Mass Timber Shafts *and* Shaft-Wall Solutions for Mass Timber Buildings

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Photo: Alex Schreyer

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Course Description

The rapid growth of mass timber construction in the U.S. has led to a variety of solutions for shaft wall framing. Mass timber buildings can have mass timber shaft walls, light-frame wood shaft walls, or shaft walls constructed of a different building material altogether. The prefabricated nature of mass timber shaft walls also makes them a good solution in light-frame projects. This presentation will cover material and detailing options for shaft walls within mass timber buildings as well as mass timber shaft walls in other building types. Specific emphasis will be on meeting structural demands and fire-resistance rating requirements for various construction types and building heights as demonstrated through case studies of real projects.

Learning Objectives

1. Review code provisions that define fire-resistance ratings for Types III, IV, and V construction.

2. Introduce shaft wall material and assembly options.

3. Provide detailing options that establish fire-resistance continuity at framing intersections while meeting structural demands.

4. Discuss the benefits and challenges of mass timber shaft walls and their applicability to different building types.

Shaft Wall Resource

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

Free resource at **woodworks.org**

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Shaft Wall Solutions for Light-Frame and Mass Timber Buildings

An overview of design considerations, detailing options and code requirements

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

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

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

CONTENTS

Fire Resistance

Fire Barrier Construction

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

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

Credit: StructureCraft

Hotel Magdelena in Austin, TX

Common Shaft Walls

Wood Studs

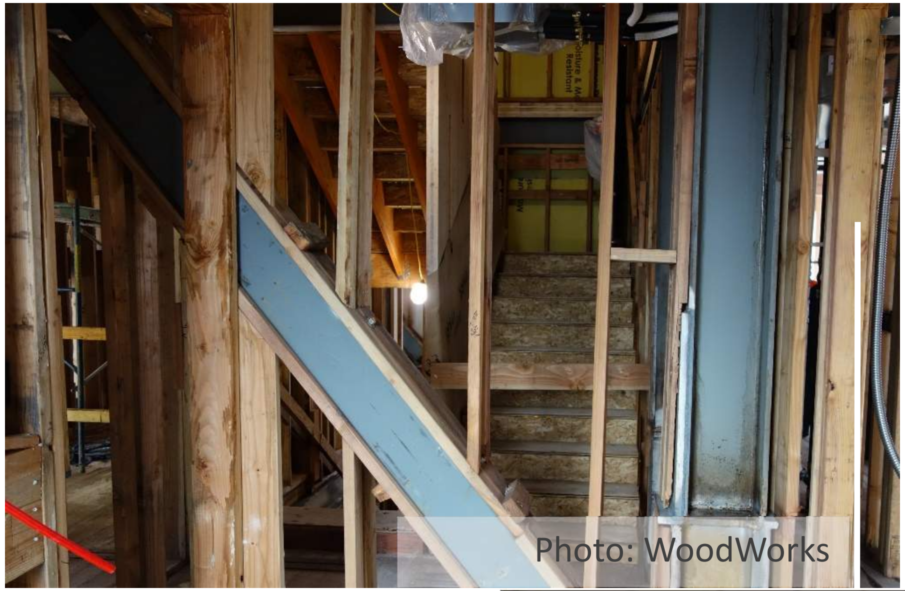


Photo: WoodWorks

Concrete Walls

Photo: C.D. Smith Construction

Photo: Quality Contractors

Shaftliner Panels

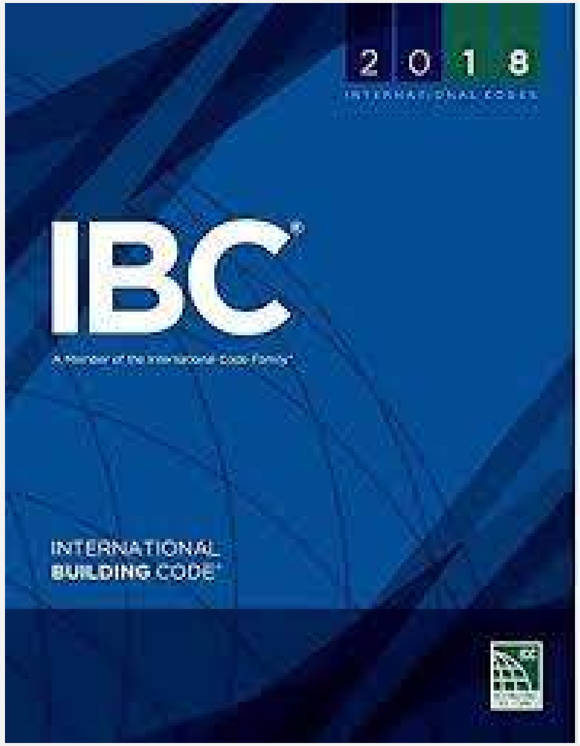
Or CFS studs

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

- Building Separation
- Openings are protected and limited
- Continuous from foundation to/through roof and exterior wall to/through exterior wall
- Structural stability

Fire Barrier

- Shafts; Occupancy Separation
- Openings are protected and limited
- Continuous from floor to floor through concealed spaces at each level

Fire Partition

- Dwelling Unit Separation; Corridors
- Openings are protected
- 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 <u>materials permitted by the building type of construction</u>.

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

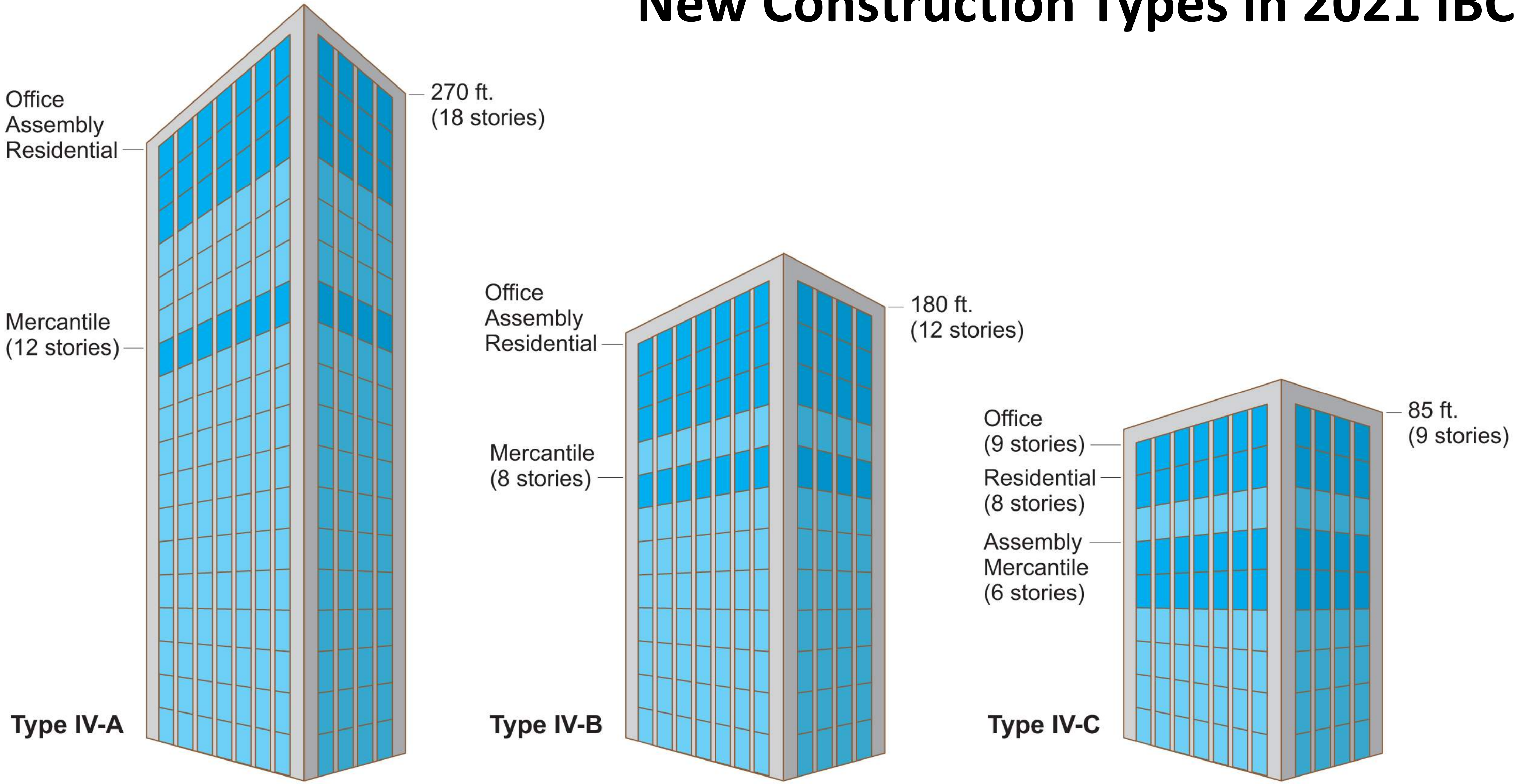
Photo: WoodWorks

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 mass timber buildings of 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** **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

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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.

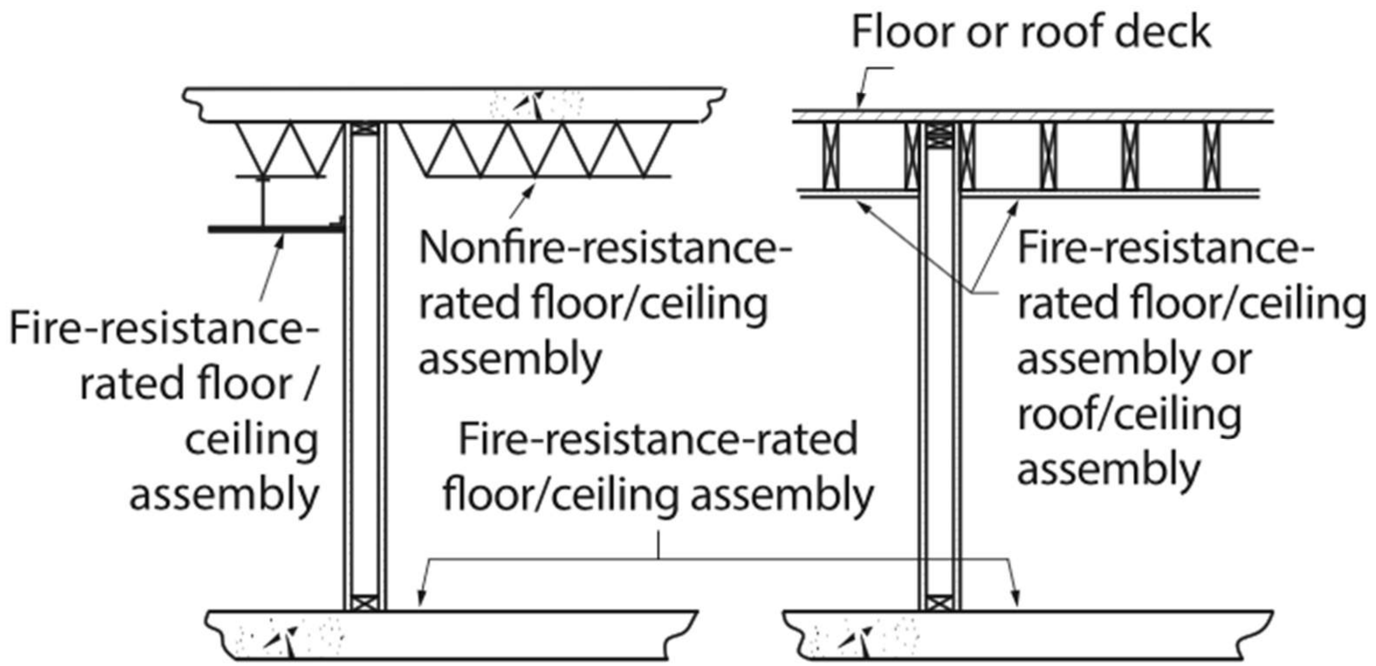
Section 707: Fire Barriers

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

FIGURE 1: IBC Commentary Figure 707.5 – Continuity of Fire Barriers



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 slab to underside of slab (mass timber panel = slab). Slab does not obstruct continuity.

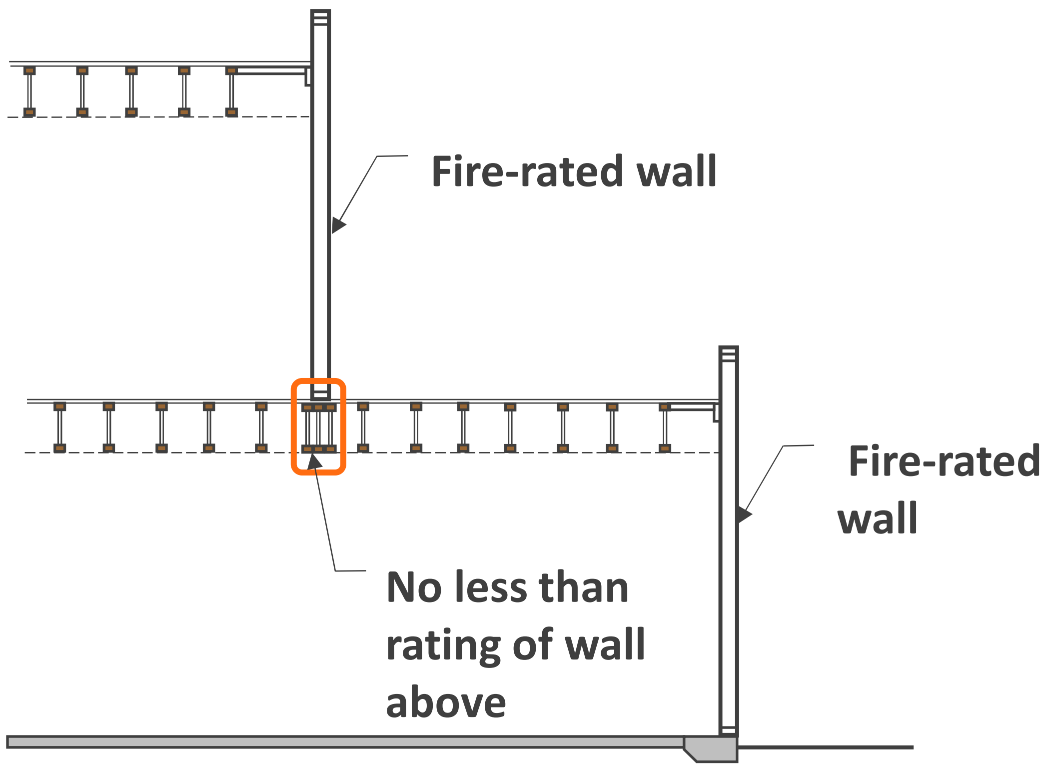
Supporting Construction Provisions

Section 707: Fire Barriers

707.5.1 Supporting Construction:

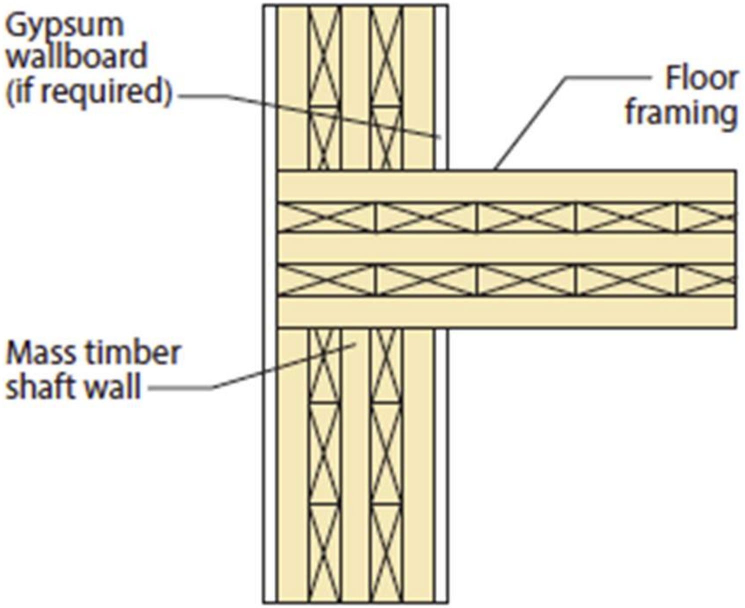
The supporting construction for a fire barrier shall be protected to afford the required fire-resistance rating of the fire barrier supported.

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



Supporting Construction Provisions

Supporting construction differences (any?)



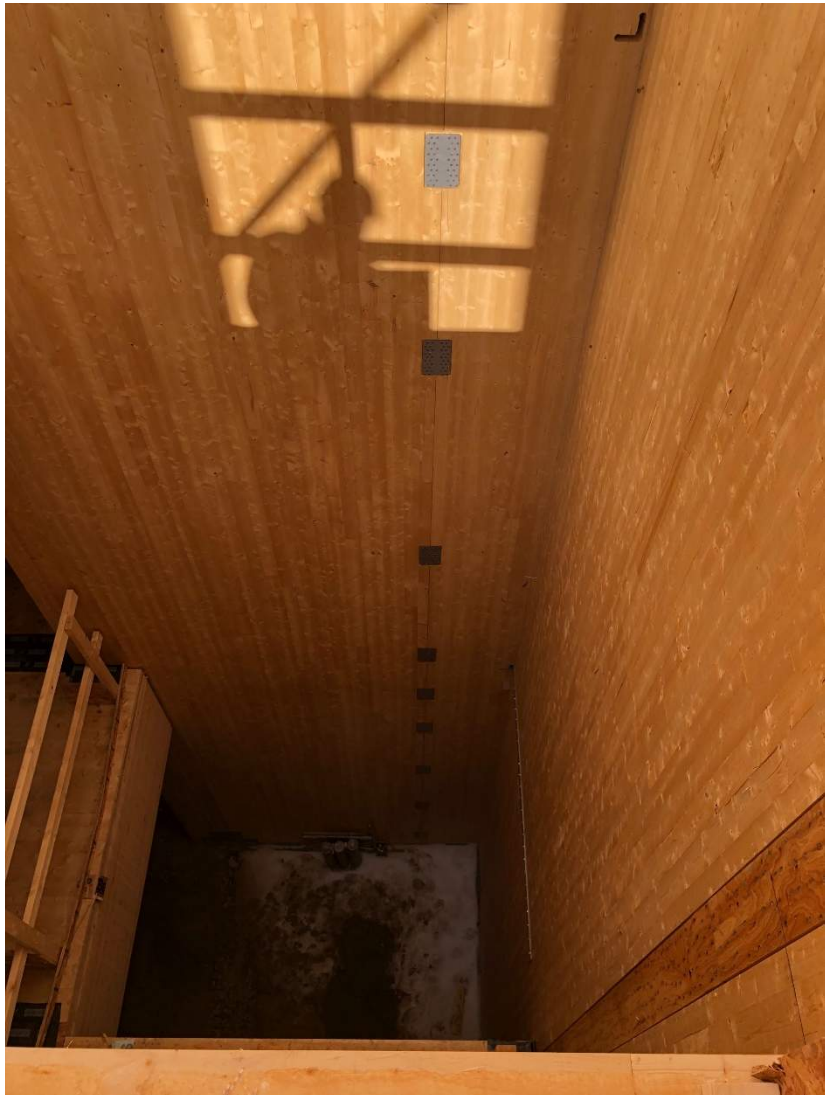


Image: WoodWorks

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 panel should not be considered a supporting element.

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.

