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Durability Assessment of Coated Cross-Laminated Timber (CLT) Wall and Slab Panels with and without Weather and Vapor Barriers under Coastal Exposure

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Cross-laminated timber (CLT) provides environmental and structural advantages; however, moisture management remains a critical challenge for long-term durability, particularly in humid and coastal climates. While commercial liquid-applied coatings are widely used to protect mass timber, the added performance of weather and vapor-resistive barriers (WRBs) under prolonged outdoor exposure remains insufficiently documented. This study presents a comparative field evaluation of coated CLT wall and slab panels, with and without WRB systems, subjected to summer and early-fall coastal exposure in Bristol, Rhode Island. One full-scale mock-up was assembled using lab-fabricated CLT panels. All faces received a three-coat liquid finish, and half of each panel was additionally covered with a vapor-permeable WRB to enable direct side-by-side comparison. Moisture and temperature sensors were installed at three depths (shallow-, mid-, and deep-depth layer) across all conditions. Data collected over a three-and-a-half-month period were analyzed alongside local weather-station records to assess the extent and depth of moisture ingress, the duration of elevated moisture levels above durability and mold-growth thresholds, and the overall effectiveness of WRB protection relative to coated-only assemblies. Results demonstrated that WRB application reduced surface wetting duration by 26 days (from 46 to 20 days above 16% MC) on horizontal shallow surfaces and shortened recovery times, especially on horizontal elements exposed to direct rainfall and ponding, while deeper layers remained largely within safe service ranges. The findings provide evidence-based guidance for best practices in moisture protection of CLT systems under coastal exposure and support ongoing efforts to develop standardized durability protocols for mass timber construction.

Keywords: Cross-Laminated Timber (CLT), Weather Barriers, Moisture Intrusion, Coastal Exposure, Durability Assessment.

Introduction

Cross-laminated timber (CLT) is primarily used in residential and commercial construction because it offers many environmental and structural benefits (Cappellazzi et al., 2020; Shams et al., 2024). However, managing the moisture content (MC) of CLT is a primary concern, especially in humid and coastal environments. Exposure to moisture for prolonged periods of time increases the risks of fungal decay, reduces structural durability, and results in deterioration of materials. Commercial liquid-applied coatings are commonly used to protect mass timber, but the additional use of weather resistant barriers (WRBs) is not well studied. Understanding the effects of using a combination of coatings and WRBs is important to developing long-term durability recommendations for CLT structures under coastal conditions. Previous research has consistently emphasized that mass timber products are highly susceptible to moisture damage, highlighting that the main durability risks come from moisture exposure. Fungal decay risks in mass timber generally occur around a MC of 30%, with more severe risks happening around MCs of 60-80%. Mass timber is typically manufactured with a MC around 12%, so even short-term exposure to rain can drastically elevate MC levels beyond what is safe, leading to swelling, cracking, and glue-lined failures (Cappellazzi et al., 2020). Similarly, CLT panels exposed to outdoor conditions in Portugal discovered that end-grain surfaces are the main locations for water absorption and quickly surpass the fiber saturation point of 25-30% when exposed to rain. These moisture entrapment zones displayed little to no drying, ultimately leading to high risks of degradation, including delamination, warping, and cracking (Lima et al., 2024). Moreover, studies conducted in rainy, coastal environments further demonstrate that exposure to moisture during construction greatly impacts the long-term durability of structures (Schmidt & Riggio, 2019; Lima et al., 2024). Field monitoring in Pacific Northwest climates during construction revealed MC to be extremely variable based on panel orientation, shading, and coatings. Coated and sun-exposed panels dried faster and had a lower MC, while moisture-trapping connections and end-grains had a MC that remained above the safe threshold for prolonged periods (Schmidt & Riggio, 2019). Understanding how CLT panels absorb and release water creates a better understanding of how coatings and WRBs can help protect mass timber, specifically horizontal elements such as roofs and slabs, which are more vulnerable to puddling water. Even though protective coatings reduce water intake, impermeable barriers tend to trap moisture inside the wood and slow the drying process (Kordziel et al., 2020). This highlights the need for protective measures that are water-resistant and permeable. Additionally, moisture behaviors in mass timber are affected by hygrothermal properties and variable outdoor conditions. Mass timber panels naturally regulate their humidity levels by absorbing and releasing moisture, but if panels are sealed too tightly with protective coatings, moisture can become trapped within the wood and accelerate the decaying process (Hameury, 2006). Humid and coastal environments have been indicated by hygrothermal modeling to possess the highest potential for condensation, mold, and freeze-thaw damage, and support the use of WRBs to increase longevity and durability of structures (Fedorik & Niemi, 2024; Shams et al., 2024). Nonetheless, CLT buildings in Nordic climates are able to reach an acceptable durability standard without weather protection systems through active moisture management, careful scheduling, and post-construction surface treatments. However, these tactics are extremely labor-intensive and unreliable in wetter environments (Time et al., 2023). This emphasizes the importance of proper WRBs and protective systems to maximize long-term performance. From a material standpoint, the use of environmentally friendly protective treatments has been investigated and revealed that wood treated with a blend of creosote and biodiesel maintained fungal resistance while also reducing negative impacts on the environment (Walker et al., 2023). This suggests that the durability of wood that is exposed to moisture can be strengthened with the use of sustainable coatings. It is important to use vapor barriers and protective wraps to fight the deterioration of wood materials in marine climates where there are high humidity levels, salt, and wind-driven rain (Biondini & Frangopol, 2023). These principles are also applicable to CLT systems in comparable climatic conditions. According to electrical resistivity tomography, moisture infiltration patterns are influenced by environmental variations (De Jong et al., 2020), similar to how joint orientation and end-grain exposure impact the moisture distribution in CLT.

