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POSTERS WITH EXTENDED ABSTRACTS

Those marked SPC were part of the student poster competition

Assessing the Innovativeness of Primary Processors and Their Interest in New Biomass Solutions—Odelia Okai, Graduate Research Assistant, Oregon State University

This study examines how primary wood processors approach innovation and how willing they are to adopt new biomass solutions. The research is motivated by conditions in the Western United States, where decades of fire suppression, selective harvesting, and climate change have left forests overcrowded with small-diameter timber, increasing wildfire risk while producing large volumes of low-value material. Although forest thinning can improve forest health, limited markets and declining processing infrastructure often make utilization of small-diameter timber economically unviable. The objective of this study is to document and better understand innovation strategies that support biomass utilization and forest restoration. The research focuses on four solution 10 categories: structural composites, non-structural composites, wood-based energy, and specialty products. Using a qualitative multiple case examples approach, the study draws on interviews and supporting company materials to examine innovation processes, products, adoption drivers, and barriers faced by primary processors.

SPC-3 **Detecting Glue-Line Skips in Veneer-Based Mass Timber Elements Using Ultrasound and Machine Learning**—Autumn Battisti, Graduate Research Assistant, Oregon State University

One class of defect that can occur in the manufacturing of a veneer-based mass timber element is glue-line skips in the secondary bonds between plywood billets being laid up. This study explores the ability of single-point through transmission ultrasonic testing perpendicular to the lamellas to detect these glue-line skips within veneer-based mass timber elements amid the many other material heterogeneities using machine learning. In this study, eight eight-ply Douglas-fir plywood panels with no cross-grain lamellas are cut into 80 two foot by two foot square billets. Ultrasound scanning is done on a two inch square grid (for 121 points per element) with a 54 kHz transducer operated by the Pundit 200 testing device. These billets are thoroughly characterized with ultrasound and are then glued into 31 two-ply elements and then those two-ply elements are glued into 20 four-ply elements. Artificial glue-line skips are created at varying positions and diameters by screening the glue application for these secondary bond layers, and both the two-ply and four-ply versions are characterized with ultrasound. This study then develops and tests two models: the first model attempts to classify elements by whether they pass or fail PRG 320’s effective bond area requirements by the time-of-flight grid for the element and the second model attempts to predict the glue-skip prevalence at individual 01points by their ultrasound signal.

P-4 **A Machine Learning-Enhanced Framework for Bolt Tightness Identification in Timber Connections via Acoustic Signature Analysis**—Chun-Yu Lin, Oregon State University

The long-term structural integrity of mass timber construction is often challenged by bolt preload relaxation due to the viscoelastic behavior of wood. This study proposes an intelligent non-destructive evaluation(NDE) framework that integrates vibro-acoustic sensing with machine learning to classify bolt tightness levels. The research design involves capturing acoustic emission data from timber joints subjected to controlled incremental torque stages to simulate various states of connection integrity. The methodology focuses on automated feature extraction from transient acoustic responses, prioritizing parameters such as spectral centroid shifts and damping coefficients. These extracted features serve as inputs to supervised learning algorithms to establish a predictive relationship between acoustic signatures and bolt tension. By training models to recognize non-linear patterns associated with interface friction and material variability, this approach aims to overcome the inherent complexities of timber's internal structure. The proposed framework provides a data-driven diagnostic tool that paves the way for automated structural health monitoring and predictive maintenance in sustainable timber engineering.

SPC- 5 **Effect of Biochar on Wettability, Mechanical and Thermal Properties of wood Sodium Silicate Composites**—Sodiq Babatunde Yusuf, Graduate Research Assistant, University of Idaho

The global bio-composites market has grown at a compound annual growth rate of 12% from 2016-2024, but major drawbacks include poor thermal stability, poor resistance to fire and biological attack, hydrophilicity causing swelling and weak interfacial bonding. Biochar is considered a sustainable filler to enhance the properties and biodegradability of polymer composites. The aim of this work is to investigate the effect of biochar addition on the mechanical, thermal, water soak, rheological and viscoelastic properties of wood-sodium silicate (W-SS) composites. Commercial biochar (B) was blended at 10% and 20% by weight with W and SS while lowering SS content. The properties of B-SS were also evaluated and compared with 50% W-50% SS and 50% B, 60% Band and 70% B content with the remainder being SS. Composite containing 50% W-10% B- 40% SS content had the best mechanical properties. Biochar improved thermal, water absorption, and flow properties compared to W-SS but lower in mechanical properties.

