Boise-22: *Using Notch Delamination to Study Moisture Adhesive interaction*

Student: Samuel Ayeni | **PI(s):** Arijit Sinha, John A. Nairn | **Site:** Oregon State University

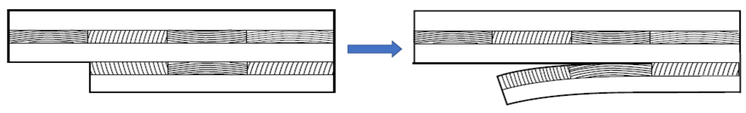
Wood-Based Composites Center

WBC Spring Meeting | Corvallis, Oregon | April 17 – 18, 2024

Need and Industrial Relevance:

A common misconception regarding moisture stability in wood composites, such as plywood, is that the dimensional stability they provide eliminates issues with wood movement. Realistically, dimensional stability is achieved through balancing internal stresses that can cause failure or limit durability.

Understanding moisture-adhesive interaction is essential for predicting failures, assessing durability, devising mitigation strategies, optimizing process, and ensuring regulatory compliance in diverse applications and environmental conditions.



Project Goals:

To determine the method of maximizing durability of layered panel products subjected to seasonal variations in environmental stresses.

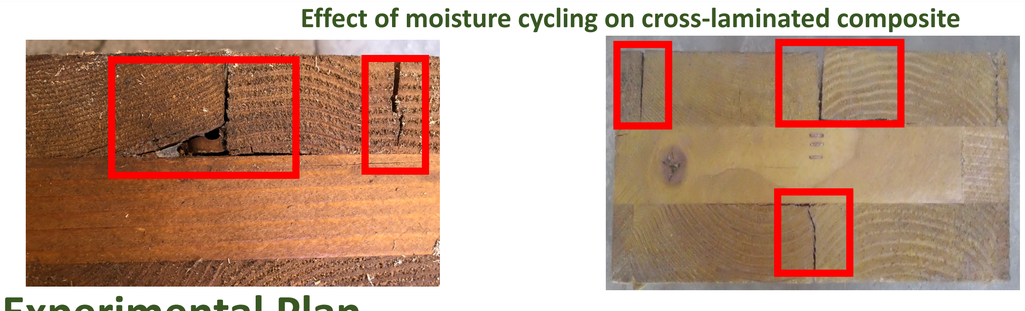
Objectives:

- The overarching goal of this research is to measure the degree of delamination and crack propagation in notched cross-laminated wood panel products as a function of layer thicknesses, notch depths, and environmental conditions.
- To quantify the effect of lamination thickness on moisture durability in notched cross-laminated products.
- To ascertain and contrast the impact of moisture on the durability of notched cross-laminated beams using primary and secondary lamination adhesives.
- To develop a reliable model to better understand the data in terms of material properties for other cross-laminated composites with notches in their design.

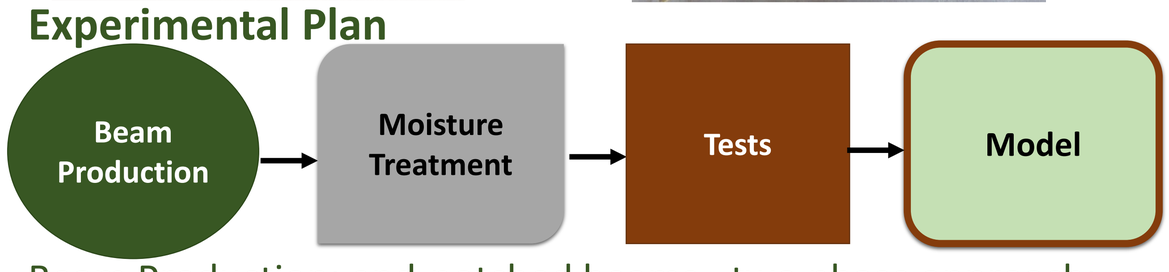
Current Ongoing Tasks:

- Develop an experimental plan for the project
- Review literature to understand notches and fracture mechanics
- Material procurement and specimen fabrication

Effect of moisture cycling on cross-laminated composite



Experimental Plan



- Beam Production: end-notched beams - two phase approach;
  - Phenol Formaldehyde as the primary adhesive.
  - Secondary lamination adhesives – Emulsion Polymer. Isocyanate (EPI) & Melamine Urea Formaldehyde (MUF).
  - 3mm thick veneer, 9 Layers and 7 lay-up.
  - Laminated Veneer Lumber & Cross-lam
- Moisture Treatment –
  - Moisture cycling
  - Static moisture conditioning
- Tests – Delamination test: three-point bending tests.
  - Cracking test : four-point bending tests.

Challenges / Opportunities

- The intricate interactions between moisture and adhesive bonding, including factors like swelling and debonding can be challenging.
- Conducting accelerated aging to simulate real-world conditions may be too slow and resource-intensive.

