FII Wood First

Research snapshots 2025/26

Insights and innovations shaping the future of wood construction in British Columbia and Canada

Forestry Innovation Investment®

Photo credits: (top left) FPInnovations | (top right) UBC Centre for Advanced Wood Processing | (bottom) Lou Bosshart, UBC

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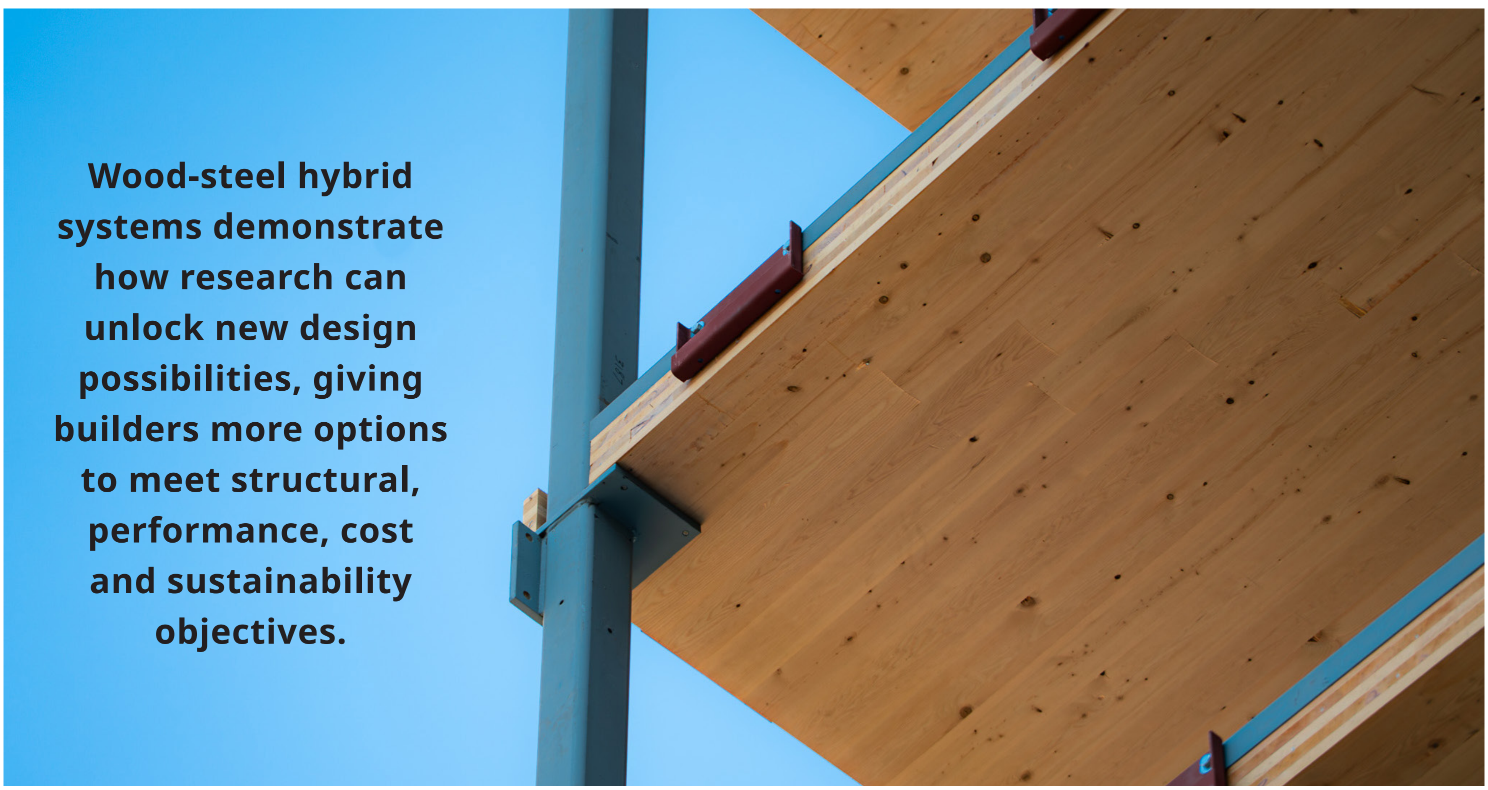
Introduction: Advancing wood construction in B.C. through research

Research and innovation are foundational to advancing wood construction in British Columbia. Through the Wood First program, Forestry Innovation Investment (FII) invests in applied research as one of four key investment categories, supporting the program's broader objectives of innovation, adoption and leadership. These investments help overcome technical, regulatory, market and implementation barriers to the broader use of wood and wood-hybrid building systems.

These investments generate the evidence, design guidance and practical solutions needed to support innovation, strengthen industry competitiveness, and enable the adoption of scalable construction approaches across the province.

FII's research investments are directed toward challenges and opportunities that can accelerate the use of wood in the built environment. Research may support new products, digital tools, technical guidance, market intelligence, best practices, and code and standards advancement. Increasingly, the focus is on generating decision-ready knowledge that improves cost and schedule certainty, supports low-carbon construction, informs procurement and investment decisions, and strengthens confidence among designers, builders, developers, regulators, lenders and investors. By addressing practical barriers and emerging opportunities, research helps create the conditions needed for broader adoption of innovative wood-based building systems.

Collaboration and knowledge sharing are central to the success of these investments. Projects are delivered through partnerships with universities, research institutions, industry organizations, governments, Indigenous partners and other stakeholders. The Wood First program places a strong emphasis on knowledge mobilization, helping ensure that research findings move beyond technical reports and into professional



981 Davie Street, Vancouver, B.C. | Photo credit: Marcus Cantagallo

practice, education, standards development, policy discussions and real-world project delivery. By supporting the exchange of knowledge between researchers, design professionals and industry, these investments help accelerate the adoption of innovative wood-based solutions and strengthen British Columbia's leadership in wood construction.

Research Snapshots 2025/26 is one way that knowledge is shared with the broader sector. The following pages highlight recently completed projects and distill key findings into concise, accessible summaries that focus on practical applications and industry relevance. Together, these snapshots demonstrate how targeted research investments are helping solve real-world challenges, inform better decisions and create new opportunities for wood construction. By connecting research outcomes with the needs of industry and the built environment, this publication helps strengthen the pathway from research to implementation and supports continued innovation in wood-based design, manufacturing and construction.

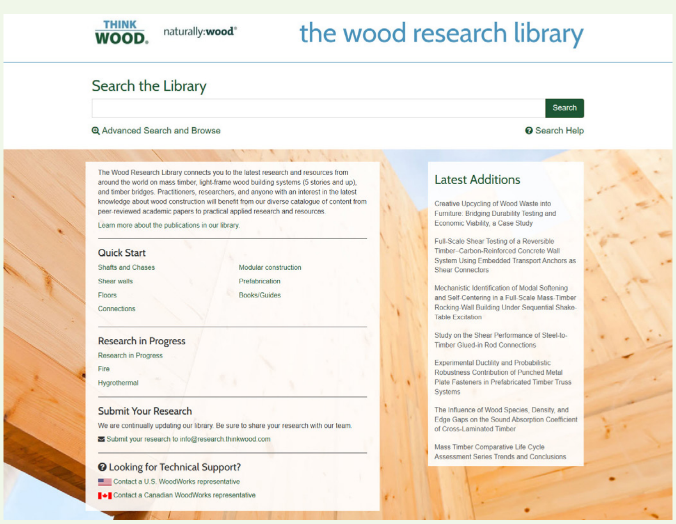
The Wood Research Library

The **Wood Research Library** is one of North America's most comprehensive online repositories of wood construction research, providing access to more than 3,400 records and 149 active research projects. It brings together peer-reviewed research, technical reports, conference papers, design resources and case studies from Canada and around the world, making evidence-based information easier to find and use.

The library serves a broad audience, including researchers, designers, engineers, builders, educators, policymakers and government agencies. Regularly updated and searchable by topic, publication type and keyword, it helps users stay informed about the latest developments in wood design, construction, performance and sustainability.

The library also houses the research featured in this publication, providing access to project profiles, citations, related resources and project team information where available.

Visit woodresearchlibrary.com to explore the collection and learn more.



3,400
records

149
active research projects

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Forestry Innovation Investment

Research categories

FII's Wood First research investments are organized into seven categories that reflect the major technical, market and sustainability challenges shaping the future of wood construction. Together, these categories support the development of evidence, tools, products and best practices that advance innovation and enable broader adoption of wood and wood-hybrid building systems.

Building physics and performance: High-performance, durable and climate-adaptive wood building systems

Focusing on thermal, moisture, acoustic, vibration, energy and indoor environmental building performance.

DfMA and prefabrication: Industrialized and prefabricated wood construction that improves speed, quality and cost certainty

Advancing design for manufacturing and assembly through modular, prefabricated and scalable construction methods.

Market and economics: Market, cost and policy research to accelerate adoption of wood construction

Improving knowledge of market conditions, competitiveness, financing, procurement, affordability, investment risk and adoption pathways.

Materials and products: Development and optimization of wood and hybrid building materials and products

Supporting the development, testing, characterization and performance of existing and next-generation wood products and assemblies.

Image credit: naturally:wood

Structural systems: Innovative and efficient wood structural systems and assemblies

Analyzing, designing, testing, modelling and optimizing structural systems, connections and assemblies.

Sustainability and circularity: Low-carbon, circular wood construction across the building life cycle

Supporting life-cycle assessment, embodied carbon reduction, biogenic carbon accounting, circularity, adaptive reuse and resource efficiency.

Resilience and safety: Safer, more resilient wood buildings under fire, seismic and climate hazards

Advancing fire performance, seismic design, durability, repairability, climate resilience and risk-informed building solutions.

Structure-borne sound generation and transmission in mass timber buildings

What you need to know

Mass timber floors can transmit structure-borne sound, especially at low frequencies, which can lead to noticeable vibration and occupant annoyance. Our research demonstrates that adding floating concrete toppings at junctions increases the flanking sound reduction index by 6–12 dB. We also validated a numerical model that predicts vibrations within 5 dB, and conducted a companion perception study confirming that standard acoustic ratings can effectively predict occupant annoyance.

