Photo: Michael Green Architecture

Mass Timber Shafts & Shaft Wall Solutions

for Mass Timber Buildings

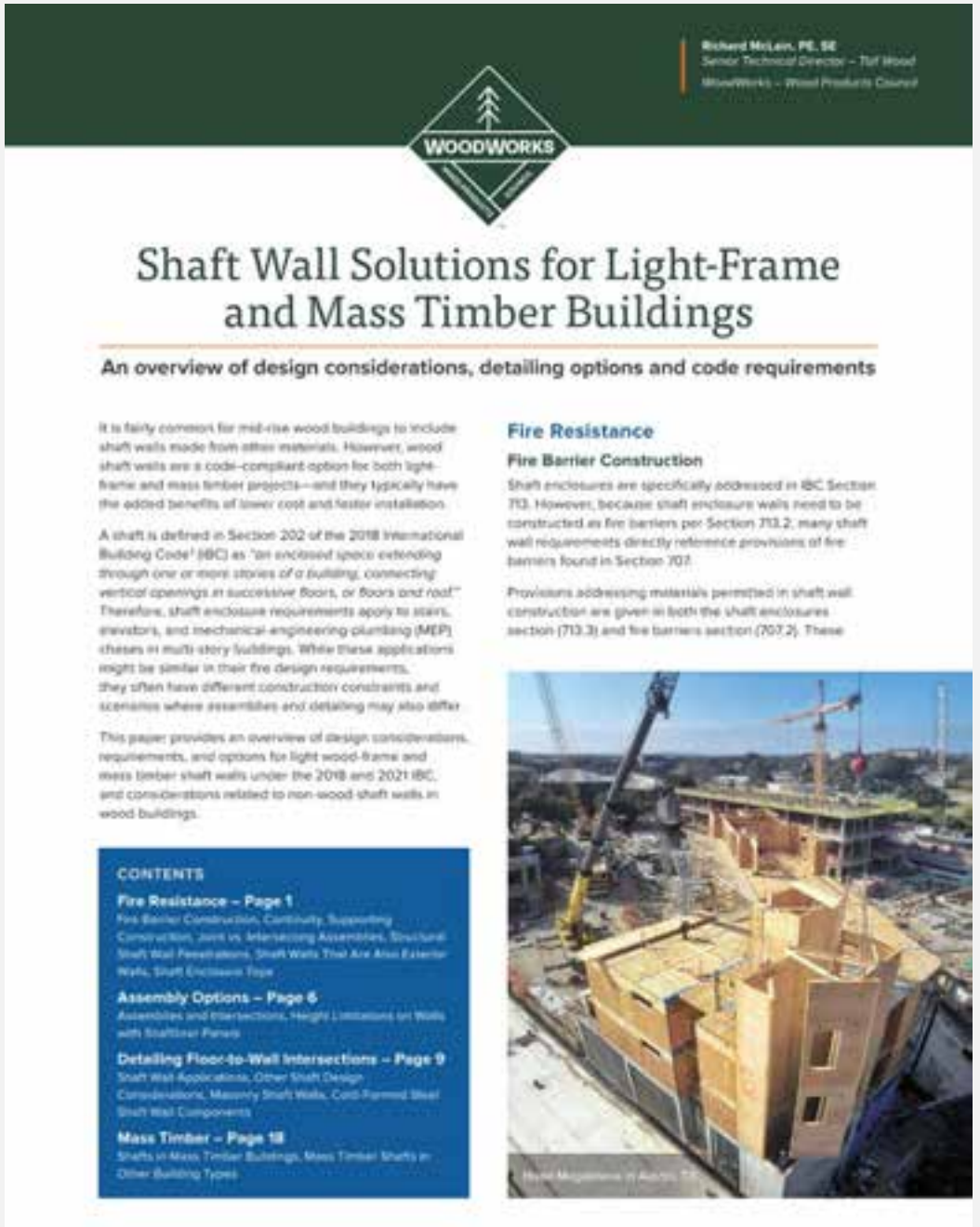
ANTHONY HARVEY, PE

DECEMBER 15, 2022

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**



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

WOODWORKS

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® (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.

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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

https://www.woodworks.org/resources/shaft-wall-solutions-for-wood-frame-buildings/

Shaft Walls

Mass Timber

Photo: Quality Contractors

Steel Studs, Wood Studs

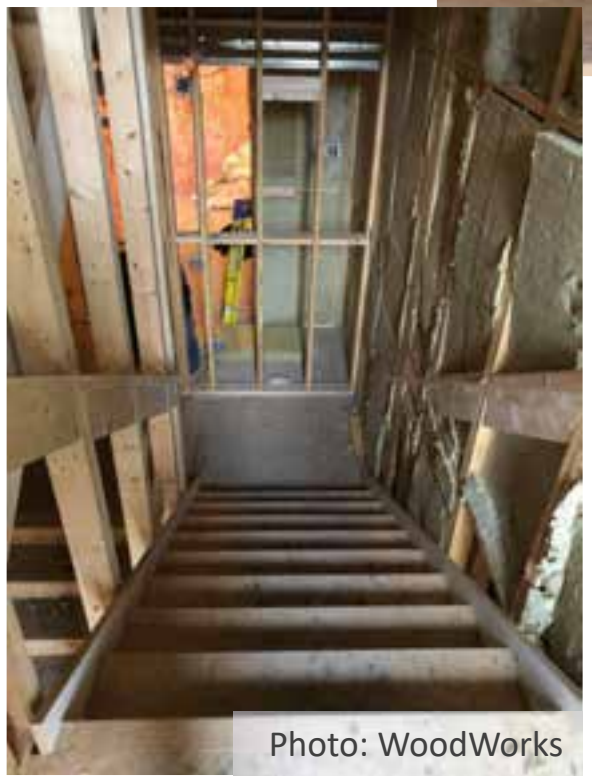


Photo: WoodWorks

Shaftliner Panels

Photo: Georgia Pacific

Masonry

Photo: WoodWorks

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*

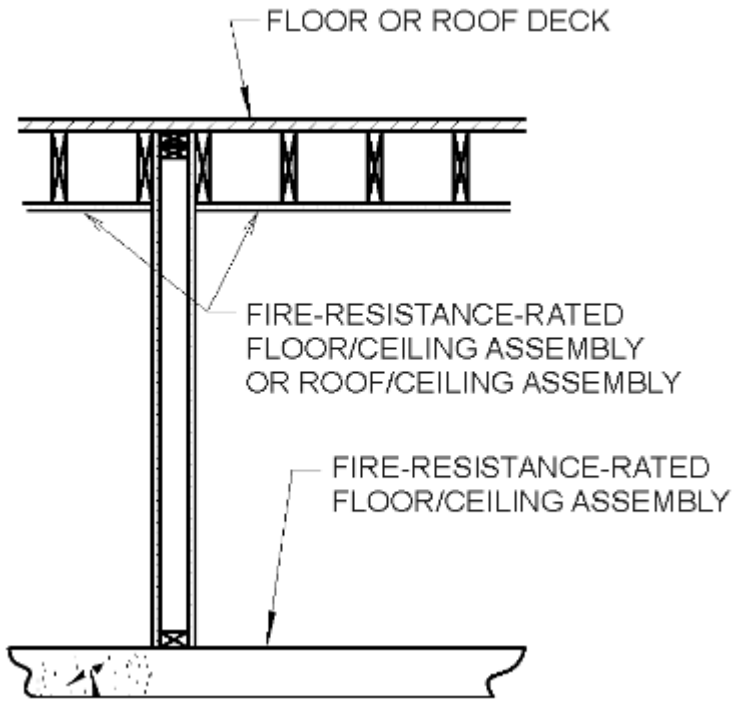
Interior Fire-Rated Walls: Differences

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

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

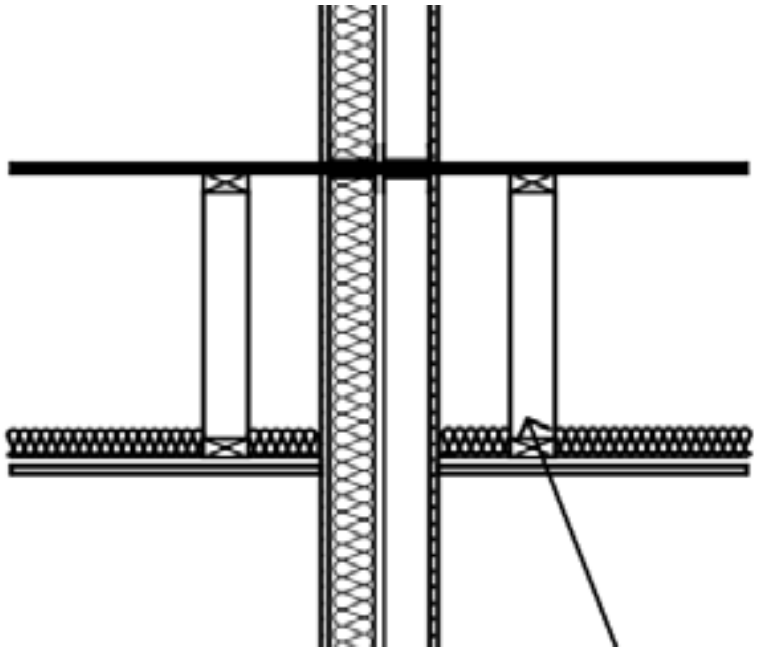
2018 IBC Code & Commentary

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 3 stories or less
- Separated Occupancies: IBC Table 508.4
- Fire Areas: IBC Table 707.3.10



Shaft Wall Materials

Type III Construction:

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

Type IV-HT Construction:

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

Type V Construction:

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

Shaft Enclosures in Tall Timber

- When can shaft enclosures be MT?
- What FRR requirements exist?
- If shaft enclosure is MT, is NC req'd?

