structural
COMPONENTS

Part 1 of this article (STRUCTURE, September 2018) addressed code considerations and detailing related to wood-frame shaft walls in multi-family and commercial buildings that are also wood-frame. Building on those fundamentals, this article examines fire design requirements, construction constraints, and other potential differences associated with applications such as stairs, elevators, and MEP shafts. With a greater understanding of the nuances, the goal is to better equip engineers to realize the cost, schedule, and other benefits of this increasingly common approach to shaft wall design.

Shaft Wall Applications

The three main types of shafts in commercial and multi-family construction are stairs, elevators, and mechanical. Some of the following principals apply to all of these shafts, while some are unique to each.

Figure 2. Stair landing framing attached to shaft wall through two layers of gypsum.

Shaft Wall Solutions for Wood-Frame Buildings

Part 2: Applications

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Stair Shafts

Stair shafts are unique when compared to elevator shafts and mechanical shafts in that they have framing within the shaft (stair and landing framing) that must be accommodated.

Once the typical wall assembly and main floor-to-shaft wall detail have been selected, the next detailing considerations involve attaching the stair framing – stringers and landing framing – to the shaft walls. Many of the same considerations exist for main floor-to-wall detailing at this stair framing-to-wall detail. The difference is that a break/joint in the wall studs is typically not present at the stair and intermediate landing framing-to-wall attachment. Due to this, it is common to run one or two layers of wall gypsum up the face of the wall and attach the stair and landing framing to the shaft wall through the wall gypsum.

To accomplish this detail, a ledger is typically attached to the shaft wall through the layer(s) of gypsum that extend continuously up the shaft with the stair/landing framing hung from the ledger. Note that this configuration requires particular attention to the design of the fasteners attaching the ledger to the wall (*Figure 1*).

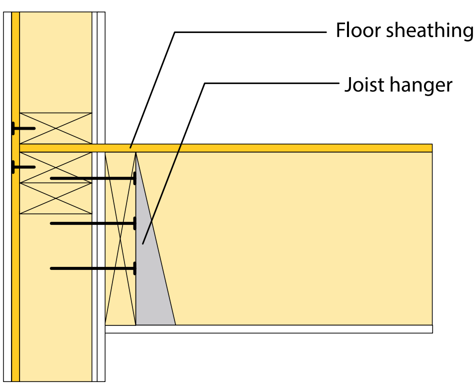

Figure 1. Floor framing ledger attached to shaft wall through two layers of gypsum.

Fasteners installed through gypsum wallboard can be large and difficult to accommodate when supporting larger loads because of the eccentricity on the fastener and the compression capacity of the gypsum. In addition to fastener requirements, regardless of the magnitude of loads, construction sequencing is a significant concern. To address this, some contractors begin by installing a strip (or strips) of moisture-resistant gypsum wallboard only where the structure will attach to the shaft wall. After all the framing is installed, the remainder of the shaft gypsum is installed (*Figure 2*).

Elevator Shafts

Many of the same design considerations and wall assembly options that exist for stair shaft walls also apply to elevator shaft walls. Acoustical design considerations are perhaps more pronounced in elevator shaft walls than they are in stair shafts and mechanical shafts. The distinguishing factor in elevator shafts is the design of the rail supports. In some instances, elevator rails are attached to the structure at each floor level. For this option, a rim joist is typically implemented in the adjacent floor framing for rail bracket attachment. These rim joists provide backing to bolt the connecting plates to the shaft. Additional blocking and strapping are provided around the perimeter of the shaft to transfer the elevator's horizontal forces into the floor diaphragm. The bracket attaching the elevator rail to the connecting plate should be vertically slotted at each floor level to compensate for shrinkage of the wood framing.

In other instances, the rails can attach at any elevation in the shaft. For this situation, vertical wood posts composed of wood members oriented with their wide face parallel to the wall are typically used for rail bracket attachment. Regardless of the situation, the elevator manufacturer should be consulted for input on the proposed detail.

Most elevator shafts are required to have a hoist beam at the top for installation safety. The elevator manufacturer specifies the location and required load resistance. In masonry and steel-frame shafts, the hoist beam is typically a structural steel wide flange beam. In wood frame elevator shafts, the hoist beam can be structural steel or in some cases wood. The elevator manufacturer should be consulted to determine the compatibility of their product with different hoist beam options.