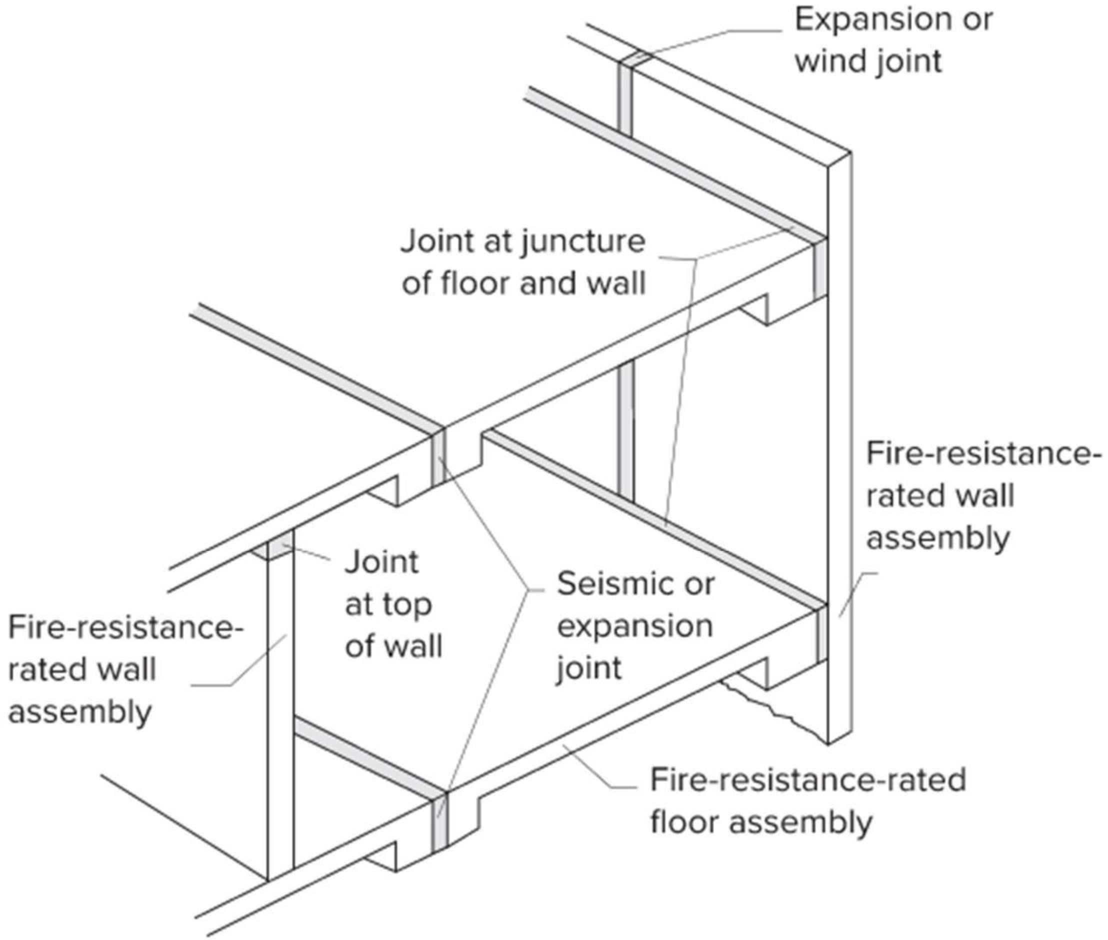


FIGURE 2: IBC Commentary Figure 715.1 – Examples of joint locations

Penetrations in Shaft Walls

Section 713: Shaft Enclosures

713.8 Penetrations.

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

Section 707: Fire Barriers

707.7 Penetrations.

Penetrations of fire barriers shall comply with Section 714.

Penetrations in Shaft Walls

Where are structural penetrations in shaft walls common?

- » Mass Timber Beams to Shaft Wall Connection
- » Stair framing to Shaft Wall Connection

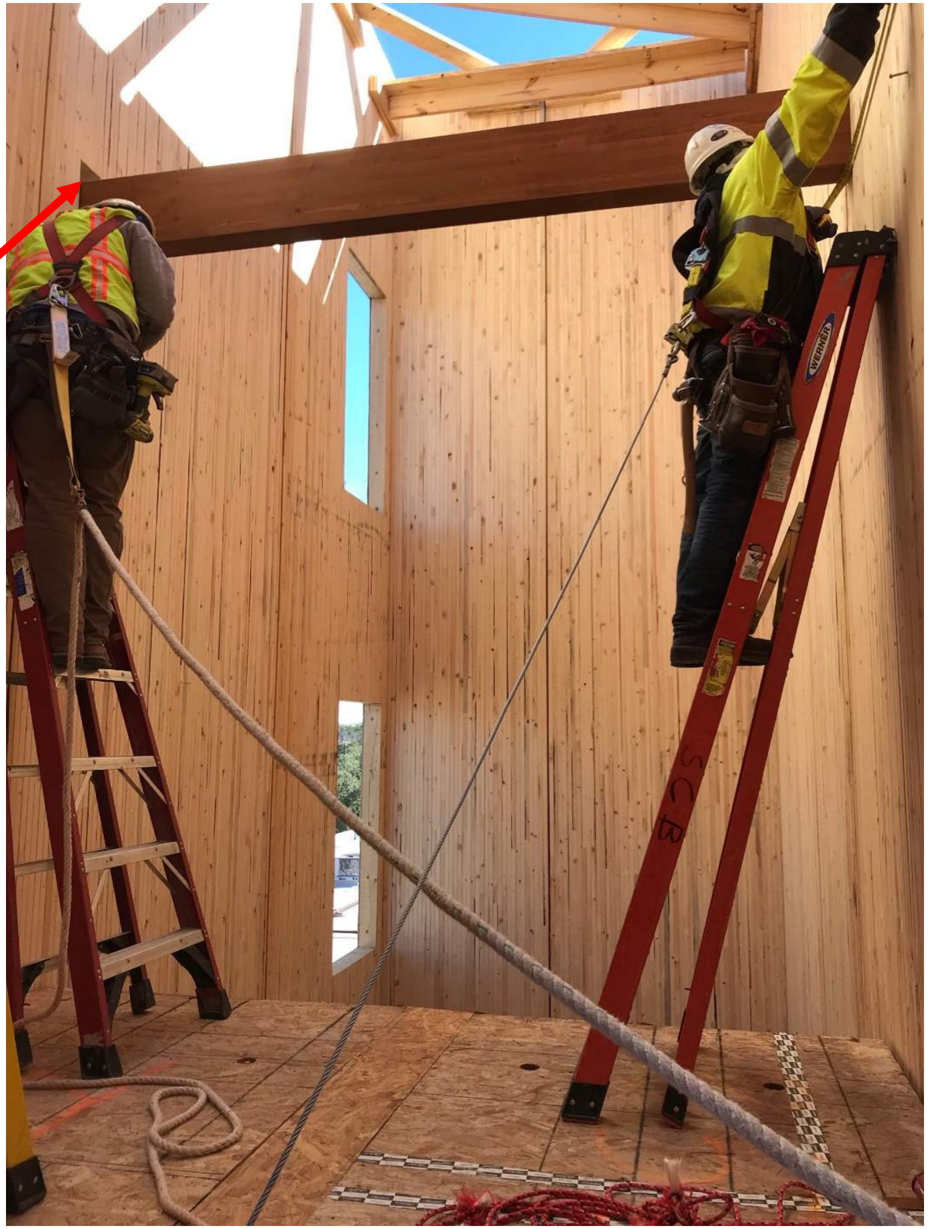
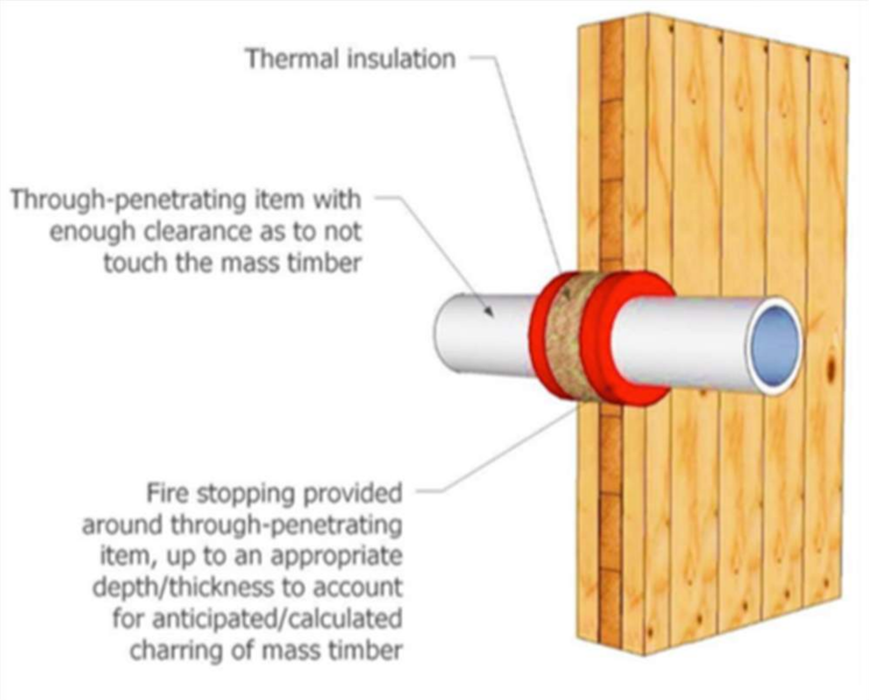


Image: StructureCraft

Penetrations in Shaft Walls



To some, a new way of thinking:

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

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

Images: AWC & FP Innovations

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)

Image: WoodWorks

Shaft Wall Assemblies

Options for Mass Timber Shaft Walls in Mass Timber Buildings

Exposed Mass Timber Shaft Walls

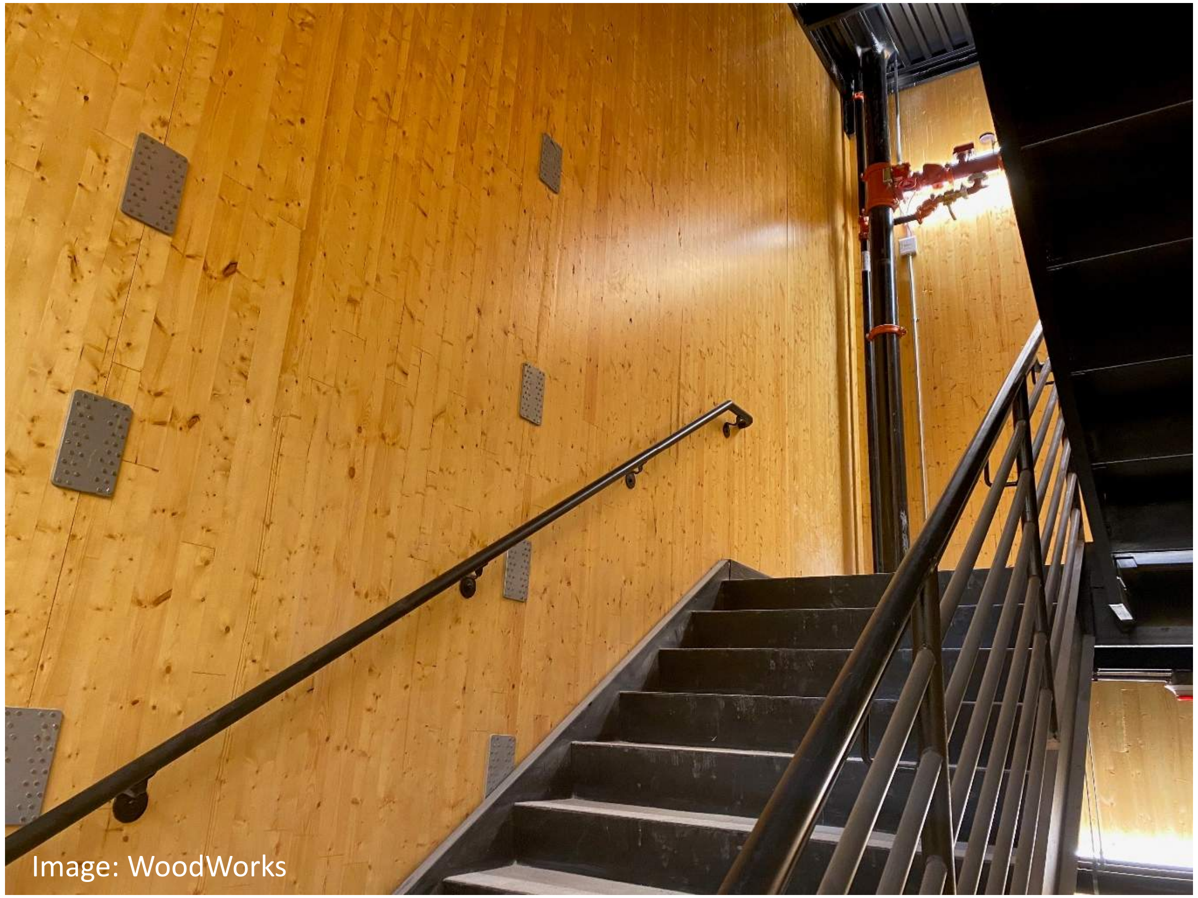


Image: WoodWorks

Mass Timber Shaft Walls w GWB

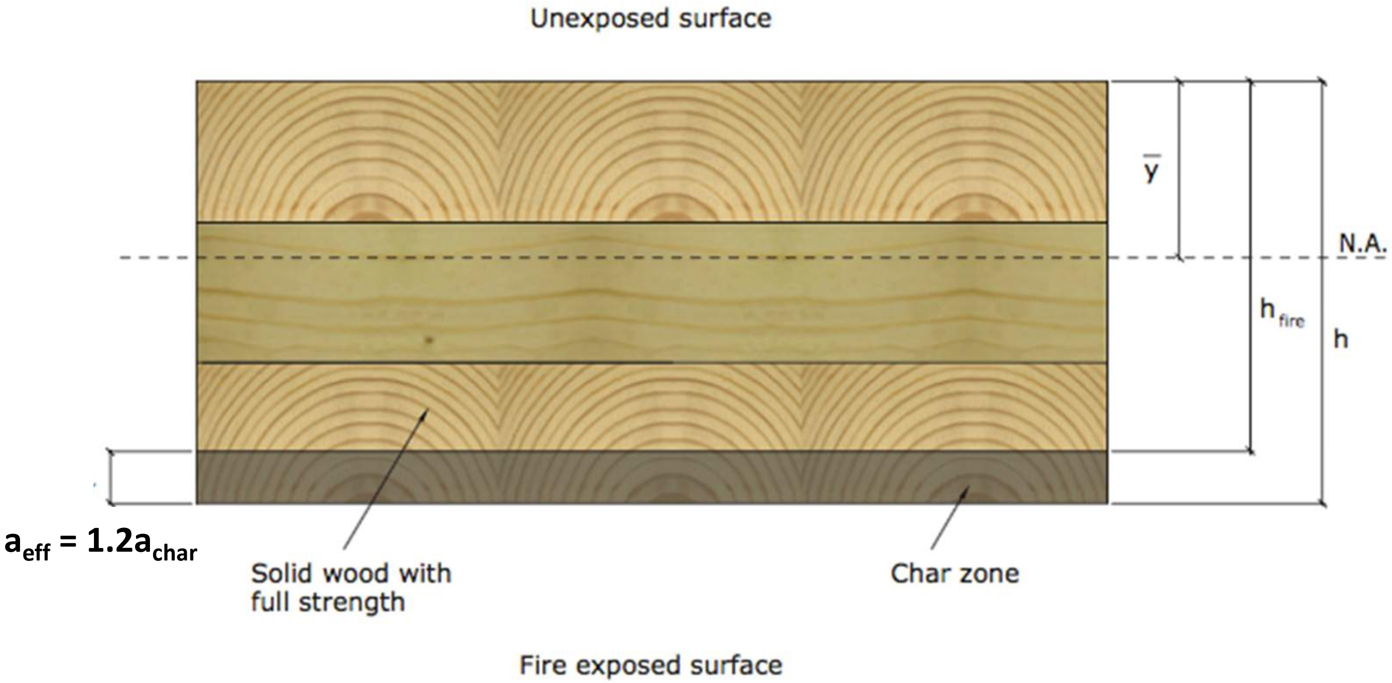
Image: Alex Schreyer

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



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)

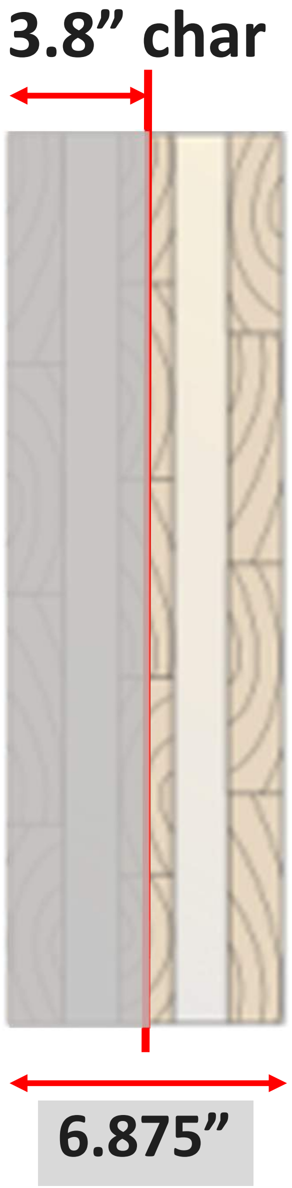
Calculate the apparent wall buckling capacity:

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

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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

Shaft Wall Assemblies

Options for Light-Frame Shaft Walls in Mass Timber Buildings

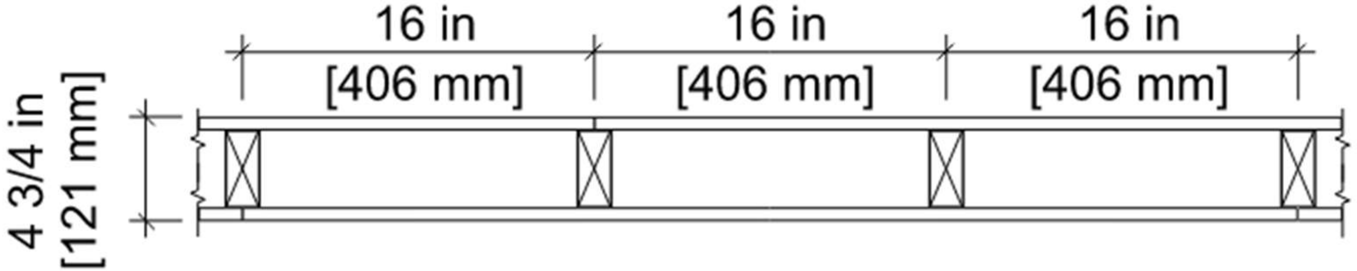


FIGURE 4: UL U305

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

Options for Light-Frame Shaft Walls in Mass Timber Buildings

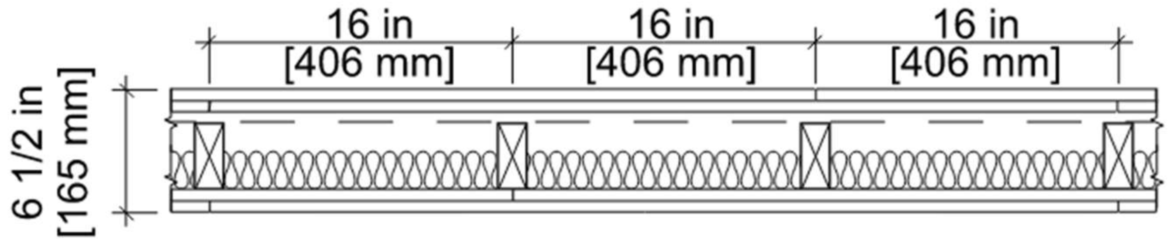


FIGURE 5: UL U334

2-Hour Single wall

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

2-Hour Double Wall

- UL U342
- UL U370
- GA WP 3820

2-Hour Wall with Shaftliner

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

Shaftliner Systems - Benefits & Limitations

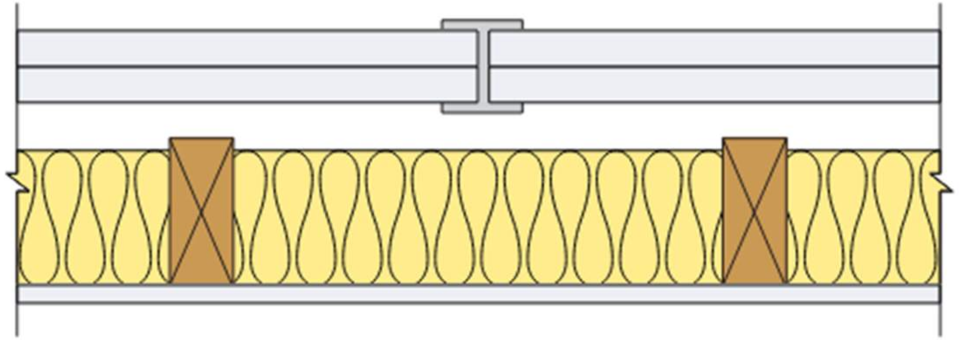
Benefits

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

Limitations

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

» Not structural, requires back-up wood wall



59 STC Sound Transmission

Test Reference: RAL TL 10-290

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

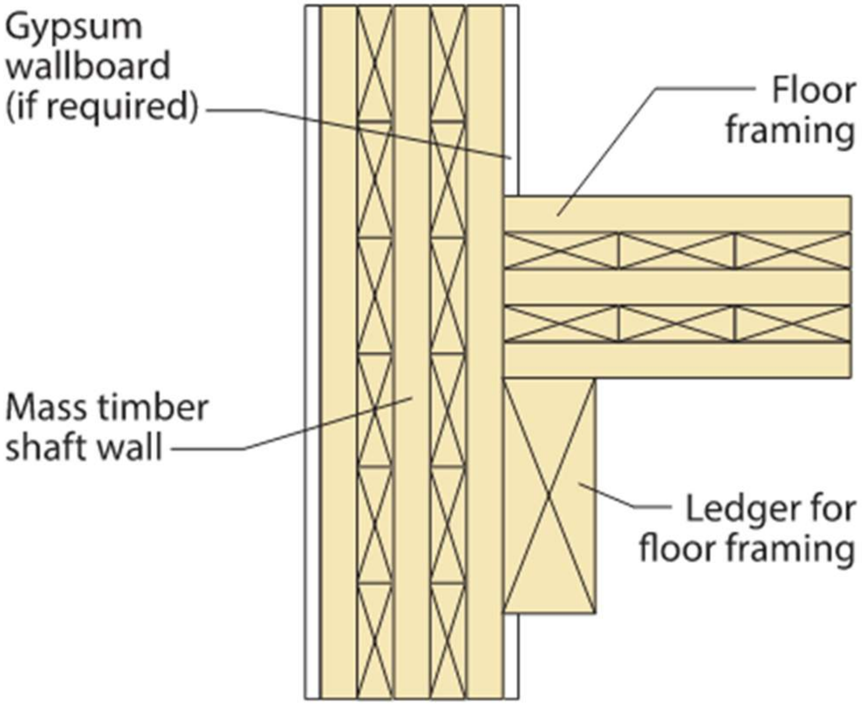
Sound tested with 2"x4" stud wall with 1/2" (12.7 mm) wallboard or interior panels and 3-1/2" (89 mm) fiberglass insulation in stud space

