



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

One of the most desired aspects of mass timber construction is the ability to leave a building's structure exposed as finish. Because large solid wood panel products—such as cross-laminated timber (CLT), glue-laminated timber (GLT), nail-laminated timber (NLT), and dowel-laminated timber (DLT)—pose the same acoustic challenges as any lightweight building structure, but without the benefits of a dropped finish ceiling, these projects require thoughtful design and detailing to achieve the desired acoustic performance. However, with the increasing use of mass timber building systems across the U.S., there are many tested assemblies and resources available to help building designers achieve this goal.

Emphasizing room-to-room noise control, this paper covers key aspects of mass timber acoustical design, including optimal techniques/rules of thumb, common assemblies and where to find them, detailing strategies, and options for eliminating flanking paths.

Basics of Acoustics and Code Requirements

Sound transmission class (STC) measures how effectively a wall or floor/ceiling assembly insulates airborne sound and reduces the sound level that passes from one side to the other directly through the wall or floor/ceiling. Examples of airborne sound include conversation and music. Impact insulation class (IIC) measures how effectively a floor/ceiling assembly blocks impact sound (or structure-borne sound) from passing directly through a floor/ceiling. Examples include footfalls, furniture movement, and items dropping on the floor.

In addition to direct sound transmission, airborne and impact sound can bypass the separating assembly through a process called flanking transmission, or simply flanking. Flanking can occur through connected structure (i.e., structural flanking) or at interruptions/joints in the separating assembly (i.e., leakage). Designers often choose mass timber panels with multiple-spans for efficiency and economy. With panels continuous over multiple supports, and bridging multiple noise-sensitive

Photo: Travis Mark



Timber House / Mesh Architectures / Silman

spaces, understanding and controlling ceiling-to-ceiling structural flanking is an important part of the acoustical design. For more background, see the HGC article, [*What's the Difference Between Direct & Flanking Sound Transmission in Building Design*](#).¹

Section 1206 of the 2024 International Building Code (IBC) includes requirements for acoustic performance of walls, partitions, and floor/ceiling assemblies in multi-family buildings. These assemblies, which separate one dwelling unit from another or from public areas, must have a direct STC rating of 50 and, in the case of floor/ceiling assemblies, a direct IIC rating of 50. (Similar ratings can be reduced to 45 when the assembly is field tested and the effects of flanking are included.) Note that these code requirements only apply to multi-family construction. Although guidelines related to acoustical performance in occupancies such as offices, schools and hospitals^{2,3,4} do exist, they are not requirements under the IBC. Special requirements for classrooms in IBC Section 1207 and therefore ICC A117.1 Section 808 are for in-room acoustics and beyond the focus of this paper.

Considerations Unique to Mass Timber

It is common practice to add components to mass timber assemblies to improve their acoustical performance. In floor/ceiling applications, owners and design teams often want to expose the ceiling side of mass timber panels for aesthetic reasons, which means components must be installed on top of the assembly. The use of asymmetrical assemblies is one of the main acoustical design distinctions between mass timber and light-frame wood floor/ceiling assemblies. In light-frame construction, acoustical components are typically included above, within, and below the assembly—e.g., underlayment and/or concrete topping above the framing, batt insulation within the framing cavity, and resilient channels/isolated clips and gypsum board underneath.

There are several main ways to improve an assembly's direct sound transmission performance:

1. Add mass
2. Add decouplers
3. Increase air cavity depth
4. Add insulation
5. Add damping

One of the characteristics of mass timber is that it has a high strength-to-weight ratio; therefore, when compared to other panel and slab-type construction materials, it weighs significantly less. This reduces building mass, which is beneficial in terms of lower seismic forces, smaller foundation requirements, and soil improvement measures such as pilings or piers. However, with acoustics, more mass typically means better noise control. For comparison, a typical 6-in.-thick concrete slab weighs approximately 75 psf and has an STC rating of 53⁵ while a ~7-in.-thick CLT panel weighs about 17 psf⁶ and has an STC of 41. Due to the lack of mass inherent in the mass timber panel, a common way to improve acoustical performance is to add a poured concrete or gypsum-based concrete ("wet") topping layer, usually in the range of 1-3 in. thick, or install a dry-laid plywood, cement-board, or gypsum-based flooring board ("dry") system.

