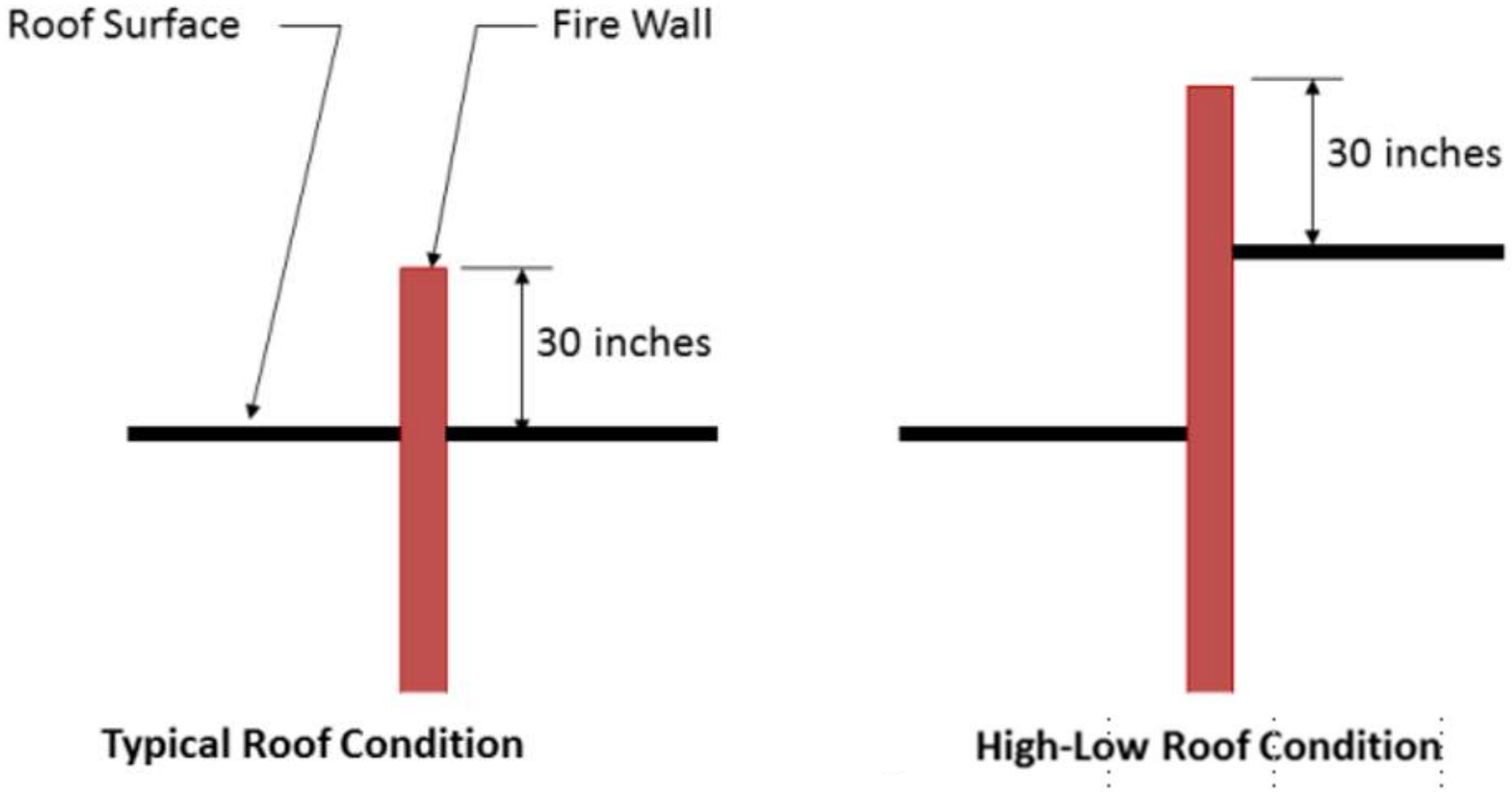
**IN CONSTRUCTION TYPES III, IV OR V**

- **NO OPENINGS IN ROOF WITHIN 4FT OF FIRE WALL**
- **MIN. CLASS B ROOF COVERING**
- **ROOF SHEATHING/DECK MIN. 4FT EACH SIDE OF WALL IS FRT OR UNDERSIDE OF SHEATHING IS COVERED WITH $\frac{5}{8}$" TYPE X GYPSUM**

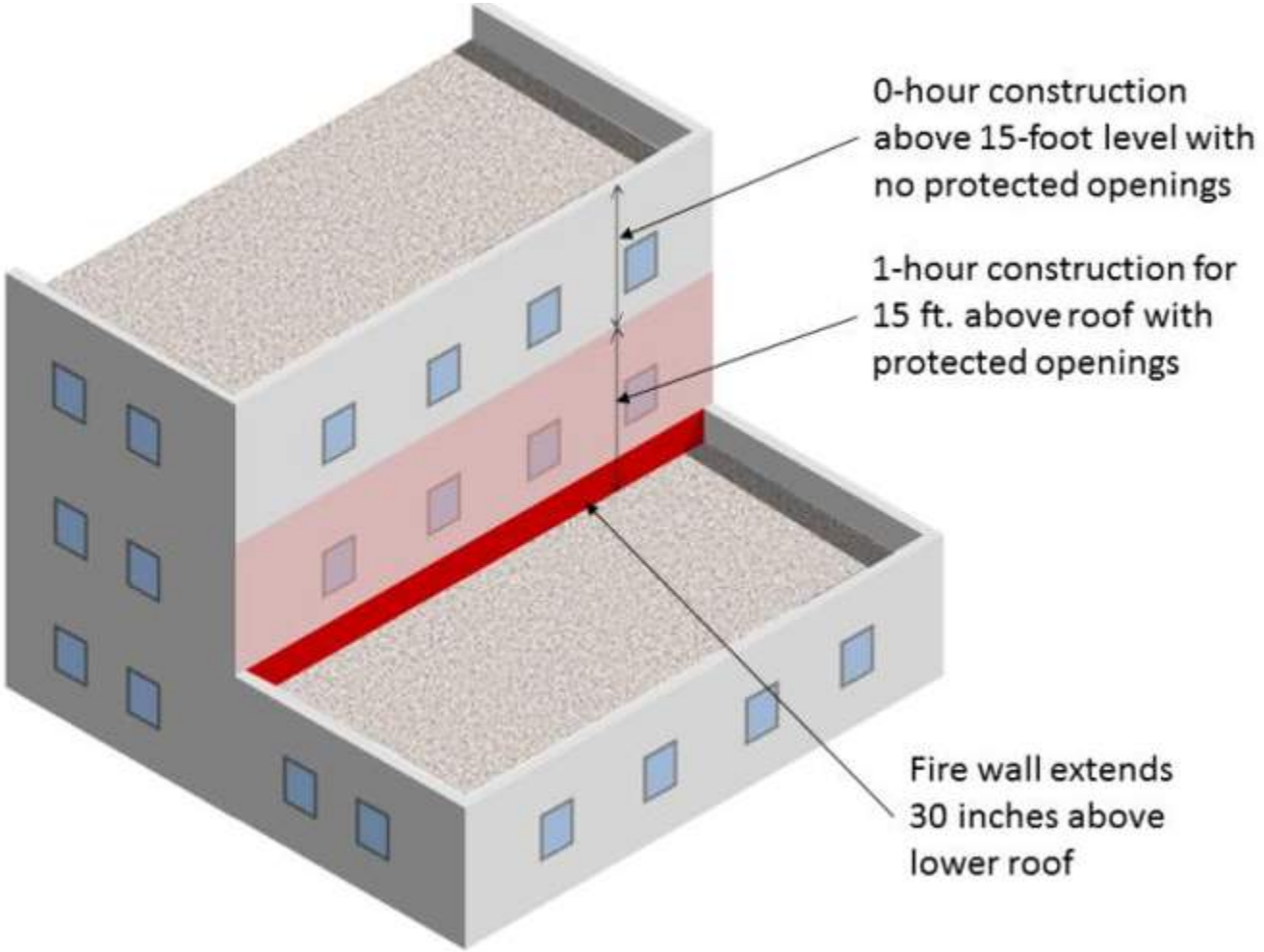



**FIRE WALL TO ROOF: OPTION 2**

# Fire Walls – Vertical Continuity



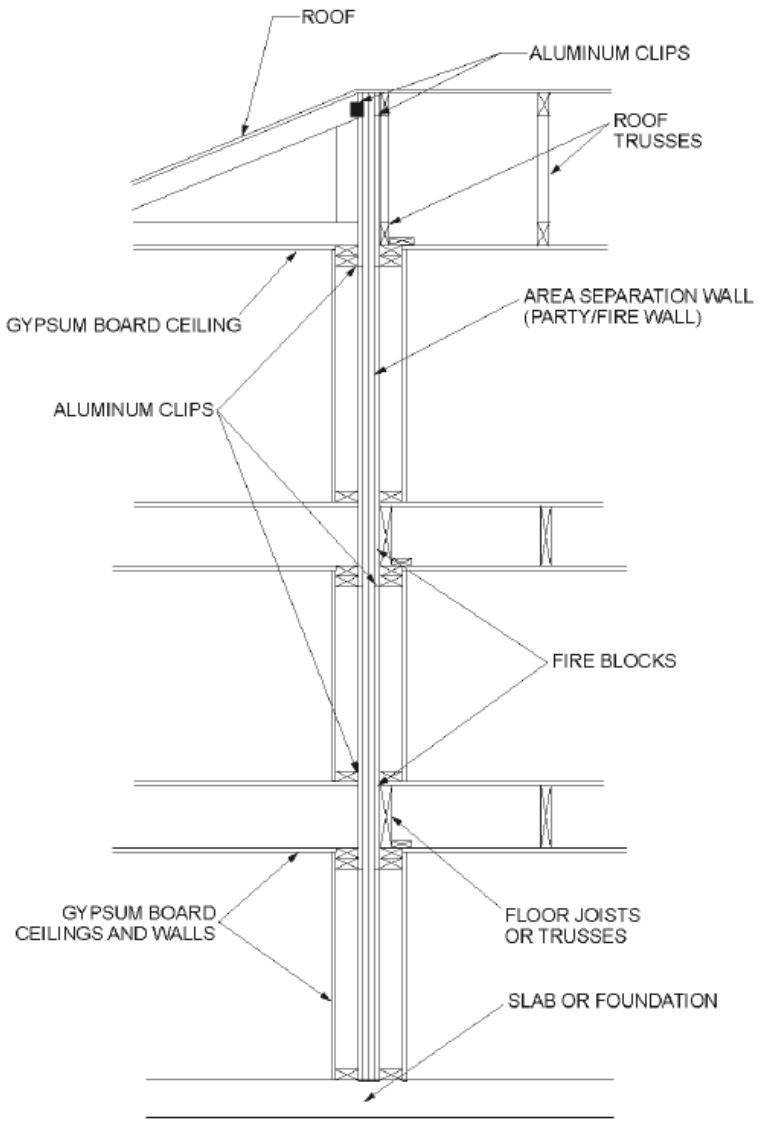
# Fire Walls – Vertical Continuity



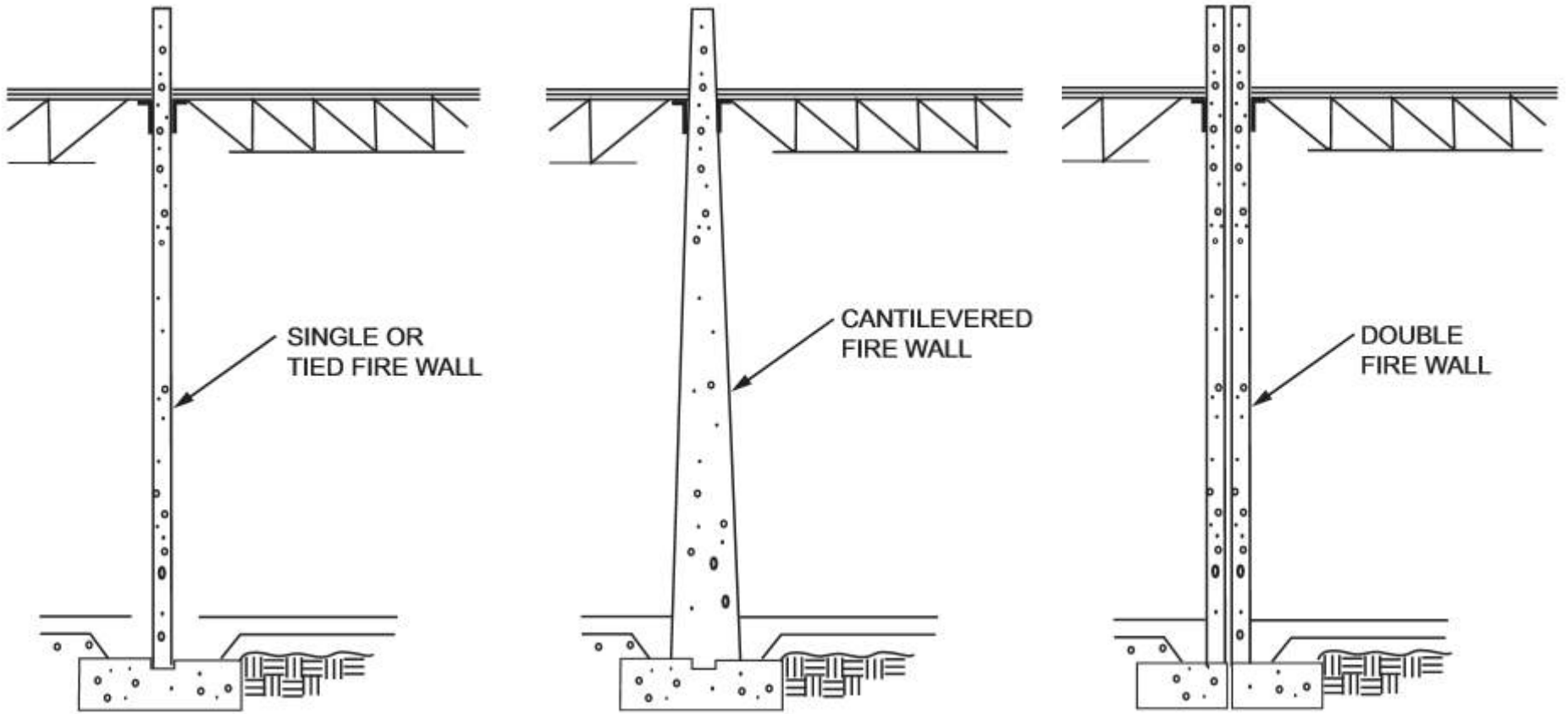
# Fire Walls – Structural Stability

**706.2 Structural Stability:**

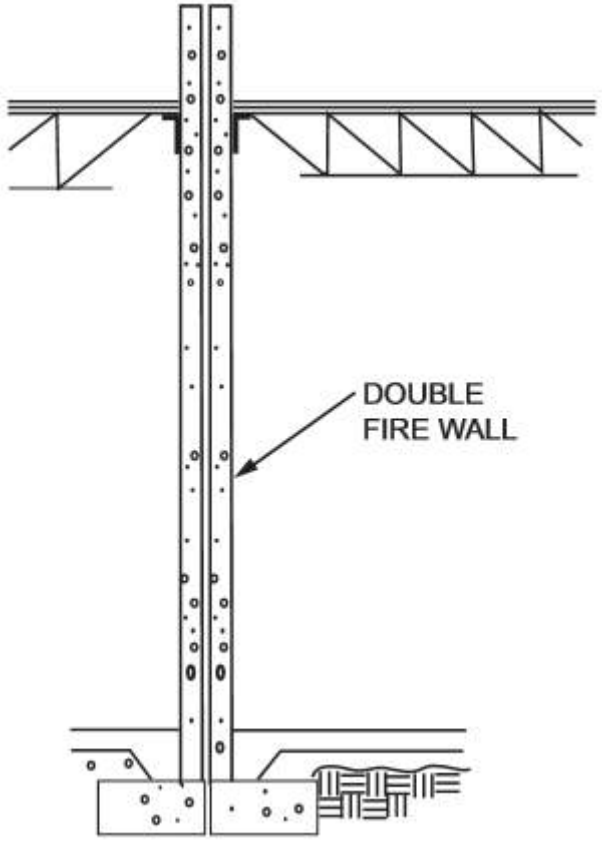
Fire walls shall have sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall for the duration of time indicated by the required fire-resistance rating or shall be constructed as double fire walls in accordance with NFPA 221.



# NFPA 221


SINGLE OR
TIED FIRE WALL
CANTILEVERED
FIRE WALL
DOUBLE
FIRE WALL

# NFPA 221 – Double Walls




**4.5* Double Wall Assemblies.** Where either wall of a double wall is laterally supported by a building frame with a fire resistance rating less than that required for the wall, double wall assemblies shall be considered to have a combined assembly fire resistance rating as specified in Table 4.5.

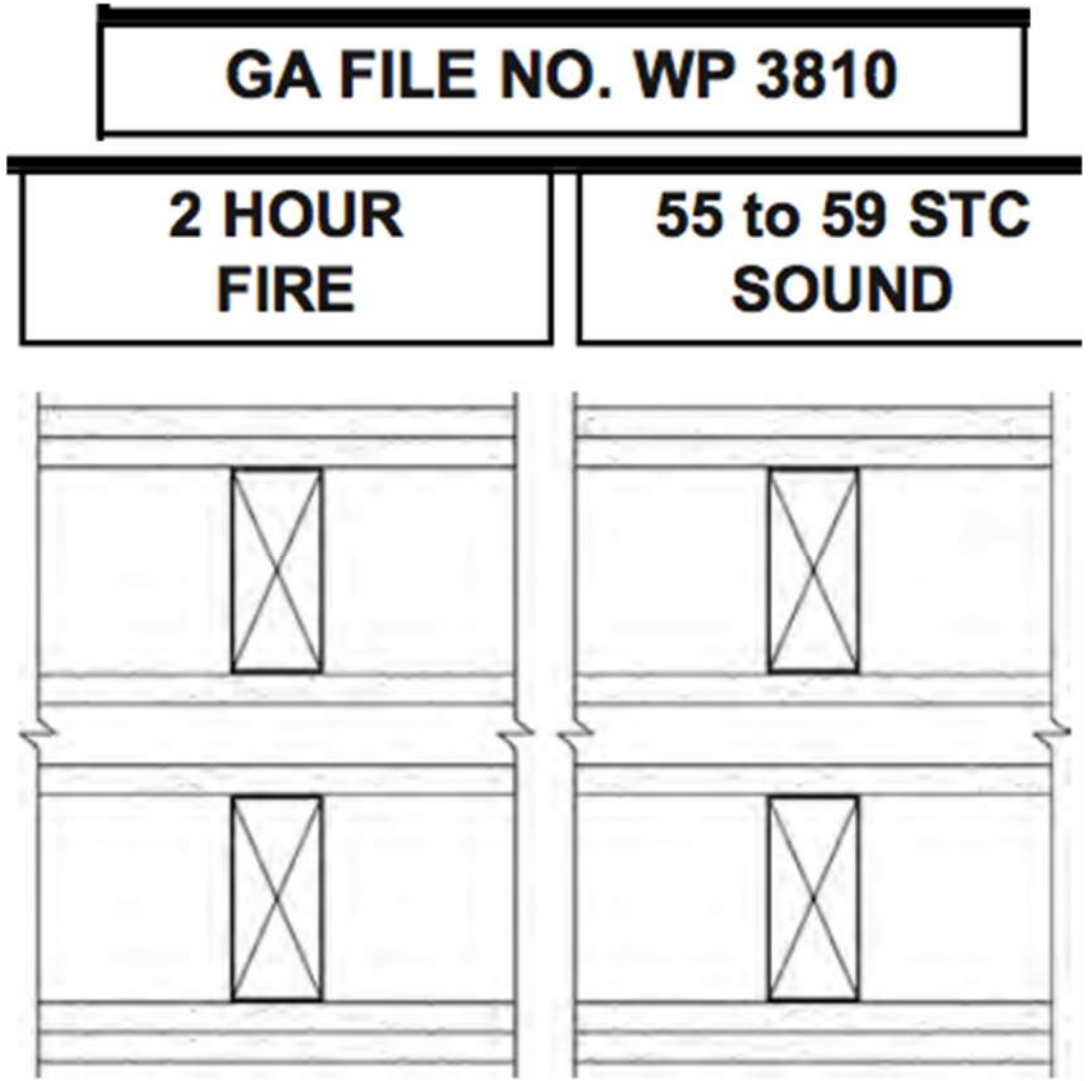
**Table 4.5 Fire Resistance Ratings for Double Wall Assemblies**

| Fire Resistance Rating of Each Wall (hr) | Equivalent to Single Wall (hr) |
|---|---|
| 3 | 4 |
| 2 | 3 |
| 1 | 2 |

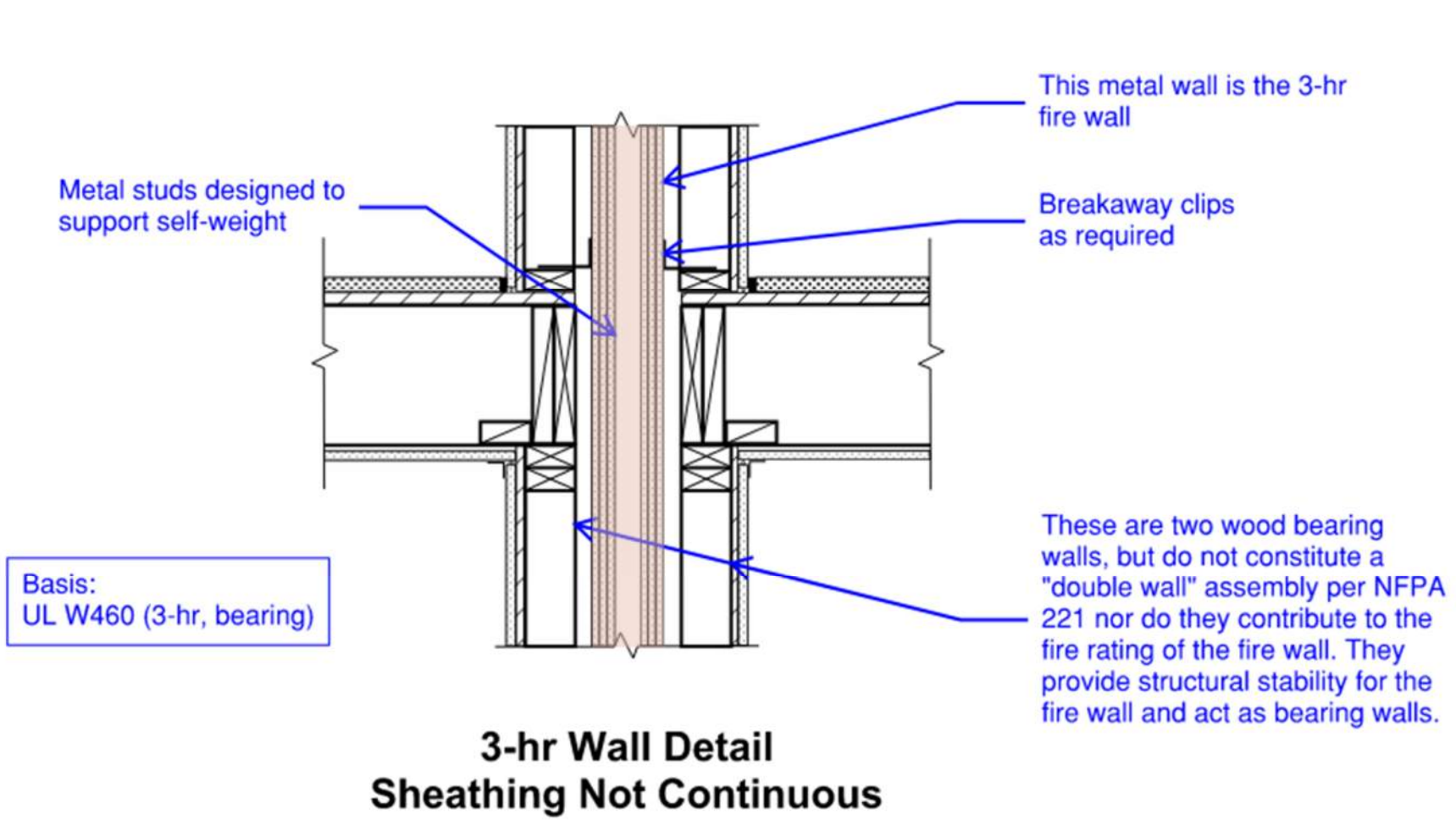
# 2-Hour Fire Wall Assembly

Construction Type:

- V



# Fire Walls – Seismic Diaphragm Continuity

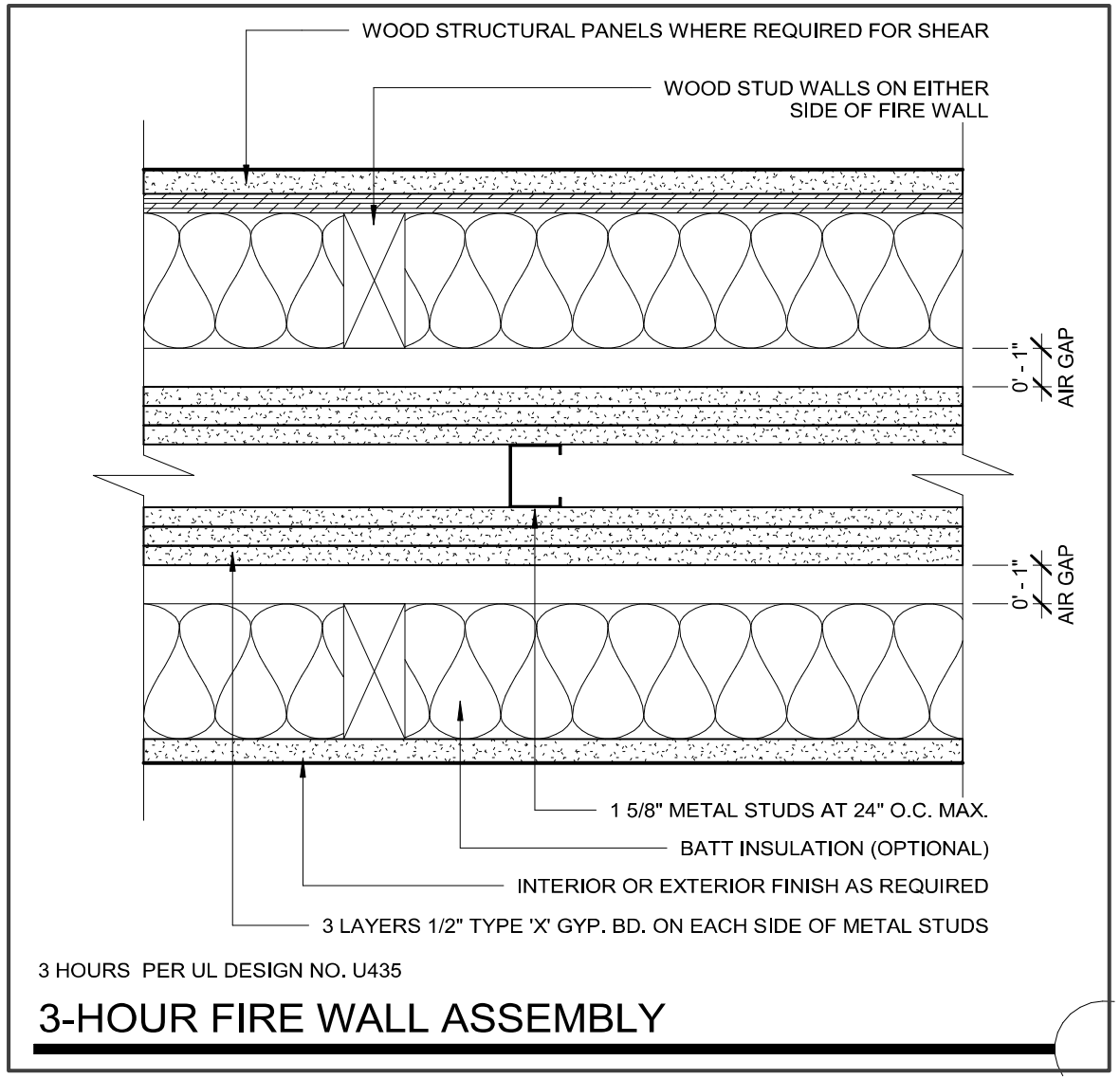



**3-hr Wall Detail**
**Sheathing Not Continuous**

# 3-Hour Fire Wall As

## Construction Types:

- III
- IV
- V



# Fire Walls – Seismic Diaphragm Continuity

SEAOSC

**SEAoSC LIGHT-FRAMING CONSTRUCTION COMMITTEE**
**STRUCTURAL ENGINEERS ASSOCIATION OF SOUTHERN CALIFORNIA**
**SEISMOLOGY OPINION**

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**DATE:** **March 21, 2008**

**Continuity of Plywood Diaphragm Sheathing in 2 hr and 3hr Fire Walls:**

**Opinion:** The continuity of plywood diaphragm sheathing should be maintained across the air gap commonly encountered in double stud Firewalls of 2 or 3 hour construction. The intent is to ensure that structural continuity is not significantly reduced in the roof and floor diaphragms.

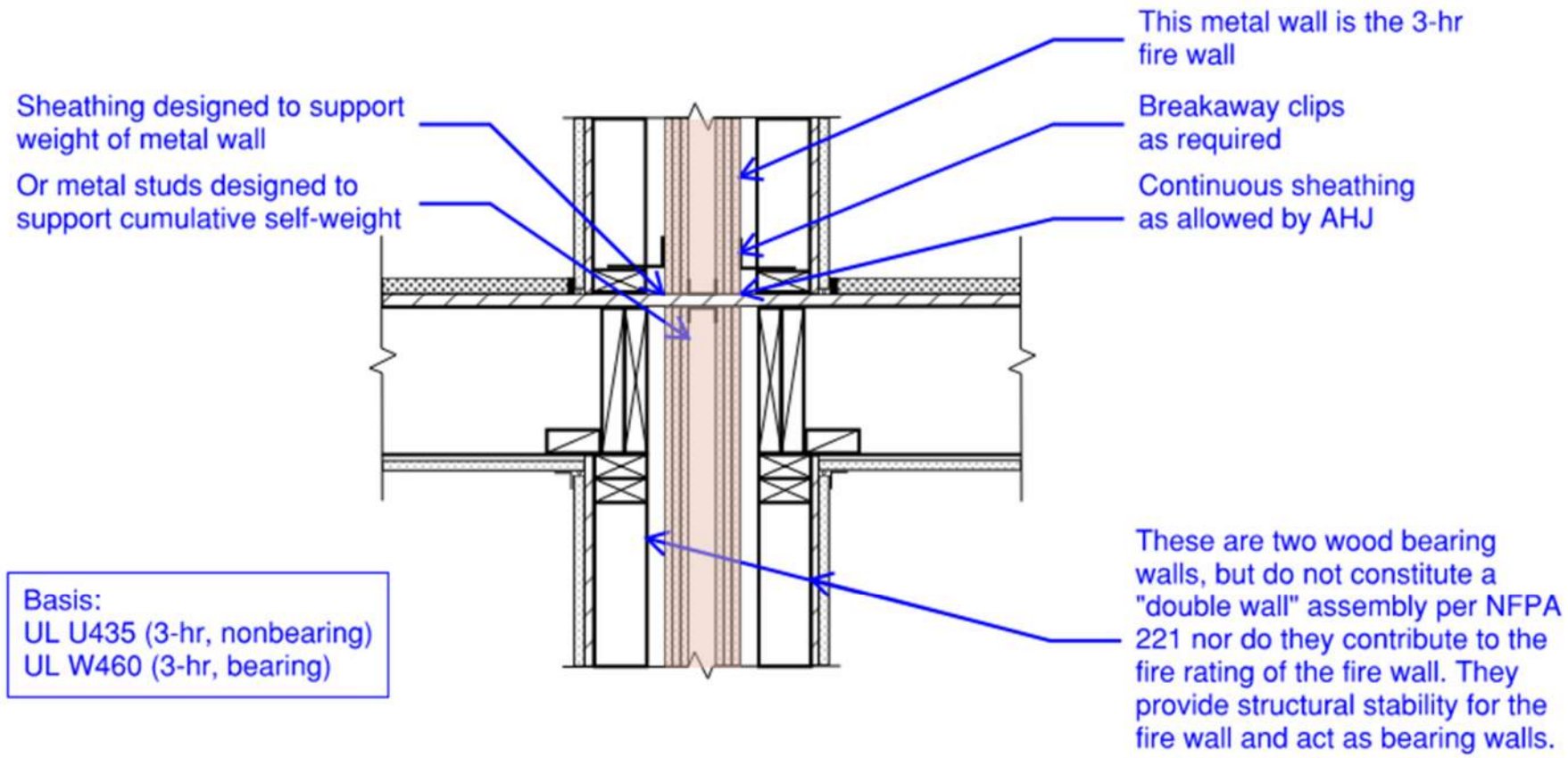
---

**Commentary:**

This opinion is prepared to address the issue of diaphragm continuity as it relates to recent changes in 2007 CBC and 2006 IBC model code. Specifically the outgoing UBC provisions for Area-Separation walls have more or less been replaced by the Fire wall provisions of the IBC. Such walls are encountered in light-frame multifamily or mixed-use construction and are often constructed as a double studwall when occurring at partywall locations. The double stud walls are typically separated by an airspace of a one to four inches.

The IBC has introduced language [IBC 705.4] that states fire walls must have "sufficient structural stability" under fire conditions to allow collapse of either side. Previous commentary to the UBC topic of Area Separation

# Fire Walls – Seismic Diaphragm Continuity




**3-hr Wall Detail**
**Sheathing Continuous**

CAD & Revit Details: www.woodworks.org

# Fire Walls – Seismic Diaphragm Continuity

## 2021 IBC Provisions Allow Floor Sheathing Through Firewall under Certain Conditions

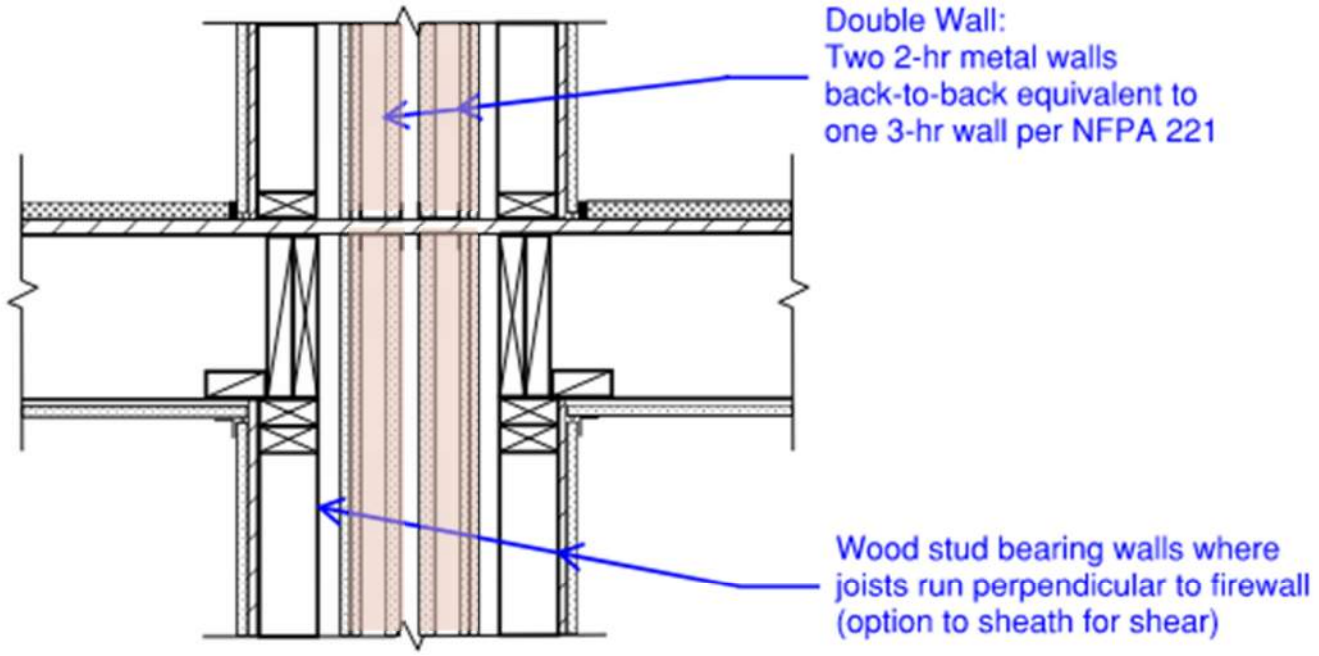
**706.2 Structural stability.**

*Fire walls* shall be designed and constructed to allow collapse of the structure on either side without collapse of the wall under fire conditions. *Fire walls* designed and constructed in accordance with NFPA 221 shall be deemed to comply with this section.

**Exception:** In Seismic Design Categories D through F, where double *fire walls* are used in accordance with NFPA 221, floor and roof sheathing not exceeding $^{3}/_{4}$ inch (19.05 mm) thickness shall be permitted to be continuous through the wall assemblies of light frame construction.

# Double Walls in Type III

## Noncombustible Construction Required




**NFPA 221 Double Wall**
**3-hr Wall Detail for use in Type III**
**(noncombustible)**

# Fire Walls - Openings

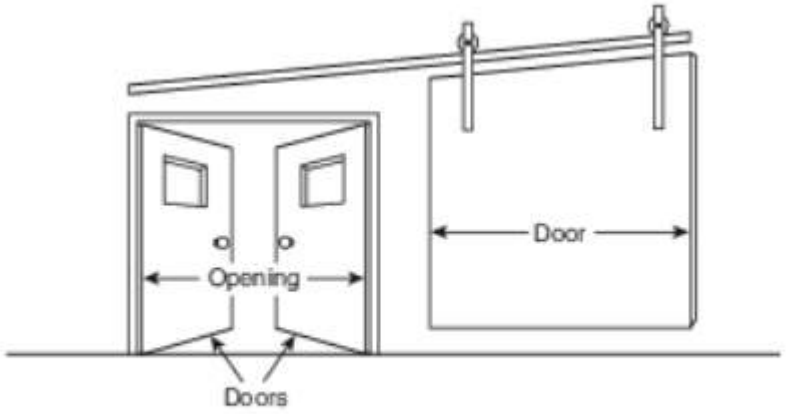



FIGURE A.5.8.3(a) Swinging Door and Sliding Door Configuration for Egress Purposes in an HC Fire Wall.

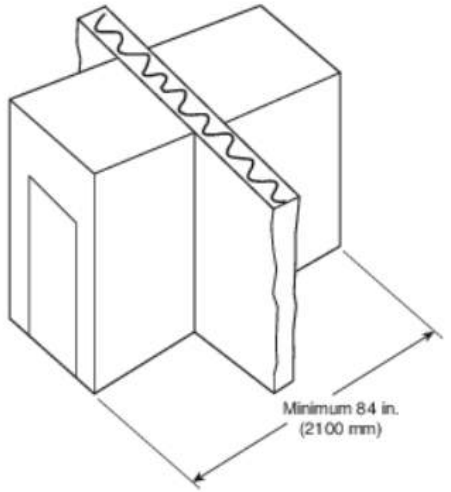



FIGURE A.5.8.3(b) Vestibule Arrangement for Egress Purposes in an HC Fire Wall.

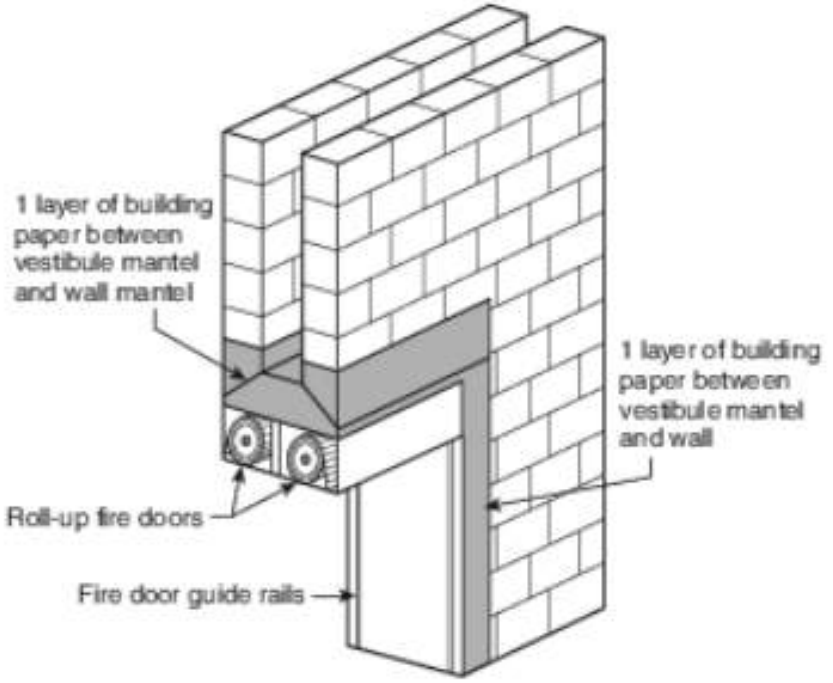
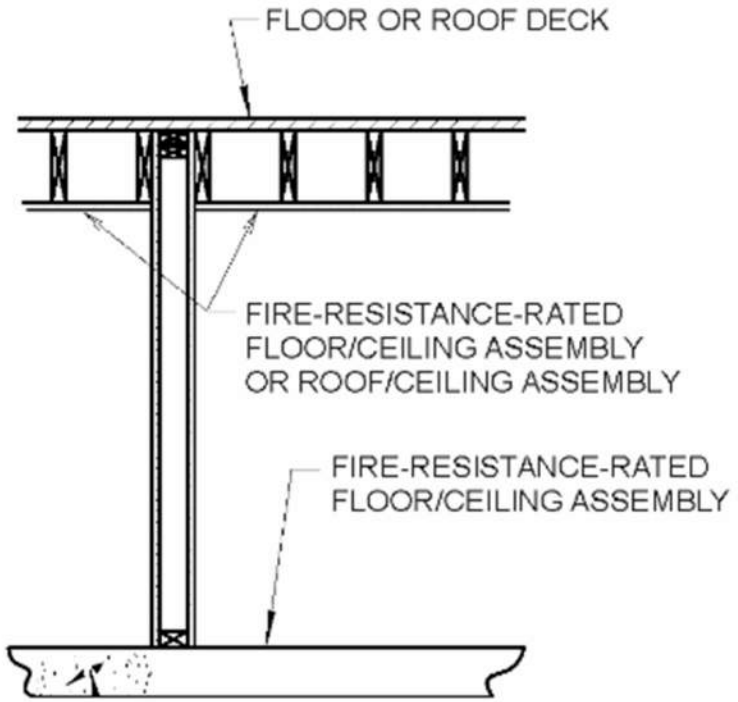



FIGURE A.5.8.4 Double Doors on a Freestanding Vestibule.