FIGURE 8: UL U373

Credit: Georgia Pacific

Floor to Shaft Wall Detailing

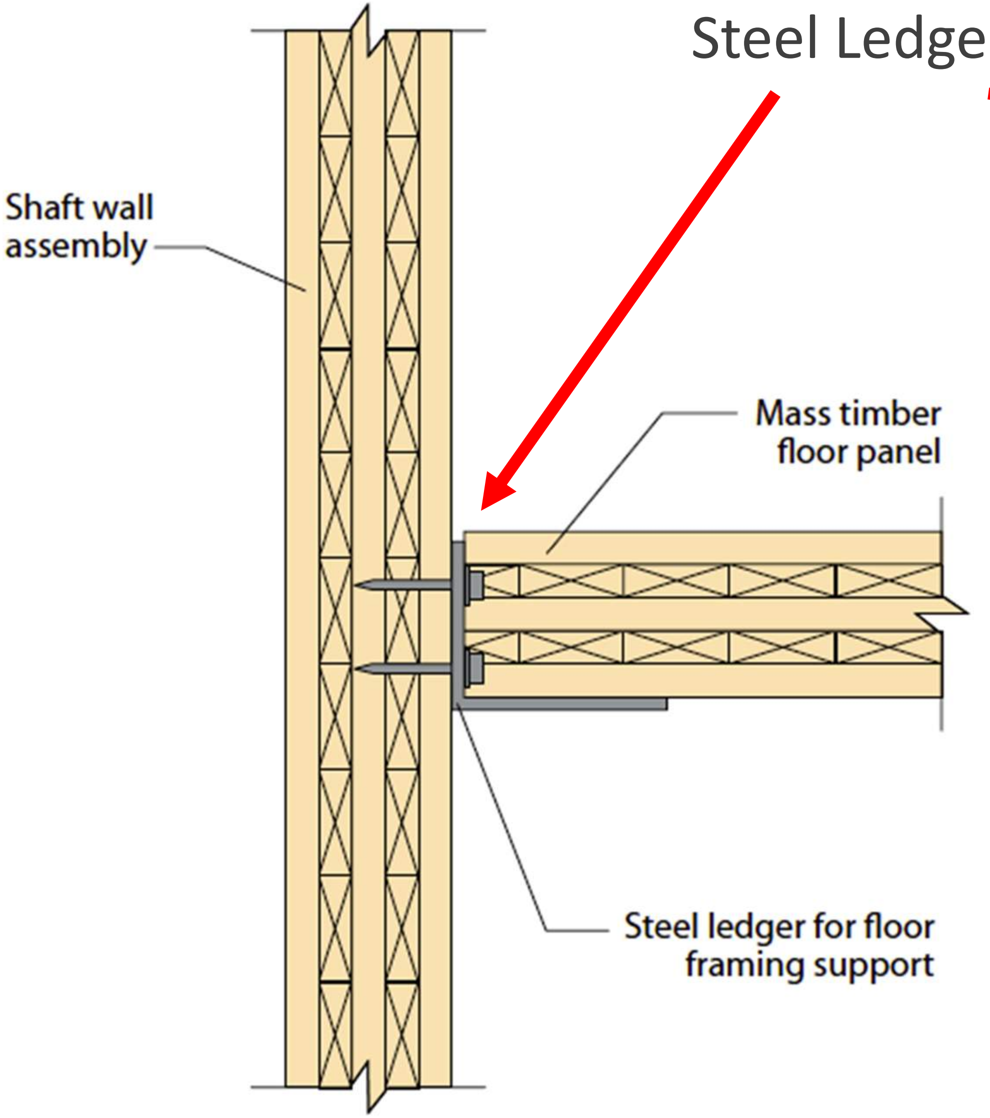
Construction erection and sequencing will inform efficient floor to wall intersection



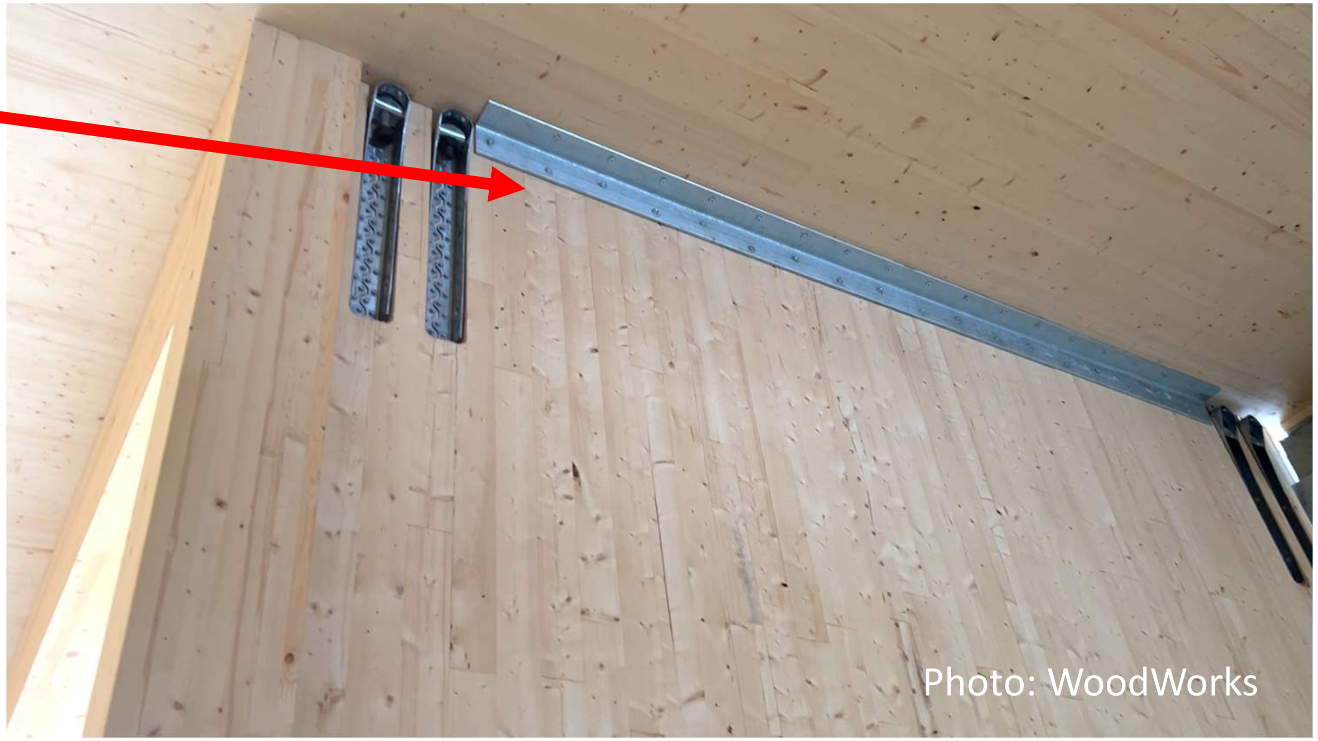
Wood Ledger

Photo: Alex Schreyer

Floor to Shaft Wall Detailing



Steel Ledger



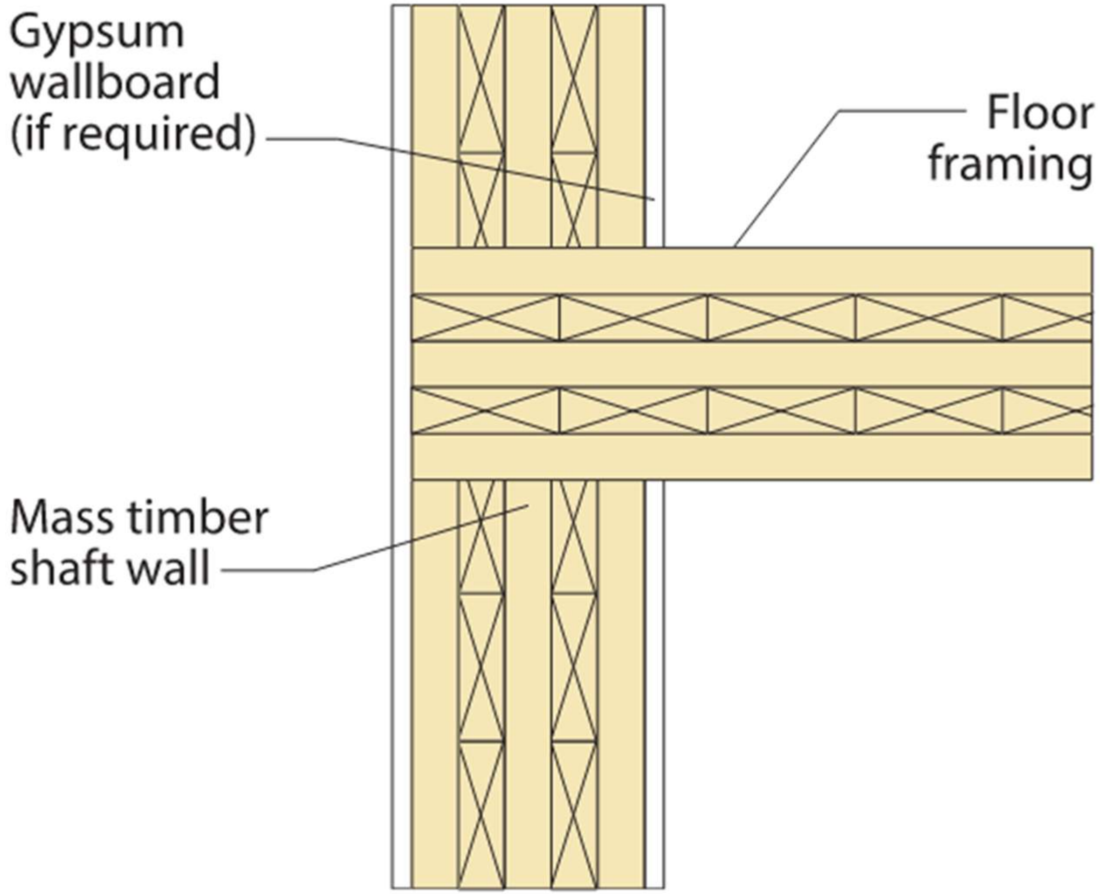
Floor to Shaft Wall Detailing

Recall fire barrier continuity definition:

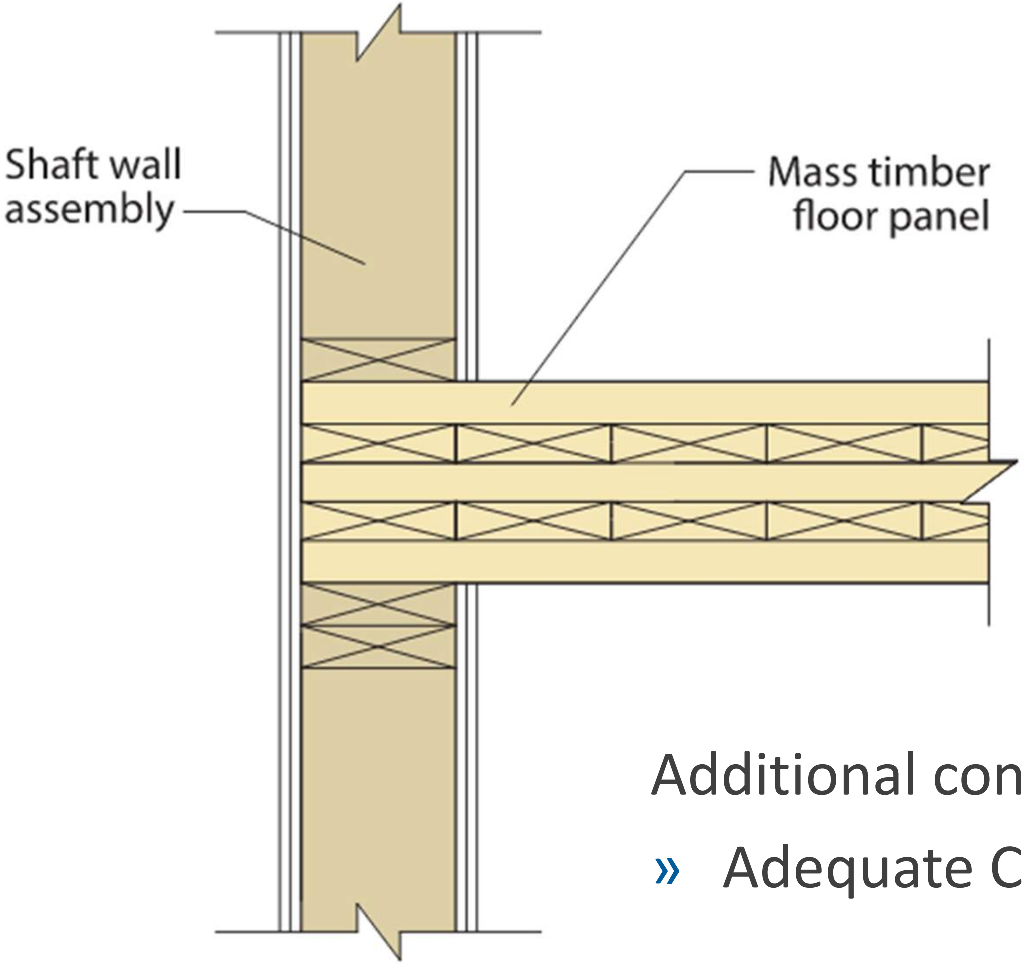
shall extend … to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto

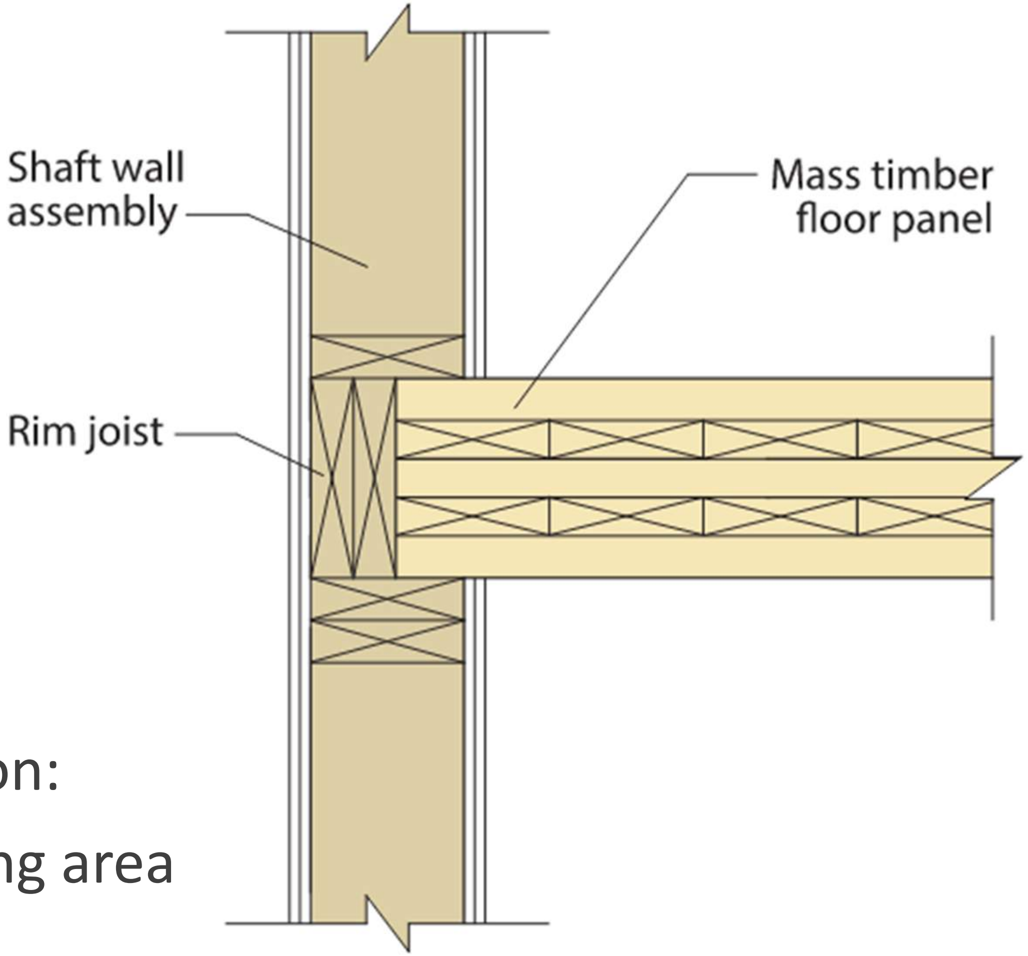
CLT is the "slab," and it is not disrupting the continuity of the shaft wall.