Database of Acoustically-Tested Mass Timber Assemblies

WoodWorks' *Mass Timber Fire & Acoustic Database*⁷ includes detailed information on assemblies that have been acoustically tested to meet North American direct sound transmission standards, including STC and IIC ratings, and links to test reports and providers.

While most acoustic tests to date have been performed on CLT assemblies, the database incorporates a full range of tested panel products, including CLT made from sawn lumber, CLT made from structural composite lumber (SCL CLT), GLT, NLT, DLT, and tongue-and-groove decking. It includes nearly 1,000 tested assemblies at the time of publication, and continues to expand as the results of new tests become available.



Photo: USG

Concrete floor topping

Decouplers are products that decouple, or break direct connections between, finishes on one side of an assembly and the other. This reduces the amount of noise that can directly travel through finish layer to structure to finish layer. Common examples in light-frame wood construction include resilient channels, isolation clips, and air gaps. In mass timber floor/ceiling systems, the most common decoupling products are roll-out isolation mats or discrete isolators spaced in a grid pattern placed between the mass timber panel and topping. The type and thickness of material varies by product line and manufacturer, but the purpose is the same: to isolate the direct connection

between structure/ceiling finish (the exposed mass timber panel) and the top side finish (topping and/or finish floor). Figure 1 shows several examples of underlayment products.

Although it is common to add absorptive material within light-frame wood assemblies (e.g., batt insulation in a floor cavity), this method is rarely used in mass timber floor/ceiling assemblies with roll-out isolation mats. That said, several acoustically-tested mass timber floor assemblies include wood sleepers on top of the panels and absorptive material such as batt insulation between the sleepers. See Figure 2.

