

Noise Control Systems for Modern Timber-Framed Structures

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Abstract: - Modular CLT systems are becoming a preferred choice for rapid, green building projects, but they face a persistent challenge with 'vibro-acoustic' performance. Because they are lighter than traditional materials, they often fail to block deep, low-end frequencies or the thud of impact noise traveling between structural pods. This paper presents an investigation into the acoustic performance of timber volume elements (volumetric units) through laboratory testing and/or in-situ, factory-assembled measurements. The study evaluates the impact sound and airborne sound insulation of mass layers. Key findings suggest that while bare CLT modules struggle to meet high-end building regulations (e.g., sound class C), the addition of engineered resilient materials, elastomer intermediate layers, and gypsum board can significantly improve airborne and impact sound insulation. Furthermore, the study analyzes flanking sound transmission through joints and the efficiency of metallic connectors. The study shows that mass timber modules can be just as quiet as traditional buildings if the floors, ceilings, and joints are designed with care.

Keywords: - Low-Frequency Airborne Insulation, Prefabricated Mass Timber, Weighted Impact Sound Level, Volumetric Timber Modules, Cross-Laminated Timber (CLT), Flanking Transmission, Sound Transmission Class (STC), Impact Insulation Class (IIC), Resilient Mechanical Decoupling, Acoustic Performance.

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1 Introduction

In the drive towards sustainable and efficient construction, volumetric timber modules—particularly those using Cross-Laminated Timber (CLT) have gained significant traction. Factory-built 3D timber modules provide high precision and fast installation [1], [2]. Conversely, their low mass creates challenges in blocking both sound transmission and physical impacts. While the volumetric design inherently reduces leakage at structural joints, reaching top-tier soundproofing still requires careful detailing of internal wall assemblies and connections. This paper explores the acoustic performance of modern timber volume elements, evaluating, through [experiments/simulations], the impact of [floor toppings/elastic interlayers/structural modifications] on sound insulation, aiming to satisfy building regulations and occupant comfort [3], [4].

2 NZBC Standards for Airborne and Impact Noise

To guarantee residential peace, the NZ Building Code (G6) forces designers and builders to meet

strict acoustic performance levels. Essentially, it stops sound from passing through shared structures, protecting people from annoying noises coming from nearby units or common areas. The objective is to ensure that sound from one household unit does not cause a loss of amenity in another [5], [6]. To achieve compliance, G6 requires that building elements separating household units have a Sound Transmission Class (STC) of no less than 55 [6]. This applies to both walls and floors that separate occupancies [7], [8]. While this, or a comparable laboratory rating, is the baseline, it is crucial to recognize that the requirement often includes a field test allowance, generally meaning that in-situ performance (FSTC) should be at least 50 to 52, considering on-site flanking transmission [9], [10].

For inter-tenancy floors (floor-ceiling assemblies), the NZBC requires an Impact Insulation Class (IIC) of no less than 55. This rating specifically addresses structure-borne noise, such as footsteps, moving furniture, or dropped objects, which are common issues in multi-story timber buildings [11], [12]. Achieving this rating often necessitates specialized flooring systems, such as acoustic underlays or suspended ceilings, rather than

relying solely on the structural timber subfloor [13]. [14].

Compliance with STC/IIC 55 requirements in timber-framed buildings can be achieved through Acceptable Solution G6/AS1. This includes standardized designs like specialized stud assemblies (staggered or double) packed with insulation and multiple fire-rated plasterboard layers [15], [16]. These must be built exactly as designed, as any deviation in assembly or materials will significantly compromise the acoustic performance. Finally, the G6 requirements highlight the necessity for sound insulation against low-frequency noises, which are prevalent in lightweight timber structures [17], [18]. While G6/AS1 provides standard solutions, if a developer wishes to use innovative lightweight designs or non-standard materials, they must demonstrate compliance through Verification Method G6/VM1 [19], [20]. This involves field testing that ensures the installed system achieves the minimum acoustic performance requirements.

3 Environmental Noise Control

Unwanted external noises that intrude on a home are classified as environmental noise, often labeled ambient or background sound. As seen in the figures, typical sources of this nuisance include transportation and emergency services—specifically a helicopter, a train, and an ambulance.