PP-6 **Optimizing Microwave Pre-Treatment Conditions for Improved Bond Quality in Southern Yellow Pine LVL**—Shuaib Mubarak, Postdoctoral Scholar, Oregon State University

This study investigates the use of microwave treatment to enhance the quality and sustainability of Southern yellow pine laminated veneer lumber (LVL). Controlled microwave exposure is applied to wood veneers to modify their internal microstructure prior to adhesive bonding and panel assembly. The research examines the effect of microwave treatment on microstructural changes, bond formation, and overall panel performance. Comprehensive characterization includes microscopic analysis of cell wall and pore structure, evaluation of adhesive bond quality, and mechanical testing of manufactured LVL to assess stiffness and strength. Results from this study are used to identify processing conditions that improve bonding efficiency while maintaining or enhancing material integrity. This approach offers a pathway toward higher-performance LVL with improved resource efficiency, supporting sustainable production and broader adoption of engineered wood products.

SPC-7 **Outdoor Moisture Durability of Hybrid Cross-Laminated Timber—**Abasali Masoumi, Master's Student, Virginia Tech

Outdoor durability is a major challenge for cross-laminated timber (CLT), especially under prolonged wetting, fluctuating humidity, and natural weathering. The objective of this study was to evaluate the outdoor moisture durability and weathering performance of hybrid CLT incorporating thermally modified wood (TMW) outer plies, compared with unmodified CLT and solid wood controls. The year-long outdoor performance of yellow-poplar single-layer boards (unmodified and TMW) and CLT assemblies, unmodified 5-layer CLT and hybrid 5-layer CLT with unmodified core layers and TMW outer plies, was evaluated. Specimens were exposed to a one-year outdoor cycle, with moisture durability assessed through moisture content monitoring and visual inspection for checking, cupping, and delamination. During the initial drying period, the middle-layer moisture content of hybrid CLT was 1.28 percentage points lower than unmodified CLT after 3 days of drying and 0.24 percentage points lower after 7 days, with lower observed variability. Based on visual inspection, hybrid CLT exhibited no delamination and only minor surface checking after one year of exposure, whereas unmodified CLT showed extensive delamination and pronounced cupping. These results indicate that CLT incorporating TMW outer plies exhibits reduced moisture accumulation and improved moisture durability compared to unmodified CLT.

P-8 **Structural Safety–Based Alternative Design and Carbon Substitution Analysis of Hybrid Timber–Steel Systems for Vertical Extension Remodeling**—Keon-Ho KIM, Research Official, National Institute of Forest Science

To quantify the carbon substitution effect of timber application, this study establishes a conventional reinforced concrete (RC) vertical extension as a baseline design and develops alternative timber and hybrid timber–steel structural systems based on equivalent structural safety and performance criteria. The proposed alternatives employ steel or glulam beam–column frames combined with timber–concrete composite (TCC) slabs, designed to satisfy strength, stiffness, serviceability, fire resistance, and acoustic requirements. Structural redesign and analysis confirmed that the alternative systems provide performance comparable to or exceeding that of the RC baseline while significantly reducing structural self-weight. Based on the verified designs, material quantities for concrete, steel, and timber were calculated for each structural system. A carbon substitution analysis was then conducted by comparing material quantities between the baseline RC system and the alternative designs, enabling estimation of avoided carbon emissions resulting from reduced concrete and steel use. The results demonstrate that structurally equivalent timber-based vertical extension systems can achieve substantial carbon substitution while maintaining structural feasibility for multi-family housing remodeling.