Acoustical floor underlayments

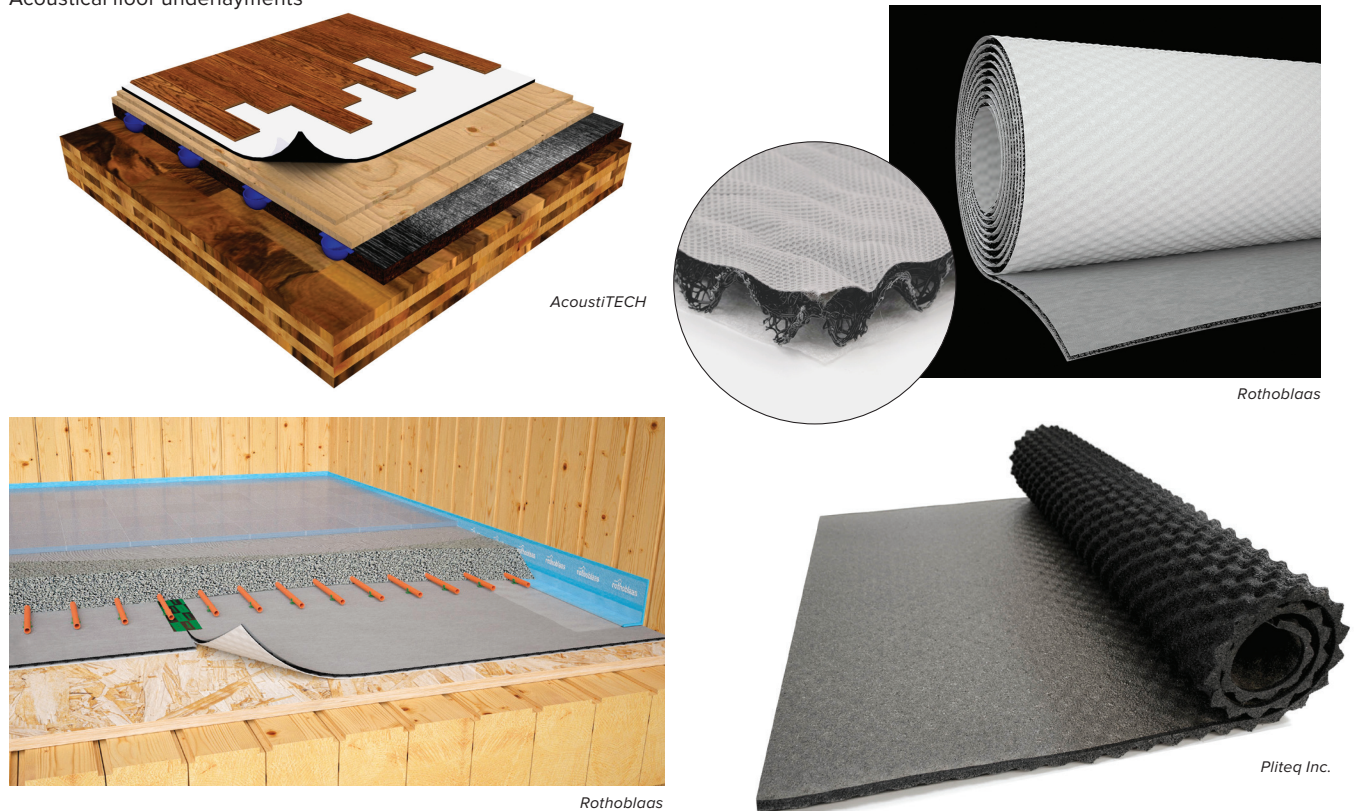


FIGURE 1: Examples of underlayment options

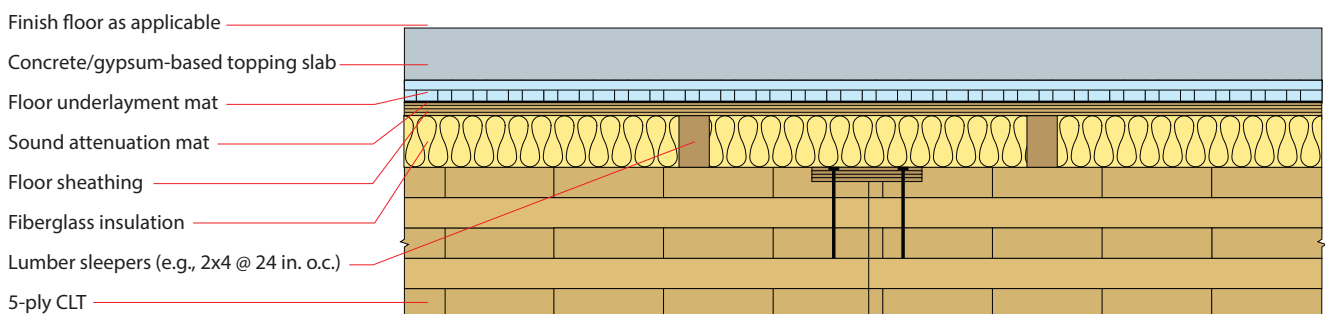


FIGURE 2: CLT floor assembly with wood sleepers and fiberglass insulation

Mass Timber Assembly Options: Floors

A common mass timber floor/ceiling assembly includes the following (from top to bottom):

- Finish flooring (if applicable)
- Acoustical floor underlayment (if applicable)
- Dry/wet topping (usually 1-3 in. thick)
- Isolation mat
- Mass timber panel

Using a typical 5-ply CLT floor panel, STC ratings in the range of 50-55 (but up to 60+) have been achieved for this assembly build-up independent of finish floor underlayment. However, IIC ratings are greatly influenced by the presence and type of finish flooring and acoustical finish floor underlayment. For this build-up with no finish floor (e.g., concrete topping is the exposed floor surface), IIC ratings in the range of 35-50 have been achieved. When finish flooring is added, such as luxury vinyl tile, engineered wood flooring, ceramic tile, or carpet and pad underlayment, IIC ratings of 55+ (60+ with premium products) have been achieved. Acoustical tests have been completed on variations of this assembly, with the primary variables being the specific acoustical mat product and thickness, and type of topping.

Tests have also been completed on a number of alternatives, including options that involve isolators in a grid pattern. WoodWorks' *Mass Timber Fire & Acoustic Database* offers a wide range of assemblies for comparison.

Where higher acoustical ratings (STC of 60+) are required for floor/ceiling assemblies in mass timber structures, installing a dropped gypsum board ceiling, suspended 4-6 in. below the mass timber panel with insulation in the ceiling cavity, is a viable approach. Although this conceals the mass timber panel from view, covering all or some of the panels may already be necessary to conceal mechanical/electrical/plumbing (MEP) services (in bathrooms and kitchens for example) and/or the covering material may be part of the floor assembly's fire resistance. Alternative wood ceiling finishes (e.g., thin-profile nonstructural 3-ply CLT) can sometimes be used in lieu of gypsum board to maintain the wood ceiling aesthetic as well as improved acoustical separation (e.g., in residential units below an amenity space). Unlike these dropped ceilings, direct gypsum board encapsulation to address fire ratings generally does little to improve the acoustical performance. Tested floor/ceiling assemblies with applied ceilings are included in the WoodWorks database.

