Q-07-RI

Vibrational and stress-wave methods for rapid and cost-effective assessment of veneer-based mass timber elements

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Anticipated Start Date: *September 2024* | **Expected Duration:** *24 Months*

Need & Industrial Relevance | Goals & Objectives

Need & Industrial Relevance

Pre- manufacturing design-based methods (i.e., K-method, Gamma method, SAM) for mass timber quality assurance are unable to confirm grade post-manufacture. Post-manufacture static tests are costly and time-consuming. There is a need for non-destructive testing (NDT) of mass timber elements both at the production stage and in use to: a) better QC; b) increase confidence in the product; c) validate analytical models; d) optimize products.

Research Roadmap Topics

Topic 2024-12

Evaluation of Mass Timber Products with transverse and/or longitudinal vibration techniques.

Topic 2024-11

System Effects in Mass Timber Products.

Long Term Goals

Developing an NDT method for mass timber elements as in-line quality evaluation tool for manufacturers, and, with adjustments, for on-site inspections and forensics.

Objectives

The specific objectives for the 1st year of the project are to:

1) Develop an experimental program for vibration-based and acoustic-based testing of veneer-based mass timber elements.

2) Collect and analyze NDT data from vibration and stress-wave (SW) testing for use in the second year to a) develop machine learning (ML) prediction models; b) validate the models against static bending data.

Materials and Methods

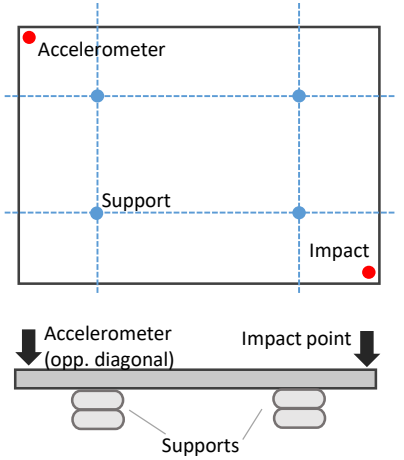
Vibration and Stress-wave NDT testing (first year)

Materials

- Veneer-based mass timber elements in structural dimensions (wooden species: DF)
- For VLT and MPP panels, typical length-to-thickness ratios (thin plate behavior[1])

NDT Test setup

- Boundary conditions suitable for in-line system (e.g., all-sides freely supported conditions[2])
- Surface-mounted accelerometer and electronic impact hammer
- Point-wise, transverse through transmission for stress-wave time-of-flight
- Data collected with a sound and vibration data logger (NI) and processed with LabVIEW.



Panel vibration test setup adapted from Faircloth et al. 2023

Data analysis

- Dynamic moduli determined using analytical techniques for beam-like and plate-like geometries. Rayleigh-Ritz method for thin plate analysis (determination of E_x, Ey and Gxy from 1st mode of vibration).
- Time-of-flight analysis of stress waves

[1]Zhou et al. 2020 and Opazo-Vega et al. 2021
[2]Faircloth et al. 2021

Outcomes and Deliverables

first year of the project.

Expected Outcome	Deliverable (s)	2024				2025										
		S	O	N	D	J	F	M	A	J	J	A	S	O	N	D
Material acquisition – grad student onboarding – NDT setup	Set up the experimental plan and setup															
Vibrational data for new LVL, VLT, MPL, and MPP elements	Vibration data collected															
Analyze vibrational properties of tested elements based on natural frequency from free vibration and determine dynamic moduli based on analytical solutions	Dynamic properties of the tested elements analyzed and dynamic moduli calculated.															
Stress-wave (SW) time-of-flight (ToF) data for new LVL, VLT, MPL, and MPP elements	SW data collected and ToF determined															
Analyze local vs global properties of the tested mass timber elements.	Correlate SW-ToF data and global vibrational data															
Static test setup	Static tests for NDT results initiated															
Dissemination of Phase I	NDT study presented at a relevant conference such as WCTE 2025 (vibration) and report on Phase I prepared for dissemination															
Initiate Phase II (weathering – NDT + static tests - Machine Learning analysis for prediction)	Experimental setup for NDT during weathering complete. ML analysis plan initiated.															

Expected Practical Implications/Impacts

The advancement of an effective NDT method for mass timber elements will have widespread positive impacts across the industry. These benefits extend not only to manufacturers and adhesive suppliers but also encompass developers, contractors, and insurance companies. Such innovation enables:

1. Implementing rapid, reliable, and cost-effective quality control in the plant.
2. Reducing the potential for litigation by more easily segregating below-standard products.
3. Increasing confidence in mass timber products and therefore their acceptance by the market.
4. Building a database of post-manufacturing panel properties.
5. Developing more accurate mechanical models, by using such a database.
6. Increasing material efficiency and improving production processes.
7. Identifying production and in-service factors affecting the product's quality and performance

Budget

Budget justification & request for funding

Funds are requested for a Graduate student at 0.49 FTE during academic year with equivalent summer appointment costs in year 1 using a base monthly salary of $4,874 for a total of 28,659. The graduate student will be responsible for data collection and analysis.
Fringe benefits for graduate student follow institutional approved guidelines and start at 34% in year 1 for a total of $9,774.

Graduate student tuition and fees are budgeted for 3 terms total with the per term academic year cost at $5,187 per institutional guidance.

Funds are requested for travel expenses incurred by the student to perform the research, including those needed for data collection at the partnering plants.

Funds are requested to ship test materials to OSU.

BUDGET	AMOUNT
First Year Expenses	
GRA & Benefits	$ 38,403
Tuition & Fees	$ 15,561
Materials/Supplies	
Travel	$ 1,536
Other (shipping costs):	$ 3,500
YEAR 1 TOTAL:	$ 59,000
Expected future request amounts:	$ 60,000

Thank You

Questions?