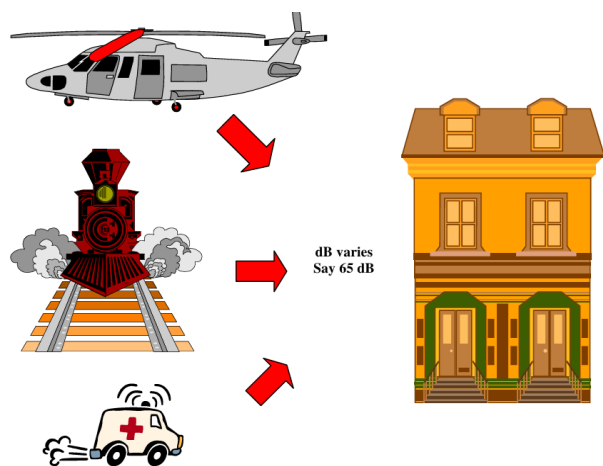


Fig. 1: Acoustic impact of environmental sound on residential structures

Source: [21]

Because wood-framed structures lack the density of traditional masonry, they are susceptible to poor acoustic performance through vibration. Without specialized design and engineering, these lighter structures often transmit external sound.

In Figure 1, the researcher highlighted 65 dB to illustrate the range of noise levels generated by these external sources. This represents the incident sound pressure level hitting the external facade of the dwelling. Urban soundscapes are seldom consistent; they fluctuate based on temporal factors and distance. Timber-framed residences face a unique challenge in this environment: low-frequency acoustic energy, such as the rumble of transport, readily penetrates inadequately insulated wall structures.

The central concept shown is the calculation of required sound insulation. When the exterior noise peaks at 65dB and the desired indoor comfort is 35dB, a 30dB reduction is necessary. This isn't just about one material—the necessary acoustic reduction is achieved through the combined performance of timber framing, cavity insulation, external cladding, and plasterboard. In modern timber construction, this often requires "decoupling" components (like using resilient channels) so that the vibration from the external noise doesn't travel directly through the wooden studs.

Acoustic performance is dictated by the building envelope's weakest points. Even with high-performance mineral wool insulation in the stud bays, a single-pane window or an unsealed door sweep creates a 'noise bridge' that compromises the assembly. To hit the targets shown in the figure, designers must prioritize sealing flanking paths at all junctions.

Controlling acoustics in mass timber isn't just about adding bulk; it's a strategic trade-off between decoupling and density. Since wood doesn't provide the same inertial dampening as masonry, we have to lean on staggered-stud configurations and high-performance damping compounds. Once we've mapped the peak dB frequencies from nearby traffic or sirens, we can move past guesswork and specify the exact STC ratings—whether that's doubling up on 5/8" Type X gypsum or tweaking the mineral wool cavity depth.

4 Solving the Timber Noise Problem

Managing acoustics in timber frames is about addressing the mass-stiffness-mass deficit. Because wood doesn't dampen airborne or impact noise as effectively as masonry, the design must prioritize decoupling the floor-ceiling assembly. Integrating sand-cement screeds or heavy-duty gypsum board into the initial build-up—rather than as an afterthought—is the only way to manage the low-frequency vibrations typical of lightweight construction.

Acoustic attenuation in mass timber hinges on the mass-air-mass principle. Since CLT doesn't have the inherent dampening of a thick concrete slab, we introduce density through wet or dry floor toppings to shift the assembly's resonance. This added inertial mass is what moves the needle on STC ratings. From there, it's about decoupling and dampening—using rockwool batts to mitigate the 'cavity effect' within the joist and wall framing.

Stopping structure-borne noise is all about breaking the physical connection. Think of it as 'decoupling'—if the vibration doesn't have a continuous path to travel, the sound dies out. In wall assemblies, the researcher does this by hanging drywall on resilient channels rather than screwing it directly into the studs. This simple separation significantly boosts the STC rating. For flooring, the goal is to kill footfall impact at the source. The researcher uses floating floor systems and acoustic underlayment to isolate the finish from the subfloor, preventing energy from dumping into the timber joists. However, even the best wall or floor fails if they ignore flanking paths. In CLT (Cross-Laminated Timber) projects, the continuous panels are notorious for carrying sound around your primary partitions. Designing in acoustic breaks—like elastic bearing strips at the junctions—to snap those transmission lines. Finally, the researcher advises not to overlook the small stuff: if they aren't back-sealing electrical penetrations and joints with acoustic sealant, they're essentially leaving the door open for noise leaks.

Acoustics shouldn't be an afterthought or a 'bolt-on' feature; it must be baked into the schematic phase. If aiming for a 'KOMFORT' class rating in timber, look at a total system approach. This means coordinating HVAC runs and window specs early so they don't undermine wall assemblies.

For unit-to-unit privacy, the researcher suggests moving beyond single-stud partitions. Staggered or twin-stud walls are far more effective because they offer true structural separation—basically building two independent walls so sound can't vibrate through shared framing. When noise control is integrated into the initial layout rather than patched in during the punch list, you get a building that performs the way the models promised.