Overview

Cross-laminated timber (CLT) is increasingly used in mid-rise construction, but its low mass and stiffness create challenges for structure-borne sound insulation at low frequencies (20–315 Hz). These vibrations can amplify floor resonances, significantly compromise acoustic serviceability and occupant comfort, and are perceived as annoying noise by occupants.

This research combines two investigations: a study to quantify vibration reduction at CLT junctions with and without concrete topping, and a perception study of how occupants experience acoustic annoyance. Together, they provide an integrated evidence base for the acoustic design of mass timber buildings.

Research approach

Vibroacoustic testing and numerical modelling (Hossein): This study examined two vibroacoustic improvements for CLT structures. Experiments in a 5.4 m × 4.0 m room showed that adding localized pre-cast concrete slabs at floor–wall edges increased the flanking sound reduction index (R_{ij}) by a consistent mean of 8.7 dB. The study also developed a combined finite element model with an integral transform method to predict sound power levels. Excitation forces were characterized using inverse methods and Loadsol sensors, and the model was validated against experimental data, achieving agreement within about 5 dB.

Human perception study (Jacy): Thirty-one participants in a receiving room rated annoyance, noisiness, disturbance and amenity for 10 floor assemblies (from bare CLT to a well-insulated system) during live overhead walking excitation. Emotional state, cognitive interference and noise sensitivity were also measured. Acoustic performance was characterized using a tapping machine and rubber ball sources per ISO and JIS standards.

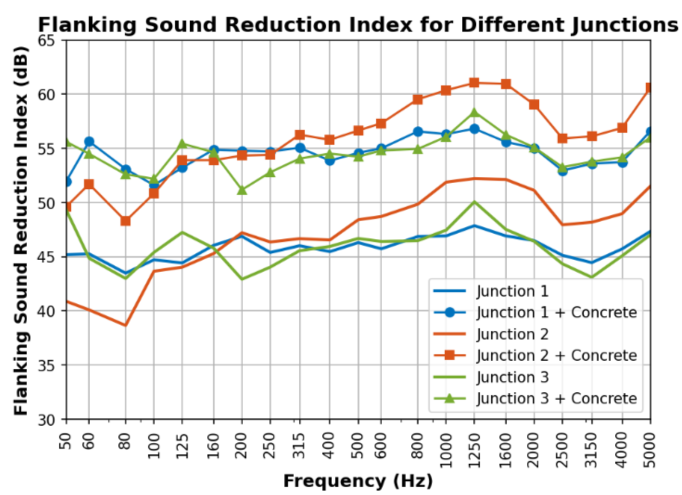

Figure 1. R_{ij} at three CLT floor–wall junctions with (markers) and without (solid) concrete topping slabs, ISO†10848-1, 50–5000 Hz.

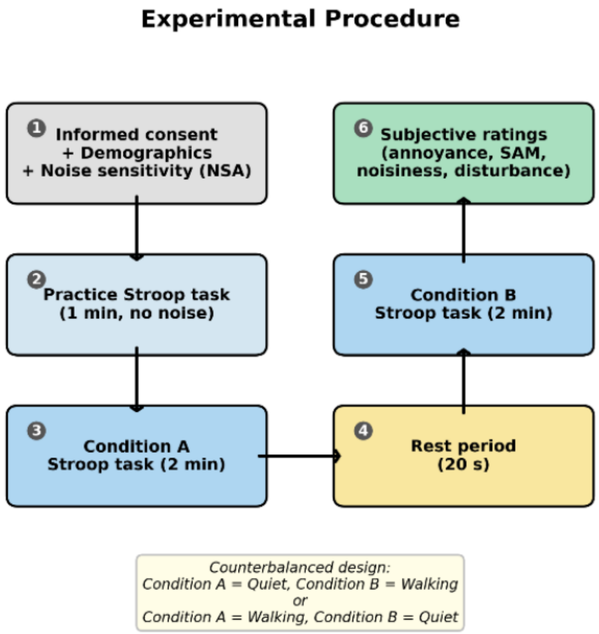

Figure 2. Experimental session procedure. Each participant completed nine sessions (one per floor configuration) in counterbalanced order.

Key findings

Vibroacoustic performance: Adding pre-cast slabs at floor edges above each CLT wall increased R_{ij} by 5–10 dB across 50–5,000 Hz at all junctions without full-floor coverage. The 38 mm slab (234 kg) matched the 50 mm slab (307 kg), confirming that localized edge mass governs flanking reduction. As shown in Table 1, measured natural frequencies closely matched finite element predictions, with less than 1 Hz deviation for primary modes and near-exact agreement at higher modes, validating the integral transform method and stiffness assumptions.

OMA (Hz)	FEM (Hz)
16.82	16.02
20.34	18.73
39.31	38.40
49.57	48.70
69.86	76.60
145.27	140.90
186.19	185.90
261.93	261.90
290.74	292.97

Table 1. Comparison of natural frequencies (Hz) obtained from experimental Operational Modal Analysis (OMA) and the validated finite element model (FEM) for the bare CLT floor assembly.

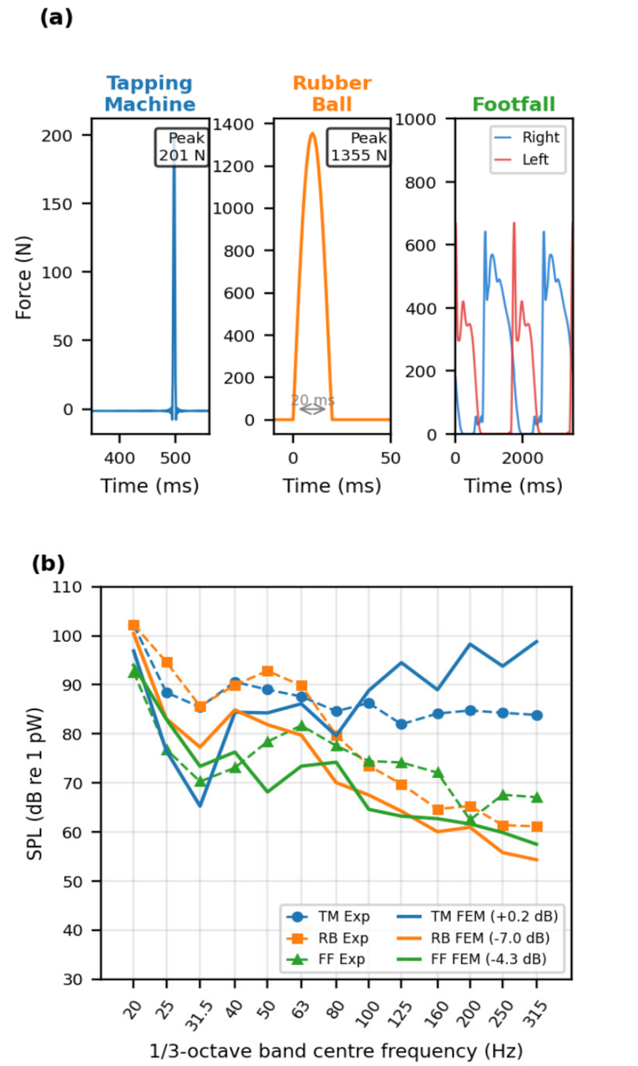

Figure 3. (a) Force spectra. (b) Per-band FEM vs experiment error (20–315 Hz).

Human perception: Mean annoyance on a nine-point scale ranged from 1.8 (best treated floor) to 5.9 (bare CLT). Only bare CLT and carpet on CLT produced highly annoyed responses; all configurations with resilient underlayment and concrete topping kept annoyance levels below the midpoint. ISO $L_{n',w}$ and ASTM AIIC were the strongest annoyance predictors ($r > 0.94$, $p < 0.001$); a combined mixed-effects model with noise sensitivity explained 61% of individual rating variance.

Low-frequency content below 63 Hz was most strongly associated with walking annoyance ($r = 0.80–0.86$). Noise sensitivity acted as an additive offset rather than a moderator. Bare CLT caused 194 ms cognitive interference on the Stroop task.

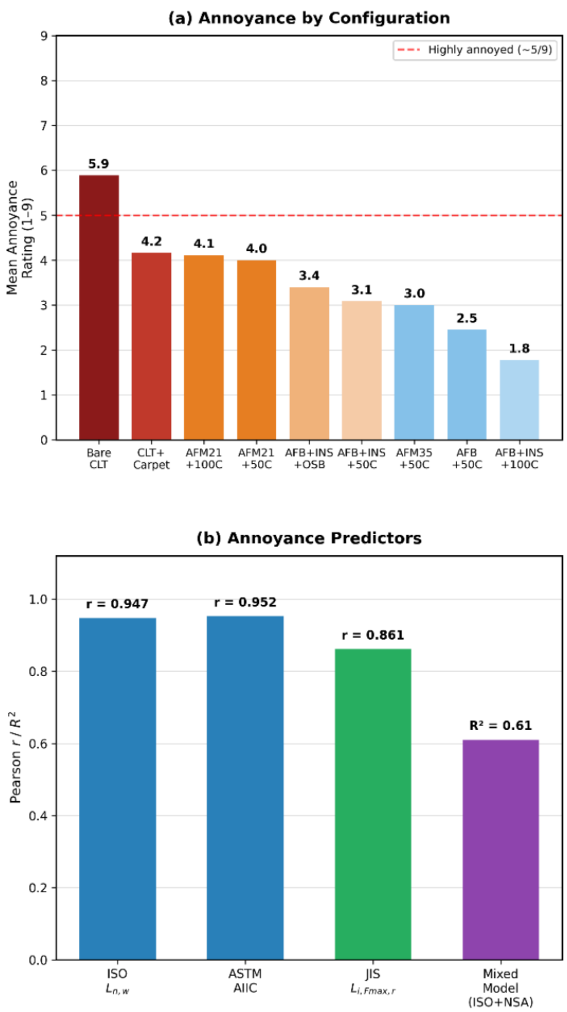

Figure 4. (a) Mean annoyance rating (1–9) by floor configuration, n = 30. (b) SNQ–annoyance correlations and mixed-effects model, R^2 = 0.61.