This study addresses the performance of coated lab-fabricated CLT wall and slab panels with and without WRBs under a three-and-a-half-month period of outdoor coastal exposure during summer and early-fall. The structural mock-up was constructed using CLT and glulam components, which allowed for a direct comparison between the panels with only coatings and the panels with coatings and WRBs. This research addresses three primary objectives. First, it aims to determine how much moisture intrusion occurs in coated CLT wall and slab panels when there are no WRBs applied. Second, it looks into safety thresholds and to what depth and how long temperature and moisture levels exceed mold-growth or durability thresholds. Lastly, it evaluates the effectiveness of coatings and WRBs at limiting moisture penetration when compared to CLT panels that are coated-only. Addressing these objectives will provide data on the performance of CLT panels in outdoor coastal environments, ultimately providing guidance on the use of combining coatings and WRBs in mass timber construction in coastal climates.

Methodology

This study evaluated the short-term moisture performance of coated CLT wall and floor panels, with and without weather- and vapor-resistive barriers, when exposed to a coastal outdoor environment. The objective is to quantify the depth, duration, and intensity of moisture ingress through coated CLT assemblies under natural weathering, and to determine the additive protective effect of WRBs in CLT walls and vapor barriers in CLT decks in combination with industry-standard coating systems. One full-scale mock-up was constructed for side-by-side exposure testing. The mock-up was assembled with the panels fabricated in the laboratory under controlled conditions. Although the test assembly was exposed to outside environmental conditions from early-June to mid-October, it was only monitored continuously from early-July through mid-October because of an incomplete data set from June, representing approximately three-and-a-half-months of collected data from coastal summer and early-fall.