Platform Construction



Floor to Shaft Wall Detailing

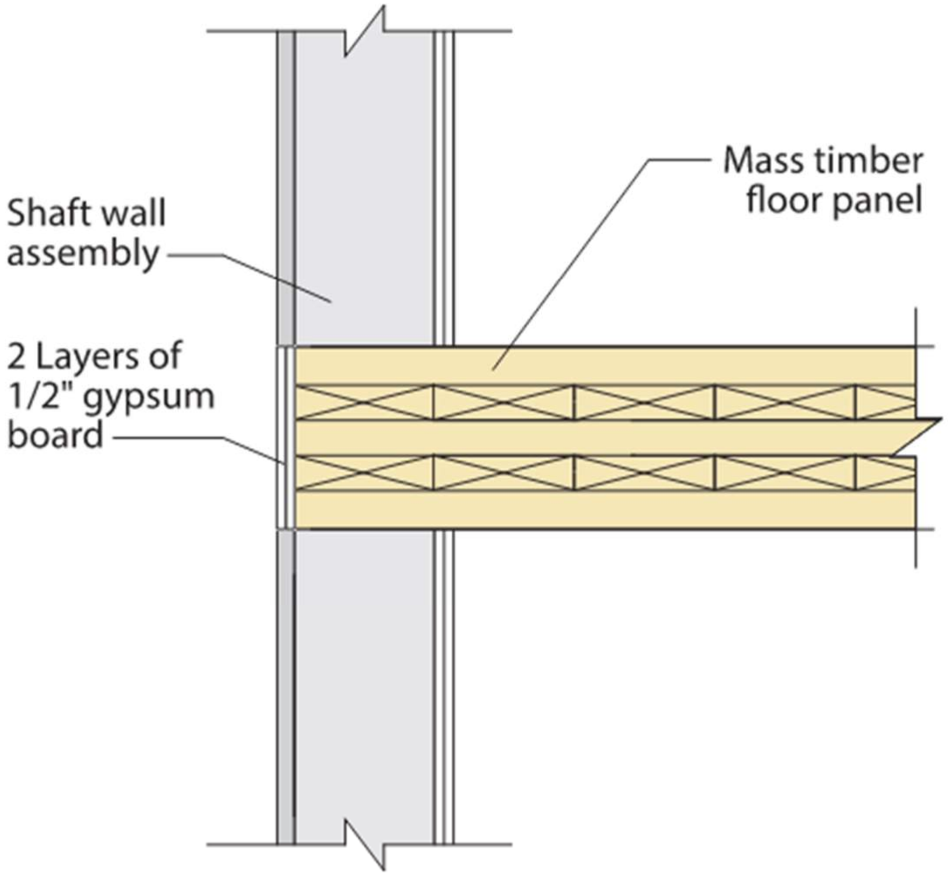


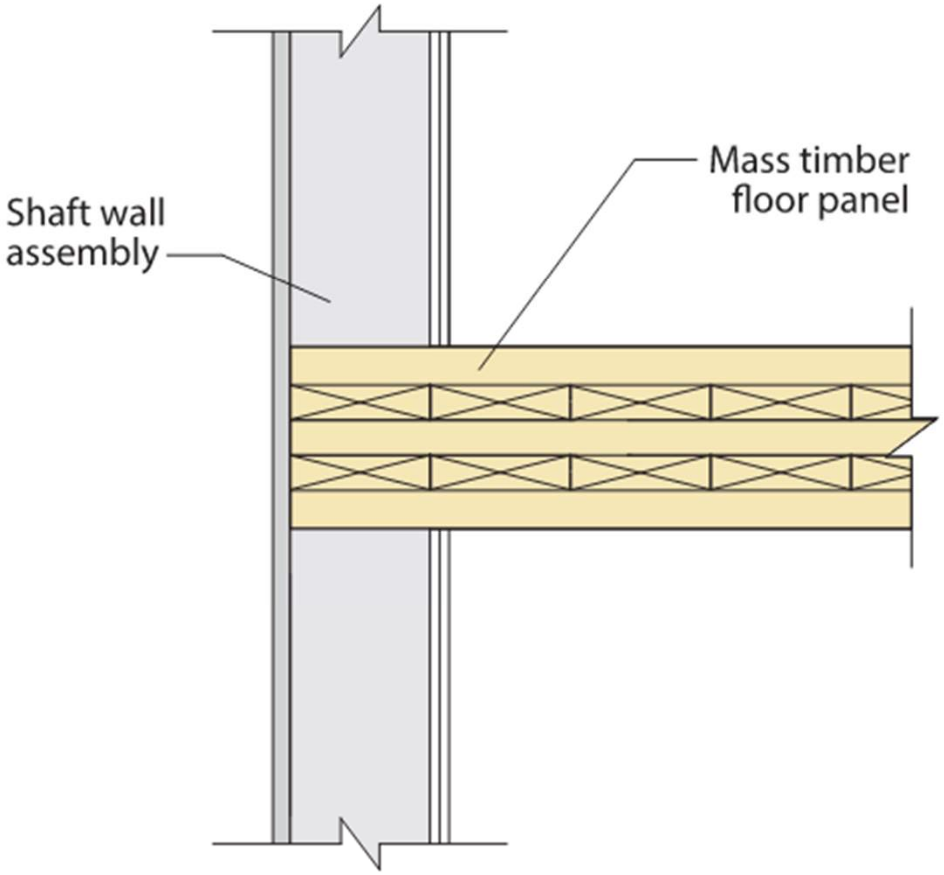


Additional consideration:

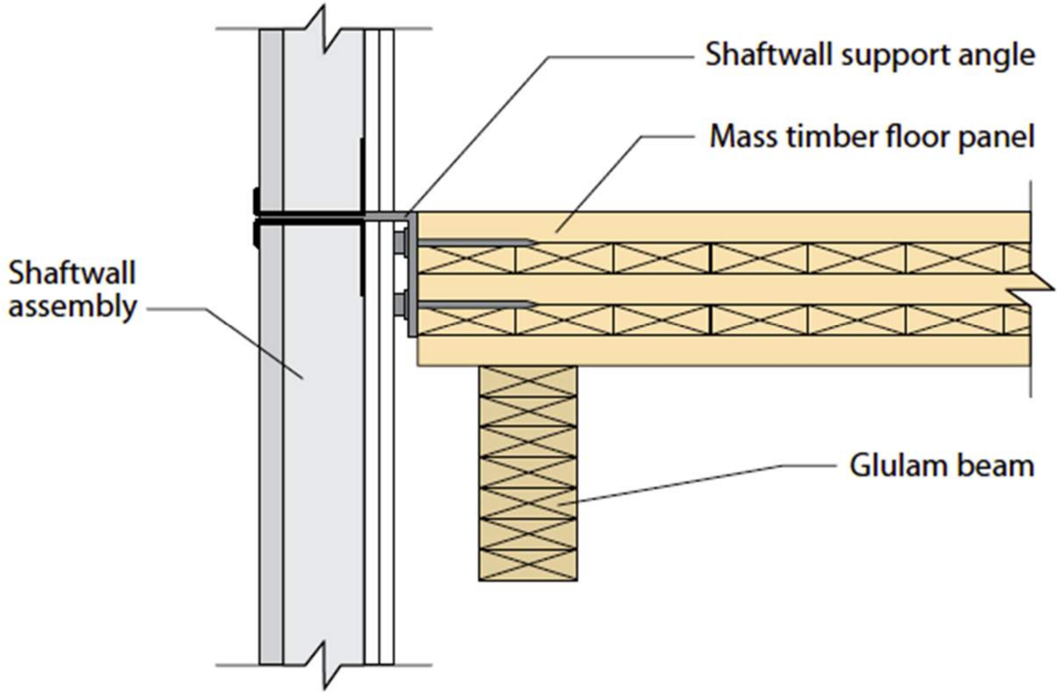
» Adequate CLT bearing area

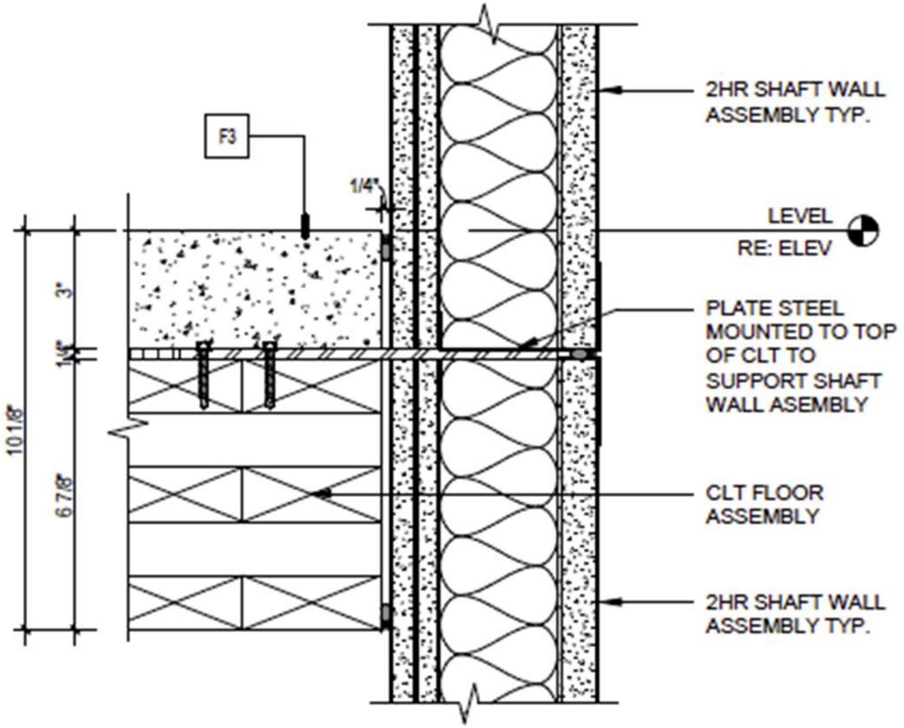
Shaft wall – Support Details





Shaftliner Systems – Support Details





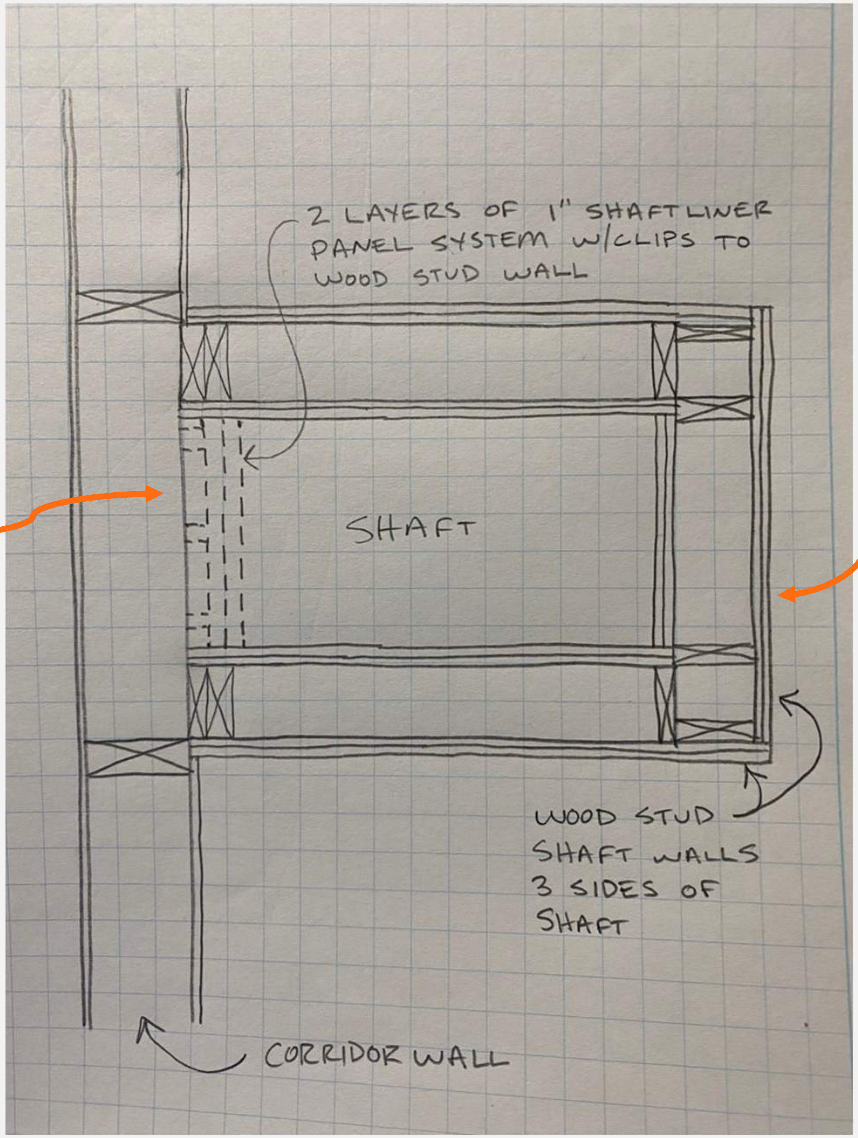
Shaftliner Systems – Configuration Options

Can also utilize wood framed shaft walls or mass timber shaft walls on 1-3 sides and CH studs with shaftliner on remaining side(s)

Image: WoodWorks

Shaftliner Systems – Configuration Options

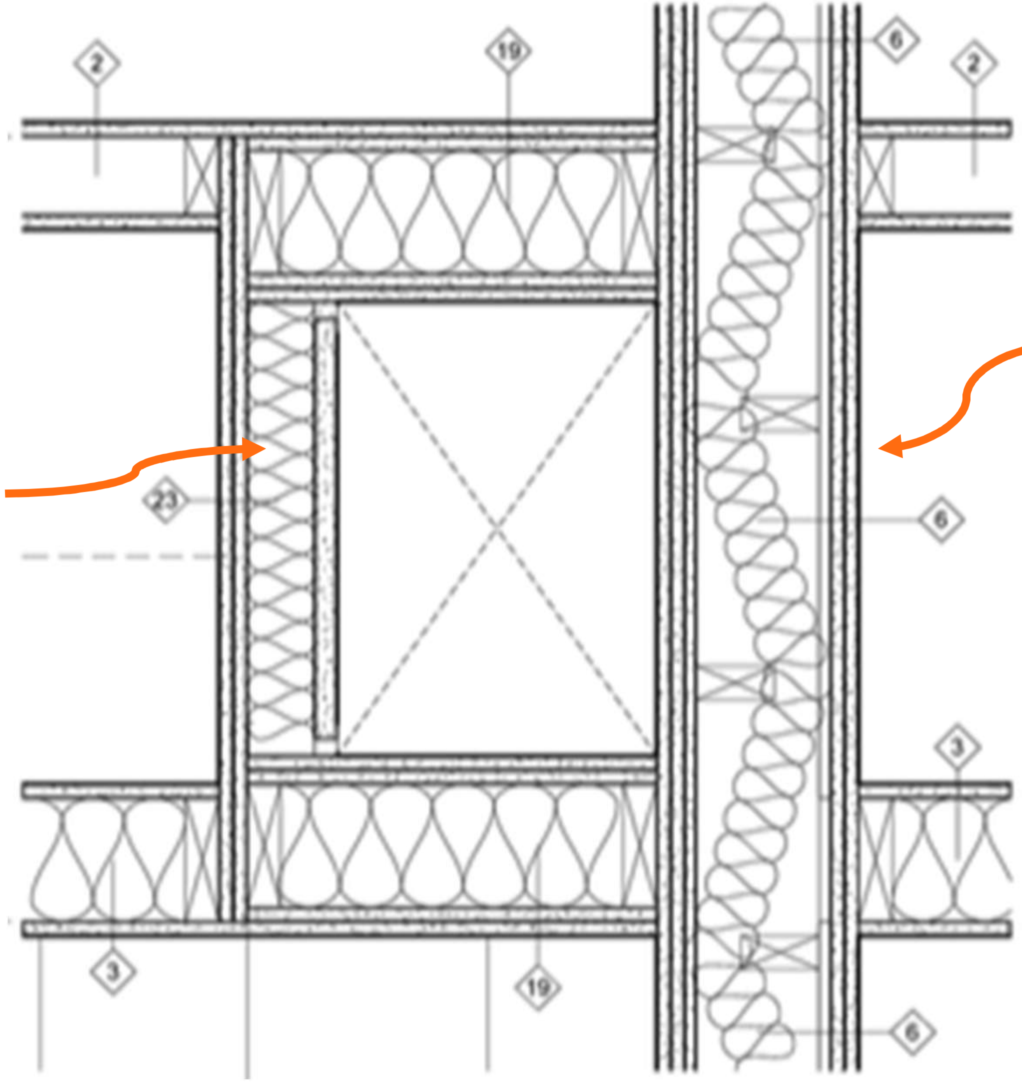
H-stud shaftliner with wood stud wall backup



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

Shaftliner Systems – Configuration Options

CH-stud shaftliner



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

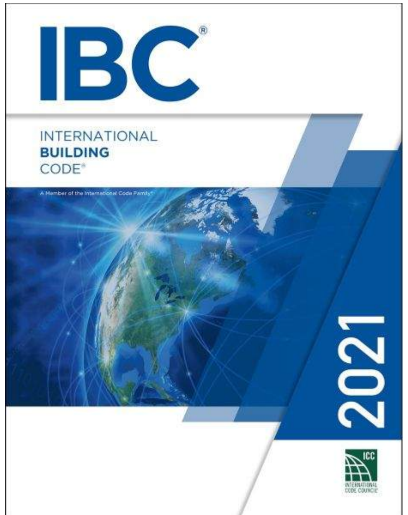
Considerations for Lateral Systems

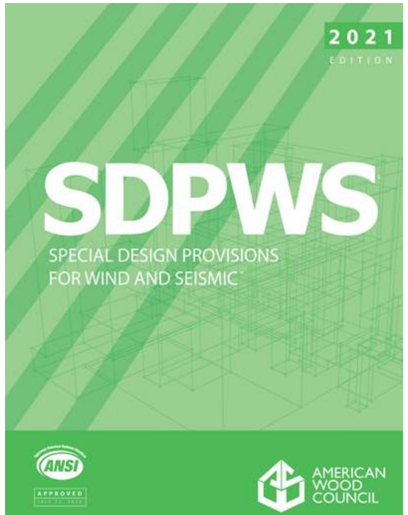
Prescriptive Code Compliance:

- ☑ 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 testing!





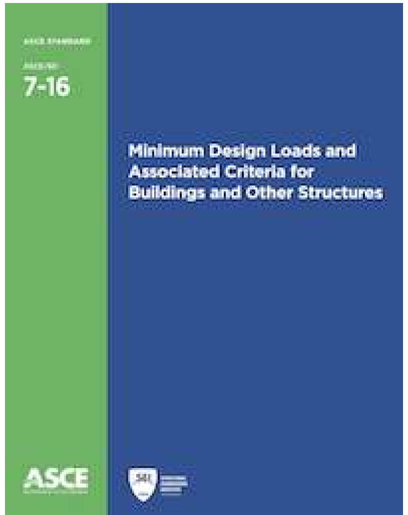



Photo: WoodWorks

Slide 45

GU0 A prescriptive method for CLT rocking walls has been proposed (in case we get questioned on this)

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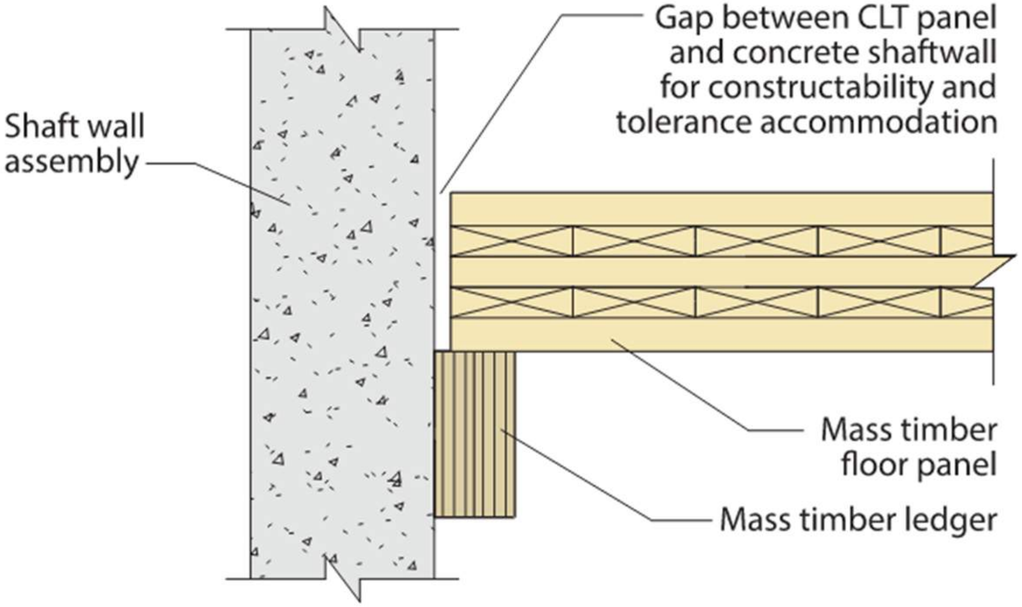
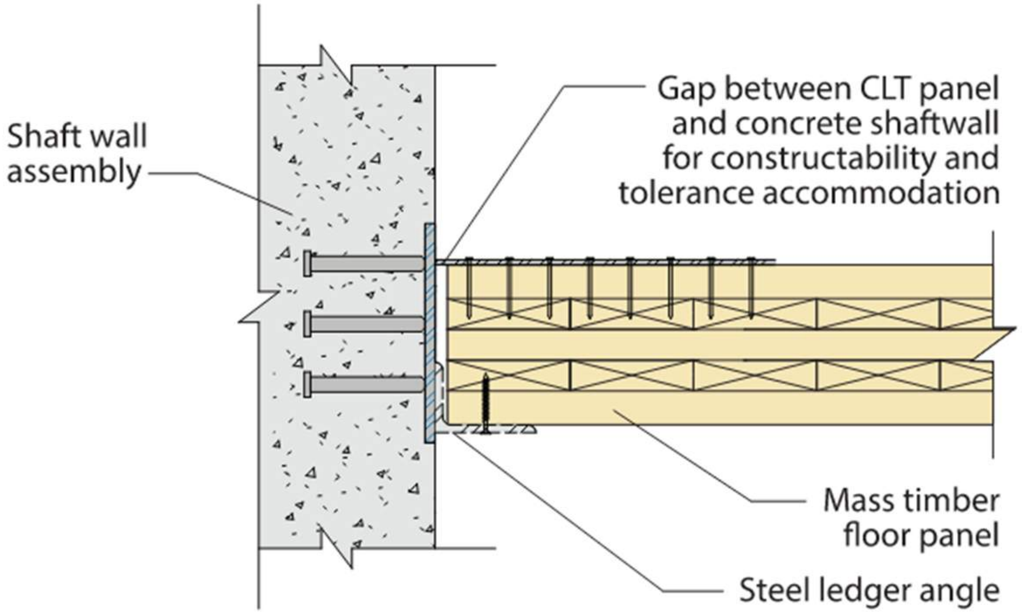
Floor to Shaft Wall Detailing

Consider Differential Material Movements & Tolerances in Detailing



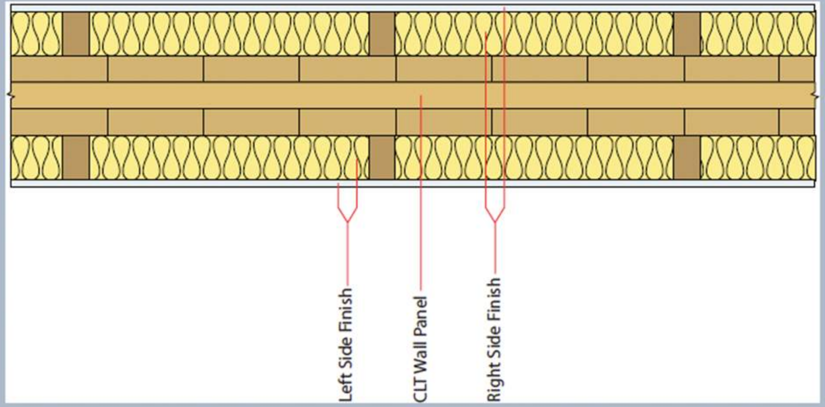


Mass Timber Shaft Wall Acoustics

Acoustics & Sound Control

Inventory of Tested Assemblies

Table 7: Single CLT Wall



CLT Wall Panel	Left Side Finish	Right Side Finish	STC[1]	Source
CLT 3-ply (3.07")	None	None	33	20
	2 layers ½" type X gypsum	None	38	
		2 layers ½" type X gypsum	38	
	2 layers ½" type X gypsum + 2x2 studs @ 16" o.c.	None	40[5]	
		2 layers ½" type X gypsum	44[5]	
		2 layers ½" type X gypsum + 2x2 studs @ 16" o.c.	39[5]	
	2 layers ½" type X gypsum + 2x2 studs @ 24" o.c.	None	45	
		2 layers ½" type X gypsum	47	
		2 layers ½" type X gypsum + 2x2 studs @ 16" o.c.	50	
		2 layers ½" type X gypsum + 2x2 studs @ 24" o.c.	51	

Mass Timber Shafts and Shaft Wall Solutions for Mass Timber Buildings

Presented by:
Matt Harwood (Holmes)

Content also provided by:
Alyson Blair (Holmes)
Chris Grosse (LEVER Architecture)

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

Project Information

- Confidential Office Project in the Pacific Northwest
- 6 Stories Mass Timber Type III-A over Type I-A basement structure
- Team
  - Architect: LEVER
  - Structural Engineer: Holmes
  - Fire & Life Safety Code Consulting: Holmes

Shaft Code Requirements

- IBC Section 713: Shaft Enclosures

- Shafts are constructed as fire barriers

> **713.2 Construction.** Shaft enclosures shall be constructed as *fire barriers* in accordance with Section 707 or horizontal assemblies in accordance with Section 711, or both.