Why this matters

The combined vibroacoustic and perception results allow architects and acoustic engineers to link acoustic performance with occupant comfort. The validated numerical model parameters and R_{ij} data can be used to predict flanking transmission and specify targeted concrete mass at junctions without requiring full-floor toppings. The SNQ–annoyance correlations allow performance targets to be set from occupant perception data. Future research will extend the model to multi-room configurations and refine perception models for diverse populations.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4334

About the researchers

Project lead

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Jacy Xu, Master's student, UNBC (perception and database analysis)

Research supported by Forestry Innovation Investment® NSERC CRSNG

Vibration performance and design of mass timber buildings

What you need to know

Mass timber buildings face vibration challenges at two scales. At the floor level, lightweight timber floors are highly susceptible to walking-induced vibrations and current design standards can give different verdicts on the same floor. At the building level, there is a growing need for comprehensive knowledge of lateral vibration performance as multi-storey mass timber construction increases. This project addresses both issues through parametric floor studies and an integrated program of field testing, numerical and analytical modelling, and laboratory experiments on multi-storey structures.

Overview

Vibration serviceability is a governing design consideration for mass timber buildings at two scales. At the floor scale, cross-laminated timber (CLT), mechanically laminated timber (MLT) and glued-laminated timber (GLT) floors are lightweight and lightly damped, making them prone to walking-induced vibrations. Three design frameworks—Canadian Standard for Engineering Design in Wood (CSA O86-24), American AISC Design Guide 11 and the preliminary draft Eurocode 5 (prEN 1995)—address this problem, but differ substantially in their mechanics and acceptance criteria. At the building scale, lateral dynamic properties such as natural frequency, mode shapes and damping are essential for wind and seismic design yet remain poorly characterized for mass timber structures.

This project maps vibration performance through parametric studies and finite element modelling, and characterizes the dynamic properties of multi-storey mass timber buildings through field testing, numerical and analytical modelling and laboratory experiments.

Research approach

Floor vibration (parametric studies): Hundreds of floor configurations were evaluated by panel type (CLT, MLT, GLT), span (4–12 m), width (4–14 m), concrete topping (0 or 50 mm) and supporting beam span (6–14 m). Every floor passed CSA O86-24 strength and deflection checks before vibration assessment. Three vibration design methods were then applied to characterize frequency, peak acceleration and multi-criterion performance levels. Analytical predictions were validated against finite element models in OpenSees, and case studies were conducted for further examination.

Building dynamics: Equivalent flexural and shear rigidity parameters were derived for surrogate beam models of CLT shear walls and braced frames. Analytically predicted fundamental frequencies were benchmarked against experimental data from 13 full-scale buildings and laboratory mock-ups. Ambient vibration tests (AVTs) were conducted on two hybrid mass timber buildings (10- and 12-storey), and the results were used to develop finite element models. A 41-building global database and AVTs of seven Canadian structures provided the data to develop empirical fundamental period formulas and calibrate both finite element and analytical beam models. Two-storey CLT shear walls were subjected to quasi-static cyclic and vibration tests to correlate stiffness degradation with natural frequency reduction.

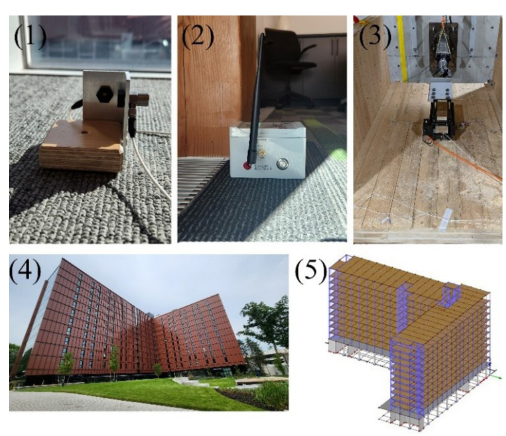

Figure 1: Overview of research methodology:
(1) cable sensor
(2) wireless sensor
(3) 2-storey CLT shaker test
(4) tested 12-storey hybrid mass timber buildings (BCIT)
(5) FE of 12-storey (BCIT)

Key findings

Floor vibration:

- **Span influences frequency**: Fundamental frequency falls from ~18 Hz at 4 m to ~5 Hz at 12 m; concrete topping reduces frequency by an additional 1–2 Hz. (Figure 2)
- **Floor width affects acceleration:** Narrow bays (4 m) fail the AISC office limit at most spans; widths of 10–14 m bring most spans into compliance. A 50 mm topping roughly halves peak acceleration.
- **Concrete topping lifts prEN 1995 performance** by 1–3 levels at moderate spans (6–10 m) through higher damping and increased floor mass.
- **Beam flexibility matters:** Long beam spans (14 m) reduce system frequency by 25–45%, potentially shifting a floor from transient to resonant behaviour (Figure 3).

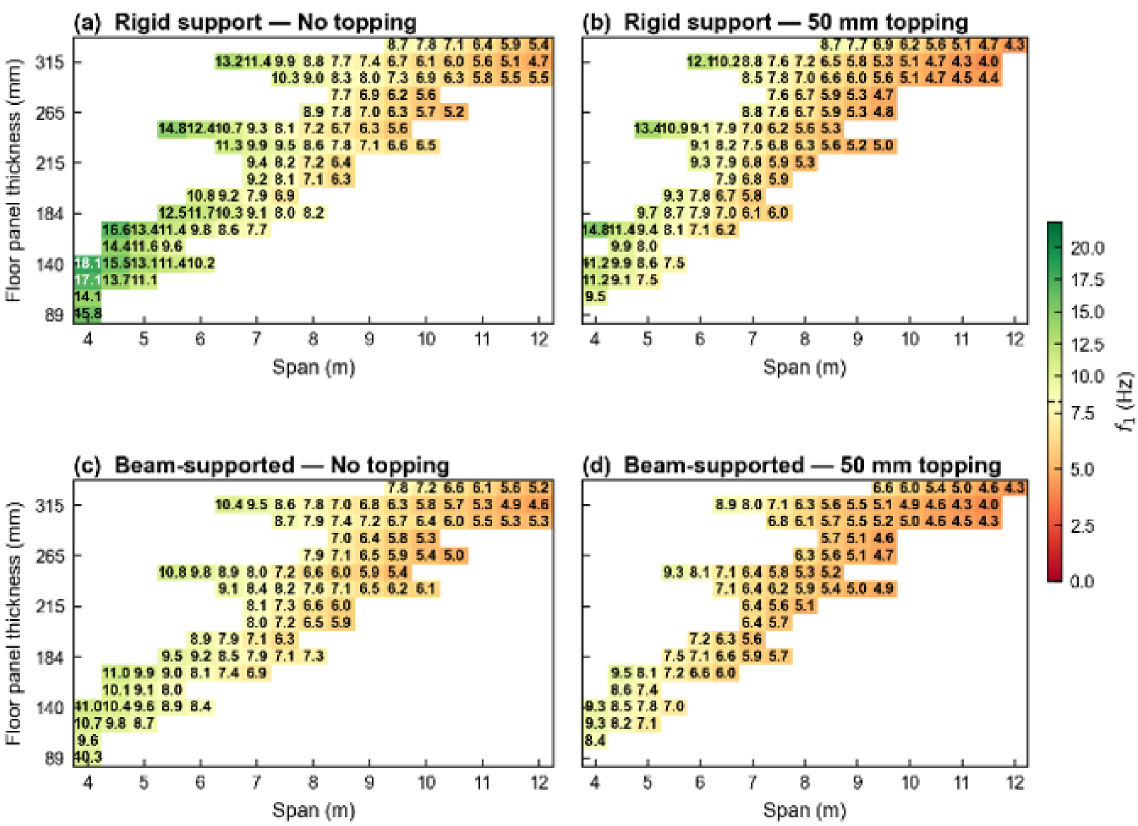

Figure 2: Fundamental natural frequencies across panel span, grouped by support condition and concrete topping thickness.

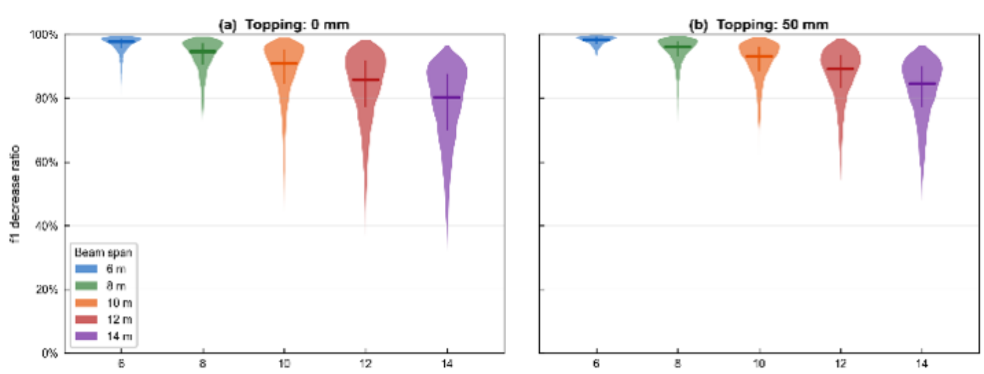

Figure 3: Effect of supporting beam span on floor system frequency.

Building dynamics:

- A regression analysis of the database produced a new empirical, height-based fundamental period formula for different lateral systems.
- Damping averaged over 2% for buildings under 20 m but fell below 2% for taller structures.
- Dynamic properties are largely insensitive to connection constraint types but highly dependent on non-structural components and CLT shear wall in-plane shear stiffness.
- Coupled beam models accurately predicted the first translational mode for CLT shear wall buildings (average experimental-to-analytical frequency ratio: 0.92–1.14), while a shear-only beam analogy was most accurate for timber/steel braced frame buildings (average ratio: 1.00).
- Laboratory tests of two-storey CLT shear wall structures correlated stiffness degradation with an observed natural frequency reduction of up to 32%, providing a framework for vibration-based damage detection.