# Fire Barriers – IBC 707

Commonly used for:

- Shaft enclosures
- Interior exit stairway
- Exit stairway enclosures
- Exit passageways
- Incidental uses
- Separated occupancies
- Fire Areas



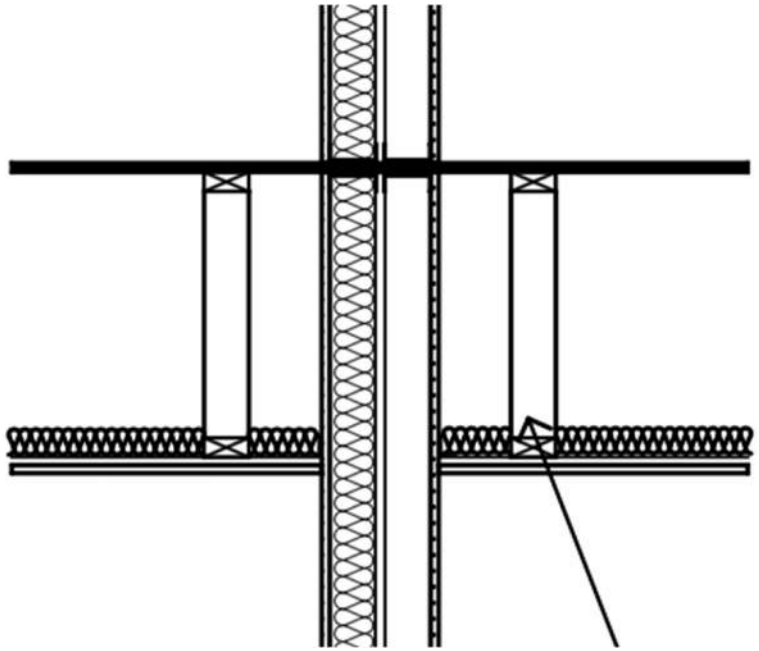

Fire Barrier Example

2018 IBC Code & Commentary

# Fire Barriers – IBC 707

May be constructed with any materials permitted by the construction type

- Fire Resistance Ratings:
  - Shaft Enclosures: IBC 713.4
    - 2-hr when connecting 4 stories or more,
    - 1-hr when connecting less than 4 stories
  - Separated Occupancies: IBC Table 508.4
  - Fire Areas: IBC Table 707.3.10



# Fire Barriers – IBC 707

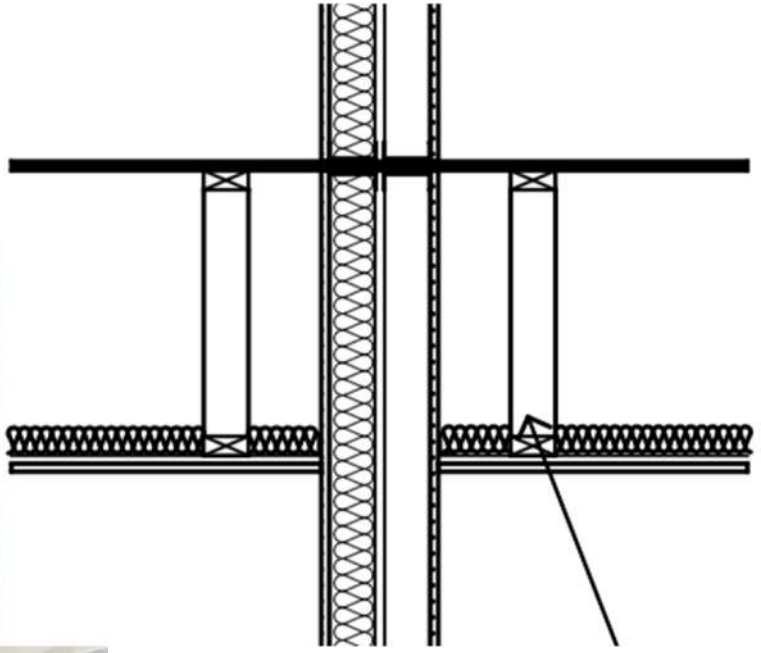
**707.5: Continuity.** Fire barriers shall extend from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto. Such fire barriers shall be continuous through concealed space, such as the space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

**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. Hollow vertical spaces within a fire barrier shall be fireblocked in accordance with Section 718.2 at every floor level.

**Exceptions:** for... walls separating incidental uses in buildings of Type IIB, IIIB and VB construction.

Other requirements for openings, penetrations, joints

# Fire Barriers – IBC 707



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

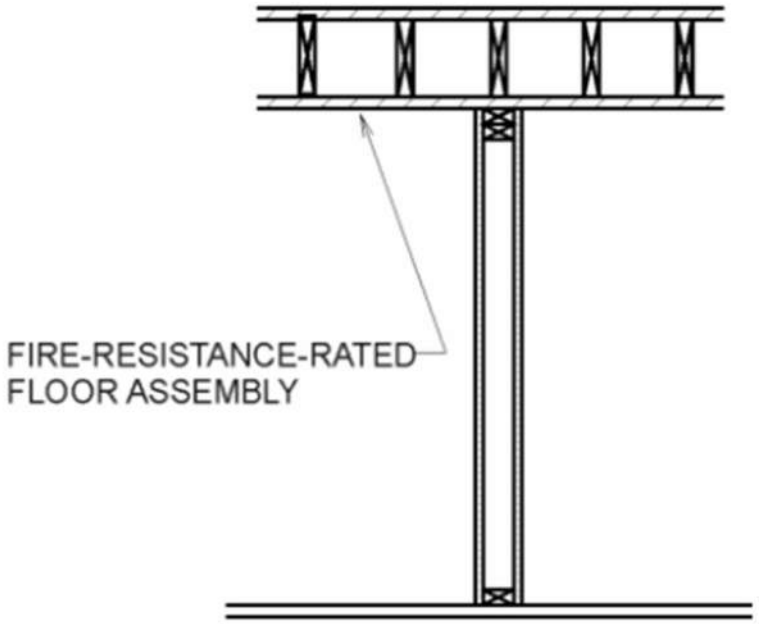
# Fire Partitions – IBC 708

Commonly used to separate:

- Dwelling or sleeping units in same bldg.
- Tenant spaces in malls
- Corridor walls

Minimum 1-hr rating except:

- Some corridors
- Separate dwelling units in II-B, III-B and V-B




Fire Partition Example

2018 IBC Code & Commentary

# Fire Partitions – IBC 708

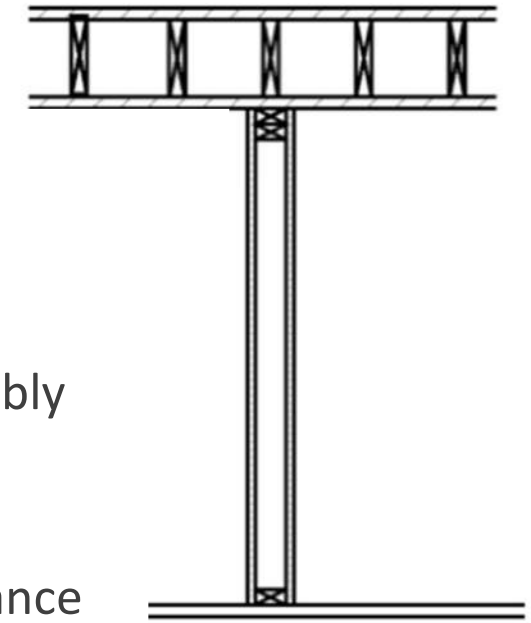
**Fire Partitions:**

- May be constructed with any materials permitted by the construction type
- 708.3 Fire Resistance Ratings:
  - » Fire partitions shall have a *fire-resistance rating* of not less than 1 hour.

**Exceptions:**

1. Corridor walls permitted to have a ½-hour fire-resistance rating by Table 1020.1
2. Dwelling unit and sleeping unit separations in buildings of Type IIB, IIIB and VB construction shall have fire-resistance ratings of not less than ½ hour in buildings equipped throughout with an [NFPA 13] automatic sprinkler system in accordance with Section 903.3.1.1.

# Fire Partitions – IBC 708



**708.4 Continuity.**

Fire partitions shall extend from the top of the foundation or floor/ceiling assembly below and be securely attached to one of the following:

1. The underside of the floor or roof sheathing, deck or slab above.
2. The underside of a floor/ceiling or roof/ceiling assembly having a fire-resistance rating that is not less than the fire-resistance rating of the fire partition.

**Exceptions:** for certain crawlspace conditions, corridor conditions (See Section 708.4).

**708.4.1 Supporting construction.**

The supporting construction for a fire partition shall have a fire-resistance rating that is equal to or greater than the required fire-resistance rating of the support fire partition.

**Exceptions:** for... walls separating dwelling units, walls separating sleeping units, and corridor walls, in buildings of Type IIB, IIIB and VB construction.

# Fire Partitions – IBC 708

Common Detailing Method: Fire Partition & membrane stop at underside of rated floor/ceiling with fireblocking/draftstopping if required

# Corridors – Fire Resistance Ratings

Check requirements of IBC Tables 601 and 1020.1 for Corridor Wall and Floor/Ceiling Fire-Resistance Ratings

**TABLE 1020.1**
**CORRIDOR FIRE-RESISTANCE RATING**

| OCCUPANCY | OCCUPANT LOAD SERVED BY CORRIDOR | REQUIRED FIRE-RESISTANCE RATING (hours) | |
|---|---|---|---|
| | | Without sprinkler system | With sprinkler system |
| H-1, H-2, H-3 | All | Not Permitted | 1[c] |
| H-4, H-5 | Greater than 30 | Not Permitted | 1[c] |
| A, B, E, F, M, S, U | Greater than 30 | 1 | 0 |
| R | Greater than 10 | Not Permitted | 0.5[c]/1[d] |
| I-2[a] | All | Not Permitted | 0 |
| I-1, I-3 | All | Not Permitted | 1[b, c] |
| I-4 | All | 1 | 0 |

**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, b] | 2[a, b] | 1[b] | 0 | 1[b] | 0 | HT | 1[b] | 0 |
| Bearing walls<br>Exterior[e, f]<br>Interior | 3<br>3[a] | 2<br>2[a] | 1<br>1 | 0<br>0 | 2<br>1 | 2<br>0 | 2<br>1/HT | 1<br>1 | 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 2304.11.2 | 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 |

# Corridors – Fire Resistance Ratings

# Corridor Walls – 708.4 Exception 2

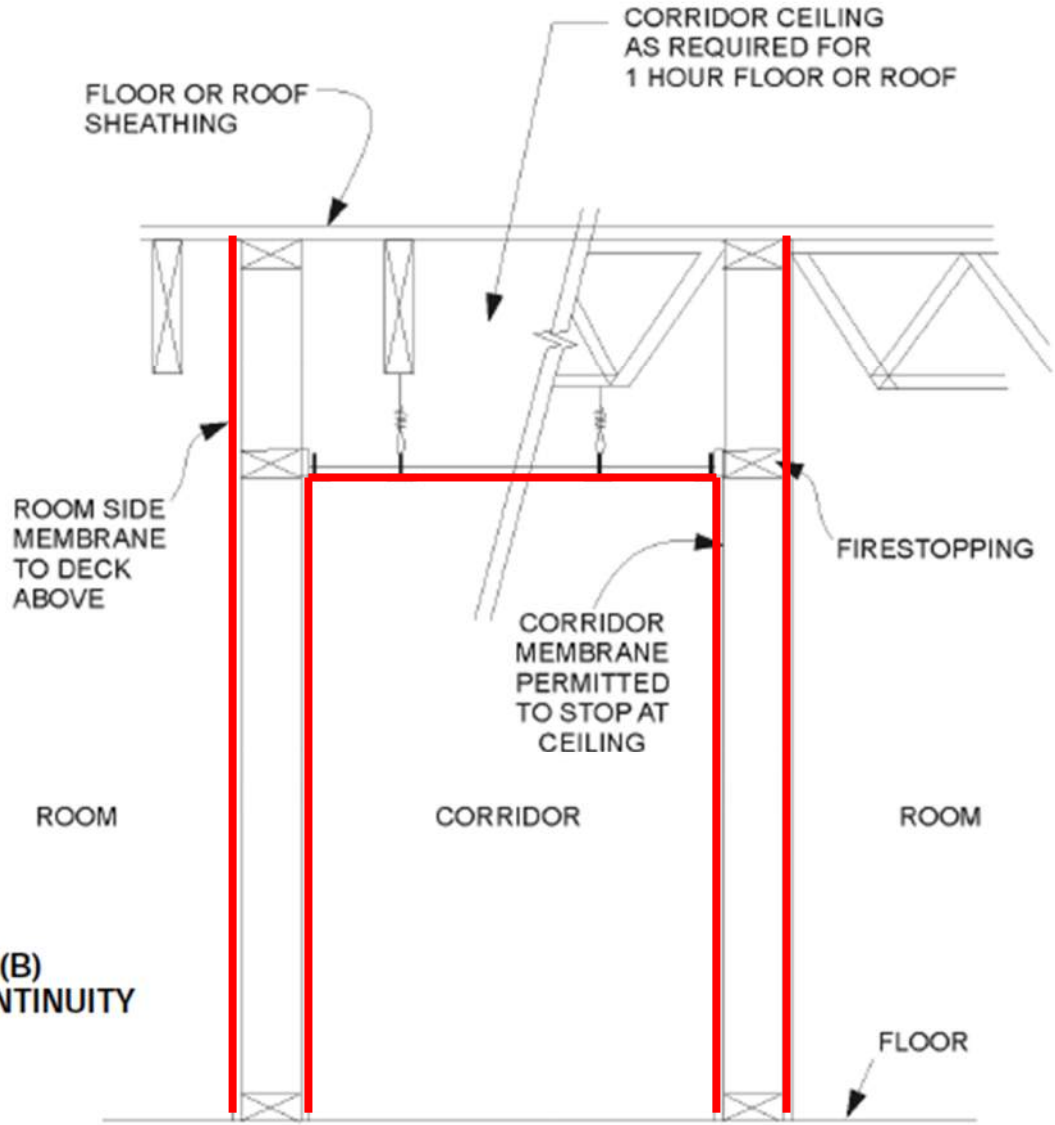
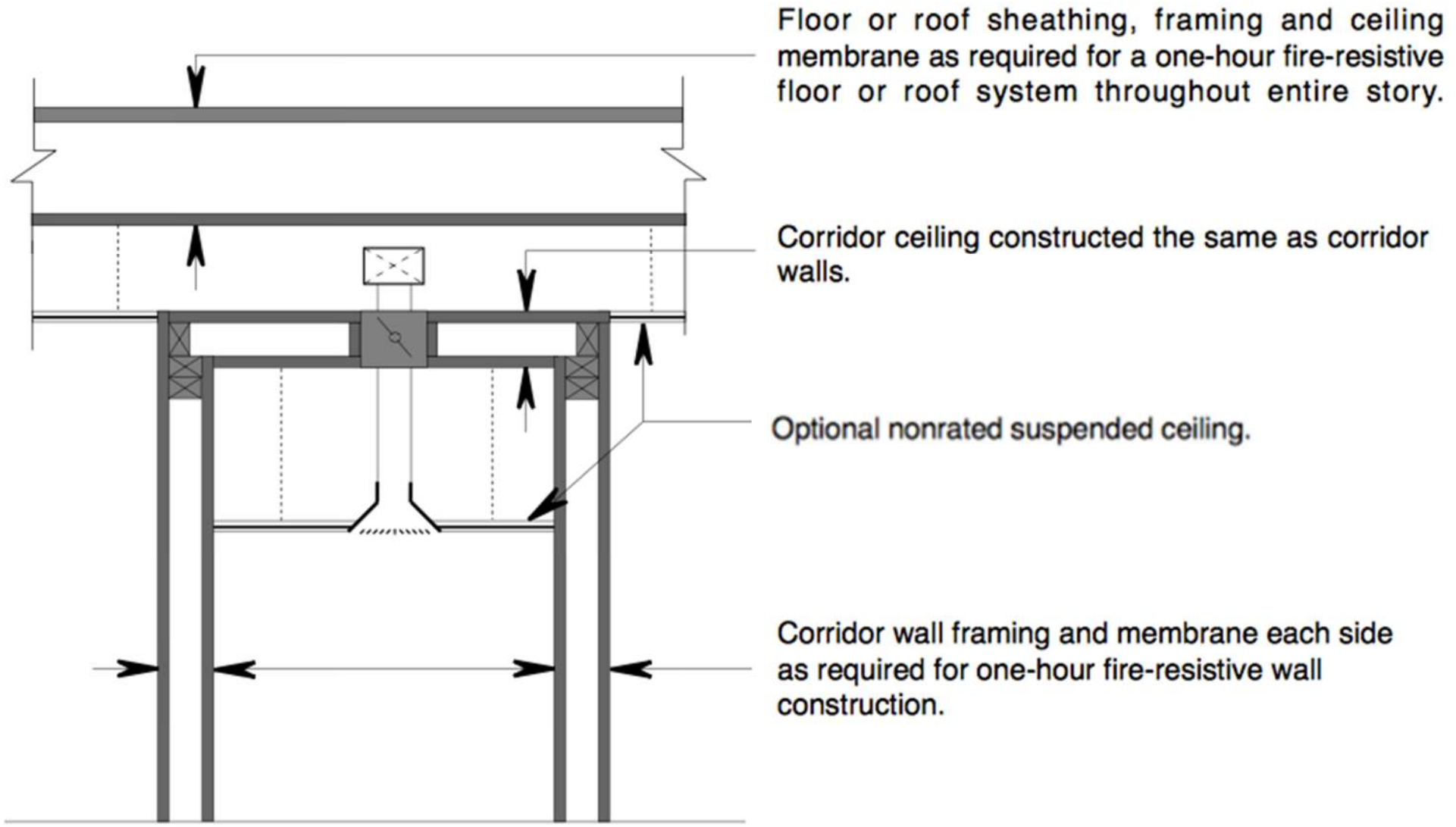
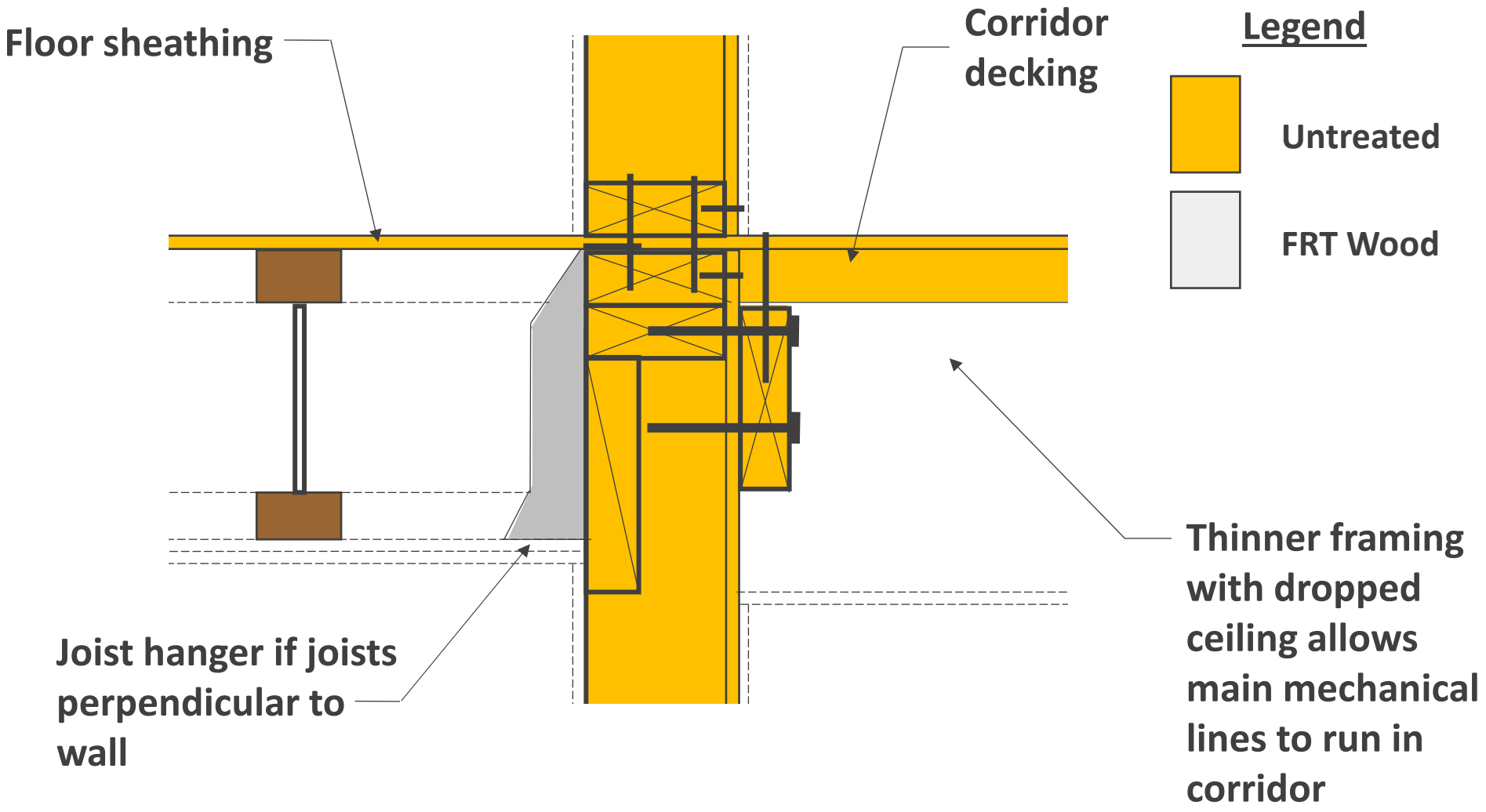



Figure 708.4(2)(B)
FIRE PARTITION CONTINUITY

# Corridor Walls – 708.4 Exception 3

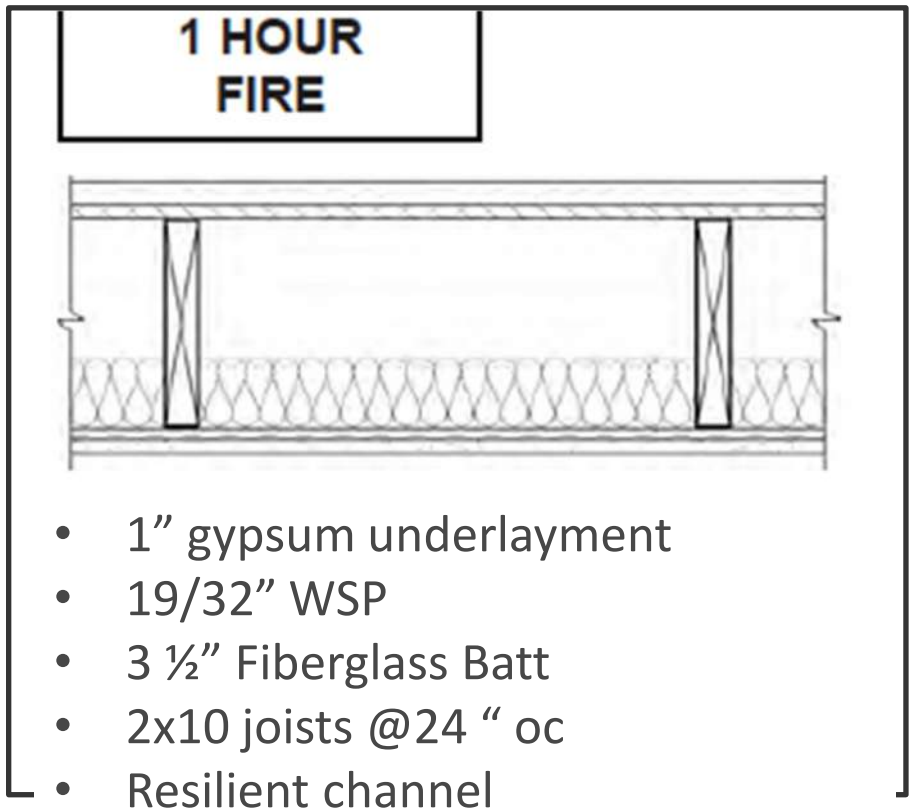


# Corridors – 1-hr Floor



# Shallow Floor Depths

**UL L502**
**GA FC5104**




- 1” gypsum underlayment
- 19/32” WSP
- 3 ½” Fiberglass Batt
- 2x10 joists @24 “ oc
- Resilient channel
- 5/8” Type-X Gyp

Common issues with UL approved assemblies:

- Shallow Floor depth-
  - Use prescriptive assemblies - IBC 721.1(3) assembly 21-1.1
  - Or use the CAM method in IBC 722

# Unit Demising Walls

**IBC 708.3:**

Fire-resistance = 1 hour

except = 0.5 hour in IIB, IIIB and VB

**708.3 Fire-resistance rating.** *Fire partitions* shall have a *fire-resistance rating* of not less than 1 hour.

**Exceptions:**

1. Corridor walls permitted to have a $^1/_2$-hour *fire-resistance rating* by Table 1020.1.
2. *Dwelling unit* and *sleeping unit* separations in buildings of Types IIB, IIIB and VB construction shall have *fire-resistance ratings* of not less than $^1/_2$ hour in buildings equipped throughout with an *automatic sprinkler system* in accordance with Section 903.3.1.1.

# Acoustical Design

Code requirements for residential occupancies:

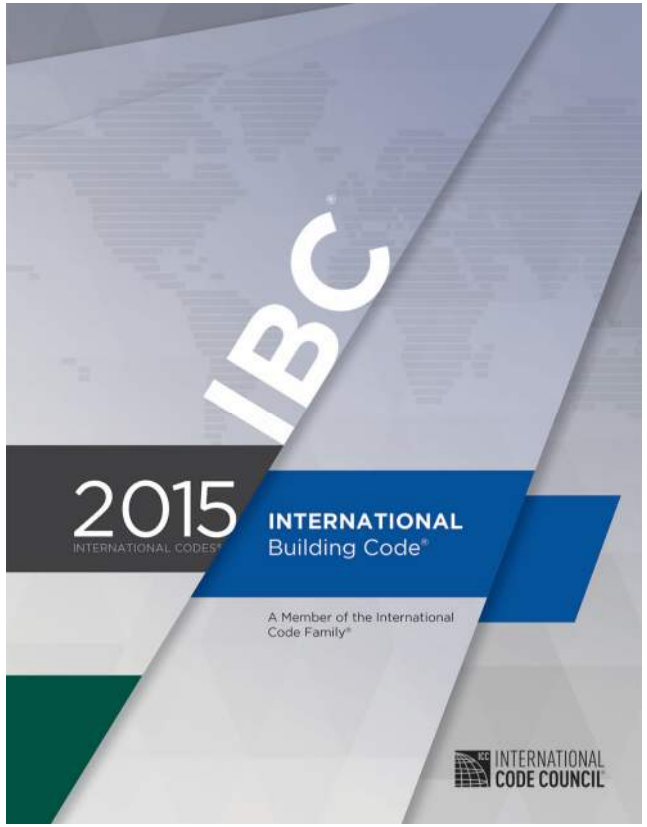
For unit to unit or unit to public or service areas:

**Min. STC of 50 (45 if field tested):**

- Walls, Partitions, and Floor/Ceiling Assemblies

**Min. IIC of 50 (45 if field tested) for:**

- Floor/Ceiling Assemblies

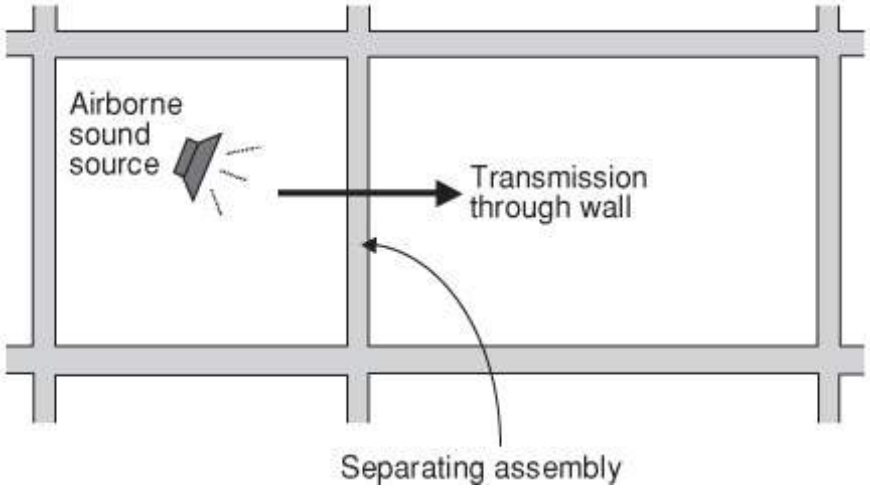


# Acoustical Design

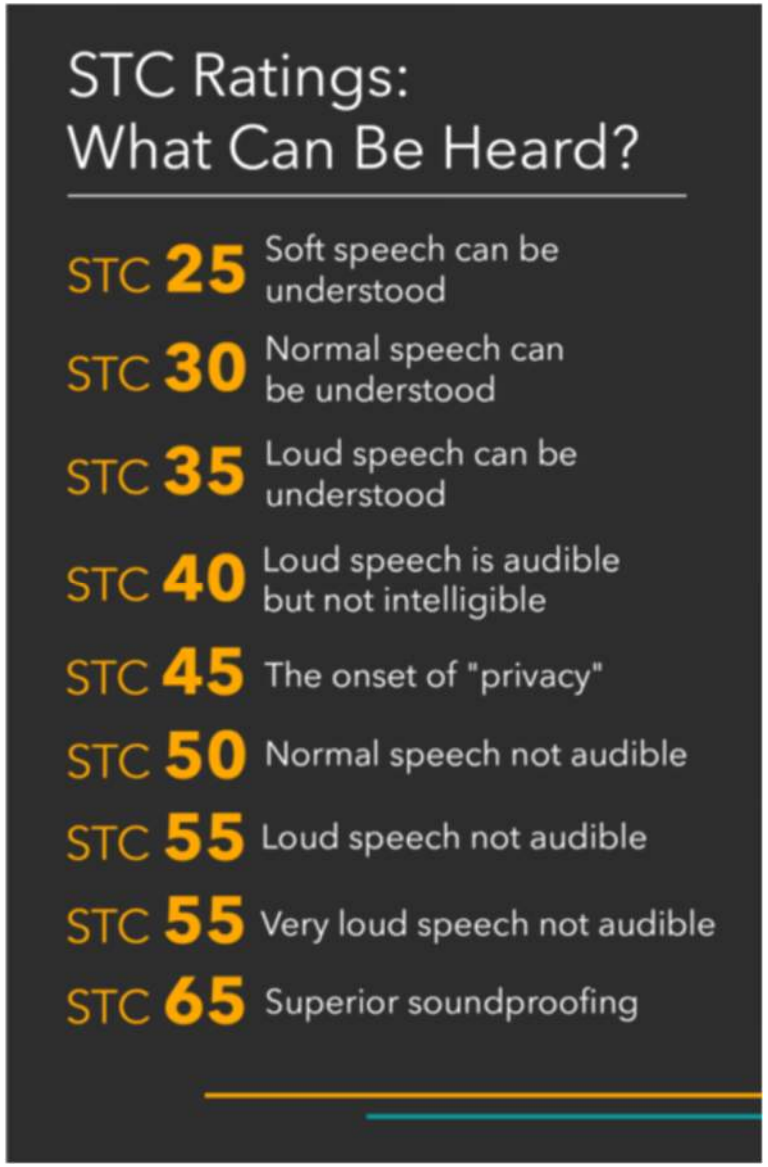
**<u>Air-Borne Sound:</u>**

**Sound Transmission Class (STC)**

- Measures how effectively an assembly isolates air-borne sound and reduces the level that passes from one side to the other
- Applies to walls and floor/ceiling assemblies




# Acoustical Design




**What is adequate sound control?**

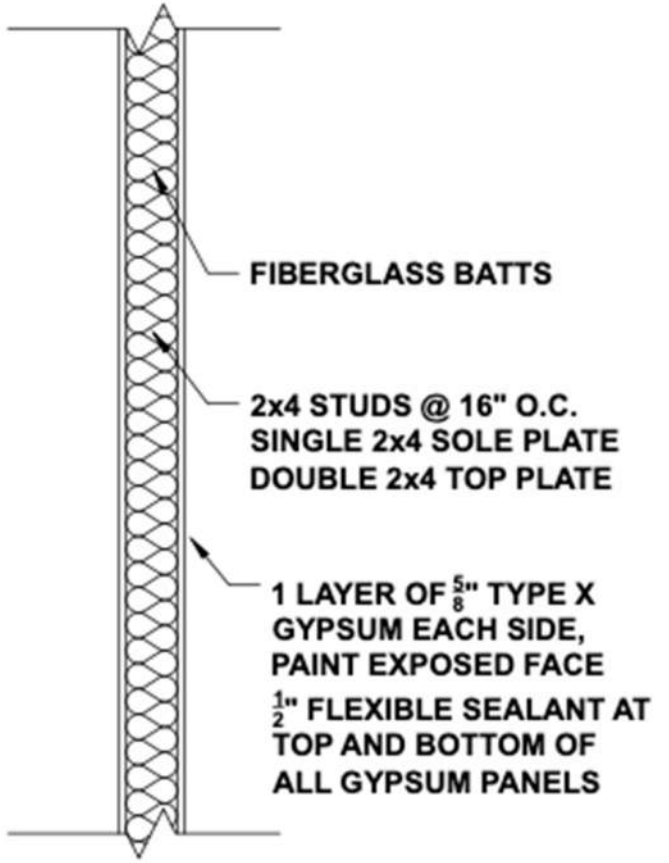
# Unit Demising - Wall Types

Can generally group interior wall types into these 3 categories

- Single stud wall
- Staggered stud wall
- Double stud wall

# Interior Wall Types

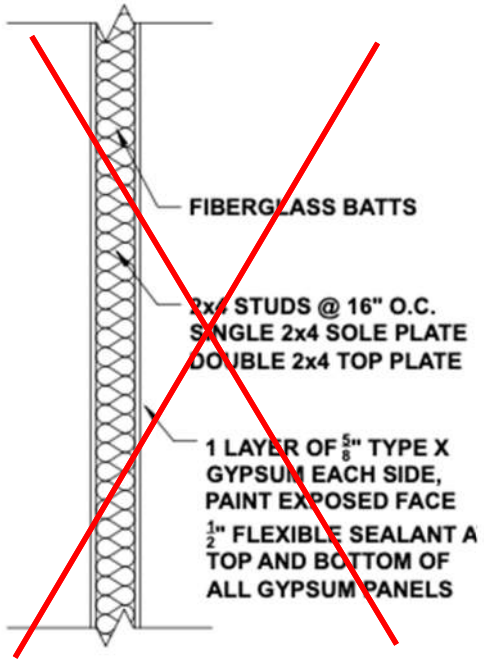
Single stud walls



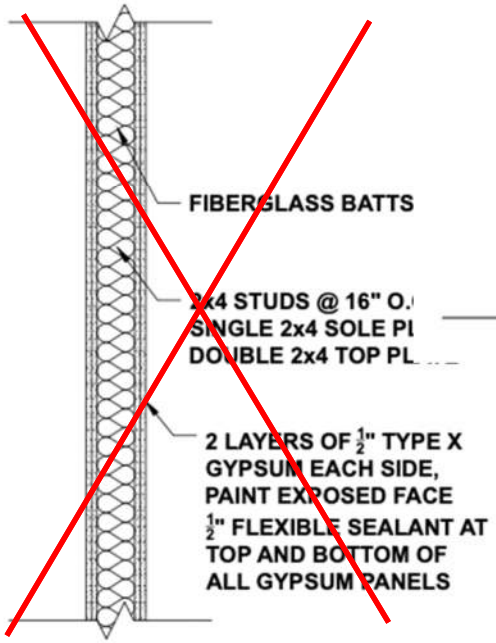

Single stud walls: 1 Hour (UL U305), but…
STC = 38
No shearwall sheathing

# Interior Wall Types

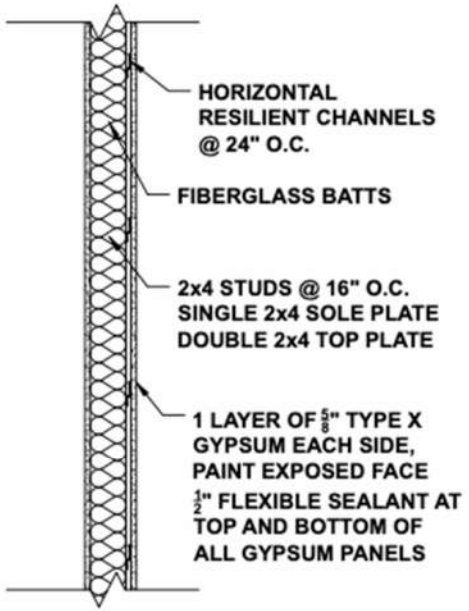
Single stud walls, 1 hr options



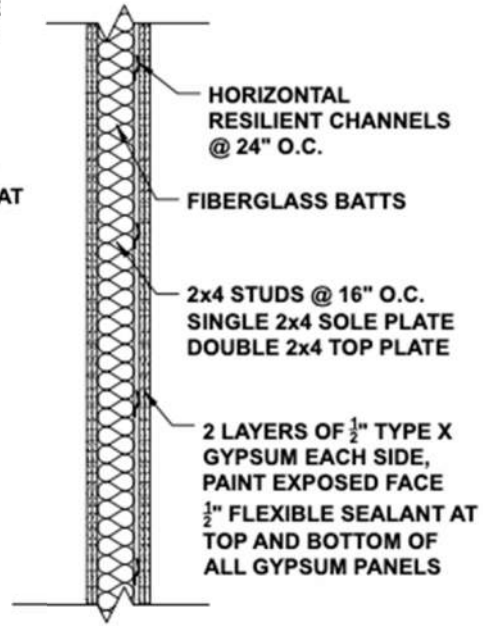

1 layer gyp
STC = 38




2 layers gyp
STC = 45




1 layer gyp + RC
STC = 50




2 layers gyp + RC
STC = 56

# Shearwall Design

Very common for unit demising walls and corridor walls to function as shearwalls. Wood structural panels (plywood or OSB) directly attached to wood studs and blocking.

Credit: WoodWorks

# Interior Wall Types – Addition of WSP

Can include WSP in assemblies which were tested without them:

- ESR 2586
- AWC's DCA4
- Gypsum Association Manual

GA Fire Resistance Design Manual item 23 in Section 1 of the General Explanatory Notes:

*"When not specified as a component of a fire- resistance rated wall or partition system, wood structural panels shall be permitted to be added to one or both sides."*

ESR 2586:

**4.7 Fire-resistive Construction:**

Structural-use panels may be installed between the fire protection and the wood studs on either the interior or exterior side of fire-resistance-rated wood frame wall and partition assemblies described in the applicable code, provided the length of fasteners is adjusted for the added thickness of the panel.


**Component Additive Method (CAM) for Calculating and Demonstrating Assembly Fire Resistance**

Wood-frame walls and floors offer designers a unique opportunity to provide structures with economy as well as proven energy performance. Where these assemblies are required by the building codes to

veloped from conducting a series of fire resistance tests. The Component Additive Method (CAM) provides for calculating the fire resistance of load bearing and non-load bearing floor, wall, ceiling and roof

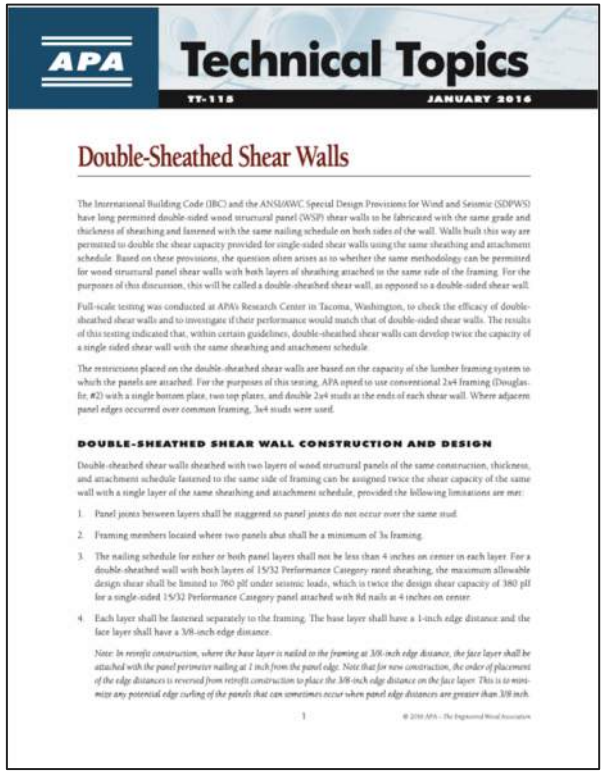
# Acoustical Design

- My interior, acoustically rated wall also needs to be a shearwall (think unit demising wall)
- Can I add wood structural panels to an acoustically tested wall?

Yes, but placement is very important!

# Interior Wall Types

- For walls with resilient channels, put WSP on opposite side of wall
- For highly loaded shearwalls, can (maybe) use double layer of sheathing on same side of wall



APA Technical Topics

TT-118 JANUARY 2016

Double-Sheathed Shear Walls

The International Building Code (IBC) and the ANSI/AWC Special Design Provisions for Wind and Seismic (SDPWS) have long permitted double-sided wood structural panel (WSP) shear walls to be fabricated with the same grade and thickness of sheathing and fastened with the same nailing schedule on both sides of the wall. Walls built this way are permitted to double the shear capacity provided for single-sided shear walls using the same sheathing and attachment schedule. Based on these provisions, the question often arises as to whether the same methodology can be permitted for wood structural panel shear walls with both layers of sheathing attached to the same side of the framing. For the purposes of this discussion, this will be called a double-sheathed shear wall, as opposed to a double-sided shear wall.

Full-scale testing was conducted at APA's Research Center in Tacoma, Washington, to check the efficacy of double-sheathed shear walls and to investigate if their performance would match that of double-sided shear walls. The results of this testing indicated that, within certain guidelines, double-sheathed shear walls can develop twice the capacity of a single sided shear wall with the same sheathing and attachment schedule.

The restrictions placed on the double-sheathed shear walls are based on the capacity of the lumber framing system to which the panels are attached. For the purposes of this testing, APA opted to use conventional 2x4 framing (Douglas-fir, #2) with a single bottom plate, two top plates, and double 2x4 studs at the ends of each shear wall. Where adjacent panel edges occurred over common framing, 3x4 studs were used.

DOUBLE-SHEATHED SHEAR WALL CONSTRUCTION AND DESIGN

Double-sheathed shear walls sheathed with two layers of wood structural panels of the same construction, thickness, and attachment schedule fastened to the same side of framing can be assigned twice the shear capacity of the same wall with a single layer of the same sheathing and attachment schedule, provided the following limitations are met:

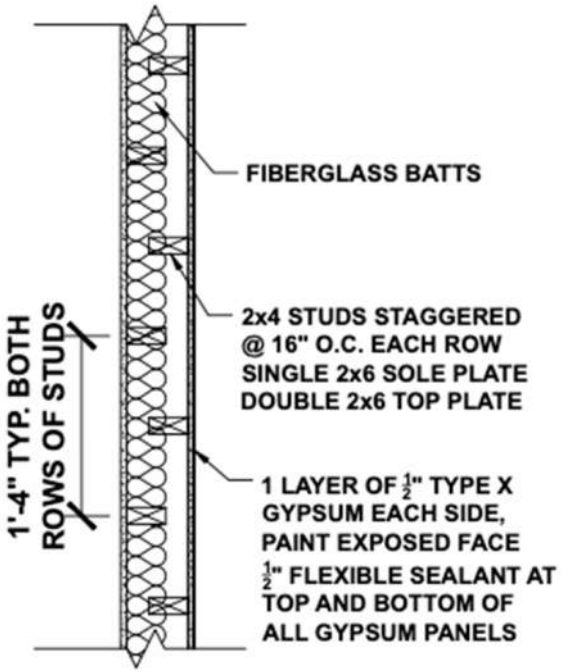
1. Panel joints between layers shall be staggered so panel joints do not occur over the same stud.
2. Framing members located where two panels abut shall be a minimum of 3x framing.
3. The nailing schedule for either or both panel layers shall not be less than 4 inches on center in each layer. For a double-sheathed wall with both layers of 15/32 Performance Category rated sheathing, the maximum allowable design shear shall be limited to 760 plf under seismic loads, which is twice the design shear capacity of 380 plf for a single-sided 15/32 Performance Category panel attached with 8d nails at 4 inches on center.
4. Each layer shall be fastened separately to the framing. The base layer shall have a 1-inch edge distance and the face layer shall have a 3/8-inch edge distance.

