Shaft Wall Solutions for Wood-Frame Structures

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Shaft Walls

Shaft Walls Form Shaft Enclosures

“The purpose of shafts is to confine a fire to the floor of origin and to prevent the fire or the products of the fire (smoke, heat and hot gases) from spreading to other levels”

Source: IBC Commentary to Section 713.1
Types of Shaft Walls

Types of Shafts:
• Elevator
• Stair
• Mechanical

Code requirements apply to any/all shaft enclosures. Some points of shaft wall construction and detailing apply to all types of shafts. Some are unique to each type of shaft.

More on the differences later...
Shaft Wall Materials

Light Frame Wood Shaft Walls

- Cost
- Construction Schedule
- Material Compatibility (movement & lateral load resistance)
Shaft Wall Savings – Case Study

Switch to Wood Framed Shaft Walls Saves Project $176,000

- Gala at Oakcrest, Euless, TX
- 4 Story, 135,000 sf multi-family building
- 2 Elevator Shafts, 3 Stair Shafts, all originally designed in masonry – project was otherwise all wood framed
- Initial estimates were total of $266,000 for all 5 shafts
- Team switched to wood shafts, cut $176,000 from cost and at least 3 weeks from schedule

Source: Gardner Capital Construction, project General Contractor & Developer
Shaft Wall Materials

Photo: Will Pryce
Shaft Wall Materials

Mass Timber Shaft Walls

• Cost
• Construction Schedule
• Material Compatibility (movement & lateral load resistance)
• Can double as architectural feature
• Similar to tilt up or continuous wall applications
• Successful fire tests for 2 Hr mass timber shaft walls exist (exposed and protected)
Shaft Wall Design Topics - Agenda

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

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

• Light Frame Bearing Walls (IBC 704.4.1)
• Exterior Walls (IBC 705)
• Fire Walls (IBC 706)
• Fire Barriers (IBC 707)
• Fire Partitions (IBC 708)
Defining Shaft Wall Requirements

Code requirements for shaft enclosures contained in IBC Section 713

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

SECTION 707
FIRE BARRIERS

707.2 Materials.
Fire barriers shall be of materials permitted by the building type of construction.

• Wood-framed shaft walls permitted for any shaft walls in construction types III, IV and V
• FRT wood-framed shaft walls may be used for non-bearing shaft walls in construction types I and II (pending AHJ interpretation)
Shaft Wall Materials

**Type III Construction:**
Any material permitted by code for all interior elements
Fire-retardant treated wood for exterior walls

**Type IV Construction:**
Heavy/mass timber members (or any wood wall min. 1 hr) for all interior elements
Fire retardant treated wood or CLT for exterior walls

**Type V Construction:**
Any material permitted by code for all interior and exterior elements
### Shaft Wall Materials

<table>
<thead>
<tr>
<th></th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior Shaft Walls</td>
<td>Any code permitted wood framing</td>
<td>Heavy timber or any code permitted wood framing (min. 1 hr rated required)</td>
<td>Any code permitted wood framing</td>
</tr>
<tr>
<td>Exterior Shaft Walls</td>
<td>Fire-retardant treated wood</td>
<td>Fire-retardant treated wood or CLT</td>
<td>Any code permitted wood framing</td>
</tr>
</tbody>
</table>

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

Shaft Wall Hourly Ratings:

713.4 Fire-Resistance Rating:
- 2 hours when connecting 4 stories or more
- 1 hour when connecting less than 4 stories
- Number of connected stories includes basement but not mezzanine
- Fire rating of shaft walls shall not be less than floor assembly penetrated, but need not exceed 2 hours
There is no restriction on combustible material within shaft walls or fire barriers in Types III, IV or V construction.
Continuity Provisions

SECTION 713
SHAFT ENCLOSURES

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

SECTION 707
FIRE BARRIERS

707.5 Continuity.
Fire barriers shall extend from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto. Such fire barriers shall be continuous 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