Materials

The experimental assembly consists of one five-ply CLT slab panel, one CLT wall panel, and supporting glulam beams and columns in the mock-up. The CLT panels were manufactured from two by four by ten feet, Spruce-Pine-Fir (SPF) common grade No. 2 or better dimensional lumbers, purchased from local lumber yard in Middletown, RI, as kiln-dried to an average equilibrium MC of (12 ± 2%) and stored in an ambient room temperature of 70°F prior to fabrication to maintain stable moisture conditions. The laboratory-fabricated CLT panels were produced in the Construction Methods and Materials Laboratory at the host university, using a layup identical to that of the commercially donated panels. Each panel comprised a lamellae of 1.35-inch final thickness, 48-inch of width and 48-inch of length after surfacing (S4S) and planing, face-glued using Henkel (Henkel Adhesive Technologies, n.d.) 1C-PUR (Loctite® HB X602) adhesive in combination with the Loctite® PR 3105 PUR-bond primer. Adhesive was applied at a nominal spread rate of 180 g/m². The lamellae were assembled in alternating grain orientations, and the stacks were pressed under vacuum pressure maintained at 24 inHg (0.82 MPa) , which previous testing confirmed to be sufficient for achieving full bond integrity without glue-line failure (Shoberg, 2000). The pressing duration was 42 hours, exceeding the minimum manufacturer requirement of 24 hours before release. Glulam elements were not the focus of this study but were used to support the CLT panels structurally within the mock-up. Before coating, all CLT panel faces and edges were inspected for surface defects, sanding irregularities, or glue-line gaps. Surfaces were prepared using 60–80 grit sandpaper applied with a random-orbital sander to achieve a clean, even finish suitable for coating adhesion. Following sanding, the surfaces were thoroughly vacuumed and cleaned with compressed air to remove residual dust and debris.

Coating Application

The CLT slab panels received an industry-standard liquid-applied three-coat system (the product name is not disclosed per the manufacturer’s preference), while the CLT wall panels received the two-coat system. The first coat in each system was a penetrating sealer applied to the point of saturation at approximately 6–8 wet mil thickness. Intermediate and topcoats were applied at 3.5–4.5 wet mils with drying intervals of 4–8 hours at 20°C and 50% relative humidity. Panels were left to cure for a minimum of one week prior to testing. To protect exposed edges and end-grain regions, all panel perimeters were treated with one-coat liquid-applied end sealer, applied twice to saturation (8–10 mils per application) with 2–12 hours of drying time between coats. Coating applications were performed in an indoor environment controlled at 70 °F to minimize environmental variability. Film thicknesses were verified using a wet-film gauge, and each coat's uniformity and coverage were visually inspected and documented. This coating process ensured that all panels shared equivalent surface protection and enabled the subsequent analysis to isolate the effects of WRBs.

Weather Barrier Application

Following the coating cure, each CLT panel face was divided longitudinally into two equal halves to allow direct comparison between coated-only and coated with WRB conditions under identical exposure. For wall assemblies, a VaproShield (VaproShield LLC, n.d.) WallShield IT® Integrated Tape, vapor-permeable water resistive, vapor permeable membrane, was mechanically attached over one half of the wall panel. For the slab assembly, a VaproShield SlopeShield® Plus Self-Adhered multi-purpose air barrier and permeable vapor retarder membrane designed for horizontal surfaces was applied with a peel and stick method and pressed sufficiently to eliminate air pockets. All overlaps, seams, and terminations were sealed using compatible single-sided three-inch black ultraviolet VaproTape®, ensuring continuous protection. Prior to installation, all coated surfaces were confirmed dry, clean, and free of contaminants. The half-panel WRB approach allowed side-by-side monitoring of identical assemblies that differed only in the presence of the WRB, thereby improving experimental control and comparability. All WRB product data sheets, permeability ratings, and installation specifications were archived in the project record to enable future replication.