- Shaft fire resistance rating (independent of construction type)
    - 1 hr: < 4 stories
    - 2 hrs: 4 stories or more

    *not less than the floor it is penetrating

Shaft Code Requirements

- 713.5 Shaft continuity requirements per fire barrier requirements

713.5 Continuity. Shaft enclosures shall be constructed as *fire barriers* in accordance with Section 707 or *horizontal assemblies* constructed in accordance with Section 711, or both, and shall have continuity in accordance with Section 707.5 for *fire barriers* or Section 711.2.2 for *horizontal assemblies*, as applicable.

- 707.5 Fire barrier continuity requirements

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

Shaft Code Requirements

- 707.5.1 Supporting Construction: required to be the same fire resistance rating of the fire barrier being supported

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.

Shaft Code Requirements

Floor & secondary members FRR requirements per construction type

	Type I		Type II		Type III		Type IV				Type V	
	A	B	A	B	A	B	A	B	C	HT	A	B
FRR	2	2	1	0	1	0	2	2	2	HT	1	0

Shaft FRR (independent of construction type*)

	< 4 stories	4 or more stories
FRR	1 hr	2 hr

Shaft Code Requirements

Floor & secondary members FRR requirements per construction type

	Type I		Type II		Type III		Type IV				Type V	
	A	B	A	B	A	B	A	B	C	HT	A	B
FRR	2	2	1	0	1	0	2	2	2	HT	1	0

Shaft FRR (independent of construction type*)

	< 4 stories	4 or more stories
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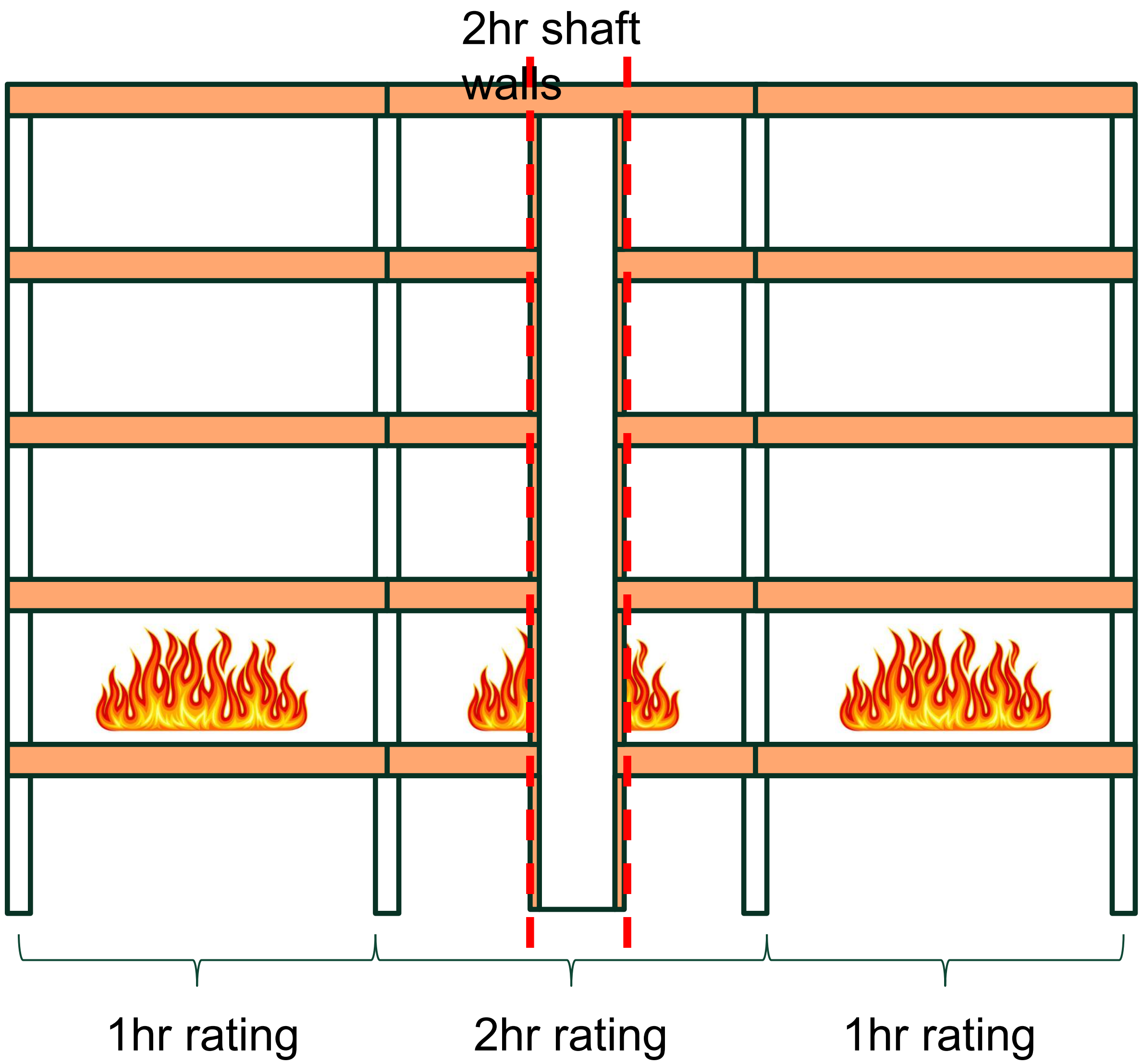
Shaft Code Requirements

"Why have a shaft supported by a floor with a fire rating higher than the remainder of the building? Won't you just end up with your shaft still standing while the building collapses around it?"

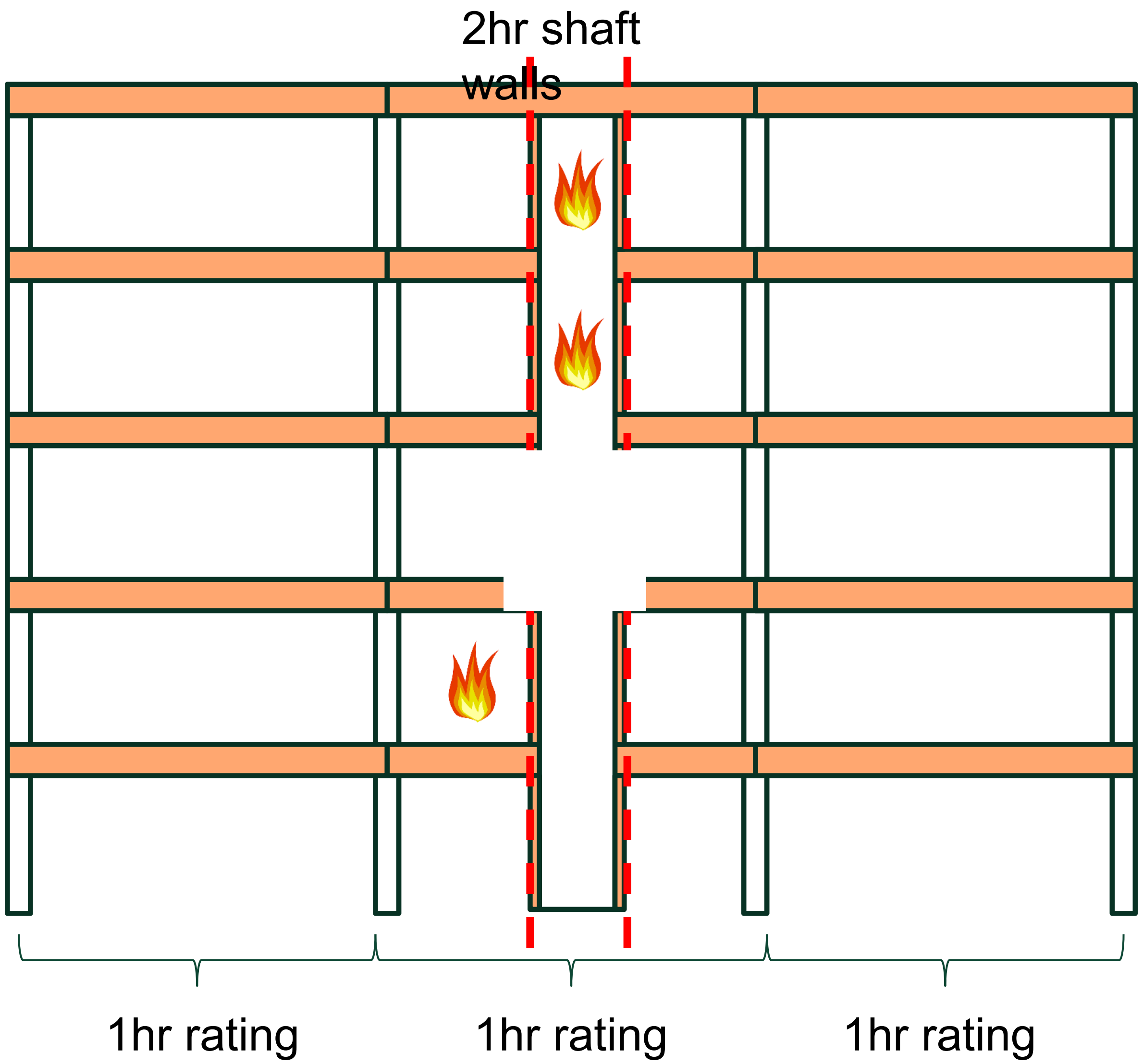


Shaft Code Requirements

"Why have a shaft supported by a floor with a fire rating higher than the remainder of the building? Won't you just end up with your shaft still standing while the building collapses around it?"

Answer:

- Required by IBC!
- Without this, potential for fire spread through 2hr shaft to occur at 1hr fire exposure



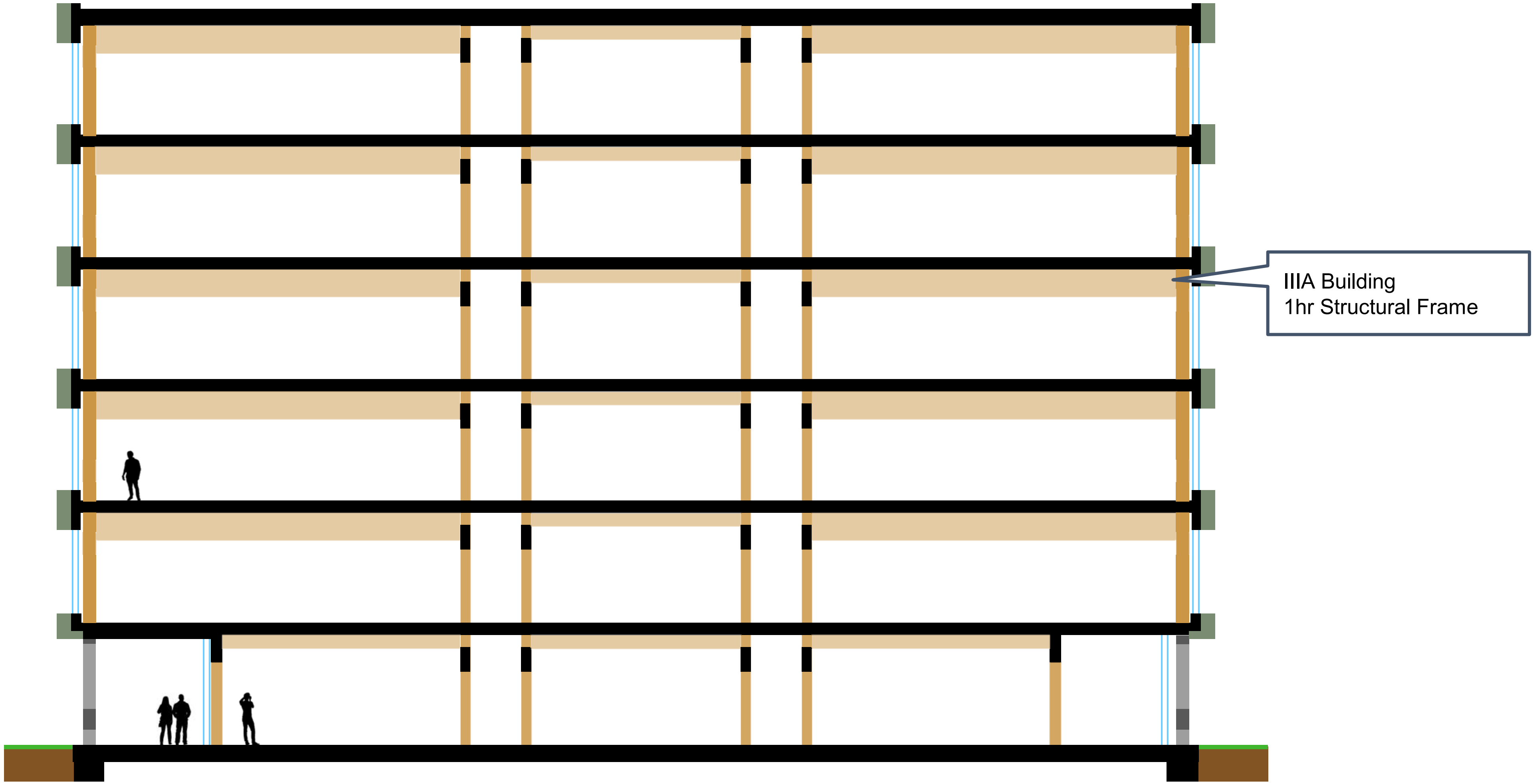
Building Overview

270’x140’ 6 storey all mass timber superstructure

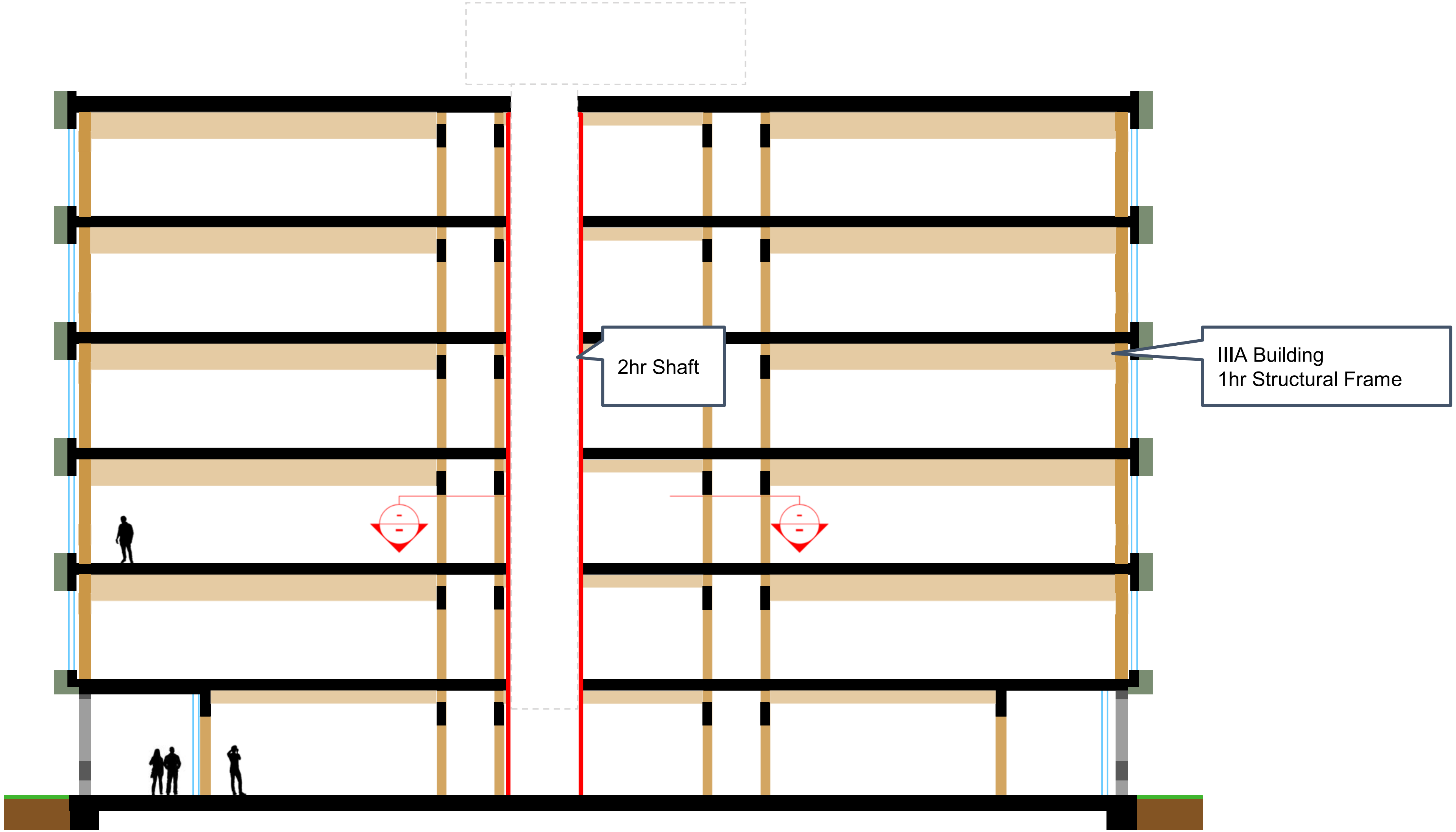
Structural System:

- Number of innovative structural solutions outside of design codes
- Long-span composite (CLT/GLT) floor cassettes (requires testing)
- Perimeter lateral & gravity structure (requires testing)
- Internal CLT shear walls with BRB hold-downs (relies on previous testing)