*Note: In retrofit construction, where the base layer is nailed to the framing at 3/8-inch edge distance, the face layer shall be attached with the panel perimeter nailing at 1 inch from the panel edge. Note that for new construction, the order of placement of the edge distances is reversed from retrofit construction to place the 3/8-inch edge distance on the face layer. This is to minimize any potential edge curling of the panels that can sometimes occur when panel edge distances are greater than 3/8 inch.*

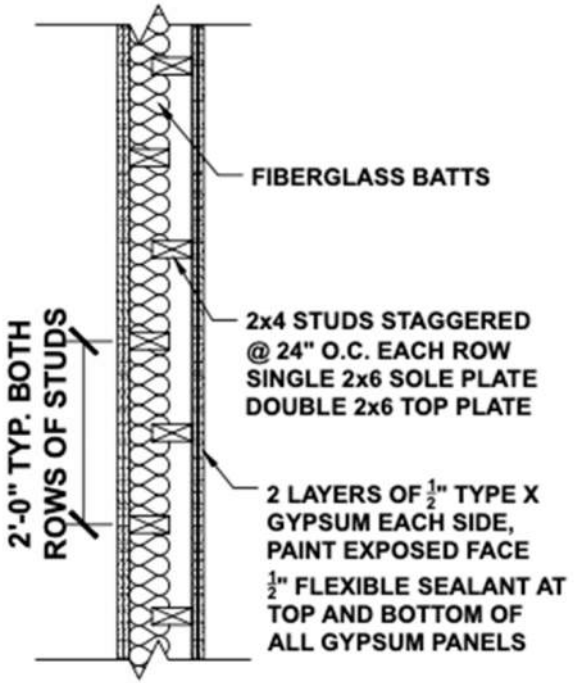
1 © 2016 APA – The Engineered Wood Association

# Interior Wall Types

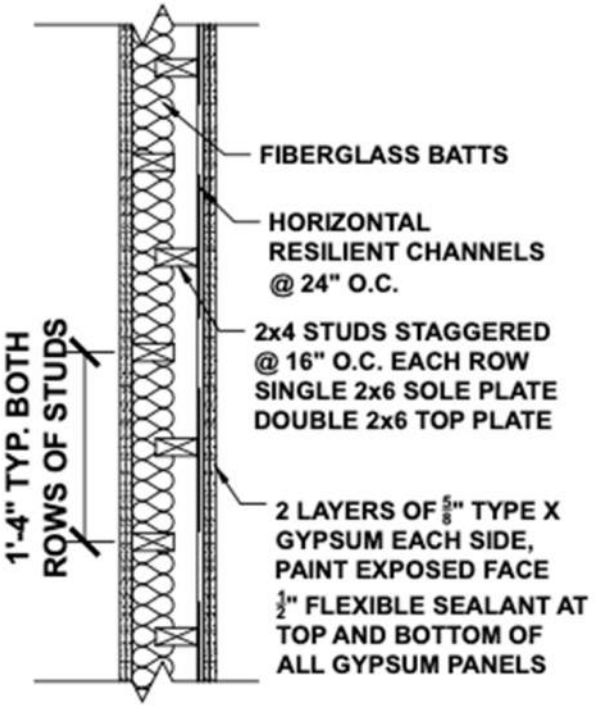
Staggered stud walls, 1 hr options




STC = 50




STC = 55



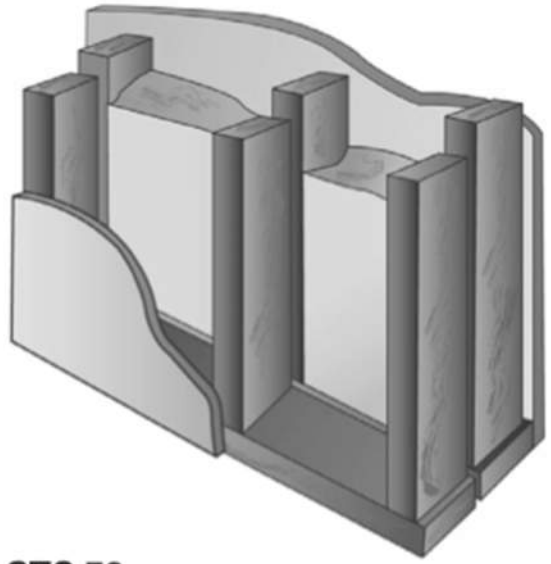

STC = 63

# Interior Wall Types

- Staggered stud wall condition:
- Blocking bridges finish on one side of wall to studs on opposite side, defeats purpose.
- Solution: use flat blocking in wall (wide face against WSP)

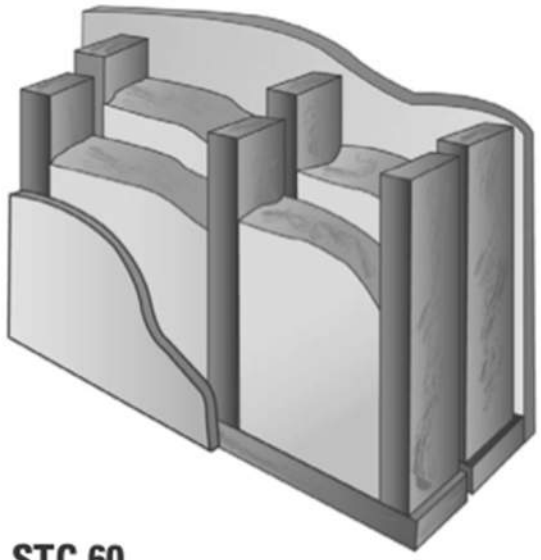
# Interior Wall Types

Double stud walls, 1 hr options



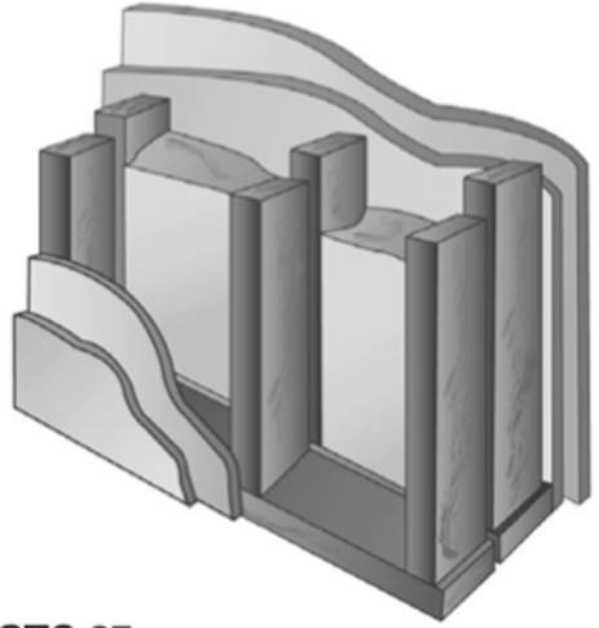
STC 56

Studs @ 16” o.c.
Single gyp. each face



STC 60

Studs @ 24” o.c.
Single gyp. each face



STC 65

Studs @ 16” o.c.
Double gyp. each face

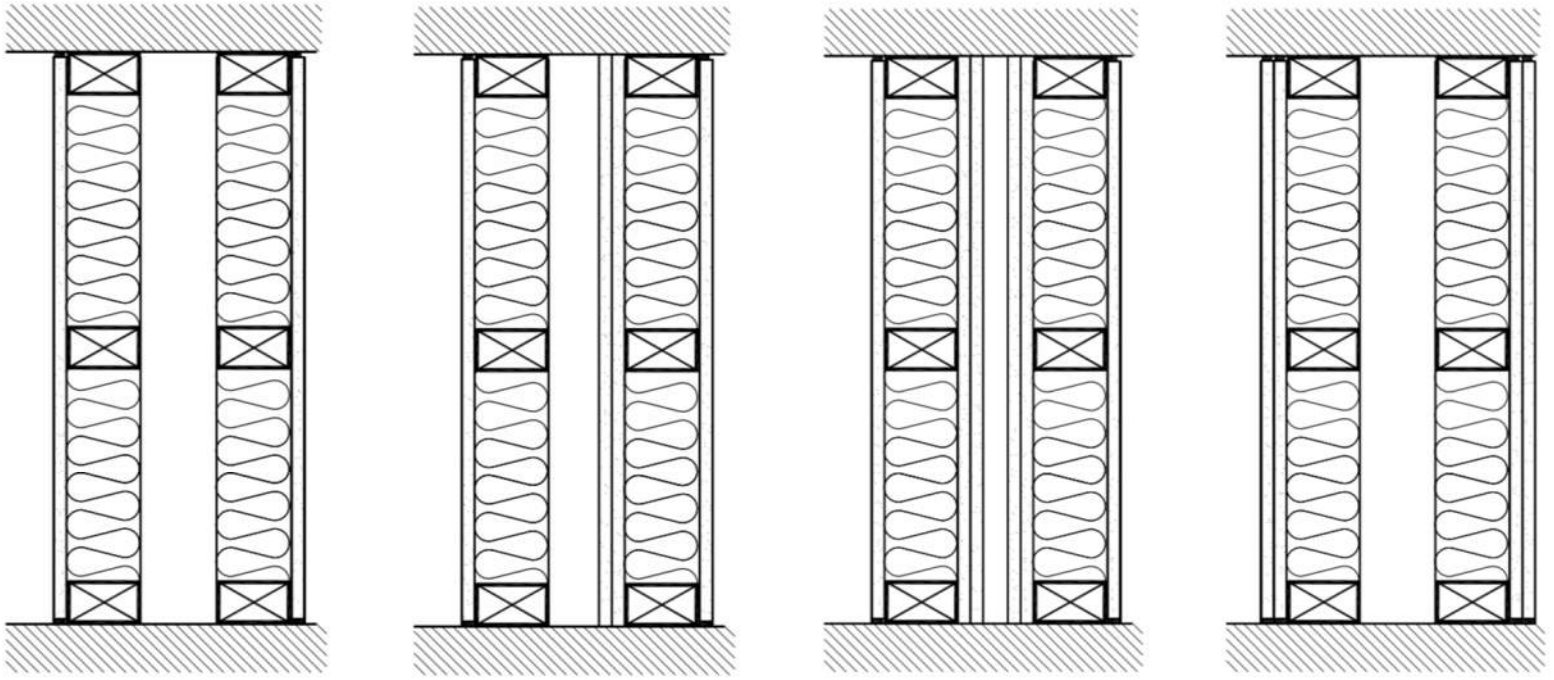
Source: Johns Manville

# Interior Wall Types

WSP placement in double stud walls – big impact on STC

*FIGURE 6*

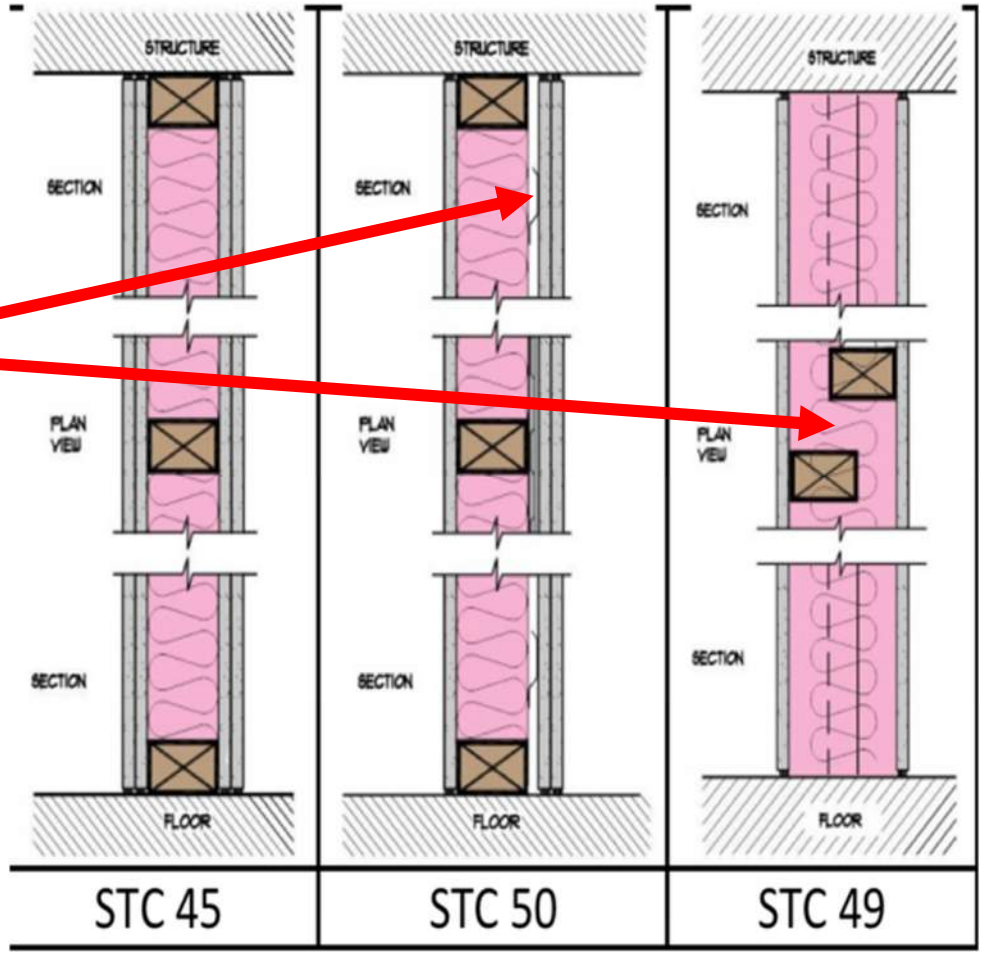
Effect of Sheathing Placement on Acoustical Performance (Plan View)



# Interior Wall Types

**The moral of the story…**

**Make sure that structural elements don't defeat the purpose of acoustical enhancers, especially decouplers**



# Fire Barriers & Partitions – Horizontal Continuity

- Code language exists to clarify vertical & horizontal continuity requirements of **fire walls**.
- However, for **fire barriers** & **fire partitions**, only vertical continuity requirements exist.
- How are partition wall to partition wall (or partition wall to exterior wall) intersections handled?

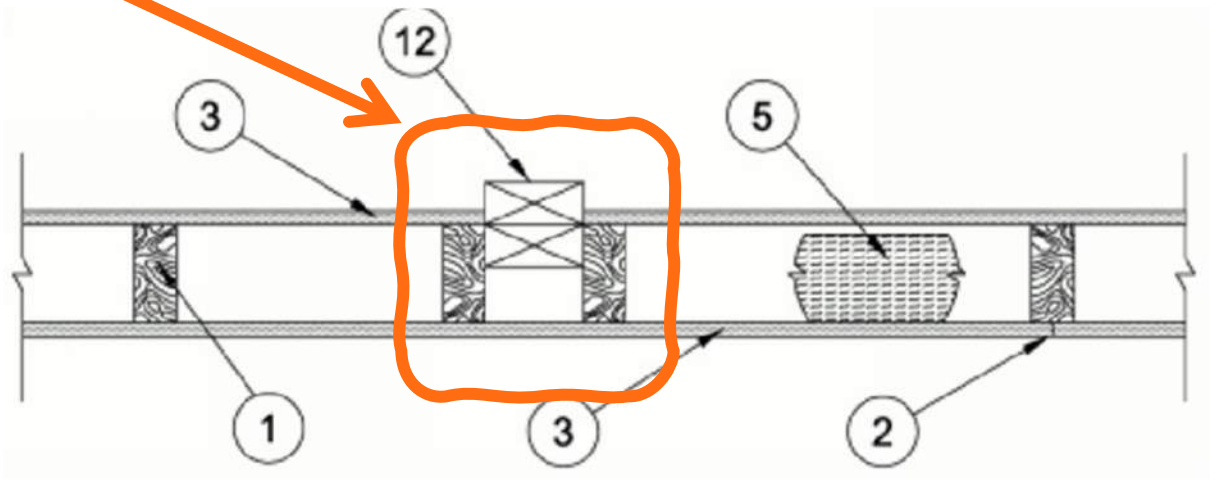
# Fire Barriers & Partitions – Horizontal Continuity

Permitted as noted in tested wall assembly

**Design No. U305**

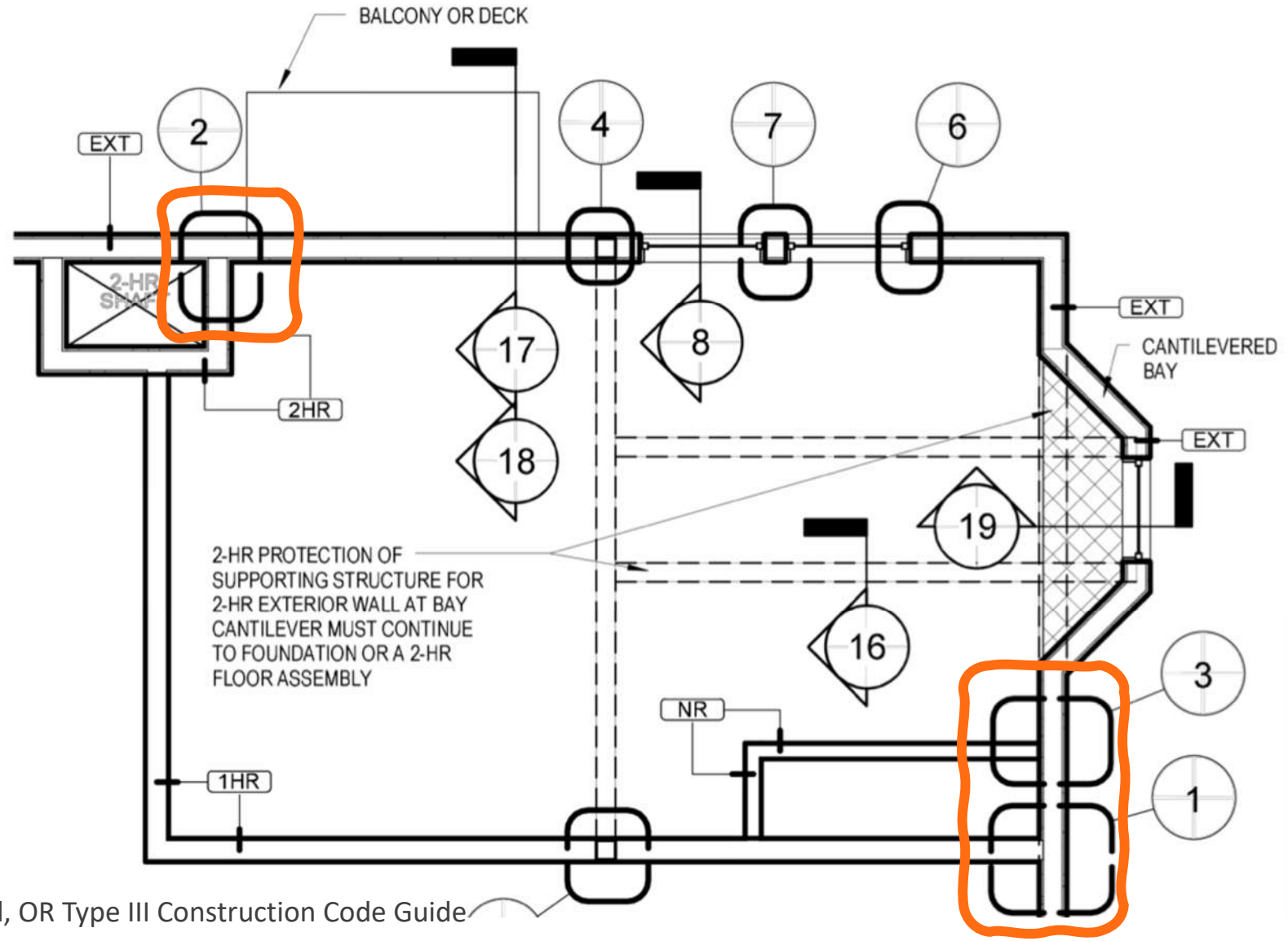
March 10, 2020

**Bearing Wall Rating — 1 Hr**




12. **Non-Bearing Wall Partition Intersection —** (Optional) —Two nominal 2 by 4 in. studs or nominal 2 by 6 in. studs nailed together with two 3 in. long 10d nails spaced a max. 16 in. OC. vertically and fastened to one side of the minimum 2 by 4 in. stud with 3 in. long 10d nails spaced a max. 16 in. OC. vertically. Intersection between partition wood studs to be flush with the 2 by 4 in. studs. The wall partition wood studs are to be framed by with a second 2 by 4 in. wood stud fastened with 3 in. long 10d nails spaced a max. 16 in. OC. vertically. Maximum one non-bearing wall partition intersection per stud cavity. Non-bearing wall partition stud depth shall be at a minimum equal to the depth of the bearing wall.

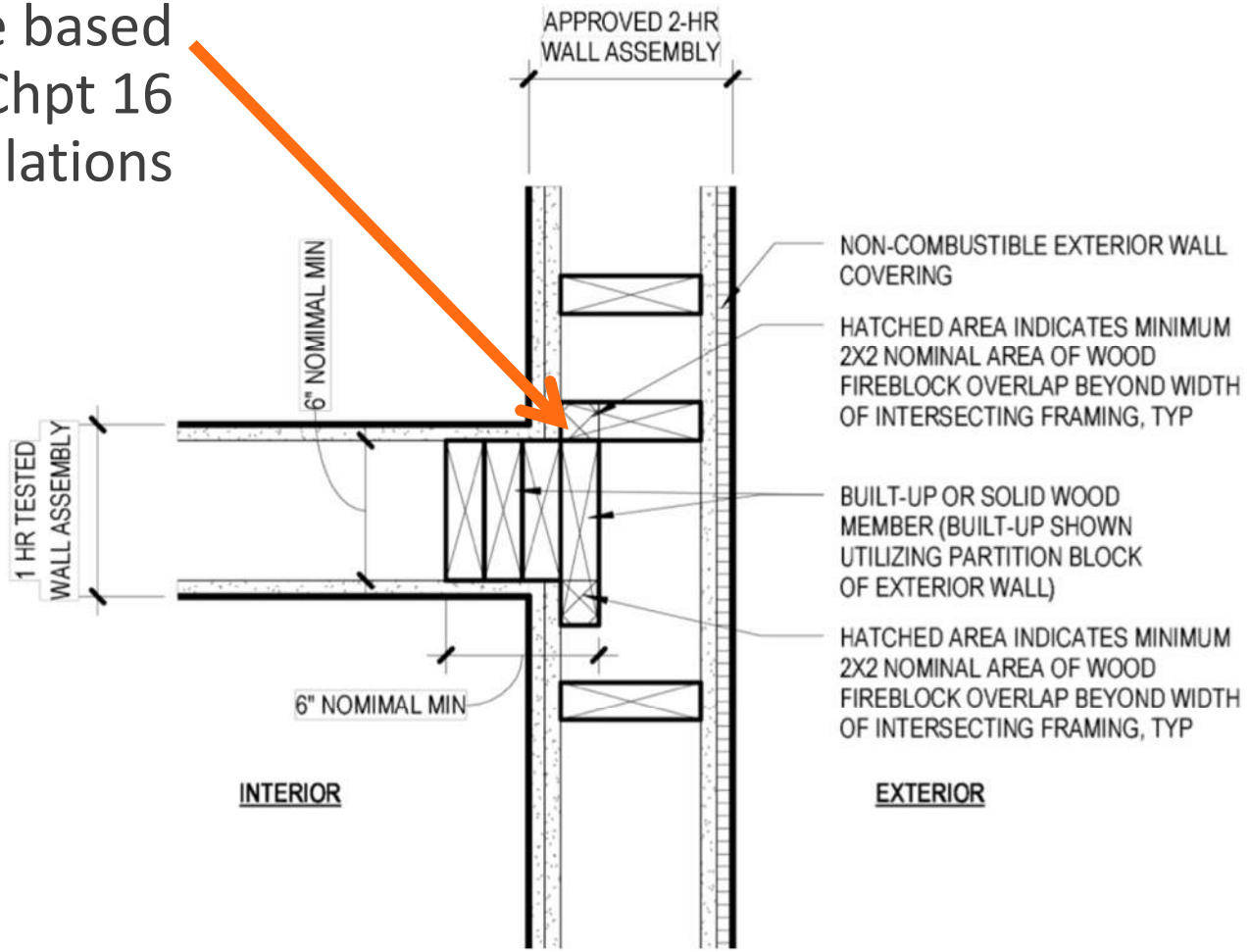
# Fire Barriers & Partitions – Horizontal Continuity




Source: City of Portland, OR Type III Construction Code Guide

# Fire Barriers & Partitions – Horizontal Continuity

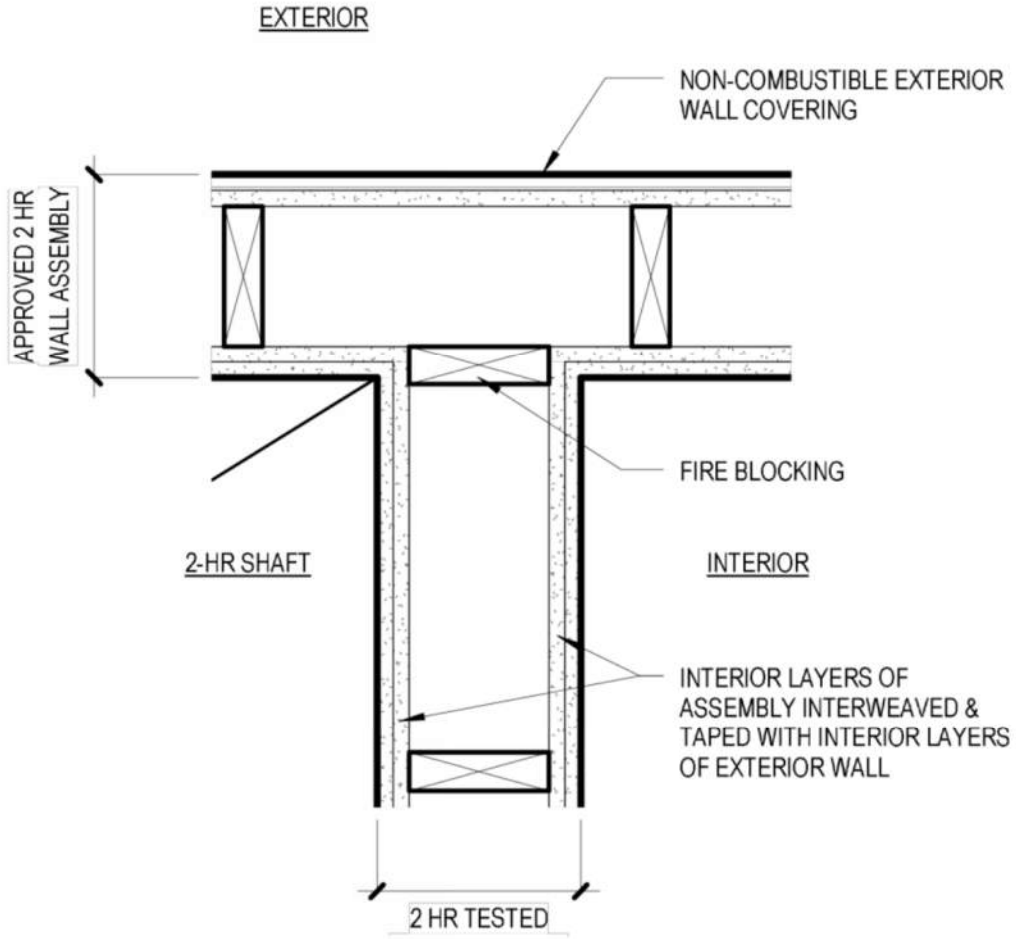
Rationale based on NDS Chpt 16 char calculations




1-HR INTERIOR WALL AT 2-HR EXTERIOR WALL

Source: City of Portland, OR Type III Construction Code Guide

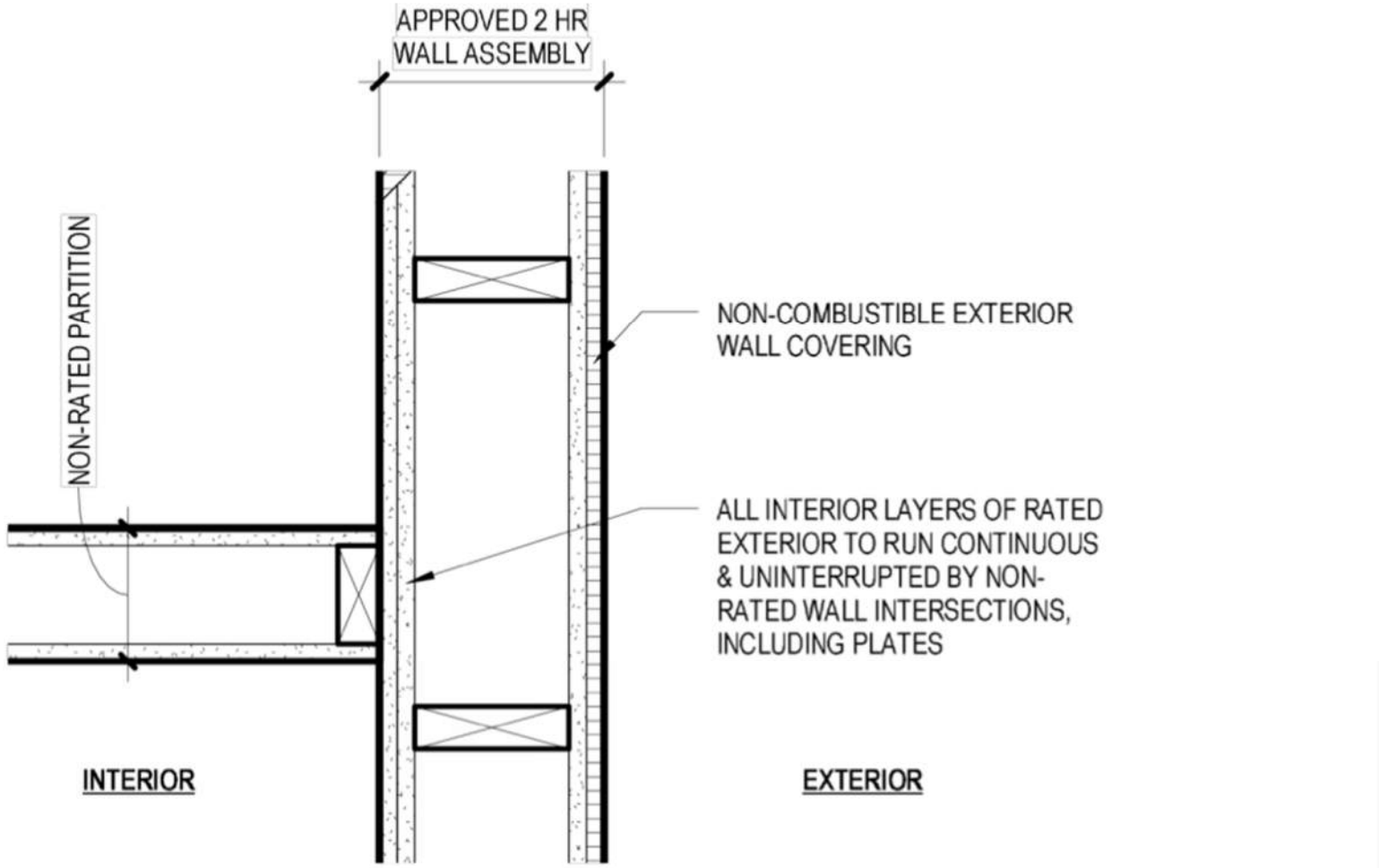
# Fire Barriers & Partitions – Horizontal Continuity




2-HR INTERIOR WALL AT 2-HR EXTERIOR WALL

Source: City of Portland, OR Type III Construction Code Guide

# Fire Barriers & Partitions – Horizontal Continuity




NON-RATED INTERIOR WALL AT EXTERIOR WALL

Source: City of Portland, OR Type III Construction Code Guide

# Outline

- Review of Fire Resistance Methods
- Interior Fire Rated Wall Assemblies
  - Fire Walls
  - Fire Barriers
  - Fire Partitions/Corridors
- **Horizontal Assemblies**

1430 Q, The HR Group Architects, Buehler Engineering, Greg Folkins Photography

# Horizontal Assemblies

- A floor or roof assembly required to have a fire resistance rating such as for occupancy separations and fire area separations
- May be constructed with any materials permitted by the construction type
- Occupancy separation: Fire resistance ratings per IBC Table 508.4
- Required to be continuous without vertical openings except as permitted in IBC 712
- Supporting construction required to have same fire-resistance rating as the fire barrier being supported (with exceptions per 711.4)
- Other requirements for openings, penetrations, joints

# Fire Resistance Ratings – 711.2.4

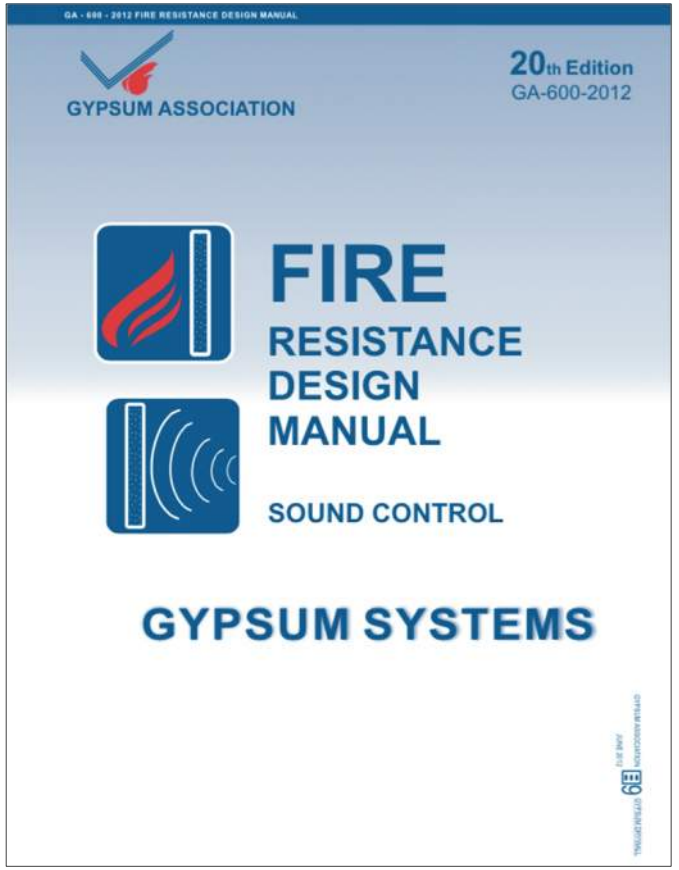
Fire resistance shall not be less than that required for:

- Separating mixed occupancies – 508.4
  - Up to 1-hr for sprinklered for other than I and H occupancy
  - Up to 2-hr for non-sprinklered for other than I and H occupancy
- Separating fire areas – 707.3.10
  - 2-hr for most occupancies for other than H and F-1
  - 3-hr for S1/ 1-hr for U
- Dwelling units – not less than 1hr
  - Except for IIB, IIIB, VB with NFPA 13 sprinklers is ½-hr
- Separating smoke compartments – 709
- Separating incidental uses – 509

# Fire Resistance – Insulation Effects

*"The addition of up to 16-3/4 inches of 0.5 pcf glass fiber insulation (R-40), either batt or loose-fill, to any 1- or 2-hour fire resistance rated floor-ceiling or roof-ceiling system having a cavity deep enough to accept the insulation is permitted provided that one additional layer of either 1/2 inch or 5/8 inch type X gypsum board is applied to the ceiling. The additional layer of gypsum board shall be applied as described for the face layer of the tested system except that the fastener length shall be increased by not less than the thickness of the additional layer of gypsum board."*

Section 1.12 Gypsum Association
Fire Resistance Design Manual

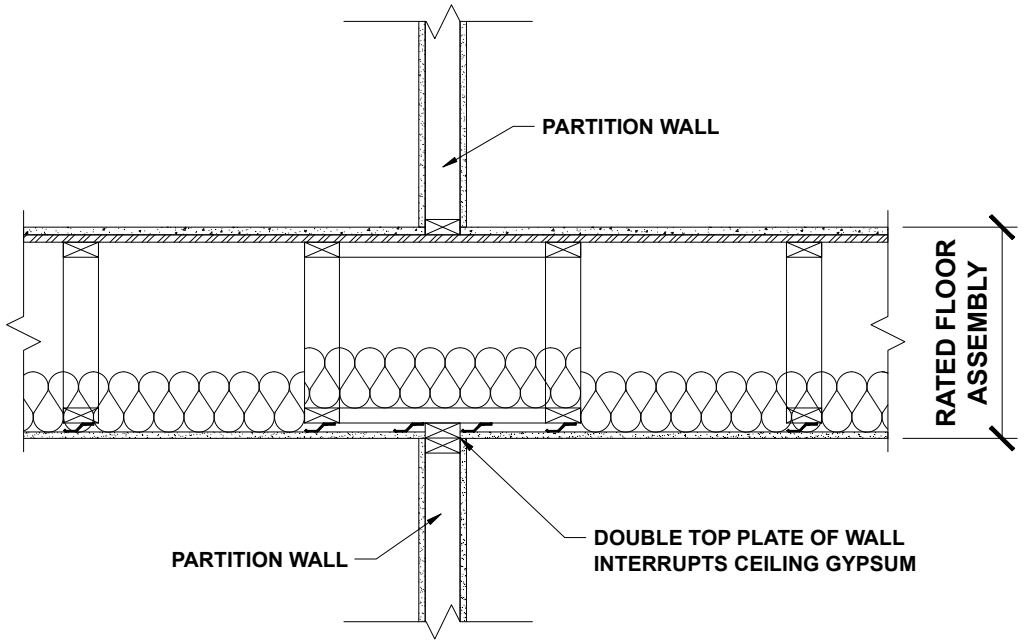


# Assembly Intersection

Can a wall interrupt the ceiling gypsum of a rated horizontal assembly?

## Yes!

» IBC 2018 714.5.2, Exception 7: Permitted if wall is covered with type X gypsum each side

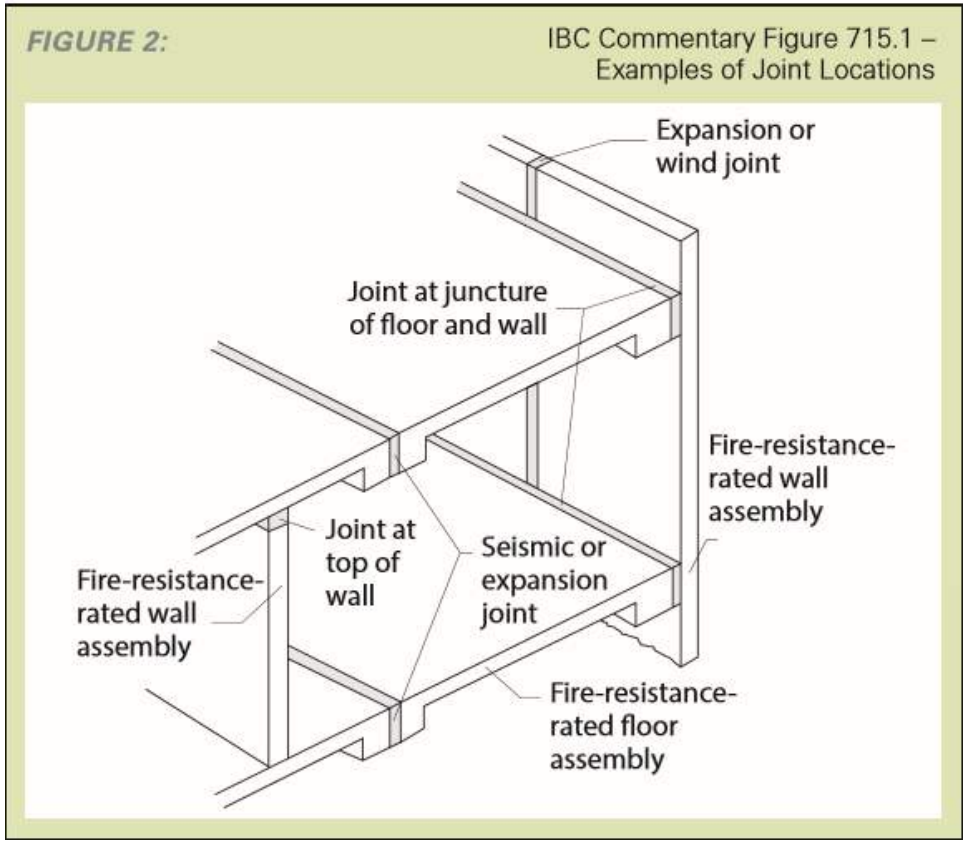



INTERIOR WALL TO FLOOR INTERSECTION

# Joint vs. Assembly Intersection

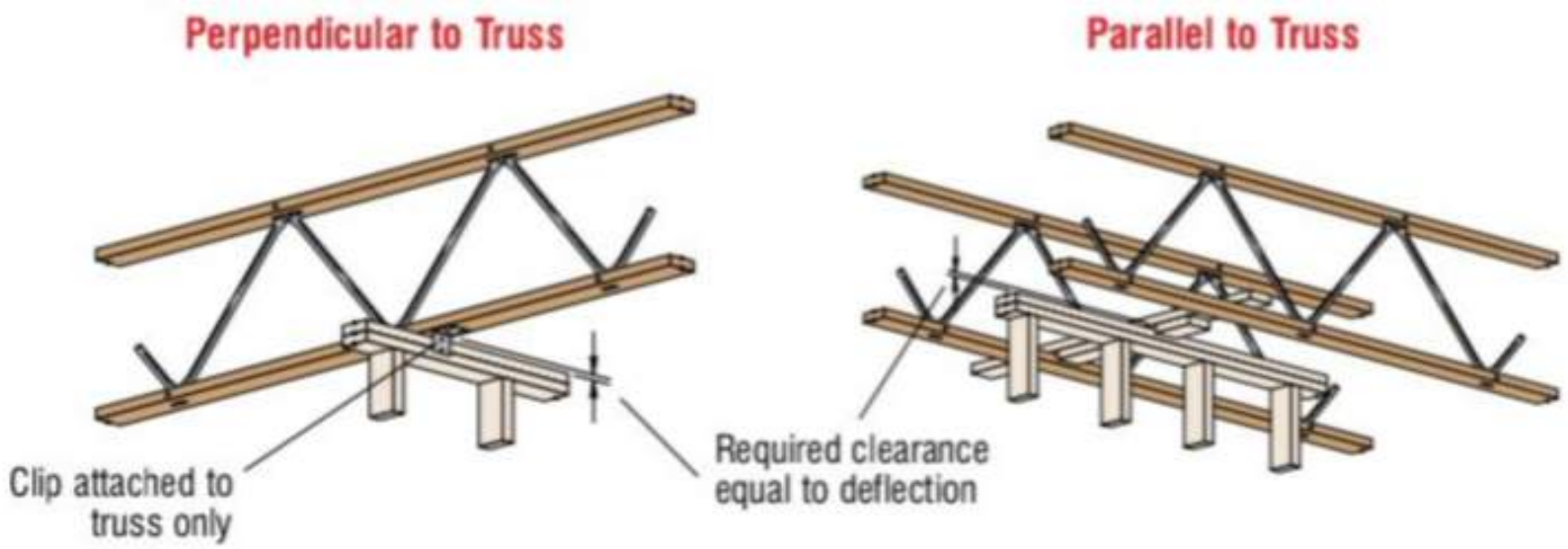
**SECTION 202**
**DEFINITIONS**

***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.*



# Joints

Truss manufactures often recommend a gap to accommodate deflection between the bottom chord and interior non-bearing walls. How is that detailed?



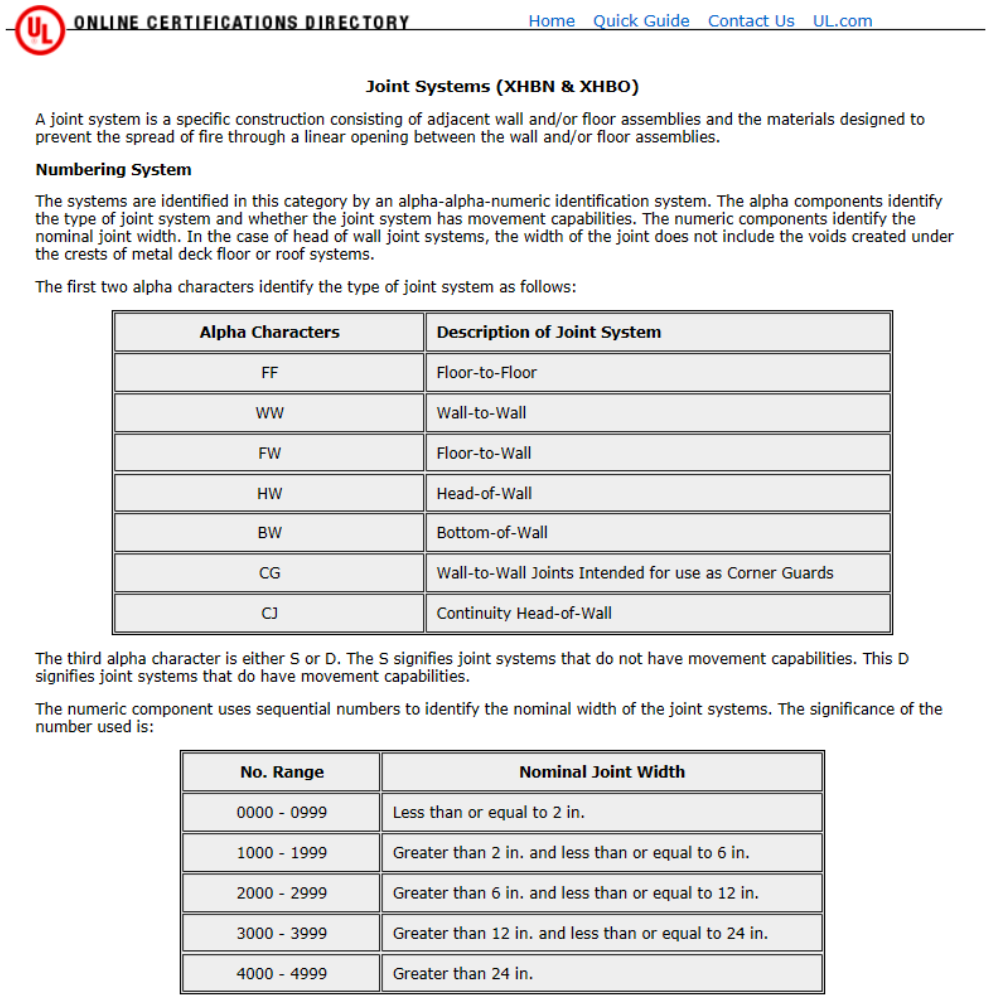
# Joints – IBC 715

Exceptions to rated joints:

- Walls that allow unprotected openings
- Control joints not exceeding .625” and tested in E119 assembly

Joint Assemblies available through UL Directory

- Not easily searchable
- HWS or HWD
- Very few wood assemblies
- Joint manufacturer may supply engineering judgement



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**Joint Systems (XHBN & XHBO)**

A joint system is a specific construction consisting of adjacent wall and/or floor assemblies and the materials designed to prevent the spread of fire through a linear opening between the wall and/or floor assemblies.