- Fire-resistance-rated floor/ceiling assembly
- Nonfire-resistance-rated floor/ceiling assembly
- Fire-resistance-rated floor/ceiling assembly
- Fire-resistance-rated floor/ceiling assembly or roof/ceiling assembly
- Floor or roof deck
Continuity Provisions
Fire barriers, including shaft walls, must extend from top of sheathing to underside of sheathing. Sheathing does not obstruct continuity.
IBC 707.5.1 Supporting Construction:

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

i.e. shaft walls that are not continuous to lowest level
The intent of a fire barrier is to provide fire confinement. If a fire barrier wall is supported directly by a wall below, the intersecting floor should not be considered a supporting element.
Penetrations in Shaft Walls

SECTION 713
SHAFT ENCLOSURES

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

SECTION 707
FIRE BARRIERS

707.7 Penetrations.
Penetrations of fire barriers shall comply with Section 714.
Penetrations in Shaft Walls

Where are structural penetrations in shaft walls common?

• Main Floor Joists to Shaft Wall Connection
• Stair framing to Shaft Wall Connection
Penetrations in Shaft Walls

SECTION 714
PENETRATIONS

714.3.1.1 Fire-resistance-rated assemblies.
Penetrations shall be installed as tested in an approved fire resistance rated assembly.

OR

714.3.1.2 Through-penetration firestop system.
Through penetrations shall be protected by an approved penetration firestop system installed as tested in accordance with ASTM E814 or UL 1479, with a minimum positive pressure differential of .01 inch of water and shall have an F rating of not less than the required fire-resistance rating of the wall penetrated.
Penetrations in Shaft Walls

To some, a new way of thinking:
Many are familiar with firestopping for MEP, but not structure, especially wood structure
Penetrations in Shaft Walls

- 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

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)
Structural members are specifically called out as allowable penetrants in shaft enclosures.
Shaft Walls that are also Exterior Walls

Stair and elevator shaft enclosures are commonly placed along the exterior of the building.

When a shaft wall also serves as the exterior wall of a building, unique provisions exist.
Shaft Walls that are also Exterior Walls

713.6 Exterior walls. Where exterior walls serve as a part of a required shaft enclosure, such walls shall comply with the requirements of Section 705 for exterior walls and the fire resistance-rated enclosure requirements shall not apply.

Exception: Exterior walls required to be fire-resistance rated in accordance with Section 1021.2 for exterior egress balconies, Section 1023.7 for interior exit stairways and ramps and Section 1027.6 for exterior exit stairways and ramps.
Shaft Walls that are also Exterior Walls

Exterior bearing wall fire resistance rating per Table 601

<table>
<thead>
<tr>
<th>BUILDING ELEMENT</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
<th>TYPE IV</th>
<th>TYPE V</th>
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<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>HT</td>
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<tr>
<td>Primary structural frame(^e) (see Section 202)</td>
<td>3(^a)</td>
<td>2(^a)</td>
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<td>0</td>
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<tr>
<td>Bearing walls</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Exterior(^d)</td>
<td>3(^a)</td>
<td>2(^a)</td>
<td>1</td>
<td>0</td>
<td>1(^b)</td>
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<tr>
<td>Interior</td>
<td>3(^a)</td>
<td>2(^a)</td>
<td>1</td>
<td>0</td>
<td>1(^b)</td>
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<tr>
<td>Nonbearing walls and partitions</td>
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<tr>
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<td>0</td>
</tr>
<tr>
<td>Interior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor construction and associated secondary members (see Section 202)</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>HT</td>
</tr>
</tbody>
</table>
| Roof construction and associated secondary members (see Section 202) | 1\(^{1/2}\) | 1\(^{b\text{a}}\) | 1\(^{b\text{a}}\) | 0\(^e\) | HT     | 1\(^{b\text{a}}\) | 0
Shaft Walls that are also Exterior Walls

**Exterior Walls (IBC 705):**

- Materials as permitted for type of construction (same as fire barrier) – 705.4
- Fire resistance only required from inside if fire separation distance is > 10 ft – 705.5
- Possible to have exterior shaft wall that does not require a fire resistance rating
Shaft Walls that are also Exterior Walls