Shaft Schematic Approaches



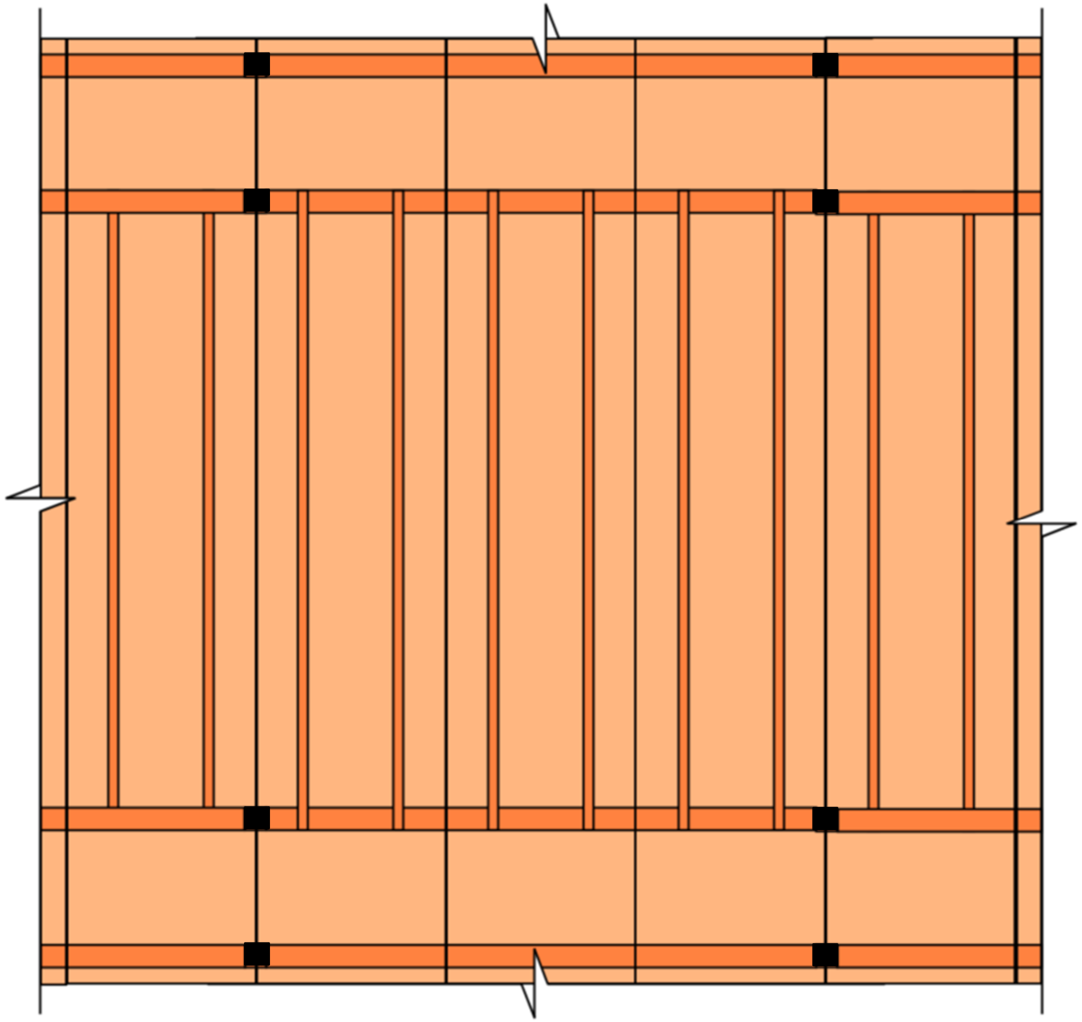
Shaft Schematic Approaches



Shaft Schematic Approaches

General Structural Gravity System:

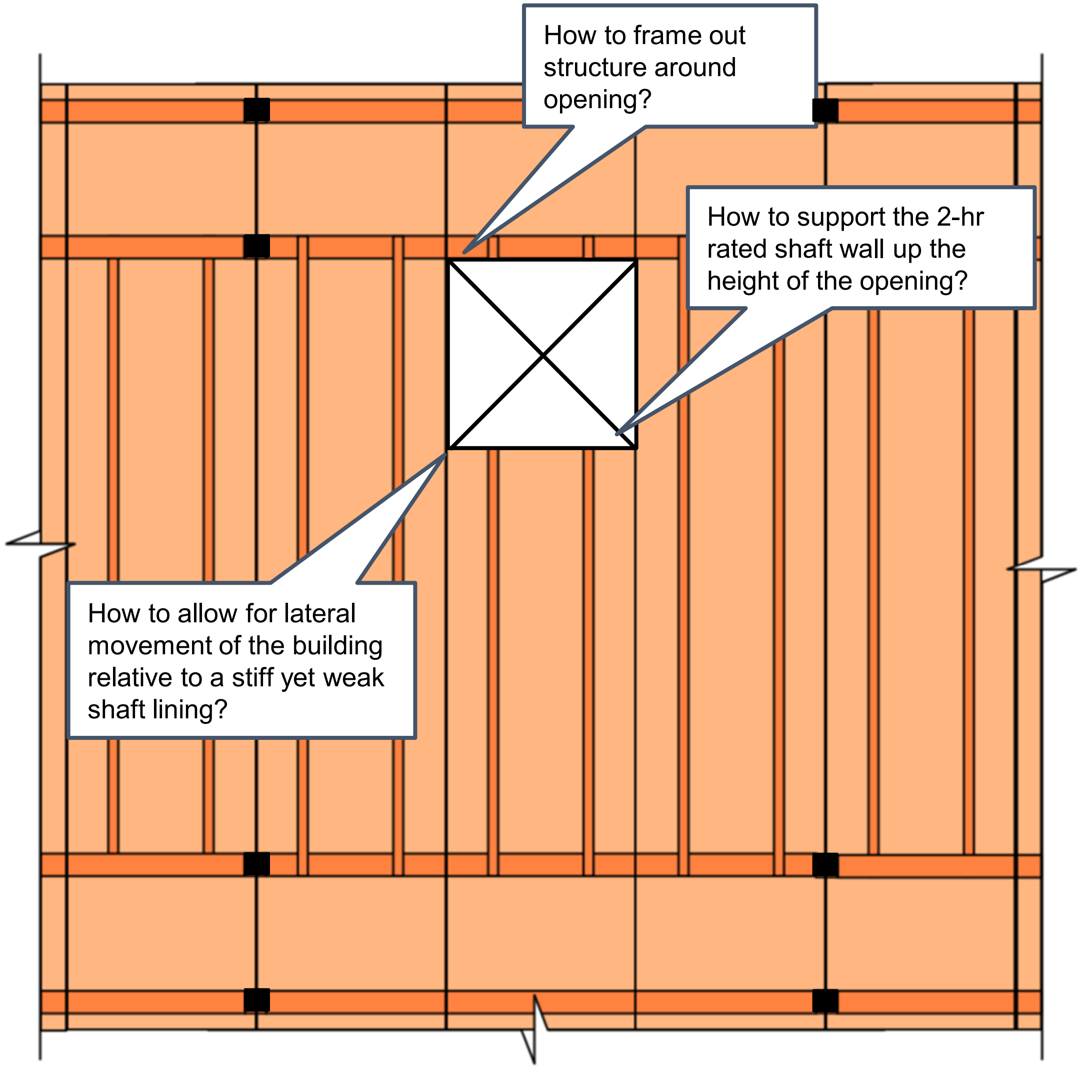
- Columns
- Girders spanning east-west
- Mass Timber Double T Cassettes spanning north-south



Shaft Schematic Approaches

Particular shaft difficulties

- This project uses an exterior distributed lateral system, therefore no internal shear cores to frame out shaft openings
- All shaft openings must accommodate lateral movement without attracting lateral load
- Intent is to avoid cracking of brittle materials during a serviceability level event
- Exposed cassette soffit makes framing out openings difficult



Shaft Schematic Approaches

<table>
<tr><th rowspan="2">Number</th><th rowspan="2">Name</th><th colspan="3">Shaft</th><th colspan="3">Floor</th><th rowspan="2">Example</th><th rowspan="2">Reason to use</th><th rowspan="2">Reason to not use</th><th rowspan="2">Notes</th></tr>
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Shaft Schematic Approaches

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1d	Tied-in Shaft			Floor			Tied into shaft	Shaftlined core w/ gap, steel frame	Doesn't require seismic gap, shaft strength not required	Detailing would be difficult. Shaft needs to be slipped in-plane to not attract load & crack	Option 1 - Initial Design
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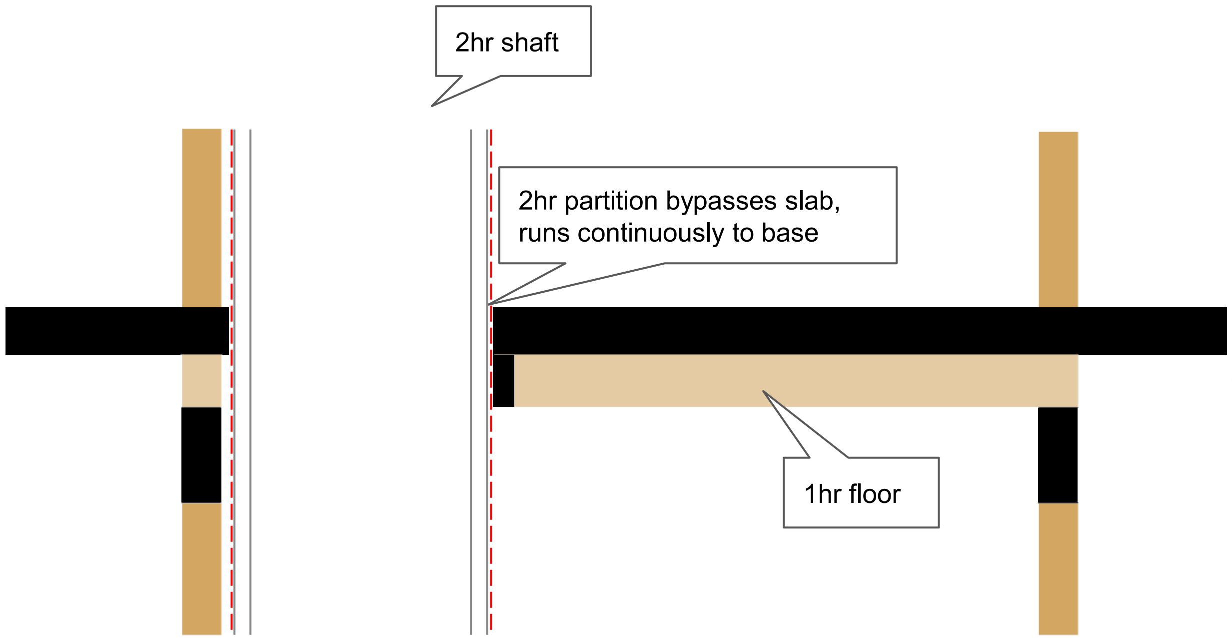
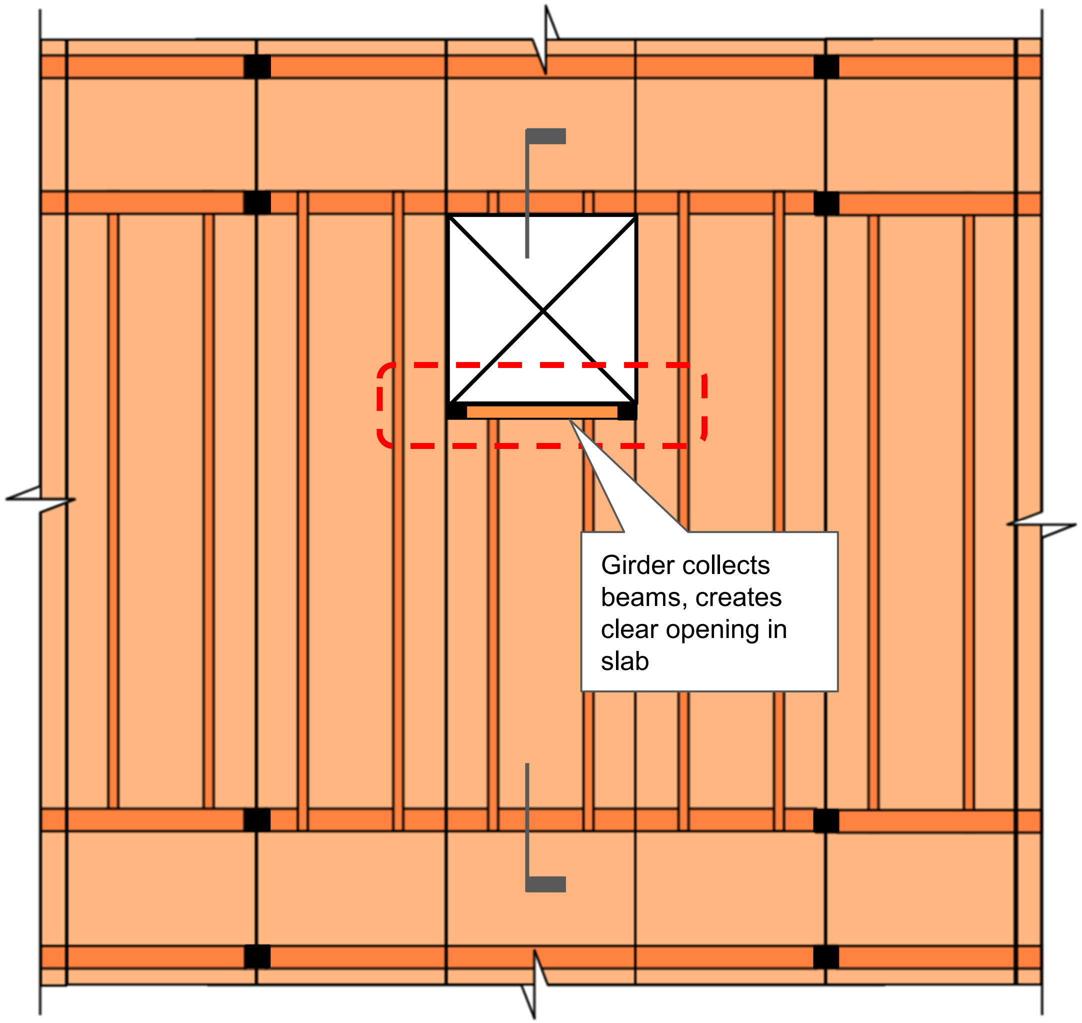
1: Floor Framed Around Shaft Opening





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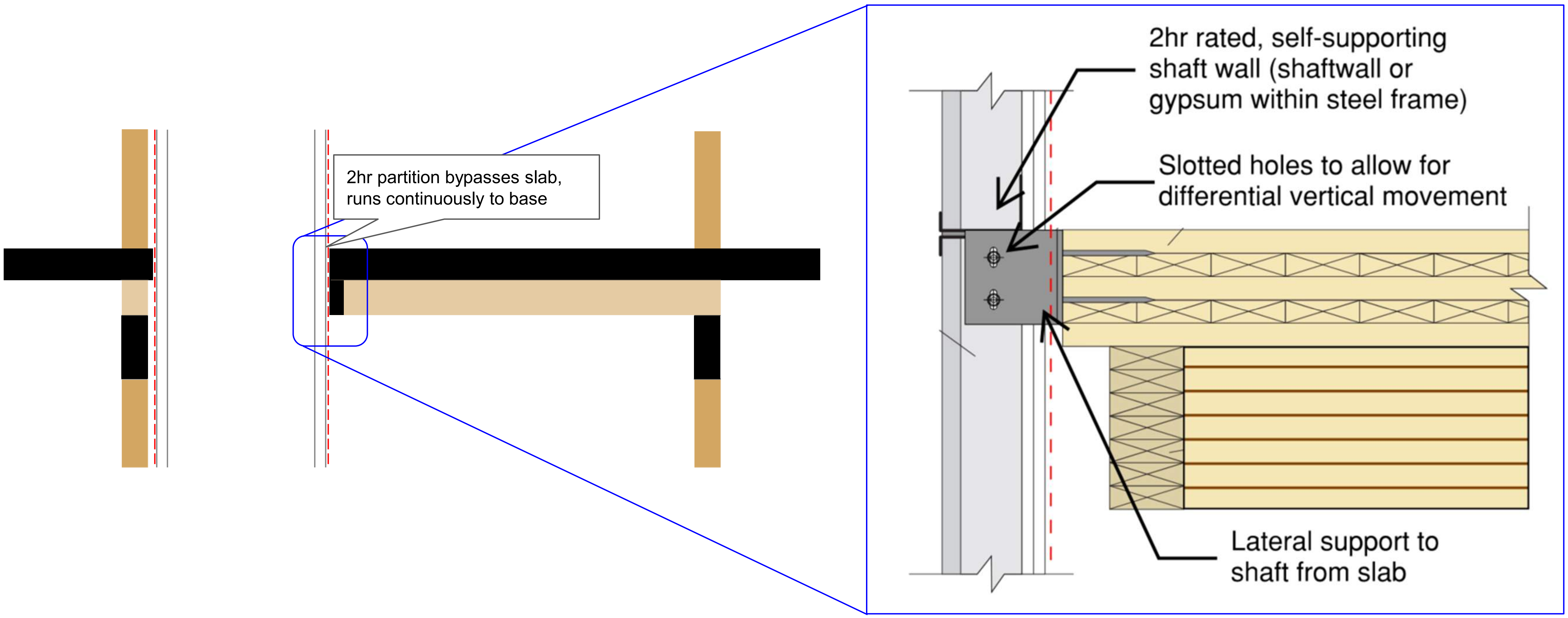

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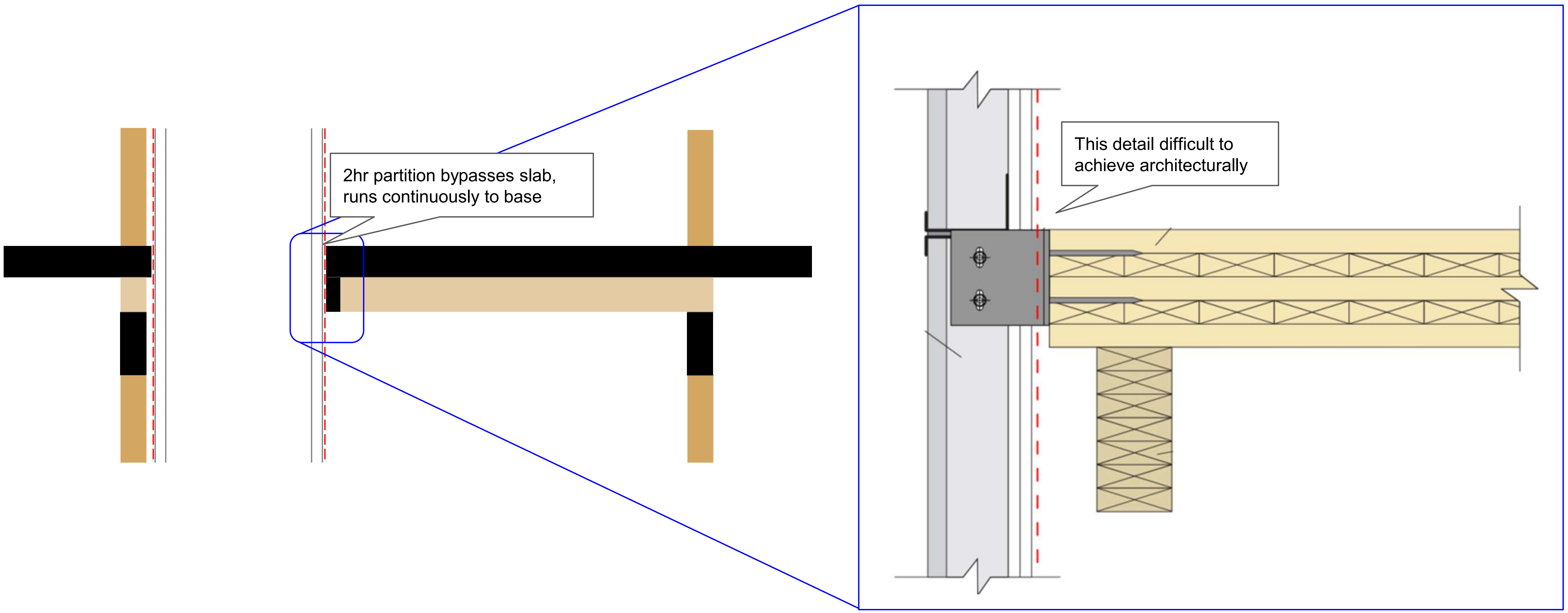