5 Single Figure STC

When working with timber-framed assemblies, hitting a specific STC or R_w target is a unique challenge because timber lacks the inherent damping of masonry. Figure 2 breaks down the measured sound reduction index (R) from 125 Hz

to 4000 Hz. Note the shape of the blue data line: it highlights the typical 'timber profile,' where the structure struggles to mitigate low-end bass frequencies while performing quite well against mid-to-high range speech. This low-frequency dip is the primary hurdle in timber design, requiring us to look beyond simple mass and focus on the specific resonance of the assembly.

The core of the fitting process involves comparing these real-world measurements against standard reference curves, such as the ASTM E413 (used for STC) or ISO 717-1 (used for R_w). These reference curves have a specific shape: they are relatively flat in the high-frequency range and slope downward at lower frequencies. To determine the final rating, the designer or acoustic engineer vertically shifts this standard reference curve until it fits the measured data according to strict mathematical rules regarding deficiencies.

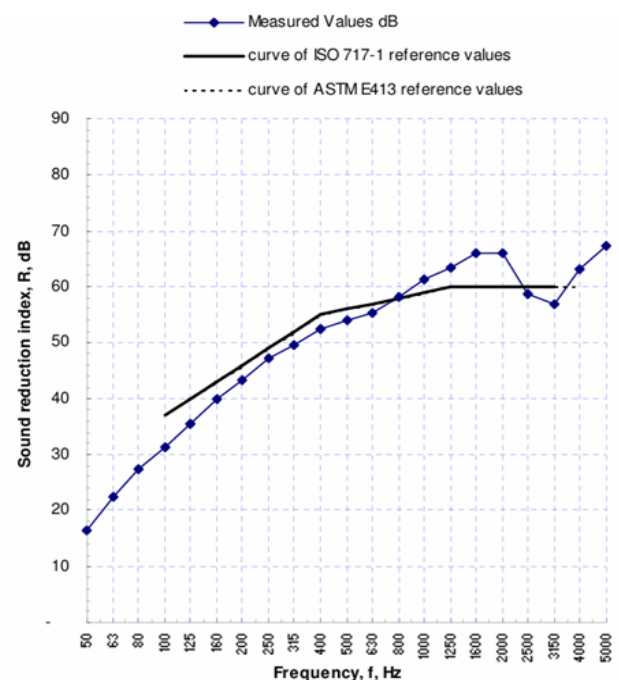


Fig. 2: Shifted reference curve vs. measured R values for STC determination

Source: [22]

A deficiency occurs at any frequency where the measured blue line falls below the reference curve. Per standard procedures, the curve is raised as high as possible until the sum of these deficiencies across all frequencies does not exceed 32 dB. Furthermore, as visible in your graph near the 3150 Hz mark, there is a distinct V-shaped drop known as the coincidence dip. Design rules dictate that the measured value cannot be more than 8 dB below the reference curve at any single point. This prevents an assembly from getting a high rating if it has one

major "hole" where specific sounds can easily leak through.

Based on Figure 2, it suggests that materials like GIB Noise line or cavity insulation cannot work in isolation to satisfy these curve requirements. Designing for noise control requires an integrated system approach. For instance, the coincidence dip seen in the graph is often caused by the inherent stiffness of the timber or gypsum panels. Designers mitigate this by using multiple layers of varying thickness or "staggering" the studs to break the direct path of vibration, effectively pushing the measured blue line higher and allowing the reference curve to be "fitted" at a higher decibel value.

The final STC rating is pulled directly from the reference curve's value at the 500 Hz intercept. This metric serves as the primary benchmark for code compliance; in multi-family timber builds, for instance, a minimum of STC 50 is typically the non-negotiable threshold for demising walls. While the R_w or STC rating is a simplified composite, the underlying curve-fitting ensures the partition is weighted against the frequencies most critical to residential privacy, preventing common speech and activity from bleeding between units.

5.1 Designing Impact Noise Control (IIC)

Designing for noise control in modern timber-framed structures requires a deep understanding of Impact Insulation Class (IIC), which focuses on structure-borne noise. Unlike airborne noise (voices or music), impact noise is generated by direct physical contact with the floor, such as footsteps, moving furniture, or a basketball bouncing. The inherent challenge with timber is its lack of mass; unlike concrete, it doesn't have the density to soak up low-frequency energy. This makes timber assemblies particularly prone to 'thumping', the kind of impact noise that radiates directly into the space below. Figure 3 highlights the performance delta between a bare timber deck and one treated with carpet. While the bare assembly offers almost no resistance to footfall, adding a compliant layer fundamentally changes the IIC (Impact Insulation Class) profile. It's the difference between the structure acting as a sounding board and isolating the impact energy before it hits the joists.