**Numbering System**

The systems are identified in this category by an alpha-alpha-numeric identification system. The alpha components identify the type of joint system and whether the joint system has movement capabilities. The numeric components identify the nominal joint width. In the case of head of wall joint systems, the width of the joint does not include the voids created under the crests of metal deck floor or roof systems.

The first two alpha characters identify the type of joint system as follows:

| Alpha Characters | Description of Joint System |
|---|---|
| FF | Floor-to-Floor |
| WW | Wall-to-Wall |
| FW | Floor-to-Wall |
| HW | Head-of-Wall |
| BW | Bottom-of-Wall |
| CG | Wall-to-Wall Joints Intended for use as Corner Guards |
| CJ | Continuity Head-of-Wall |

The third alpha character is either S or D. The S signifies joint systems that do not have movement capabilities. This D signifies joint systems that do have movement capabilities.

The numeric component uses sequential numbers to identify the nominal width of the joint systems. The significance of the number used is:

| No. Range | Nominal Joint Width |
|---|---|
| 0000 - 0999 | Less than or equal to 2 in. |
| 1000 - 1999 | Greater than 2 in. and less than or equal to 6 in. |
| 2000 - 2999 | Greater than 6 in. and less than or equal to 12 in. |
| 3000 - 3999 | Greater than 12 in. and less than or equal to 24 in. |
| 4000 - 4999 | Greater than 24 in. |

# Joint Systems

ONLINE CERTIFICATIONS DIRECTORY

**System No. HW-S-0088**
**XHBN.HW-S-0088**
**Joint Systems**

Page Bottom

## Design/System/Construction/Assembly Usage Disclaimer

- Authorities Having Jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of UL Certified products, equipment, system, devices, and materials.
- Authorities Having Jurisdiction should be consulted before construction.
- Fire resistance assemblies and products are developed by the design submitter and have been investigated by UL for compliance with applicable requirements. The published information cannot always address every construction nuance encountered in the field.
- When field issues arise, it is recommended the first contact for assistance be the technical service staff provided by the product manufacturer noted for the design. Users of fire resistance assemblies are advised to consult the general Guide Information for each product category and each group of assemblies. The Guide Information includes specifics concerning alternate materials and alternate methods of construction.
- Only products which bear UL's Mark are considered Certified.

## XHBN - Joint Systems

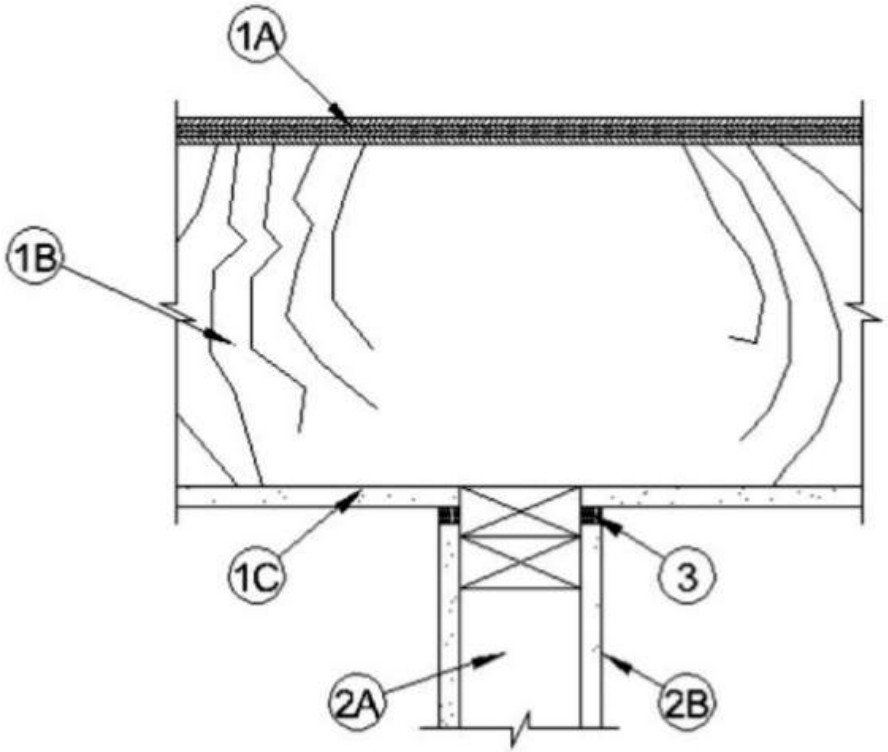
See General Information for Joint Systems

### System No. HW-S-0088

December 05, 2008

**Assembly Rating — 1 Hr**

**Joint Width — 1/2 In. (13 mm) Max**



Tell a Friend

# Do light-frame wood columns that are located entirely within fire-resistance-rated walls also require individual fire protection or encasement?

Section 704.2 of the 2012 International Building Code (IBC) requires that columns which are part of the primary structural frame be individually encased for fire resistance protection.

**704.2 Column protection.**
*Where columns are required to have protection to be fire-resistance rated, the entire column shall be provided individual encasement protection by protecting it on all sides for the full column length, including connections to other structural members, with materials having the required fire-resistance rating. Where the column extends through a ceiling, the encasement protection shall be continuous from the top of the foundation or floor/ceiling assembly below through the ceiling space to the top of the column.*

View All Expert Tips

http://www.woodworks.org/ask-an-expert/

# Individual Encasement - Columns

**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, b] | 2[a, b] | 1[b] | 0 | 1[b] | 0 | HT | 1[b] | 0 |
| Bearing walls | | | | | | | | | |
| Exterior[e, f] | 3 | 2 | 1 | 0 | 2 | 2 | 2 | 1 | 0 |
| Interior | 3[a] | 2[a] | 1 | 0 | 1 | 0 | 1/HT | 1 | 0 |
| Nonbearing walls and partitions Exterior | See Table 602 | | | | | | | | |
| Nonbearing walls and partitions Interior[d] | 0 | 0 | 0 | 0 | 0 | 0 | See Section 2304.11.2 | 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 |

***BEARING WALL STRUCTURE.*** *A building or other structure in which vertical loads from floors and roofs are primarily supported by walls.*

***FRAME STRUCTURE.*** *A building or other structure in which vertical loads from floors and roofs are primarily supported by columns.*

# Light Frame Bearing Walls – 2018 IBC

**2018 IBC: 704.2 Column protection.**

*Where columns are required to have protection to achieve a fire-resistance rating, the entire column shall be provided individual encasement protection by protecting it on all sides for the full column height, including connections to other structural members, with materials having the required fire-resistance rating. Where the column extends through a ceiling, the encasement protection shall be continuous from the top of the foundation or floor/ceiling assembly below through the ceiling space to the top of the column.*

***Exception: Columns that meet the limitations of Section 704.4.1***

**2018 IBC: 704.4.1 Light-frame construction.**

***Studs, columns and boundary elements*** *that are integral elements in walls of light-frame construction and are located entirely between the top and bottom plates or tracks shall be permitted to have required fire-resistance ratings provided by the membrane protection provided for the wall.*

# Column vs. Boundary Elements

- If studs/ columns/ boundary elements in a wall lie between plates:
  - Considered “secondary members”
  - Fire rating can be provided by membrane
  - Per Table 601, need to be 2-hr rated for IIIA and 1-hr for VA

- If studs/ columns/ boundary elements break the top and/or bottom plate:
  - May be considered primary frame and be considered a “column” member
  - Need to be individually encased
  - Per Table 601, need to be rated to 1-hr for IIIA and VA construction
  - Protection can be provided by charring effects
  - Protection of connections needs to be considered

# Beam Encasement

**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, b] | 2[a, b] | 1[b] | 0 | 1[b] | 0 | HT | 1[b] | 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 2304.11.2 | 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) | $1\frac{1}{2}$[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | HT | 1[b,c] | 0 |

***BEARING WALL STRUCTURE.*** *A building or other structure in which vertical loads from floors and roofs are primarily supported by walls.*

***FRAME STRUCTURE.*** *A building or other structure in which vertical loads from floors and roofs are primarily supported by columns.*

# Beam Encasement

***704.3 Protection of the primary structural frame other than columns.***

*Members of the primary structural frame other than columns that are required to have protection to achieve a fire-resistance rating and support more than two floors or one floor and roof, or support a load-bearing wall or a non load-bearing wall more than two stories high, shall be provided individual encasement protection by protecting them on all sides for the full length including connections to other structural members, with materials having the required fire-resistance rating.*

***Exception:** Individual encasement protection on all sides shall be permitted on all exposed sides provided the extent of protection is in accordance with the required fire resistance rating as determined in Section 703.*

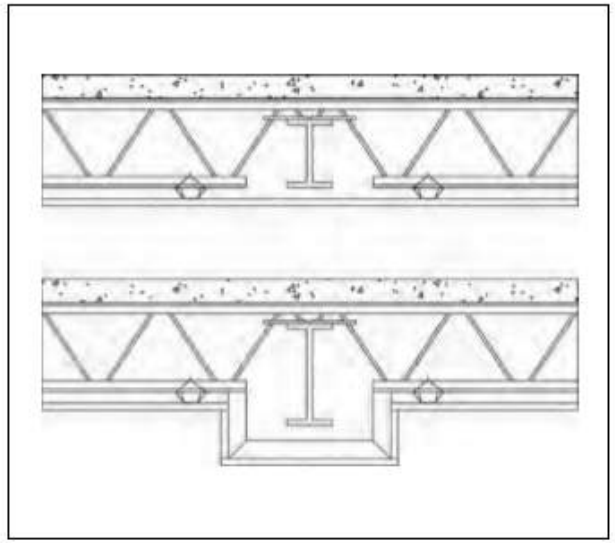


Figure 4
Membrane Protected Steel Beam- Continuous

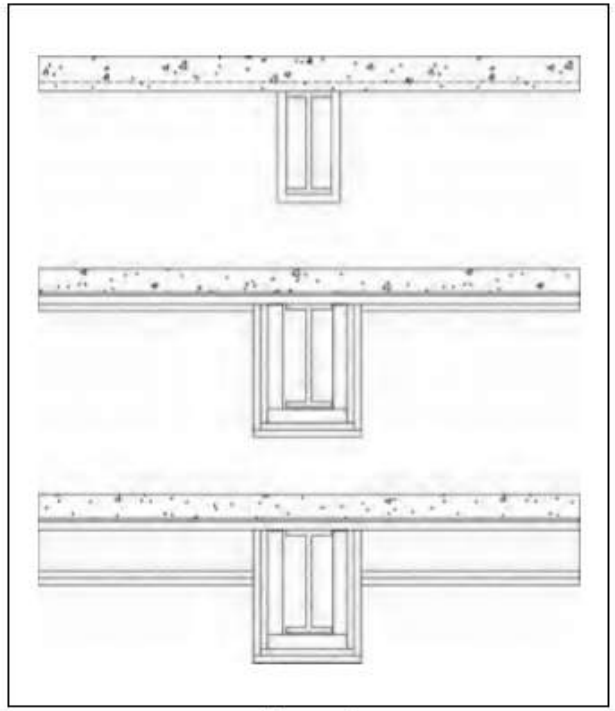


Figure 5
Steel Beam - Individual Encasement Protection

# Interior Fire-Rated Walls: Differences

| Fire walls | Fire Barrier | Fire Partition: |
| --- | --- | --- |
| • Building Separation<br>• Openings are protected and limited<br>• Continuous from foundation to/through roof and exterior wall to/through exterior wall<br>• Structural stability | • Shafts; Occupancy Separation<br>• Openings are protected and limited<br>• Continuous from floor through concealed space at each level | • Dwelling Unit Separation; Corridors<br>• Openings are protected<br>• May terminate at a fire rated floor/ceiling/roof assembly |

# Shaft Wall Solutions for Wood-Frame Structures

CHELSEA DRENICK, PE, SE


Photo: Avesta Housing

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

AIA Approved Continuing Education

# 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**

https://www.woodworks.org/wp-content/uploads/wood_solution_paper-shaft-wall-light-frame-mass-timber.pdf

Richard McLain, PE, SE
*Senior Technical Director – Tall Wood*
*WoodWorks – Wood Products Council*

## 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 – Page 1**
Fire Barrier Construction, Continuity, Supporting Construction, Joint vs. Intersecting Assemblies, Structural Shaft Wall Penetrations, Shaft Walls That Are Also Exterior Walls, Shaft Enclosure Tops

**Assembly Options – Page 6**
Assemblies and Intersections, Height Limitations on Walls with Shaftliner Panels

**Detailing Floor-to-Wall Intersections – Page 9**
Shaft Wall Applications, Other Shaft Design Considerations, Masonry Shaft Walls, Cold-Formed Steel Shaft Wall Components

**Mass Timber – Page 18**
Shafts in Mass Timber Buildings, Mass Timber Shafts in Other Building Types

### 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 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

# Common Shaft Walls

## Wood Studs

Photo: WoodWorks

## Concrete/ Masonry Walls

Photo: C.D. Smith Construction

## Mass Timber

Photo: Quality Contractors

## Shaftliner Panels

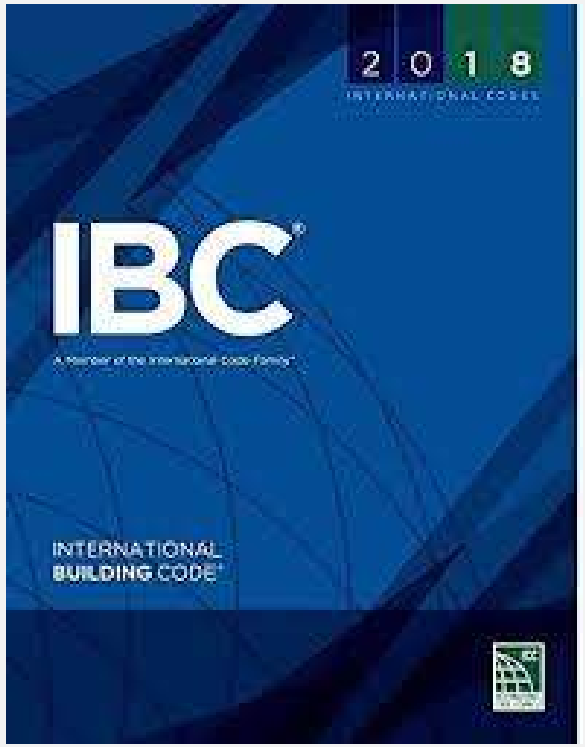
## Or CFS studs

# 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


Photo: Jeff Morrow

- 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.

# 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*

# Interior Fire-Rated Walls: Differences

| Fire walls | Fire Barrier | Fire Partition |
| --- | --- | --- |
| • Building Separation<br>• Openings are protected and limited<br>• Continuous from foundation to/through roof and exterior wall to/through exterior wall<br>• Structural stability | • Shafts; Occupancy Separation<br>• Openings are protected and limited<br>• Continuous from floor to floor through concealed spaces at each level | • Dwelling Unit Separation; Corridors<br>• Openings are protected<br>• May terminate at a fire rated floor/ceiling/roof assembly |

# 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.*

**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 interior elements
- 1-hr min rating 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

Photo: WoodWorks

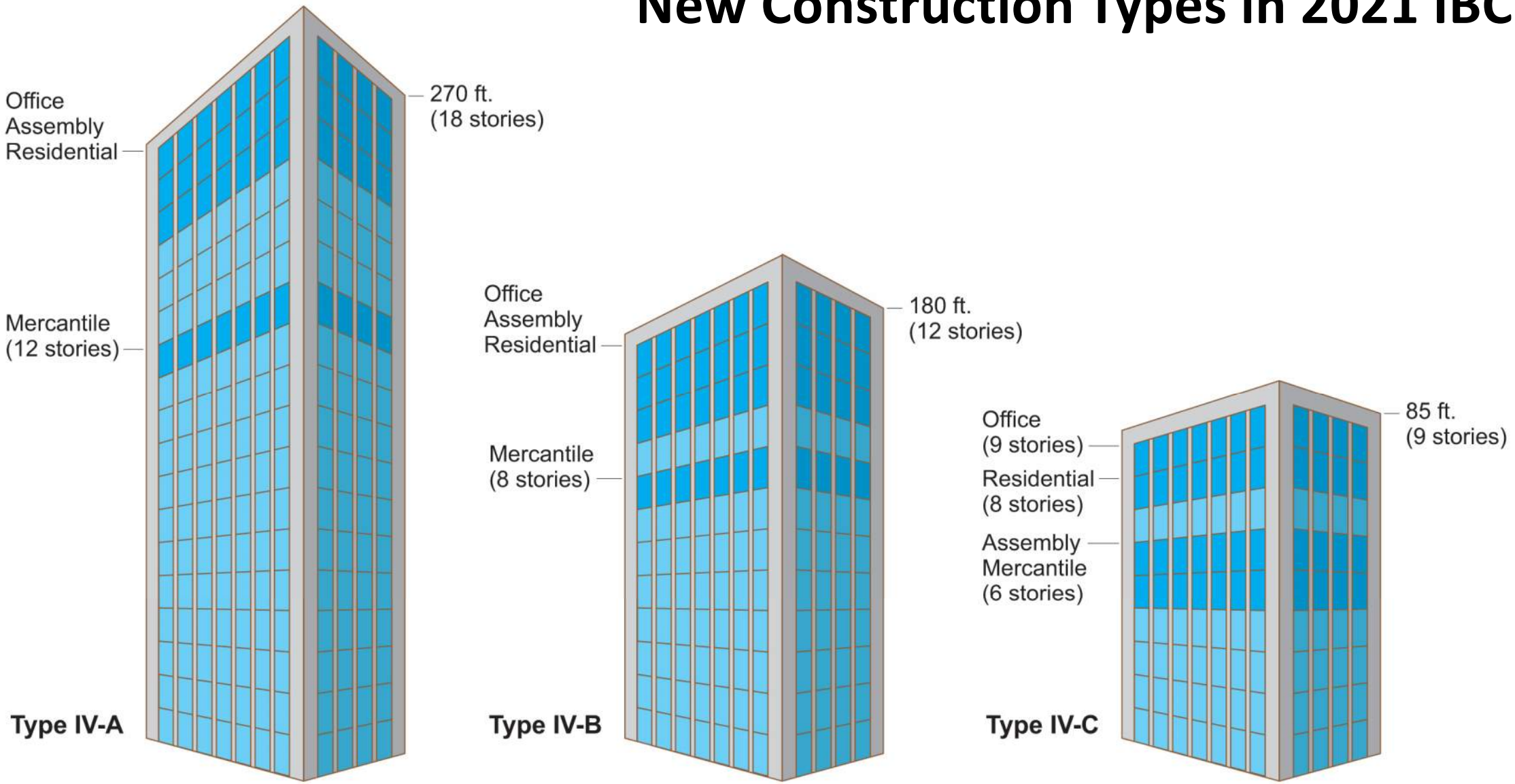
# Shaft Wall Materials

| | 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 |

There is no restriction on the use of combustible materials (light-frame wood and mass timber) in shaft walls or fire barriers in wood buildings of Types III, IV-HT or V construction

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

# Tall Mass Timber:
# New Construction Types in 2021 IBC



*NC = non-combustible*

*MT = mass timber*

# Shaft Enclosures in Tall Timber

| | IV-A | IV-B | IV-C |
|---|---|---|---|
| **Shaft material requirements and timber exposure limitations** | **Up to 12 Stories or 180 ft: MT protected with 2 layers 5/8” type X gyp (if 2 HR req’d) or 3 layers 5/8” type X gyp (if 3 HR req’d) both sides**<br><br>**Above 12 Stories or 180 ft: Noncombustible shafts (IBC 2021 602.4)** | **NC or MT protected with 2 layers 5/8” type X gyp (IBC 2021 602.4.2.6) both sides** | **NC or MT protected with 1 layer 5/8” type X gyp (IBC 602.4.3.6) both sides** |
| **Fire-resistance ratings req’d** | **2 HR (not less than FRR of floor assembly penetrated, IBC 713.4)** | | |

# Shaft Enclosure Design in Tall Timber

Richard McLain, PE, SE
*Senior Technical Director – Tall Wood*
*WoodWorks – Wood Products Council*

## Shaft Wall Requirements in Tall Mass Timber Buildings

The 2021 International Building Code (IBC) introduced three new construction types—Type IV-A, IV-B and IV-C—which allow tall mass timber buildings. For details on the new types and their requirements, see the WoodWorks paper, *Tall Wood Buildings in the 2021 IBC – Up to 18 Stories of Mass Timber.*[1] This paper builds on that document with an in-depth look at the requirements for shaft walls, including when and where wood can be used.

Generate Architecture and Technologies + MIT – John Klein

### Shaft Enclosure Requirements in the 2021 IBC

A shaft is defined in Section 202 of the 2021 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/electrical/plumbing (MEP) chases in multi-story buildings. While these applications may be similar in their fire design requirements, they tend to differ in terms of their assemblies, detailing, and construction constraints.

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

### Allowable Shaft Wall Materials

Provisions addressing materials permitted in shaft wall construction can be found in both the shaft enclosures section (713.3) and fire barriers section (707.2) of the code

A relatively new category of wood products, mass timber can encompass well known and widely used products such as glue-laminated timber (glulam) and nail-laminated

# 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?

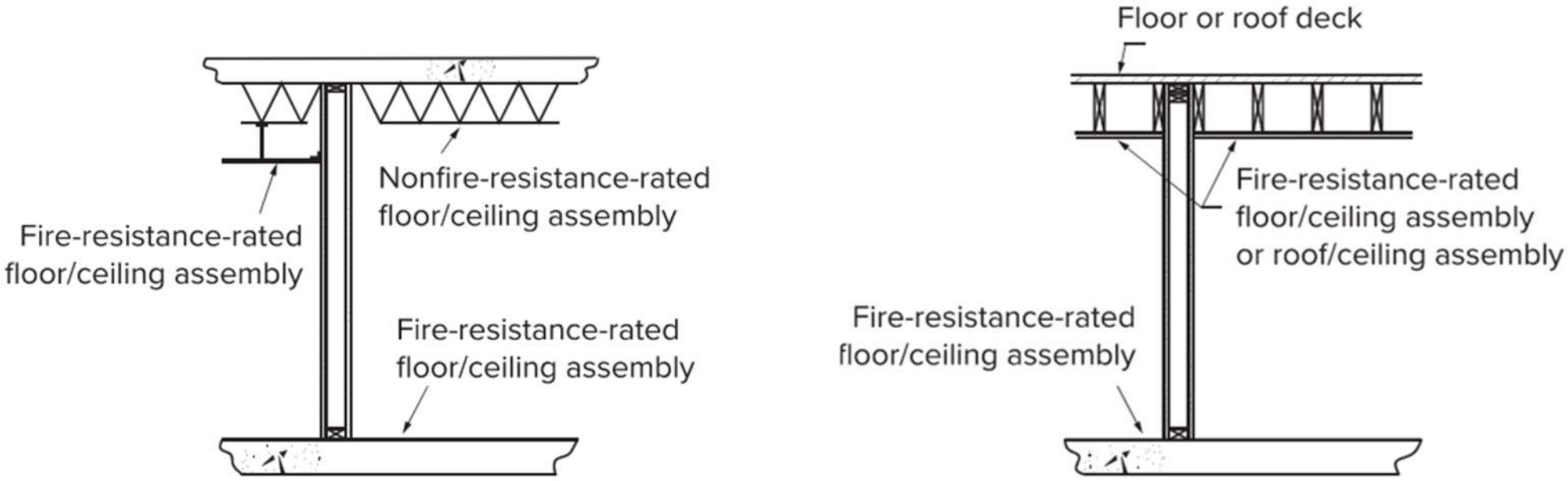



**FIGURE 1:** IBC Commentary Figure 707.5 – Continuity of fire barriers

# Continuity Provisions


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

# Continuity Provisions

What do these continuity provisions look like?

**In mass timber construction, the mass timber floor panel is the "slab"**

**The mass timber floor panel (slab) does not interrupt the wall's continuity per the continuity definition of a fire barrier.**

**Platform mass timber floor to shaft wall permitted by code**

Image: WoodWorks

**Fire barriers, including shaft walls, must extend from top of sheathing to underside of sheathing (or slab, mass timber = slab).**

**Sheathing/slab/deck does not obstruct continuity.**

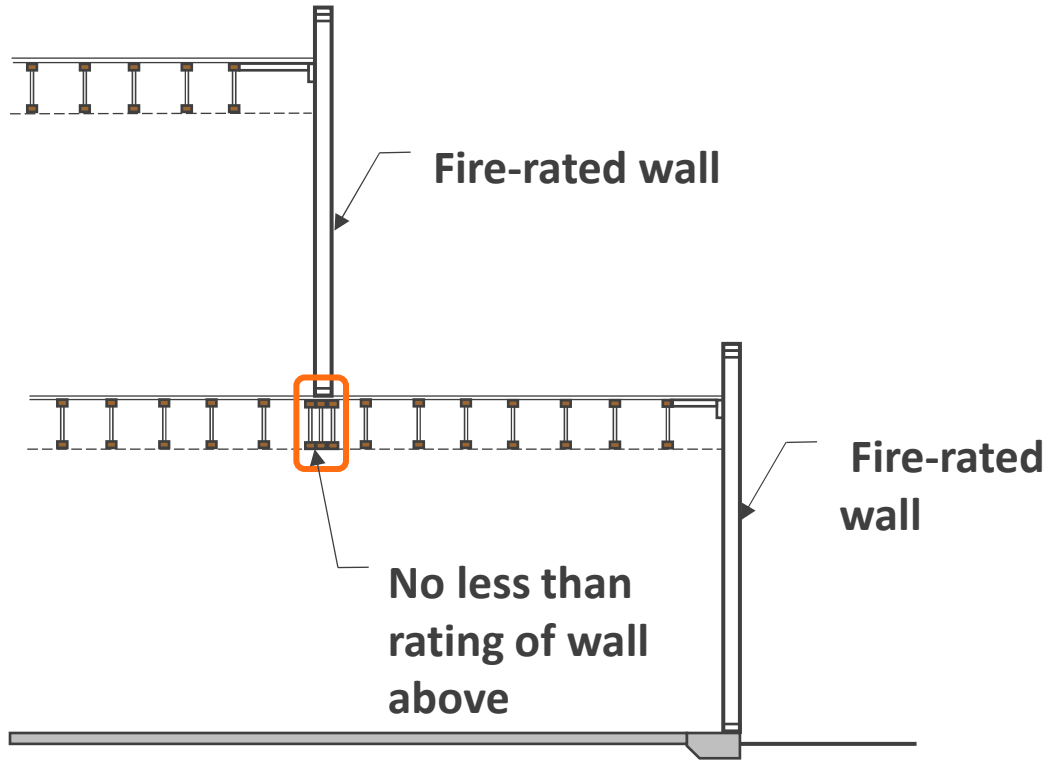
# Supporting Construction Provisions

**Section 707: Fire Barriers**

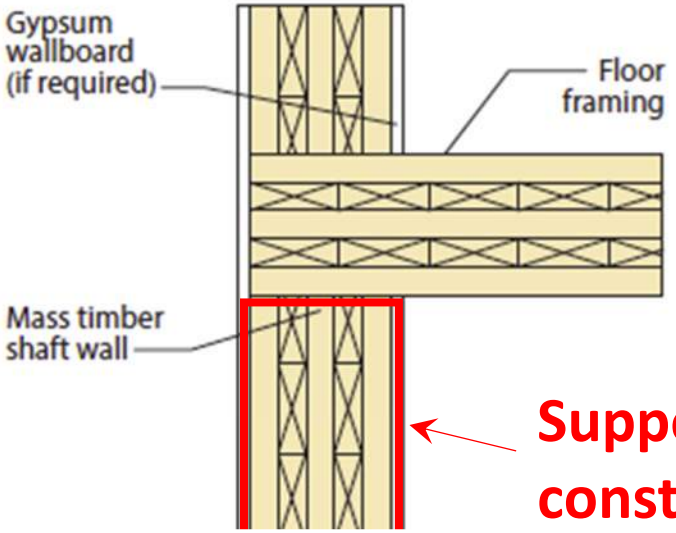
*707.5.1 Supporting Construction:*

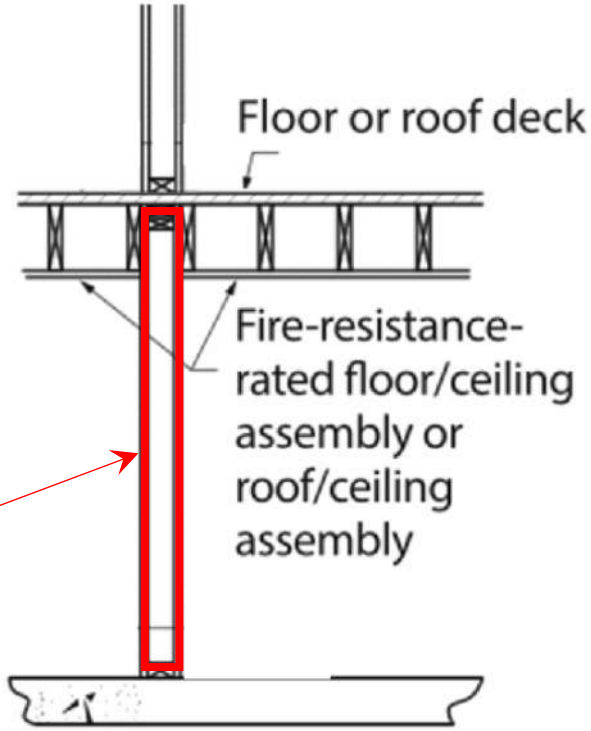
The supporting construction for a fire barrier shall be protected to afford the required fire-resistance rating of the fire barrier supported.

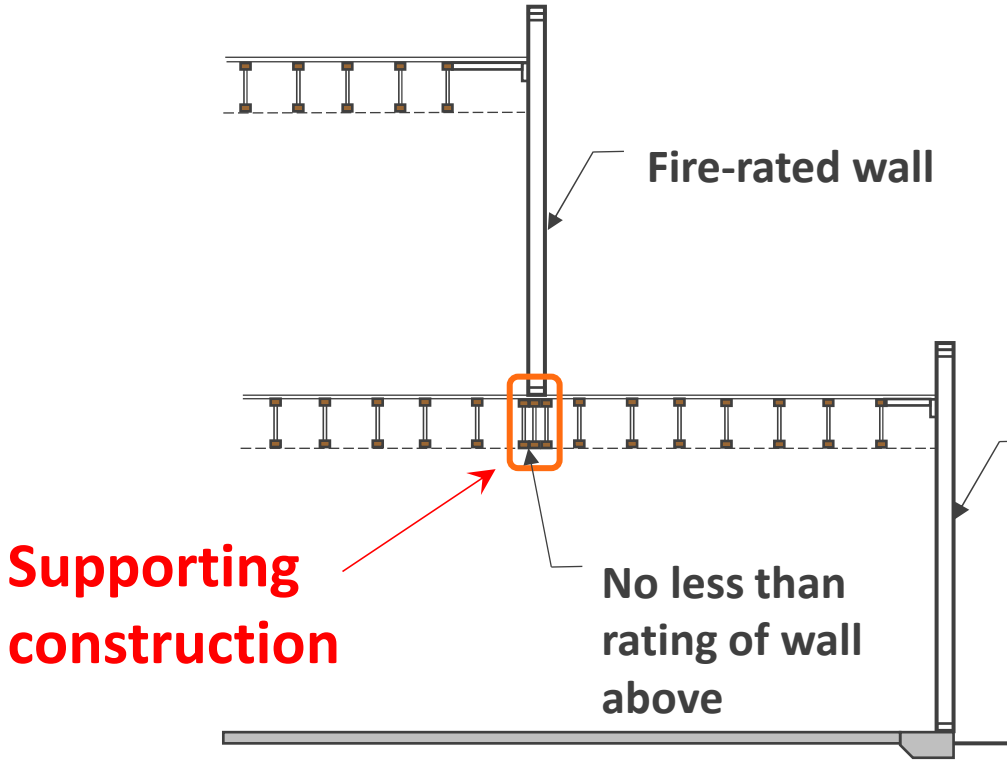
Ex., shaft walls that are not continuous to lowest level



# Supporting Construction Provisions



**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.

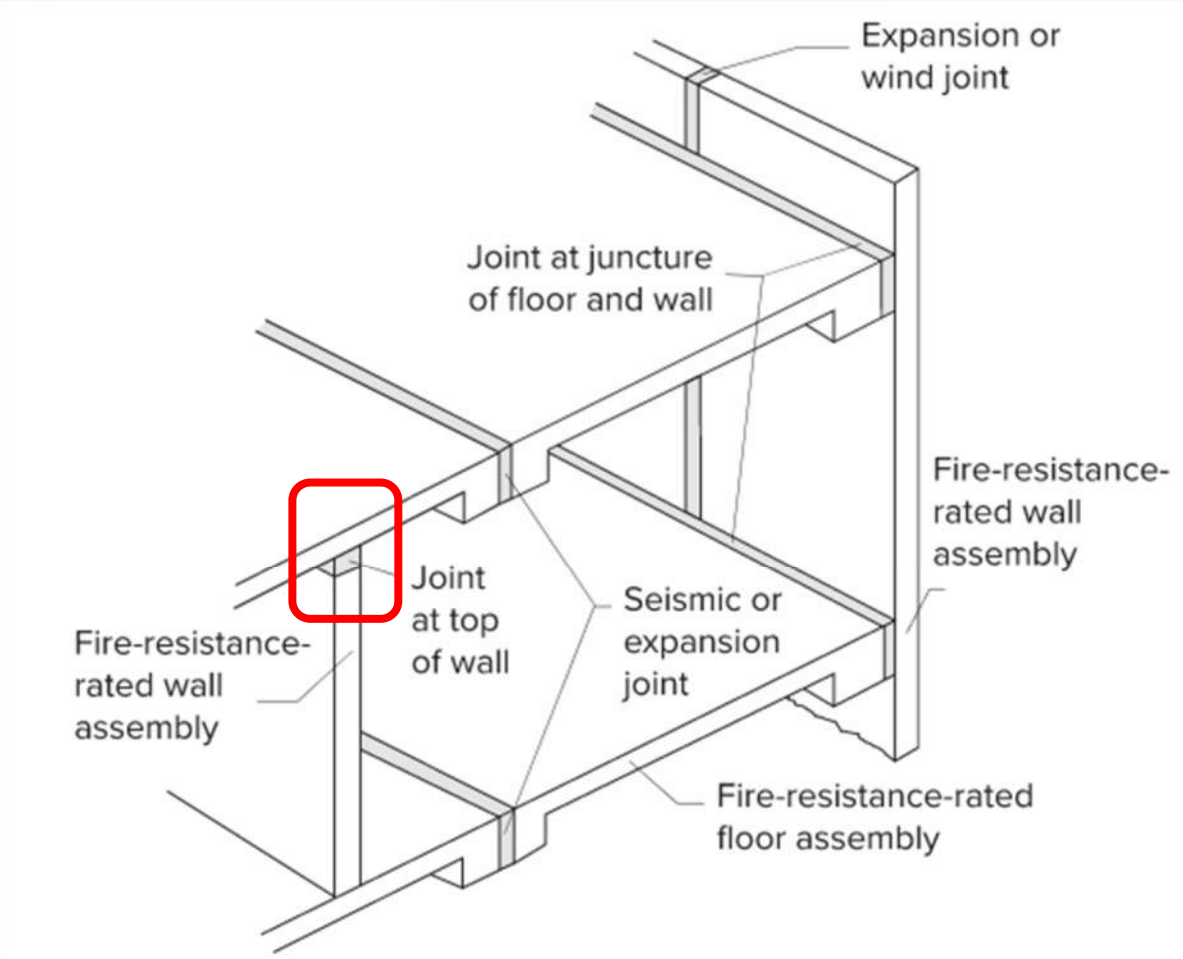



**FIGURE 2:** IBC Commentary Figure 715.1 – Examples of joint locations

**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.*

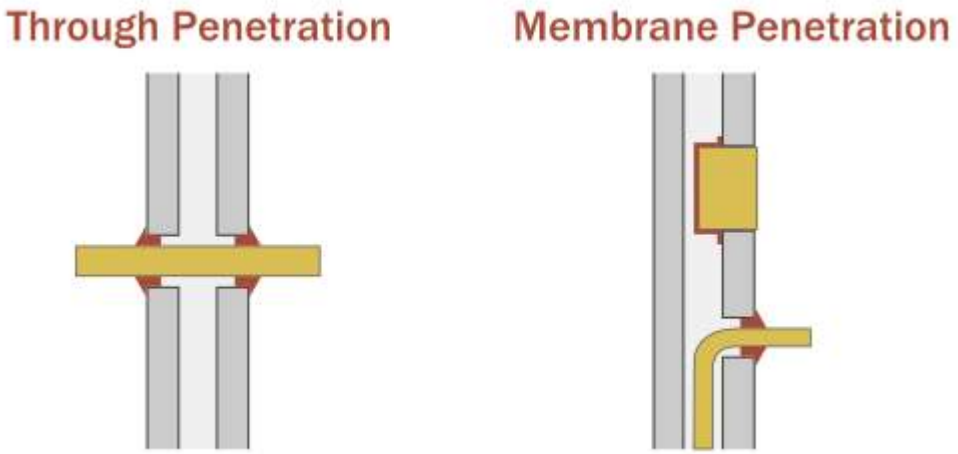
Penetrations in shaft enclosure shall be protected in accordance with Section 714 as required for fire barriers. Structural elements such as beams or joists, where protected in accordance with Section 714 shall be permitted to penetrate a shaft enclosure.

**Section 707: Fire Barriers**

*707.7 Penetrations.*

Penetrations of fire barriers shall comply with Section 714.

# Penetrations in Shaft Walls




**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:

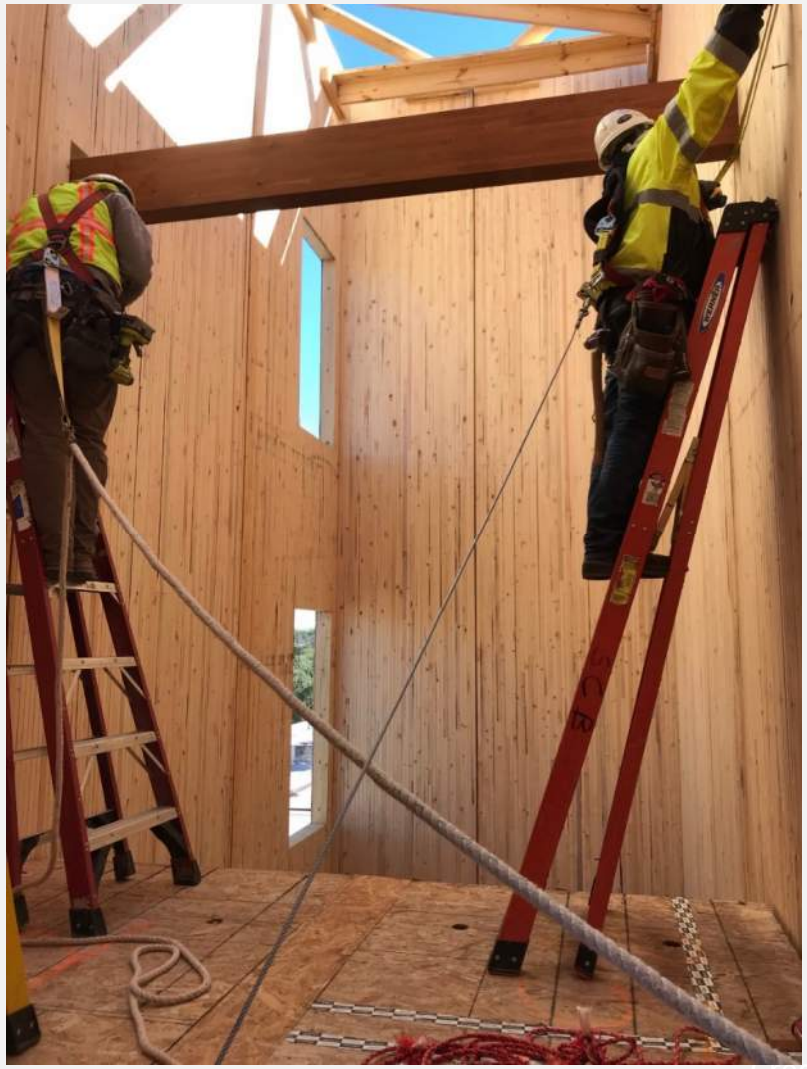
Many are familiar with firestopping for MEP, but not structure, especially wood structure


Credit: STI


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

Credit: WoodWorks

# Penetrations in Shaft Walls



Credit: WoodWorks

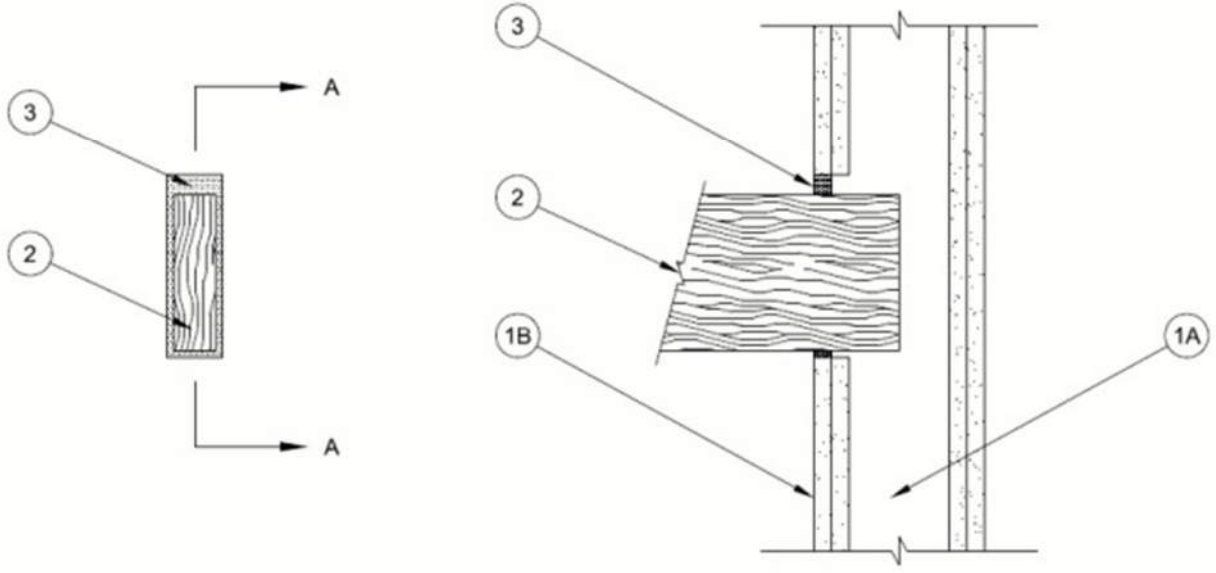
- Some firestopping systems available as tested configurations for wood conditions
- Most manufacturers can provide engineering judgement details, certification statements for this condition

# 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

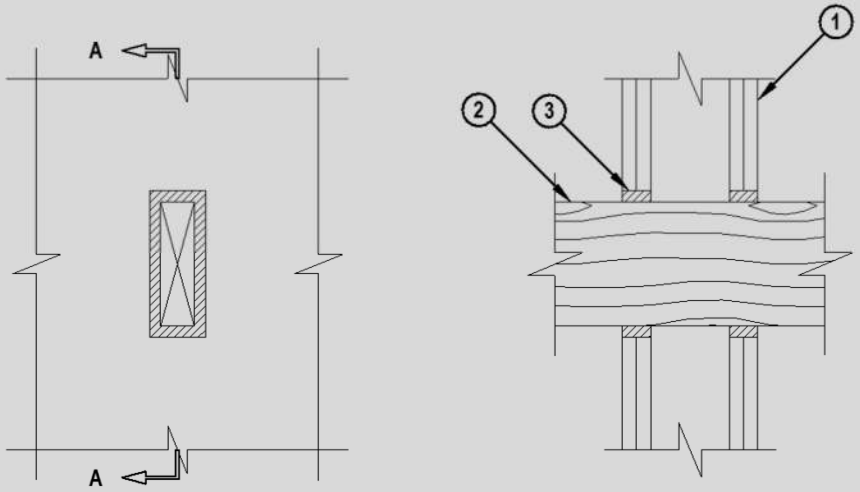
DH

## ENGINEERING JUDGMENT FIRESTOP DETAIL

F-RATING = 2-HR.