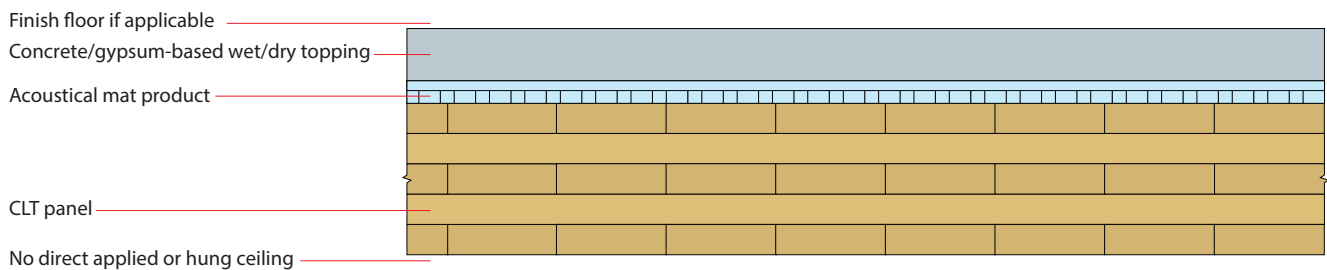


FIGURE 3: Typical mass timber floor assembly with exposed ceiling

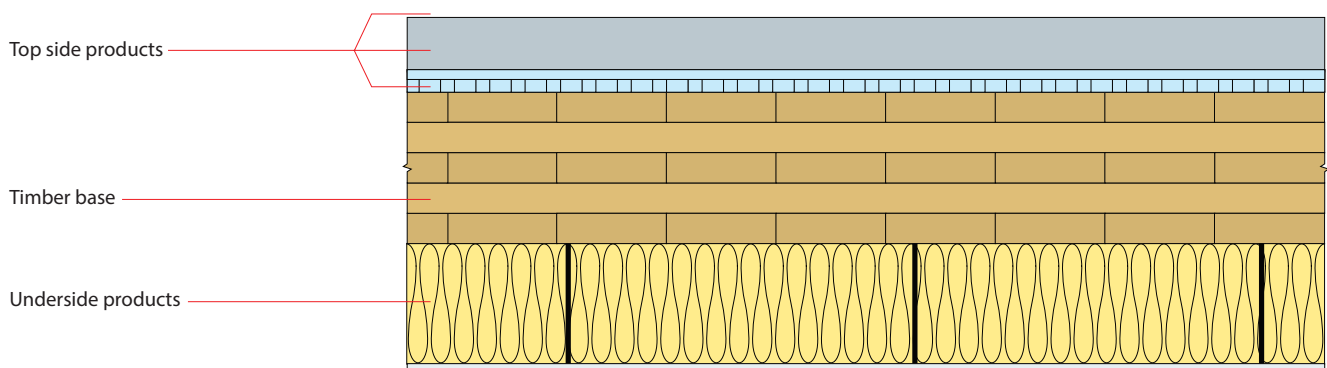


FIGURE 4: Sample configuration of mass timber floor assembly with concealed ceiling

Mass Timber Assembly Options: Walls

Mass timber panels can also be used for interior and exterior walls, both bearing and non-bearing. For interior walls, the need to conceal services such as electrical and plumbing is an added consideration. Common approaches include building a chase wall in front of the mass timber wall with gypsum wall board on studs and insulation in the stud cavities. As with mass timber floor panels, components are often added to mass timber walls for noise control, and chase walls also function as acoustical improvements. For example, a 3-ply CLT wall panel with a thickness of 3.07 in. has an STC rating of 33.⁸ In contrast, Figure 5 shows an interior CLT partition wall with chase walls on both sides. This assembly achieves an STC rating of 55+, exceeding the IBC's acoustical requirements for multi-family construction. Other examples are included in the WoodWorks database.