SPC-9 **Application of Biochar in Geotechnics: Enhancing pH Buffering Capacity of Soil—** Bhawana Dhakal, Oregon State University

Cement is commonly used for stabilization of soil to improve the engineering properties and make soil suitable for construction. Long-term stabilization depends on pozzolanic reactions, which require a highly alkaline environment; however, maintaining such high pH can be challenging in acidic soils. Research in agricultural soils suggests that biochar can help maintain alkalinity. To evaluate its geotechnical potential, this study investigates Douglas-fir biochar as a soil additive to enhance pH buffering capacity and mechanical performance. Biochar produced at 350°C, 500°C and 700°C was added to acidic loam soil at varying contents to assess its effects on soil pH and pH buffering. The most effective biochar was selected and different dosages of biochar were added for unconfined compressive strength (UCS) testing. Preliminary findings indicate that the pyrolysis temperature significantly influences pH buffering capacity of the soil. This work highlights the potential of forest-based biochar for sustainable geotechnical applications.

PSPC-11 **Extraction, Characterization and Adhesive Application Potential of Biomass-Derived Tannins**—Augustine J. Sackey, Research Assistant, University of Idaho

Tannins are naturally occurring polyphenolic compounds widely distributed in forest and agricultural biomass. They have abundant hydroxyl groups which can form strong complexes with other macromolecules, making them useful alternatives for use in wood adhesives and composites. In this study, tannins were extracted from low-value biomass sources (pecan shells (PS), Douglas-fir bark (DFB), and walnut shells (WS) using large scale hot water extraction. The tannin extracts were chemically characterized by a combination of FTIR and 13C NMR spectroscopies and electrospray ionization mass spectrometry (ESI-MS) confirming that these extracts were composed of condensed tannins. Thermogravimetric analysis showed tannins from PS and DFB exhibited higher thermal stability compared to WS tannins. The extracted tannins were evaluated for their performance as wood adhesives by lap-shear tests and compared to a commercial phenol-resorcinol formaldehyde (PRF) resin. Hybrid resin formulations (50% tannin – 50% PRF) were also evaluated. Lap shear tensile testing showed that tannin-only systems exhibited lower bonding performance, while tannin-PRF hybrid systems, particularly DFB-PRF formulation, demonstrated significantly improved bonding strength. These results demonstrate the potential of PS, DFB and WS for hybrid biobased adhesive systems, supporting the development of sustainable wood adhesive systems using biomass-derived phenolic compounds.

SPC-13 **Effects of Ultraviolet Irradiation and Ultrasonic Sonication on Biochar for Methylene Blue Adsorption**—Madeline Gnann, Graduate Research Assistant, Mississippi State University

Biochar is a black, carbon-rich material produced by heating biomass in a low-oxygen environment, known for its carbon sequestration and agricultural benefits. Although its natural properties include high adsorption, little research has examined the use of ultraviolet (UV) irradiation and ultrasonic sonication to further increase this capacity. This study assesses the impact of particle size distribution, UV treatment, and ultrasonic sonication on industry-specific biochar to optimize its methylene blue adsorption. Biochar from multiple companies, with varying particle-size distributions, was upgraded at different power levels to increase adsorption rates to noteworthy levels. Future work will involve creating Artificial Intelligence (AI) CNN models to predict biochar size in industry settings.

SPC-15 **Effect of Thermo-Hydro-Mechanical Treatment on Adhesive Performance of Hardwoods**—Kevin Mongold, Undergraduate Student, West Virginia University

This research investigates the adhesive performance of yellow poplar (Liriodendron tulipifera) subjected to combined thermal and compression treatments, aiming to enhance bonding quality for wood-based products. Samples were thermally treated in absence of oxygen at controlled temperatures to modify their chemical and physical structure, followed by densification through mechanical compression using two compression rates to increase surface density and reduce porosity. The study evaluates how these treatments influence the wood's interaction with adhesives that includes epoxy, polyurethane and soy-based adhesives. Adhesive performance was assessed through shear strength, delamination resistance, and bond line integrity under both dry and wet conditions.