Image: Generate Architecture and Technologies + MIT – John Klein

Shaft Enclosures in Tall Timber

	IV-A	IV-B	IV-C
Exit & Hoistway Enclosures	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
E&H Enclosures FRR	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.

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.

https://www.woodworks.org/resources/shaft-wall-requirements-in-tall-mass-timber-buildings/

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

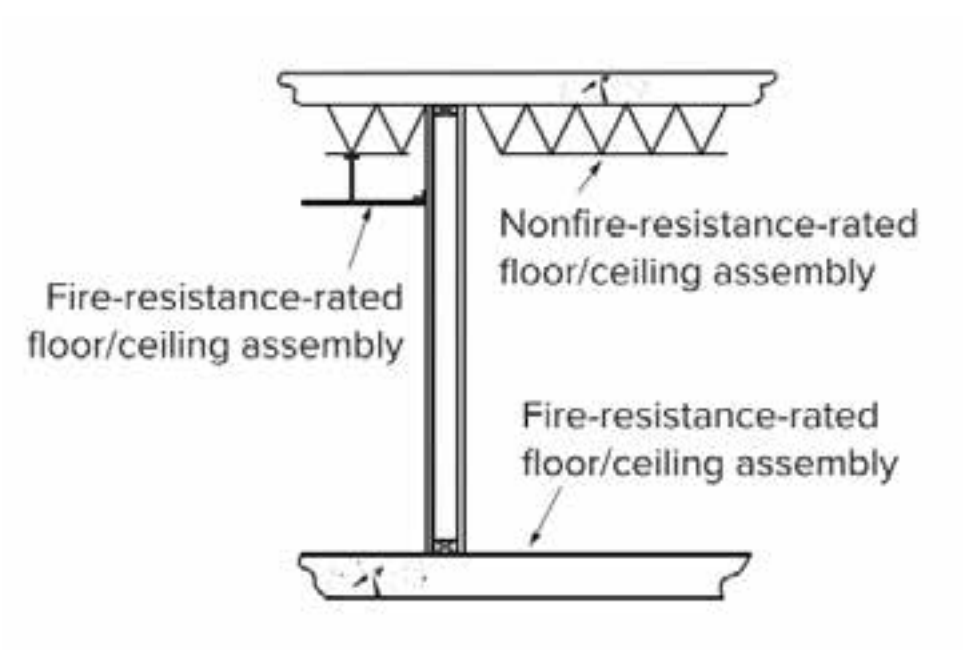
707.5.1 Supporting Construction. The supporting construction for a fire barrier shall be protected to afford the required fire-resistance rating of the fire barrier supported. Hollow vertical spaces within a fire barrier shall be fireblocked in accordance with Section 718.2 at every floor level.

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

Other requirements for openings, penetrations, joints

Continuity Provisions

What do these continuity provisions look like?