Opportunities for Tall Timber

The introduction of three new construction types in the 2021 IBC—Types IV-A, IV-B and IV-C—allows designers to leverage mass timber construction for structures much larger and taller than prescriptively allowed under previous codes (up to 18 stories and 270 feet). One of the main ways to demonstrate a certain level of passive fire protection, regardless of the structural materials used, is with hourly fire-resistance ratings (FRRs). Required FRRs for the three new tall mass timber construction types are provided in Table 601 of the IBC and are similar to those required for Type I construction.

All timber elements in Type IV-A projects (up to 18 stories) and most in Type IV-B projects (up to 12 stories) require applied noncombustible protection. This is typically accomplished in the form of Type X gypsum board, which achieves two thirds of the assembly's required FRR. From an acoustics perspective, this has a minor impact on the design of mass timber assemblies and floor assemblies in particular. Where floor/ceiling panels in tall timber structures are not exposed on the ceiling side, designers can leverage the ceiling side protection and possibly a dropped ceiling to enhance acoustical performance. They can also potentially reduce the materials required on the top side of the assembly (compared to assemblies exposed on the underside). Note that introducing small air cavities (e.g., 1/2 in. deep) between the mass timber and gypsum board can introduce acoustic resonances that significantly reduce the acoustic performance of the floor/ceiling assembly.

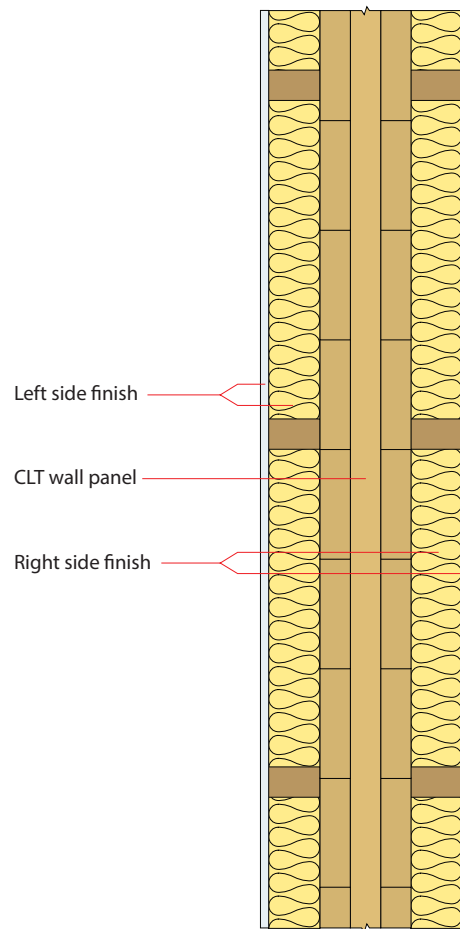


FIGURE 5: Interior CLT partition wall with chase walls on both sides

Photo: Dan Armstrong Photography



The Lark Hotel Addition
THINKTANK Design Group / Nishkian Monks

Minimize Flanking to Improve Overall Performance

Even when the assemblies in a building are carefully designed and installed for a high direct sound transmission performance, consideration of flanking paths—in areas such as assembly intersections, beam-to-column/wall connections, and MEP penetrations—is necessary for a building to meet its acoustic objectives.

Wall-to-Wall or Wall-to-Floor/Ceiling Flanking

Flanking is also a consideration for interior mass timber partition walls. Early approaches involved framing partition walls on top of the floor topping, which interrupted the topping and reduced or eliminated flanking within the topping slab. However, in addition to creating an extra step in the construction schedule, sequencing wall construction after pouring a floor topping doesn't tend to be ideal. It is now more common to place partition walls directly on the mass timber floor panels, which interrupts the floor topping while allowing a typical wall framing sequence. Careful detailing at the topping-to-wall interface limits flanking potential. Of course, there is still the potential for flanking to occur within the mass timber floor panel.

One way to minimize structural flanking paths is to use resilient connection isolation and sealant strips. These products are capable of resisting structural loads in compression between structural members and connections while providing isolation and isolating stiff, direct connections between members. In the context of the methods for improving acoustical performance noted earlier, these strips act as decouplers. With airtight connections, interfaces, and penetrations, they can help designers of mass timber buildings meet or exceed their acoustic expectations. These products are generally not critical in hybrid construction except where upgraded acoustical performance is targeted.