Mock-Up Construction and Exposure Setup

The mock-up was assembled outdoors on the Shell Path of the host university campus (41°39'07.5"N 71°15'19.0"W), a coastal region characterized by high humidity, salt exposure, and wind-driven rain. The mock-up was oriented North-West to South-East (South-West-facing) to maximize exposure to prevailing winds and solar radiation. The assembly was elevated eight inches above grade on concrete masonry unit supports placed on top of a water-proof tarp member to prevent direct ground moisture contact and allow air circulation beneath the horizontal panels. The mock-up consisted of one wall panel installed vertically and one floor slab panel mounted horizontally, connected via one glulam beam fastened via Simpson Strong Tie (SST) (Simpson Strong-Tie Company Inc., n.d.) HU Galvanized Face-Mount Hanger to a column to simulate building geometry. The CLT wall also was fastened to the CLT slab with SST® ZMAX Galvanized Heavy Tie Plates, and SST® ZMAX Galvanized Reinforcing L Angle brackets. Additionally, the glulam columns were fastened to the CLT slabs using an SST® RPBZ ZMAX Galvanized Retrofit Post Base.

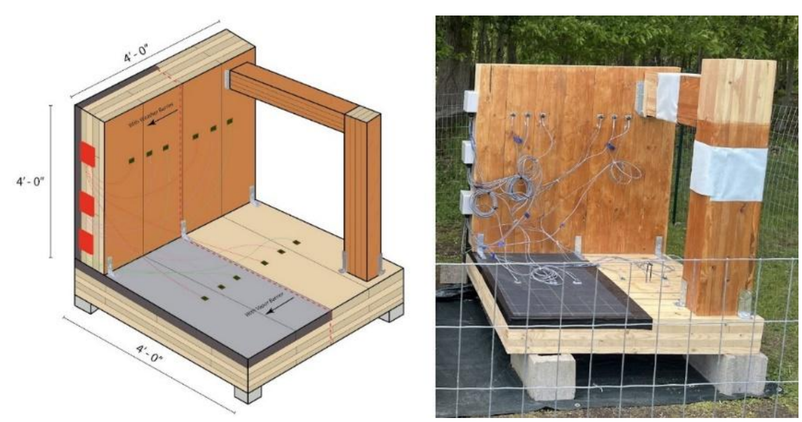

Figure 1. The CLT Mock-up and Sensors Attachment Details

Sensor Installation and Instrumentation

Monitoring of internal panel moisture and temperature was achieved using an array of Structural Monitoring Technology (SMT) (SMT Research Ltd., n.d.) wireless sensors integrated with a data logger transmitting the readings to the Building Information Gateway (BiG) data platform where temperature compensation and wood species correction factors were applied. The system provided continuous measurements of wood MC and temperature at multiple depths within each CLT element, enabling assessment of moisture gradients and temporal variations during the coastal exposure period.

The SMT system employs the electrical resistance method to determine wood MC, in which two metallic electrodes were embedded into the wood, and the measured electrical resistance between them is converted to MC using temperature-compensated calibration curves. This technique, widely adopted for long-term timber monitoring (Dietsch et al., 2014), allows repeated, non-destructive measurement of MC across the 9–30% range typical of service conditions.

Each Point Moisture Measurement (PMM) sensor couple consisted of one pair of stainless-steel pin electrodes for MC measurement and one pearl-shaped MF52 series thermistor (coated in ethoxyline resin) temperature sensor positioned immediately adjacent to the electrodes. This configuration ensured temperature correction of the resistance-based moisture readings and allowed assessment of hygrothermal interactions at each depth.

Each test condition (coated-only and coated with WRB, for CLT slab and CLT wall panels) included three depth-specific sensor couples installed at representative cross-sectional locations:

- Shallow-depth layer – immediately beneath the coated surface 0.5-inch depth.
- Mid-depth layer – approximately at the panel midline 4 inches.
- Deep-depth layer – within 6 inches of the final ply or underside lamella.

Sensors were arranged along a common line at mid-width of each panel condition (no WRB, or with WRB) to capture through-thickness gradients without interference from fasteners or grain variation. The sensor's spacing was maintained at about 10 inches, oriented perpendicular to the grain direction to minimize anisotropic effects.