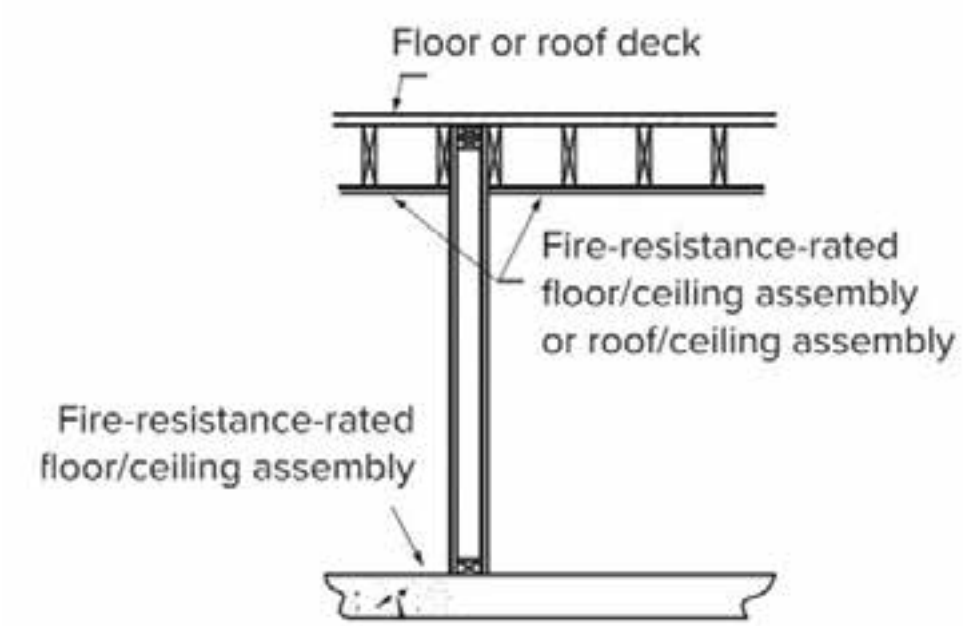


FIGURE 1: IBC Commentary Figure 707.5 – Continuity of fire barriers

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

Mass Timber Shaft Walls in Mass Timber Buildings

Floor to Shaft Wall Detailing

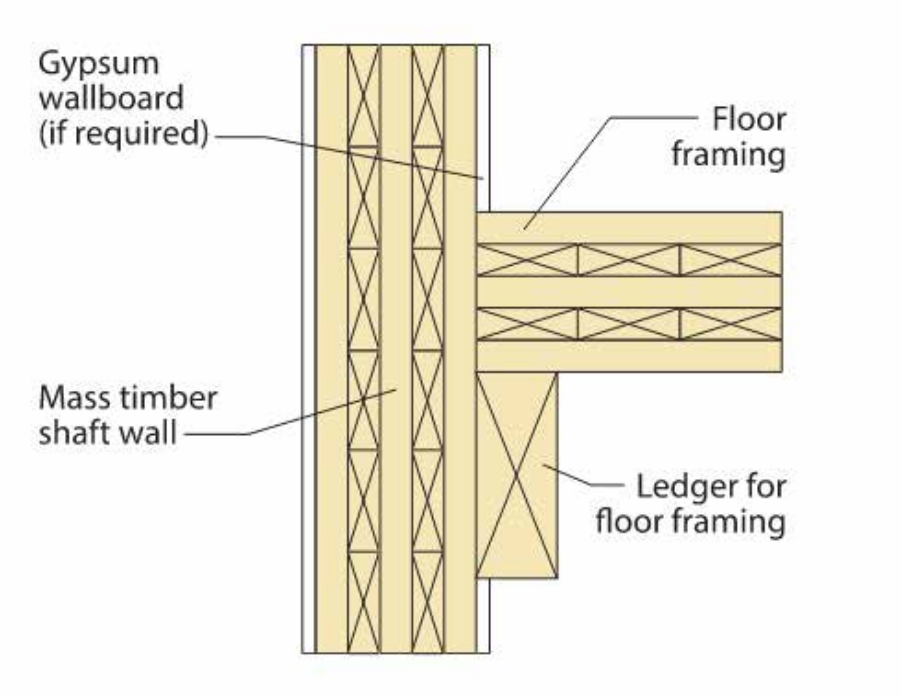



Photo: Alex Schreyer

Floor to Shaft Wall Detailing

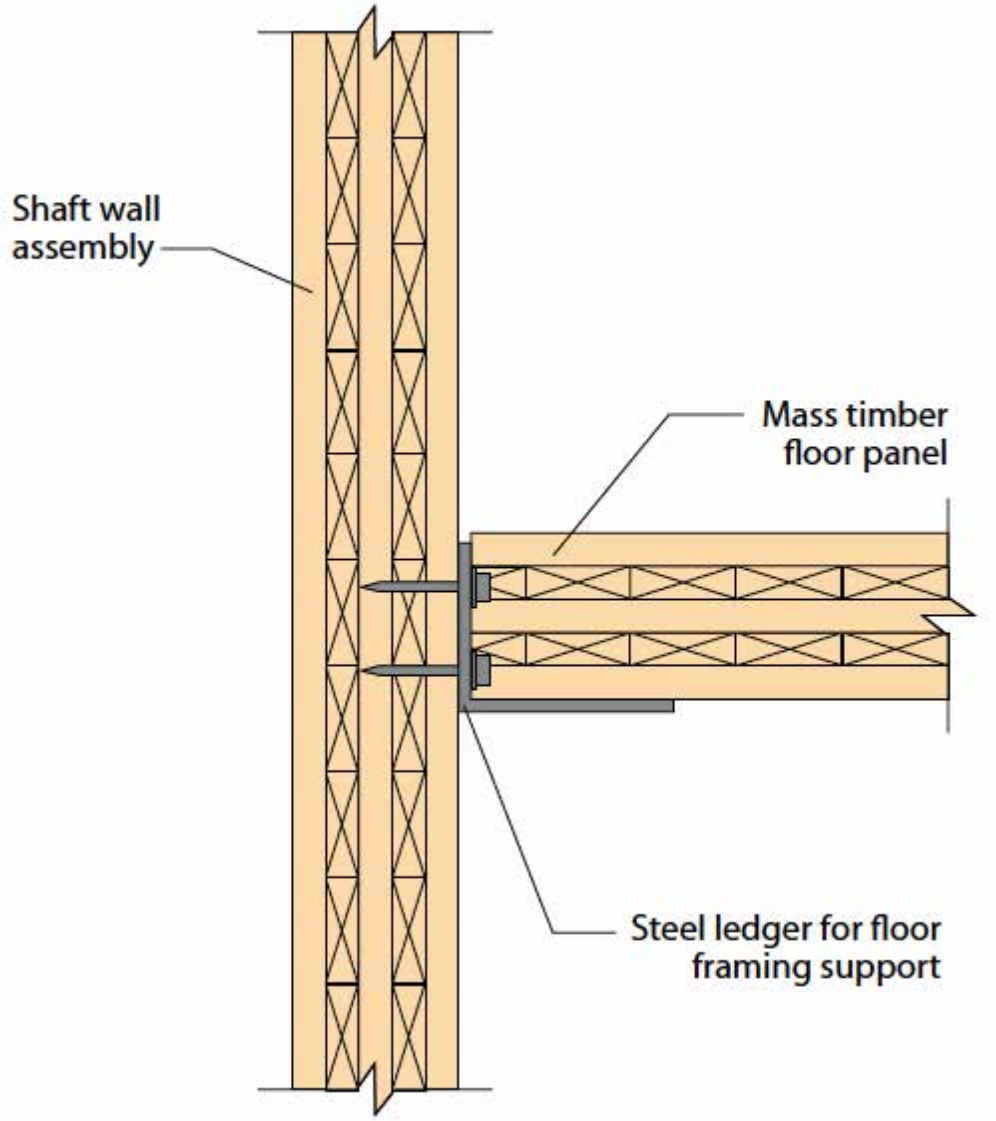
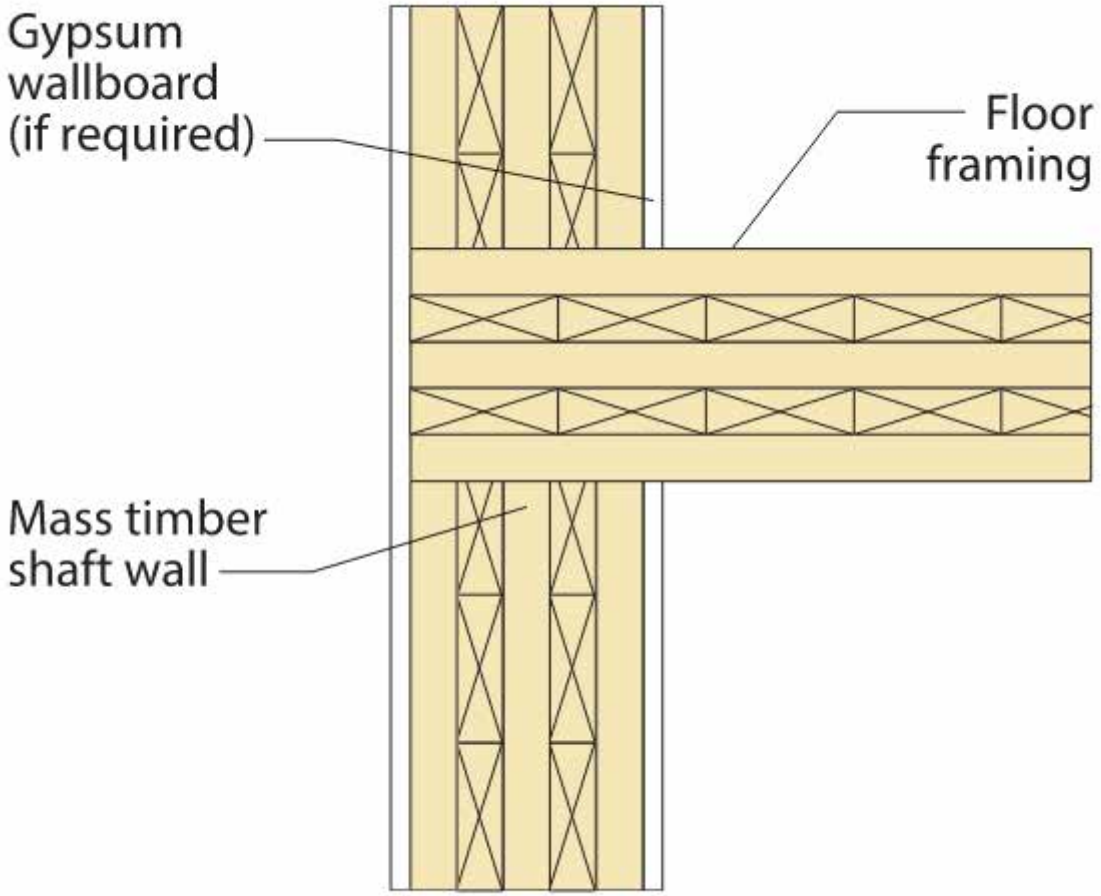


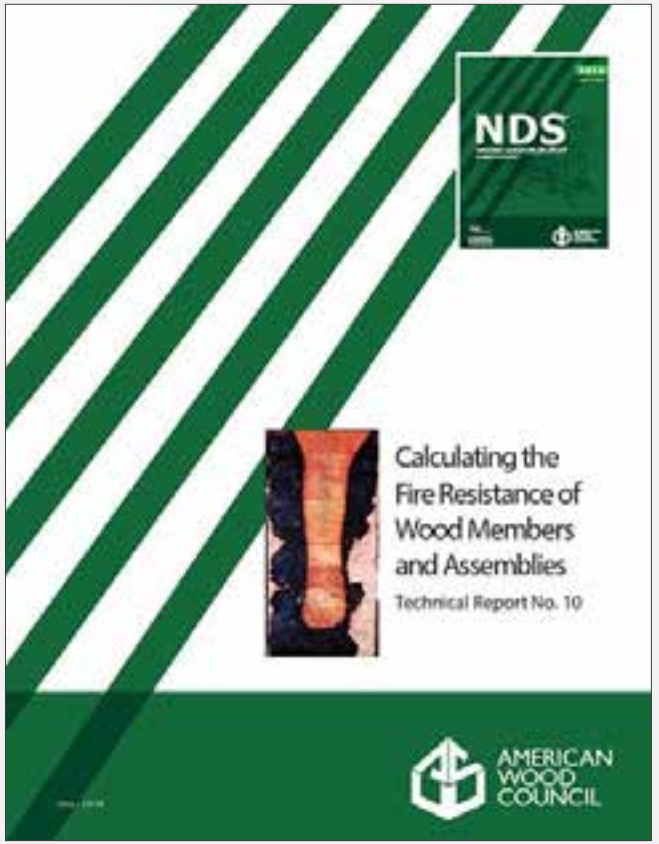
Photo: PES Structural Engineers

Floor to Shaft Wall Detailing



Calculated Fire Resistance of Wood

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



Calculated Fire Resistance of Wood

Assumptions:

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

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

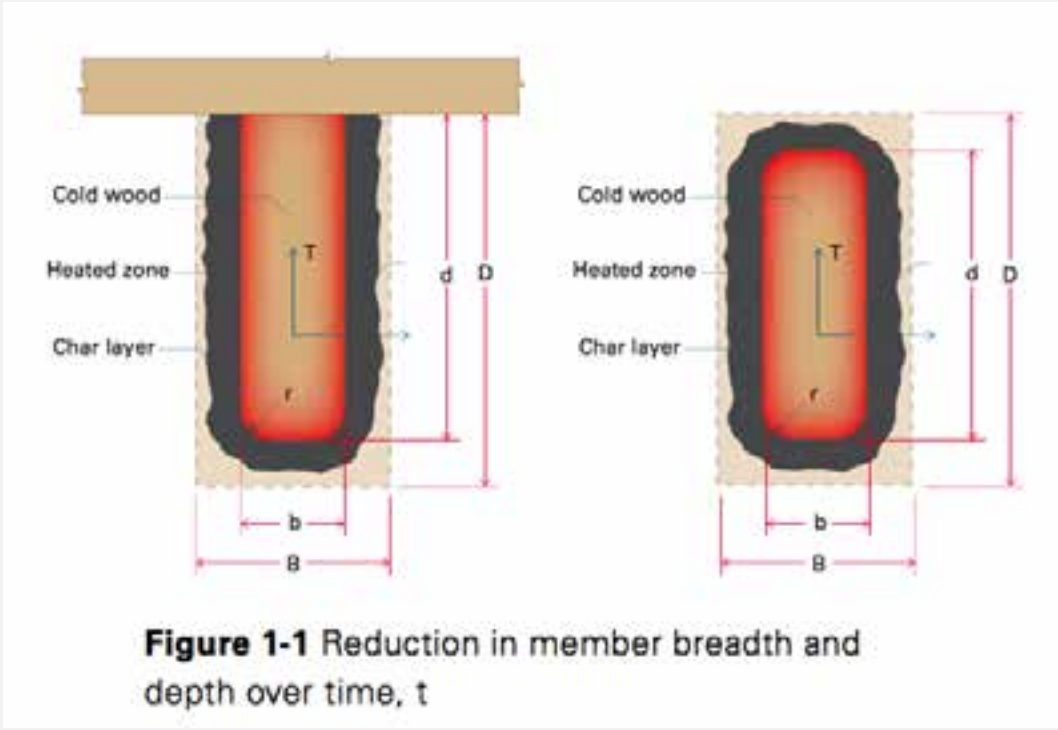
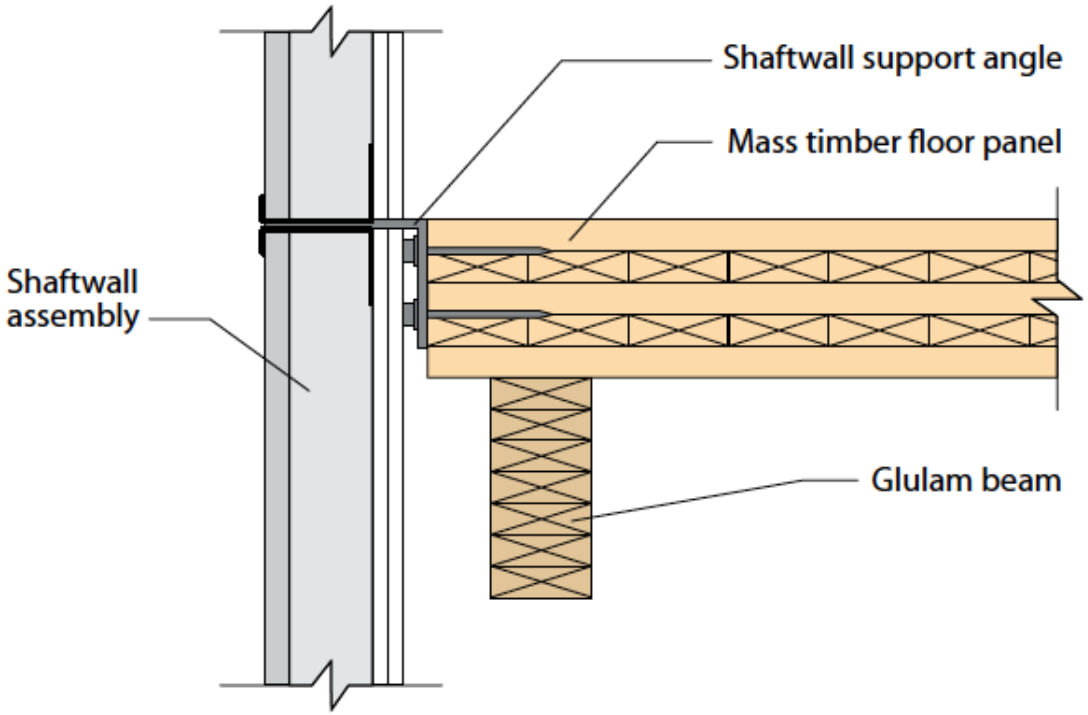


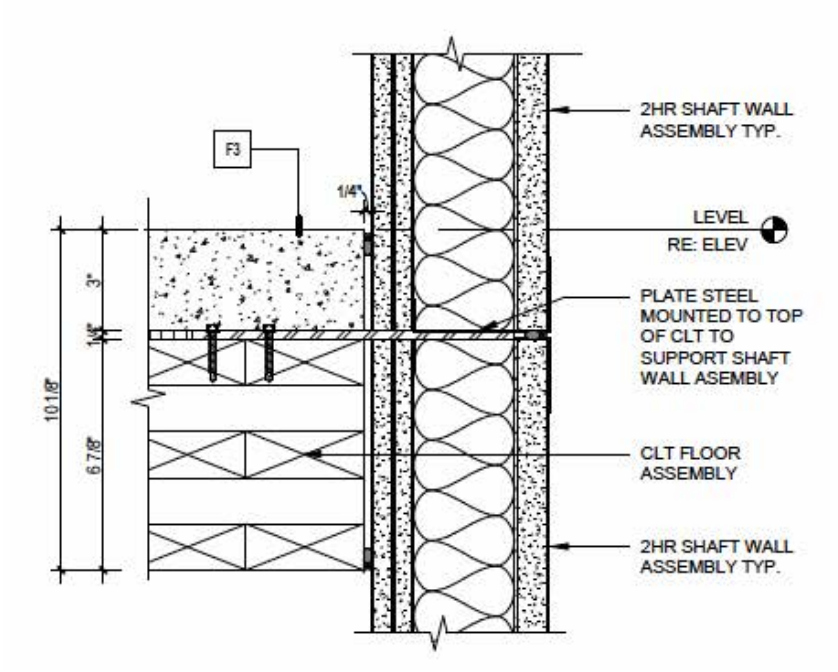
Figure 1-1 Reduction in member breadth and depth over time, t