On the left, the bare timber floor has an IIC of 43, and the large "TAP" arrows indicate that a significant amount of impact energy passes straight through the structure. In a real-world setting, this would mean occupants below could clearly hear every footstep or dropped object.

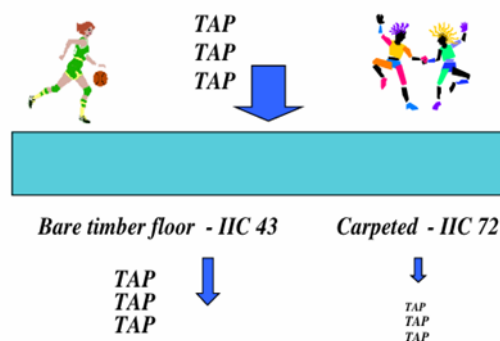


Fig. 3: Illustration of the IIC concept

Source: [23]

The right side of the diagram shows the effect of adding a soft floor covering, which increases the rating to IIC 72. This jump in numbers represents a massive reduction in transmitted noise, visualized by the much smaller "tap" arrows. Introducing a compliant layer—think thick carpet or a high-performance acoustic underlayment—acts as a decoupler, neutralizing impact energy before it can saturate the timber frame. This highlights a fundamental rule in mass timber: the acoustic performance isn't tied to the slab alone. It's a game of layers. They're building a composite system where the finish, the underlayment, and the structure must work in tandem to break the vibration path. Determining the IIC rating involves a standardized "tapping machine" test, which creates a performance curve that is then fitted to a reference contour, like how STC ratings are calculated. The catch with IIC is that it's a 'best-fit' single-number rating—and it conveniently ignores everything below 100 Hz. For timber builds, that's a major blind spot, as those low-frequency thuds are usually the biggest source of tenant complaints. Relying strictly on IIC can be misleading; they might hit the code minimum without solving the noise problem. To get timber structures to perform, they have to look beyond the NZBC (New Zealand Building Code) baseline. It requires a layered strategy: adding mass with a Gypcrete topping to handle the low end, using resilient underlayment for impact, and decoupling the ceiling below with isolated hangers. It's about building a system, not just checking a box. If you don't address these layers in tandem, the lightweight benefits of timber will be overshadowed by a lack of acoustic privacy.

Standardized noise control in timber framing is dictated by the 'best-fit' curve-shifting method shown in Figure 4. This graph shows the Normalized impact sound pressure level (L_n) across various frequencies. Unlike airborne noise ratings, where a higher number is better, the data points on

this specific graph represent the noise that leaks through the floor. Therefore, the goal for a designer is to push that blue "test record" line as low as possible, indicating that less sound is reaching the room below.

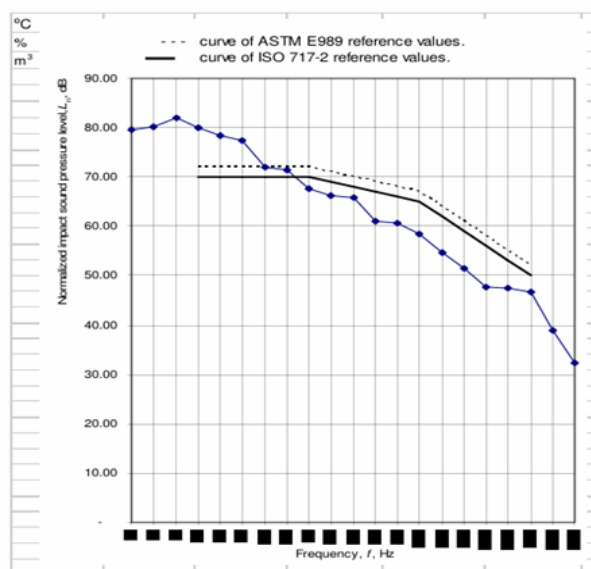


Fig. 4: Best fit of test record to a standard curve determines IIC rating
Source: [24]

Class (IIC) rating involves comparing the measured blue dots against the standardized reference curves (the solid black lines representing ASTM or ISO standards). By shifting the reference curve vertically to find the best fit—accounting for "deficiencies" where the test data exceeds the standard—engineers arrive at a single-figure rating. As shown in the graph, timber structures often struggle at lower frequencies, where the decibel levels remain high (around 80 dB), making the curve-fitting process a vital check on the floor's real-world performance.