Shaft Schematic Approaches

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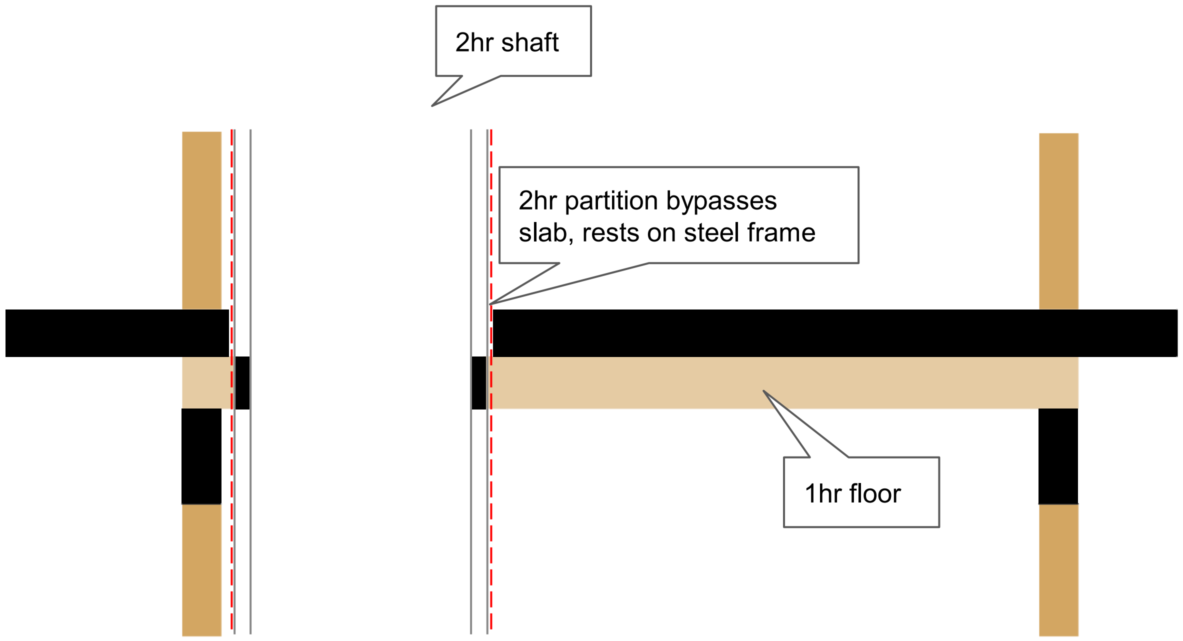
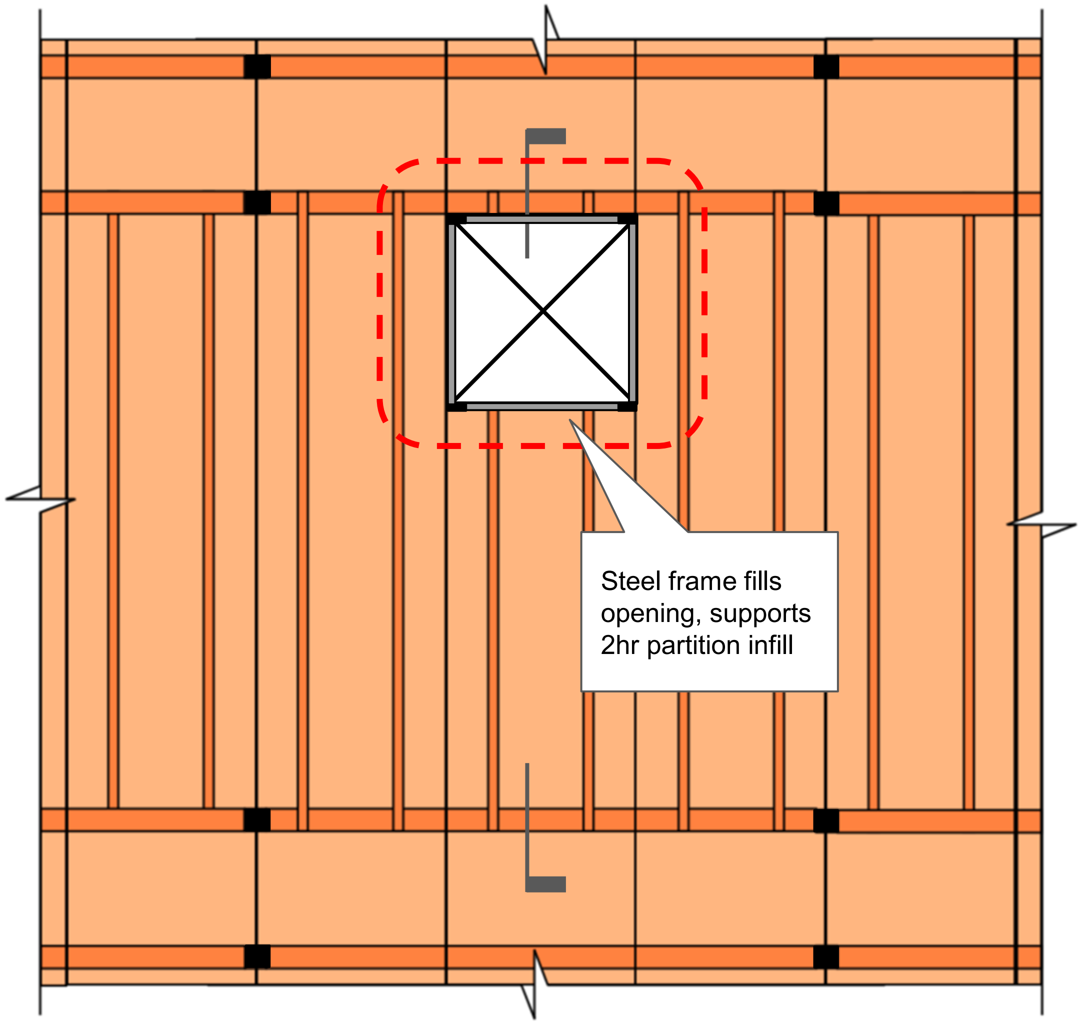
2: Floor Supported by Shaft





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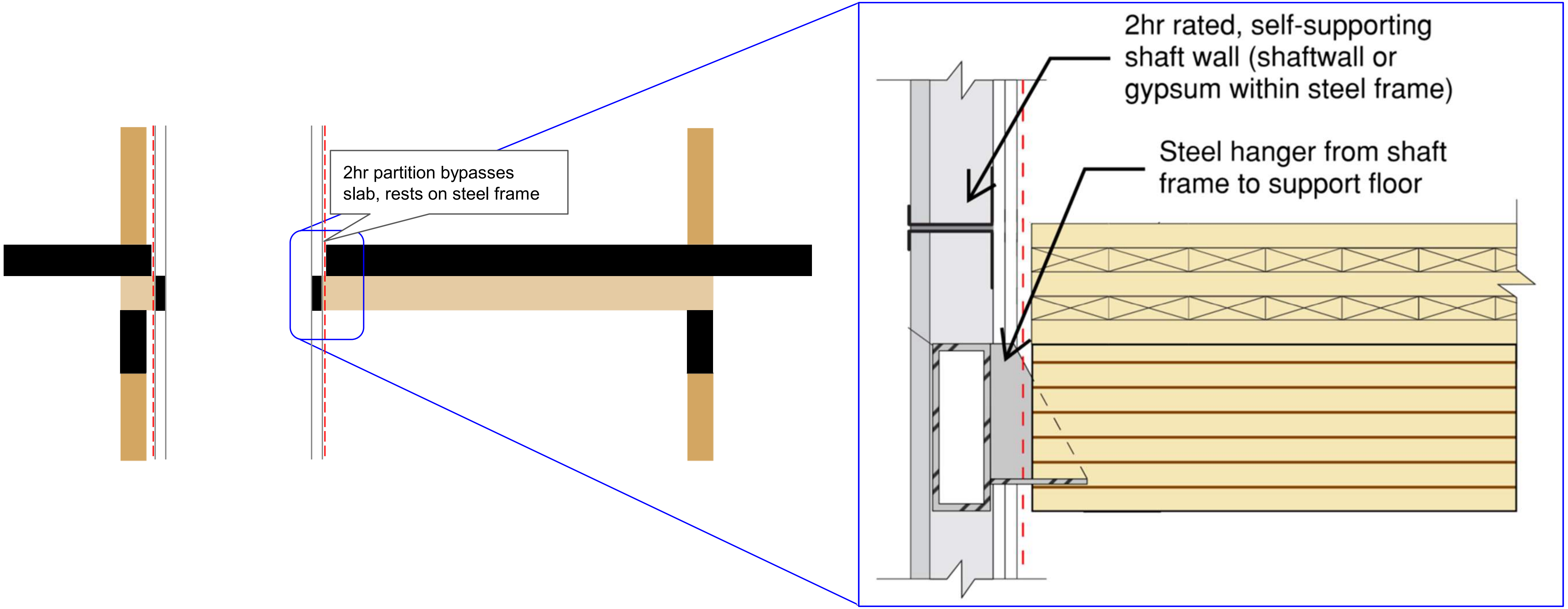

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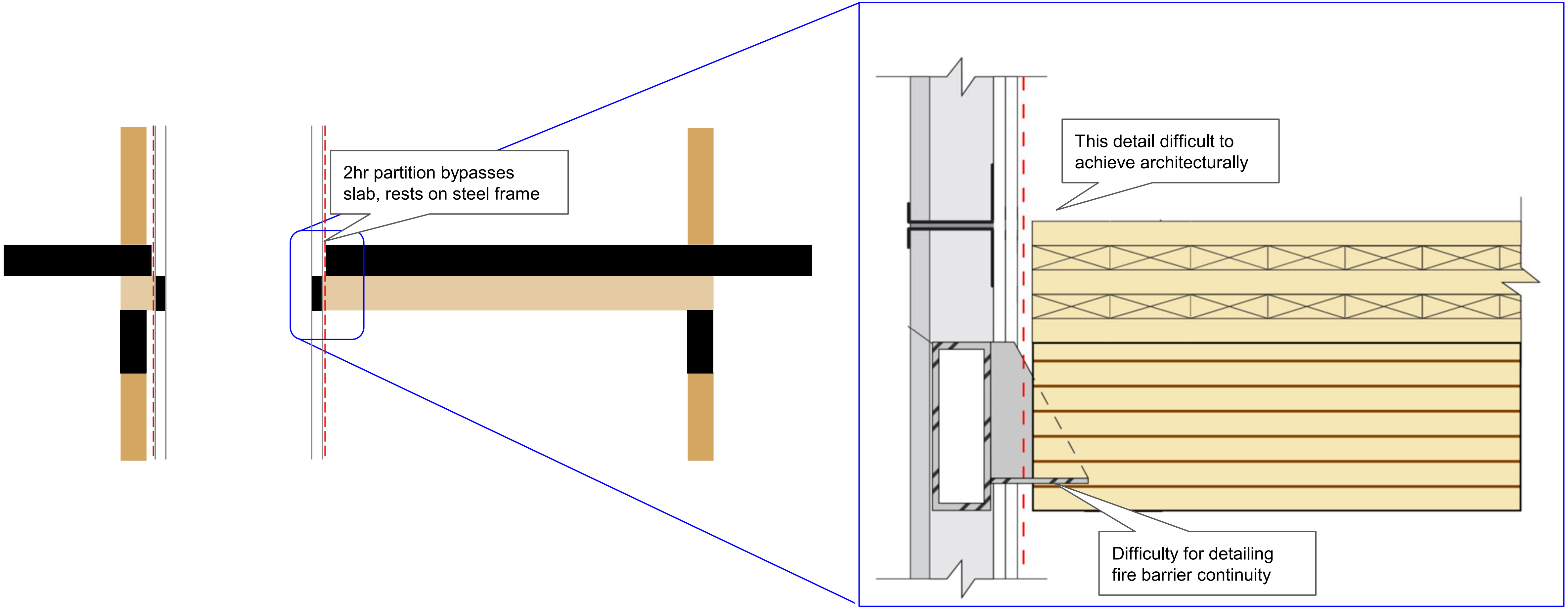

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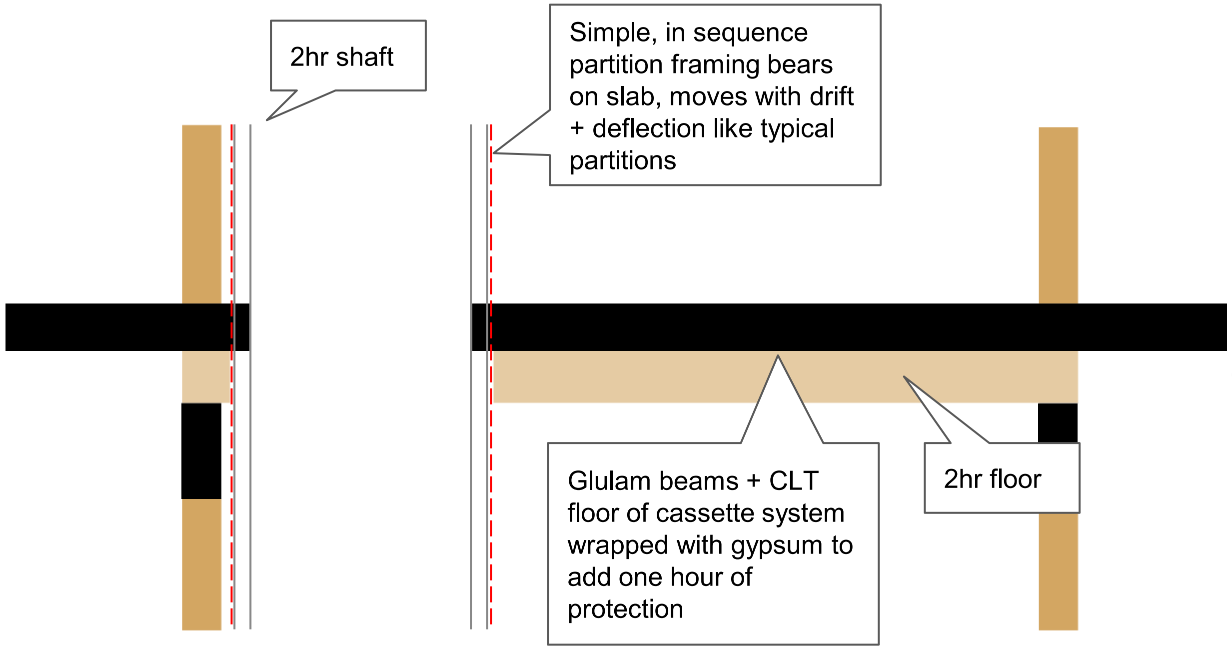
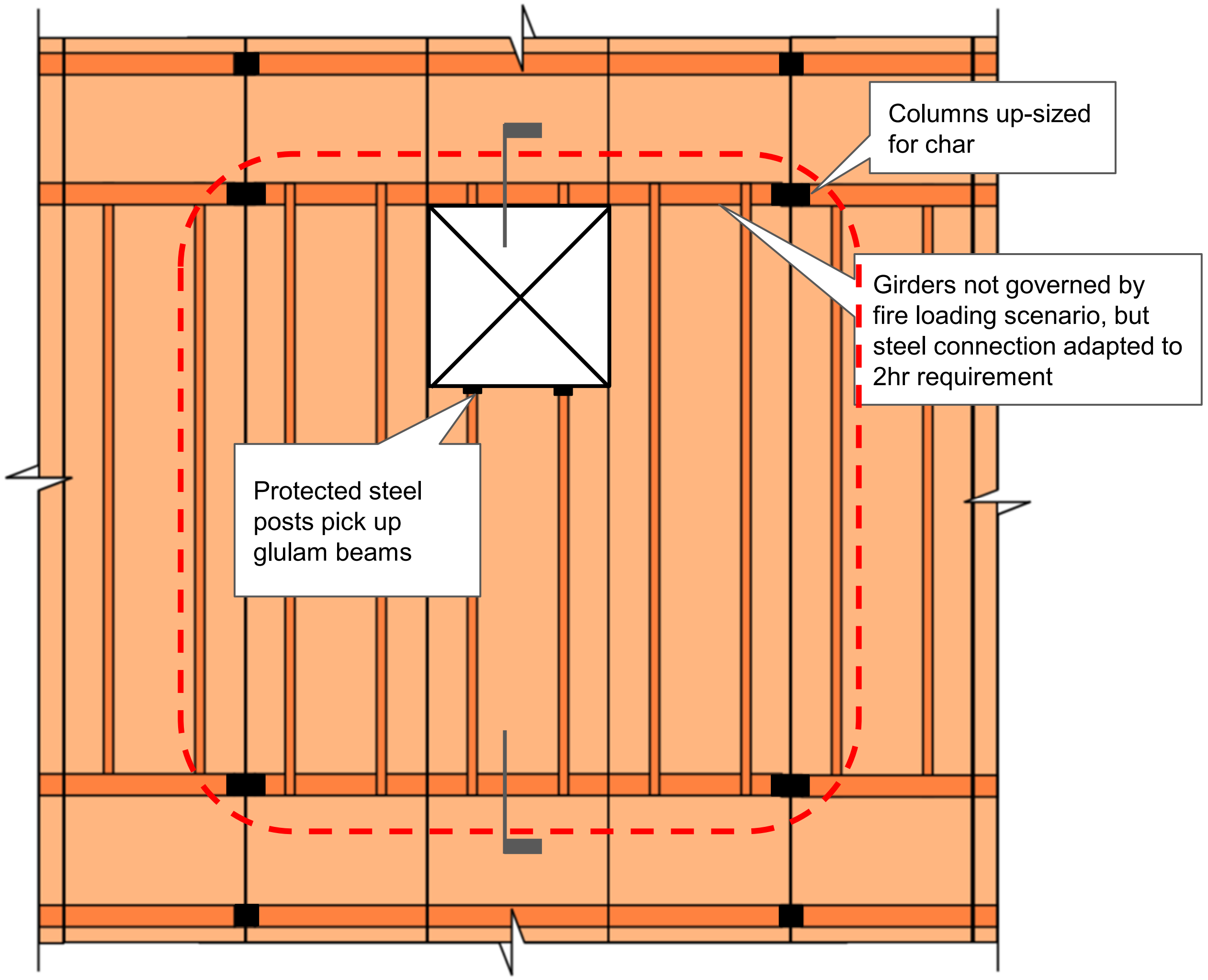
1c	Isolated Shear Core		Self		1Hr	Framed around shaft		Shaftlined core w/ steel frame	Simpler detailing than 1b	Still requires seismic gap, shaft likely not strong enough	
1d	Tied-in Shaft	2Hr						Shaftlined core w/ steel frame	Doesn't require seismic gap, shaft strength not required	Detailing would be difficult. Shaft needs to be slipped in-plane to not attract load & crack	Option 1 - Initial Design
1e	Tied-in Grav Core			Floor		Shaft	Tied into shaft	Sim to platform framing but with 'flexible' walls	Typical construction., simple detailing	Vertical load down shaft needs to be resisted at transfer slab level. Also shaft can't sit on floor which is preferred detail	Option 2 - Second Design
2a	Typ Partition Framing		Floor	Floor		Framed around shaft		Typ light-framed partition on 1hr floor	Often used on projects, similar to typ partition framing	1hr structure supporting 2hr shaft doesn't comply with IBC	
2b	2hr Partition Framing				2Hr			Typ light-framed partition on 2hr floor	Per above but complies with IBC	Satisfies all requirements, however requires addn'l bays of 2hr structure in project	Option 3 - Final Design

Shaft Schematic Approaches

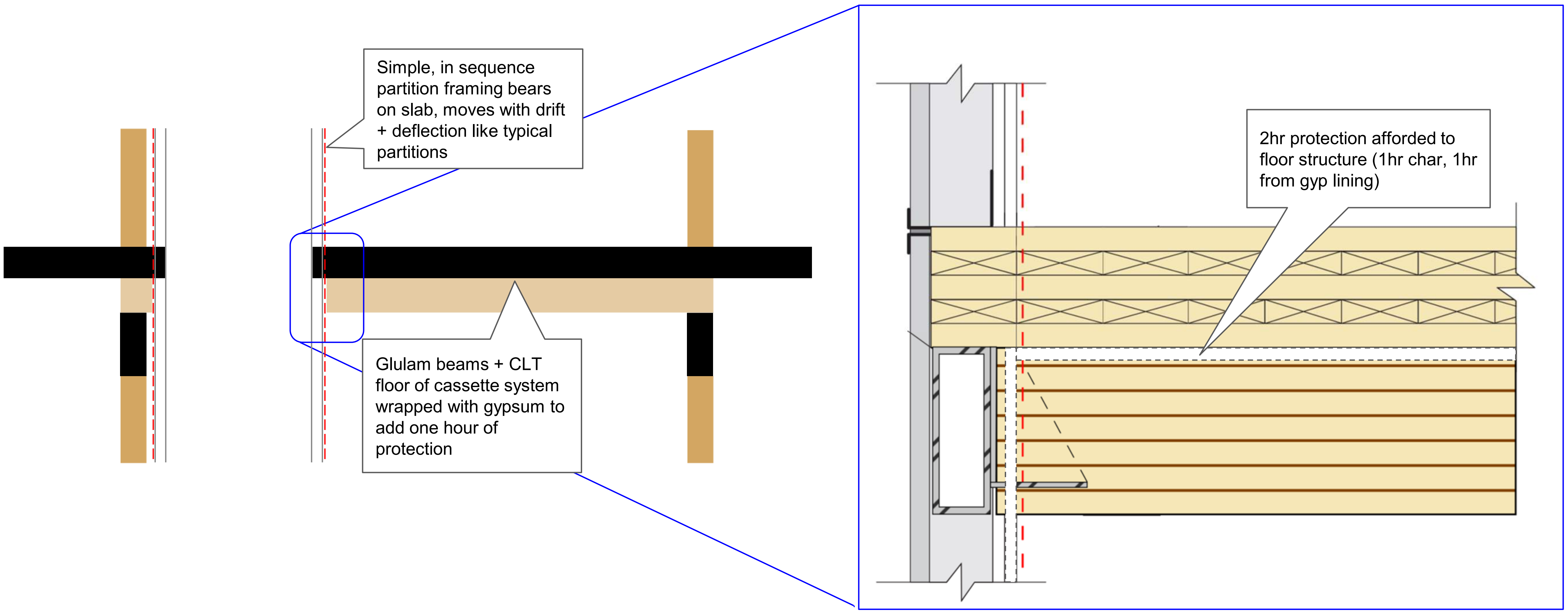
Number	Name	Shaft			Floor			Example	Reason to use	Reason to not use	Notes
		Rating	Vertical	Lateral	Rating	Vertical	Lateral				
1a	Typ Shear /Grav Core	2Hr	Self	Self	1Hr	Shaft	Tied into shaft	CMU core, platform-framed wood construction	Typical construction., simple detailing	Core not strong enough to resist loads attracted. Could detail to yield but may crack at SLE. Poor seismic performance.	
1b	Isolated Shear /Grav Core						Isolated from shaft	CMU core	Stops core attracting seismic load	Tricky detailing to slip floor relative to shaft, negates benefit of CMU core, seismic gap may be large	
1c	Isolated Shear Core					Framed around shaft		Shaftlined core w/ steel frame	Simpler detailing than 1b	Still requires seismic gap, shaft likely not strong enough	
1d	Tied-in Shaft			Floor			Tied into shaft	Shaftlined core w/ steel frame	Doesn't require seismic gap, shaft strength not required	Detailing would be difficult. Shaft needs to be slipped in-plane to not attract load & crack	Option 1 - Initial Design
1e	Tied-in Grav Core					Shaft		Sim to platform framing but with 'flexible' walls	Typical construction., simple detailing	Vertical load down shaft needs to be resisted at transfer slab level. Also shaft can't sit on floor which is preferred detail	Option 2 - Second Design
2a	Typ Partition Framing		Floor	Floor		Framed around shaft		Typ light-framed partition on 1hr floor	Often used on projects, similar to typ partition framing	1hr structure supporting 2hr shaft doesn't comply with IBC	
2b	2hr Partition Framing				2Hr			Typ light-framed partition on 2hr floor	Per above but complies with IBC	Satisfies all requirements, however requires addn'l bays of 2hr structure in project	Option 3 - Final Design