FRONT VIEW

SECTION A-A




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)

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

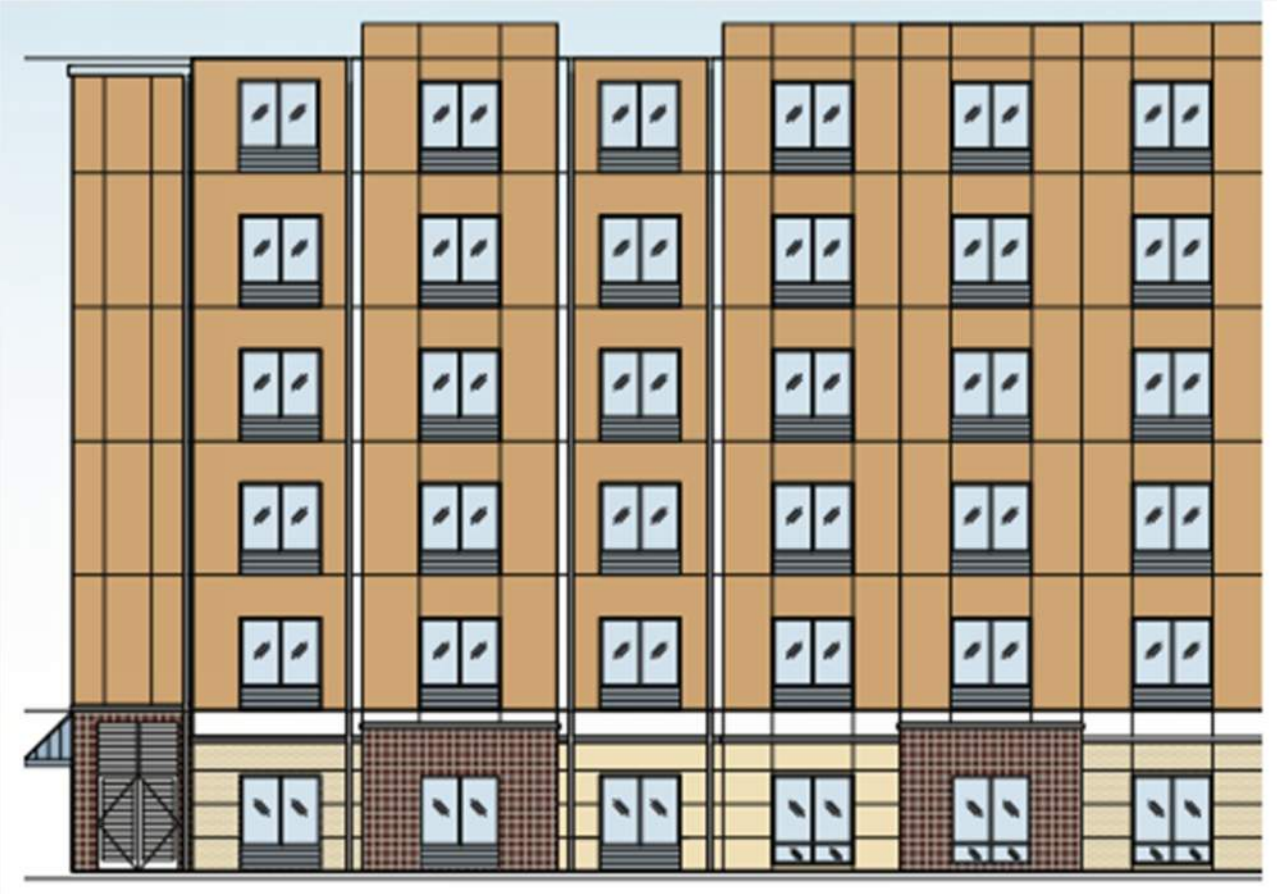
*Saving Lives through Innovation and Education*

**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 | A | B | C | HT | A | B |
| Primary structural frame[f] (see Section 202) | 3[a, b] | 2[a, b, c] | 1[b, c] | 0[c] | 1[b, c] | 0 | 3[a] | 2[a] | 2[a] | HT | 1[b, c] | 0 |
| Bearing walls | | | | | | | | | | | | |
| Exterior[e, f] | 3 | 2 | 1 | 0 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 0 |
| Interior | 3[a] | 2[a] | 1 | 0 | 1 | 0 | 3 | 2 | 2 | 1/HT[g] | 1 | 0 |
| Nonbearing walls and partitions Exterior | See Table 705.5 | | | | | | | | | | | |
| Nonbearing walls and partitions Interior[d] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | See Section 2304.11.2 | 0 | 0 |
| Floor construction and associated secondary structural members (see Section 202) | 2 | 2 | 1 | 0 | 1 | 0 | 2 | 2 | 2 | HT | 1 | 0 |
| Roof construction and associated secondary structural members (see Section 202) | 1½[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | 1½ | 1 | 1 | HT | 1[b,c] | 0 |

# Shaft Walls that are also Exterior Walls

Exterior non-bearing wall fire resistance rating per Table 705.5

**TABLE 705.5**
**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], *L* | OCCUPANCY GROUP F-1, M, S-1[f] | OCCUPANCY GROUP A, B, E, F-2, I, R[i], S-2, U[h] |
|---|---|---|---|---|
| X < 5[b] | All | 3 | 2 | 1 |
| 5 ≤ X < 10 | IA, IVA | 3 | 2 | 1 |
| | Others | 2 | 1 | 1 |
| 10 ≤ X < 30 | IA, IB, IVA, IVB | 2 | 1 | 1[c] |
| | IIB, VB | 1 | 0 | 0 |
| | Others | 1 | 1 | 1[c] |
| X ≥ 30 | All | 0 | 0 | 0 |

# Shaft Walls that are also Exterior Walls

**Exterior Walls (IBC 705):**

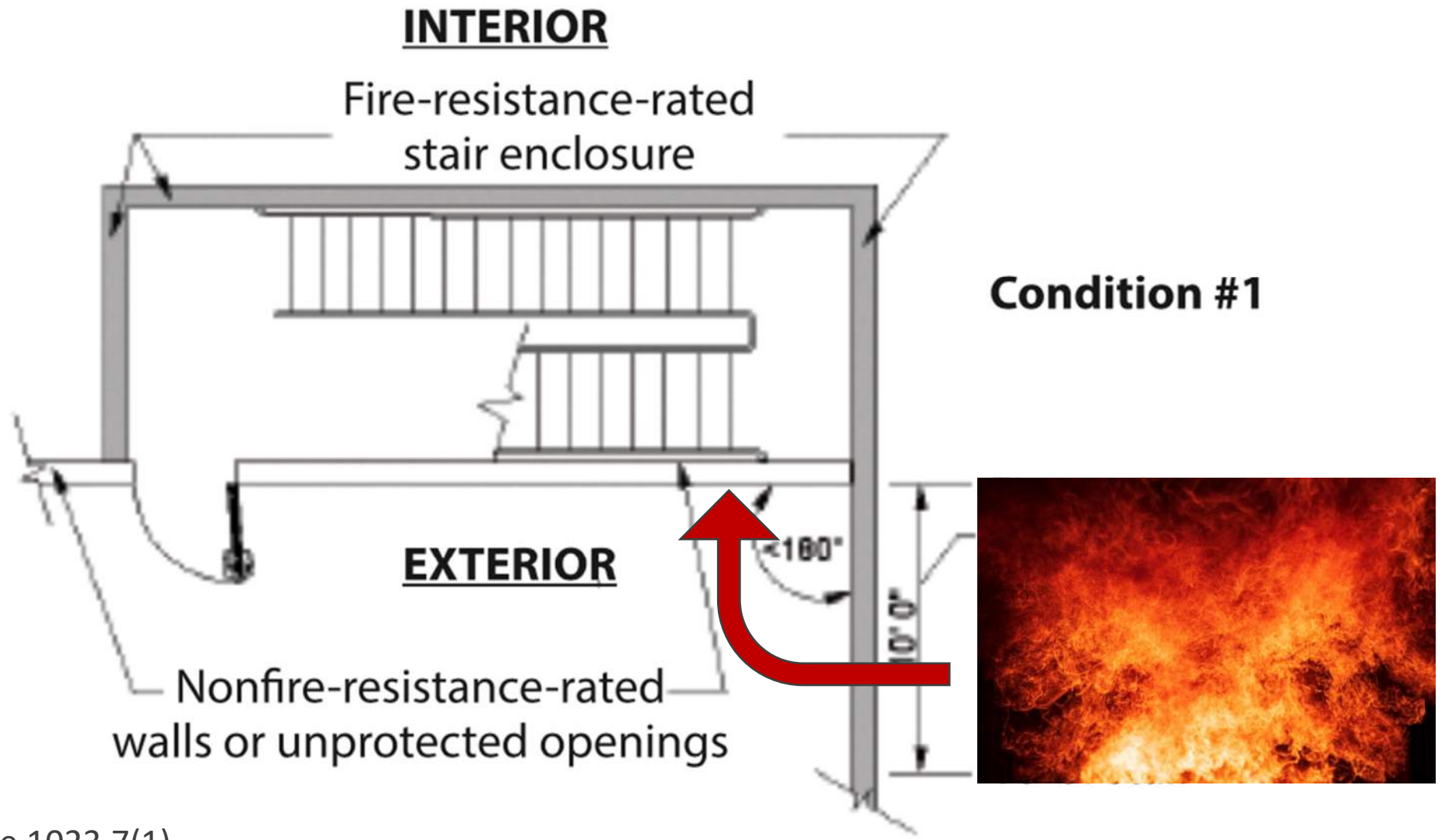
- Materials as permitted for type of construction (same as fire barrier) – 705.4
- Fire resistance only required from inside if fire separation distance is > 10 ft – 705.5 (this is different in California, see 705.5, depends on occupancy)
- Possible to have exterior shaft wall that does not require a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

# Shaft Walls that are also Exterior Walls

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

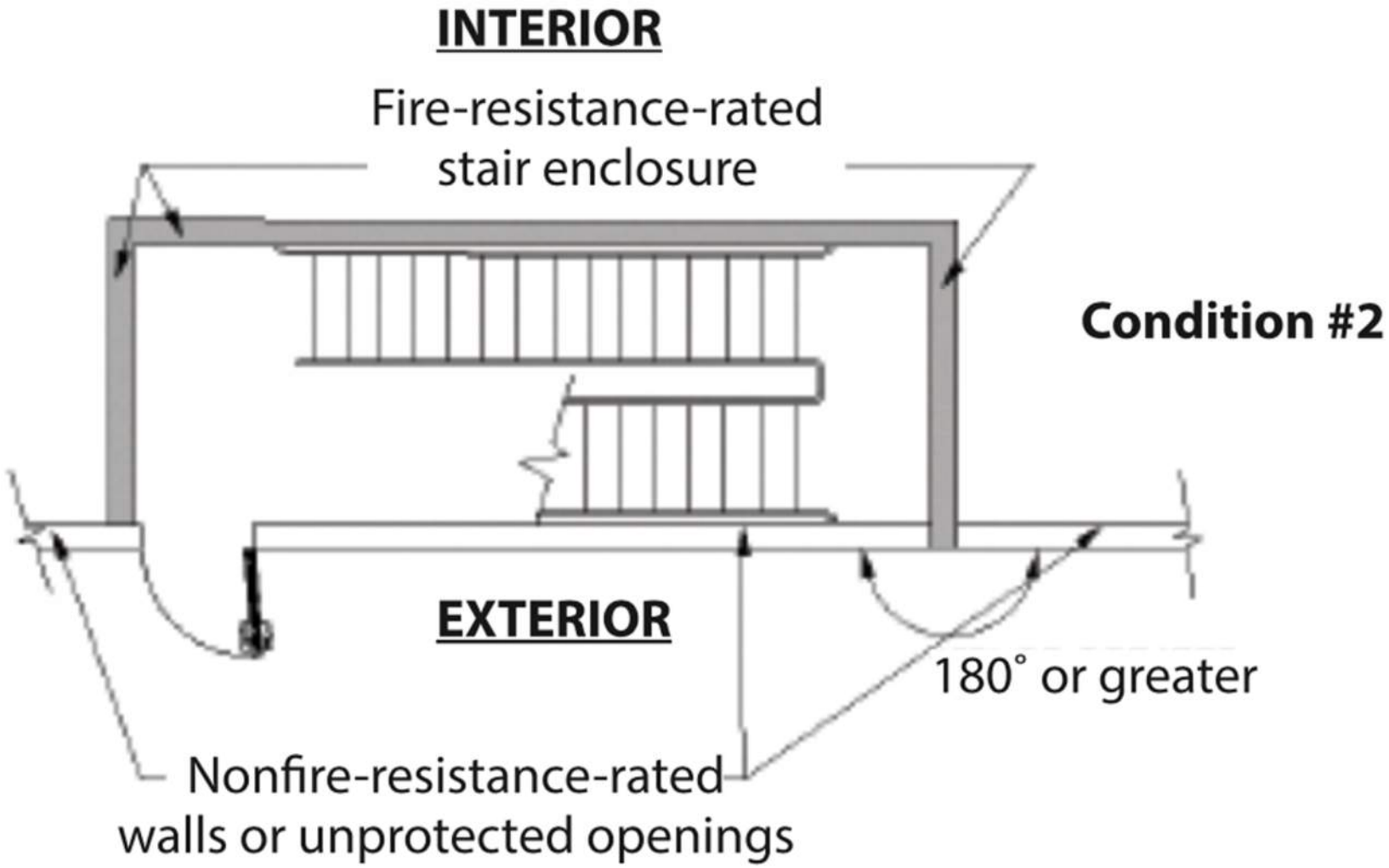
Exterior walls of the interior exit stairway or ramp shall comply with the requirements of Section 705 for exterior walls. Where nonrated walls or unprotected openings enclose the exterior of the stairway or ramps and the walls or openings are exposed by other parts of the building at an angle of less 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



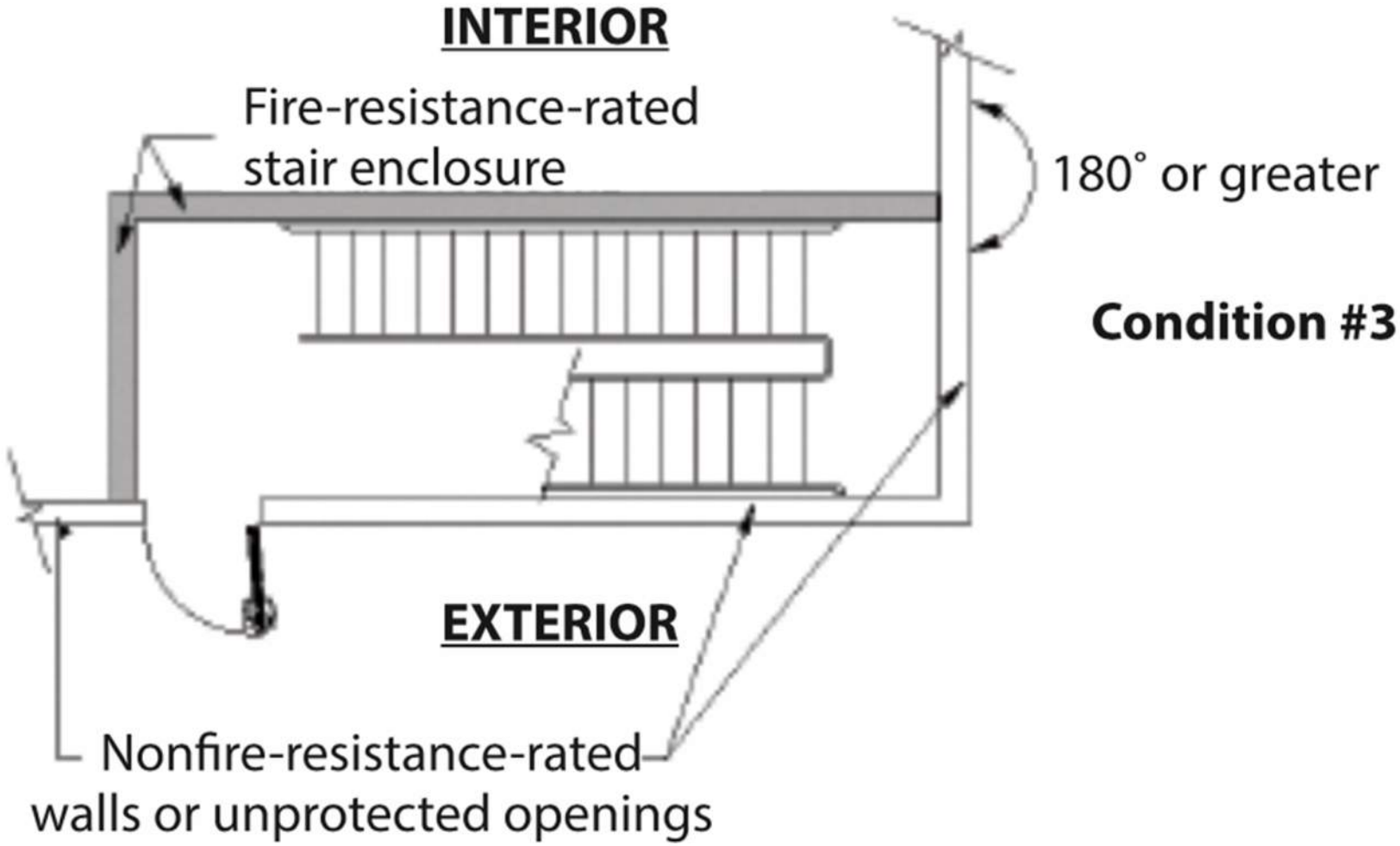

Source: IBC Commentary Figure 1023.7(1)

# Shaft Walls that are also Exterior Walls




Source: IBC Commentary Figure 1023.7(1)

# Shaft Walls that are also Exterior Walls



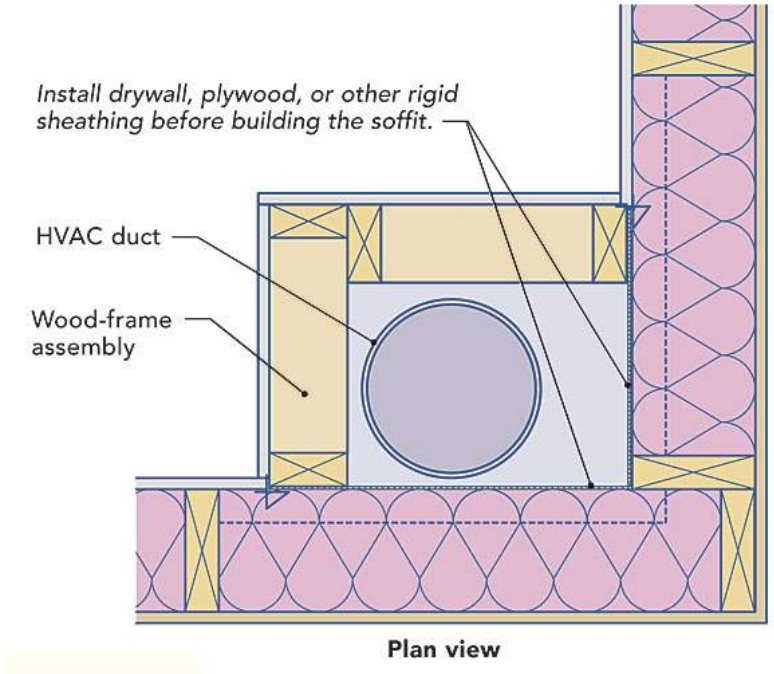

Source: IBC Commentary Figure 1023.7(1)

# Stair, Elevator & MEP Shafts

Main Differences & Unique Design Constraints:

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

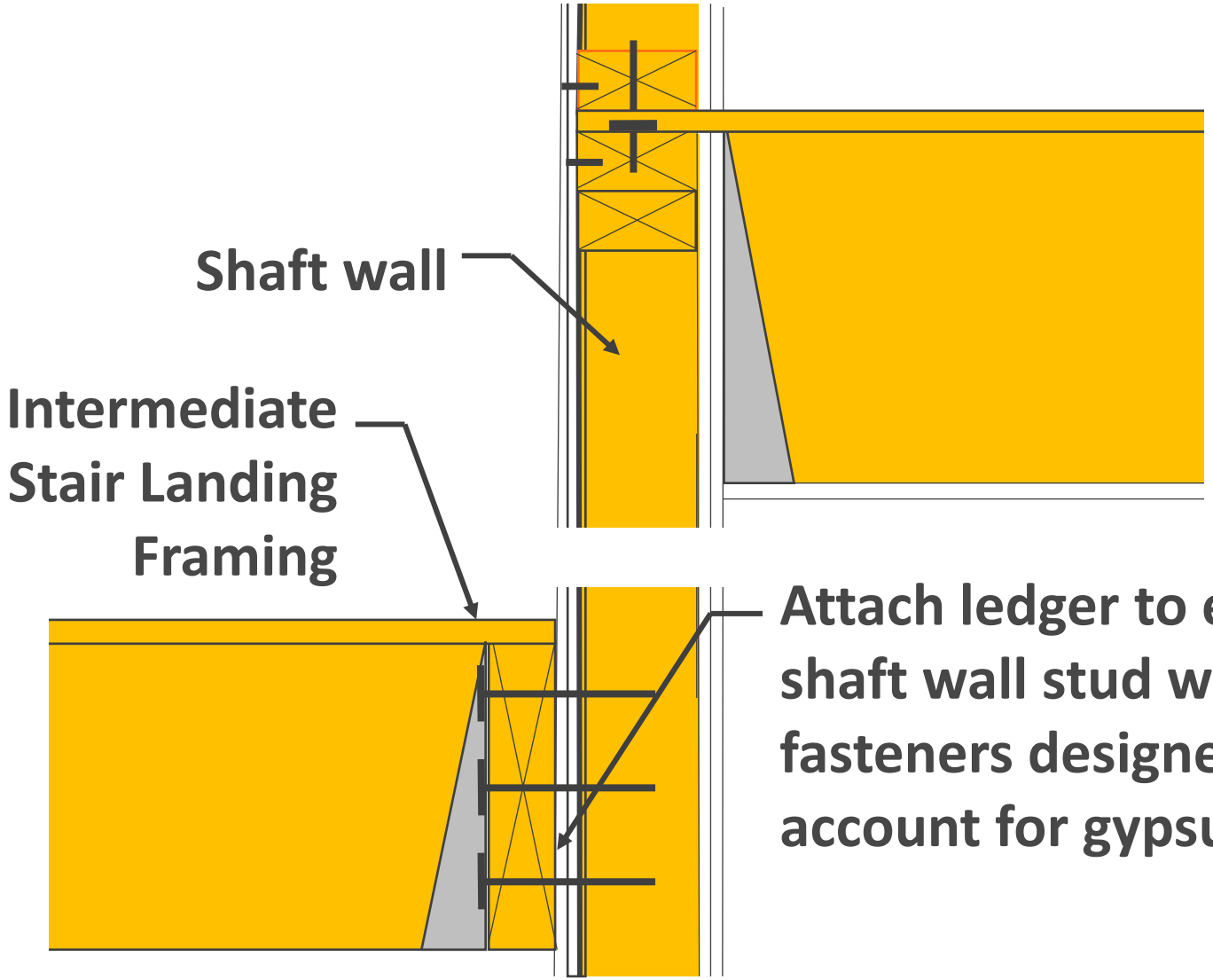

Credit: WoodWorks





Credit: WoodWorks

# Stair Shafts



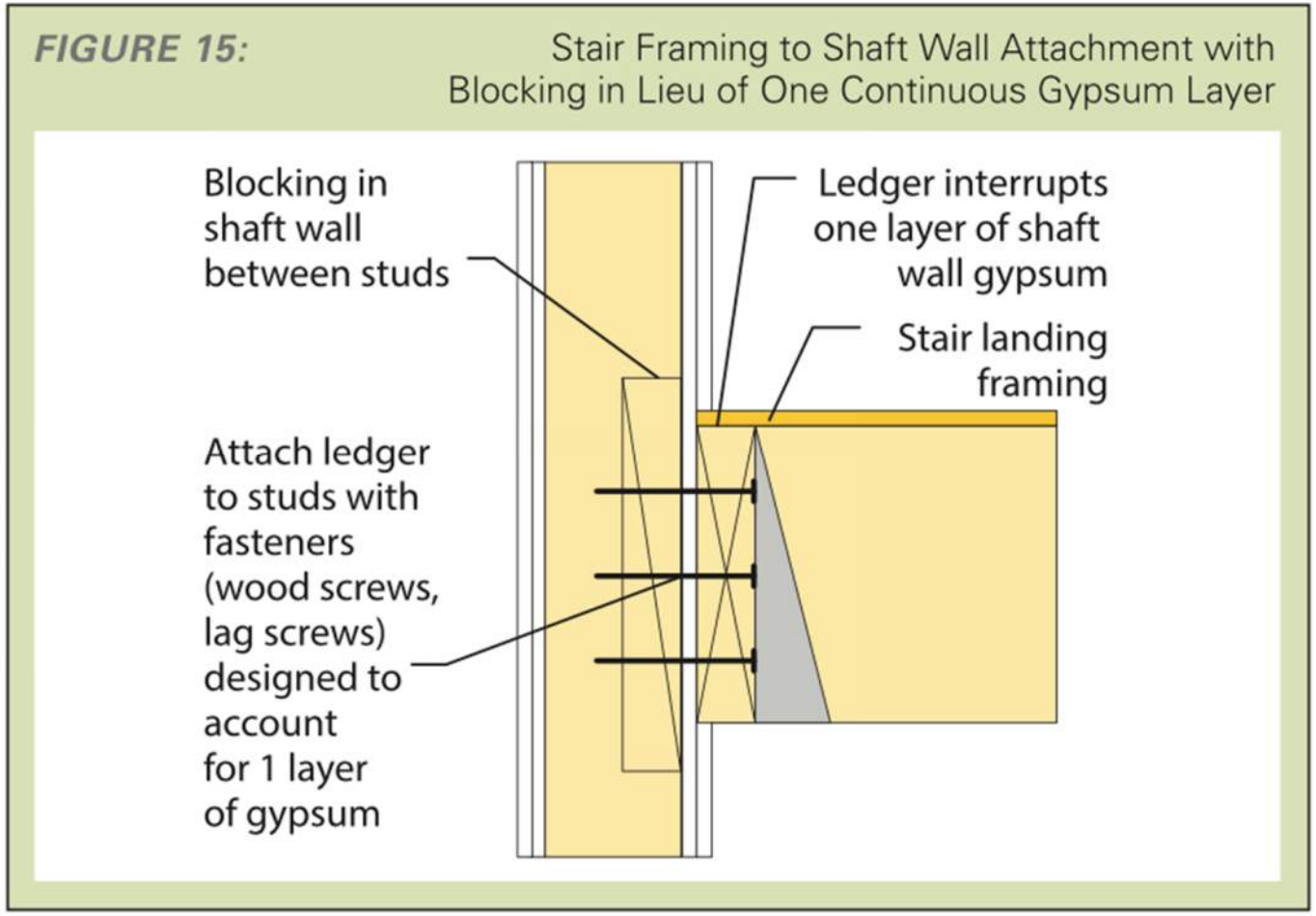


Credit: WoodWorks

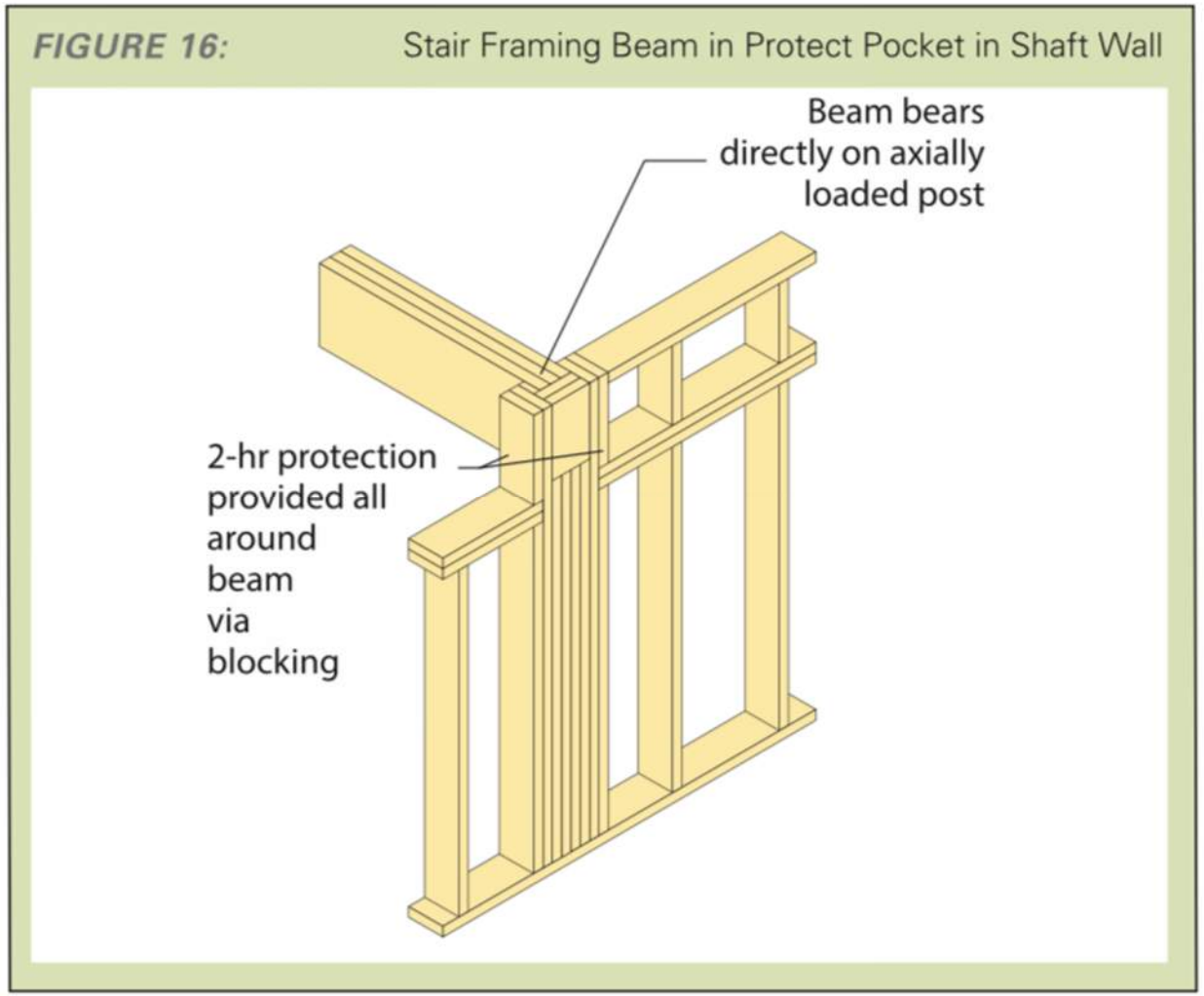
# Stairway Shaft Enclosures & Framing


# Stair Shafts

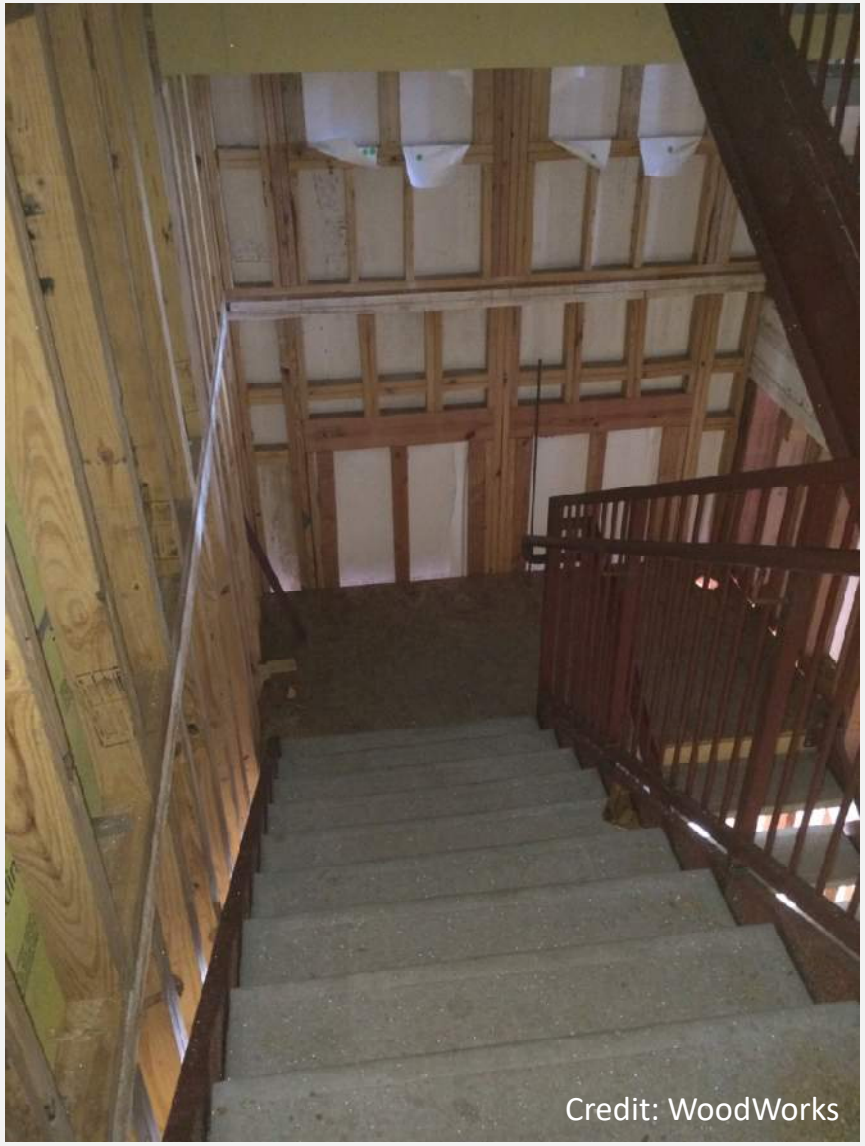
- Wood blocking in wall used to achieve 1-hr of continuity
- Alternatively – interrupt both gypsum layers and use 2 layers of blocking in wall
- Key to attach ledger to studs, not blocking



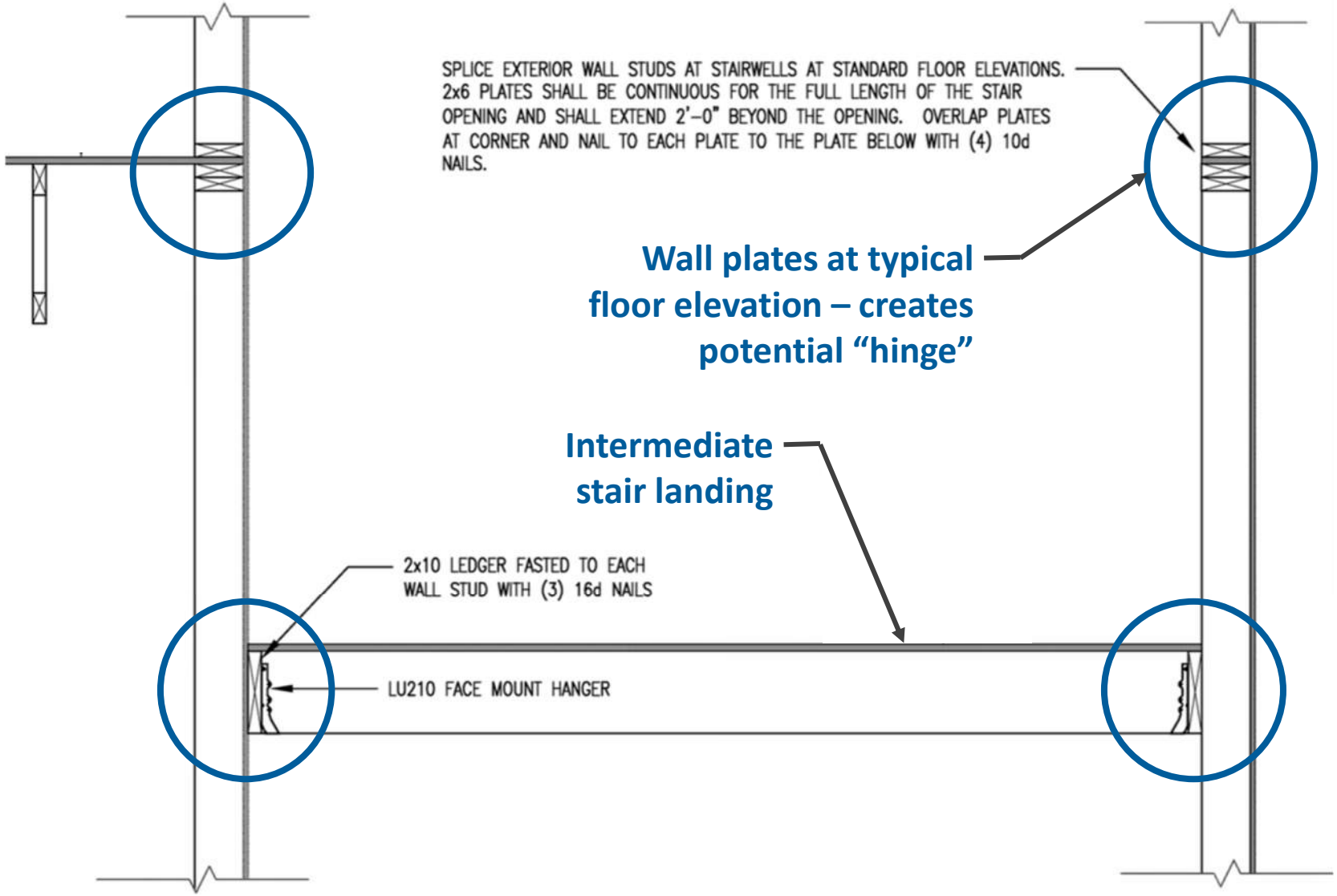
# Stair Shafts



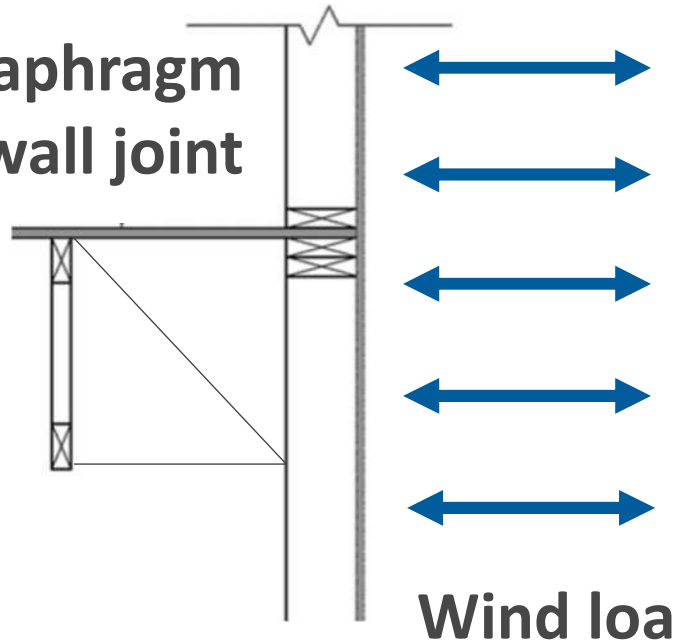

# Shaft Walls that are also Exterior Walls

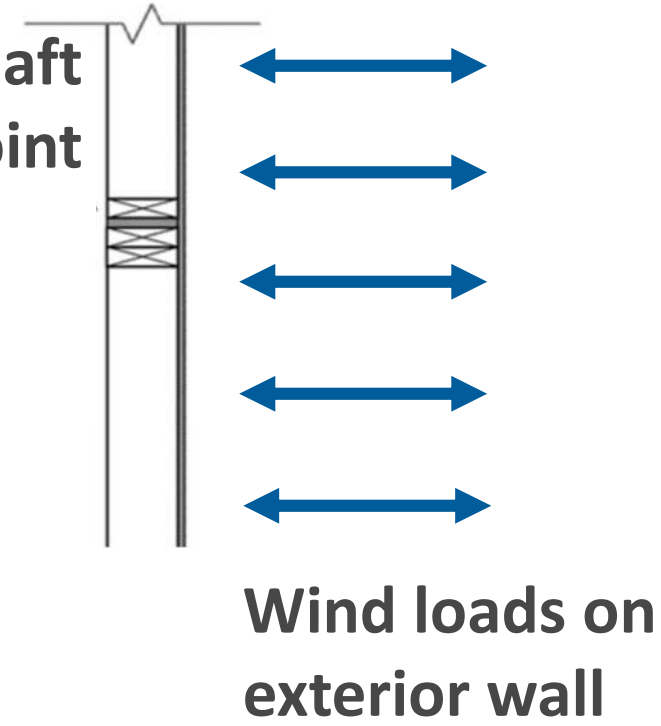



# When Stair Shaft Wall is Exterior Wall



# Shaft Walls that are also Exterior Walls

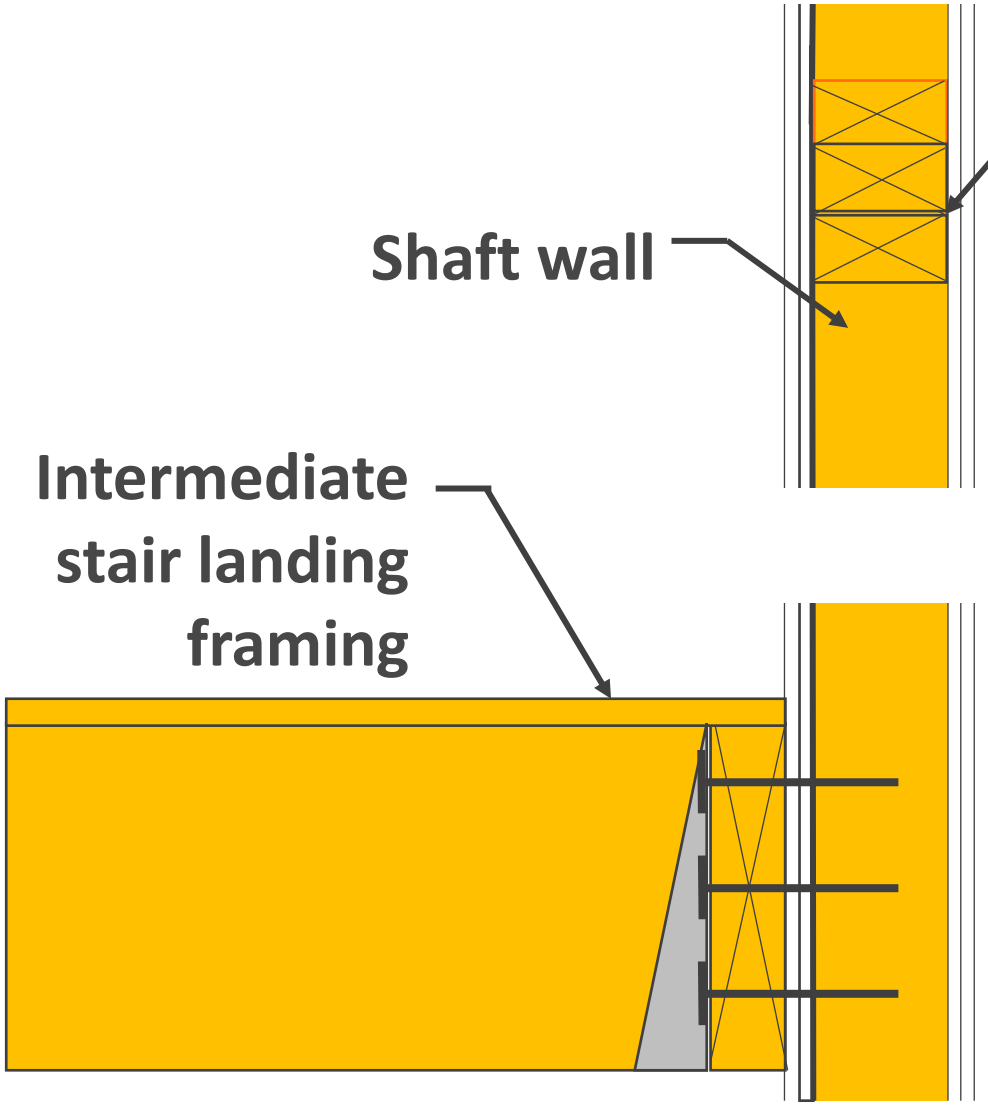



**Typical Exterior Wall**

**Exterior Wall that is Shaft Wall**

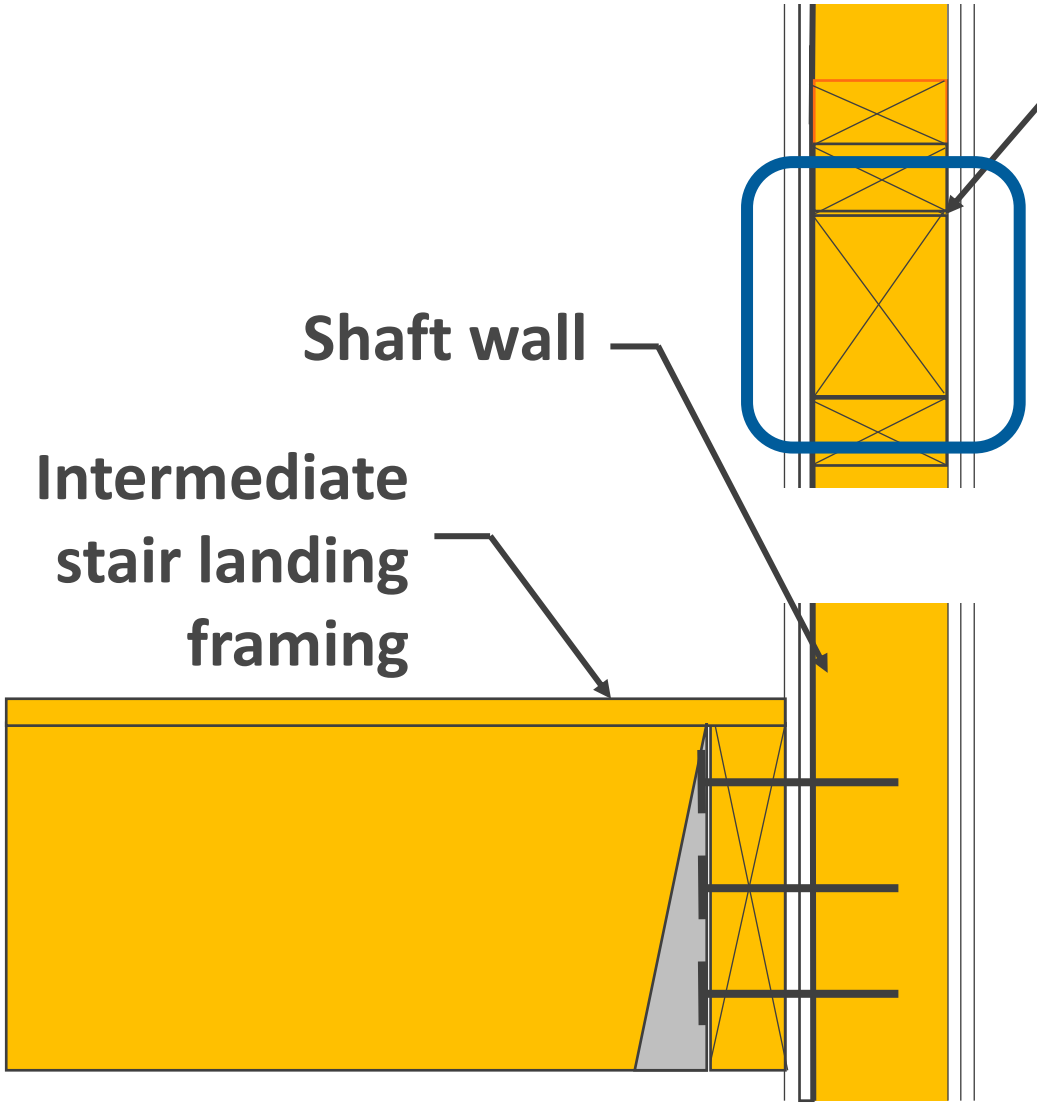
# Shaft Walls that are also Exterior Walls