Why this matters

Structural engineers can use the floor-level results to screen spans, bay widths and topping configurations early in design; floor width and concrete topping are shown to be more effective design levers than increasing panel thickness.

At the building scale, the empirical formulas support wind and seismic analysis, and the validated beam analogy offers a reliable method for predicting natural frequencies during preliminary design. Future research should validate analytical predictions against measured floor response data, extend the framework to multi-bay configurations, and expand the building-level database with additional field measurements.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4721

About the researchers

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Samira Mohammadyzadeh, PhD candidate, UNBC (building dynamics)

The two-storey CLT shear wall test was conducted with Dr. Thomas Tannert's team.

Research supported by

Forestry Innovation Investment

NSERC CRSNG

Canadian Wood Construction Research Network

ALBERTA INNOVATES

Residual withdrawal resistance of steel-wood self-tapping screw connections under cyclic moisture content load

What you need to know

Wood is a hygroscopic material that expands and contracts with moisture changes, and this movement can damage the wood-screw interface in self-tapping screw connections. The residual withdrawal resistance of these connections under cyclic moisture content load depends on the degree of damage that develops in wood-screw interaction during the wetting stage. We developed a 3D numerical modelling analysis and an analytical ordinary differential equation model to simulate the post-elastic performance of the screw-wood interaction.

Overview

Self-tapping screws (STSs) are widely used in mass timber construction due to their relatively high strength and ease of installation. However, moisture exposure can cause damage in the screw-wood interaction layer that persists even when the moisture content returns to its original level after a sequential drying process, potentially reducing the withdrawal resistance of steel-to-wood STS connections. The extent of this reduction remains unclear, as does how it is influenced by connection configurations and moisture content change levels.

Research approach

The research team developed a sophisticated 3D numerical model incorporating a cohesive zone modelling method to investigate the residual resistance of both fully threaded and partially threaded STS connections under cyclic moisture content load in combination with installation-induced torque and clamping loads. Various screw lengths and three levels of cyclic moisture content load (12-16%-12%, 12-21%-12%, 12-30%-12%) were considered in the parametric analysis. The team also developed an analytical ordinary differential equation model to simulate the post-elastic performance of screw-wood interaction.

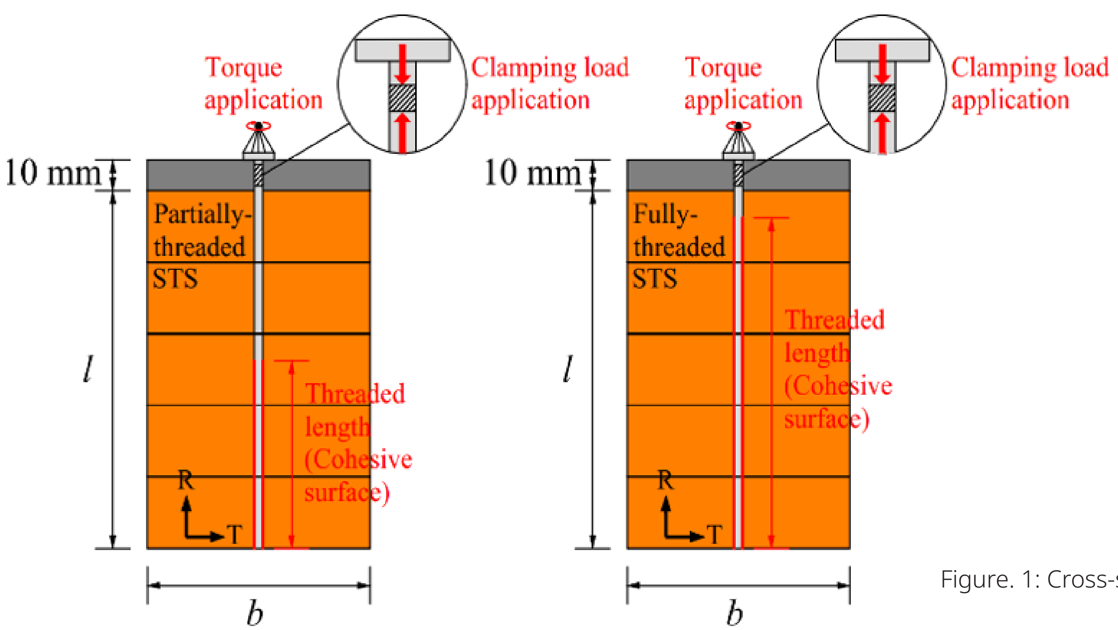

Figure. 1: Cross-sectional view of FE model.

Key findings

- Partially threaded screws retain less withdrawal resistance than fully threaded screws after being exposed to cyclic moisture content load.
- In a wetting environment, the initiation of damage on the STS-wood interaction is mainly governed by the wetting-induced STS-wood relative movement. The STS-wood relative deformation induced by the installation loads can be ignored, especially for long screws.

Why this matters

This study provides a numerical modelling database to consider the effect of cyclic moisture load and installation-induced loads on the residual resistance of STS connections. The analytical model can be used to predict the residual resistance of STS connections under cyclic moisture content load beyond the elastic range of wood-screw interaction.

Future experimental studies are needed to validate the modelling results.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:

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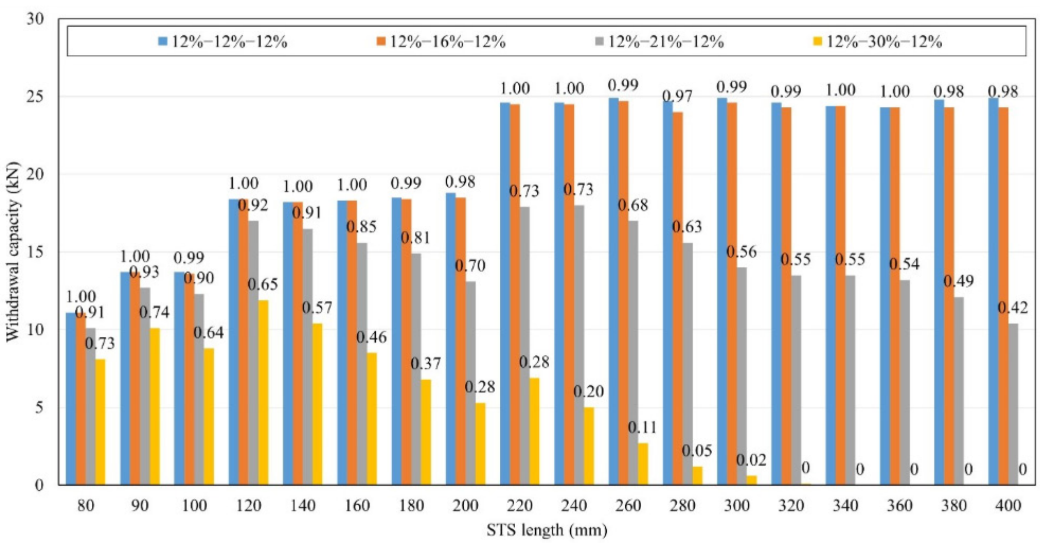

Figure 2: STS residual withdrawal resistance under cyclic MC load (partially threaded STS).

About the researchers

Project lead

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Chun Ni, Lead Scientist, Building Systems, FPInnovations (project collaborator)

Jintao Zhang, PhD student, UVic

Research supported by Forestry Innovation Investment®

Unlocking mass timber finance for the Canadian market

What you need to know

Mass timber construction can improve project financial outcomes and reduce real estate financing risk when paired with high energy performance and climate-resilient design. Evidence from more than 100 studies, financial institution engagements, webinars and real-world case studies shows that mass timber's delivery model can reduce risk, stabilize operating costs, strengthen net operating income and enable innovative financing approaches. These insights directly address lender concerns and can help unlock mass timber adoption in the Canadian market.

Overview

Mass timber is increasingly recognized as a low-carbon, prefabricated construction pathway that can improve housing delivery speed and supply. However, adoption remains limited due to financing challenges related to prefabrication timelines, upfront capital requirements, lender and underwriter unfamiliarity, and higher insurance costs. This study synthesizes secondary research and stakeholder perspectives that respond directly to these challenges and opportunities, strengthening the business case for climate-aligned real estate investment.

Research approach

The study integrated findings from more than 100 peer-reviewed studies on the financial and risk performance of climate-aligned buildings, as well as the results of targeted engagement with financial institutions through advisory committees and two mass timber financing webinars. Four case studies covering residential and commercial projects in British Columbia and Ontario were developed to assess construction sequencing, performance metrics, delivery risk and financing implications in real-world project settings.

Mass Timber's Emerging Pathway to Financial Performance

Building & Delivery Characteristics	Emerging Evidence & Insights	Desired Financial Outcomes
• Low Carbon Footprint • High Performance • Prefabrication & Speed • Cleaner & Safer Construction Sites	• Climate Alignment • Schedule Benefits • Case Studies & Success Stories • Stakeholder Feedback	• Stronger NOI • Improved Asset Value • Greater Leasing Demand • Greater Cost Certainty • Greater Lender & Insurance Confidence

While large-scale econometric evidence is still emerging, mass timber and advanced wood construction can demonstrate many of the performance characteristics that underpin the documented financial outperformance of green buildings.

Key findings

Mass timber construction can offer compelling financial benefits. Evidence shows that energy-efficient, green-certified buildings improve loan performance and reduce credit risk, strengthening the business case for sustainable investment. When paired with low carbon and climate-resilient design, mass timber construction is expected to deliver similar benefits through stronger net operating income.

Prefabrication can improve financing outcomes. Mass timber systems enable faster assembly and earlier enclosure, shortening construction schedules and accelerating occupancy—particularly when delivered by experienced teams. These time savings can reduce interest-during-construction costs and bring revenues forward.