Source: AWC’s TR 10

Shaftliner Systems in Mass Timber Buildings

Shaftliner Systems – Support Details



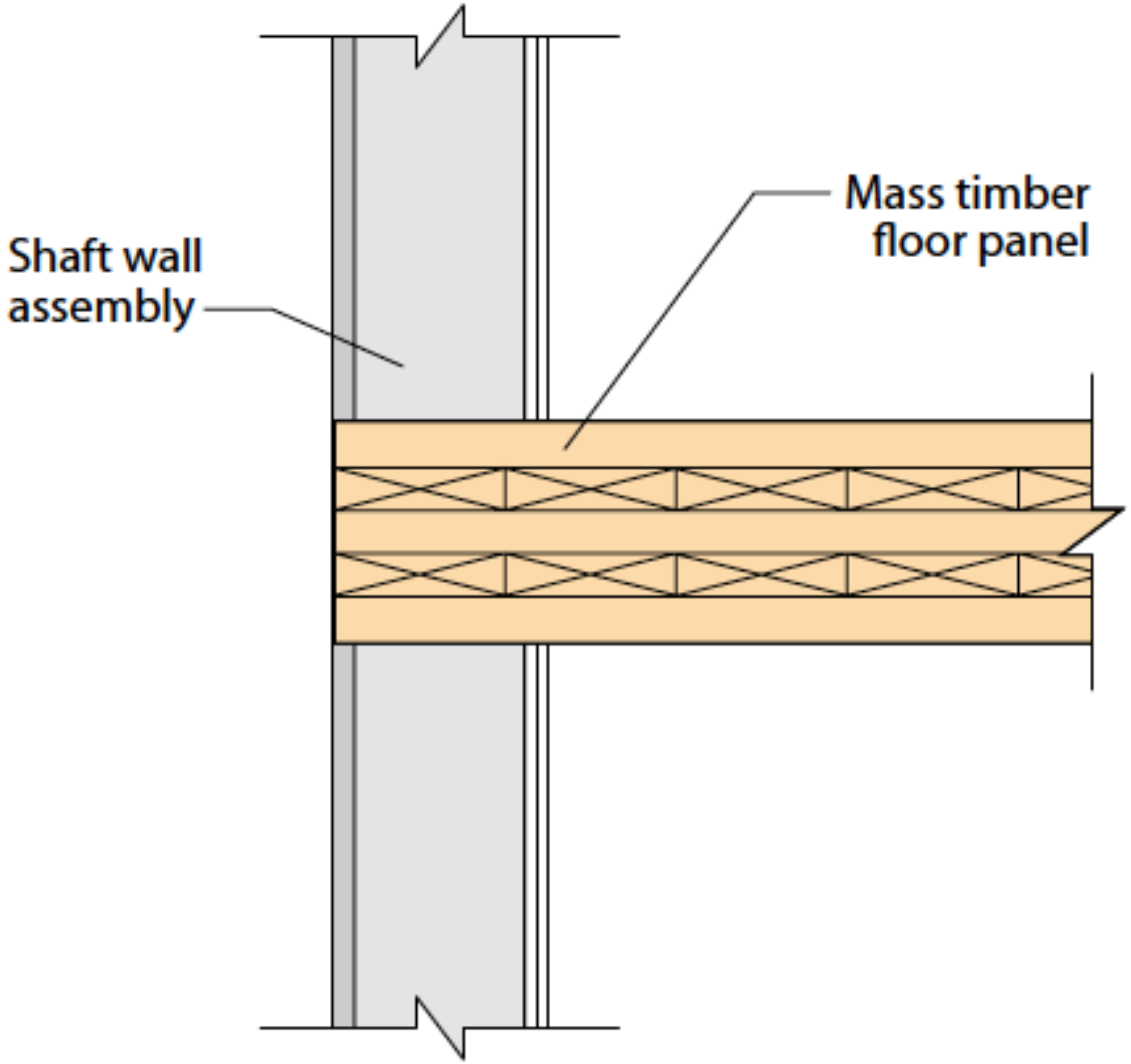


Shaftliner Systems – Support Details

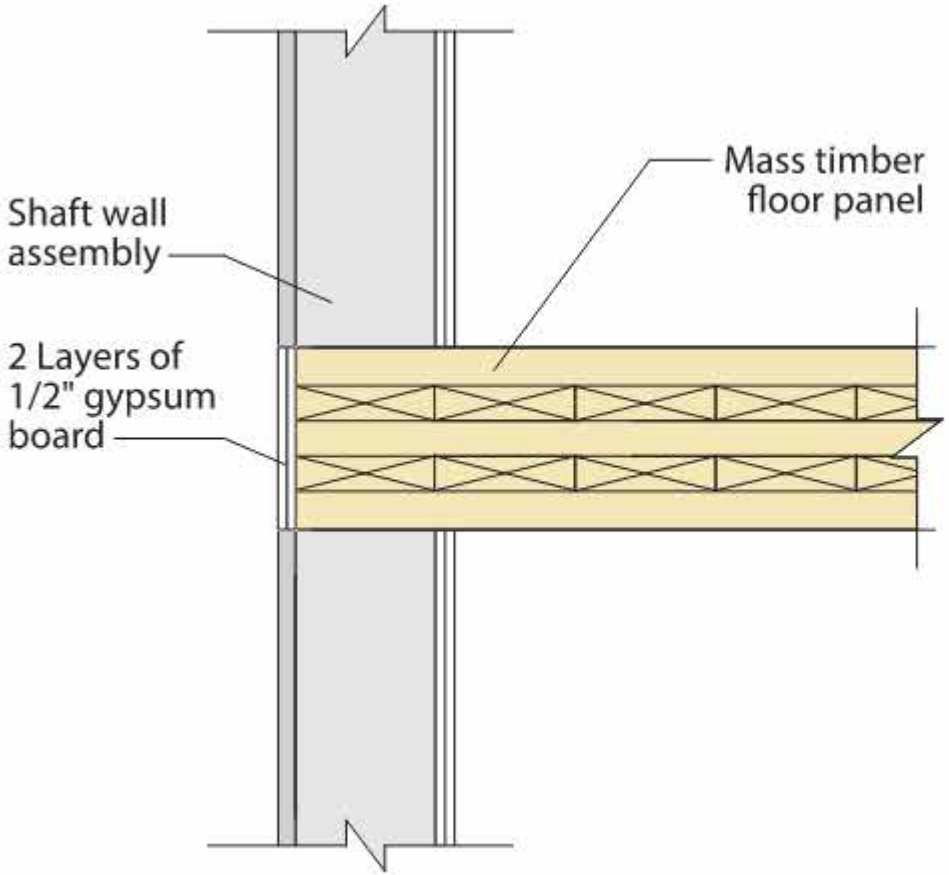
Recall fire barrier continuity definition:

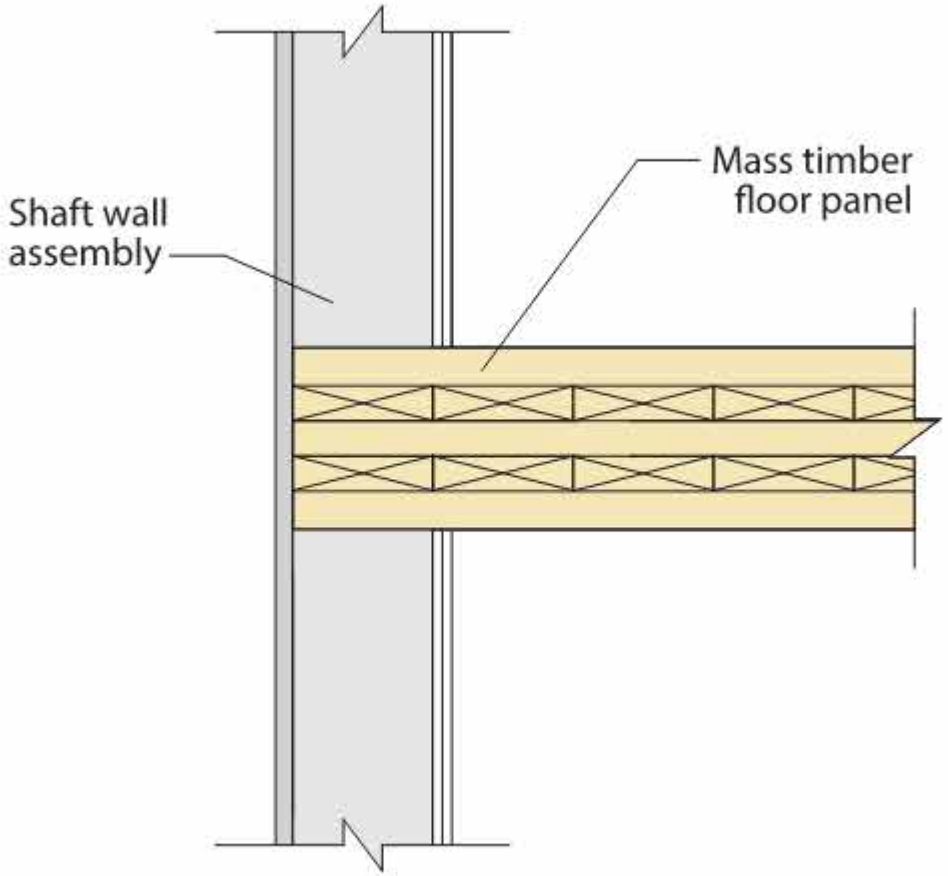
shall extend … to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto

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



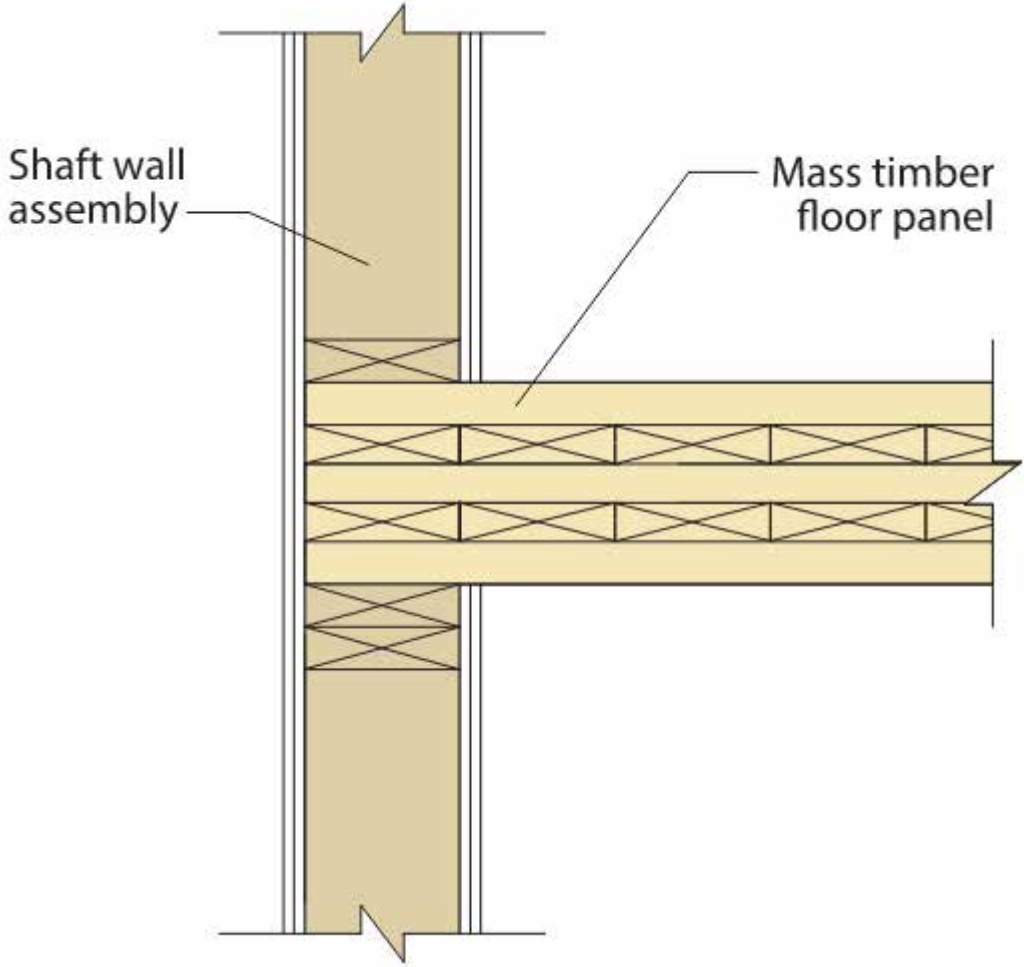
Shaftliner Systems – Support Details

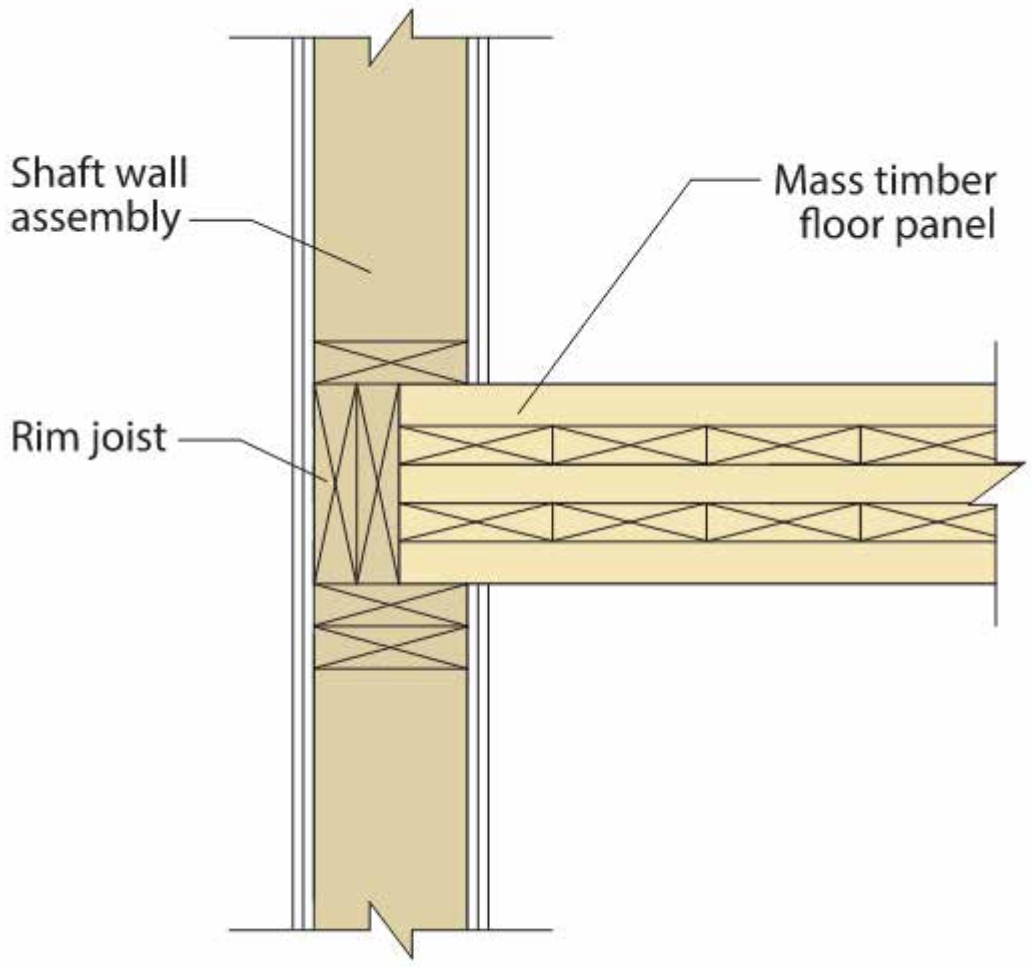




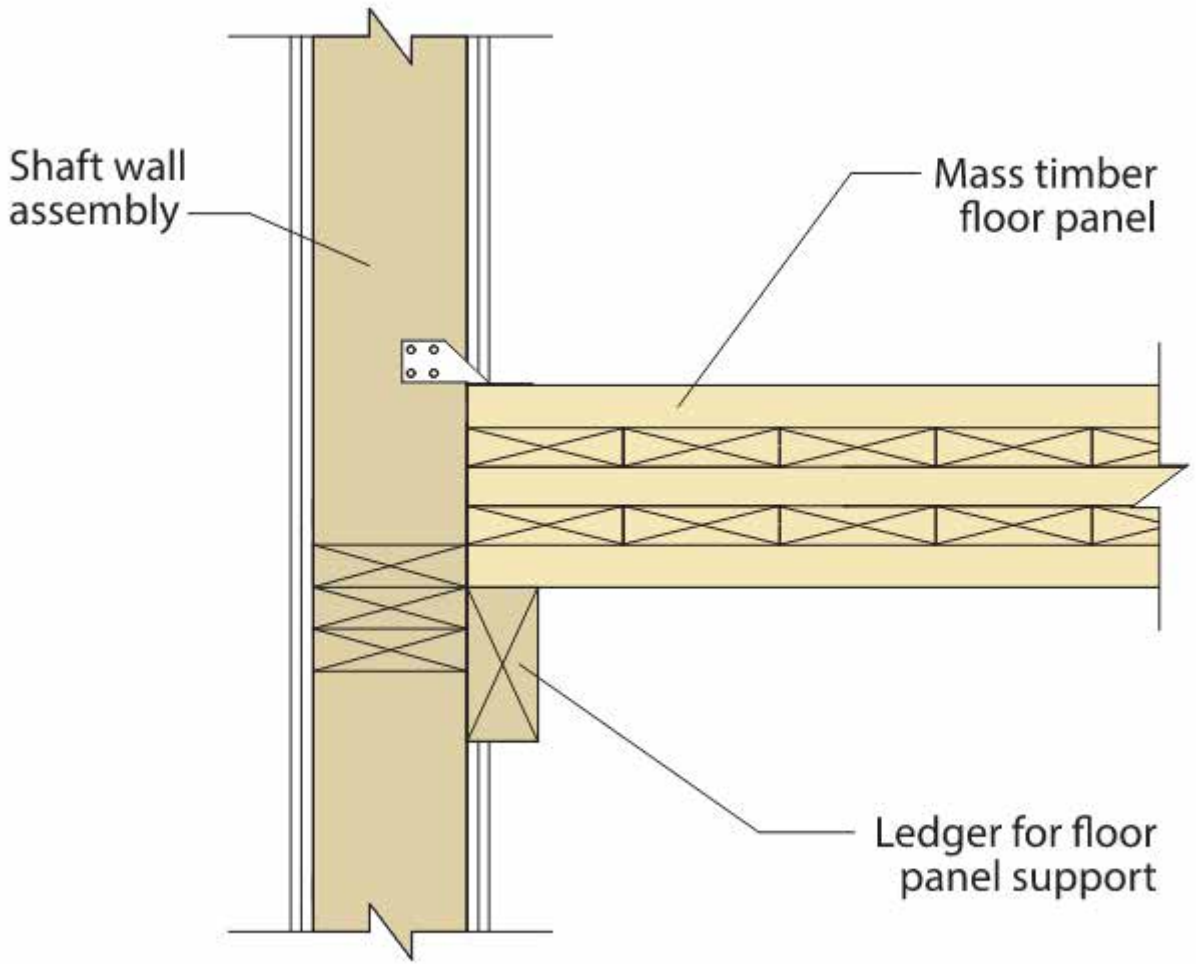
Light Wood-Frame Shaft Walls in Mass Timber Buildings