**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

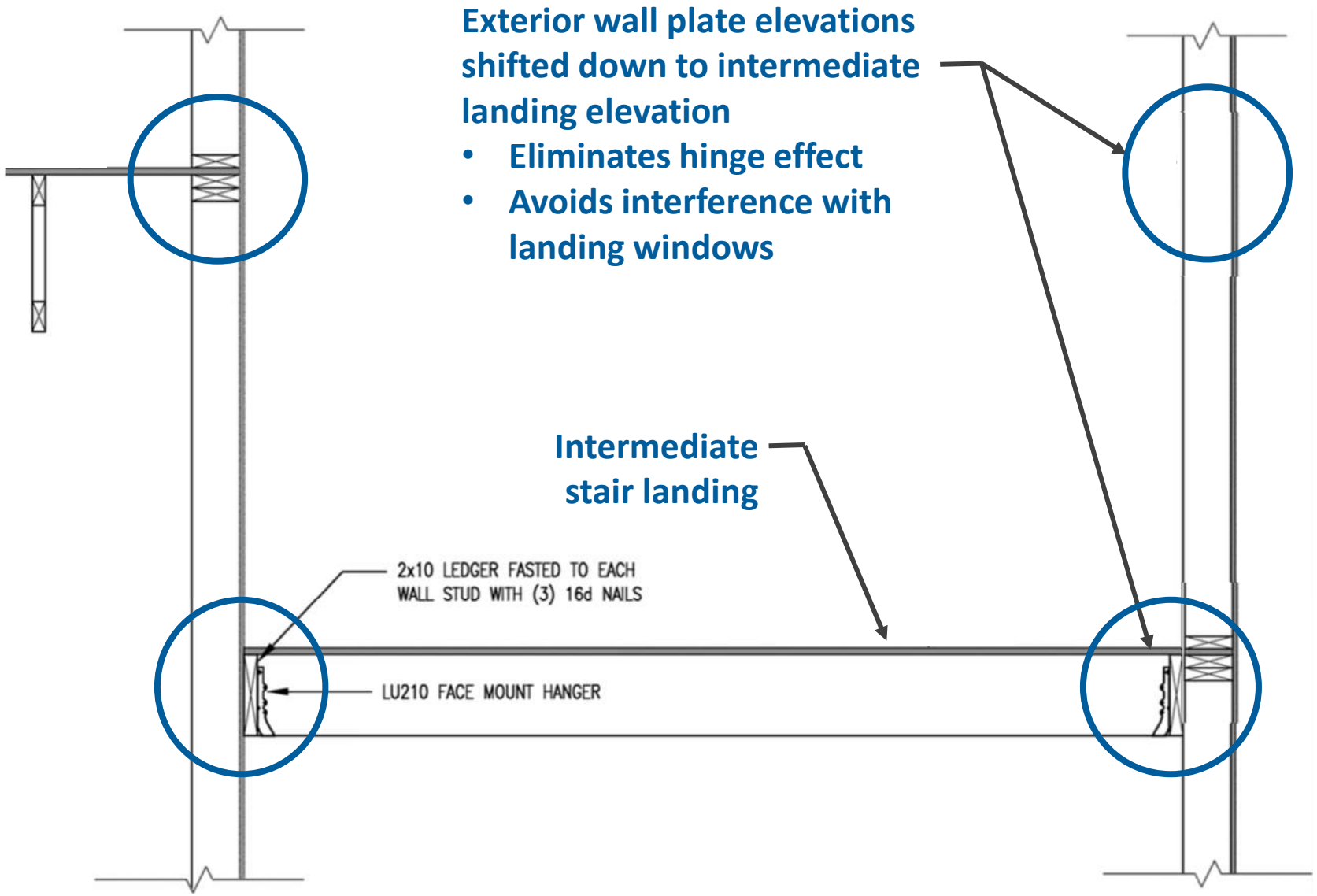



**Consider “hinge” at wall plates for out-of-plane wind & seismic loads due to lack of adjacent floor:**

- **Install additional member (rim) to span horizontally**

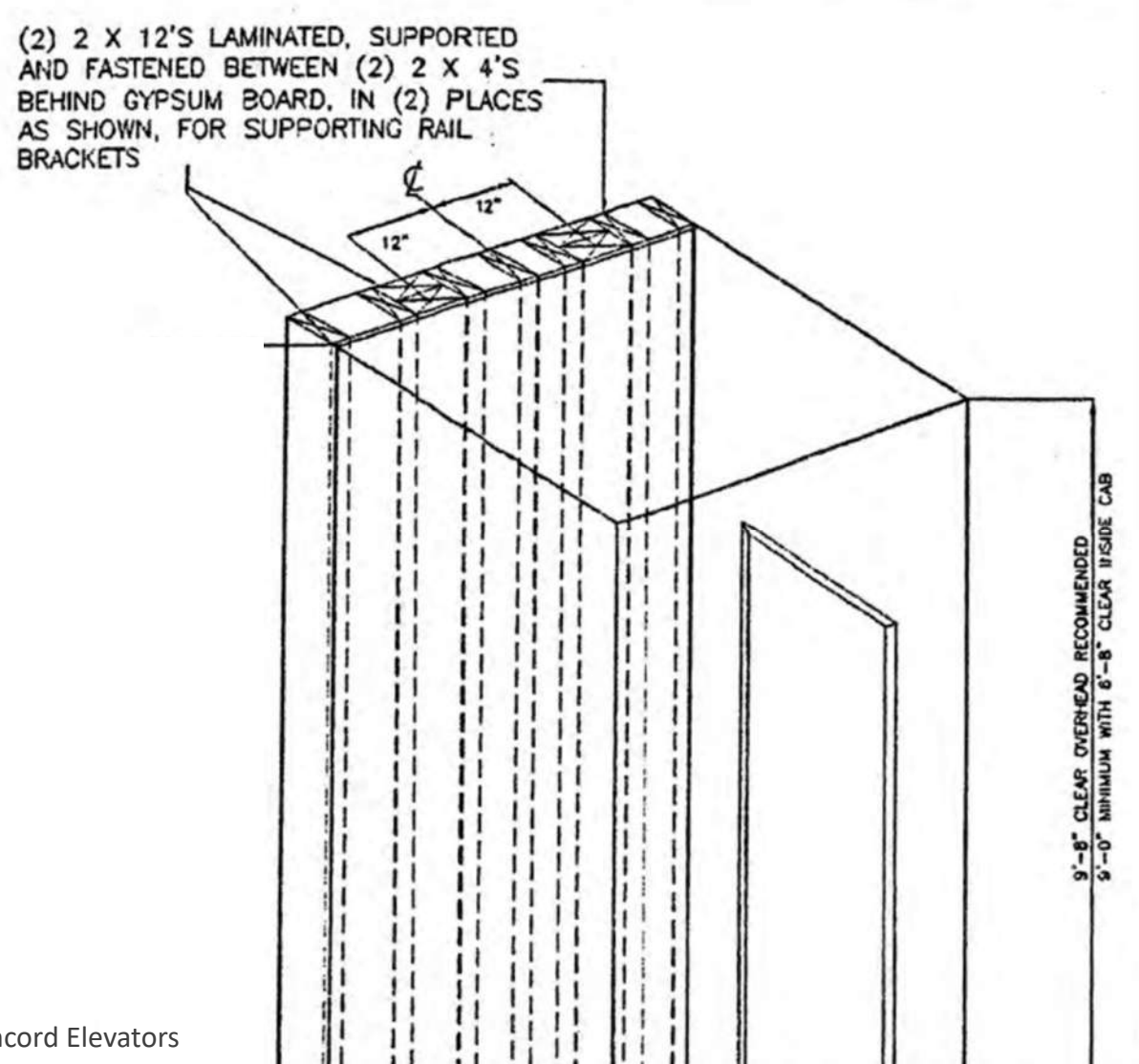

Credit: WoodWorks

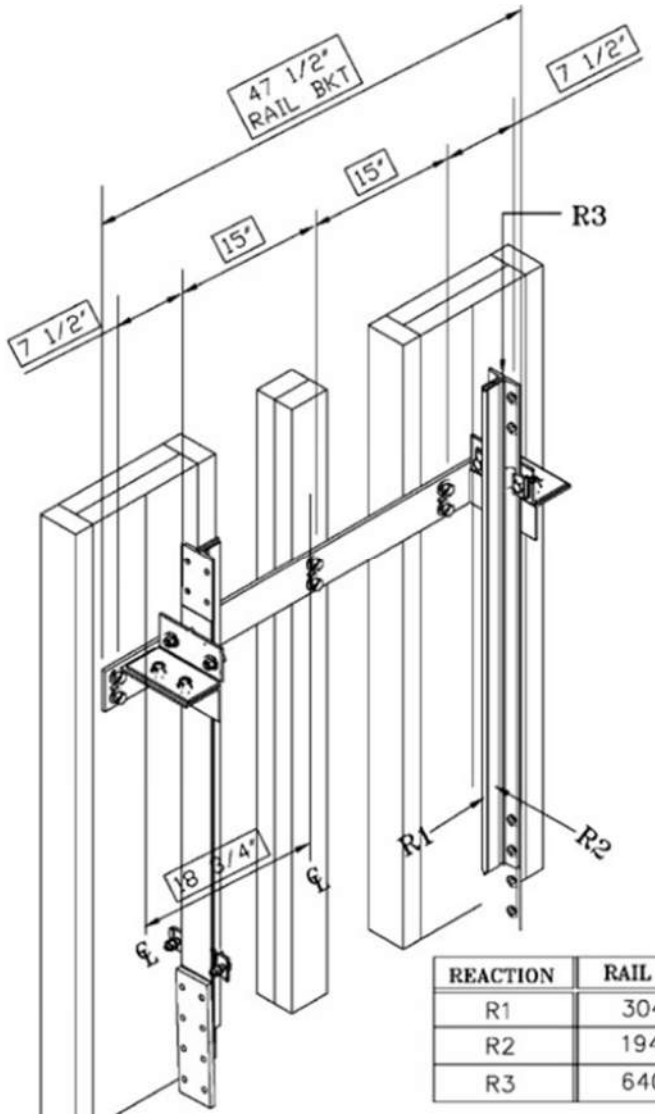
# When Stair Shaft Wall is Exterior Wall



# Elevator Shafts

# Elevator Shafts

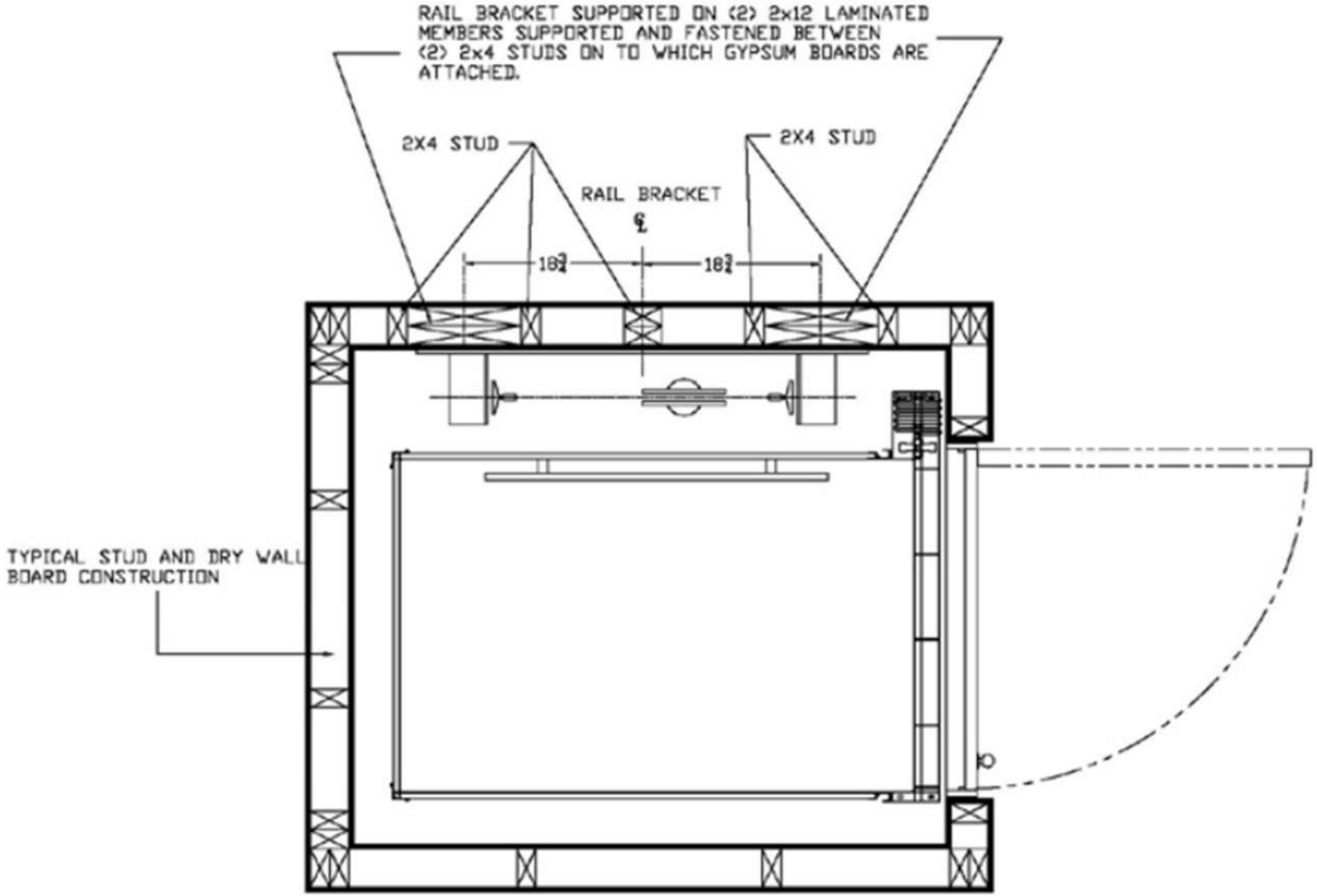



| REACTION | RAIL FORCES |
|---|---|
| R1 | 304 LBS |
| R2 | 194 LBS |
| R3 | 6400 LBS |

Credit: Concord Elevators

# Elevator Shafts




Credit: Concord Elevators

# Elevator Shafts


Credit: WoodWorks

- Elevator hoist beam can often 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 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

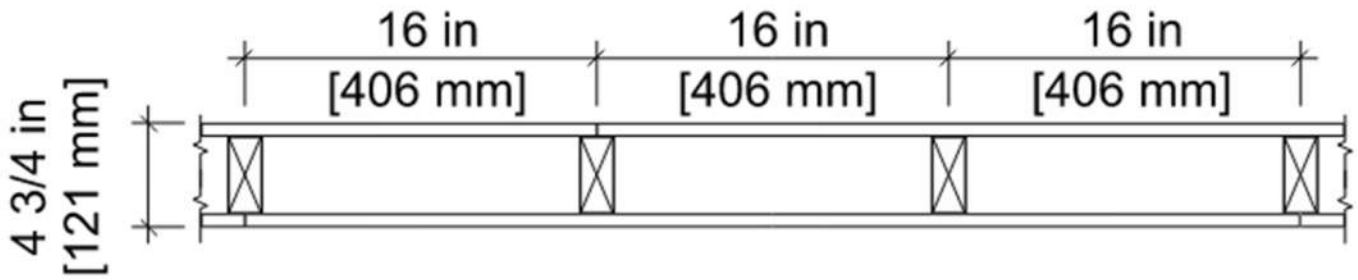



**FIGURE 4:** UL U305

**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

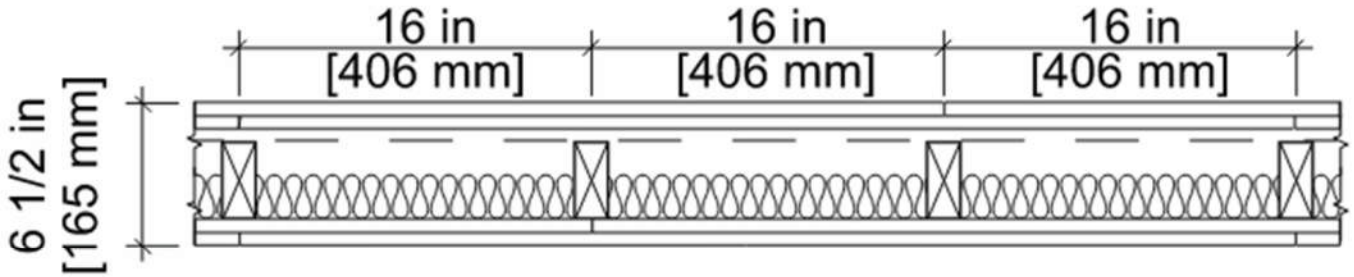



**FIGURE 5:** UL U334

**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

# Shaft Wall Assemblies

Options for Mass Timber Shaft Walls in Mass Timber Buildings

## Exposed Mass Timber Shaft Walls

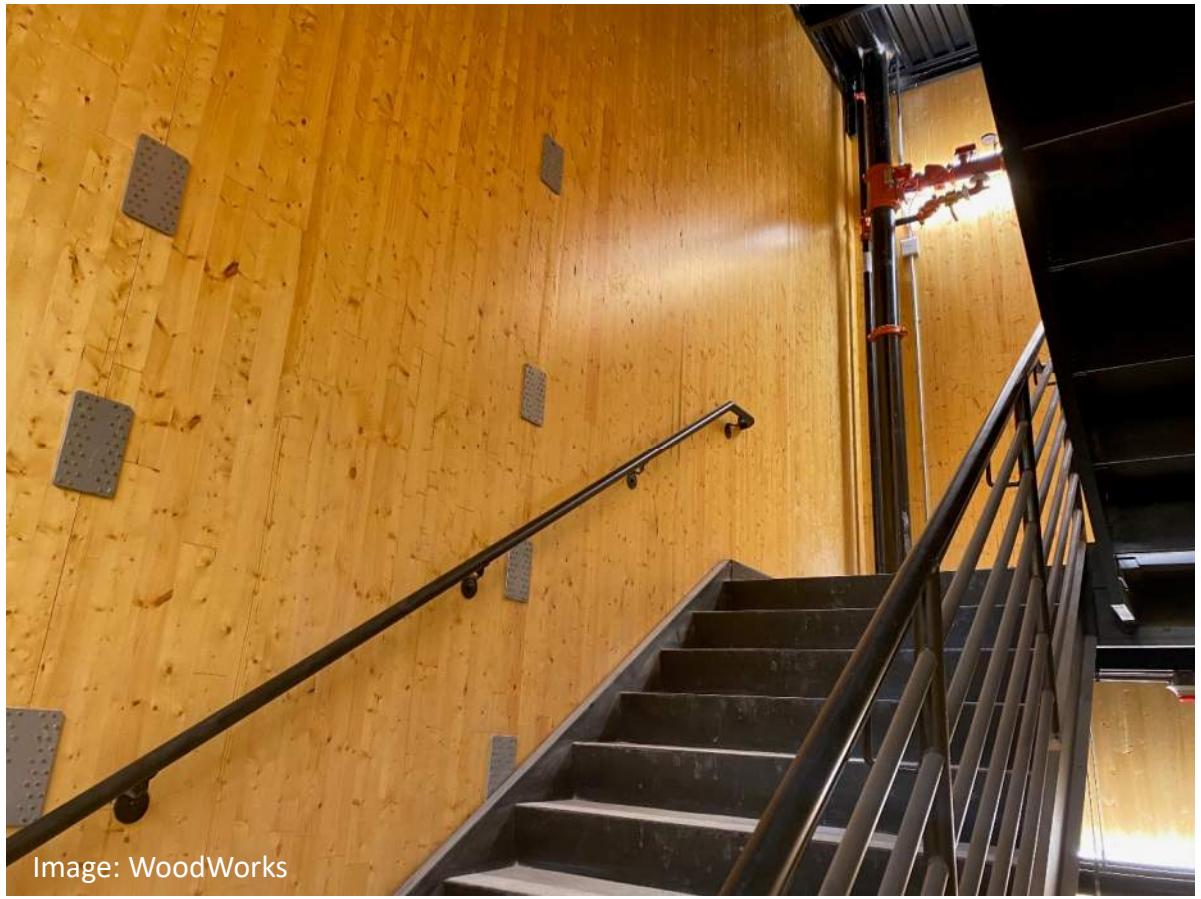


Image: WoodWorks

## Mass Timber Shaft Walls w GWB

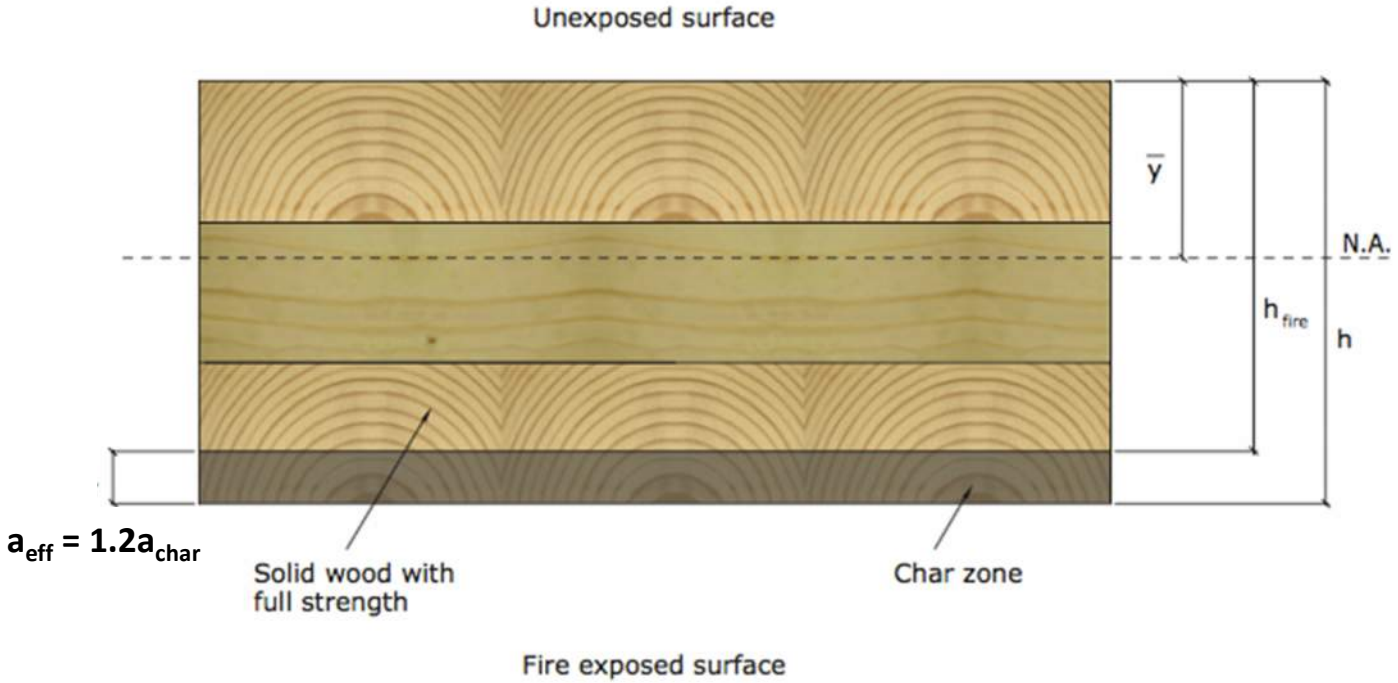
Image: Alex Schreyer

# MT Fire Resistance Ratings (FRR)

**How do you determine fire-resistance rating of exposed mass timber shaft walls?**

1. **Calculations in Accordance with IBC 722 → NDS Chapter 16**
2. **Tests in Accordance with ASTM E119**


Credit: Urban One



# 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

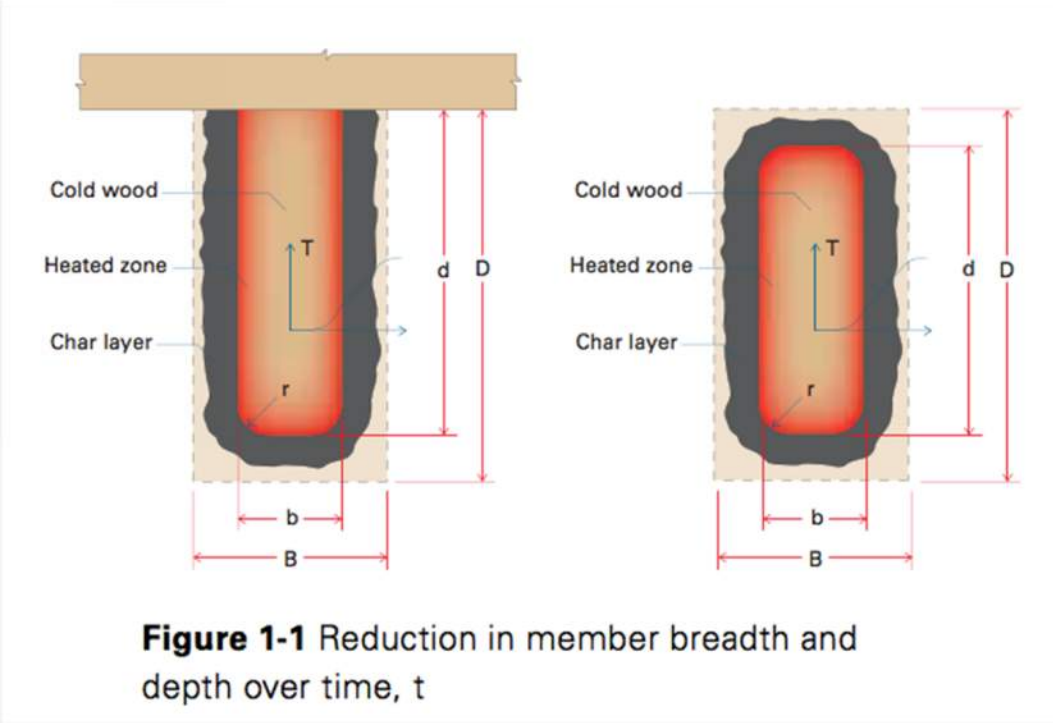



**Figure 1-1** Reduction in member breadth and depth over time, t

Source: AWC’s TR 10

# MT Fire Resistance Ratings (FRR)

## Design Example: 2-hr CLT Wall

**TECHNICAL REPORT NO. 10**

**Example 6: Exposed CLT Wall** - *Allowable Stress Design*

Cross-laminated timber (CLT) wall with an unbraced height of L=120 inches and loaded in compression in the strong-axis direction. The design loads are $w_{live}$=14,000 plf and $w_{dead}$=6,150 plf including estimated self-weight of the CLT panel. Walls above are supported on a CLT floor slab and aligned with a CLT wall below. Sealing of wall joints with fire-rated caulk restricts hot gases from venting through half-lap joints at edges of CLT panel sections. Calculate the required section dimensions for a 2-hr structural fire resistance time when subjected to an ASTM E119 fire exposure.

Calculate column load:

$P_{load} = P_{dead} + P_{snow}$ = 6,150 plf + 14,000 plf = 20,150 lb/foot of width.

From PRG 320, select a 7-ply CLT panel made from 1-3/8 in x 3-1/2 in. lumber boards (CLT thickness of 9-5/8 inches). For CLT grade E1, tabulated properties are:

| | |
|---|---|
| Reference compression stress, $F_{c,0}$ = 1800 psi | (PRG 320 Annex A, Table A1) |
| Reference bending moment, $F_bS_{eff,0}$ = 18,375 ft-lb/ft of width | (PRG 320 Annex A, Table A2) |
| Reference bending stiffness, $EI_{eff,0}$ = 1,089x10$^6$ lb-in$^2$/ft of width | (PRG 320 Annex A, Table A2) |
| Reference shear stiffness, $GA_{eff,0}$ = 1.4x10$^6$ lb/ft of width | (PRG 320 Annex A, Table A2) |

Calculate the effective wall compression capacity:

$A_{parallel}$ = bd of strong axis plies = 4(12)(1.375) = 66 in$^2$/ft of width (NDS 10.3.1)

$P_c = F_{c,0}(A_{parallel})$ = (1800)(66) = 118,800 lb/ft of width (NDS 10.3.1)

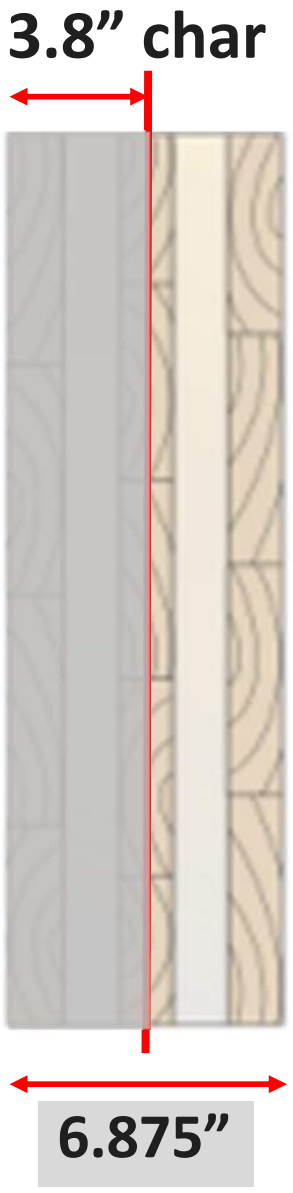
Calculate the apparent wall buckling capacity:

Using NDS Equation 10.4-1, the value for $(EI)_{app}$ can be calculated. Since PRG-320 assumes that E/G = 16 for CLT, NDS Equation 10.4-1 can be rewritten as:

$$(EI)_{app} == \frac{EI_{eff}}{1 + \frac{K_s EI_{eff}}{GA_{eff}L^2}}$$

For pinned-pinned column buckling, $K_s$=11.8; therefore:

$$(EI)_{app} = \frac{1{,}089x10^6}{1 + \frac{(11.8)(1{,}089x10^6)}{(1.4x10^6)(120)^2}} = 665x10^6\ lb/in^2/ft\ of\ width$$




Credit: AWC TR10

# MT Fire Resistance Ratings (FRR)

## Inventory of Fire Tested MT Assemblies

**Table 2: North American Fire Resistance Tests of Mass Timber Wall Assemblies**

WOODWORKS WOOD PRODUCTS COUNCIL

| Mass Timber Panel | Manufacturer | CLT Grade or Timber Grade | Exposed Side Protection | Panel Connection | Unexposed Side Protection | Load Rating | Fire Resistance Achieved (Hours) | Actual Fire Endurance | Source | Testing Lab |
|---|---|---|---|---|---|---|---|---|---|---|
| 3-ply (114mm 4.488 in) | Nordic | SPF 1650 Fb 1.5E MSR x SPF #3 | 2 layers 1/2" Type X gypsum | Half-Lap | None | Reduced 76% Axial Capacity | 1.5 | 106 min | 1 (Test 2) | NRC Fire Laboratory |
| 3-ply (3.78" 99mm) | Structurlam | V2 | 1 layer 5/8" Type X gypsum | Half-Lap | None | Reduced 60% Max Design Load | 1 | 76 min | 8 | Intertek December 2013 |
| 3-ply (3.78" 99mm) | Structurlam | V2 | 1 layer 5/8" Type X gypsum | Half-Lap | None | Unreduced 100% Max Design Load | 1 | 66 min | 9 | Intertek November 2014 |
| 3-ply (105mm) | Nordic | E1 | 1 layer 5/8" Type C or Type X gypsum | Half-Lap | 1 layer 5/8" Type C or Type X gypsum | Reduced, 30% Allowable Compression Parallel to Grain | 1 | Not Provided | 10 | UL (V320) |
| 3-ply (105mm) | Nordic | E1 | None | Half-Lap | None | Loaded, See Manufacturer | 0.5 | 32 min | 20 | Intertek 5/17/2012 |
| 3-ply (78mm) | Nordic | E1 | 5/8" Type X gypsum over 2x3 SPF Studs @ 24" oc with 2 1/5" mineral wool between stude | Half-Lap | None | Loaded, See Manufacturer | 1 | 83 min | 22 | Intertek 12/30/2011 |
| 5-ply (131 mm) | Nordic | E1 | 2 layers 5/8" Type C or Type X gypsum | Half-Lap | 2 layers 5/8" Type C or Type X gypsum | Reduced, 30% Allowable Compression Parallel to Grain | 2 | Not Provided | 10 | UL (V320) |
| 5-ply (175mm) | Nordic | E1 | 1 layer 5/8" Type C or Type X gypsum | Half-Lap | 1 layer 5/8" Type C or Type X gypsum | Reduced, 30% Allowable Compression Parallel to Grain | 2 | Not Provided | 10 | UL (V320) |
| 5-ply (175mm) | Nordic | E1 | None | Half-Lap | None | Reduced, 30% Allowable Compression Parallel to Grain | 1 | Not Provided | 10 | UL (V320) |
| 5-ply (175mm) | Nordic | E1 | 2 layers 5/8" Type X gypsum | Spline | 2 layers 5/8" Type X gypsum | Loaded, See Manufacturer | 3.5 | 219 min | 5 | NRC Fire Laboratory Nov 2014 |
| 5 ply (6 7/8") | Smartlam | SL-V4 | None | Half-Lap | None | Loaded, See Manufacturer | 2 | 120 min | 11 | Western Fire Center 5/25/2017 |
| 5-ply (175mm 6.875") | Nordic | SPF 1950 Fb MSR x SPF #3 | None | Half-Lap | None | Reduced 37% Axial Capacity | 1.5 | 113 min | 1 (Test 4) | NRC Fire Laboratory |
| 5 ply (105mm) | Structurlam | SPF #1/#2 x SPF #1/#2 | None | Half-Lap | None | Reduced 25% Axial Capacity | <1 | 57 min | 1 (Test 8) | NRC Fire Laboratory |
| 5-ply (175mm 6.875") | DR Johnson | V1 | None | Half-Lap | None | Loaded, See Manufacturer | 2 | 120 min | 13 (Test 1) | Western Fire Center 9/28/2016 |
| 5-ply (175mm 6.875") | SmartLam | SL-V4 | None | Half-Lap | None | Loaded, See Manufacturer | 1.5 | 101 min | 13 (Test 2) | Western Fire Center 9/30/2016 |
| 5-ply (175mm 6.875") | Smartlam | V1 | None | Half-Lap | None | Loaded, See Manufacturer | 2 | 120 min | 13 (Test 7) | Western Fire Center 1/26/2017 |

# 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

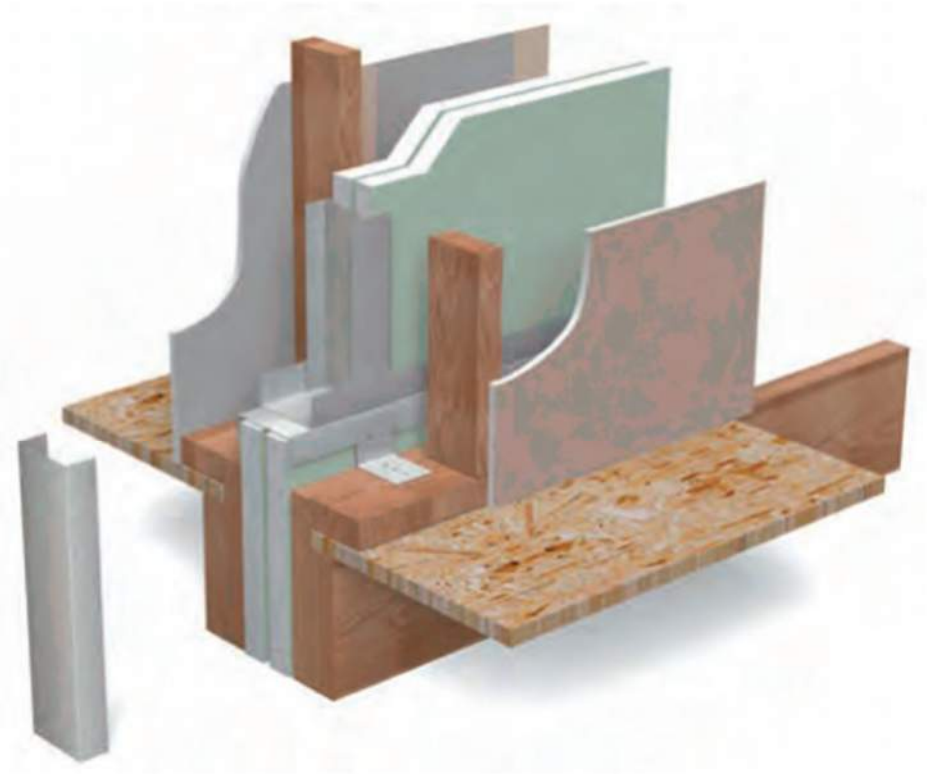


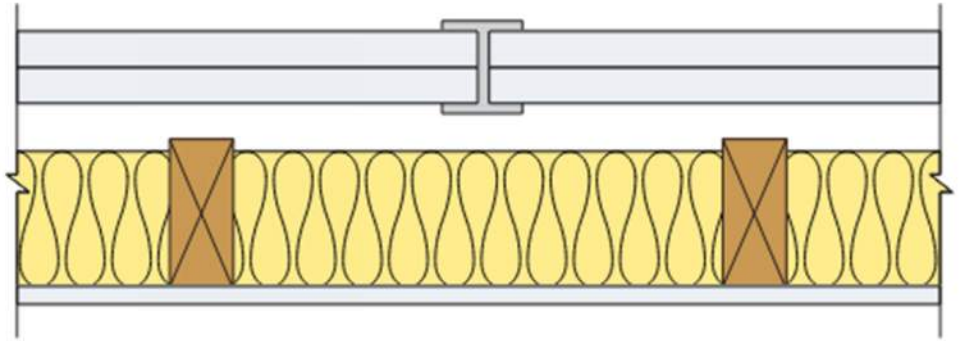
**FIGURE 6:** Shaftliner wall assembly with wood wall on each side