A significant challenge highlighted in the figure's notes is that human footfall occurs in the low-frequency (LF) range, which often falls outside or at the very edge of standard test measurements. This means that even if a timber floor achieves a decent IIC rating through curve fitting, it may still "perform poorly" in practice because the standard curve doesn't fully account for the heavy thuds of someone walking. For designers, this means an IIC rating is a starting point, but extra care must be taken to address those low-frequency vibrations that the standard "best fit" might miss.

As shown in Figure 4, achieving an IIC 55 is very difficult with bare or tiled timber floors. Timber is inherently lightweight and lacks the damping properties of concrete. While concrete

floors have their own high-frequency issues that are relatively "easier to solve" with simple underlays, timber requires more complex structural interventions. If the curve-fit reveals a deficit in the low-to-mid frequencies, simply adding a finish isn't enough; you need to increase mass—usually via a floor topping—or decouple the ceiling assembly to drop that test line.

Quantifying the 'footfall problem' through this method moves the conversation from guesswork to spectral analysis. By identifying exactly where the test data peaks above the reference curve, we can target specific frequency bands rather than over-engineering the entire assembly. This move toward precision allows timber builds to compete with the acoustic performance of masonry, meeting both code and the high expectations of modern tenants.

The GIB® system addresses this head-on by focusing on impact isolation. In timber-framed projects, fighting a two-front war: high-frequency 'clicks' and the more stubborn low-frequency thuds. Integrating a specialized sound barrier directly beneath the floor isn't just an add-on; it's a strategic break in the vibration path, killing the energy before it ever reaches the joists.



Fig. 5: Mitigating impact sound: Sub-floor isolation via GIB® Sound Barrier
Source: [25]

Figure 5 highlights the industry-wide struggle with impact isolation in mass timber. The researcher isn't just fighting high-frequency 'clicks' from hard-sole shoes; they're fighting the low-frequency energy of a heavy footfall. The GIB® Sound Barrier underlayment acts as the first line of defense, killing the vibration at the interface before it can saturate the floor diaphragm.

In Figure 6, the delta between the standard GIB® clip (blue) and the Quiet Clip (orange) across the 50 Hz to 500 Hz spectrum is the most telling data point. Even in the 'problematic' sub-100 Hz range, the Quiet Clip significantly pulls down the

impact sound levels. This isn't just a marginal gain; it's a fundamental shift in how the assembly handles energy, proving that isolating the ceiling plane is non-negotiable for high-performance timber builds.

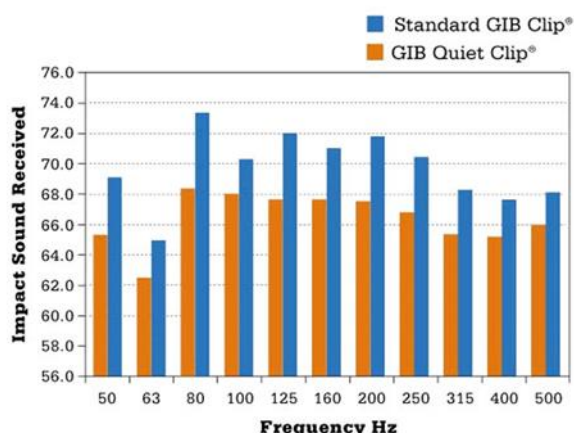


Fig. 6: Impact sound attenuation: Standard vs. Quiet Clip performance

Source: [26]

The core principle of designing for noise control illustrated in Figure 6 is mechanical decoupling. In a standard timber-framed assembly, the ceiling is rigidly attached to the floor joists. This creates a direct path for impact energy—such as footsteps—to vibrate through the structure and radiate as noise in the room below. The GIB® Quiet Clip acts as a resilient break in this path, physically separating the ceiling lining from the structural frame to intercept and dissipate vibration before it becomes audible sound.

This data highlights that effective acoustic design is not just about blocking sound with mass, but about engineering the connection points to reduce the efficiency of sound transmission.

A critical design challenge addressed by the GIB® Quiet Clip is the management of low-frequency (LF) noise, specifically in the 50 Hz to 125 Hz range. Timber-framed buildings are notoriously susceptible to these "thuds" caused by heavy footfall. The graph shows a significant reduction in decibels at these lower frequencies when the Quiet Clip is used. Designing with these clips allows architects to mitigate the most difficult-to-control sounds that typically bypass standard insulation and heavy linings.

Furthermore, the figure emphasizes that noise control is a system-wide performance issue. Achieving high acoustic ratings in timber buildings requires a combination of tested components working together.