Floor-to-Floor Flanking

Another flanking path for sound can occur at continuous floor toppings (both wet and dry). Where demising walls are intended to acoustically separate adjacent rooms, the floor topping could be interrupted to break the flanking path (Figure 8). There are several ways to achieve the separation.



FIGURE 6: Acoustical isolation strips

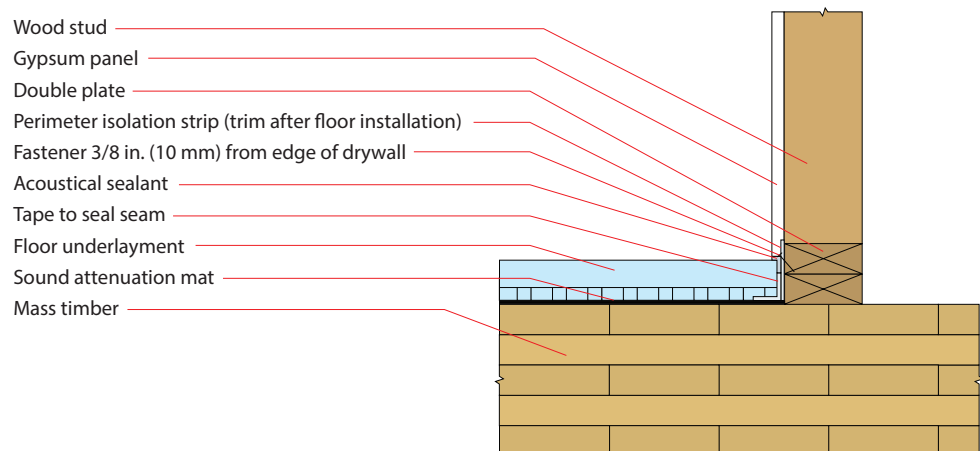


FIGURE 7: Flanking control detail at floor/wall interface

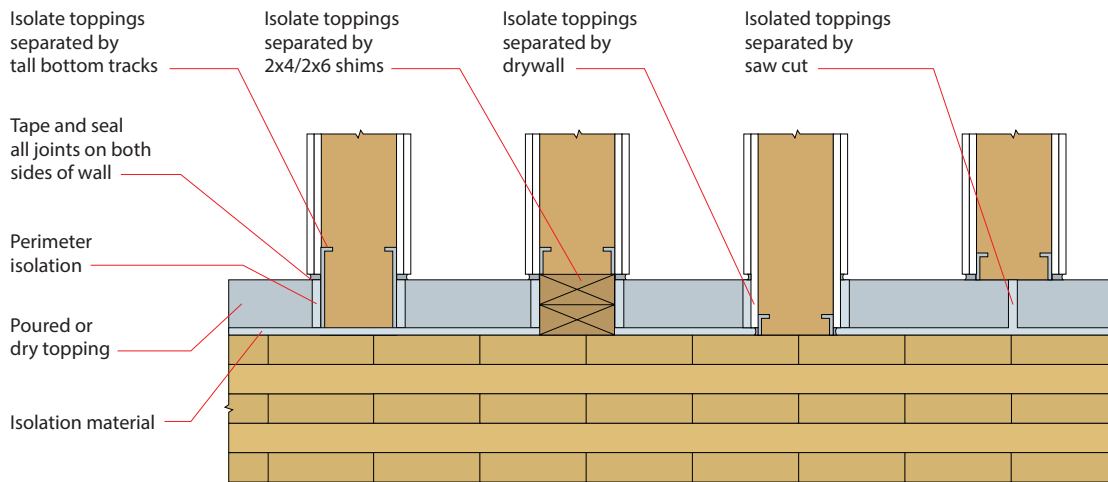


FIGURE 8: Floor topping interrupted with demising walls

Source: HGC

Ceiling-to-Ceiling Flanking

Sound transmission through floor/ceiling material is not unique to mass timber; it is also a concern for acoustical engineers of certain concrete and steel assemblies. A common mitigation approach is to provide a gypsum board ceiling, either directly applied, or via a suspended ceiling—which is a challenge for exposed mass timber ceilings.