Mechanical Shafts

Many of the same design considerations and wall assembly options that exist for stair and elevator shaft walls also apply to mechanical shaft walls. The main difference is that mechanical shafts are often small enough such that physically getting into the shaft to finish the gypsum is not possible. A common solution includes framing some or all sides of the shaft with shaftliner panels to deal with this situation.

Shaft Walls That Are Also Exterior Walls

In building types such as multi-family, it is common to have stair and elevator shafts located at the ends and corners of the building. When a shaft wall also forms a portion of the perimeter of the building, the following code provisions in the *International Building Code* (IBC) apply.

Section 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 1019.2 for exterior egress balconies, Section 1022.7 for interior exit stairways and ramps and Section 1026.6 for exterior exit stairways and ramps.

Section 1023.7 Interior exit stairway and ramp exterior walls. *Exterior walls of the interior exit stairway and ramp shall comply with the requirements of Section 705 for exterior walls. Where nonrated walls or unprotected openings enclose the exterior of the stairway 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 ¾ hour. This construction shall extend vertically from the ground to a point 10 feet (3048 mm) above the topmost landing of the stairway or to the roof line, whichever is lower.*

As noted in these code sections, shaft walls that are also exterior walls can be rated per the exterior wall requirements. IBC Tables 601 and 602 provide the fire-resistance rating requirements for exterior walls. It is important to note that exterior walls with a fire separation distance of greater than 10 feet are only required to be rated for exposure to fire from the inside face of the exterior walls per IBC Section 705.5. A definition of fire separation distance is provided in IBC Section 202. Following the provisions of the code sections cited above, it is not uncommon to have a non-rated shaft wall along the perimeter of the building. Under this circumstance, the sections of the exterior wall adjacent to the shaft must be rated for a minimum of 1 hour for a minimum of 10 feet away from the shaft. The intent of the code here is to prevent a fire in the main area of the building from running through the unrated exterior wall and then over and into the shaft. See Figure 1023.7(1) of the IBC *Commentary* for example illustrations of this condition.

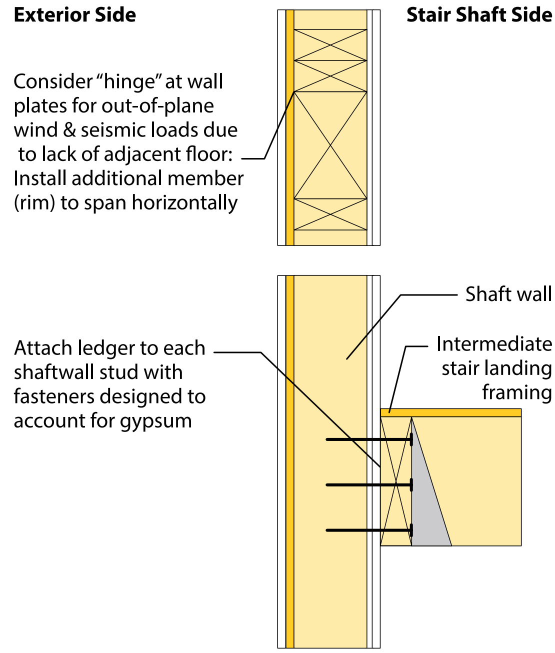

Figure 3. Stair/exterior walls with options for bracing wall plates at stud joints.

Unbraced Joints in Wall Studs at Shafts

When a shaft wall is also an exterior wall, the typical floor framing is not in place on the non-shaft side of the wall to brace it against

Figure 4. Masonry shaft wall in wood frame building.

out-of-plane wind and seismic forces. Due to this, hinge effects in the wall framing should be considered. A few options exist to address this condition. One is to use the wall plates as continuous, horizontally-spanning members to resist out-of-plane loads. If using this option, the designer should specify that the plates not be jointed in the shaft area. Another option would be to install a structural rim member between the plates with the purpose of spanning horizontally and resisting out-of-plane loads. Where this rim member ends at the end of the shaft, it would be attached to the diaphragm and shear walls to resolve its out-of-plane force reactions. See *Figure 3, page 13* for an example of this detail.

Masonry Shaft Walls

In some regions of the country, masonry shafts are commonly used in buildings that are otherwise wood-frame (*Figure 4*). In addition to acting as shaft enclosure walls, these masonry walls are often used as shear walls. While this is common practice, there are several issues with mixing masonry shear walls at the shafts with an otherwise light-frame wood structure, notably seismic compatibility of the systems and differential shrinkage.