Finally, the design philosophy presented in the "What Not to Do on Site" section reinforces that

acoustic performance is highly sensitive to installation integrity. Even a high-performance component like the GIB® Quiet Clip can be compromised if substitutes are used or if "flanking paths" are created. Effective design for noise control therefore requires not only selecting the right products but ensuring that the structural separation provided by the clips is maintained throughout the entire construction process to avoid bridging the sound.

6 Problem Formulation

The move toward modular timber units is a win for sustainability, but it's an acoustic nightmare. Because these units are so light, they lack the mass to handle low-end frequencies, and the inter-module connections create a mess of flanking paths that are incredibly hard to model. The researcher is currently flying blind because there isn't enough standardized data to accurately predict how structure-borne noise will jump between modules. Without better design strategies to kill these transmission lines early, the researcher is ending up with buildings that look great but fail to meet the privacy expectations of the people living in them

6.1 The Context and Rise of Timber Volume Elements

While the industry's pivot toward volumetric modular timber—specifically CLT and light-frame units—has solved for speed and carbon targets, the acoustic performance is still playing catch-up. Moving these buildings from the factory to the site is efficient, but the rapid scaling of this technology has exposed a major bottleneck: hitting residential noise standards. The researcher mastered the structural and sustainable aspects of the 'module,' but the acoustic reality of living in these lightweight boxes is proving much harder to get right than the documentation suggested.

6.2 Acoustic Limitations of Lightweight Structures

The fundamental issue is that timber just doesn't have the 'heft' of concrete or masonry. Because it's lightweight and relatively stiff, it lacks the natural damping needed to soak up vibration. When stacking 3D modular units, this lack of mass becomes an acoustic liability, especially with low-end frequencies below 10Hz that pass right through the structure. They end up with a 'drum effect' where the modules can't hit a Sound Class C rating because the airborne and impact insulation just isn't

there. In many cases, the raw timber frame isn't doing any of the heavy lifting for acoustics; it's acting as a conduit for noise.

6.3 The "Flanking Transmission" Challenge in Modules

The real killer in modular timber is flanking transmission. Because these units are stacked or bolted together, you're creating direct vibration paths through the junctions that essentially bypass wall insulation. The biggest headache is that these 'short circuits' are baked into the design during the factory phase. By the time the modules reach the site, those critical connections are already closed. They are left with a complex web of junctions that are nearly impossible to insulate after the fact, meaning if they do not solve the flanking problem on the assembly line, they are stuck with it.

6.4 The Research Gap in Design and Testing

The researcher is essentially trying to solve 21st-century acoustic problems with 20th-century tools. The current guidelines are built for masonry, and they fall apart when applied to modular timber. The biggest gap in our knowledge is that a single module tested in a lab tells us almost nothing about how a stacked assembly will behave on-site. Once you bolt these 3D units together, you create a whole new network of structure-borne paths that lab data just can't account for.

There's a massive disconnect between the speed of the assembly line and the reality of the living environment. The researcher needs to move beyond generic 'best guesses' and develop a framework that balances structural transport requirements—like the need for rigid shipping connections—against the need for acoustic isolation. Right now, we're missing the data on how specific junction geometries and connector types dictate low-frequency performance in a real-world, volumetric context

7 Simulation and Statistical Results

The fundamental hurdle with mass timber isn't sustainability—it's mass. Because timber lacks the inherent density of concrete, it doesn't 'soak' vibration; it transmits it. Both simulation data and field testing make one thing clear: if they aren't designing with high-performance, multi-layered assemblies, they're never going to hit modern acoustic benchmarks. They simply can't rely on the raw structure to do the work; they must build in the performance through strategic layering.

7.1 Vertical Sound Insulation

Simulations and field tests show that mounting upper floor layers and suspended ceilings elastically to load-bearing timber slabs can improve airborne and impact sound insulation by 13 to 20 dB compared to traditional screed solutions.

7.2 Impact Pressure Reduction

Floating floor systems, particularly those using "BGL floors," demonstrate impact sound pressure improvements where the insulated sound pressure is 10 to 20 times more effective than ordinary timber floors. Floating floors alone can increase sound absorption by up to 22.2 dB.

7.3 Layered Enclosures

New "L-shaped" dwelling designs using double-layer timber and 30mm embedded rock wool outperformed traditional designs by 8–14 dB.

7.4 Metamaterials and Resonators

Wall units based on the Helmholtz resonance principle improved sound transmission loss to over 50 dB in the 640–1600 Hz range. In the low-frequency range (100–320 Hz), sound absorption coefficients reached above 0.49, compared to near zero for standard structures.