Stakeholder engagement highlights both challenges and opportunities. Targeted engagements identified gaps in understanding related cost, design co-ordination, supply chains, moisture management and insurance. The engagements also identified opportunities for early integration and customized financing solutions.

Case studies confirm viability. Projects such as 981 Davie Street (Vancouver) and 1120 Ossington Avenue (Toronto) demonstrate that mass timber can deliver both environmental and economic value while building lenders' confidence.

Collaboration is essential. Scaling adoption will require deeper collaboration between industry, developers and financial institutions.

Innovative financing models are critical. There is a need to shift toward performance-based financing approaches that are better aligned with the delivery models, risk profiles, and potential energy and climate performance benefits of mass timber and advanced wood systems.

Why this matters

These insights enable financial institutions—including commercial real estate, credit risk, insurance, and valuation professionals— as well as developers and building owners to better understand how mass timber project design and delivery choices influence risk perception and financing outcomes.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4712

About the researcher

Project lead

Michaela Neuberger, Executive Director, Affine Climate Solutions

Organizations consulted include: Assembly Corp, Business Development Bank of Canada, Bank of Montreal, Coast Capital Savings Federal Credit Union, Vancity Credit Union, Canadian Wood Council, WoodWorks BC and WoodWorks Ontario.

Research supported by Forestry Innovation Investment®

Converting CLT offcuts to value-added lumber products

What you need to know

Sawn lumber is relatively weak when loaded perpendicular to the grain. To overcome this limitation, we tested whether lumber products manufactured from cross-laminated timber (CLT) offcuts could carry substantially higher compressive loads by taking advantage of CLT's cross-layer reinforcement. The results of our study show that CLT-derived lumber carries higher bearing loads than conventional Douglas-fir lumber, meets most finger-joint strength requirements and could be used in select structural applications, such as bottom plates in light-frame stud walls.

Overview

This research developed a new lumber product from CLT offcuts to address the weakness of sawn lumber under compression perpendicular to the grain. The team developed a manufacturing process for converting CLT offcuts into 2-by lumber strips and tested their mechanical performance. The goal was to determine if these products could serve as stronger alternatives to conventional sawn lumber where perpendicular-to-grain compression is a limiting factor.

Research approach

The study began by processing three-ply Douglas-fir CLT offcuts to extract small clear specimens for validating the basic material properties of the laminations (ASTM D143-25). Next, 2-by strips were cut from the CLT offcuts and finger-jointed to create CLT-derived lumber for evaluating finger-joint strength (ASTM D4688). Finally, the CLT lumber was tested in a bearing configuration to characterize its bearing strength. Conventional Douglas-fir lumber was also tested for comparison.

2-by CLT lumber (top and bottom layers are longitudinal layers while the middle is cross layer)

Key findings

Mechanical properties

The small clear specimen tests showed that the basic mechanical properties of the CLT laminations were within expectations when compared to literature values: compressive strength parallel to the grain was several times greater than perpendicular to the grain. This supports the theory that CLT-derived lumber will perform better than conventional dimensional lumber under bearing loads due to the cross-layers being loaded parallel to the grain.

Finger-joint performance

The tensile tests showed that finger-jointed CLT-derived lumber could generally meet manufacturing standards, even though the finger length used in this project was shorter than typical structural timber finger joints. More research is needed to further characterize the tensile behaviour of finger-jointed CLT-derived lumber and its unique failure modes following the test standard ASTM D198.

Bearing strength

The bearing tests showed that CLT-derived lumber achieved substantially higher bearing capacity than conventional Douglas-fir lumber because the cross-layer was loaded parallel to the grain and acted as an internal reinforcement. The measured peak loads exceeded the code-based predictions (CSA O86:24), indicating that current design approaches might be conservative for this type of cross-laminated lumber product.

Why this matters

The findings suggest that CLT offcuts can be upcycled into value-added lumber products for applications where conventional sawn lumber is limited by compression perpendicular-to-grain capacity, such as bottom plates in load-bearing walls. This creates a potential pathway to reduce CLT manufacturing waste while producing higher-performance building components.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4717

About the researchers

Project lead

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Jaewon Oh, PhD student, UBC (specimen fabrication)

Sean Yang, Graduate research assistant, UBC (specimen fabrication, data collection)

Chih-Cheng, Researcher, UBC (data collection)

Kalesnikoff Mass Timber provided material donations and collaboration support.

Research supported by Forestry Innovation Investment

THE UNIVERSITY OF BRITISH COLUMBIA

Developing hem-fir (N) glulam using manufactured lamstock

What you need to know

In this project we tested whether manufactured Hem-fir lamstock—made by processing boards to reduce knot size and randomize finger-joint locations—could produce higher-grade glulam. Two new grades showed higher tension strength and more consistent performance than regular lamstock, indicating strong potential for producing higher-grade Hem-fir glulam using manufactured lamstock.

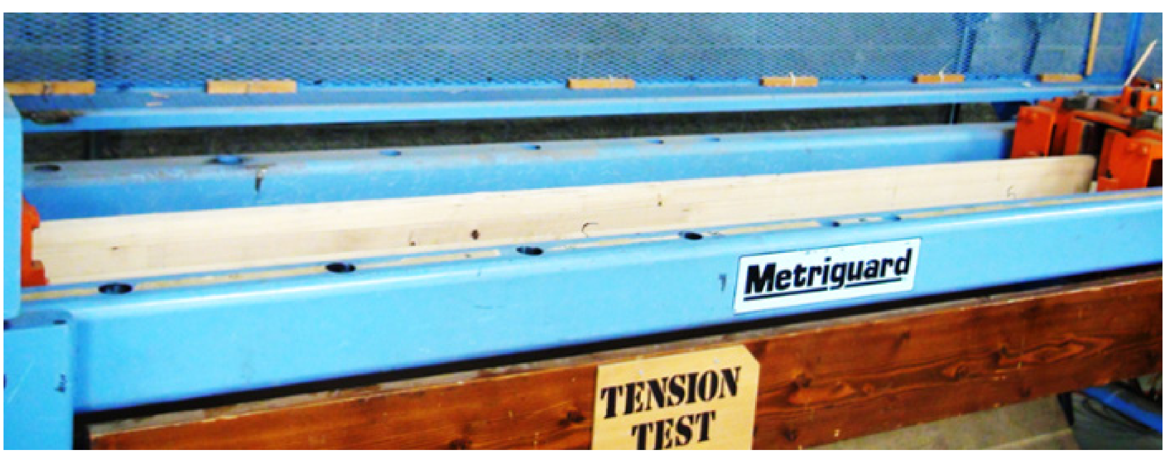
Overview

This research is informing the development of new markets for British Columbia's abundant Hem-fir resources. Building on previous work on using Hem-fir glulam as bending members, this project focused on developing high-grade manufactured lamstock by randomizing the location of finger joints across the width and reducing the knot sizes. The performance of manufactured tension lam and full-size beams was quantified through testing.

Research approach

Two new grades of manufactured lamstock, B+ and T1+, were developed based on regular B and T1, respectively. The lamstock used to make source beams for B+ and T1+ had a minimum modulus of elasticity of 13.1 GPa.

Over 115 samples of each grade were tested to measure tension strength. Full-size beams of 304 mm and 608 mm were tested under bending to measure the bending modulus of elasticity and bending strength. The failure modes of both the tension and bending tests were analyzed and compared with regular lamstock.



Lamstock tension test

Full-size glulam beam testing

Key findings

Manufactured lamstock had higher tension strength and a lower coefficient of variation compared to regular lamstock of the same grade. If regraded with a tight knot after the re-manufacturing process, about 75% of B+ could be upgraded to T1 (same fifth percentile strength) and used to produce 24f-EX glulam.

The first batch of T1+ had a fifth percentile tension strength of 34.43 MPa, which was 9.6% higher than that of T1 lamstock and 16.0% higher than that of T1 finger joints. This increase was greater than the difference between the bending strength of 26f-EX and 24f-EX.

However, the second batch of T1+ had significantly lower strength, primarily due to the low percentage of wood failure in the finger joint. A similar failure mode was also found in the lower tail specimens of the full-size beam tests.

More research is needed to understand the low wood failure at the finger joint and to confirm these findings with new specimens. When using B+ or T1+ to make higher grades of glulam, the grading procedure must be optimized to exclude off-grade pieces after re-manufacturing. This can be achieved in one of two ways: special layups of the source beam (placing pieces with smaller knots on the face layers to have smaller edge knots on the manufactured lam) or by regrading after slicing the source beams, knowing that some B+ pieces will downgrade to regular B.

Why this matters

This research highlights the potential of using manufactured lamstock to make high-grade glulam. The data helps lamstock suppliers and glulam producers understand technical issues involved in the process of making manufactured lamstock and provides guidelines for further optimization.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4718

About the researchers

Project lead

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Research supported by Forestry Innovation Investment® WESTERN Forest Products

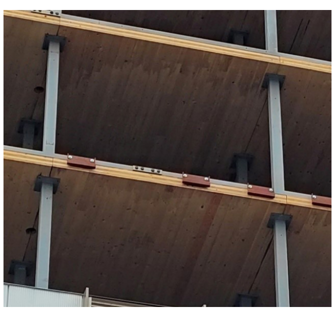
Fire testing of point-supported steel-timber connection

What you need to know

This project investigated the fire resistance of point-supported steel-timber connections with and without thermal protection. Mechanical behaviour was similar across tests, but thermal and charring behaviour differed. Results showed that these connections can achieve a two-hour fire-resistance rating without added protection when installed and loaded as tested.

Overview

This study developed structural design principles for mass timber point-supported connections (MPSC) exposed to the standard fire of CAN/ULC S101 and ASTM E119. Two full scale tests—one unprotected and one protected with firestop foam—showed that both assemblies maintained structural integrity for two hours, with differences only in thermal and charring behaviour.



Point-supported connections used in downtown Vancouver, BC.