Floor to Shaft Wall Detailing





Floor to Shaft Wall Detailing



Additional considerations:

- Adequate CLT bearing area
- Ledger size for FRR

Other Shaft Wall Materials in Mass Timber Buildings

Intro, Cleveland

Concrete Core Shear Walls

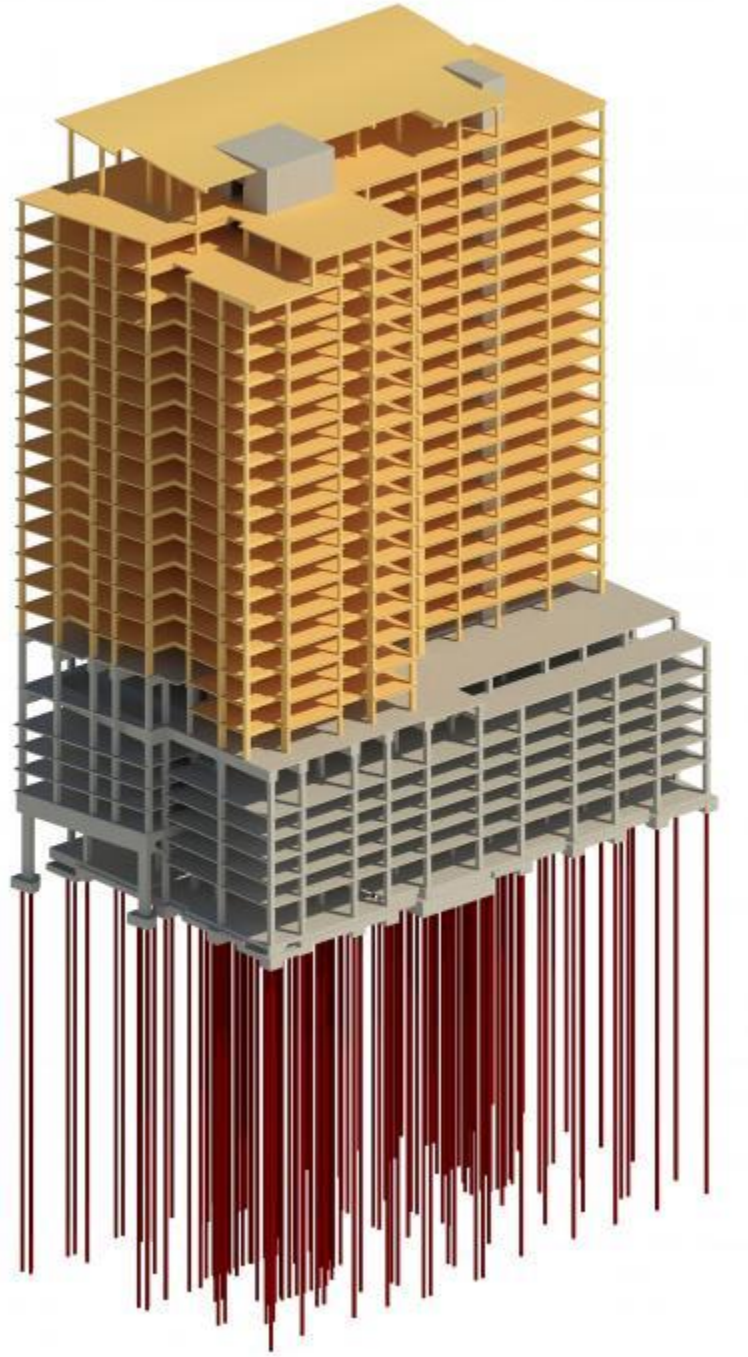
Photo: Panzica Construction

OxBlue

Carbon 12, Portland
Buckling-Restrained Braced Frame

Photos: Marcus Kauffmann, ODF

Ascent, Milwaukee
Concrete Core Shear Walls



Photos: Korb + Associates, Thornton Tomasetti

Brock Commons, Vancouver
Concrete Core Shearwalls

Photos: Acton Ostry Architects

Future Potential Lateral System for Tall Wood

Mass Timber Rocking Shear Walls

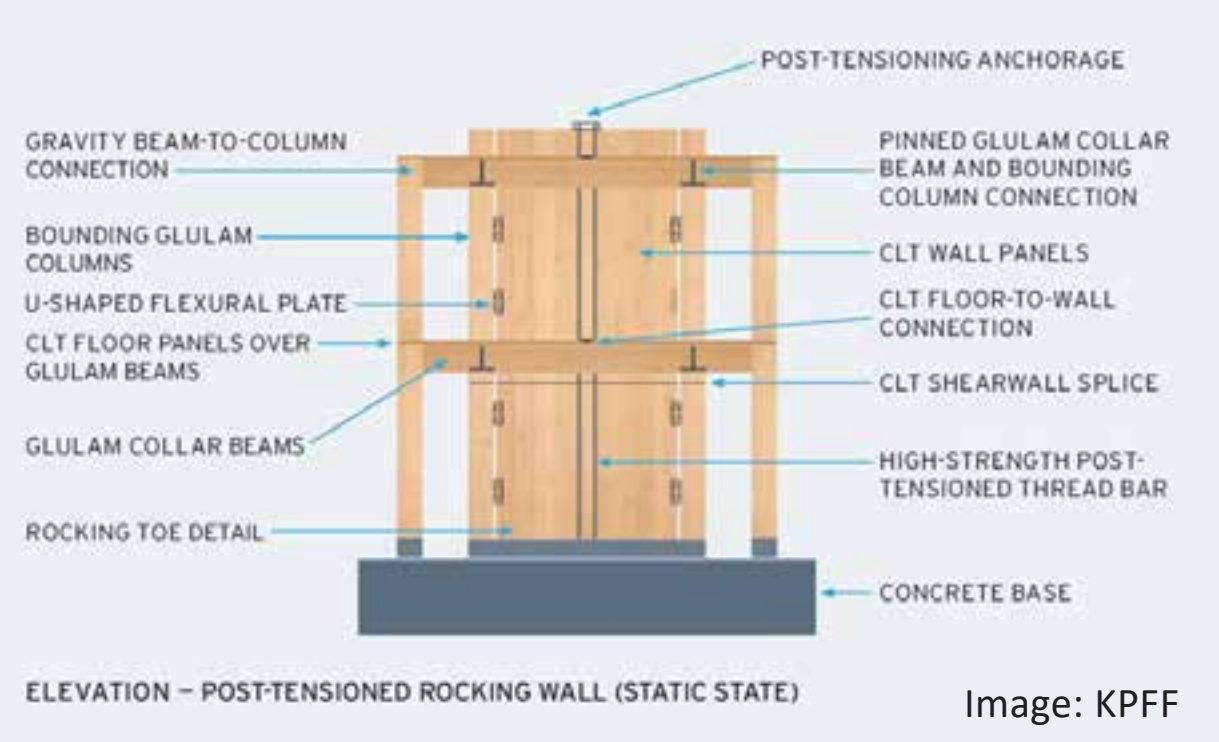


Image: KPFF

Photo: WoodWorks

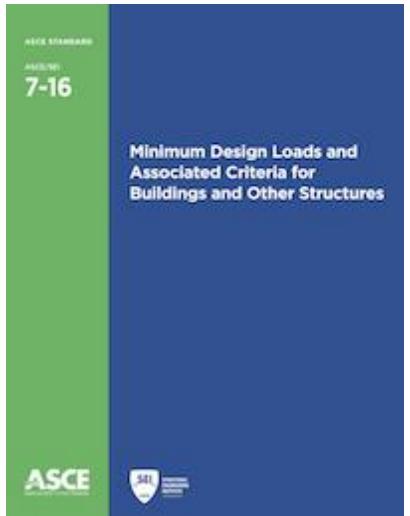
Considerations for Lateral Systems

Prescriptive Code Compliance:

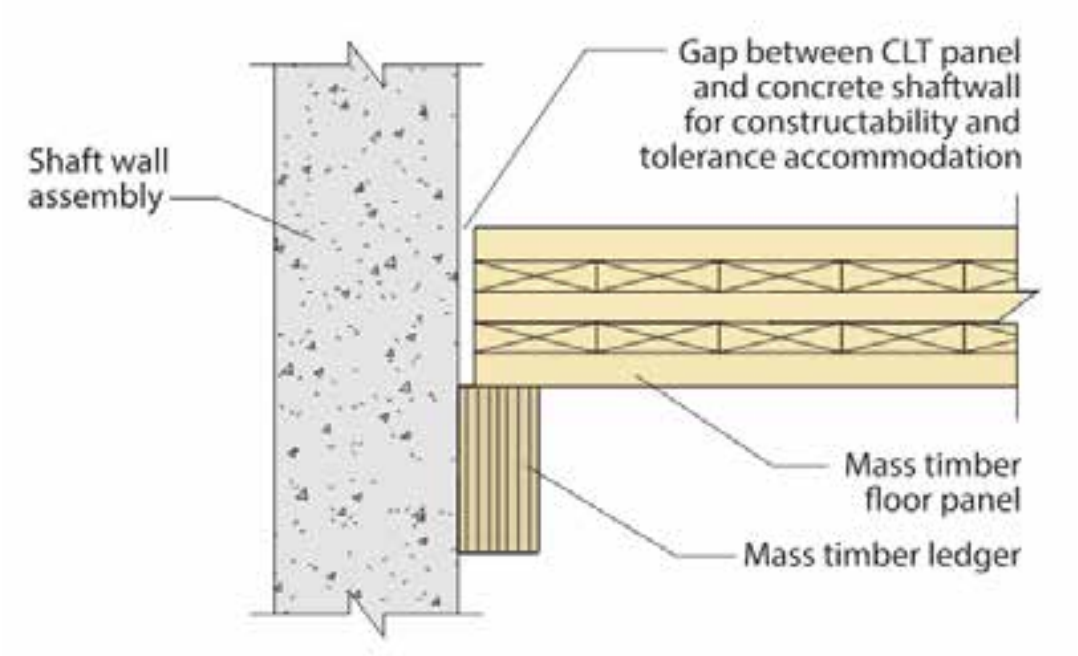
- ☑ Concrete Shear Walls
- ☑ Steel Braced Frames
- ☑ CLT Shear Walls (65 ft max)
- ☒ CLT Rocking Walls

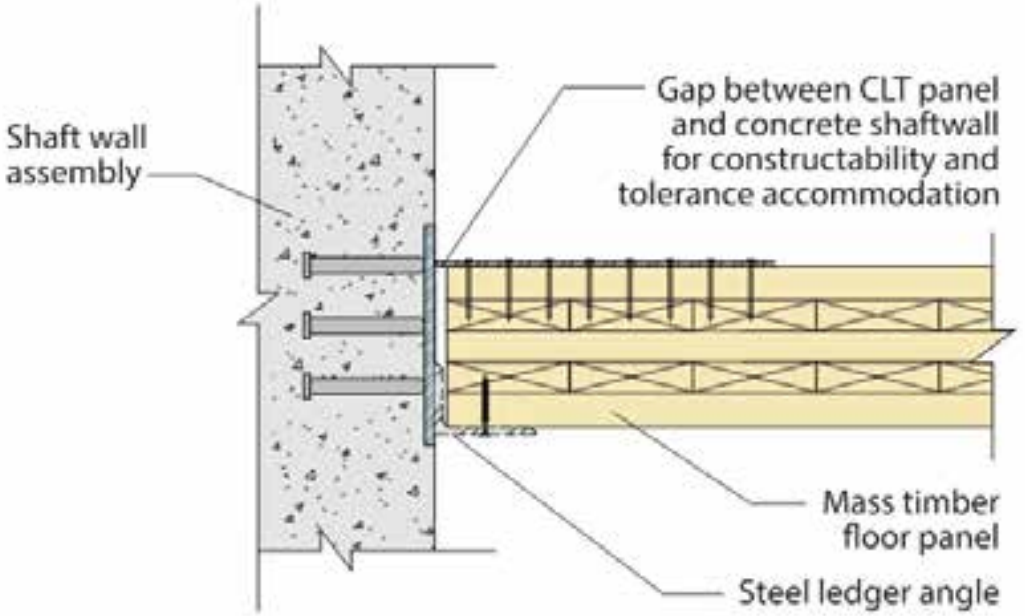
2021 SDPWS, ASCE 7-22

Photo: WoodWorks



Floor to Shaft Wall Detailing

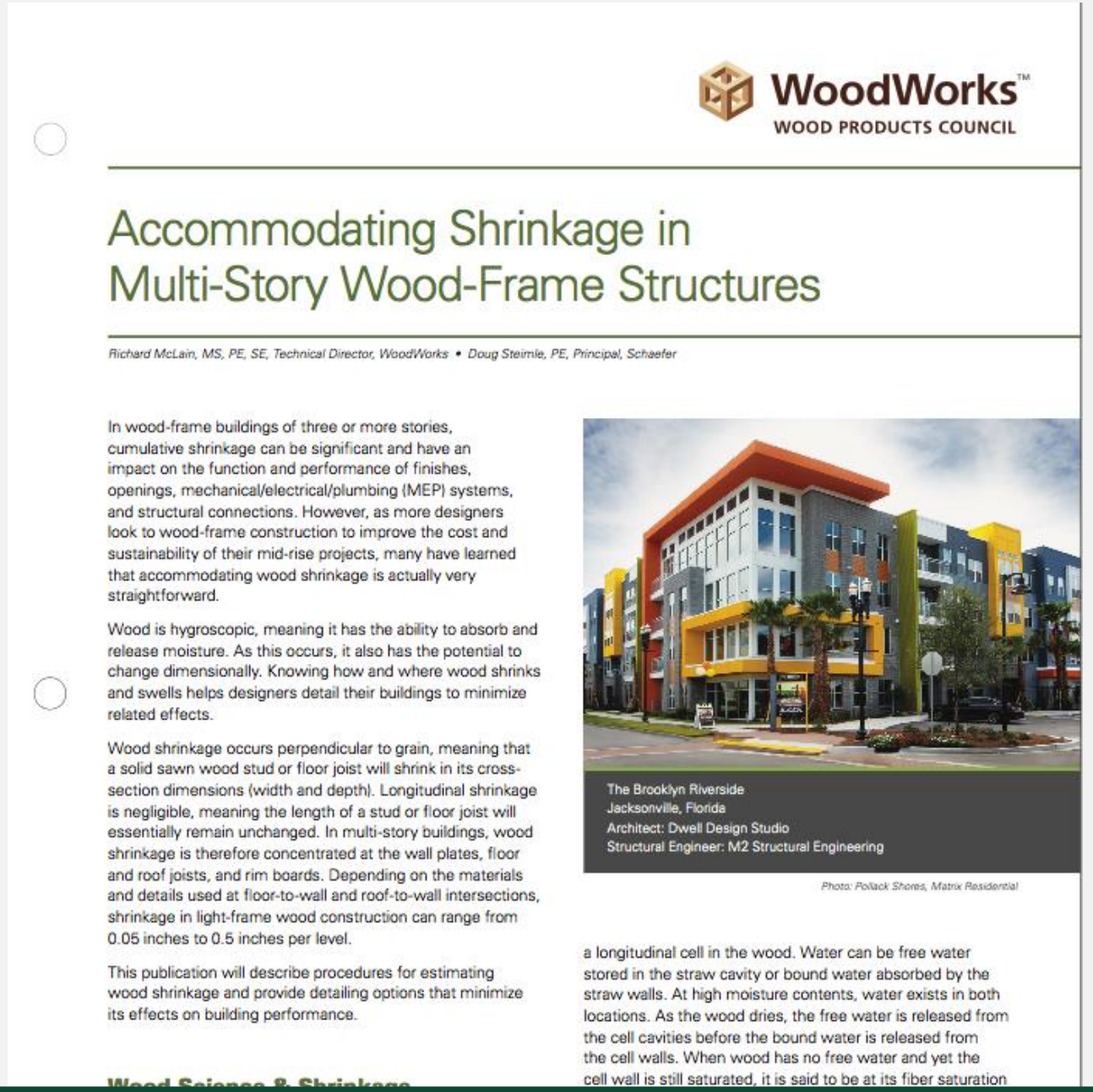




Shrinkage & Movement Resource

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

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

https://www.woodworks.org/resources/accommodating-shrinkage-in-multi-story-wood-frame-structures/

Thank You!

Anthony Harvey, PE

WoodWorks Regional Director | OH, IN, KY, MI, IL, WI

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