*Credit: ClarkDietrich*

# Shaftliner Systems – Configuration Options

## H-Stud Option

Source: Clark Dietrich

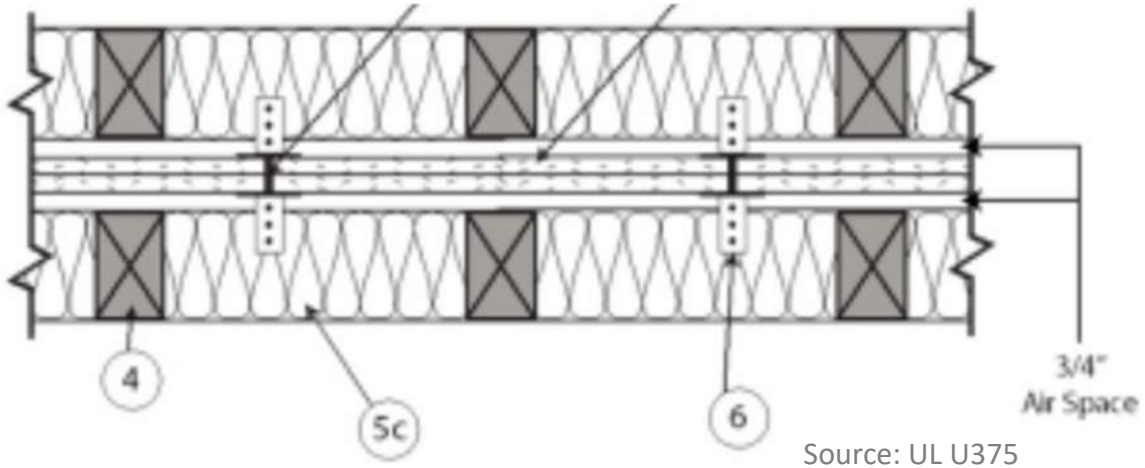


**59 STC Sound Transmission**

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




Source: UL U375

**FIGURE 8:** UL U373

*Credit: Georgia Pacific*

# 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

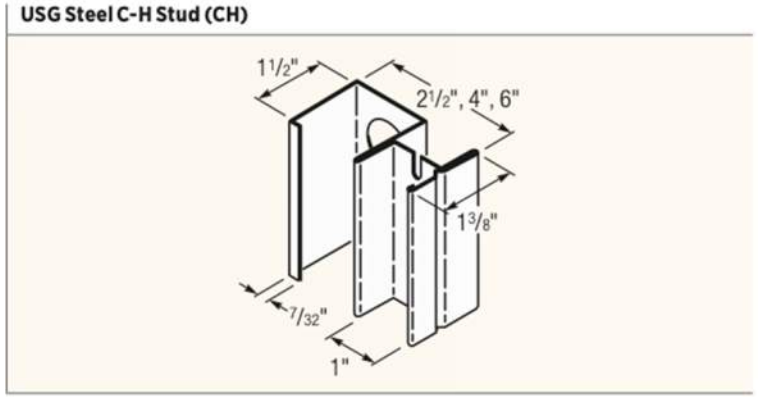
### WALL SYSTEMS—LIMITING HEIGHTS TABLE

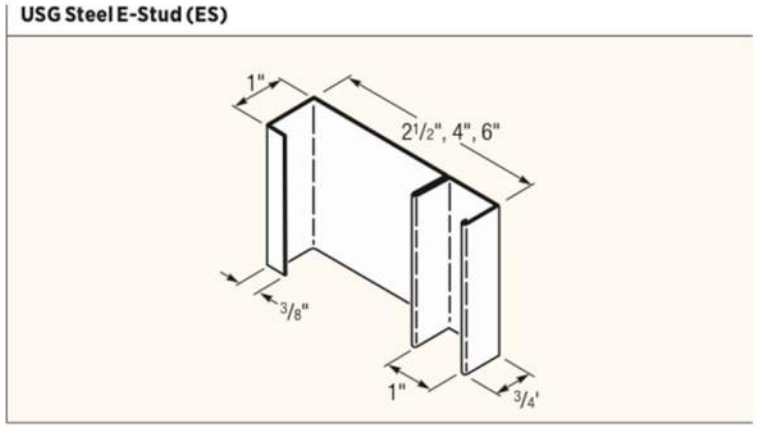
| | | | One-Hour Shaft Wall / Stairwell (U415 System A)[b] | | | | Two-Hour Shaft Wall (U415 System C)[b] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Stud Type and Size** | **Designation** | **Allowable Deflection** | **5** | **7.5** | **10** | **15** | **5** | **7.5** | **10** | **15** |
| 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 – Configuration Options

## CH-Stud Option

Source: Clark Dietrich




Source: USG

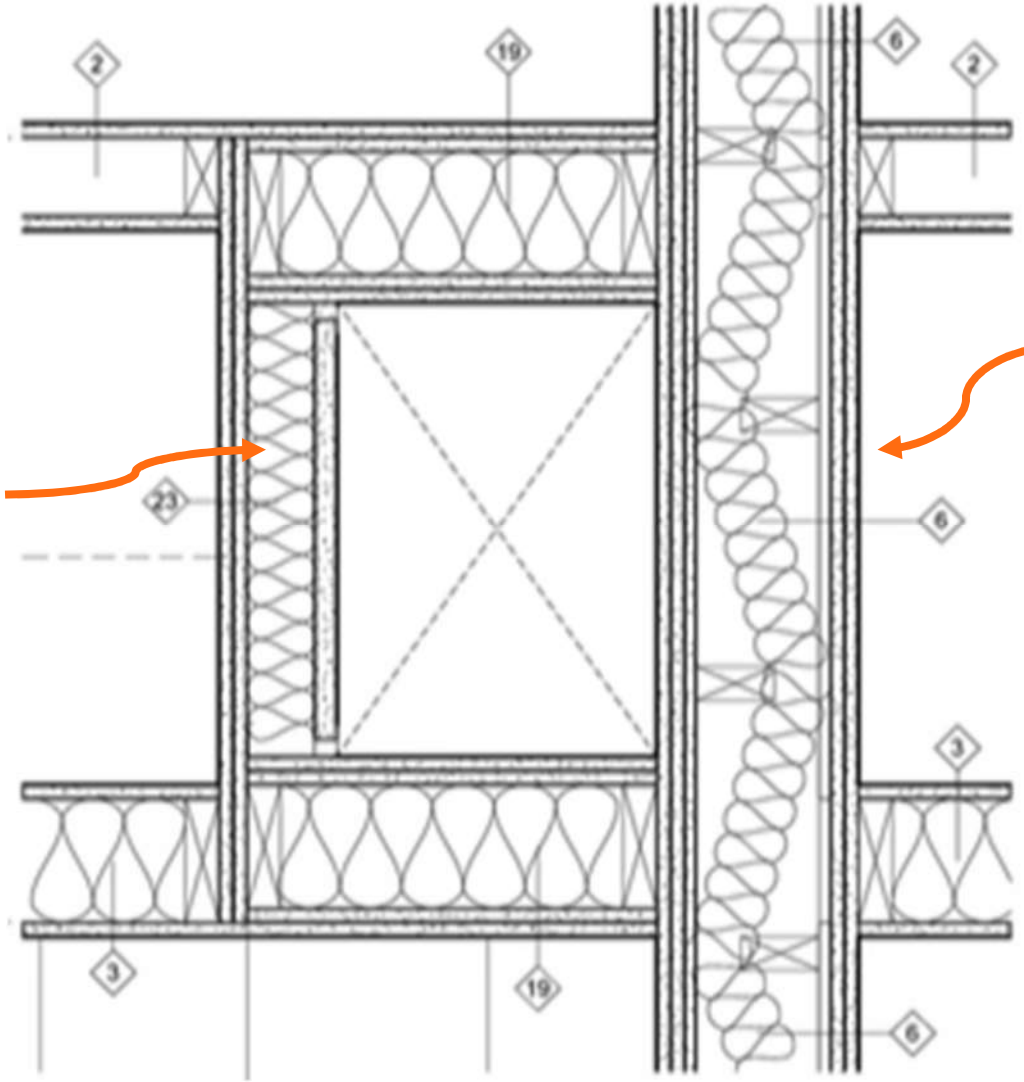
## No wood backup wall



Source: Clark Dietrich

# 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

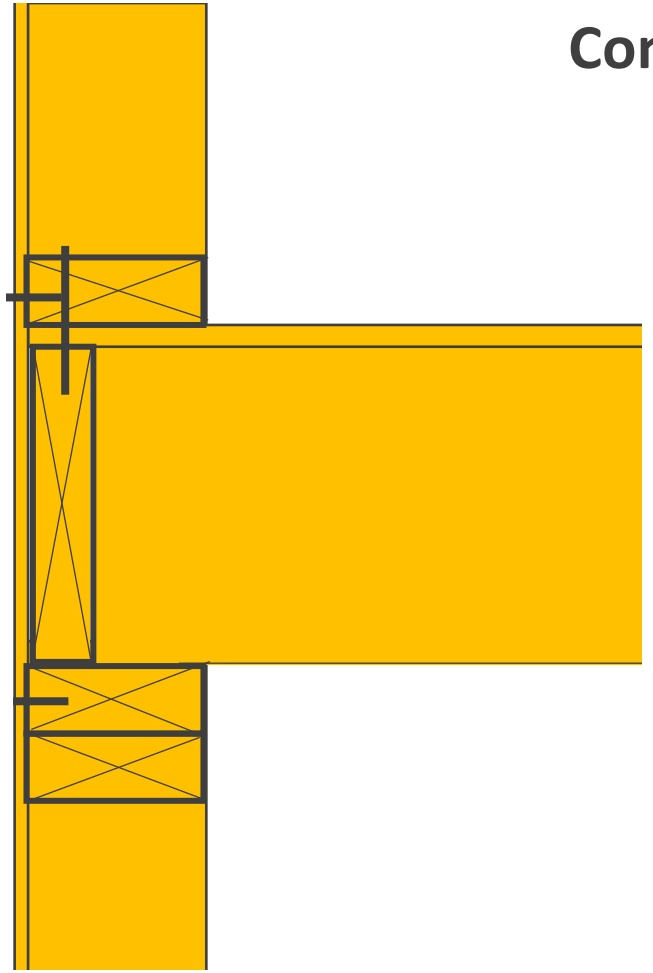
After shaft wall assembly is selected, need to consider how it will interface with floors and roof it intersects

Some key considerations are:

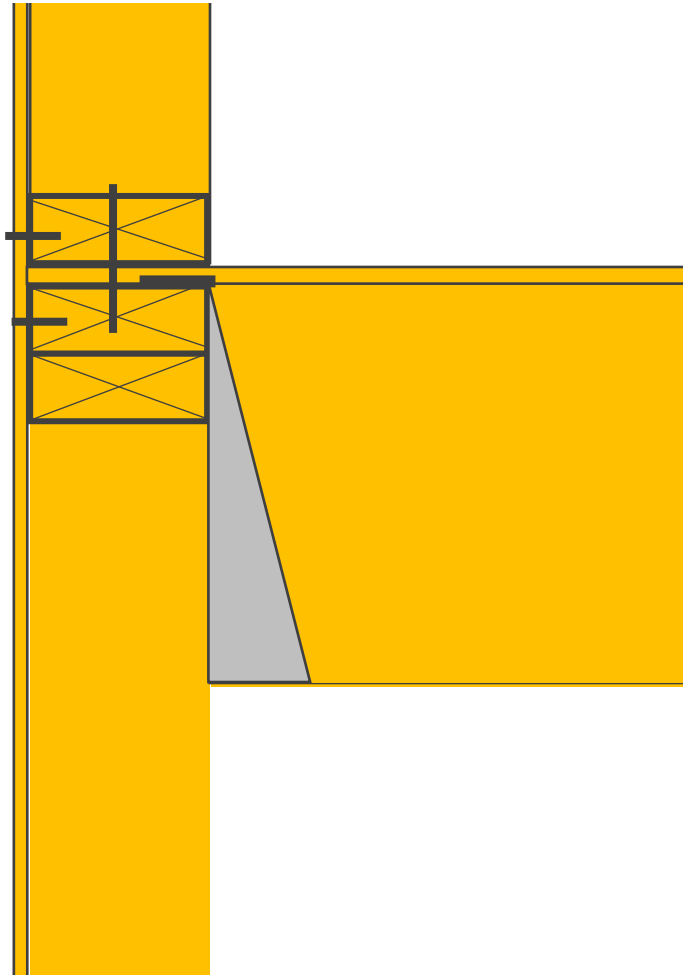
- Supporting Construction
- Continuity and Hourly Ratings
- Joints and Penetrations
- Depends on floor joist/truss type used, bearing condition
- No tested intersections exist; discuss desired detail and rationale with building official
- The following are just a few options - Contact local WoodWorks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

# Floor to Shaft Wall Detailing

**Common Details**



**Platform Framing**

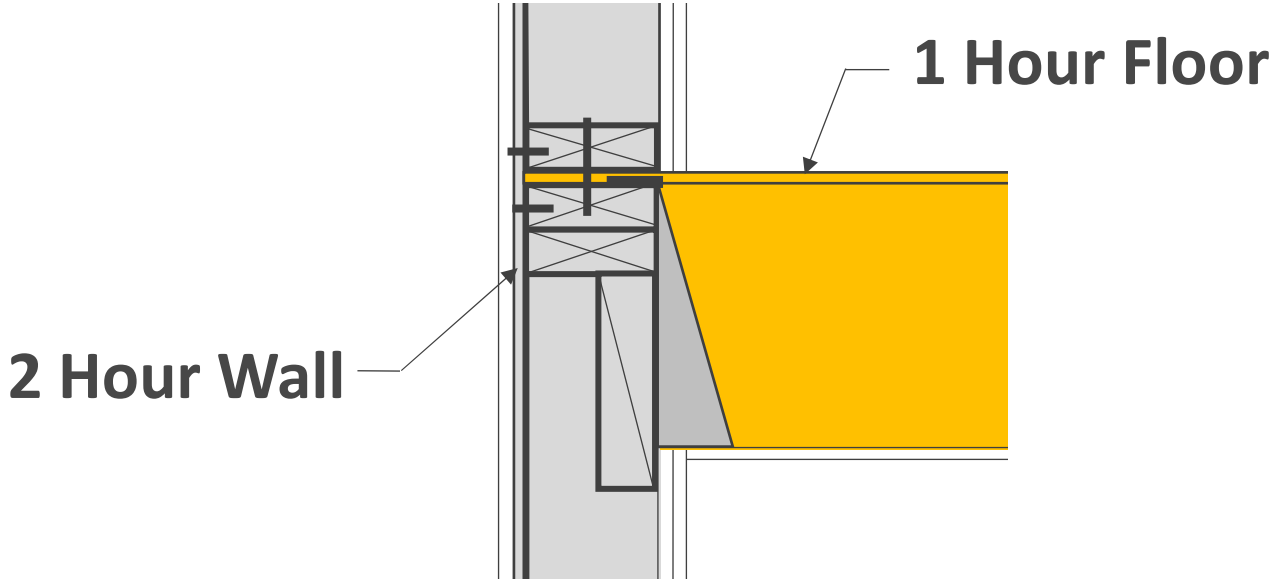


**Semi-Balloon Framing**

# 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"



# Floor to Shaft Wall Detailing

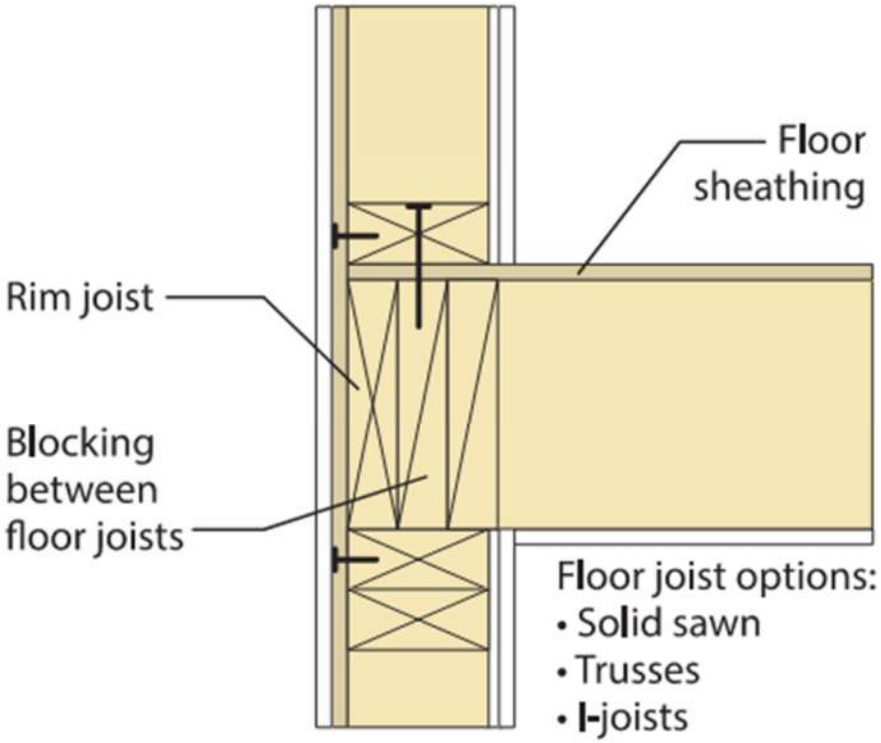



**FIGURE 11:** Floor-to-shaft wall intersection with blocking between floor joists

- 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

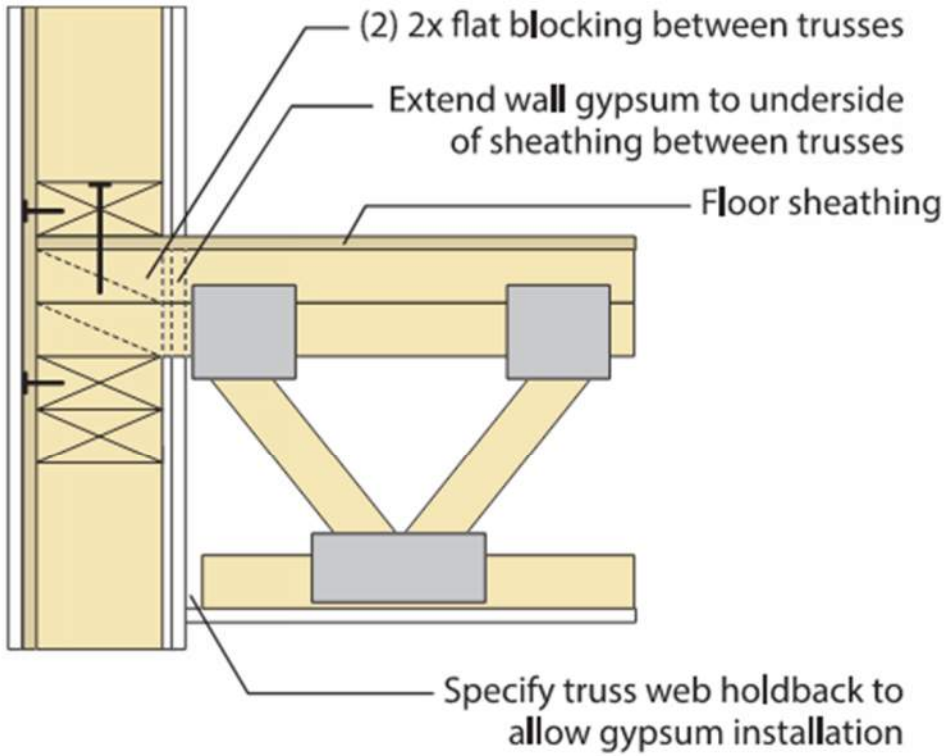



**FIGURE 12:** Floor-to-shaft wall intersection with gypsum extending to underside of sheathing between trusses

Credit: WoodWorks

# Floor to Shaft Wall Detailing

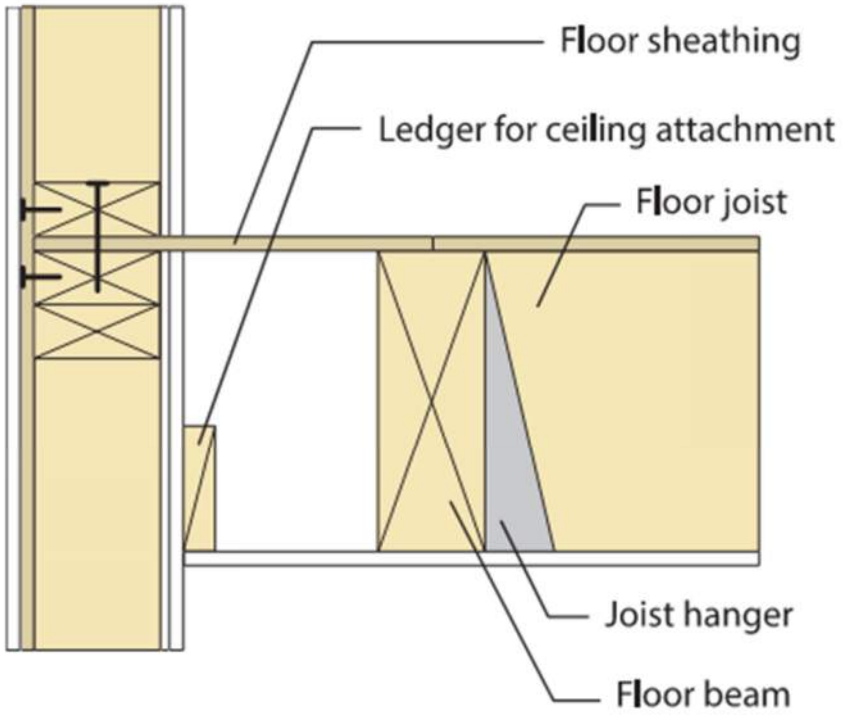



**FIGURE 13:** Floor-to-shaft wall intersection with supporting beam just inboard of wall

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

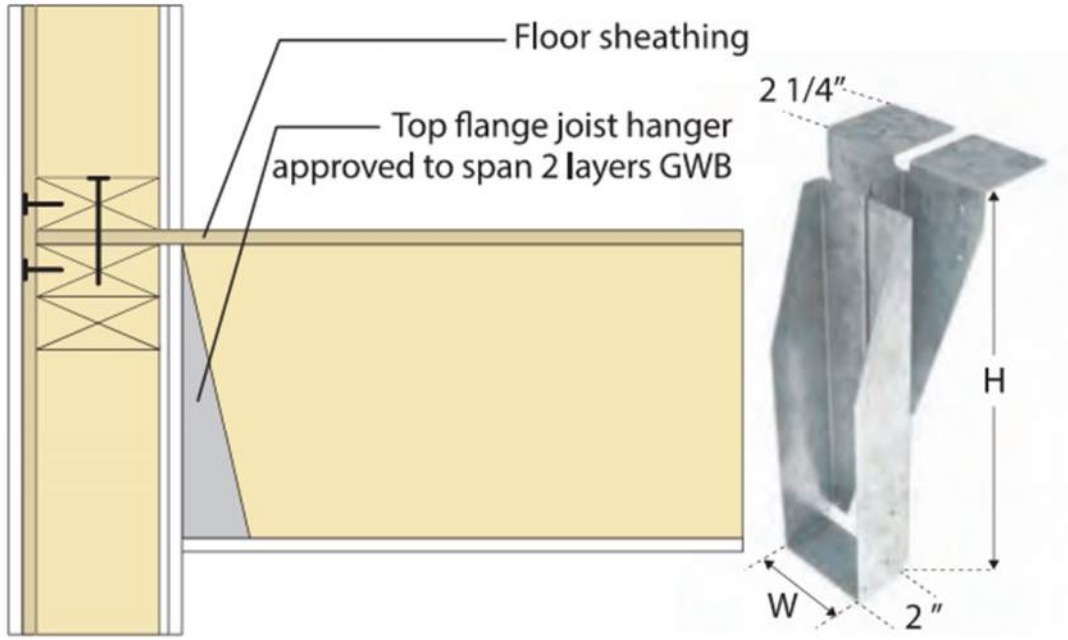



**FIGURE 14:** Floor-to-shaft wall intersection with hangers designed to span over gypsum

*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

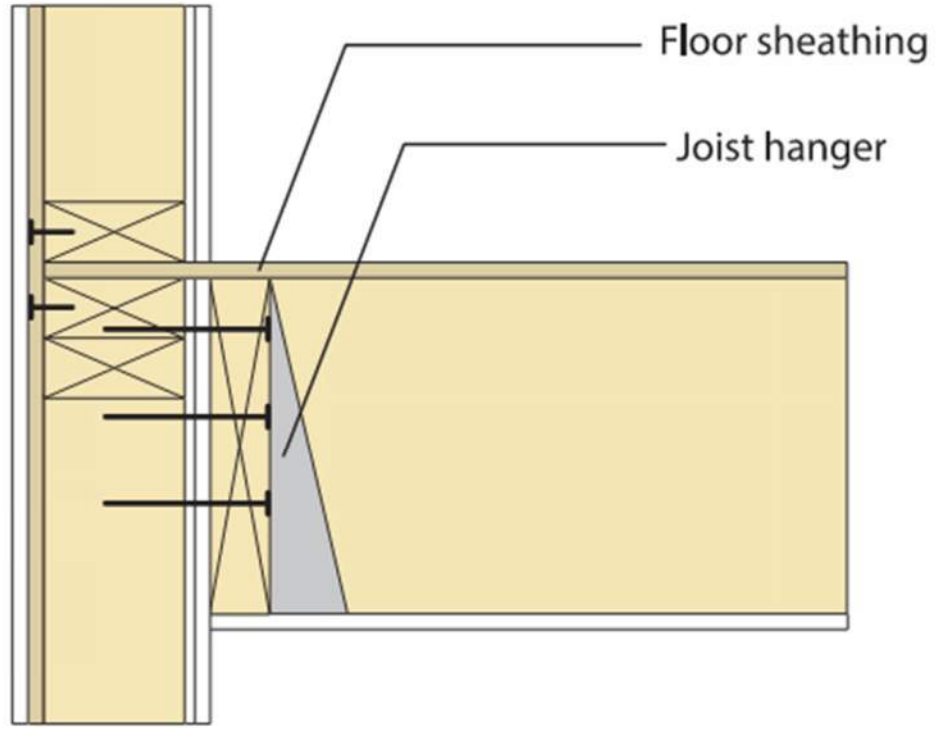
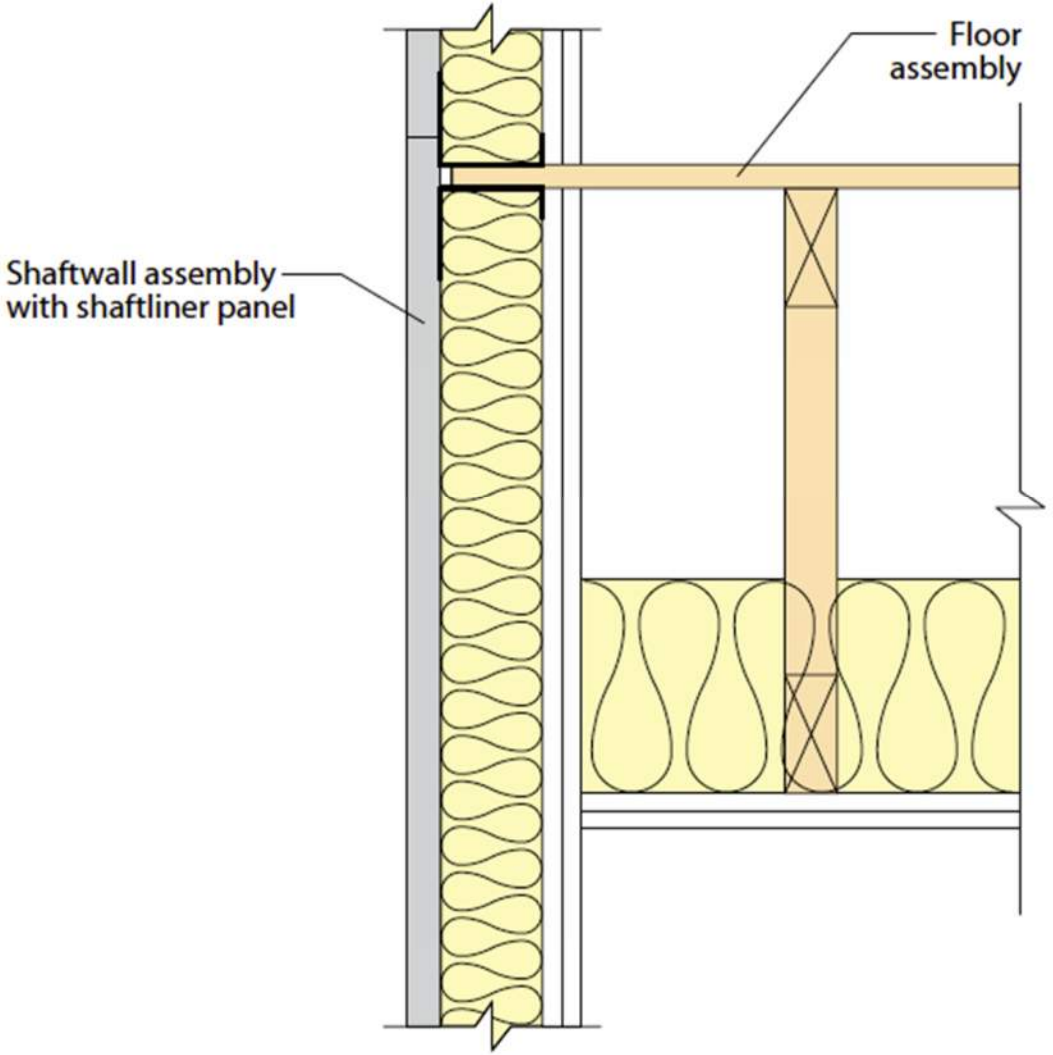
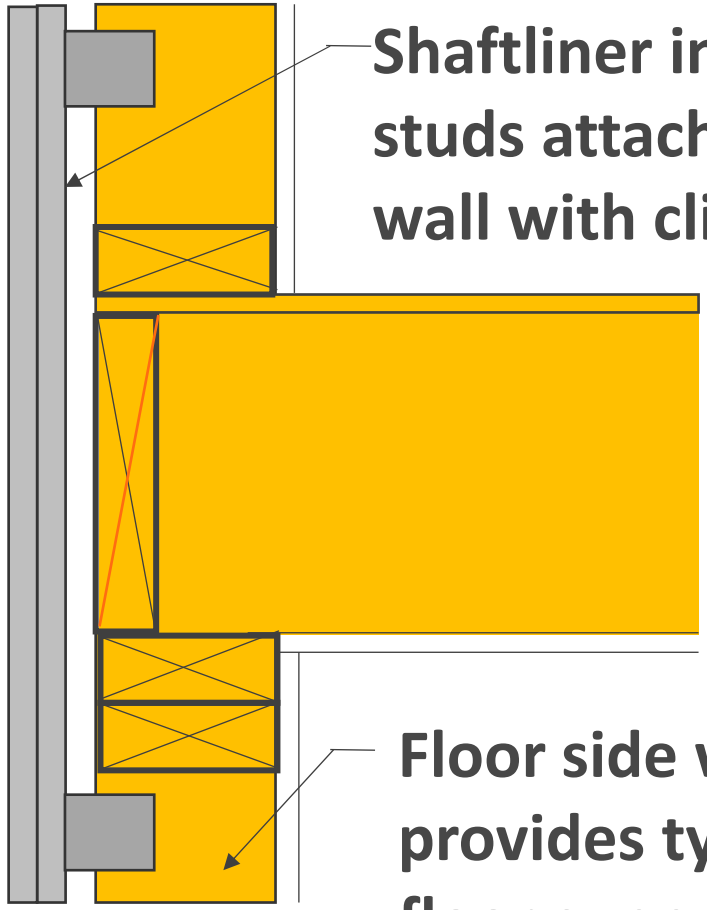



**FIGURE 15:** Floor framing ledger attached to shaft wall through two layers of gypsum

# Floor to Shaft Wall Detailing



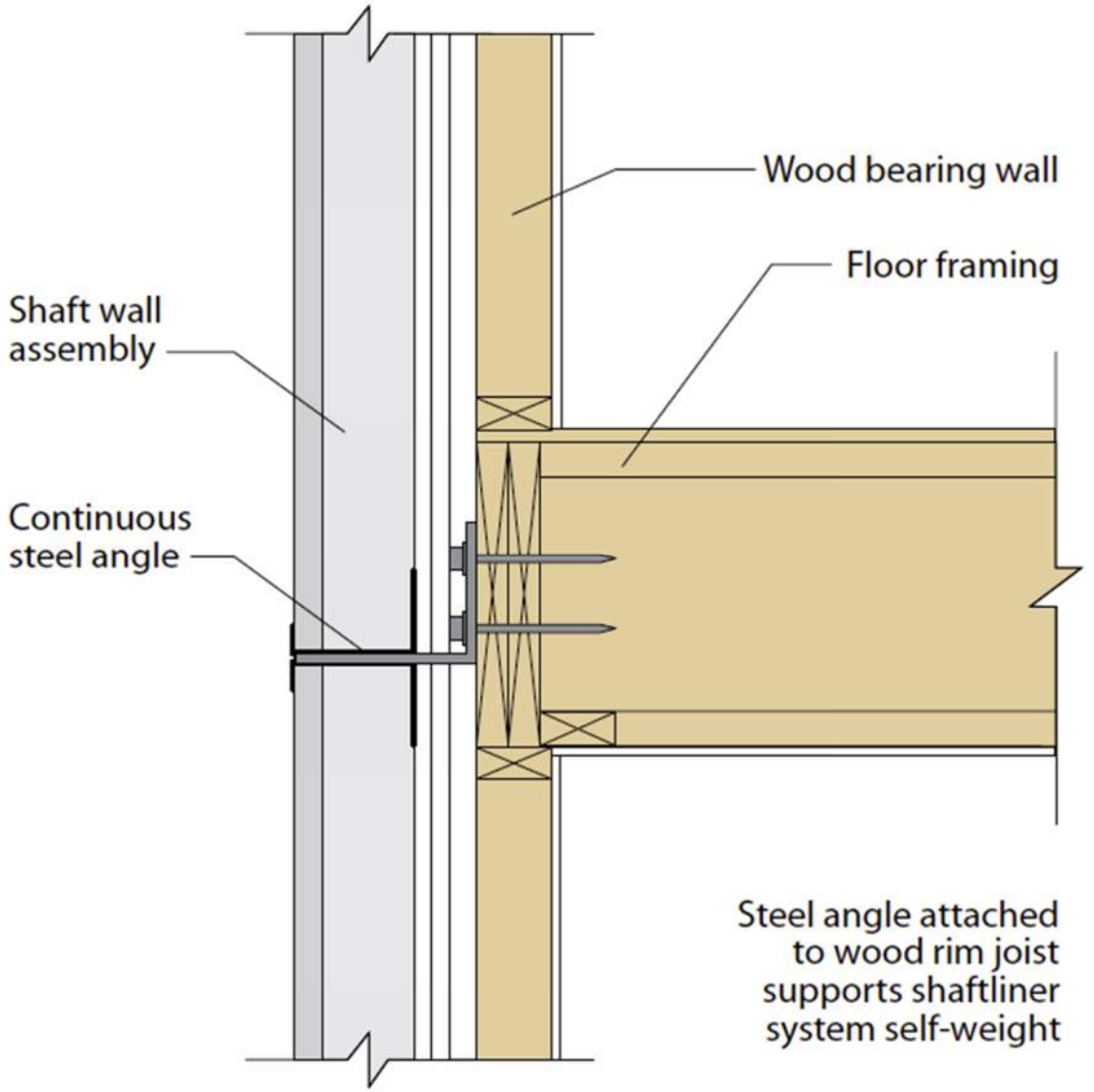



**Shaftliner in H-studs attached to wall with clips**

**Floor side wall provides typical floor support**

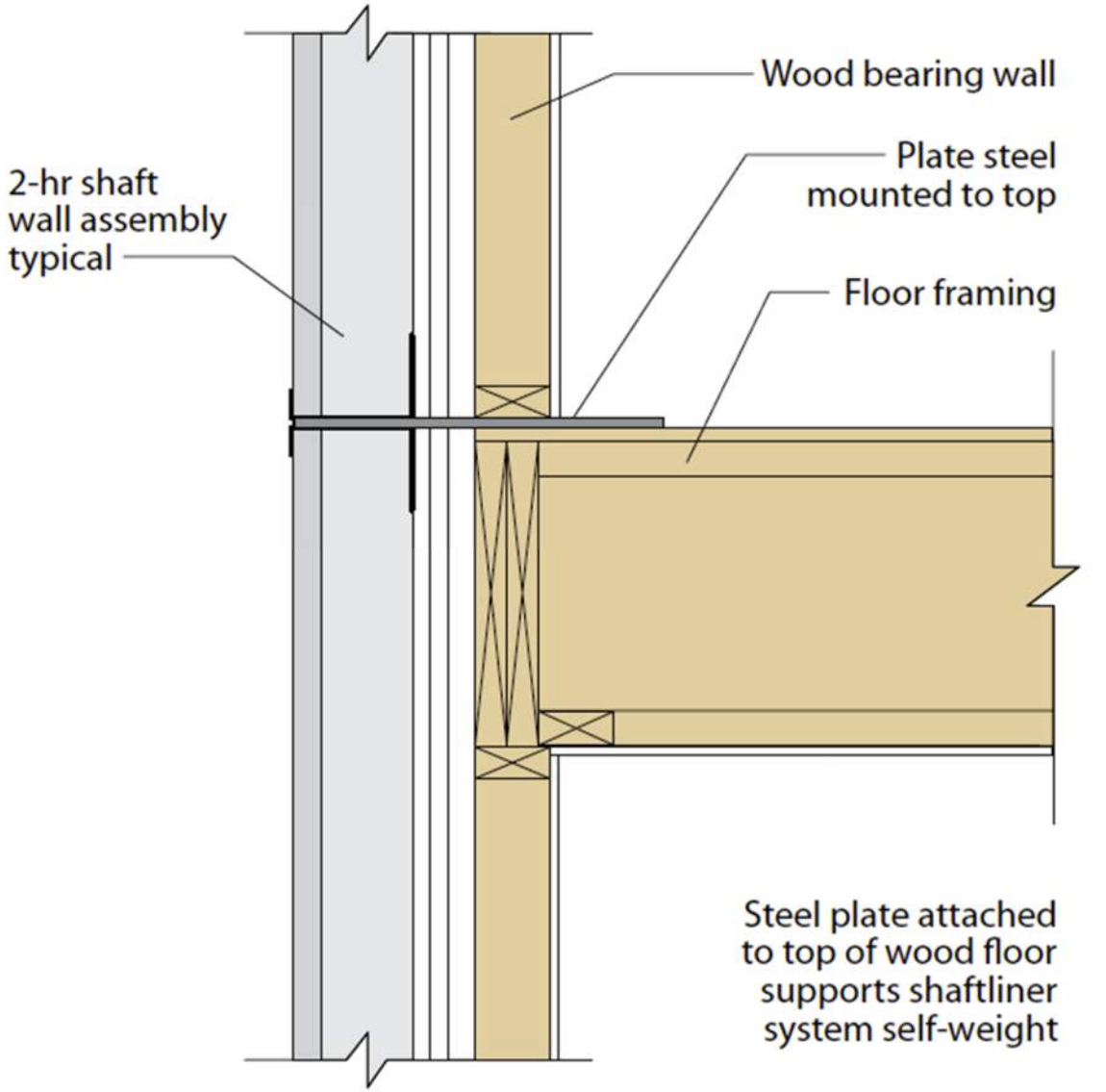
# Shaftliner Systems – Support Details

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



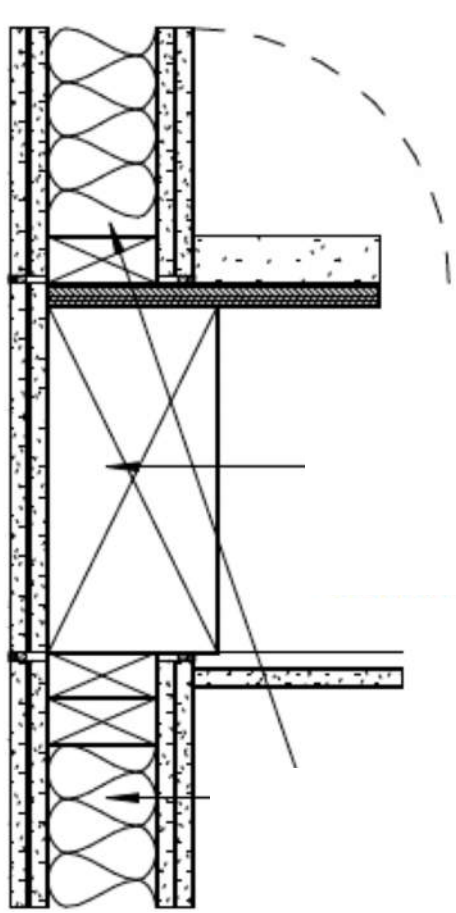
# Shaftliner Systems – Support Details

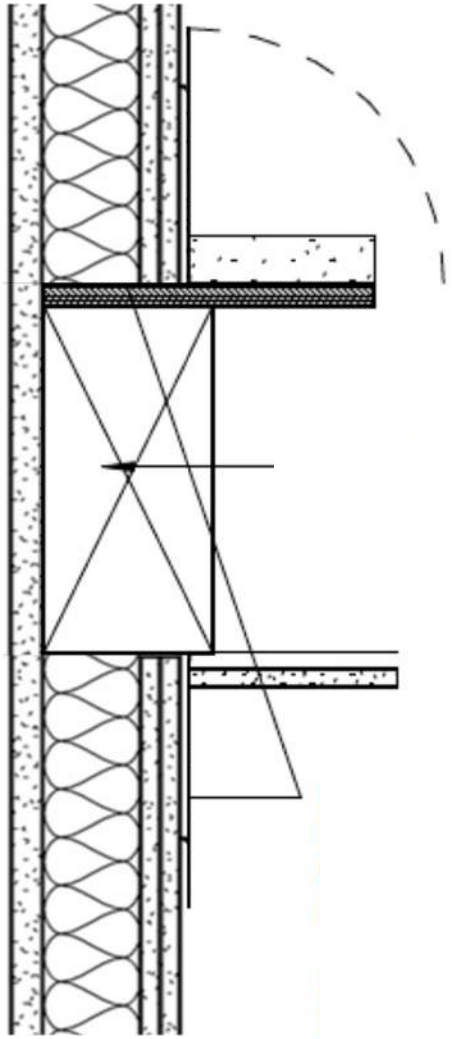
Steel plate attached to top of wood floor supports shaftliner system self-weight



# Shaftliner Systems – Support Details

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





# Floor to Shaft Wall Detailing

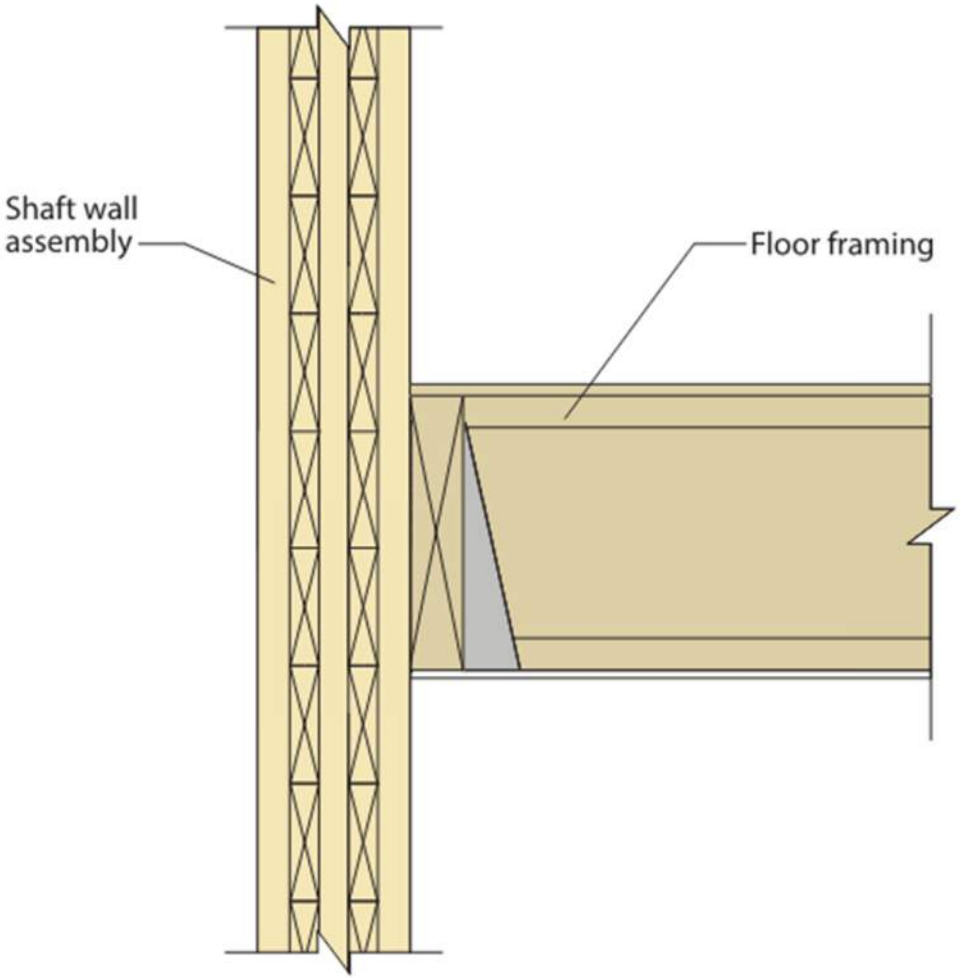
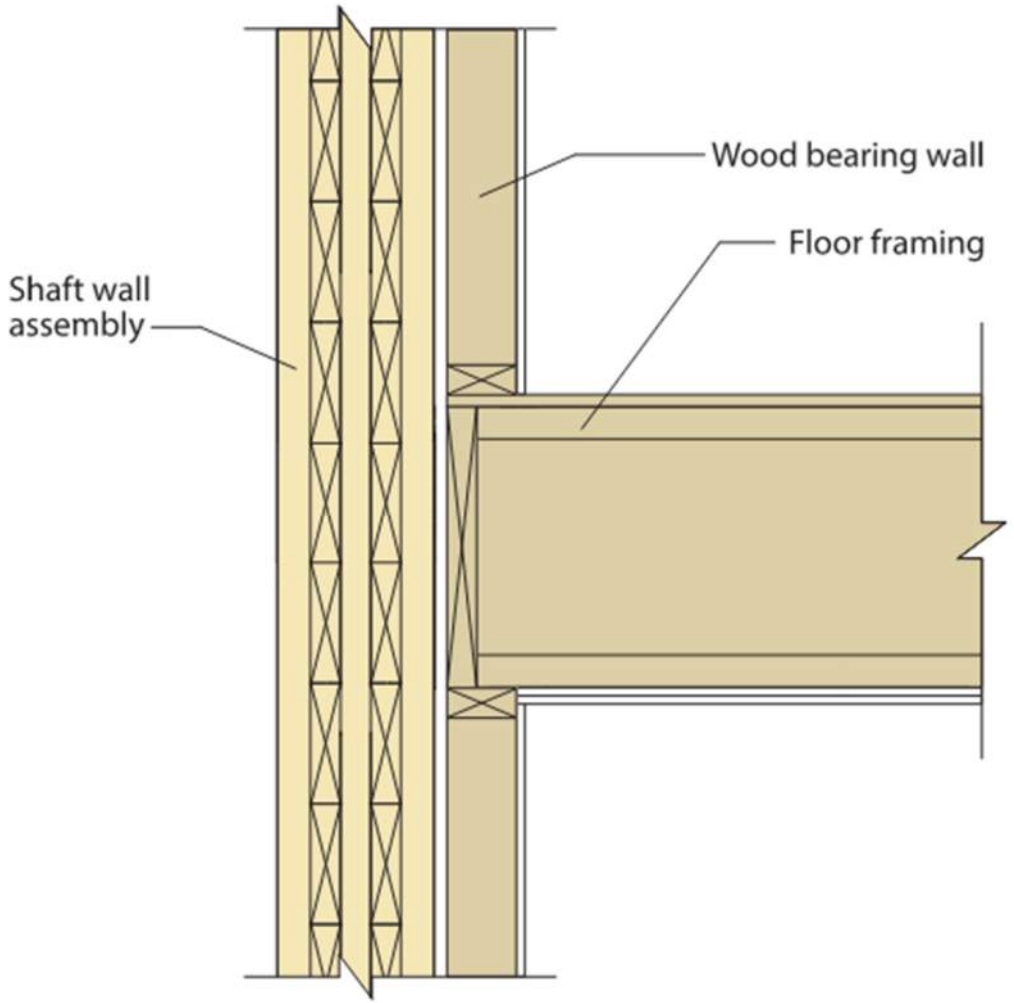