Research approach

Two structural fire-resistance tests were conducted on MPSC assemblies consisting of a five-ply (175 mm) cross-laminated (CLT) floor panel, a glulam column and an MPSC at mid-span. A structural load of 70 kN (15,375 lbs) was applied to the connection, based on the CLT rolling shear resistance.

Test 1 consisted of the MPSC assembly with an unprotected 25 mm gap between the glulam column and CLT ceiling (i.e., MPSC exposed to fire).

In Test 2, the gap was filled with a firestop foam used for linear joints in CLT construction.

Test 1: MPSC unprotected

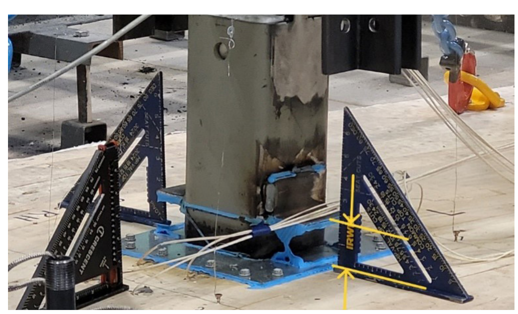
Test 2: MPSC protected

Key findings

Both assemblies maintained structural integrity after two hours of standard fire exposure, although their fire behaviour differed. In both tests, reduced CLT resistance due to charring governed performance.

Mechanical behaviour

The CLT exhibited significant upward bending deformation as the load pulled the MPSC connector upward in both tests. In Test 1, the MPSC moved up by ±50 mm due to crushing of the charred CLT above the steel plate. This differential displacement was not observed in Test 2, where no charring occurred at the plate interface.



Test 1: Upward differential displacement of the MPSC during fire testing.

Charring behaviour

Away from the connectors and columns, the charring rates of the CLT panels were consistent with the one-dimensional charring rate of 0.65 mm/min specified in Canadian Standard for Engineering Design in Wood (CSA O86:24).

In Test 1, the charring rate reduced to 0.33-0.40 mm/min, suggesting a partial shielding from the steel plate. Test 2 showed little to no signs of charring at the vicinity of the MPSC connector.

Test 1: View of the interface after the test.

Test 2: View of the interface after the test.

Thermal performance

A significant difference was observed in thermal performance: in Test 1, the edges of the steel plate reached 400°C and remained fairly stable throughout the two-hour test duration, whereas the temperature in Test 2 barely exceeded 100°C. Correspondingly, CLT loss above the steel plate was greater in Test 1 (residual 120 mm, ±3.3 plies left) whereas all five plies were retained in Test 2.

Despite these differences, neither test reached the critical steel temperature set forth in CAN/ULC S101 and ASTM E119.

Why this matters

The MPSC systems achieved a two-hour fire-resistance rating in accordance with CAN/ULC S101 and ASTM E119, confirming they can be used in North American mass timber buildings without additional protection when installed and loaded as tested.

This project also introduced a step-by-step design approach to predict steel temperatures and potential charring at the connector interface, adapted from a model presented in Buchanan & Abu (2017) for unprotected steel elements, which is a similar approach to that in the National Building Code of Canada for protected steel columns. The model assumes full convective and radiative heat fluxes on the exposed MPSC connectors, which may be overly conservative.

Findings from this research have already been used to support the design of a tall mass timber residential building in Kelowna, BC.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4715

About the researchers

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Fire-resistance testing was conducted at the National Research Council Canada's Fire Safety Unit in Ottawa.

Research supported by Forestry Innovation Investment®

Evaluation of design values for high-capacity shear walls

What you need to know

Seismic requirements in the 2024 BC Building Code make it increasingly difficult to use conventional Canadian Standard for Engineering Design in Wood (CSA O86) shear wall solutions in mid-rise wood-frame buildings. Our full-scale testing shows that high-capacity wood shear walls can meet seismic design demands, with single-sided walls delivering roughly twice the capacity of conventional walls and double-sided walls delivering approximately twice the capacity of single-sided systems. These results pave the way for including high-capacity shear walls in the 2029 edition of CSA O86.

Overview

This study evaluated the performance of high-capacity shear walls capable of delivering up to four times the lateral load resistance of conventional shear walls recognized in Canadian Standard for Engineering Design in Wood (CSA O86). Construction details, critical for preventing undesirable brittle failure modes during severe earthquakes, were selected based on previous research. Design values for the tested systems were established using the seismic equivalency criteria in ASTM D7989.

Full-scale experimental test on a high-capacity shear wall

Research approach

Full-scale tests assessed the performance of single- and double-sided high-capacity shear walls under monotonic and reversed cyclic loading, in accordance with Method C of ASTM E2126. Seismic equivalency was evaluated using ASTM D7989.

Key findings

Double-sided walls delivered roughly twice the lateral capacity of single-sided walls. However, both configurations showed the same ductile failure mechanisms and overall deformation patterns, with the double-sided system amplifying strength and distributing the failures more symmetrically.

Single-sided walls

- Peak loads were approximately twice those of comparable conventional shear walls.
- Failure modes included nail withdrawal, nail head pull-through and occasional nail fracture along panel edges and end studs, indicating ductile behaviour.
- Symmetrical rotation of the sheathing about the geometric centre, along with upward bending of the bottom plates at wall ends, resulted from uplift forces and the absence of plate washers at hold-down locations.

- Cracking and splitting developed in the bottom plates from uplift forces and eccentricity between the sheathing and anchor bolts, inducing bending stresses perpendicular to the grain. Despite this, angle brackets generally prevented stud-to-plate separation and maintained overall wall integrity.

Double-sided walls

- Lateral load resistance was significantly higher, with peak loads approximately twice those of comparable single-sided high-capacity walls.
- Failure modes were similar on both faces, primarily consisting of nail head pull-through, nail withdrawal and localized nail fracture near bottom plates and lower studs, indicating ductile performance.
- Symmetrical rotation of the sheathing was observed, along with upward bending of bottom plates at wall ends due to uplift forces and the absence of plate washers at hold-down locations.
- Cracking and splitting occurred at the ends of top and bottom plates due to uplift-induced bending stresses perpendicular to the grain, caused by eccentricity between the sheathing and anchor bolts. However, these did not result in stud-to-plate separation and overall wall integrity was maintained.

Why it matters

The findings of this research will support the inclusion of high-capacity shear walls in the 2029 edition of CSA O86. In collaboration with the O86 Mid-Rise Wood-Frame Construction Task Group, design values will be developed using ASTM D7989 seismic equivalency criteria, along with recommended construction details.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4713

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Ruite Qiang, Student, Faculty of Civil Engineering, UVic

Research supported by Forestry Innovation Investment

FPInnovations

Seismic performance and design guidelines for balloon-type CLT walls

What you need to know

Balloon-type cross-laminated timber (CLT) shear walls are a promising way for tall mass timber buildings to resist earthquake forces, but they are not yet recognized in Canadian codes and lack clear design guidance. This project developed and validated a design methodology and seismic design procedure for single-panel balloon walls using a representative 12-storey building and advanced nonlinear numerical modelling. The results show that the proposed method accurately predicts wall behaviour, provides reliable design forces and supports safe, code-ready seismic design for future adoption in Canada’s National Building Code and the Canadian Standard for Engineering Design in Wood (CSA O86).

Overview

Balloon-type mass timber shear walls are an efficient structural system for resisting lateral loads. However, because this system is not currently recognized in the National Building Code of Canada and lacks design provisions in the Canadian Standard for Engineering Design in Wood (CSA O86), it is beyond reach of most designers. This project developed a design methodology and procedure for single-panel balloon walls, creating a foundation for safe and reliable design and future code adoption.

Research approach

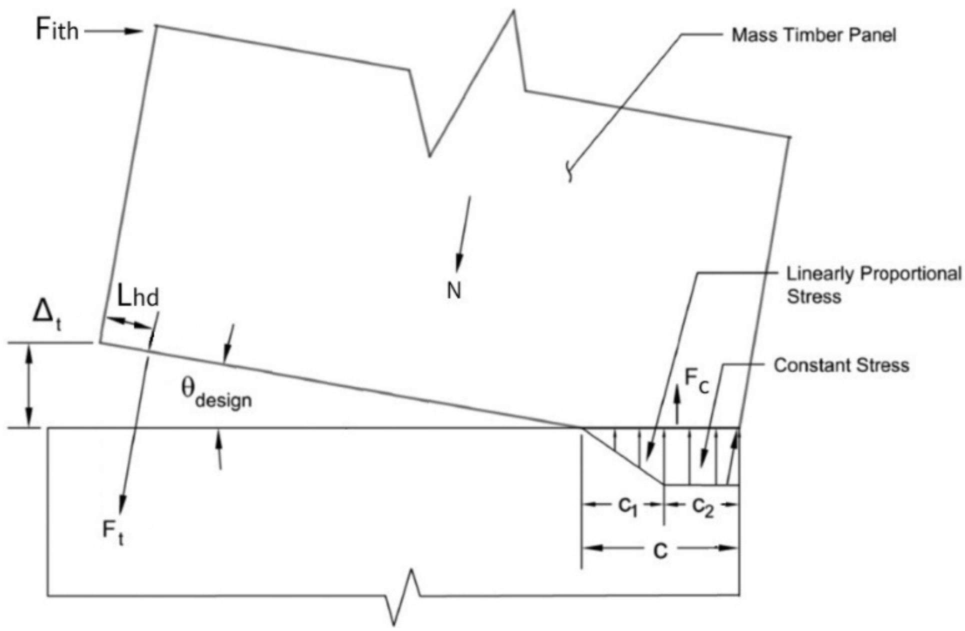
The research team developed a capacity-based seismic design procedure tailored specifically for single-panel balloon-type CLT shear walls. The procedure formalizes 10 sequential steps, from establishing design inputs to designing dissipative and non-dissipative components. The team also proposed a suite of five analytical methods to characterize and design the rocking interface components, providing designers with multiple pathways depending on project complexity and available resources.