SPC-17 **Enhancing Yellow Poplar Performance through Thermal Pre-treatment and Thermo-Mechanical Densification—**Ethan Currey, West Virginia University

Yellow poplar (Liriodendron tulipifera) is an abundant Appalachian hardwood with relatively low density, moderate mechanical properties, and limited dimensional stability, restricting its use in structural and engineered wood applications. This study evaluated the effects of thermal pre-treatment and thermo-mechanical densification at 20% and 50% compression ratios on the physical and mechanical properties of yellow poplar wood. Densification increased wood density, with the greatest gains observed at 50% compression. Although 50% compression produced the highest modulus of elasticity (MOE) and modulus of rupture (MOR), it also increased variability in mechanical performance and spring back, reducing dimensional stability. In contrast, 20% compression provided more consistent improvements in mechanical properties while better maintaining dimensional stability. Thermal pre-treatment had a smaller influence than compression ratio. Overall, moderate densification (20%) appears to provide the best balance between improved mechanical performance and dimensional stability, supporting the use of yellow poplar in higher-value engineered wood products.

SPC-19 **Mapping CLT and GLT Production Capacity and Dynamics in Europe's Growing Mass Timber Market**—Peter Romih, MSc student, UP FAMNIT; Junior researcher, InnovaWood

The European Engineered Wood Products (EWP) industry has evolved since the origin of glued laminated timber (GLT) at the beginning of the 20th century. New product types and technological innovations have been introduced and production capacities expanded in a growing European market for sustainable, resource-efficient and industrialised building solutions. This research offers a mapping of the current European GLT and cross-laminated timber (CLT) industry landscape, exploring locations of production capacities, market trends, regulatory challenges, and impacts of demand shifts for the wood construction value chain. A register of EWP manufacturers was developed by manual and AI assisted processing of official product certification records (European Technical Assessment for CLT, and the Declaration of Performance for GLT). The register records product type, wood species, properties, production locations and installed production capacity, cross-checked with multiple sources, including manufacturers' websites, machinery providers, and industry reports. Data on production and market were compared with those provided by the official databases (EUROSTAT and FAOSTAT) and industry reports (Metabolic and Timber-Online). In 2025, in Europe (EU27+CH+NO), we identified 75 CLT companies operating 83 manufacturing sites with an installed capacity of 3 352 100 m^3/year, and 188 GLT companies operating 212 manufacturing sites with an installed capacity of 4 596 325 m^3/year, mostly softwoods. Installed capacity contrasts with actual output estimates, revealing that supply is challenged by demand fluctuations and cycles in the construction sector. After steady growth of CLT production since 2000, demand weakened in 2022/2023 and led to lower utilisation and pressure on prices, until it stabilised again in 2024/2025. A continuous, systematic study of both market supply and demand trends is essential for understanding the development of competitive, efficient, and resilient wood value chains.

SPC-21 **Sustainable Extraction of Hydrolysable Tannins from Staghorn Sumac to Support Appalachian Forest Economies**—Rhianne Markovchick, Undergraduate Student, West Virginia University

Staghorn sumac (Rhus typhina) is a fast-growing, colony-forming species widely distributed throughout the Appalachian region and often considered invasive. Despite its aggressive growth, the species produces red drupes used as seasoning, dyes, and traditional remedies, while its inner bark is rich in hydrolysable tannins and flavonoids with antioxidant and anti-inflammatory properties. These tannins are particularly valuable in vegetable leather tanning. However, extraction efficiency varies significantly depending on solvent type, including methanol, acetone, or ethanol, limiting practical field application. This research aims to develop a consistent laboratory extraction method for hydrolysable tannins from staghorn sumac. By optimizing solvent systems and process parameters for field-level implementation, the project seeks to transform an underutilized invasive species into a value-added secondary forest product. The outcomes will support sustainable forest management while strengthening the Appalachian Forest products industry through innovative bio-based material development.