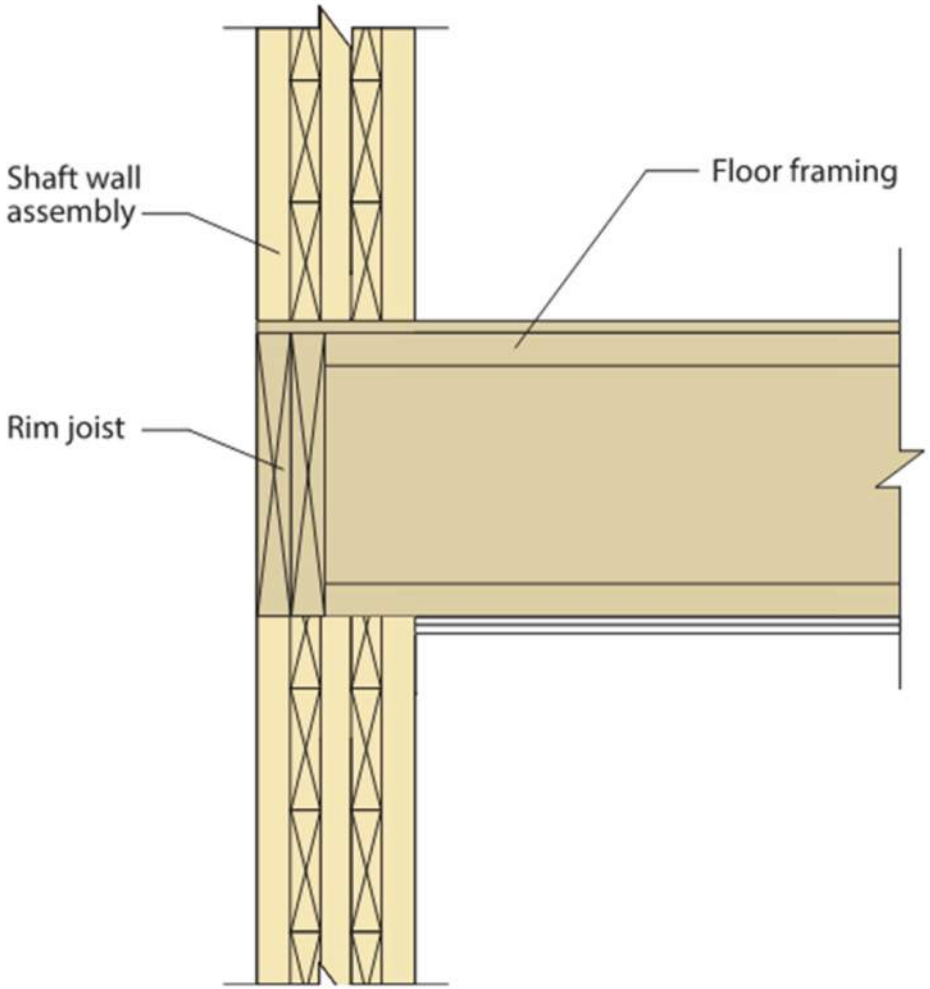


Photo: Alex Schreyer

# Floor to Shaft Wall Detailing

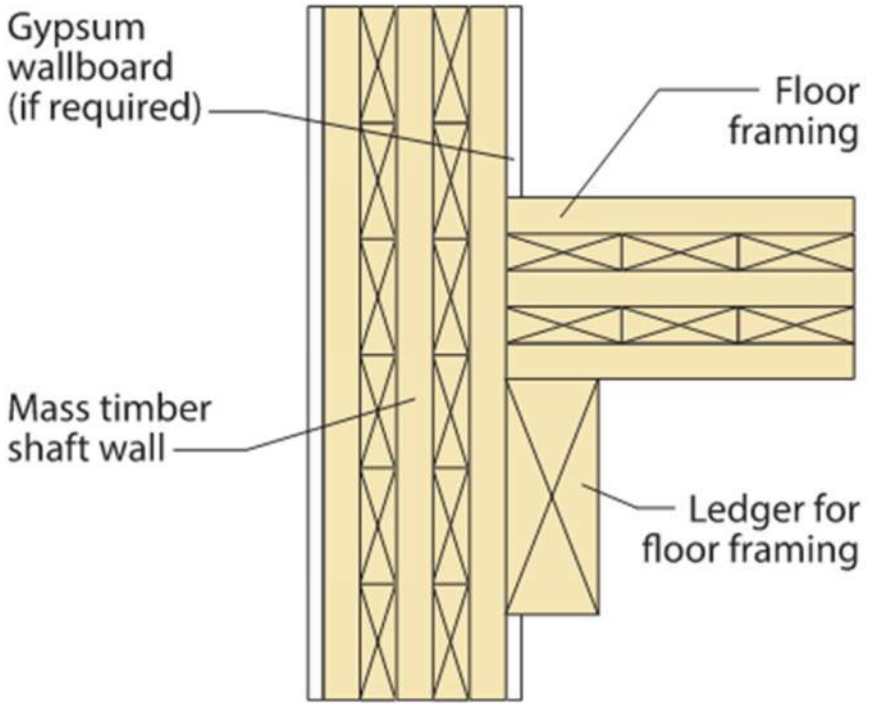


# Floor to Shaft Wall Detailing



# Floor to Shaft Wall Detailing

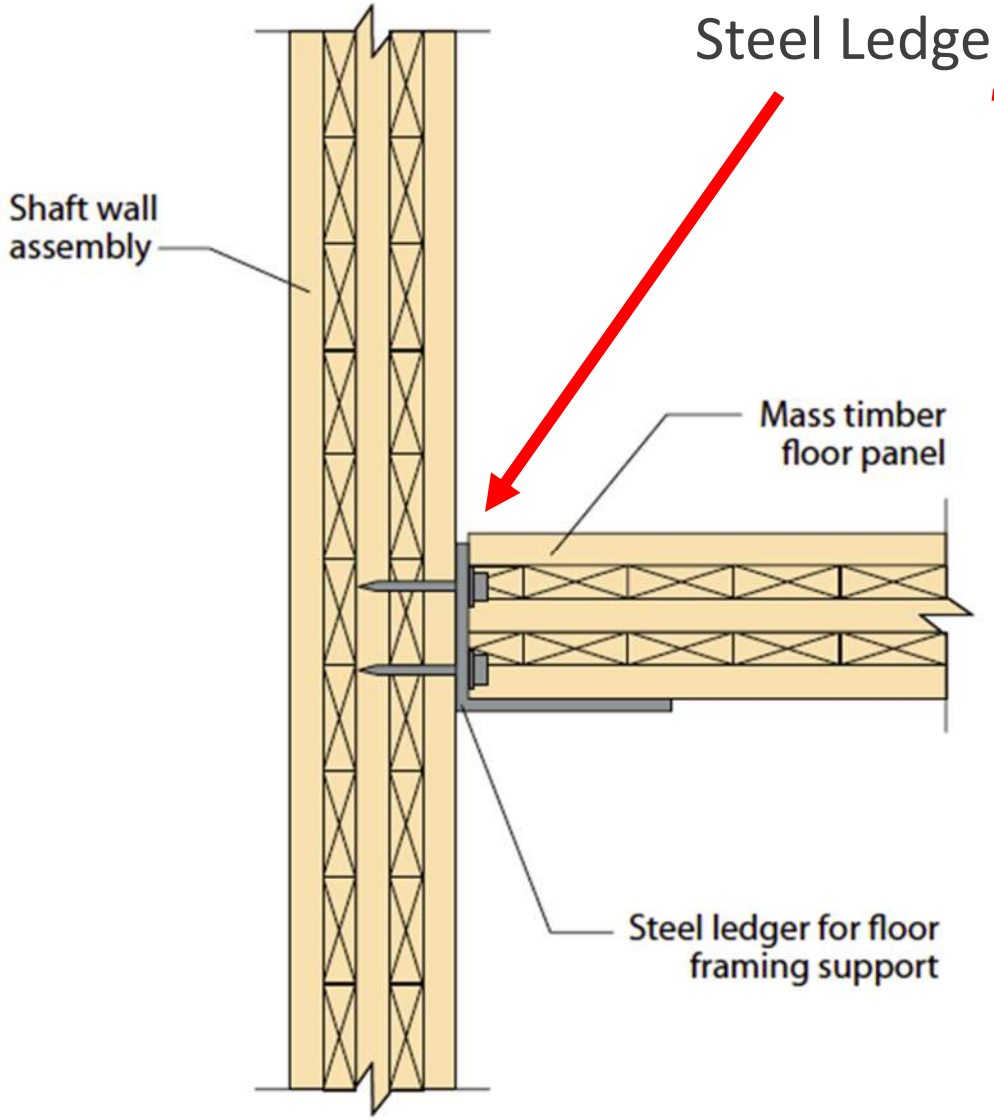
Construction erection and sequencing will inform efficient floor to wall intersection



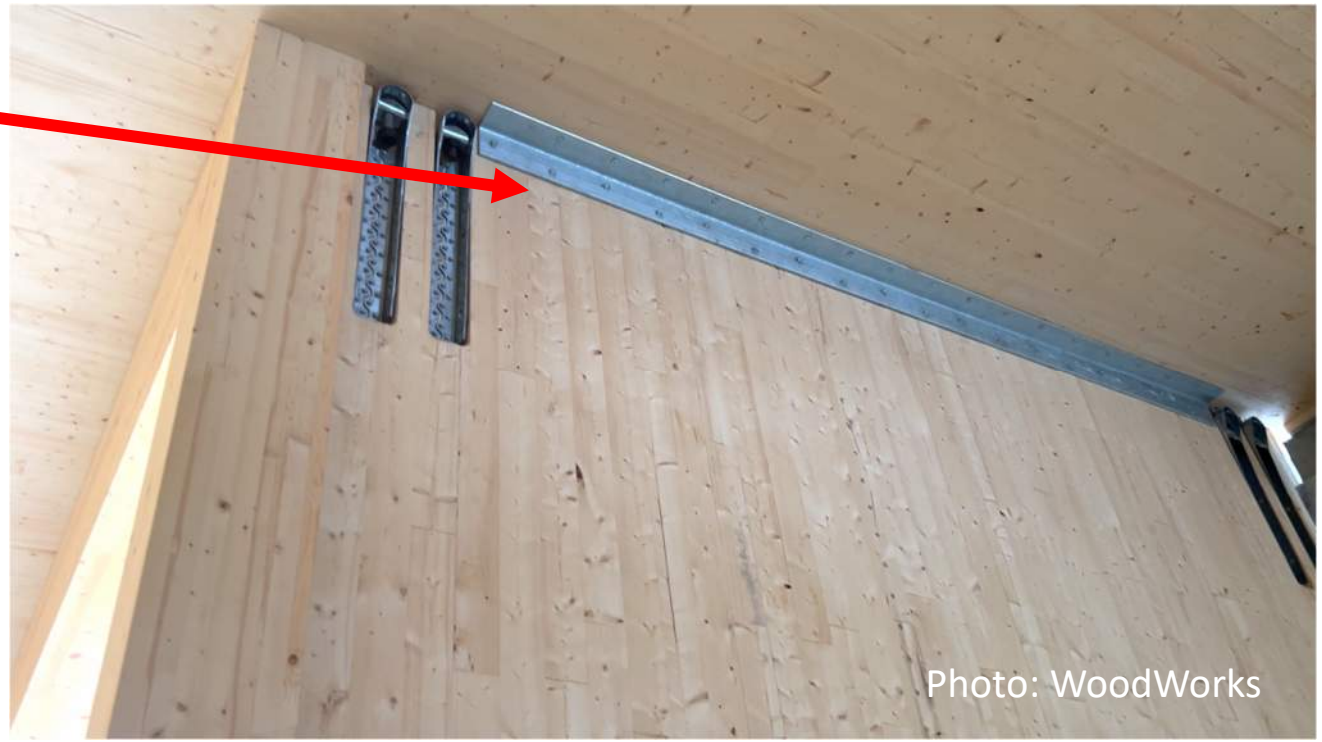

Wood Ledger


Photo: Alex Schreyer

# Floor to Shaft Wall Detailing




Steel Ledger



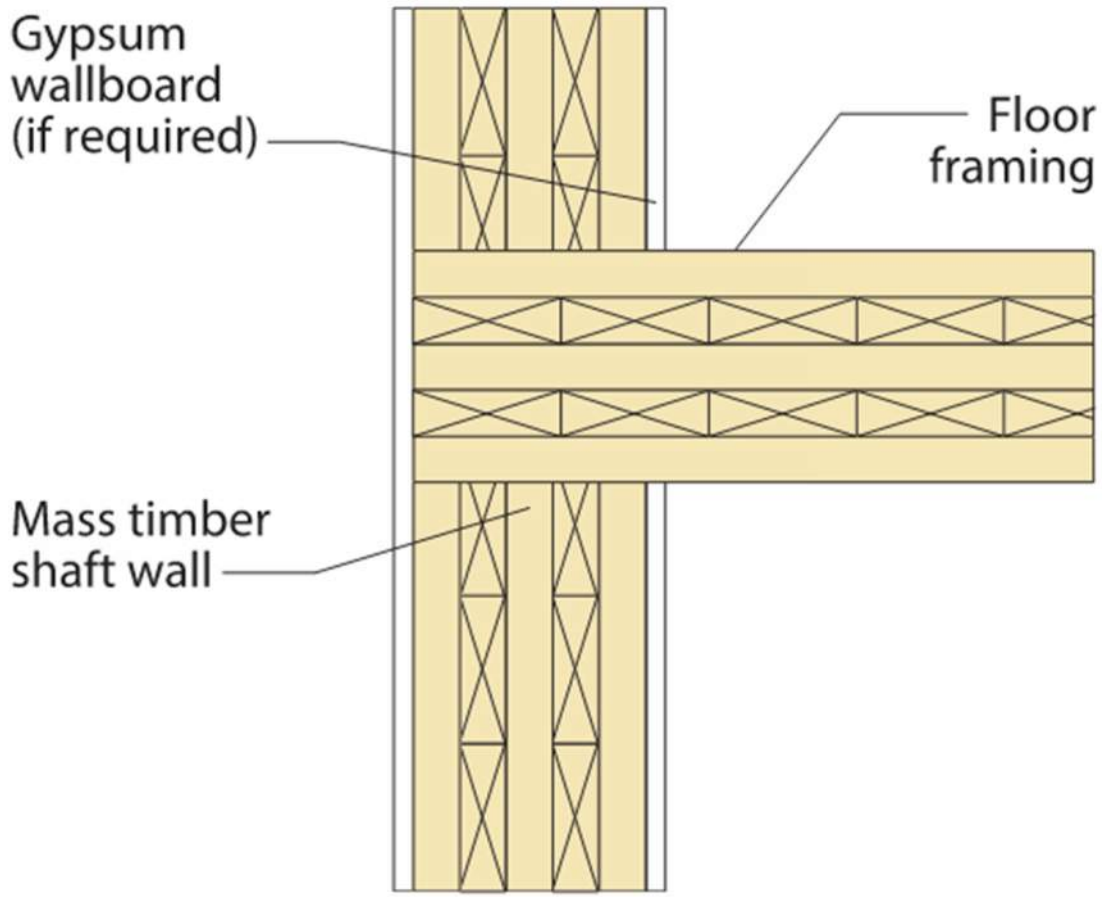
# Floor to Shaft Wall Detailing

Recall fire barrier continuity definition:

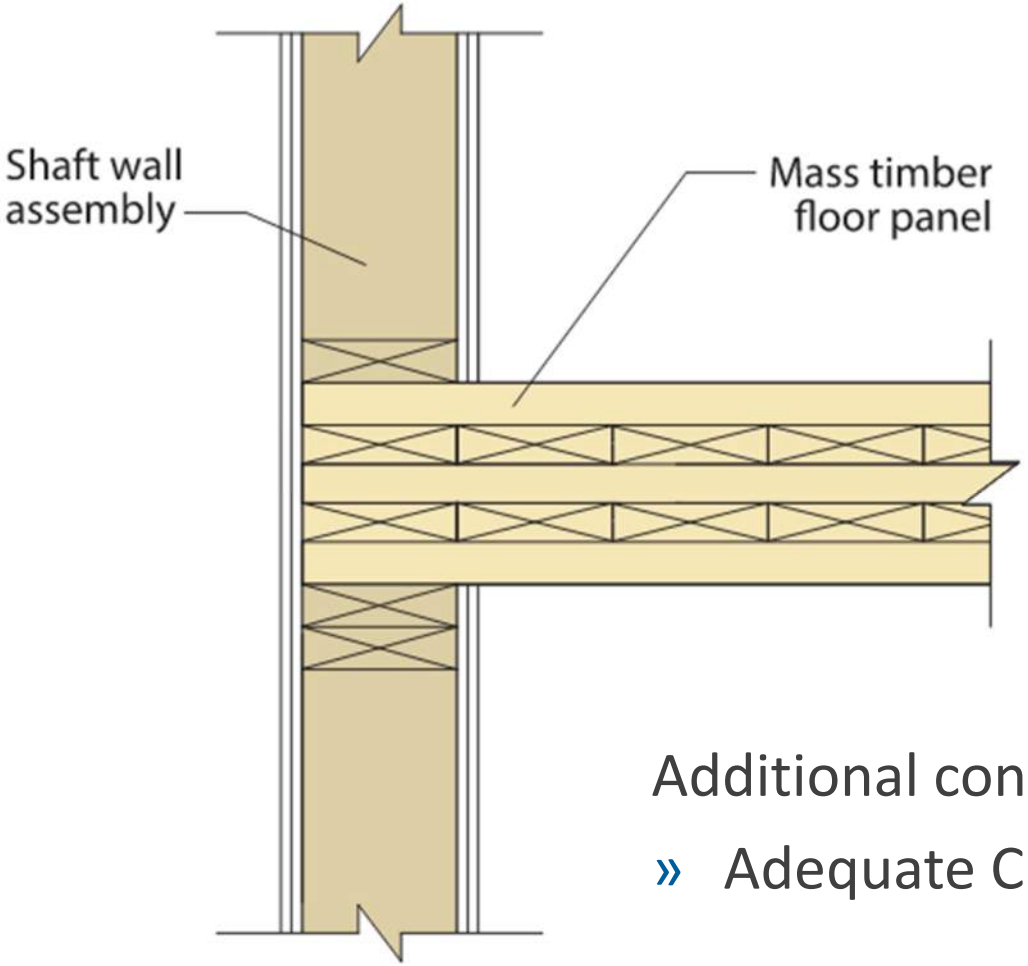
*shall extend … to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto*

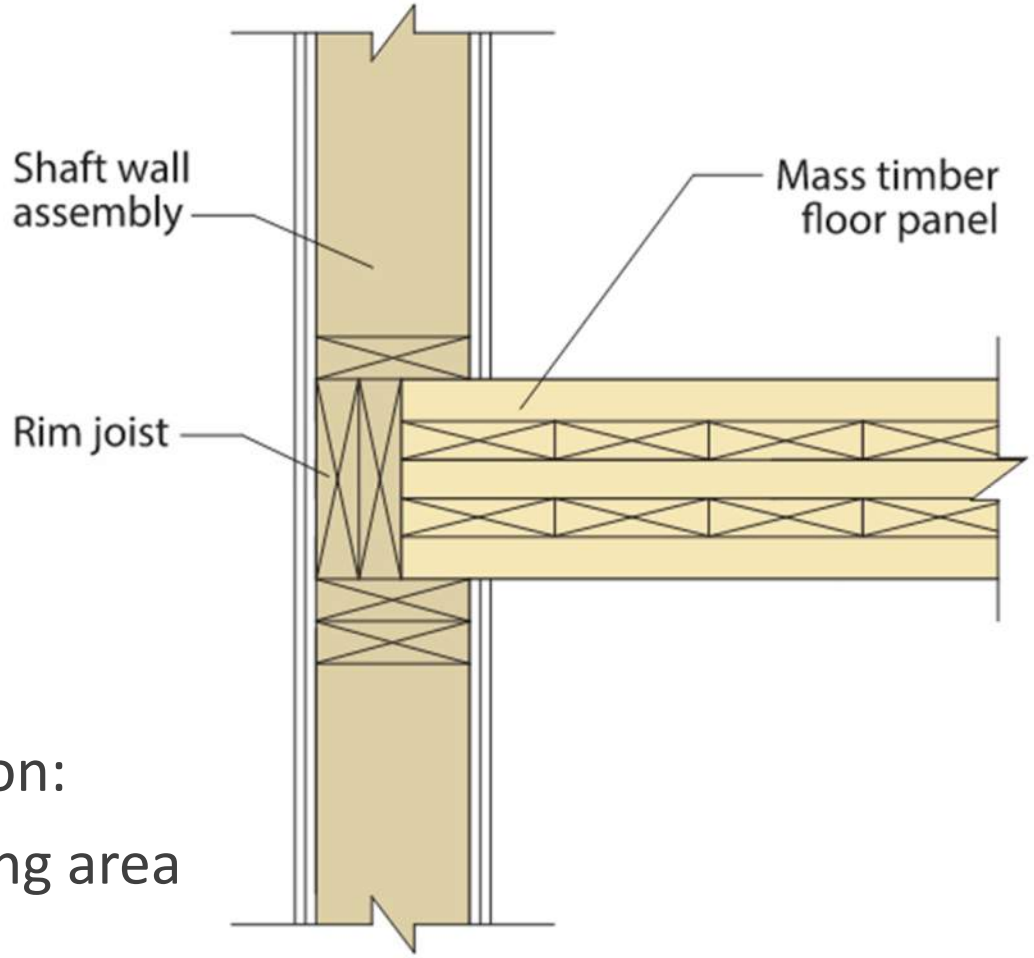
CLT is the “slab,” and it is not disrupting the continuity of the shaft wall.

Platform Construction



# Floor to Shaft Wall Detailing

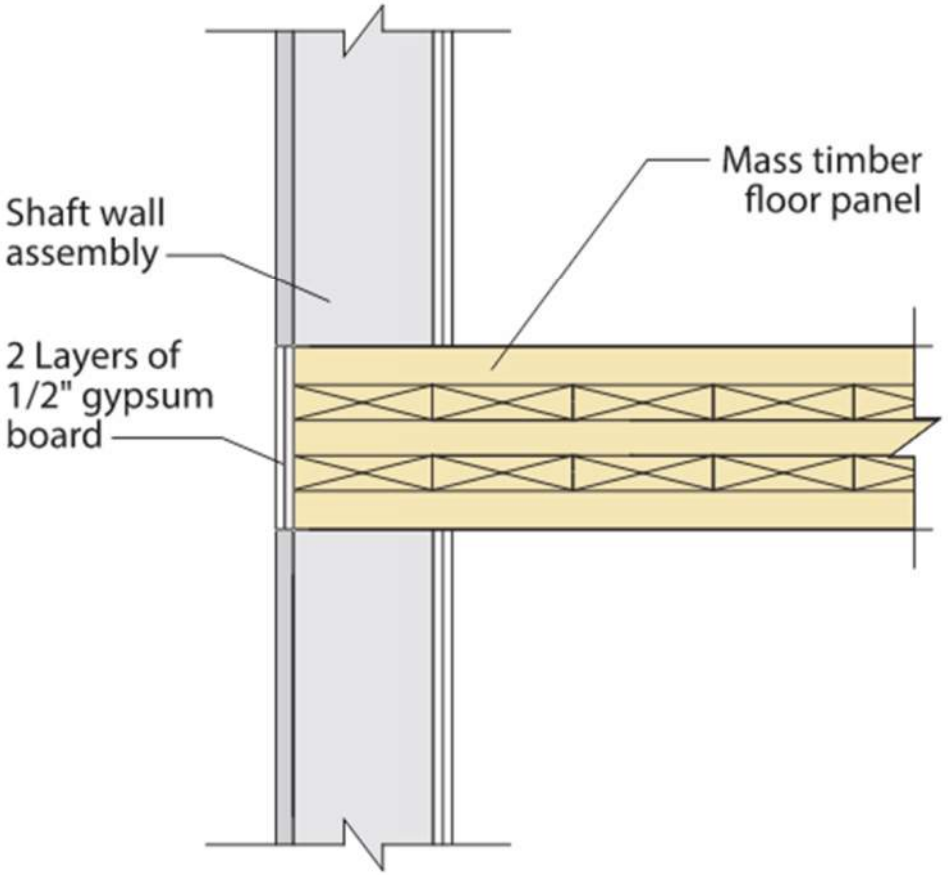


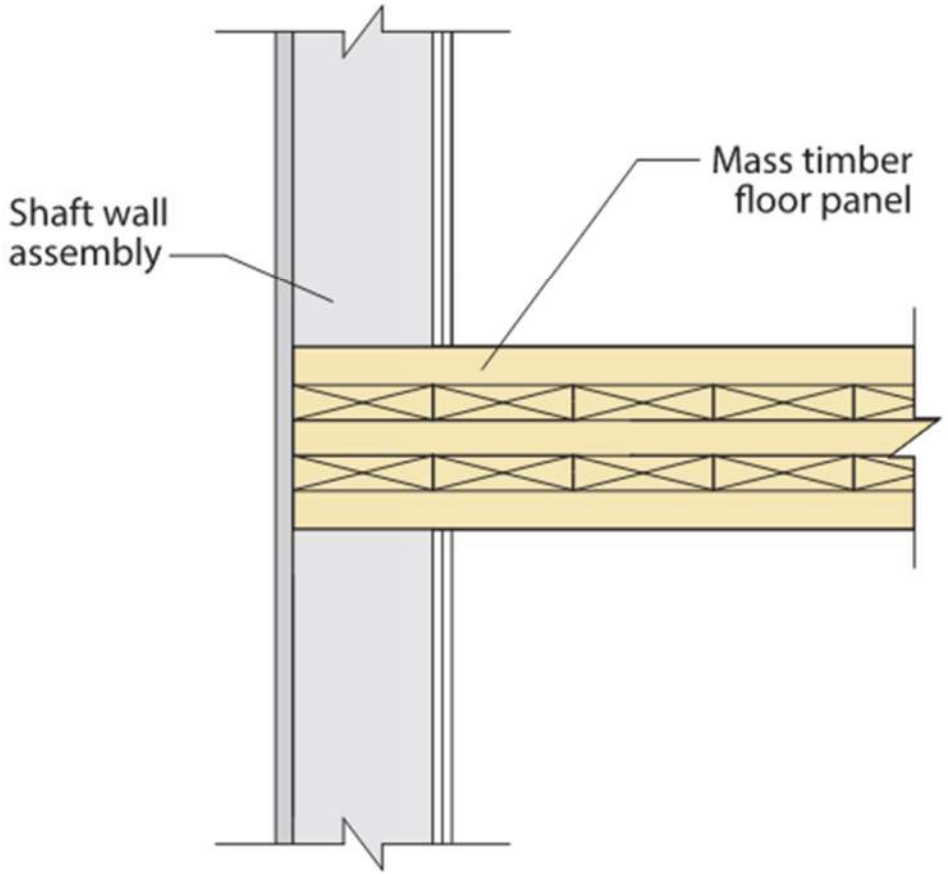




Additional consideration:

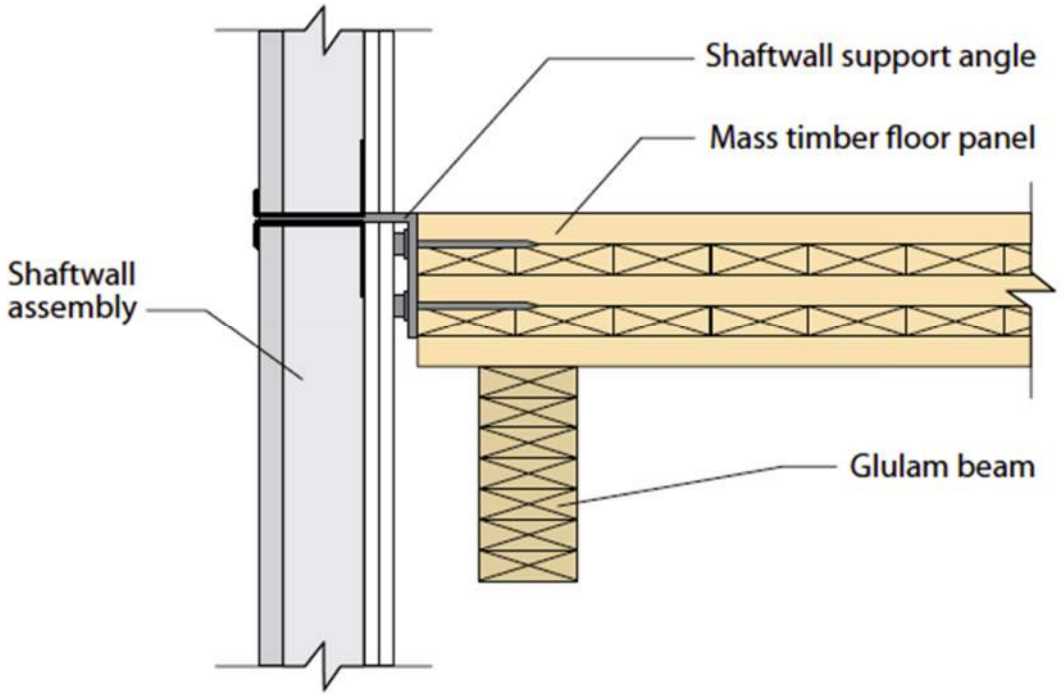
- Adequate CLT bearing area

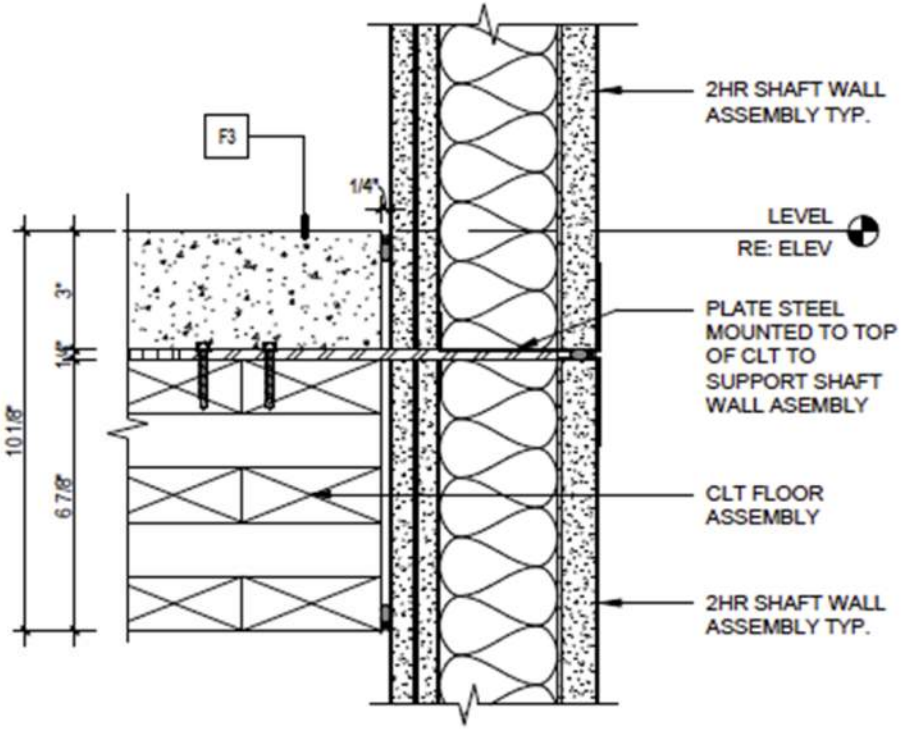
# Shaft wall – Support Details



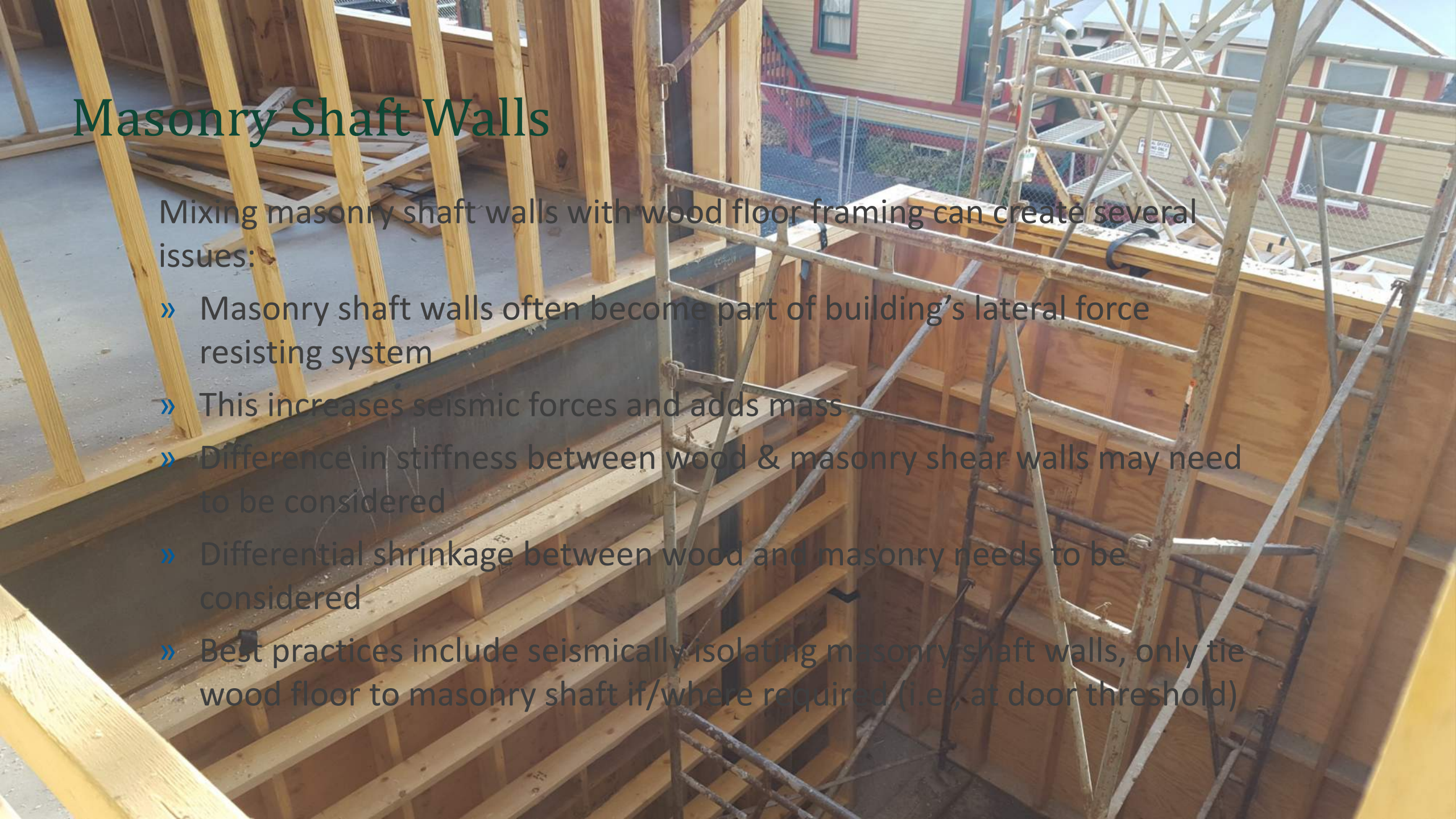
# Shaftliner Systems – Support Details



# Non-Wood Shaft Walls

# Masonry Shaft Walls



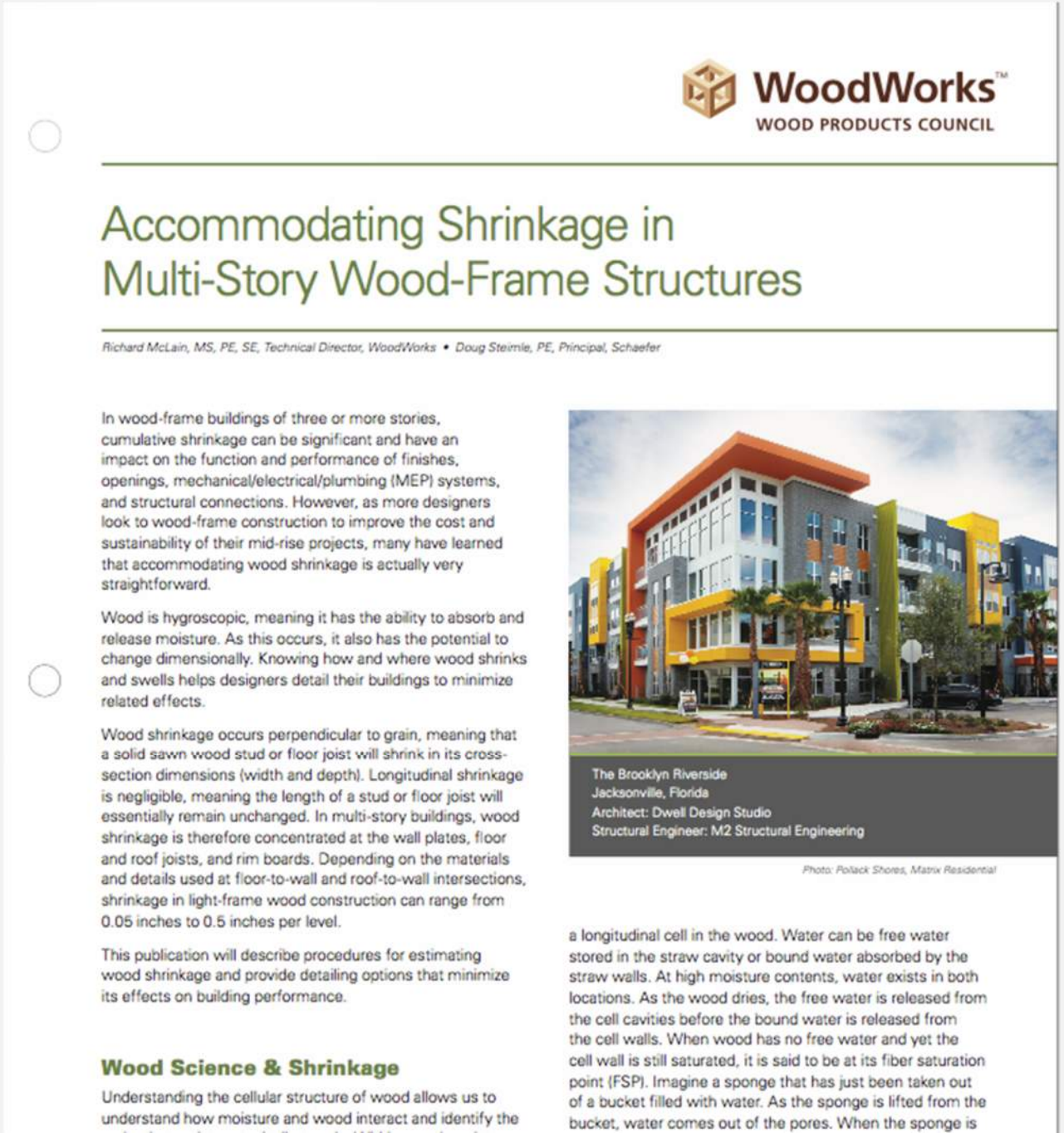
Mixing masonry shaft walls with wood floor framing can create several issues:

- 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)

# Shrinkage & Movement Resource

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

Free resource at **woodworks.org**



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## 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.

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

*Photo: Pollack Shores, Matrix Residential*

### Wood Science & Shrinkage

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

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

# Considerations for Lateral Systems

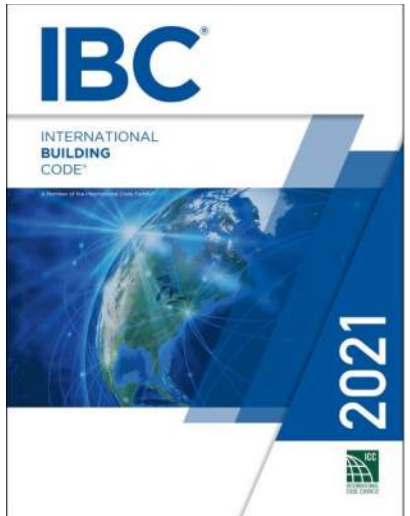
## Prescriptive Code Compliance:

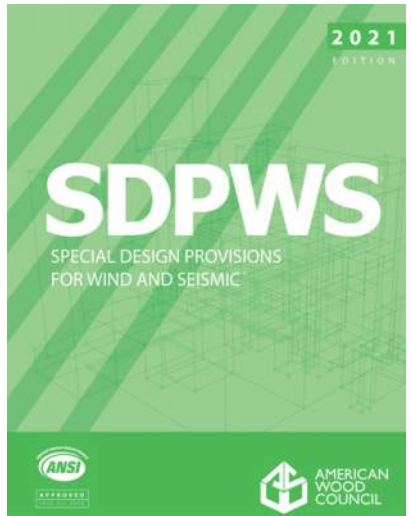
- ☑ Concrete Shear Walls
- ☑ Steel Braced Frames
- ☑ Light Frame Wood Shear Walls (65 ft max)
- ☑ CLT Shear Walls (65 ft max)
- ☒ CLT Rocking Walls

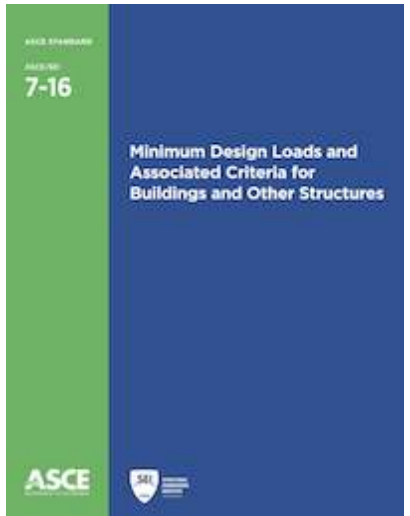
2021 SDPWS, ASCE 7-22

Currently in process!

GU0

# Questions? Ask us anything.

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

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