Sensor installation followed SMT manufacturer protocols to ensure consistent contact and minimize measurement bias. Small pilot holes were pre-drilled at precise depths using depth-limited bits, and the surrounding drilled area was immediately sealed with a non-shrinking, low-conductivity sealant to prevent moisture intrusion along the lead wire. Electrodes were then inserted to the target depth, ensuring firm seating within a single lamella. Thermistor sensors were installed adjacent to each electrode pair, embedded within the same lamella to record local temperature. Sensor leads were routed through protective conduits along the back of the panels to the data acquisition nodes and all the cable runs were secured to prevent tension or abrasion. Each sensor pair was assigned a unique channel ID within the BiG platform and physically labeled for traceability. These channel IDs were used for assuring the proper wiring and sensor channel mapping inside the WiDAQ/A3 multi-channel dataloggers which were installed vertically on one edge side of each CLT mock-up and supporting 8 channels, four PMM sensors and four MF52 series thermistor. The dataloggers were powered by three AA alkaline batteries, making the system suitable for long term operation. All the input ports were enclosed in a double gang plastic junction to minimize condensation risk.

Corresponding electrical resistance values were recorded to derive individual calibration curves, which were input into the BiG system for temperature-compensated MC conversion. Each node was configured to record at one-hour intervals. Data was transmitted via Wi-Fi to the BiG cloud server for storage and visualization. Weekly system checks confirmed data continuity, battery status, and node connectivity. Sensor performance was verified using manufacturer's calibration specifications for SPF species with temperature compensation applied via the BiG platform. Measurement consistency was confirmed during the initial 13-day equilibrium period when all depth sensors stabilized within 12-13% MC. This detailed mapping and validation protocol ensured the reliability and traceability of all time-series data collected throughout the exposure period, allowing for accurate interpretation of moisture transport behavior within the coated and WRB-integrated CLT assemblies.

Environmental Monitoring

Environmental conditions were documented using data from a nearby weather station in Tiverton, RI (~3 miles), with the exception of precipitation data which was obtained from the National Oceanic and Atmospheric Administration T. F. Green Airport weather station (KPVD), the closest long-term station to the Bristol site (~10 mi). For the purposes of this study, rainfall events greater than 0.5 inches were identified as significant, and these events were used to evaluate correlations with measured changes in panel MC during the July to mid-October monitoring period.

Data Collection and Analysis

Environmental conditions, such as relative humidity, temperature ranges, peak wind intensities, and sun exposure characteristics were found for the site. The average relative humidities for July, August, September, and October within the allotted period were 84.9%, 80.8%, 85.9%, and 80.2%, respectively; the temperature ranged from 38.65-99.7°F, 38.12-98.9°F, 38.46-99.2°F, 37.82-99.1°F, respectively; and the sun exposure had maximum monthly values of 1040 w/m^2, 986 w/m^2, 917 w/m^2, and 808 w/m^2, respectively, with similar minimum values of 0.04 w/m^2. There were 14 significant rain events producing rainfall over 0.5 in, and peak wind intensities of the site were 44.9 ft/s, 41.7 ft/s, and 40.8 ft/s. Temperature-compensated MC readings were collected continuously at three depths; shallow-, mid-, and deep-depth layer for both wall and slab panels under two exposure conditions: coated-only and coated plus a vapor-permeable weather/vapor-resistive barrier. During the first weeks of exposure, a consistent offset was observed in the deep sensors due to variations in lamella density and electrode seating. To remove this bias, deep-depth layer data were calibrated to the mid-depth layer equilibrium during the first extended dry interval (13 days) in early-mid-August, when all layers stabilized between 12–13% MC. This alignment established a uniform dry baseline without affecting the timing or amplitude of the data, allowing for reliable through-thickness comparisons.

To preliminarily evaluate differences in MC between the coated-only and WRB halves, four MC thresholds were utilized to interpret performance risk of mold growth in the layers over time:

- <16% MC: No Risk, safe service condition
- 16–18% MC: Low-Risk, early warning level for moisture ingress
- 18–25% MC: High-Risk, associated with reduced strength and potential for fungal initiation
- >25% MC: Very-High-Risk, indicating prolonged wetness and conditions favorable for fungal attack

These categories align with recommendations in the National Design Specification for Wood Construction (American Wood Council [AWC], 2018) and findings by Udele et al. (2021), which associate MCs above 25–30% with accelerated fungal growth and mechanical degradation in CLT.