To show how the procedure works in practice, the team designed a 12-storey building in Montreal that uses single-panel walls with mixed angle self-tapping screw hold downs. The researchers then built an advanced nonlinear numerical modelling framework that incorporates both compression and connection zones to test and validate the design approach.

Key findings

Different methods for estimating stresses at the wall interface led to different wall designs. Methods that do not consider the contribution of the wall’s compression zone overestimate the demand in the hold downs and therefore should only be used in preliminary designs. Methods that use rectangular, triagonal or trapezoidal compression zones at the bottom of the wall provide better defined forces and designs of the walls, with a more realistic compression zone. In most cases, the method that uses trapezoidal stress distribution is the preferred choice.

Pushover analyses conducted with the developed numerical models accurately predicted lateral load–displacement response, the evolution of the compression zone length, and force distribution among self-tapping screw fasteners. These results validate both the proposed design procedure and the seismic performance of the 12-storey building designed using it. They also confirm that the methodology reliably estimates deformation capacity, rocking behaviour and energy dissipation.



One of the developed methods for calculating wall interface forces and stresses.

Why this matters

This work establishes a robust foundation for the force-based seismic design of single-panel CLT balloon walls in Canada. It provides designers, researchers and code developers with a validated methodology, a broad archetype dataset and draft provisions that can be further refined and proposed for acceptance of the system in both the National Building Code and CSA O86.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4716

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Research supported by Forestry Innovation Investment® Natural Resources Canada / Ressources naturelles Canada Canada

UNIVERSITY OF NORTHERN BRITISH COLUMBIA

Design models for multi-storey platform-type CLT shear walls incorporating floor-to-wall interaction

What you need to know

The current Canadian Standard for Engineering Design in Wood (CSA O86) covers the design of cross-laminated timber (CLT) shear walls. These provisions apply to platform-type construction, where one storey's ceiling forms the platform for the next storey's walls. However, there are shortcomings with respect to how to account for the interaction between shear walls and the floor above and the impact of this interaction on the lateral stiffness of CLT shear walls. This project developed and validated an analytical model that incorporates these interactions.

Overview

This project developed analytical design models that account for the impact of floor-to-wall interactions on the seismic performance of multi-storey platform-type CLT shear walls. The research team tested full-size two-storey structures with two lines of coupled shear walls and used these results to refine and validate analytical and numerical models.

Full-scale experimental test

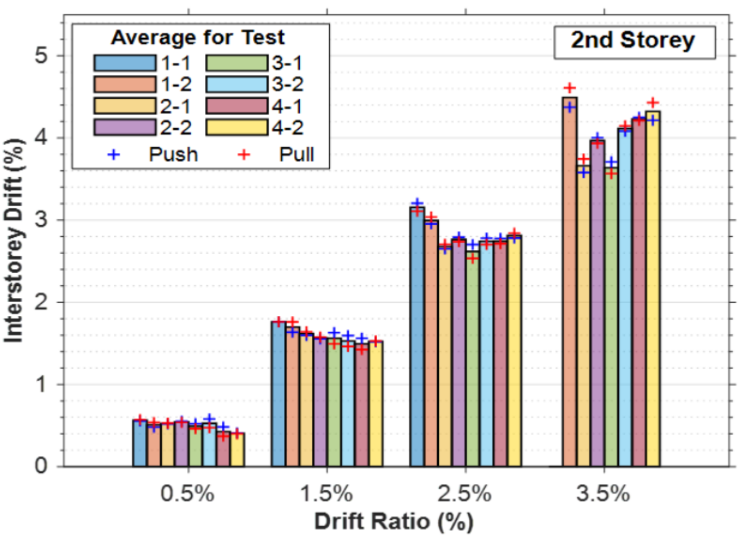
Research approach

The team developed and refined an analytical model incorporating floor-to-wall interactions to align with the design framework in Canadian Standard for Engineering Design in Wood (CSA O86). The proposed expressions were verified against numerical simulations and experimental data from previous testing programs.

New full-scale tests were conducted on two-storey multi-panel CLT shear wall structures. These tests investigated the influence of connection detailing on kinematic behaviour, strength degradation, energy dissipation, drift uniformity and the impact of dead load on the system's response.

Key findings

- The analytical expressions aligned well with CSA O86 and showed good agreement with numerical models.
- All tested structures satisfied the 2.5% drift limit and exhibited adequate seismic performance.
- Connection detailing was the primary driver of overall seismic performance in platform-type CLT shear wall systems.



2nd-storey interstorey drift at different total drifts

Why this matters

The validated analytical expressions provide a foundation for refining design provisions for multi-storey platform-type CLT shear wall systems and could inform future updates to CSA O86.

The proposed modification factors, aligned with the current CSA O86 framework, can be readily adopted by practitioners to improve the accuracy of seismic designs of platform-type CLT structures in multi-storey applications.

The experimental observations also support the development of numerical models to broaden the investigated parameter space, enabling further refinement of the proposed expressions.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4719

About the researchers

Project lead

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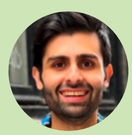
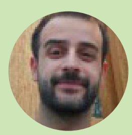


Mohammad Masroor, Post-doctoral researcher, UNBC



Orhan Sahutoglu, PhD candidate, UNBC

Antoine Bérubé, PhD candidate, University of Ottawa

The research team thanks MTC Solutions Inc., Aspect Structural Engineers and the UNBC lab team for their support.

Research supported by Forestry Innovation Investment NSERC CRSNG

Seismic performance of an innovative rocking and pivoting balloon-type CLT shear wall system

What you need to know

The current Canadian Standard for Engineering Design in Wood (CSA O86) provides design guidance for platform-type cross-laminated timber (CLT) shear wall construction, but does not address balloon-type systems. These systems face known challenges related to pre-stress losses, local crushing of CLT rocking toes and damage to hold downs. This project tested a new balloon-framed rocking CLT shear wall system that uses replaceable steel dampers to control seismic response. Full-scale tests show that the concept is feasible and provides data for further model development.

Overview

To address the limitations of current balloon-type CLT shear wall systems, this project developed and evaluated an alternative balloon-framed rocking CLT shear wall system that consists of three CLT panels coupled through ductile dampers along the vertical panel joints. The central panel rests directly on the foundation and is allowed to rotate alternately about two base corners (rocking toes), with lateral sliding restricted using shear stoppers. The two side panels are pinned at their exterior base corners. The research team conducted full-scale two-storey tests to understand how this configuration behaves under seismic loading.

Research approach

The experimental program tested full-scale, two-storey structures under quasi-static reversed cyclic loading under constant gravity load. The structure consisted of two identical shear wall lines connected by CLT floor panels. The specimens were subjected to reversed cyclic loading in accordance with ASTM E2126 Test Method B and the target displacement amplitude was selected based on a roof drift limit of 2.5%.

Two shear fuse configurations were investigated: butterfly-shaped dampers and U-shaped flexural plates.

Full-scale test structure

Key findings

The experiments demonstrated that the proposed balloon-framed rocking CLT shear wall system can sustain lateral deformation of up to 4% roof drift while maintaining a stable hysteretic response. Energy dissipation was provided by the replaceable steel fuse elements, while the CLT panels and all other structural connections remained elastic. These observations confirm the feasibility of the proposed system and provide the foundation for further evaluation of the system behaviour.

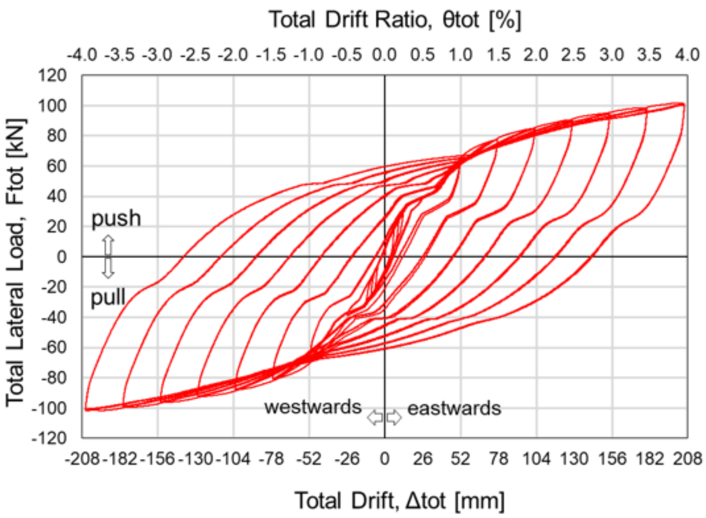


Figure 1: Hysteretic responses of system with UFP

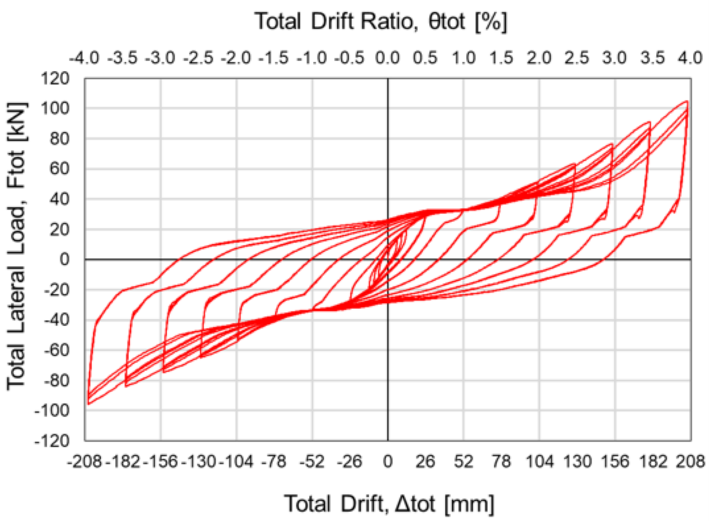


Figure 2: Hysteretic responses of system with BSP

Why this matters

The experimental data will be used to validate system kinetics and calibrate numerical models to optimize design parameters for a balloon-type rocking system.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4720

About the researchers

Project lead

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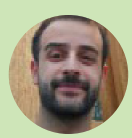
Fei Tong, Assistant Professor, UNBC



Orhan Sahutoglu, PhD candidate, UNBC

The research team thanks UNBC lab lead Maik Gehloff and technicians James Andal, Nathan Downie and Ryan Stern for their support.