SPC-23 **Machine Learning Approach to Decay and Defect Detection in Mass Timber Buildings Using the Resistance Drilling Technique—**Opeyemi Odule, Graduate Research Assistant, Oregon State University

The increase in mass timber buildings worldwide and the material's susceptibility to biological degradation have necessitated early detection methods for internal deterioration. This research develops machine learning models to detect and classify decay and manufacturing defects in Cross-Laminated Timber (CLT) and Mass Ply Panels (MPP) using resistance drilling data. Specimens are subjected to fungal decay (two brown rot, one white rot species) over 8 months. Resistance drilling profiles (graphical records of torque vs. depth) are captured alongside mass loss and visual inspection data at 2, 4, 6, and 8-month intervals. These data are used to train machine learning models to classify mass timber condition: sound wood, decay level (early vs. advanced), delamination, and manufacturing defects (knots or voids). The research addresses challenges of identifying hidden internal deterioration before structural compromise and discusses opportunities for implementing resistance drilling in routine mass timber building inspections.

SPC-25 **Understanding Elevated Temperature Response of Wood and Wood-based Composites**—Samuel Olajide, Graduate Research Assistant, Oregon State University

Wood and wood-based composites are increasingly used in residential and commercial buildings, where exposure to elevated temperatures can critically affect performance and service life. This study investigates the effects of elevated temperature on the physical, mechanical, and chemical properties of solid wood and selected wood-based composites. Samples were subjected to controlled thermal exposure over a range of temperatures prior to ignition. Changes in mass loss, thermal stability, microstructural evolution, mechanical performance, and moisture behavior were evaluated using a combination of thermogravimetric analysis, Raman spectroscopy, Fourier transform infrared spectroscopy, and scanning electron microscopy. The study aims to elucidate the mechanisms of thermally induced degradation and failure by examining microstructural and cell wall-level changes in hemicellulose, cellulose, and lignin. The outcomes are expected to provide insight into how elevated temperature exposure affects mechanical performance prior to ignition, offering implications for fire performance prediction and the design of more thermally resilient wood-based materials.

SPC- 27 **Investigating the Evolution of Shear Failure in CLT Transverse Layer Using Acoustic Emission (AE)**—Harika Undadi, Master's Student, Mississippi State University

Cross-laminated timber (CLT), being the alternative for sustainable construction, is susceptible to rolling shear failure in the transverse layers. This study evaluated the rolling shear failure in CLT panels fabricated from southern pine (Pinus spp.) and yellow poplar (Liriodendron tulipifera) using block shear, delamination, and interlaminar shear tests that follow the ANSI/APA PRG-320 standard. Acoustic emission (AE) monitoring was integrated with video recording to capture structural damage while loading. The results indicated that southern pine CLT panels exhibited higher interlaminar shear strength than yellow poplar. It also showed that rolling shear failure was the dominant failure mode in the transverse layer along with interlaminar shear and tension for both species. The accumulative AE energy followed by the stress-strain curve was classified into stages i) a deformation stage with negligible AE signals indicating the elastic behavior with no structural changes; ii) crack propagation stage where AE energy signals were increased with the loading. These signals associated with cracking sounds showed signs of initiation and propagation of microcracks; iii) failure stage where high AE activity along the load drops followed by ultimate failure. The correlation between AE energy, mechanical performance with the evidence of video recording demonstrates the potential use of AE monitoring for the structural health monitoring of CLT structures. Further studies should incorporate advanced techniques such as cluster analysis to further classify the AE signals and improve damage characterization.

SPC- 29 **Radial Variation of Density and Extractives in Coast Redwood**—Galen O Fox, PhD Candidate, Oregon State University

Coast redwood (Sequoia sempervirens [D.Don] Endl.) is renowned for its longevity and durable reddish heartwood, owing to the presence of extractive compounds. The extractive content of coast redwood is known to vary up the tree, by latitude, and between primary and secondary forests. However little is known about redwood extractive composition or radial variation. Increment cores were collected from twenty trees at 10, 30, and 60 meters, including both primary and secondary trees, and divided between northern and southern locations in Northern California. Xylem density was measured radially using X-ray densitometry and averaged approximately 350 kg/m3, decreasing slightly from pith to bark. Latewood densities of 800-1000 kg/m3 and earlywood densities of 200-300 kg/m3 were observed. Preliminary extractions of milled redwood lumber indicate extractive content at 19.9% of dry mass. Chemical analysis of extractive compounds and their radial distribution will be conducted using GC/MS and this work summarizes preliminary findings.

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