Figure 2 shows the daily MC average for the vertical CLT wall. The rainfall dots (≥0.5 in) align closely with short-term moisture spikes, indicating a direct relationship between rainfall and MC response. In the shallow-depth layer, both coated-only and WRB sides generally remained below 16% MC for most of the exposure but did rise into the high-risk range (18–25%) immediately following heavier rain events, particularly in early-September. The peaks were brief, and recovery to the safe range was rapid. The similar amplitude of shallow-depth layer responses between the two halves suggests that for vertical faces, the coating alone was largely sufficient to prevent water retention, aided by gravity drainage and solar exposure.

At the mid-depth layer, the WRB appeared to provide measurable benefit in reducing moisture intrusion. After clusters of rainfall, the coated-only section recorded several extended excursions within the high-risk range, while the WRB section showed only short-lived elevations limited mostly to the low-risk zone. This suggests that the WRB effectively restricted moisture transfer and moderated through-thickness diffusion.

At the deep-depth layer, both protection conditions remained mostly below 16% MC after calibration, though the WRB side consistently registered slightly higher values and longer return times to baseline. The deep-depth layer trace with WRB rose modestly after the early- and late-September rainfall events and declined more gradually than the coated-only side. This resulted in a few extra low-risk days and one high-risk day. The pattern reflects slower natural drying rather than added wetting, meaning that once moisture diffused inward during wet periods, the vapor-permeable WRB slightly limited outward vapor flow, extending recovery time under passive conditions. With no fans, drainage mats, or airflow at edges, the inner lamellae relied entirely on diffusion to equilibrate, explaining the longer drying tails on the WRB side despite similar peak magnitudes.

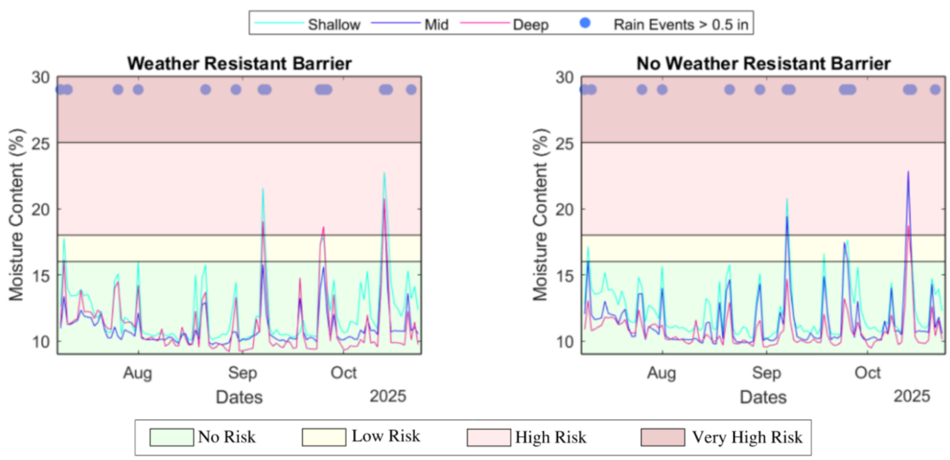

Figure 2. Daily MC (%) Averages for Vertical CLT Wall. Daily averages with typical standard deviations of ±0.5% MC during stable periods and ±1.5% MC during wetting events.