Research supported by Forestry Innovation Investment® mitacs

Buckling resistance of high-capacity light wood frame shear walls

What you need to know

The buckling equation for traditional light wood frame shear walls in CSA O86-24 is based on the assumption of a four-edge simply supported thin plate, which tends to underestimate the buckling resistance of high-capacity shear walls with multiple rows of nails along sheathing edges. Our parametric study confirmed that additional rows of nails on sheathing edges and intermediate stud nailing increases panel restraint and raises buckling resistance.

Overview

The 2014 edition of the Canadian timber design standard, Canadian Standard for Engineering Design in Wood (CSA O86-14) introduced a mechanics-based approach to predict the lateral resistance of light wood-frame shear walls in which the lateral resistance of a wood-frame shear wall is governed by either sheathing-to-framing nail joints or sheathing panel buckling, whichever is smaller.

A three-year testing program by the University of Victoria and FPInnovations showed that high-capacity shear walls with multiple rows of nails are still governed by the sheathing-to-framing nail joints, even though the current code predicts that panel buckling governs. This discrepancy may be due to the neglect of sheathing-to-intermediate stud nails, and the rotational restraint provided by multiple rows of nails along sheathing edges in high-capacity shear walls.

To support the future implementation of high-capacity shear wall systems in CSA O86-29, the current code's buckling resistance prediction needs to be re-evaluated and improved to better reflect the actual boundary conditions of wood sheathing panels.

Research approach

The research team developed a numerical model via ABAQUS to predict the buckling resistance of a 4 ft by 8 ft sheathing panel. A parametric study was carried out on the thin plate model considering various boundary conditions, including: fully simply supported on four edges, fully fixed supported, pin or fixed supported with discrete supports at locations of sheathing-to-framing nail joints (nail spacing from 50 mm to 150 mm), and additional discrete supports on multiple rows of nails and intermediate stud nails.

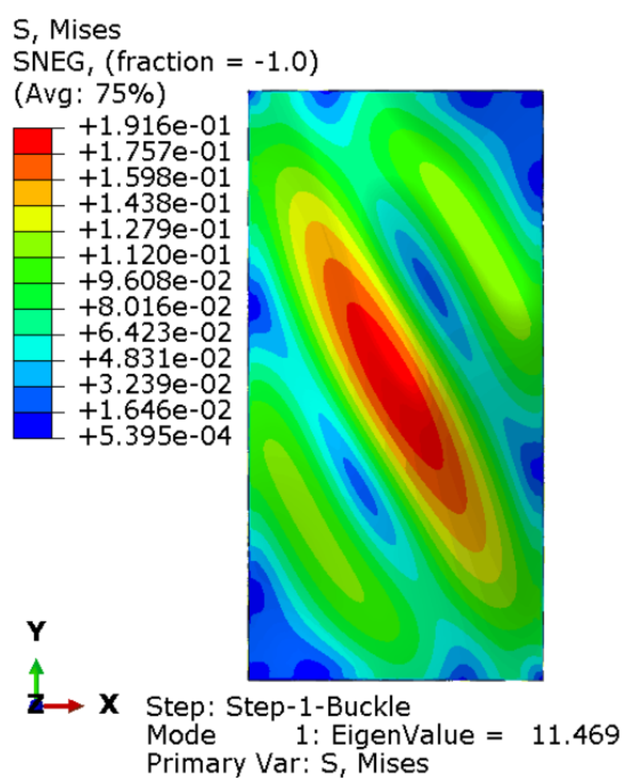


Figure. 1: Double rows of nails with 50 mm nail spacing and without intermediate stud nails.

Key findings

- Increasing the nail joint spacing decreases the buckling resistance of shear walls.
- Adding additional rows of nails on sheathing edges increases the buckling resistance of shear walls.
- Intermediate stud nailing has a positive effect on the buckling resistance of wood frame shear walls.

Why this matters

This research provides a numerical modelling database to develop an improved buckling resistance equation that more accurately reflects the actual boundary conditions of sheathing panels. Future experimental studies are needed to verify the research findings from numerical modeling analysis in this study.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
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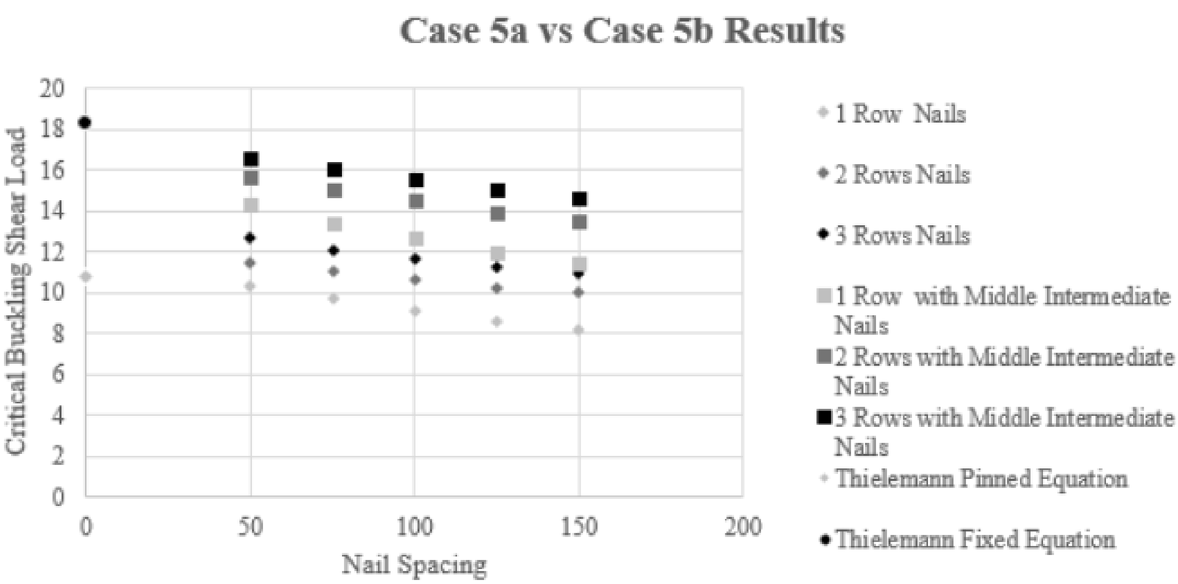

Figure. 2: Comparison of sheathing panel buckling resistance (1-3 rows of nails, with and without intermediate stud nails).

About the researchers

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Research supported by Forestry Innovation Investment

UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

Reliability-based calibration of moment-resisting timber frame systems

What you need to know

Moment-resisting timber frame systems show strong potential for ductile seismic performance, but their reliability has not been systematically evaluated. This research develops a reliability-based framework for these systems that integrates component- and system-level assessments. By explicitly accounting for uncertainties in seismic hazard, structural demand and resistance, the study derives safety factors aimed to achieve consistent target reliability across seismic regions and performance levels.

Overview

Explicit seismic design guidelines for moment-resisting timber frame (MRTF) systems are not yet available in Canada's National Building Code, and the reliability of these systems has not been systematically studied, despite their potential for ductile seismic performance and flexible open-plan spaces. This research develops a design framework for MRTFs and evaluates their reliability at both the connection and system levels. At the component level, it examines connection resistance and material variability-based overstrength ratio for capacity-based design. At the structural level, it applies probabilistic performance-based methods to assess overall frame performance and system reliability, quantify key sources of uncertainty, and calibrate partial safety factors to achieve more uniform safety levels.

Research approach

The research team examined MRTF systems at both the component and system levels. At the component level, analytical strength predictions were carried out for beam-column moment connections, and a variability-based overstrength factor to support capacity-based design was determined.

At the system level, a four-storey MRTF archetype with moderately ductile connections was designed separately for two seismic regions and analyzed using nonlinear time-history analysis. Multiple Stripe Analysis was used to estimate structural failure probabilities by performing nonlinear dynamic analyses at multiple discrete intensity levels. Two nonlinear connection models, Pinching4 and SAWS, were used to capture the hysteretic response of the beam-column connection and examine its influence on system behaviour. The performance of each design was evaluated based on the maximum inter-storey drift ratio. Finally, demand was fitted with power-law models and hazard distributions were fitted using Fréchet and lognormal models to derive reliability indices and safety factors.

Key findings

- Reinforced moment connections exhibited ductile behaviour, and their analytical yield and peak strength were predicted using the current Canadian Standard for Engeering Design in Wood (CSA O86-19) equations.
- Material variability was incorporated in the connection analysis, and a variability-based overstrength ratio of 2.1 was determined for capacity-based design of timber elements.
- A design framework for MRTFs was developed to satisfy both strength- and displacement-based seismic demands.
- Seismic demand uncertainty, particularly record-to-record variability, was found to dominate MRTF system reliability.

- Lognormal approximation of lifetime seismic intensity enables practical reliability calculations with acceptable accuracy.
- Constant, site-independent resistance factors can be calibrated to achieve target reliability, aligning reliability theory with code practice.
- The MRTF systems satisfied collapse-prevention drift limits and showed low residual drifts, indicating good reparability performance.

Why this matters

This work supports reliability-based calibration of seismic design provisions for mass timber systems. It can inform future code development, guide the selection of resistance factors for MRTFs, and provide a framework for evaluating new timber systems across seismic regions. Future research would include a broader investigation of multiple connection specimens to establish a more conclusive variability-based overstrength factor for timber design, as well as a reliability-based study at the component level. Further evidence is also required across different building heights and ductility levels to generalize the findings.

For more information and related resources, including citations where available, visit the project profile on the Wood Research Library:
woodresearchlibrary.com/en/permalink/catalogue4722

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Research supported by

Forestry Innovation Investment

NSERC CRSNG

Canadian Wood Council
Conseil canadien du bois