When designed effectively, assemblies on top of mass timber panels can mitigate flanking from above, but ceiling-to-ceiling flanking, where continuous mass timber panels across demising walls allow sound to travel laterally between suites, requires additional techniques. One approach is to provide a break between panels at demising walls that separate adjacent units. Some preliminary testing shows that certain isolated topping configurations can increase the stiffness of the

CLT sufficiently to help mitigate flanking through these ceilings; however, this approach should be considered with caution unless test data is available. Even the installation of bulkheads on one or both sides of the demising wall can help reduce flanking potential (i.e., by increasing the distance for the sound to travel between exposed ceilings). It is both challenging and important to negotiate the occupant's experience (i.e., the desire for exposed mass timber ceilings) with the impact on other design aspects (e.g., panel layout and structural performance).

While ceiling flanking has long been a consideration in the world of acoustic engineering, the information available for exposed mass timber is in its infancy. At the time of writing, several studies (with both lab and field testing) aim to provide more information on STC rating losses associated with exposed wood ceilings so they can be addressed during design. For more information on research underway, see the article, *New Acoustic Design Guidance and Research for Mass Timber Construction*,⁹ from Wood Design & Building magazine.

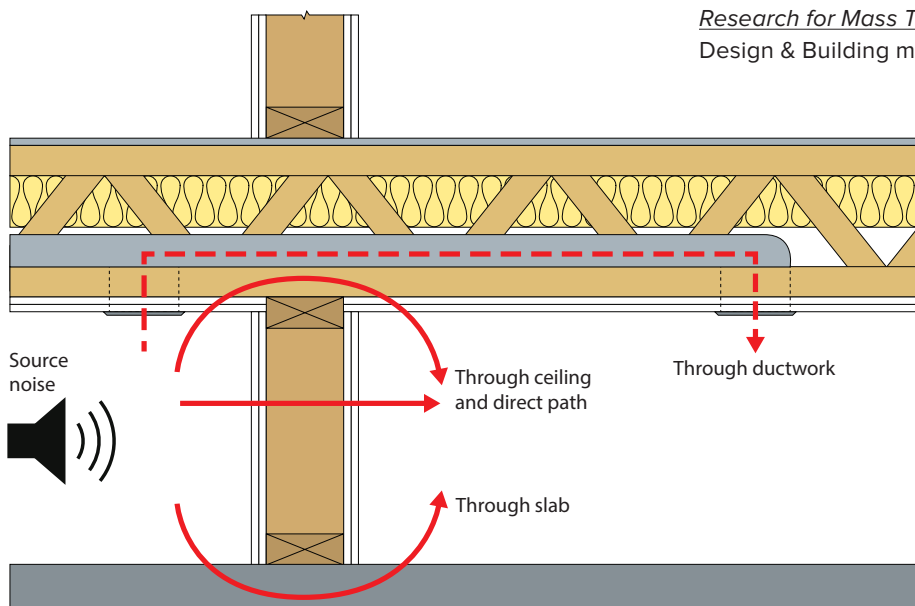


FIGURE 9: Possible flanking paths

Room Acoustics and Reverberation Control

While not the focus of this paper, it is worth mentioning that in-room acoustics and reverberation for spaces with exposed mass timber requires a similar design approach as other materials. Mass timber is slightly more absorptive (with a Noise Reduction Coefficient [NRC] of 0.05-0.15) than materials such as gypsum (0.05) and concrete (0.00-0.20). For acoustically sensitive spaces, standard absorption control techniques, such as placing acoustic panels on ceilings and/or walls, still apply. Another option is to use acoustically optimized dowel-laminated timber (ADLT), which has a reported NRC of 0.70, or other modified mass timber panels.

An acoustical consultant with experience in mass timber can model reverberation control strategies to keep as much wood exposed as possible while achieving the required acoustic performance. WoodWorks can also refer designers to appropriate experts.

Conclusion

Designing a building for noise control has a tremendous impact on the overall satisfaction of tenants. Laboratory and field tests have shown that mass timber assemblies can provide satisfactory sound insulation—and this is supporting increased use of these materials. As mass timber buildings are built, they generate more knowledge and lead to more field testing, and the result is an expanding inventory of cost-efficient assemblies and details that perform well acoustically. Mass timber buildings are unique in that designers often try to maximize the visibility of structural members, which creates the need for unique solutions to address noise control. With appropriate attention to detail in the design and construction of assemblies, as well as consideration of flanking paths and sound isolation in connections and penetrations, mass timber buildings can deliver acoustic high performance.

References

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