1023.7 Interior exit stairway and ramp exterior walls.

Exterior walls of the interior exit stairway or ramp shall comply with the requirements of Section 705 for exterior walls. Where nonrated walls or unprotected openings enclose the exterior of the stairway or ramps and the walls or openings are exposed by other parts of the building at an angle of less than 180 degrees (3.14 rad), the building exterior walls within 10 feet (3048 mm) horizontally of a nonrated wall or unprotected opening shall have a fire-resistance rating of not less than 1 hour. Openings within such exterior walls shall be protected by opening protectives having a fire protection rating of not less than 3/4 hour. This construction shall extend vertically from the ground to a point 10 feet (3048 mm) above the topmost landing of the stairway or ramp, or to the roof line, whichever is lower.
Shaft Walls that are also Exterior Walls

Source: IBC Commentary Figure 1023.7(1)
Shaft Walls that are also Exterior Walls

Structural Considerations
When Stair Shaft Wall is Exterior Wall

Wall Plates at Typical Floor Elevation – Creates Potential “Hinge”

Intermediate Stair Landing

2x10 Ledger fasted to each wall stud with (3) 16d nails

LU210 Face Mount Hanger

splice exterior wall studs at stairwells at standard floor elevations. 2x6 plates shall be continuous for the full length of the stair opening and shall extend 2'-0" beyond the opening. Overlap plates at corner and nail to each plate to the plate below with (4) 10d nails.
Shaft Walls that are also Exterior Walls

Typical Exterior Wall Condition

Floor Diaphragm Braces Wall Joint

Wind Loads on Exterior Wall

No Floor at Shaft to Brace Wall Joint

Wind Loads on Exterior Wall

Exterior Wall That is Shaft Wall
Intermediate Stair Landing Framing

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**

- **Shaft wall**
- **Intermediate Stair Landing Framing**

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
Shaft Wall Assemblies

Assembly selection considerations
• Fire resistance rating requirement (1 hr or 2 hr)
• Size and height of shaft
• Structural needs (gravity & lateral loads)
• Acoustics
• Space available for wall (allowed thickness)
Shaft Wall Assemblies

1-Hour Single Wall
- UL U305
- GA WP 3510
- UL U311
- IBC 2012 Table 721.1(2), Item 14-1.3
- UL U332

1-Hour Double Wall
- UL U341

1-Hour Wall with Shaftliner
- UL V455
- UL V433
Shaft Wall Assemblies

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

2-Hour Double Wall
- UL U342
- UL U370
- GA WP 3820

2-Hour Wall with Shaftliner
- UL U336
- UL U373
- UL U375
- UL V455
- UL V433
- GA ASW 1000
Shaft Wall Assemblies with Shaftliner

Shaftliner Unique Considerations

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

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

Some key considerations are:

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

Common Details

Platform Framing

Semi-balloon Framing
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”
Concept of stacking different rated assemblies isn’t new
Floor to Shaft Wall Detailing

- Fire-resistance rating still continues to the underside of the deck
- Assumes a tested assembly to the top of wall plate
- Above wall top plate, uses 703.3 allowance for fire-resistance calculations per 722
- 722 allows NDS Chapter 16 methods for fire resistance calculations for exposed wood
- The combustibility of the material is not an issue; must meet the fire rating requirement
Calculated Fire Resistance of Wood

For Exposed Wood Members: IBC 722.1 References AWC’s NDS Chapter 16 (AWC’s TR 10 is a design aid to NDS Chapter 16)
Calculated Fire Resistance of Wood

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

Source: AWC’s TR 10
Calculated Fire Resistance of Wood

Report FPL-RP-610 from USDA FPL summarizes results from fire testing on rim boards
Floor to Shaft Wall Detailing

**Figure 11:**
Floor-to- Shaft Wall Intersection Detail with Gypsum Extending to Underside of Sheathing between Trusses

- (2) 2x flat blocking between trusses
- Extend wall gypsum to underside of sheathing between trusses
- Specify truss web holdback to allow gypsum installation
Floor to Shaft Wall Detailing

**FIGURE 12:** Floor-to-Shaft Wall Intersection Detail with Supporting Beam Just Inboard of Wall

- **Floor sheathing**
- **Ledger for ceiling attachment**
- **Floor joist**
- **Joist hanger**
- **Floor beam**
Floor to Shaft Wall Detailing