Figure 3 illustrates the daily MC average trends for the horizontal slab. Here, the impact of rainfall was more severe since the horizontal surface directly intercepted precipitation and retained it longer, allowing short-term ponding and slower runoff compared to the vertical panel. Every rainfall dot coincided with sharp shallow-depth layer increases, reflecting direct rainfall and ponding on the surface. The coated-only section frequently entered and sustained MC values in the high-risk and very-high-risk ranges, sometimes remaining elevated for several days. The WRB section, by contrast, exhibited lower peak values and faster return to baseline. Most of its rainfall responses remained within the low- to high-risk zones but rarely exceeded 25%. This difference suggests the WRB's ability to limit liquid water absorption on horizontal exposures, the condition which is most vulnerable to surface pooling and prolonged wetting. At the mid-depth layer, both halves displayed relatively small responses, but their behavior differed slightly across the three major rainfall events. The WRB half rose into the high-risk range three times, each aligned with the early- and late-September, and early-October storms, yet recovered within a day or two after each event. The coated-only half also entered the high-risk range during the first two events but reached the very-high-risk threshold during the early-October rainfall before returning to safe levels. These patterns indicate that while both conditions experienced short-term moisture transmission to the mid-depth layer, the WRB moderated the magnitude and duration of those peaks, preventing extreme saturation even under the heaviest rainfall.

At the deep-depth layer, both conditions remained within the safe zone for nearly the entire monitoring period, yet the responses after the early- and late-September and early-October rainfall events reveal subtle differences in how moisture moved and dissipated through the slab. In early-September, both traces showed small increases, with the WRB curve rising slightly higher than the coated-only side, likely because the shallow-depth layer under the WRB also absorbed more moisture during that rainfall event, and a portion of this additional surface intake gradually redistributed downward as vapor into the inner lamellae. In late-September, the WRB side climbed only into the low-risk range, while the coated-only side continued upward into the high-risk zone. During the early-October storm, both deep traces reached similar peaks near the high-risk threshold, but the WRB half dropped back to no-risk levels more quickly afterward. Throughout drier periods, the WRB curve consistently trended at the lower end of the safe range, suggesting that its surface protection reduced cumulative moisture migration through the section and helped maintain drier equilibrium conditions at depth even under passive, natural drying.

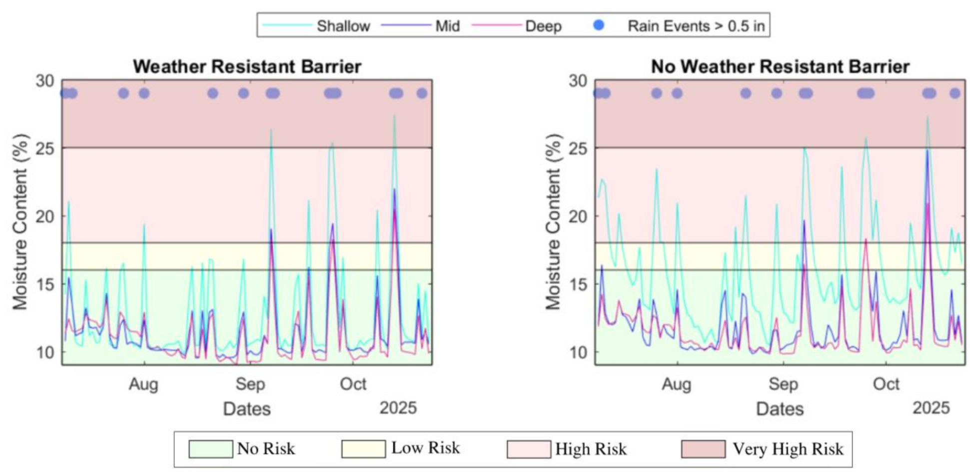

Figure 3. Daily MC (%) Averages for Horizontal CLT Slab. Daily averages with typical standard deviations of ±0.5% MC during stable periods and ±1.5% MC during wetting events.