7.5 Material Density Impacts

Increasing OSB (Oriented Strand Board) density was found to enhance the sound insulation index more significantly than other parameters like stud size or spacing

7.6 Performance Comparison (Timber vs. Concrete/Steel)

Recent Life Cycle Assessments (LCAs) are beginning to account for noise, resulting in a more nuanced ranking of structural impacts. Concrete still carries the heaviest noise-integrated footprint, largely due to the sheer volume of material required and the intensity of its production. In contrast, timber frames tend to score better across the board when they treat noise as a measurable environmental stressor. It suggests that once they account for the full acoustic lifecycle, timber's lower overall density and localized build footprint give it a significant edge over traditional masonry.

7.7 The Low-Frequency Gap

The real friction in timber builds is the sub-50 Hz range. While code-minimums often focus on mid-range frequencies, the most persistent tenant

complaints stem from the 20 Hz to 50 Hz band—essentially the 'thud' of a footstep. Simulation data reveals a massive blind spot here: standard ratings frequently overlook these ultra-low frequencies, meaning a building can technically pass inspection while still failing the residents' expectations for acoustic privacy.

7.7.1 The Low-Frequency Deficit

The primary acoustic bottleneck in timber construction lies in the sub-50 Hz band. While regulatory benchmarks typically focus on mid-range performance, the most persistent source of tenant litigation stems from the 20 Hz to 50 Hz range—essentially the heavy 'thud' of footfall. Simulation data reveals a massive blind spot in current standards because these ultra-low frequencies are often excluded from IIC/STC calculations; a building can technically achieve code compliance while failing miserably to provide a liveable acoustic environment

7.7.2 Flanking Transmission

A strong correlation exists between metallic connectors in Cross-Laminated Timber (CLT) panels and increased vibration/noise transmission. The use of elastomers between floor plans and separated ceiling layers is essential to break these mechanical paths.

7.8 Key Statistical Findings on Noise Control

The sub-50 Hz band remains the primary acoustic bottleneck in mass timber—and it's the one we're least equipped to handle. Because ISO and ASTM benchmarks effectively 'tune out' everything below 100 Hz, the most persistent source of tenant litigation—the low-frequency 20 Hz to 50 Hz 'thud'—remains largely unregulated. Simulation data consistently exposes this regulatory blind spot: a timber assembly can easily hit its target IIC\$ rating on paper while failing miserably in the field. The researchers are essentially designing to pass a test that ignores the very frequencies that define resident comfort.

7.8.1 Impact Noise Reduction (Floors)

Bare CLT slabs often have poor acoustic performance (70–77 dB, where lower is better). Dropping a floating floor—specifically a concrete or gypsum screed over a resilient mat—is the most effective way to kill impact energy in timber builds. This setup can yield a 20 to 30 dB reduction in transmission, often dragging impact levels down

comfortably below the 50 dB threshold. By decoupling the walking surface from the structural slab, the elastic layer acts as a 'shock absorber' that prevents footfall energy from ever entering the joist

7.8.2 Airborne Isolation-The CLT Mass Gap

On its own, a bare CLT wall is an acoustic sieve. A single-board panel 100-175 mm usually hits an R_w somewhere between 33 dB and 45 dB. While that might sound decent on paper, it's nowhere near the performance needed for residential separation. In a volumetric context, relying on the raw mass of the CLT is a mistake; it effectively lacks the density to block airborne noise without being bolstered by additional linings or cavity insulation

7.8.3 Mass vs. Efficiency

While increasing CLT thickness enhances sound insulation, it is often considered inefficient regarding material usage. A 10 mm increase in slab thickness only reduces impact noise by approximately 1.5–1.8 dB. Adding mass through separate layers (e.g., gypsum board) is more effective.

7.8.4 Floating Floor Effectiveness

This shows that floating constructions can raise the impact sound insulation class to Level 4 (outperforming standard requirements), while bare CLT remains low performing.

7.8.5 Flanking & Low-End Control

In a rigid CLT assembly, flanking noise is essentially a 'leak' through the structural frame. It can kill that transmission by 5-10 dB simply by sticking resilient interlayers—like high-density elastomers—into the structural junctions to break the vibration path. However, the real fight is in the sub-100 Hz range. This low-frequency energy is a different beast; you can't just throw standard insulation at it. It requires a specialized, heavy-mass approach or tuned resonators to actually 'soak up' the bass before it vibrates through the entire building.

8 Problem Solution

While modular timber is a win for the construction schedule, it has created a significant acoustic liability. The researcher is essentially building high-density housing out of lightweight, interconnected boxes. Because timber lacks the 'dead' mass of concrete, these structures act like a rigid lattice that is incredibly efficient at carrying noise—especially

the low-frequency 'thud' of a footstep—directly between units.