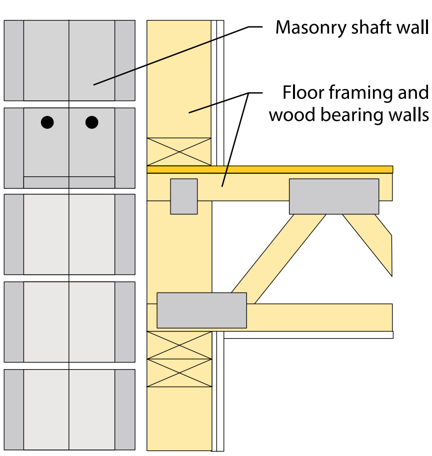

Figure 5. Masonry shaft wall isolated from wood floor framing by using wood bearing wall.

Seismic Compatibility

ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures*, Table 12.2-1, lists design coefficients and factors for seismic-force-resisting systems. This table does not include a lateral load-resistance combination for both light-frame wood shear walls and masonry shear walls. Each is categorized separately, and they have significantly different seismic-resistance properties. The seismic response modification coefficient, R, of light-frame wood-sheathed shear walls is 6.5, while the R of masonry shear walls can vary from 2 (ordinary reinforced masonry shear walls) to 5 (special reinforced masonry shear walls). Regardless of which type of masonry shear wall is used, the associated lower R of masonry shear walls will produce higher seismic forces when compared to a wood shear wall system. When using more than one type of lateral-force-resisting system in the same force direction, ASCE 7-10 section 12.2.3.3 requires that the least value of R be used for all systems in the direction under consideration.

Although there are a few conditions that allow this requirement to be waived, in most commercial and multi-family buildings the lower R factor of the masonry shear walls would need to be used throughout the building for the loading direction considered, even for the design of the wood shear walls.

Wood shear walls and masonry shear walls also have inherently different stiffness properties. When using a flexible diaphragm analysis, the diaphragm forces are distributed to vertical-resisting elements based on their tributary area, regardless of their relative stiffness. A flexible diaphragm analysis is typically done for light-frame construction. If accounting for the difference in relative stiffness of the vertical-resisting elements (shear walls) is desired, a semi-rigid or rigid diaphragm analysis would be required. Section 4.2.5 of the American Wood Council's *Special Design Provisions for Wind and Seismic* (SDPWS) discusses this in further detail.

To address this requirement of using a lower R factor associated with the masonry walls, as well as to address the requirement of SDPWS Section 4.1.6, many engineers are recognizing the benefits of switching shaft walls to wood. This reduces the seismic forces (lower wall mass) and allows the entire building's lateral system to use an R of 6.5, while also dealing with issues such as differential movement/shrinkage which can occur between a wood-frame floor and its supporting masonry shaft wall. Switching to wood shaft walls may also be beneficial from the perspective that it eliminates the need for two construction trades and has the potential to speed the construction schedule and reduce cost.

Differential Movement

When mixing materials, detailing best practices include consideration of how each of these construction materials will move relative to each other. Wood framing will likely shrink, with the amount varying depending on how the building is detailed, the moisture content of the wood before construction, and the equilibrium moisture content of the site. Masonry will shrink very little if at all (in some instances it can expand). Also, the differential movement between the wood walls supporting the wood-frame floor and the masonry shaft wall may cause floors to slope, finishes to be damaged, or issues at door thresholds to occur.

If using masonry shaft walls in a wood-frame building, the best option for detailing to avoid issues is to isolate the wood framing from the masonry shaft walls. See *Figure 5* for an example of this detail. For further information on differential material detailing, see the WoodWorks publication, *Accommodating Shrinkage in Multi-Story Wood-Frame Structures*.

Conclusion

Shaft wall assembly and detail selection should be carefully considered regardless of the material used. The IBC provides ample opportunities for wood-frame shaft walls that should be explored before assuming that other materials are necessary for an otherwise wood-frame structure. A variety of detailing options exist at assembly intersections. This is a positive, as it allows for flexibility in shaft wall solutions and enables the designer and building official to explore options and determine the most appropriate solution for a given project.▪

This article is excerpted from the WoodWorks paper, *Shaft Wall Solutions for Wood-Frame Buildings*, available at **www.woodworks.org**.