• Perhaps most conservative solution
• Cost and schedule are considerations
• Some require that wall gypsum be installed prior to hanger, some allow post-install
• Not uncommon in type III floor to exterior wall details – easy extension to shaft walls
• Several options on the market
Floor to Shaft Wall Detailing

Shaftliner in H-studs attached to wall with clips

Floor side wall provides typical floor support
Floor to Shaft Wall Detailing

**FIGURE 20:** Mass Timber Floor Framing-to-Shaft Wall Attachment

- Gypsum wallboard (if required)
- Floor framing
- Mass timber shaft wall
- Ledger for floor framing

Photo: Alex Schreyer
Stair, Elevator & MEP Shafts

Main Differences & Unique Design Constraints

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

Attach ledger to each shaft wall stud with fasteners designed to account for gypsum.
Stair Shafts

**FIGURE 16:** Stair Framing Beam in Protect Pocket in Shaft Wall

Beam bears directly on axially loaded post

2-hr protection provided all around beam via blocking
Elevator Shafts
Elevator Shafts

Rail bracket supported on (2) 2x12 laminated members supported and fastened between (2) 2x4 studs on to which gypsum boards are attached.

2x4 stud

Rail bracket

TYPICAL STUD AND DRY WALL BOARD CONSTRUCTION
MEP Shafts

- Size of MEP shaft may require a solution with one or more sides being shaftliner panels
- Ability to get inside shaft to finish gypsum panels often the controlling factor in wall assembly selection
Non-Wood Shaft Walls
Masonry Shaft Walls

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

• Masonry shaft walls often become part of building’s lateral force resisting system
• This increases seismic forces and adds mass
• Difference in stiffness between wood & masonry shear walls may need to be considered
• Differential shrinkage between wood and masonry needs to be considered
• Best practices include isolating masonry shaft walls, only tie wood floor to masonry shaft if/where required (i.e. at door threshold)
## Masonry Shaft Walls

### Table 12.2-1 Design Coefficients and Factors for Seismic Force-Resisting Systems

<table>
<thead>
<tr>
<th>Seismic Force-Resisting System</th>
<th>ASCE 7 Section Where Detailing Requirements Are Specified</th>
<th>Response Modification Coefficient, $R^*$</th>
<th>Overstrength Factor, $\Omega_0^*$</th>
<th>Deflection Amplification Factor, $C_L^*$</th>
<th>Structural System Limitations Including Structural Height, $h_s$ (ft) Limits</th>
<th>Seismic Design Category</th>
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</thead>
<tbody>
<tr>
<td>15. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance</td>
<td>14.5</td>
<td>6½</td>
<td>3</td>
<td>4</td>
<td>NL</td>
<td>NL NL 65 65 65</td>
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<td>16. Special reinforced masonry shear walls</td>
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<td>17. Intermediate reinforced masonry shear walls</td>
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<td>NL NL NP NP NP</td>
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<td>18. Ordinary reinforced masonry shear walls</td>
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<td>2</td>
<td>2½</td>
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<td>NL 160 NP NP NP</td>
</tr>
</tbody>
</table>

### Mass Matters:

- 8” CMU Wall, grout & reinforcing @ 48” o.c.: **44 psf**
- 2x6 wood wall w/2-layers of 5/8” gypsum each side: **16 psf**

Source: ASCE 7-10
Masonry Shaft Walls

- CMU Wall
- Wood Floor Sheathing
- Vert Reinf + Grout, See Plan for Size & Location
- Wood Floor Framing (TYP)

Provide gap between wood framing and CMU wall - width as required.

See Arch

T/Framing

See Plan
Masonry Shaft Walls

4'-0" MIN TO GIRDER
TRUSS OR BEAM

WOOD FLOOR SHEATHING

SEE ARCH

CMU WALL

VERT REINF + GROUT
AS REQUIRED

WOOD FLOOR FRAMING

HANGER AS REQUIRED

LEDGER AND FASTENERS AS REQUIRED

GIRDER TRUSS
OR BEAM

T/J FRAMING
SEE PLAN
Resource for Material Movement

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

Free resource at woodworks.org
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
This concludes The American Institute of Architects Continuing Education Systems Course

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