3: Shaft Supported by Floor

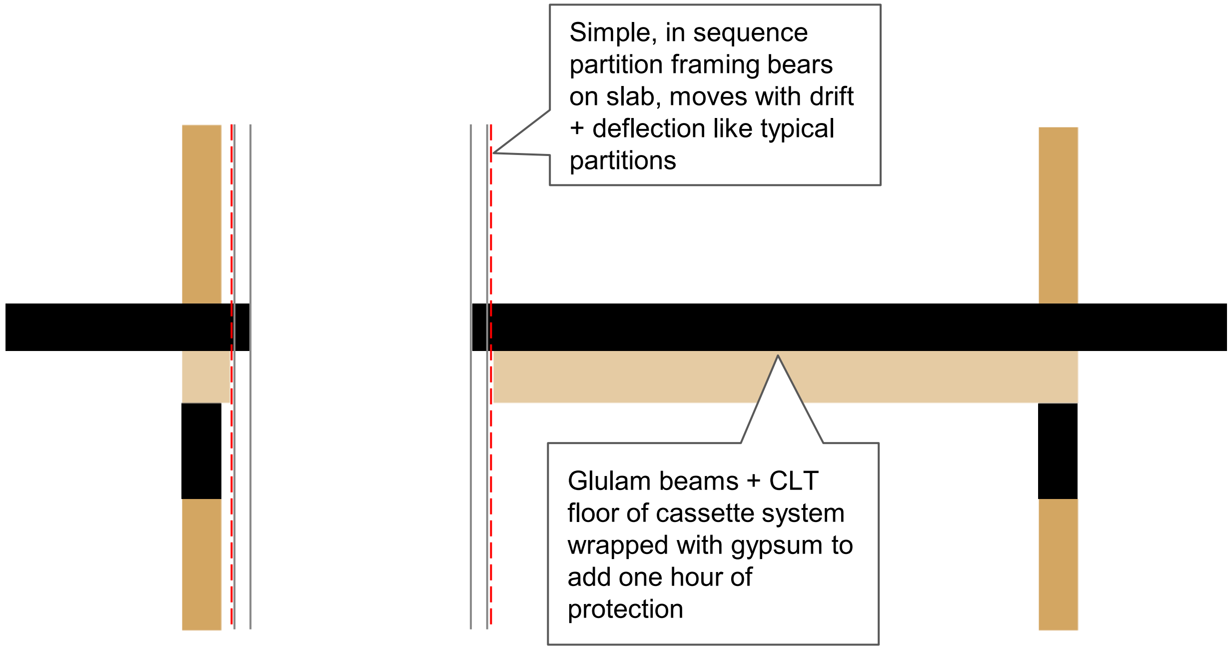




3: Shaft Supported by Floor

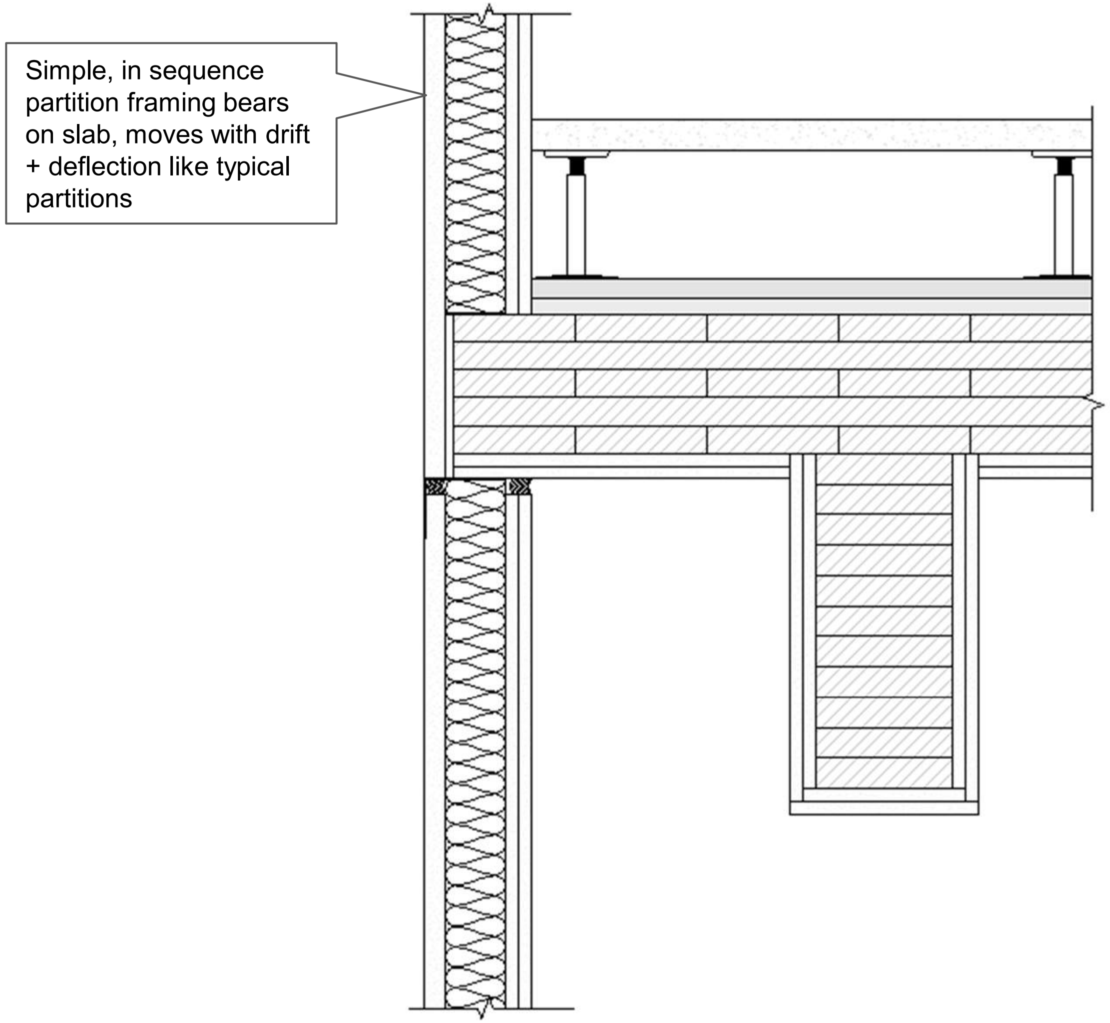


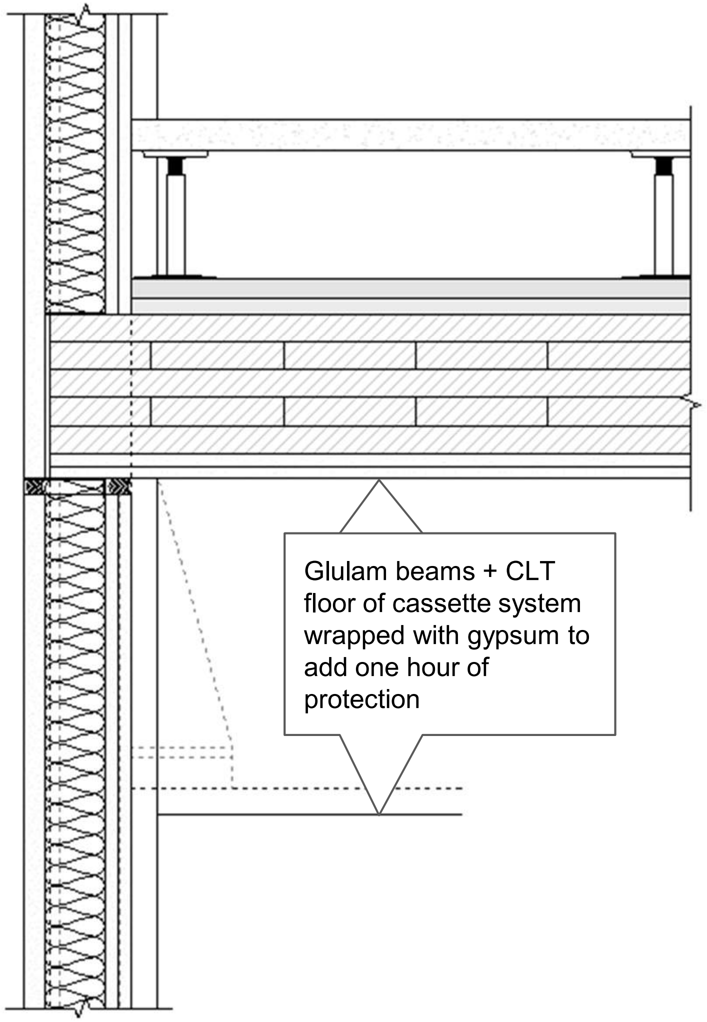
3: Shaft Supported by Floor



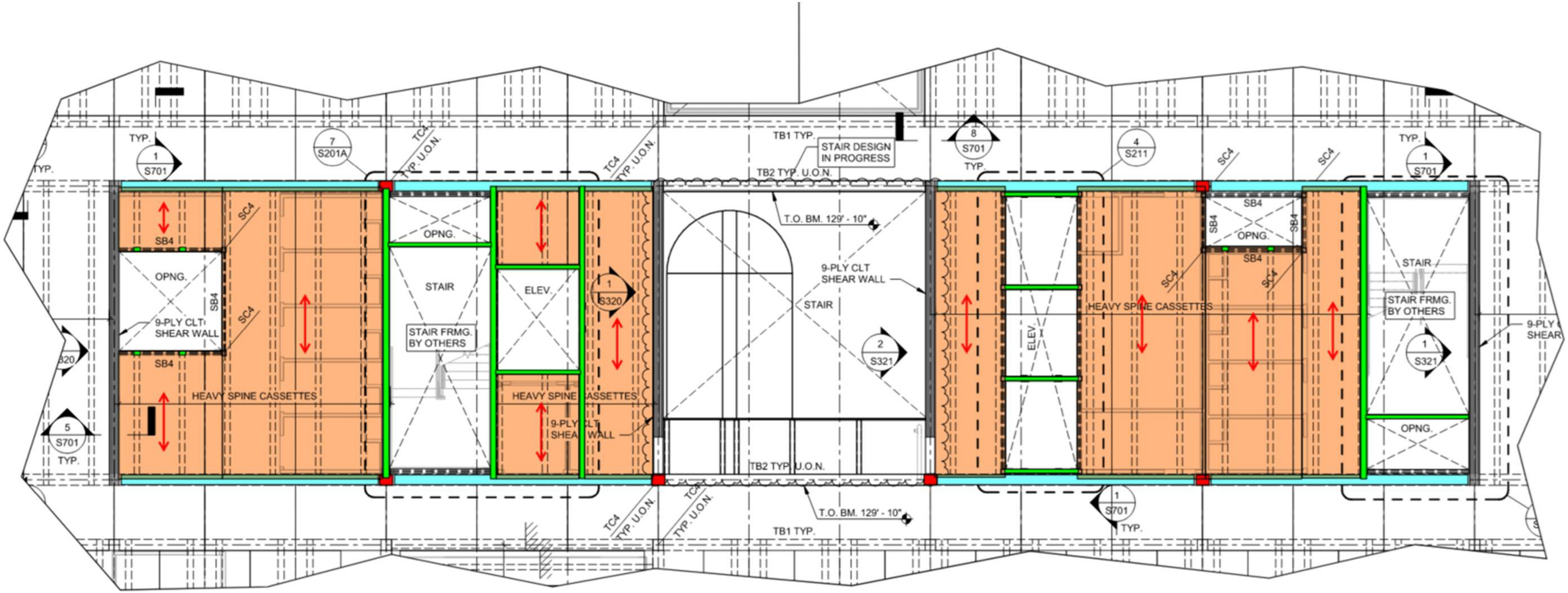
2hr Structure Impacts		
Element	1hr	2hr
CLT Deck & GLT Ribs	Unwrapped	(2) layers ⅝” gyp added
GLT Girders	Unwrapped	Unwrapped
GLT Girder - Column Connection	Embedded bearing pl w/ 1.8” blocking for char protection	Embedded bearing pl w/ 1.8” gyp for insulation protection
GLT Column Size (at base)	14.25x18”	14.25x25.5”

Detailing

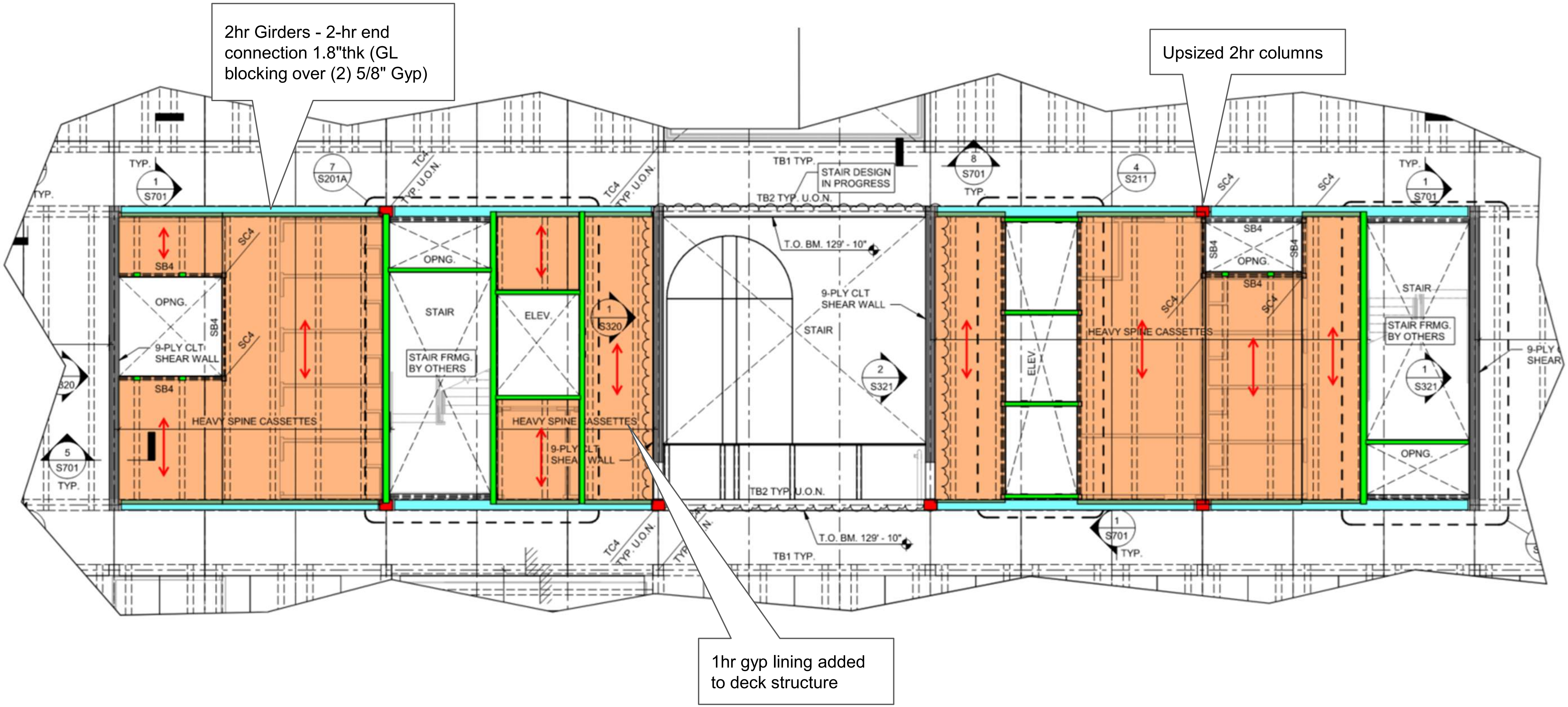

Simple, in sequence partition framing bears on slab, moves with drift + deflection like typical partitions


Glulam beams + CLT floor of cassette system wrapped with gypsum to add one hour of protection

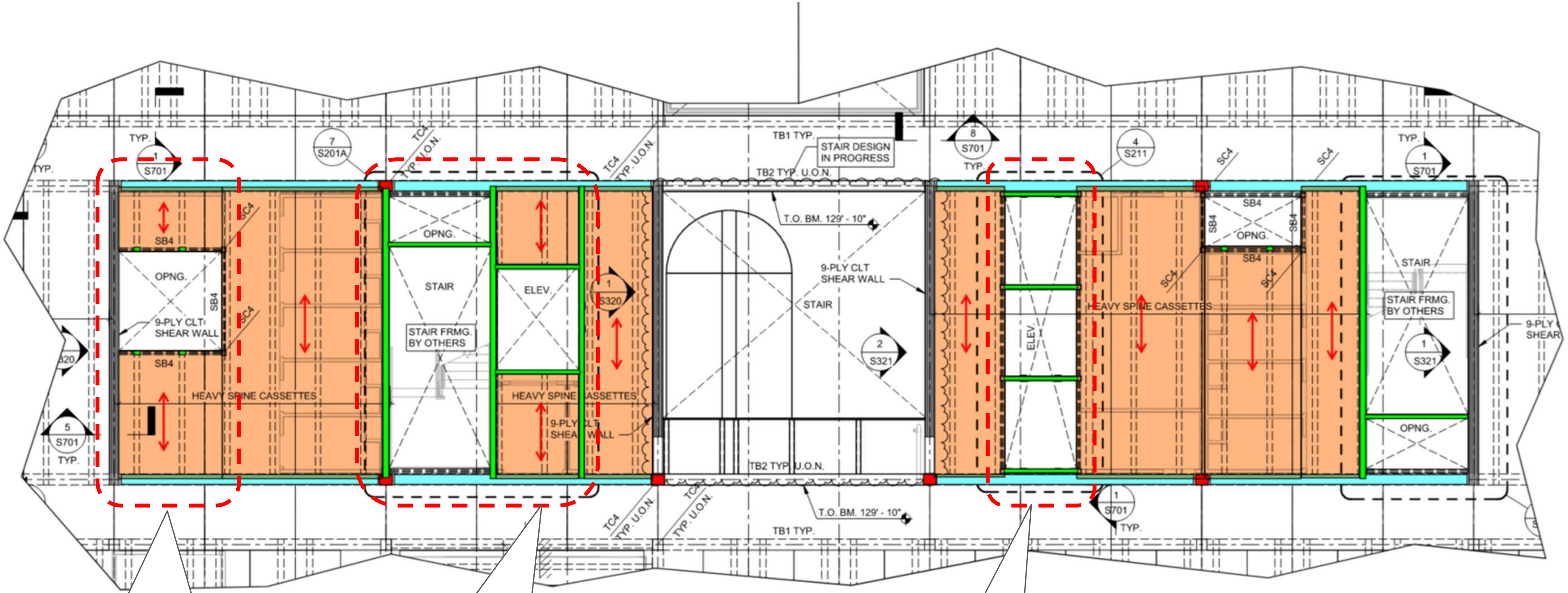
Framing Variations



Framing Variations



Framing Variations



Floor supported on steel posts, posts track down to ground floor concrete transfer slab

Floor supported on steel beams which frame out opening. Transfer slab inefficient due to openings

Elevator shaft walls supported by 2hr rated floor

Questions?

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