Expected Practical Implications/Impacts:

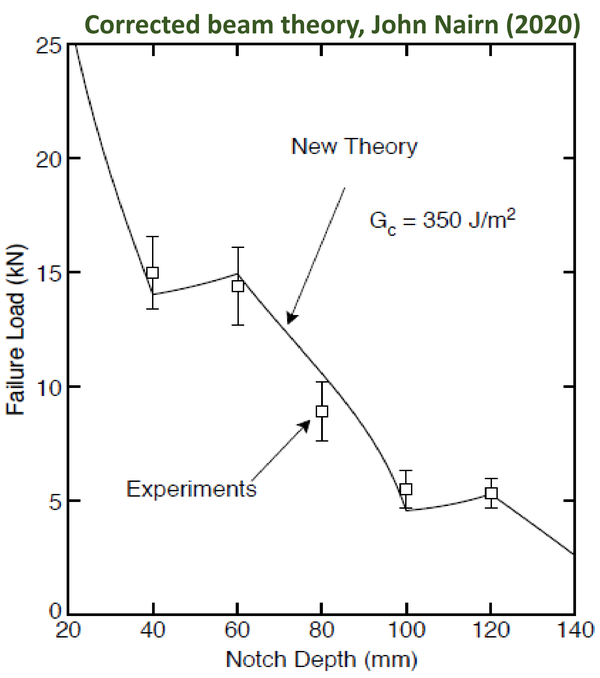
- Layer of thickness has a profound effect – our hypothesis.
- If confirmed, then veneer based composites, especially for mass timber application will be a logical choice as it will prevent these durability limit states.
- Thinning of layers would imply higher use of adhesives. Delamination and cracking experiments can determine the maximum thicknesses allowed in a layered composite.

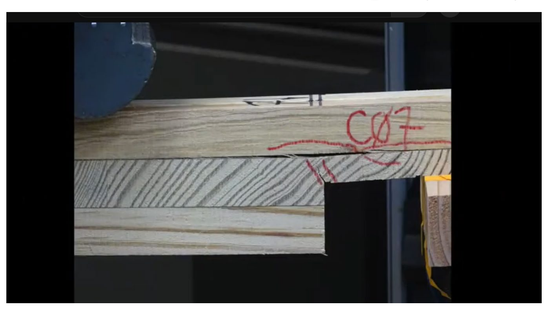
Preliminary Notching Results

John A. Nairn's theory of fracture mechanics will be tested further by comparing to experiments on:

- Layer thicknesses
- Resin effect
- Moisture effects.

Notched CLT Delamination test @ depth 1 layers





Notched CLT Delamination test @ depth 1.5 layers

Notched CLT Delamination test @ depth 2 layers

Planned Deliverables & Timeline

Specific Goal	Deliverable (s)	2023				2024										
		S	O	N	D	J	F	M	A	J	J	A	S	O	N	D
Set up Analytical models based on Nairn's theory and other literature	Draft Analytical model															
Model refinement	Finalized analytical model															
Material procurement	Samples prepped for experiments to begin															
Carry out experiments	Completed experiments															
Data Reduction and Analysis	Data analysis, stress concentration and moisture interactions discerned															
Validation of models	Validated models															
Final Report and Dissemination	Final report, student thesis, and journal paper(s)															

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Award Date: September 2022 **Start Date:** October 2023 **Anticipated End Date:** August 2025

Research Team & Technical Advisors

Research Team	IAB Technical Advisors
Arijit Sinha John A. Nairn Ian Morrell Samuel Ayeni	Daniel Way (**IAB Lead**) Patrick Farrell

Interim Conference Call Record:

Date: March 1, 2024
Participants: Arijit Sinha, John Nairn, Ian Morrell, Daniel Way, Patrick Farrell, Samuel Ayeni
Outcomes: Experimental plan was proposed, and participants deliberation aimed at refining adhesive selection for improved experimental outcomes. Following thorough examination, a consensus was reached to utilize phenol formaldehyde as the primary adhesive, complimented by Emulsion Polymer Isocyanate (EPI) and Melamine Urea Formaldehyde (MUF) as secondary adhesives. This strategic approach is anticipated to enhance bonding performance and durability within the experimental framework in achieving desired results and advancing research objectives.

Response to Recent IAB TC Feedback (from prior meeting):

Use last LIFE Form Summary for specific feedback, found on website www.wbc.center/research/planning/research-planning-site/

Expected Project Outcomes and Deliverables (from proposal):

For continuation funding requests, include any comments with budget showing request. Note any leveraged funding received or expected.

(Insert updated budget here)

PROJECT BUDGET/FUNDING CONTINUATION REQUEST				
Four Year, Single-Site Project (all entries in USD)				
Project Title and ID:				
Project Start Date:				
Date of this Report:		(Year ?)		
Expected Project End Date:				
Site/Partner:				
Award Date:				
Item (*TOTAL cost of project*)	Year One Funding Requested or Awarded	Year Two Funding Expected or Awarded	Year Three Funding Expected or Awarded	Year Four Funding Expected or Awarded
Check One:	Expected:	Expected:	Expected:	Expected:
	Awarded:	Awarded:	Awarded:	Awarded:
Graduate Assistantship(s) & Fringe Benefits (#)				
Tuition and Fees (#)				
Travel (faculty only for OSU/VT, ALL travel for Partners)				
Materials and Supplies				
Other: (specify)				
Other: (specify)				
Other: (specify)				
Cost Total:	$0	$0	$0	$0
Leveraged (non-WBC) Funds *(What are you, your department, or college contributing to the total costs listed above?)*				
Graduate Assistantship(s) & Fringe Benefits (#)				
Tuition and Fees (#)				
Other: (specify)				
Other: (specify)				
Other: (specify)				
Total WBC Funding Estimate or Request:	$0	$0	$0	$0

Note:
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