The real culprit is flanking transmission. It's rarely the direct wall-to-wall path that fails; it's the junctions. When modules are bolted together rigidly, a footstep on the floor above doesn't just vibrate the ceiling—it saturates the entire structural frame. In the sub-100 Hz range, wood provides almost zero natural damping, so these vibrations travel through the assembly largely unchecked, leading to buildings that pass structural code but fail the 'livability' test.

Solving this requires fighting the lack of mass with strategic density. We aren't just adding layers; we are trying to force energy dissipation by 'loading' the structure with gypsum or using a gypcrete screed to sink the sound. Integrating viscoelastic damping between timber plies is equally critical—it effectively turns the floor into a shock absorber, killing structure-borne energy at the source.

Perhaps most vital is breaking the physical bridges between modules. Rigid, screw-only connections are acoustic short-circuits. The researcher must move toward full structural decoupling, using elastomeric interlayers or high-density rubber strips to 'float' the units. By combining this with a true floating floor—physically separating the finish from the diaphragm—the researcher can finally break the transmission path before that energy ever hits the structural frame.

9 Conclusions

The takeaway is clear: the speed and carbon benefits of volumetric timber are only viable if we stop treating acoustics as an afterthought. Because timber is naturally 'loud' in the 50-100 Hz range, the researcher must engineer in the mass that the raw material lacks. They can't rely on a single-leaf CLT panel to do the job; they need a composite strategy—mineral wool in the cavities and double-layer assemblies—to hit residential standards. The data shows that while factory modules can reach a Class B impact rating, performance lives or dies at the junctions. If they don't solve for flanking transmission, the best wall system in the world won't matter. This makes structural isolation the primary priority for design. High-performance elastomers are the gold standard for decoupling these units, but they aren't a silver bullet—they must weigh their cost against smarter, simpler detailing that achieves similar breaks. Ultimately, achieving a Sound Class C or better comes down to three things: adding mass where it counts (like floating floors),

breaking vibration paths, and ensuring the assembly is perfectly airtight. The researcher has to move toward a holistic model where acoustic planning isn't a post-script, but a core part of the initial structural design. That's the only way to build modular wood environments that people want to live in

10 Recommendations

While the industry pushes timber for its carbon credentials, the researcher must be honest about the acoustic trade-off: lightweight frames are naturally efficient conductors of noise. To get timber to behave like concrete or steel, they can't just follow a checklist; they must break the structural paths. This starts with wall assemblies—forget single studs. They need staggered or double-stud configurations to create a physical air brake. Without that gap, even the best mineral wool filling is just a mitigation tactic rather than a cure.

The floor-ceiling interface is usually where these projects win or lose. They cannot rely on the structural subfloor alone. The 'floating floor' is the gold standard here, using a resilient mat (rubber or cork) to disconnect the finished floor from the structure. If they can't float the floor, they have to 'load' it; adding a gypcrete or lightweight concrete topping is the only way to get the mass needed to soak up low-frequency energy. Combine this with independent ceiling joists or resilient channels to ensure the downstairs ceiling isn't physically coupled to the upstairs floor.

Flanking paths are the 'silent killers' in timber builds. A single back-to-back electrical box in a shared wall can ruin the entire STC rating of a partition. The researcher must treat the build like a pressure vessel—every gap and penetration needs non-hardening acoustic caulk, and every outlet box needs a putty pad wrap. Beyond the walls, the weakest links are usually the doors and windows. In urban buildings, standard glazing is a liability; you need laminated acoustic glass and solid-core doors with automatic drop-down seals to maintain any semblance of privacy.

The reality is that they can't fix a loud timber building after it's built—at least without massive cost. Acoustic planning must be baked into the initial layout, ensuring we aren't placing bedrooms next to elevator shafts or mechanical rooms. It's about more than just hitting a code minimum; it's about using high-density CLT and OSB alongside obsessive detailing at every junction to ensure the sustainable choice isn't a livability failure.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the author(s) utilized artificial intelligence (AI) technologies solely for the purpose of linguistic refinement and grammatical correction. Following the application of these tools, the author(s) comprehensively reviewed, verified, and edited the resulting text. The author(s) maintain full accountability and responsibility for the accuracy, integrity, and final content of the publication.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

Tomas U. Ganiron, Jr. is the sole author of this manuscript. He conceptualized the study, designed the methodology, performed the acoustic simulations and data analysis, drafted the original text, and reviewed/edited the final manuscript layout. No ghostwriters were utilized in the production of this article.

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