The data summarized in **Table 1** presents the cumulative count of days within each MC threshold for each sensor shown in **Figures 2** and **3**. For the horizontal slab, the WRB was most effective at the shallow-depth layer, where it notably reduced the number of days above safe moisture levels. At the mid-depth layer, both conditions performed nearly the same, indicating that rainfall during the summer and early-fall period did not drive prolonged wetting through the section. At the greatest depth, both with and without a WRB remained within the safe range for most of the monitoring period, though the WRB half recorded one additional day in the high-risk band, reflecting a minor drying delay rather than greater moisture ingress. For the vertical wall, surface exposure was broadly comparable between conditions, with equal no-risk days and only slight differences in the elevated moisture ranges. The WRB half for the shallow-depth layer had one fewer low-risk day but one additional high-risk day compared to the coated only half, consistent with short, event-driven increases that quickly returned to baseline. At the mid-depth layer, the WRB improved performance, increasing no-risk days, eliminating low-risk days, and reducing time in the high-risk range, suggesting its benefit in limiting through-thickness diffusion. At the deep-depth layer, the WRB showed fewer no-risk days and slightly more time in the low- and high-risk ranges, suggesting brief and shallow moisture increases under passive drying conditions rather than added wetting. Overall, the vertical assembly demonstrates mid-depth reduction in moisture response due to the WRB, comparable surface behavior between conditions, and a deeper response characterized by minor, short-lived moisture increases that reflect diffusion-controlled drying beneath the vapor-permeable barrier.

Table 1. Duration of Exposure within defined MC for CLT Panels with and without WRBs

MC% Range	Days within Each Moisture Content Threshold											
	Vertical CLT Wall						Horizontal CLT Slab					
	Shallow		Mid		Deep		Shallow		Mid		Deep	
	No WRB	WRB	No WRB	WRB	No WRB	WRB	No WRB	WRB	No WRB	WRB	No WRB	WRB
<16%	100	100	103	106	106	102	61	87	101	101	104	104
16-18%	5	4	2	0	0	2	17	8	3	3	1	0
18-25%	2	3	2	1	1	3	26	9	3	3	2	3
>25%	0	0	0	0	0	0	3	3	0	0	0	0

Current Study Limitations and Future Work

This study has several limitations. The sample size consisted of one mock-up assembly due to sensor performance issues in a second commercially-fabricated mock-up deployed concurrently. The three-and-a-half-month monitoring period captured only summer and early-fall conditions, excluding winter freeze-thaw cycles and prolonged cold-weather saturation. The laboratory-fabricated panels may differ from commercial products, and the passive outdoor exposure lacked typical building enclosure details such as ventilation systems and drainage mats. Future work will address these limitations through continued full-year monitoring of both mock-ups to capture seasonal variations. Comparative analysis between laboratory-fabricated and commercial CLT will be conducted using data from periods when both assemblies achieve reliable sensor performance.

Conclusion

The preliminary monitoring results demonstrate that a breathable WRB, when applied in combination with a high-performance coating, can measurably enhance the short-term moisture performance of CLT assemblies exposed to coastal environmental conditions. The WRB reduced both the intensity and duration of moisture spikes at surface and mid-depth layers, particularly in the horizontal slab where direct rainfall and ponding posed the highest risk, while maintaining drier conditions at deeper layers and confirming effectiveness in limiting through-thickness moisture migration. For vertical panels, the WRB provided meaningful protection at mid-depths, though slightly extended drying times at the deepest sensors under passive exposure indicated that vapor diffusion, not additional wetting, controlled lingering moisture. These results align with Schmidt and Riggio (2019) regarding coating effectiveness in coastal climates and extend this work by quantifying the added protection of vapor-permeable WRBs. The higher moisture risk on horizontal surfaces corroborates Lima et al. (2024), while the effectiveness of breathable barriers validates hygrothermal modeling by Shams et al. (2024). These findings underscore that proper detailing and use of breathable WRB systems can mitigate moisture intrusion risks during construction and early service life of mass-timber buildings in humid and coastal climates. From a practical standpoint, ensuring continuous edge and end-grain sealing, incorporating drainage or ventilation pathways, and maintaining temporary protection during extended rainfall periods can further optimize performance while retaining the WRB's protective benefit.

Acknowledgement

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